

# Joint Shuttle-ISS Operational Flight Rules Annex

## 12A/STS-115

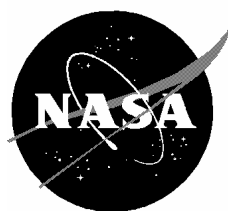
## 12A-12A.1 Stage

Mission Operations Directorate

**Final**

July 31, 2006

**Advance Copy - To be briefed to the  
JPRCB scheduled July 31, 2006.**



National Aeronautics and  
Space Administration

Lyndon B. Johnson Space Center  
Houston, Texas

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JOINT SHUTTLE-ISS OPERATIONAL FLIGHT RULES ANNEX

STS-115/12A, 12A-12A.1 STAGE

FINAL

PREFACE

THIS DOCUMENT, DATED JULY 31, 2006, CONTAINS THE FINAL VERSION OF THE 12A/STS-115, 12A-12A.1 STAGE FLIGHT-SPECIFIC FLIGHT RULES AND IS INTENDED TO BE USED IN CONJUNCTION WITH NSTS-12820, SPACE SHUTTLE OPERATIONAL FLIGHT RULES, VOLUME A; ISS GENERIC OPERATIONAL FLIGHT RULES, VOLUME B; JOINT SHUTTLE/ISS GENERIC OPERATIONAL FLIGHT RULES, VOLUME C, OR SOYUZ/PROGRESS/ISS JOINT FLIGHT RULES, VOLUME D, WHICH CONTAIN THE GENERIC FLIGHT RULES FOR ALL FLIGHTS.

IT IS REQUESTED THAT ANY ORGANIZATION HAVING COMMENTS, QUESTIONS, OR SUGGESTIONS CONCERNING THESE FLIGHT RULES CONTACT DA8/ B. A. LEVY, FLIGHT DIRECTOR OFFICE, BUILDING 4 NORTH, ROOM 3027A, PHONE 281-483-8586.

ALL FLIGHT RULES ARE AVAILABLE ON THE INTERNET. THE URL IS: **HTTP://MOD.JSC.NASA.GOV/DA8**. NO ID OR PASSWORD WILL BE REQUIRED TO ACCESS ANY OF THE RULES PROVIDED THE USER IS ACCESSING FROM A TRUSTED SITE (ALL NASA CENTERS, CONTRACTORS AND INTERNATIONAL PARTNERS). IF UNABLE TO ACCESS, USERS NEED TO SEND AN E-MAIL NOTE TO DA8/M. L. GRIFFITH (MARY.L.GRIFFITH@NASA.GOV) WITH THEIR FULL NAME, COMPANY, IP ADDRESS, AND A JUSTIFICATION STATEMENT FOR ACCESS.

THIS IS A CONTROLLED DOCUMENT AND ANY CHANGES ARE SUBJECT TO THE CHANGE CONTROL PROCEDURES DELINEATED IN APPENDIX B. THIS DOCUMENT IS NOT TO BE REPRODUCED WITHOUT THE WRITTEN APPROVAL OF THE CHIEF, FLIGHT DIRECTOR OFFICE, DA8, LYNDON B. JOHNSON SPACE CENTER, HOUSTON, TEXAS.

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JOINT SHUTTLE-ISS OPERATIONAL FLIGHT RULES ANNEX

STS-115/12A (12A-12A.1 STAGE)

FINAL

JULY 31, 2006

THIS DOCUMENT INCORPORATES CHANGES TO THE FOLLOWING RULES (SINCE THE BASIC, REV A, DATED MAY 11, 2006) BY THE APPLICABLE DISCREPANCY NOTICES (DN'S) AND CHANGE REQUESTS (CR'S).

<u>RULE NO.</u>	<u>DN/CR NO.</u>	<u>RUSSIAN REFERENCE</u>	<u>RULE NO.</u>	<u>DN/CR NO.</u>	<u>RUSSIAN REFERENCE</u>
12A_A1-2	CR 7334		12A_A3-1	CR 7442A	
12A_A1-3	CR 7419		12A_A3-2	CR 7629	
12A_A2-2	CR 7689		12A_A4-1	CR 7626	
12A_A2-4	CR 7687		12A_A4-2	CR 7627	
12A_A2-6	CR 7560		12A_A4-5	CR 7628	
12A_A2-7	CR 7560		12A_B4-1	CR 7659A	[RC]
12A_A2-8	CR 7590				
12A_A2-9	CR 7617		12A_A5-1	CR 7621	
12A_A2-10	CR 7601		12A_A5-2	CR 7622	
12A_A2-11	CR 7692		12A_A5-3	CR 7623	
12A_A2-11	CR 7704				
12A_A2-12	CR 7690		12A_A8-1	CR 7639	
12A_A2-13	CR 7691		12A_B8-1	CR 7530	
12A_C2-1	CR 7625A				
12A_C2-12	CR 7588	[RI]	12A_A9-1	CR 7599A	
12A_C2-13	CR 7650		12A_A9-2	CR 7599A	
12A_C2-15	CR 7402		12A_A9-3	CR 7609	
12A_C2-16	CR 7667	[RI]	12A_A9-4	CR 7609	
12A_C2-31	CR 7686		12A_A9-5	CR 7609	[RI]
12A_C2-32	CR 7494		12A_A9-6	CR 7609	
12A_C2-33	CR 7495		12A_B9-5	CR 7608B	[RI]
12A_C2-33	CR 7618		12A_B9-12	CR 7555A	
12A_C2-41	CR 7606A	[RC]	12A_B9-13	CR 7654	[RI]
12A_C2-47	CR 7528		12A_C9-1	CR 7646	
12A_C2-48	CR 7534	[RC]			
12A_C2-49	CR 7669		12A_A10-1	CR 7560	
12A_C2-52	CR 7680		12A_A10-2	CR 7613	
12A_C2-53	CR 7665		12A_A10-3	CR 7614	
12A_C2-54	CR 7698	[RI]	12A_A10-4	CR 7615	
12A_C2-55	CR 7699A		12A_A10-5	CR 7616	
12A_C2-59	CR 7553		12A_C10-1	CR 7666	
12A_C2-61	CR 7688		12A_C10-2	CR 7668	
12A_C2-62	CR 7694	[RI]	12A_C10-3	CR 7670	
12A_C2-62	ED	[RI]	12A_C10-4	CR 7697	
12A_C2-64	CR 7635		12A_C10-5	CR 7671	
12A_C2-65	CR 7660C		12A_C10-6	CR 7672	
12A_C2-65	CR 7706		12A_C10-7	CR 7674	
12A_C2-66	CR 7593A	[RI]			
12A_C2-101	CR 7663	[RI]	12A_A11-8	CR 7493	
12A_C2-102	CR 7661		12A_B11-2	CR 7636	
12A_C2-103	CR 7641	[RI]	12A_B11-3	CR 7637B	[RI]
12A_C2-104	CR 7641	[RI]	12A_B11-4	CR 7711A	
12A_C2-105	CR 7641		12A_C11-1	CR 7633	
			12A_C11-3	CR 7518	

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<u>RULE NO.</u>	<u>DN/CR NO.</u>	<u>RUSSIAN REFERENCE</u>	<u>12A C11-4 RULE NO.</u>	<u>CR 7709 DN/CR NO.</u>	<u>RUSSIAN REFERENCE</u>
12A_A12-1	CR 7701		12A_B15-4	CR 7649	[RC]
12A_A12-2	CR 7701		12A_B15-5	CR 7651	
12A_A12-3	CR 7701		12A_B15-7	CR 7655	[RI]
12A_A12-4	CR 7701		12A_B15-8	CR 7656A	[RI]
12A_A12-11	CR 7701		12A_C15-7	CR 7657	
12A_A12-13	CR 7701				
12A_A12-21	CR 7701		12A_A17-1	CR 7603	
12A_A12-22	CR 7701		12A_A17-2	CR 7705	
12A_A12-31	CR 7701				
12A_A12-41	CR 7701		12A_A18-1	CR 7474	
12A_C12-4	CR 7701				
12A_C12-5	CR 7701		12A_B19-1	CR 7638	
			12A_B19-2	CR 7638	
12A_A13-1	CR 7480		12A_B19-3	CR 7638	
12A_C13-2	CR 7700		12A_B19-4	CR 7638	
			12A_B19-5	CR 7714	
12A_A15-1	CR 7642		12A_B19-6	CR 7713B	
12A_A15-2	CR 7643				
12A_A15-3	CR 7644				
12A_B15-1	CR 7645				
12A_B15-2	CR 7647				
12A_B15-3	CR 7648				
				BOOK MGR	<u>BAL 07/31/06</u>
				FINAL QA	<u>ned 07/31/06</u>

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## FLIGHT RULES

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#### SHUTTLE ONLY RULES

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 1 - GENERAL, AUTHORITY, AND DEFINITIONS

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#### SHUTTLE ONLY RULES

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#### 12A\_A1-1 CONFLICTING RULES

FOR ANY RULE IN THIS VOLUME THAT MAY CONFLICT WITH RULES IN VOLUMES A, B, OR C, THE RULE IN THIS VOLUME TAKES PRECEDENCE AS A ONE FLIGHT/ONE SUB-INCREMENT WAIVER TO THE GENERIC BOOKS.

*All rules in this volume are approved by the appropriate authorities as the specific rules for STS-115, Stage 12A.*

#### 12A\_A1-2 STS-115 DEVELOPMENT TEST OBJECTIVE (DTO)/SHORT DURATION BIOASTRONAUTICS INVESTIGATION (SDBI) FCR RESPONSIBILITIES @[DN 34 ] @[CR 7334 ]

THE FOLLOWING FCR POSITIONS ARE RESPONSIBLE FOR THE LISTED DTO'S AND SDBI'S:

A. FLIGHT DYNAMICS OFFICER (FDO):

    DTO 805      CROSSWIND LANDING PERFORMANCE (DTO OF OPPORTUNITY)

B. SURGEON: @[DN 34 ]

    SDBI 1490    BIOAVAILABILITY AND PERFORMANCE EFFECTS OF PROMETHAZINE DURING SPACE FLIGHT, PROTOCOL B (PRE-, IN-, AND POSTFLIGHT)

    SDBI 1493    MONITORING LATENT VIRUS REACTIVATION AND SHEDDING IN ASTRONAUTS (PRE-, IN-, AND POSTFLIGHT)

    SDBI 1634    SLEEP-WAKE ACTIGRAPHY AND LIGHT EXPOSURE DURING SPACE FLIGHT (PRE-, IN-, AND POSTFLIGHT) @[CR 7334 ]

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## FLIGHT RULES

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**12A\_A1-2                    STS-115 DEVELOPMENT TEST OBJECTIVE (DTO)/DETAILED  
SUPPLEMENTARY OBJECTIVE (DSO)/SHORT DURATION  
BIOASTRONAUTICS INVESTIGATION (SDBI) FCR  
RESPONSIBILITIES (CONTINUED)**

SDBI 1490B    BIOAVAILABILITY AND PERFORMANCE EFFECTS OF  
PROMETHAZINE DURING SPACE FLIGHT @[DN 34 ] @[CR 7334 ]

SDBI 1493    MONITORING LATENT VIRUS REACTIVATION AND SHEDDING  
IN ASTRONAUTS

SDBI 1634    SLEEP-WAKE ACTIGRAPHY AND LIGHT EXPOSURE DURING  
SPACEFLIGHT

C.    EMERGENCY, ENVIRONMENTAL, AND CONSUMABLES MANAGER (EECOM) :

SDTO 12004-U    SHUTTLE BOOSTER FAN BYPASS

D.    EXTRAVEHICULAR ACTIVITIES OFFICER (EVA) :

DTO 851        IR CAMERA OBJECTIVE 1 @[DN 34 ]



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**FLIGHT RULES**

**12A\_A1-3**

**STS-115 VEHICLE CONFIGURATION**

STS-115/OV-104 FLIGHT SPECIFIC VEHICLE CONFIGURATIONS AS RELATED TO THE GENERIC RULES ARE LISTED IN THE FOLLOWING TABLE:

VEHICLE CONFIG DEPENDENT RULES	COMPONENT/SYSTEM	CONFIGURATION
{A10-361}, {A10-362}, {A10-363}, {A10-364}, {A10-365}	VIEWPORT	NO
{A15-201}, {A15-202}, {A17-202}, {A17-302}, {A18-60}, {A18-61}, {A18-62}, {A18-306}	AIRLOCK	EXTERNAL
{A17-202}, {A17-302}	TUNNEL ADAPTER	NO
{A10-341}, {A10-342}, {A10-343}, {A10-344}, {A10-345}, {A10-346}	ODS	YES
{A10-281}	PRLA	4 PRLA (2 MIDDLEWEIGHT, 2 SUPER MIDDLEWEIGHT) 2 AKA (STANDARD WEIGHT)
{A2-112}, SECTION 12	PDRS	YES
{A2-105}, {A2-1001}, {A7-102}, {A7-5}, {A7-109}, {A7-1001}, {A8-18}	DISPLAY SYSTEM	MEDS
{A15-26}	SSOR/SSER	YES
{A9-257}, {A9-262}	CRYO TANK SET	5
{A17-202}, {A17-302}	N <sub>2</sub> TANK SET	6
{A2-1001}, {A13-152}, {A13-155}, {A17-53}, {A17-106}, {A17-155}, {A17-156}, {A17-1001}	CO <sub>2</sub> CONTROL	LIOH
{A10-73}	HYD ACCUMULATOR	BELLOWS (ALL)
{A13-30}, {A17-551}	IODINE REMOVAL	GIRA
{A2-1001}, {A9-154}, {A18-256}, {A18-1001}	RAD ISOLATION VALVE	YES
{A9-154}, {A17-3}, {A17-103}, {A17-151}, {A17-153}, {A17-154}, {A17-1001}	AV BAY 3A FAN	STD AVIONICS BAY FAN
{A2-265}	GPS	SINGLE STRING

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

12A\_A1-3

**STS-115 VEHICLE CONFIGURATION (CONTINUED)**

VEHICLE CONFIG DEPENDENT RULES	COMPONENT/ SYSTEM	CONFIGURATION
{A9-154}	TACAN	SLOTS 1,2,3 COLLINS
{A5-2}, {A5-10}, {A5-11}, {A5-12}, {A5-153}	SSME	C - <u>TBD</u> L - <u>TBD</u> R - <u>TBD</u> (PHASE II, BLOCK I, BLOCK II, OR BLOCK IIA)
{A6-2}, {A6-3}	OMS	L - 108 R - 109 (SERIAL NUMBER)
{A2-105}	SPARE HUD	NO
{A2-105}	PAYLOAD RECORDER	NO
{A2-323}	SPARE PDI	NO

©[CR 7419 ]

## FLIGHT RULES

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### ISS ONLY RULES

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#### 12A\_B1-1

#### ISS SUPPORT EQUIPMENT FCR RESPONSIBILITY

- A. PCS HARDWARE AND SOFTWARE - ODIN
- B. SSC, OPS LAN - CIO
- C. OCA - OPS PLAN
- D. UOP
  - 1. POWER OUTLETS - PHALCON
  - 2. DATA OUTLETS - ODIN
  - 3. ISS PLUG-IN PLAN - CIO

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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12A\_C1-1

FLIGHT CONTROL TEAM (FCT) [RI]

- A. THE FCT IS RESPONSIBLE FOR EXECUTING THE FLIGHT WITHIN THE GUIDELINES AND AUTHORITY ESTABLISHED WITHIN THE SPACE SHUTTLE OPERATIONAL FLIGHT RULES.
  
- B. THE FLIGHT DIRECTORS AND VARIOUS PAYLOAD OPERATIONS DIRECTORS ARE THE PRIMARY POINTS OF CONTACT FOR SHUTTLE OPERATIONS COORDINATION, ALTHOUGH THE PRIMARY PAYLOAD OPERATIONS CONTROL CENTER (POCC) INTERFACE TO THE MISSION CONTROL CENTER (MCC) STS FCT IS NOMINALLY THROUGH THE MCC ASSEMBLY AND CHECKOUT OFFICER.
  
- C. THE ISS FLIGHT DIRECTORS AND THE PAYLOAD OPERATIONS DIRECTORS ARE THE PRIMARY POINTS OF CONTACT FOR ISS OPERATIONS COORDINATION ALTHOUGH IF REQUIRED THE PAYLOAD OPERATIONS INTEGRATION CENTER (POIC) INTERFACE TO THE MCC ISS FCT IS THROUGH THE OPS PLANNER FOR OFF NOMINAL SITUATIONS.

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

12A\_C1-1

**FLIGHT CONTROL TEAM (FCT) [RI] (CONTINUED)**

D. PRIMARY POINTS OF CONTACT:

ORGANIZATION	LOCATION	CALL SIGN	TITLE
SPACE SHUTTLE	MCC-H	SHUTTLE FLIGHT	NASA SHUTTLE FLIGHT DIRECTOR
SPACE STATION	MCC-H	STATION FLIGHT	NASA STATION FLIGHT DIRECTOR
SPACE STATION	MCC-M	SRP	MCC-M SHIFT FLIGHT DIRECTOR
SPACE STATION	MCC-M	PRP	AID TO MOSCOW FLIGHT DIRECTOR
SPACE STATION	CSR	IMC	12A ISS MANAGEMENT CENTER
SPACE STATION	MCC-H	RIO	RUSSIAN INTERFACE OFFICER
SPACE SHUTTLE & SPACE STATION	MCC-H	ACO [1]	NASA ASSEMBLY AND CHECKOUT OFFICER
MCC-H	HOUSTON SUPPORT ROOM (HSR) @ MCC-M	HSG	HOUSTON SUPPORT GROUP
MCC-M	RUSSIAN SUPPORT ROOM (RSR) @ MCC-H	RUSSIAN SUPPORT GROUP	RUSSIAN SUPPORT GROUP
ISS PAYLOADS	MSFC POIC	POD	PAYLOAD OPS DIRECTOR
RAMBO	DOD POCC	DOD REP	DOD REPRESENTATIVE

NOTES:

- [1] THE ASSEMBLY AND CHECKOUT OFFICER (ACO) MONITORS & COORDINATES ISS ASSEMBLY OPERATIONS AND IS THE MCC INTERFACE FOR THE ISSPO, STS PAYLOADS, AND CERTAIN DTO'S. THE OPS PLANNER IS THE MCC POC FOR ISS PAYLOADS IF THE MSFC POIC IS UNAVAILABLE FOR ANY REASON.

## FLIGHT RULES

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### 12A\_C1-2

### SHUTTLE SUPPORT EQUIPMENT FCR RESPONSIBILITY

THE FOLLOWING ORBITER SUPPORT EQUIPMENT IS THE RESPONSIBILITY OF THE FCR DISCIPLINES AS INDICATED:

- A. OIU - INCO
- B. TCS - GNC
- C. DTV - INCO
- D. SSV - INCO
- E. WVS - INCO
- F. PRLA'S - MMACS
- G. SHUTTLE ORBITAL COMMUNICATIONS ADAPTER (OCA) - INCO, FAO
- H. PGSC HARDWARE - FAO
- I. PGSC/PCS SOFTWARE RESPONSIBILITIES:
  - 1. RPOP/TCS SOFTWARE - RNDZ GPO
  - 2. RPOP/TRAD - GPO
- J. PAYLOAD DATA INTERFACE PANEL 1 (PDIP 1):
  - 1. ELECTRICAL OUTLETS - EGIL
  - 2. PAYLOAD AND GENERAL SUPPORT COMPUTER (PGSC) COMM PORTS:
    - J103 AND J107 - ODIN
    - J101 AND J105 - INCO
  - 3. KU BAND RATE SWITCH - INCO, FAO
  - 4. DATA I/O PORT - FAO

*The PGSC comm ports, J103 and J107, are used by the PCS to connect into the ISS busses. J101 and J105 are used by the OIU. The data I/O port is used by OCA.*

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## FLIGHT RULES

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12A\_C1-2

**SHUTTLE SUPPORT EQUIPMENT FCR RESPONSIBILITY**  
**(CONTINUED)**

K. PAYLOAD DATA INTERFACE PANEL 2 (PDIP 2):

1. ELECTRICAL OUTLETS - EGIL
2. PAYLOAD AND GENERAL SUPPORT COMPUTER (PGSC) COMM PORTS:  
J101 - GPO  
J107 - INCO

*The PGSC comm port J101 is used by TCS. J107 is used by the SVS.*

L. SHUTTLE A31P LAPTOP HARDWARE AND SOFTWARE COMPONENTS:

1. LAPTOP SHELL HARDWARE COMPONENTS, INCLUDING HARD DRIVE(S) AND CD-ROM DRIVE(S) - FAO
2. NETWORK INTERFACE CARD, CABLING AND CONNECTORS - FAO
3. WINDOWS 2000 OPERATING SYSTEM - FAO
4. QNX OPERATING SYSTEM FOR THE LASER CAMERA SYSTEM (LCS) - INCO
5. LCS APPLICATION SOFTWARE - INCO
6. WING LEADING EDGE SENSORS (WLES) APPLICATION SOFTWARE (A.K.A. "EWBMTAU-WLE") - ACO
7. DOUG APPLICATION SOFTWARE - FAO
8. ET UMBILICAL CAMERA SOFTWARE (KODAK DCS CAMERA MANAGER) - MMACS

M. WLES HARDWARE (LAPTOP RECEIVER UNIT, CABLE RELAY UNITS, AND CABLES FOR A13 PANEL) - ACO

N. ET UMBILICAL CAMERA HARDWARE (FIREWIRE CABLE AND CONVERTER) - MMACS

O. LCS RJ45 CABLE (TO OPP) - INCO

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## **FLIGHT RULES**

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# FLIGHT RULES

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### ISS ONLY RULES

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**FLIGHT RULES**

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**JOINT SHUTTLE/ISS RULES**

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# FLIGHT RULES

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## FLIGHT RULES

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### SECTION 2 - FLIGHT OPERATIONS

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#### SHUTTLE ONLY RULES

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**12A\_A2-1**

**STS-115 PREDOCK THERMAL ATTITUDES**

ORBITER ATTITUDE FROM LAUNCH TO DOCKING WILL BE MANAGED PER THE FOLLOWING (ATTITUDES IN ORBITER COORDINATES):

- A. THE PREFERRED ATTITUDE IS -ZLV -XVV (PLB TO EARTH); HOWEVER, ANY PAYLOAD BAY TO EARTH ATTITUDE IS ACCEPTABLE WITH NO RECOVERY TIME AFTER RETURN TO -ZLV -XVV.

*This is a benign attitude and maintains all P3/4 components within the desired temperature limits. Thermal analysis was performed using the preferred attitude and includes OMS burns, planned water dumps, and IMU alignments.*

*Source: Launch-to-Activation CIR Status for Flight 12A/STS-115, Boeing memo AG-92-J353-STN-RAH-2002-0014, July 24, 2002.*

- B. THE NOMINAL RNDZ PROFILE, FOR ALL BETA ANGLE CASES, WILL MAINTAIN ALL P3/4 COMPONENTS ABOVE THEIR SURVIVAL LIMITS. THE FOLLOWING DEVIATIONS ARE ACCEPTABLE:

1. TI DELAY/ONE REV LATE
2. LOSS OF RNDZ RADAR RNDZ PROFILE
3. LOSS OF -Z STAR TRACKER RNDZ PROFILE

*The thermal analysis timeline includes the nominal rendezvous profile. The above deviations do not adversely affect the desired thermal condition of the P3/4 truss element.*

*Source: Launch-to-Activation CIR Status for Flight 12A/STS-115, Boeing memo AG-92-J353-STN-RAH-2002-0014, July 24, 2002.*

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## FLIGHT RULES

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12A\_A2-1

**STS-115 PREDOCK THERMAL ATTITUDES (CONTINUED)**

- C. THREE HOURS IN THE HEADS-UP OMS BURN ATTITUDE (+ZLV) IS ACCEPTABLE. FOLLOWING AN OMS BURN, 2 HOURS IN AN ATTITUDE DEFINED IN PARAGRAPH A IS REQUIRED PRIOR TO THE NEXT ATTITUDE DEVIATION OR THE START OF THE RNDZ PROFILE.

*The heads-up OMS burn attitude is an acceptable deviation for the time limit specified above. The recovery time allows P3/4 components to return within the predicted temperature band.*

*Source: Launch-to-Activation CIR Status for Flight 12A/STS-115, Boeing memo AG-92-J353-STN-RAH-2002-0014, July 24, 2002.*

- D. PRIOR TO DOCKING, ANY ATTITUDE THAT PLACES SUN IN THE PLB IS ACCEPTABLE FOR UP TO 3 HOURS. AFTER THIS DEVIATION, 10 HOURS IN AN ATTITUDE DEFINED IN PARAGRAPH A IS REQUIRED PRIOR TO THE NEXT ATTITUDE DEVIATION OR THE START OF THE RNDZ PROFILE.

*Attitudes that place Sun in the PLB could cause P3/4 components to exceed their upper temperature limits within 3 hours.*

*Source: Launch-to-Activation CIR Status for Flight 12A/STS-115, Boeing memo AG-92-J353-STN-RAH-2002-0014, July 24, 2002.*

- E. PRIOR TO DOCKING, ANY ATTITUDE THAT PLACES NO SUN IN THE PLB IS ACCEPTABLE FOR UP TO 5 HOURS. AFTER THIS DEVIATION, 10 HOURS IN AN ATTITUDE DEFINED IN PARAGRAPH A IS REQUIRED PRIOR TO THE NEXT ATTITUDE DEVIATION OR THE START OF THE RNDZ PROFILE.

*Attitudes that place no Sun in the PLB could cause P3/4 components to exceed their lower temperature limits within 5 hours.*

*Source: Launch-to-Activation CIR Status for Flight 12A/STS-115, Boeing memo AG-92-J353-STN-RAH-2002-0014, July 24, 2002.*



## FLIGHT RULES

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**12A\_A2-2**

**STS-115 CONTAMINATION CONSTRAINTS MATRIX**

**TABLE 12A\_A2-2-I - CONTAMINATION CONSTRAINTS MATRIX**

ISS ELEMENT OR PAYLOAD	H <sub>2</sub> O DUMPS (SUPPLY, WASTE, FES)	ORBITER LEAKS (OMS/RCS/APU)	FUEL CELL PURGES
RAMBO	DESIRABLE: INHIBIT 15 MINUTES PRIOR TO TEST THROUGH 5 MINUTES AFTER TEST COMPLETE	NONE	DESIRABLE: INHIBIT 15 MINUTES PRIOR TO TEST THROUGH 5 MINUTES AFTER TEST COMPLETE
MAUI	DESIRABLE: INHIBIT 15 MINUTES PRIOR TO TEST THROUGH 5 MINUTES AFTER TEST COMPLETE	NONE	DESIRABLE: INHIBIT 15 MINUTES PRIOR TO TEST THROUGH 5 MINUTES AFTER TEST COMPLETE
P3/P4	HIGHLY DESIRABLE TO INHIBIT SUPPLY AND WASTE H <sub>2</sub> O NOZZLE DUMPS AFTER 4A SAW DEPLOY.	NONE	NONE

©[DN 25 ] ©[CR 7689 ]

*The RAMBO and MAUI water dump and fuel cell purge constraints are desired to minimize potential interference during burn observations, but neither payload will decline an observation opportunity if these constraints are not met. It is highly desired to inhibit supply and waste H<sub>2</sub>O nozzle dumps (supply, waste, or CWC/PWR dumps) following 4A SAW deploy due to contamination concerns. Flash Evaporator System (FES) dumps, if needed, are permitted. If situation demands, nozzle-based supply, waste, and CWC/PWR H<sub>2</sub>O will be considered on a case-by-case basis.* ©[DN 35 ] ©[DN 25 ]

*Sources: Ram Burn Observation PIP (NSTS 21508), Basic + CHG-1, section 4.2.2.4, January 2002, and Maui Analysis of Upper-Atmospheric Injections PIP (NSTS 21530), Basic + CHG-1, section 4.2.2.4, May 2005.* ©[DN 35 ] ©[CR 7689 ]

**12A\_A2-3**

**RESERVED** ©[DN 33 ]

## FLIGHT RULES

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12A\_A2-4

### WLES ON-ORBIT OPERATIONS PRIORITIES

ON-ORBIT OPERATIONS WILL BE CONDUCTED SO AS TO MANAGE SYSTEM BATTERY POWER TO SUPPORT THE FOLLOWING PRIORITIES:

- A. ACCESS TO ASCENT DATA MUST BE MAINTAINED THROUGH THE OPENING OF THE FOCUSED INSPECTION CHIT OR THE MMT DECISION NOT TO CONDUCT AN ASCENT DEBRIS FOCUSED INSPECTION. DURING THIS TIMEFRAME, ANY OF THE FOLLOWING ACTIVITIES ARE ACCEPTABLE: ©[CR 7687 ]
1. ASCENT DATA COLLECTION, PROCESSING, AND RETRIEVAL
  2. ALL ACTIVITIES REQUIRED TO MAINTAIN OR RECOVER SYSTEM CAPABILITY (E.G., DOWNLINK OF HEALTH AND STATUS DATA)
  3. ANY ENGINEERING EVALUATION DATA TAKE OF NO MORE THAN 5 SECONDS (APPROXIMATELY 0.5 AMPERE-SECOND)
  4. ANY ENGINEERING EVALUATION DATA TAKE GREATER THAN 5 SECONDS THAT DOES NOT REDUCE BATTERY CAPACITY BELOW WHAT IS REQUIRED TO DOWNLOAD 40 HALF-SECOND RAW WINDOWS (APPROXIMATELY 480 AMPERE-SECONDS), USING THE WORST CASE PREDICTED TEMPERATURE FOR ESTIMATING BATTERY CAPACITY THAT IS REMAINING
- B. ACCESS TO ASCENT SUMMARY DATA MUST BE MAINTAINED THROUGH THE BEGINNING OF THE FD5 MMT MEETING. THIS REQUIREMENT MAY BE MET BY THE DOWNLINK OF ALL ASCENT SUMMARY DATA THAT IS REQUIRED BY WLE MER PERSONNEL.
- C. COLLECTION AND DOWNLINK OF MMOD MONITORING DATA

*Access to data in the wing-mounted sensor units is constrained by limited battery power and loss of system access at low temperatures (due to the battery output voltage dropping below the electronics cutoff voltage limit). However, within those constraints, the system will be operated to ensure that the SSPO has access to WLES data when needed to corroborate other sources of TPS assessment data. At the opening of the focused inspection chit, all requests for WLES data to corroborate other sources should have been satisfied. By the beginning of the FD5 MMT meeting, any additional corroboration requests that are created out of the focused inspection should have been satisfied. ©[CR 7687 ]*

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## FLIGHT RULES

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### 12A\_A2-4                    WLES ON-ORBIT OPERATIONS PRIORITIES (CONTINUED)

*Ascent raw data is the highest fidelity source, but the large amount of raw data and limited data transfer rates make it impractical to downlink all ascent raw data during flight. Ascent summary data provides insight into probable impacts and uses file sizes that allow the downlink of all summary data. Use of summary data for corroborating other TPS assessment sources after the opening of the focused inspection chit was reviewed and approved by the Orbiter Configuration Control Board (OCCB) on June 27, 2006, and reviewed and approved by the SSPO in Chit 3902 on July 6, 2006. Note that the nominal plan is to downlink all required ascent summary data on FD1. WLE MER decides what summary data is required to most efficiently identify impacts. This involves setting user-defined parameters that alter the way summary data is calculated in addition to deciding which summary file types are value added. @[CR 7687 ]*

*System use for engineering evaluations was reviewed and approved at the Orbiter Configuration Control Board on June 27, 2006. A data take of 5 seconds requires approximately 4 percent of the battery capacity required to accomplish one half-second raw data download and, therefore, has no significant effect upon capability to access ascent raw data. To date, the download of 5-10 half-second raw windows from any single sensor unit is typical, so protecting forty half-second raw data windows provides approximately six times the capacity needed. @[DN 32 ] @[CR 7687 ]*

### 12A\_A2-5                    A31P LAPTOP USAGE PRIORITIES - TBR

#### A. ACCESS TO WING LEADING EDGE SENSORS (WLES) ASCENT PEAKS DATA

*WLES ascent peaks data is considered highest priority since it provides a direct indicator of debris impacts to orbiter TPS. Even though it is currently only a crit 3 system, it is a tool that the SSP is installing on the vehicle to support ascent detection capability. A secondary function is to detect MMOD impact during orbit operations. The availability and analysis results of the WLES data will be used to perform detailed robotic inspection with the Orbiter Boom Sensing System (OBSS) planned throughout the mission.*

#### B. ACCESS TO WLES DETAILED DATA IF REQUIRED TO IDENTIFY SUSPECTED ASCENT IMPACT LOCATION

#### C. LASER CAMERA SYSTEM (LCS) OPERATIONS

*LCS data is a sensor used for direct measurement of TPS integrity. The LCS provides the capability to perform direct measurement of specific areas of concern that may be identified by other inspection/detection assets.*

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## FLIGHT RULES

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12A\_A2-5

A31P LAPTOP USAGE PRIORITIES - TBR (CONTINUED)

## D. DOUG FOR UNTRAINED ROBOTIC OPERATIONS

*The robotic operations required during the SRMS/OBSS's inspection of the orbiter WLE and Nose Cap are very complex and very close to orbiter structure. Dynamic Onboard Ubiquitous Graphics (DOUG) functions as a situational awareness (SA) tool. DOUG provides the robotics operator with a 3D visualization of the operational environment independent of H/W limitations presented by camera and window views. In addition, DOUG will be used by the crew to review uplinked procedures for focused inspections, which will be created and uplinked R/T during the mission. This capability would meet NSTS 60514 Systems Requirements Document for the Orbiter Boom Sensor System, 3.2.1.8.4 Situational Awareness.*

## E. DOUG FOR TRAINED ROBOTIC OPERATIONS

*For normal operations, the crew should not utilize DOUG as a real-time clearance monitoring tool as the tool has not been certified for this function, but it is highly desirable as a situational awareness tool. For all nominal Robotic/OBSS inspection operations, the crew will be well trained to ensure proper clearance between the OBSS and orbiter structure.*

## F. DOWNLINK OF EXTERNAL TANK (ET) UMBILICAL WELL DIGITAL CAMERA IMAGERY

*ET imagery is used to determine if ET debris prevention measures are effective. Retrieval of the ET imagery can wait if there are conflicts with the computer resources required to retrieve the images. In addition, all ET imagery can be retrieved after landing, since the images are not lost if not downlinked in real time.*

*ET imagery is used to determine if ET debris prevention measures are effective. Any acquired digital still imagery of the ET shall be downlinked within 24 hours after ET separation. Retrieval of the ET imagery has a high priority to the Shuttle Program/Flight Control Team and the need for this data must be factored into other conflicts with the computer resources required to retrieve the images. ET imagery can be retrieved after landing, since the images are stored onboard if not downlinked in real time, but the need for this data during the mission must be factored into any decision that would prevent real-time analysis of ET umbilical well digital camera imagery. ©[DN 36 ]*

*Source: Flight Requirements Document, STS-115, NSTS 17462-115, Rev 028, section 3.1 m 6. ©[DN 36 ]*

## G. MANAGEMENT AND DOWNLINK OF WLES ON-ORBIT DATA

*Management of the WLES post ascent is lowest priority due to potential lack of capability that the system batteries have to last for the entire mission. Life expectancy of the battery operation is not predictable even with voltage monitoring capability. In addition, all WLES data can be retrieved after landing, since data is not lost if not downlinked in real time.*

## FLIGHT RULES

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12A\_A2-6

IN-FLIGHT MAINTENANCE (IFM) [HC]

A. DEFINITIONS: @[CR 7560 ]

1. SCHEDULED IN-FLIGHT MAINTENANCE (IFM) IS ACCOMPLISHED ON A PERIODIC (NOT NECESSARILY TIMELINED) BASIS TO KEEP EQUIPMENT OPERATIONAL AND EXTEND ITS LIFE. SCHEDULED IFM TASKS INCLUDE INSPECTION, CLEANING, AND REPLACING FILTERS AND CONSUMABLES. SPECIFICALLY EXCLUDED FROM THIS DEFINITION ARE REPAIR TYPE ACTIVITIES TO CORRECT OR WORK AROUND MALFUNCTIONS.

*Examples of this type of maintenance are filter cleaning, LiOH canister replacement, and calibration of equipment.*

2. UNSCHEDULED IFM IS UNDERTAKEN AS A RESULT OF ANOMALIES AND SPECIFICALLY INCLUDES TEST, MEASUREMENT, INSPECTION, AND REPAIR TYPE ACTIVITIES TO CORRECT OR WORK AROUND MALFUNCTIONS.

*Definitions of categories of maintenance provide common terms for activities which may be constrained by flight rules. For example, scheduled maintenance is planned and approved preflight and usually accomplished without real-time consultation with the MCC-H. Unscheduled maintenance, which is conducted as a result of a hardware malfunction, is usually reviewed real time by the MCC-H whether or not it was preflight approved. This real-time review is conducted to determine orbiter/crew safety impacts.*

B. IMPLEMENTATION OF IFM

1. SCHEDULED IFM:
  - a. IN GENERAL, SCHEDULED MAINTENANCE IS PERFORMED AS REQUIRED WITHOUT CONSULTING MCC. EXCEPTIONS TO THIS RULE MAY BE REQUIRED FOR EQUIPMENT WHICH CANNOT BE ISOLATED FROM THE ORBITER ELECTRICAL POWER SYSTEM, AIR REVITALIZATION SYSTEM, PRESSURE CONTROL SYSTEM, OR THERMAL SYSTEM. THOSE SCHEDULED IFM PROCEDURES WHICH REQUIRE MCC NOTIFICATION PRIOR TO IMPLEMENTATION WILL BE NOTED IN THE FLIGHT SPECIFIC FLIGHT RULE ANNEX.

*Scheduled maintenance is usually considered a routine task. These procedures are reviewed preflight for impact on orbiter systems. In the interest of safety, some procedures may require MCC notification prior to implementation. @[CR 7560 ]*

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## FLIGHT RULES

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12A\_A2-6

**IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)**

- b. SCHEDULED IFM PROCEDURES ON ORBITER HARDWARE WILL BE PERFORMED BY THE CDR, PLT, OR MISSION SPECIALISTS. PAYLOAD HARDWARE MAY BE MAINTAINED BY PAYLOAD SPECIALISTS. @[CR 7560 ]

*CDR's, PLT's, and MS's undergo training specific to orbiter scheduled maintenance.*

2. UNSCHEDULED IFM:

- a. UNSCHEDULED IFM PROCEDURES ON ORBITER HARDWARE WILL BE PERFORMED BY THE CDR, PLT, OR MISSION SPECIALISTS. REPAIR PROCEDURES ON PAYLOAD HARDWARE MAY BE PERFORMED BY PAYLOAD SPECIALISTS IF THE CDR/PLT OR MS IS COGNIZANT OF THIS ACTIVITY.

*CDR's, PLT's, and MS's have an experience and training base to assess the overall impact of a repair procedure on hardware in general and the orbiter in particular.*

- b. UNSCHEDULED IFM PROCEDURES SHALL BE INITIATED ONLY WITH THE APPROVAL OF MCC-H. WHEN COMMUNICATION WITH THE MCC-H IS NOT POSSIBLE AND THE CDR DETERMINES THE SITUATION TO BE CRITICAL, REPAIR MAY BE PERFORMED TO ENSURE THE INTEGRITY OF THE ORBITER OR SAFETY OF THE CREW. SPECIFIC PAYLOAD REPAIR PROCEDURES MAY BE EXEMPTED FROM THIS RULE PREFLIGHT FOR EQUIPMENT ISOLATED FROM THE ORBITER ELECTRICAL POWER SYSTEM, AIR REVITALIZATION SYSTEM, PRESSURE CONTROL SYSTEM, OR THERMAL SYSTEM. THESE EXEMPTIONS WILL BE NOTED IN THE MISSION SPECIFIC FLIGHT RULES ANNEX.

*Repair procedures are written preflight assuming particular hardware configurations, interrelationships, and sequences of hardware failures. In the interest of safety, the procedure is reviewed real time by the MCC-H to ensure that the assumptions under which it was written actually exist during on-orbit operations.*

- c. UNSCHEDULED IFM PROCEDURES WILL BE PERFORMED ONLY IF ADEQUATE TECHNICAL DOCUMENTATION AND POSSIBLY REPRESENTATIVE HARDWARE ARE AVAILABLE. MCC-H WILL DETERMINE THE ADEQUACY OF THIS DOCUMENTATION/HARDWARE, WHICH MAY INCLUDE, BUT IS NOT LIMITED TO, TECHNICAL DRAWINGS, FLIGHT LIKE HARDWARE, AND CLOSEOUT PHOTOS. @[CR 7560 ]

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**FLIGHT RULES****12A\_A2-6****IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)**

*IFM procedures are always verified to the maximum extent possible. Past orbiter flight experience has shown that, when working to repair hardware, line drawings and specifications are not adequate to ensure that the final equipment closeout is known. On numerous occasions, preflight closeout photo documentation has revealed the presence of safety wire, ground straps, and other articles which could pose a hazard or cause permanent damage to the hardware. Closeout photos in the context of this rule include interior views of hardware taken during equipment fabrication/assembly as well as final module/pallet installation. @[CR 7560 ]*

## 3. GENERAL:

- a. WHEN MULTIPLE IFM'S ARE REQUIRED, THE FOLLOWING PRIORITY WILL BE USED IN THEIR IMPLEMENTATION. MISSION SPECIFIC EXCEPTIONS WILL BE NOTED IN THE FLIGHT RULE ANNEX.
  - (1) ORBITER SYSTEMS
  - (2) SPACELAB SYSTEMS (WHEN APPLICABLE)
  - (3) EXPERIMENTS/PAYLOADS SELF-EXPLANATORY
- b. AN IFM WILL BE PERFORMED ASAP TO REGAIN THE REDUNDANCY AND/OR CAPABILITY NECESSARY TO SATISFY THE GO/NO-GO REQUIREMENTS TO CONTINUE PAST THE NEXT PLS OPPORTUNITY. AN IFM TO ESTABLISH ORBITER FAIL-SAFE CAPABILITY WILL HAVE PRIORITY OVER ALL FLIGHT ACTIVITIES AND WILL BE PERFORMED ASAP. FOR EXISTING VALIDATED IFM REPAIR PROCEDURES, IF TIME DOES NOT PERMIT COMPLETION PRIOR TO THE NEXT PLS OPPORTUNITY, A "GO" WILL BE GIVEN ASSUMING A SUCCESSFUL COMPLETION (FOR REAL-TIME DEVELOPED IFM'S, CONSIDERATION WILL BE GIVEN TO DECLARING A "GO" PRIOR TO COMPLETION).

*There is a high level of confidence in existing, validated IFM's. Therefore, the orbiter will remain on orbit, assuming the IFM will be successful, rather than terminate the mission for lack of time to complete the IFM. The confidence level may not be as great for real-time developed IFM's; therefore, the GO to stay on orbit is not automatic, but instead, depends on the level of confidence in the procedure. @[CR 7560 ]*

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## FLIGHT RULES

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12A\_A2-6

**IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)**

- c. ON ENTRY DAY, PRIOR TO BEGINNING DEORBIT PREPARATION (DEORBIT TIG MINUS 4.0 HOURS), AN IFM WILL BE PERFORMED ONLY IF REQUIRED TO REGAIN THE REDUNDANCY AND/OR CAPABILITY NECESSARY TO SATISFY THE MINIMUM ENTRY REQUIREMENTS. AN IFM WILL NOT BE ATTEMPTED DURING DEORBIT PREPARATION EXCEPT FOR THE FOLLOWING SCENARIOS: @[CR 7560 ]
- (1) A ROTATIONAL HAND CONTROLLER (RHC) OR DATA DISPLAY UNIT (DDU) WILL BE REPLACED IF FAILURES IN THESE SYSTEMS RESULT IN THE LOSS OF TWO RHC CHANNELS PRIOR TO ENTERING OPS 3.
  - (2) ENTRY WILL BE DELAYED TO DO AVIONICS BAY FAN CHANGEOUT IF BOTH FANS HAVE FAILED IN AVIONICS BAYS 1 OR 2 AND A FAN CHANGEOUT MAY RECOVER COOLING IN THAT AVIONICS BAY.
  - (3) ENTRY WILL BE DELAYED IF IFM CAPABILITY EXISTS AND IS NEEDED TO MEET ENTRY VENT OPERATION CONSTRAINTS IN RULE {A10-261E}, VENT DOOR MANAGEMENT [HC]:
    - (A) TO REGAIN REDUNDANCY FOR ZERO FAULT TOLERANCE, CONSIDERATION WILL BE GIVEN TO PERFORMING THE IFM IF THE FAILURE OCCURS ANY TIME PRIOR TO THE DEORBIT BURN.
    - (B) TO REGAIN CAPABILITY, THE IFM WILL BE PERFORMED IF THE FAILURE OCCURS AT ANY TIME PRIOR TO ACHIEVING SAFE HP.

*IFM's require use of equipment and tools which are normally stowed. Their use affects the stowage timeline and other activities related to preparing the orbiter for entry.*

*To regain vent door redundancy, consideration will be given to performing an IFM when zero fault tolerant to the next worse failure. However, increasing this fault tolerance will be weighed against deorbit consumables (i.e., propellant, water, O<sub>2</sub> and N<sub>2</sub>), available deorbit opportunities, and landing site weather. After the deorbit burn has been initiated, it is not warranted to stop the burn to regain fault tolerance.*

*Rationale for the remaining exceptions is contained under the appropriate system in paragraph C.*  
@[CR 7560 ]

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

12A\_A2-6

**IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)**

- d. IFM PROCEDURES ON EXPERIMENTS WITH TOXIC HAZARDS - NO IFM PROCEDURES WILL BE INITIATED ON AN EXPERIMENT KNOWN TO REPRESENT A TOXIC HAZARD WITHOUT MCC-H CONCURRENCE. PROTECTIVE EQUIPMENT MAY BE REQUIRED (REF. RULE {A13-155}, ORBITER HAZARDOUS SUBSTANCE SPILL RESPONSE [HC]). PAYLOAD EQUIPMENT THAT REPRESENTS A TOXIC HAZARD WILL BE IDENTIFIED IN THE FLIGHT RULE ANNEX. ©[CR 7560 ]

*A real-time assessment of the possibility of repairing and the risk of exposing the crew to a toxic substance during the repair will be required. The IFM may require that the cleanup equipment specified in Rule {A13-155}, ORBITER HAZARDOUS SUBSTANCE SPILL RESPONSE [HC], be used to minimize risk of crew exposure to toxic substance.*

C. SYSTEMS REPLACEMENT CRITERIA:

1. ANY MDU CAN BE REPLACED WITH ANY OTHER MDU.

*Because of the large number of MDU's (11), an IFM to replace a failed aft MDU with a forward MDU may aid the crew in critical aft station operations (RNDZ, dock/undock) without losing any capability in the forward cockpit. Because of the simple and low risk MDU IFM (45 minutes), the MDU can be reinstalled in the forward cockpit after the critical aft operations.*

2. A KEYBOARD (1 OR 2) WILL BE REPLACED WITH THE AFT KEYBOARD.

*The same rationale is used for the keyboard 1 or 2 IFM as for CRT's and also satisfies the requirement for fail-safe redundancy in entry-critical LRU's.*

3. A SPECIFIC KEY ON (KEYBOARD 1 OR 2) WILL BE REPLACED WITH THE "ACK" OR "MSG RST" KEY FROM THE AFT KEYBOARD.

*If a specific key in one of the forward keyboards is identified as failed, replacing that key with the ACK key from the aft keyboard can restore the keyboard to full operational status. Since the ACK key is only used to acknowledge fault messages by stopping them from flashing and turning off alarm tones, the aft keyboard may continue to be used even if the ACK key has been removed. As an alternative to the ACK key, the MSG RST key may be used. Forward keyboards are required for entry purposes, while no requirement exists for the aft keyboard. An IFM on a forward keyboard key will be done when required, while an IFM on an aft keyboard may be done.*

4. A DEU (1, 2, OR 3) WILL BE REPLACED WITH DEU 4.

*IFM for DEU replacement rationale is the same as the CRT's except DEU 3, due to its location, is capable of being replaced whereas CRT 3 is not. ©[CR 7560 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A2-6

**IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)**

5. AN RHC (LEFT OR RIGHT) WILL BE REPLACED WITH THE AFT RHC IF MORE THAN ONE CHANNEL IS FAILED ON THE SAME CONTROLLER. ©[CR 7560 ]

*Although the loss of two RHC channels does not violate minimum entry requirements (system is still fail-safe), an RHC will be changed out to increase redundancy anytime prior to OPS 3 transition due to its criticality in the CSS/takeover role for entry/landing.*

6. THE FORWARD THC WILL BE REPLACED WITH THE AFT THC.

*An IFM to replace the forward THC with the aft THC is required to ensure at least fail-safe redundancy is available for manual translational control for the deorbit burn.*

7. A DDU (LEFT OR RIGHT) WILL BE REPLACED WITH AFT DDU.

*An IFM to replace a failed DDU may be required if necessary to regain RHC redundancy (ref. paragraph 5).*

8. THE LEFT OR RIGHT HUD WILL BE REPLACED WITH THE SPARE HUD. FOR FLIGHTS WHICH DO NOT CARRY A SPARE HUD, REPLACEMENT OF THE LEFT HUD WITH THE RIGHT HUD WILL BE PERFORMED, TIME PERMITTING, IF A NIGHT LANDING IS PLANNED.

*HUD replacement is considered highly desirable for entry in cases where visibility is restricted on the outer glide slope or for night landings. If a night landing is planned and no spare is available, the right HUD can be moved to the left side to provide the CDR with an operable HUD. The decision to perform the IFM will be based on consideration of the severity of the situation (e.g., weather, day or night, etc.). Reference: Memorandum CB-89-265.*

9. AN ACCU (1 OR 2) WILL BE REPLACED WITH BYPASS CONNECTOR J4.

*An IFM to bypass a failed ACCU is required to ensure redundant voice links for entry and to determine whether next PLS must be declared. A failed IFM would be cause for next PLS with one ACCU down.*

10. TRANSPONDER (1 OR 2) BYPASS WILL BE CONSIDERED IF ONE FAILED. THE BYPASS WILL BE PERFORMED IF BOTH HAVE FAILED.

*An IFM to recover S-band downlink telemetry is required if both transponders have failed. If one is failed, consider expenditure of crew time to perform the IFM to ensure redundancy. ©[CR 7560 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A2-6

IN-FLIGHT MAINTENANCE (IFM) [HC] (CONTINUED)

11. IF BOTH AVIONICS FANS IN AV BAY 1 OR 2 HAVE FAILED, ENTRY WILL BE DELAYED TO REPLACE ONE FAN WITH A FAN FROM ANOTHER AV BAY. ©[CR 7560 ]

*AV bay fan replacement is done to recover cooling for two GPC's, which provide redundancy for entry.*

12. THE PF1/PF2 MDM'S WILL BE SWAPPED ONLY IF REQUIRED TO CLOSE PLBD'S. PLBD MOTOR OPERATION UTILIZING THE IFM PIN KIT WILL BE USED IN LIEU OF SWAPPING PL MDM'S IF, AFTER THE MDM'S ARE SWAPPED, THE PLBD MOTOR IFM WOULD STILL BE REQUIRED TO CLOSE AND/OR LATCH THE DOORS.

*Due to the potential for connector pin damage during demate/mate operations, replacement or swapping of PL MDM's is only considered for PLBD closure. No consideration is made to swap PL MDM's for mission success reasons. The PLBD motor operation IFM is a collection of pin kit procedures to recover PLBD motor functions lost as a result of a failed PL MDM, and the motor driven by the other PL MDM has hard failed. If swapping PL MDM's will not recover all the necessary functions to close and latch the doors, the pin kit procedures will be used to regain the lost functions in lieu of swapping the MDM's.*

13. FOR FLIGHT CRITICAL MDM'S - FF4 WILL BE SWAPPED WITH FF1, FF2, OR FF3 AFTER POWER CYCLING AND PORT MODING FAILS TO CLEAR A NON-GPC CAUSED "I/O ERROR FFX" OR TOTAL OUTPUT CARD FAILURE AND IT RESULTS IN THE LOSS OF:

a. A SECOND IMU

B. A SECOND ACCELEROMETER ASSEMBLY (AA) (AA4 MUST BE FAILED)

*Where previous LRU failures would cause a loss of at least fail-safe redundancy in an entry critical system, it is considered viable to replace FF1, FF2, or FF3 with FF4. The operation would be accomplished to recover an IMU for redundancy in onboard navigation for entry. The same is true for an AA to regain redundancy for entry control. ©[CR 7560 ]*

## FLIGHT RULES

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### 12A\_A2-7

### ENTRY STRING REASSIGNMENT

- A. PRIOR TO MM 304, RESTRINGING WILL BE PERFORMED TO REGAIN FULL CAPABILITY FOLLOWING A GPC FAILURE. @[CR 7560 ]

*The timeframe between post-deorbit burn and the transition to MM 304 is generally quiet from a computer point of view and crew workload. As such, the risk of restringing is considered to be low. Consequently, restringing will be performed to regain full capability for the dynamic phases of entry (MM 304/305).*

- B. RESTRING GPC/STRING COMBINATIONS WILL BE SELECTED WHICH MOVE THE FEWEST NUMBER OF STRINGS WHILE SATISFYING CRITICAL CAPABILITY OR ONE-FAULT TOLERANT REQUIREMENTS AS IDENTIFIED IN PARAGRAPH C.

*The greater the number of strings moved during a restring attempt, the more complicated the restring process. With this in mind, "good" strings should not be taken from "good" GPC's unless there is no other method of satisfying the identified requirements in orbiter systems.*

- C. DURING ENTRY/GRTLs (MM 304, 305, 602, AND 603), RESTRINGING WILL BE PERFORMED AS FOLLOWS (TIME PERMITTING) TO REGAIN THE FOLLOWING CRITICAL SYSTEMS CAPABILITY:

*Certain systems capabilities are required to be maintained for safety considerations where the BFS cannot provide additional systems capability.*

1. NOSE WHEEL STEERING (NWS) (FOR RTLs/TAL/AOA (KSC) OR ANY SITE WITH KNOWN DIRECTION CONTROL PROBLEMS)

*NWS is required to maintain lateral control during rollout at landing sites where the lateral runway environment is limited. BFS engage at touchdown to recover NWS is an option. However, it was determined to attempt restring during entry to regain NWS and accept risk of BFS engage as a result of the restring instead of nominally engaging the BFS for this case at NGTD. Reference Rule {A10-141A}, NOSE WHEEL STEERING (NWS) [HC], for NWS directional control requirements.*

2. ASA COMMAND (MAINTAIN TWO ELEVON, RUDDER, AND SPEEDBRAKE; MAINTAIN ONE BODY FLAP)

*Two elevon, rudder, and speedbrake FCS command channels (each of which have four command channels) are required since flying with only one FCS channel on an actuator is an uncertified flight control mode. Only one of three body flap command channels is required to maintain acceptable drive capability. Control may be available long enough to allow restring procedures to be completed to regain the required FCS channels rather than defaulting over to the BFS. @[CR 7560 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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**12A\_A2-7****ENTRY STRING REASSIGNMENT (CONTINUED)**

3. VENT DOORS: @[CR 7560 ]

A. *THE CAPABILITY TO CLOSE ALL VENT DOORS BETWEEN MACH 24 AND MACH 3.5*

*For loss of close redundancy, the affected door is closed to limit the exposure to the next failure that would leave the door failed open. Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that vent box 3, if left open, is predicted to reach a temperature of 1100 deg F during the entry profile. Since the melting point of 2024 aluminum is 935 deg F, a breach of the box is expected to occur, possibly resulting in loss of crew and vehicle. Because the new thermal analysis data shows temperatures very similar to the old thermal analysis, the previous temperature predictions for vent doors 1/2, 5, 6, and 8/9 will be used until the new thermal analysis is complete. Currently, if left open during entry, vent box 1/2 is expected to reach a temperature of 1200 deg F, vent boxes 5 and 6 will experience 600 to 700 deg F heating, and vent box 8/9 will experience up to 550 deg F heating. Based on these temperatures, vent box 1/2 will surpass the melting point of 2024 aluminum and would result in a breach and possible loss of crew and vehicle. The reusability temperature limit of 2024 aluminum is 350 deg F and soon after reaching this temperature, the aluminum starts to lose structural integrity (around 400 deg F). Therefore, 400 deg F was chosen as the temperature limit for which to protect the vent doors. Even though vent doors 5, 6, and 8/9 do not reach the melting point of 2024 aluminum, they do exceed the structural integrity limit if left open during entry. Additionally, it is important that these doors are closed during entry heating above 400 deg F to protect various components in close proximity to the vent openings from failing, such as electrical wires, Freon lines, hydraulic lines, and APU hydrazine lines. The Mach number limits are based on the thermal analysis for vent door 3; between Mach 24 (approximately 7.5 min after EI) and Mach 3.5 (approximately 24 min after EI, or approximately 1 min prior to Vrel = 2400), the vent temperature is predicted to exceed 400 deg F.*

B. *THE CAPABILITY TO OPEN THE MINIMUM NUMBER OF VENTS DOORS IN ORDER TO PROVIDE SUFFICIENT VENTING PRIOR TO REACHING AN ALTITUDE OF 70,000 FT:*

(1) FORWARD AND AFT COMPARTMENTS: THE LEFT OR RIGHT SIDE VENTS (SINGLE SIDE) FOR EACH COMPARTMENT,  
AND

(2) MIDBODY: ANY FOUR VENTS, OR ANY THREE VENTS IF AT LEAST ONE OF THESE IS LEFT OR RIGHT VENT 3 @[CR 7560 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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**12A\_A2-7****ENTRY STRING REASSIGNMENT (CONTINUED)**

*Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that adequate venting margins could be maintained if at least one side of the forward compartment, one side of the aft compartment, and any four midbody vent doors are opened by 70,000 ft. If only three midbody vents are open by 70,000 ft, adequate venting margins can be maintained if at least one of the midbody vents open is left or right vent 3. Failures resulting in loss of open capability on both sides of the forward compartment would result in significantly exceeding Performance Enhancement (PE) certification limits for compartment pressures and structural loading resulting in loss of crew and vehicle. Failures resulting in loss of open capability on both sides of the aft compartment would result in compartment pressures very close to the PE certification limits. Therefore, entry with all aft vent doors closed depends on all other vents to open nominally and on the 1307 bulkhead check valve to repressurize the aft compartment. As a result, it is not recommended to enter with all aft vent doors closed due to venting tolerances. Additionally, failures resulting in more than three midbody vent doors failed closed would also result in structural failure and loss of crew and vehicle. ©[CR 7560 ]*

*Reference Rule {A10-261E}, VENT DOOR MANAGEMENT [HC].*

*The A/EFTP #87 members concluded that a critical bus reassignment should only be performed after loss of more than two midbody vents has occurred for either vehicle configuration. Restringing for these cases provides the most prudent venting management plan, trading the effects of a potentially dispersed entry trajectory with the potential risks of a dynamic restringing of flight-critical buses.*

**4. MPS LH<sub>2</sub> MANIFOLD ENTRY PRESSURIZATION (FOR RTLS/TAL) .**

*There is insufficient time on RTLS and TAL entries to dump all hydrogen from the Main Propulsion System (MPS) LH<sub>2</sub> manifold. The pressurization of the LH<sub>2</sub> manifold with helium prevents air from being ingested into the manifold during entry. The loss of this helium pressurization will result in the creation of an explosive mixture in the LH<sub>2</sub> manifold as air is ingested and mixes with the hydrogen residuals. Although difficult to quantify, the hazard to the flight crew from an explosive mixture in the MPS LH<sub>2</sub> manifold represents an unnecessary risk. At the A/E FTP #168, October 27, 2000, it was decided that the recovery technique for the loss of LH<sub>2</sub> manifold pressurization could be a switch throw, temporary port mode (to latch the LH<sub>2</sub> manifold pressurization commands), or restringing. In general, a switch throw will be attempted before a port mode, which will be attempted before a restringing; however, the recovery technique used will depend upon the specific flight phase and failure scenario present in the orbiter. ©[CR 7560 ]*

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## FLIGHT RULES

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12A\_A2-7

**ENTRY STRING REASSIGNMENT (CONTINUED)**

- D. RESTRINGING WILL NOT BE PERFORMED WITHOUT PRIOR MCC COORDINATION. ©[CR 7560 ]

*The MCC is prime for determining when restringing is required as a result of multiple failures and the resulting GPC/string assignments required to satisfy critical capability and systems fault tolerance as identified in the preceding rules. The MCC is prime for determining the acceptability of restringing based upon the failure signature and conditions and for determining an acceptable data bus reassignment configuration. As a minimum, voice description of the failure and identification of the proposed bus reassignment must be coordinated with the MCC prior to performing any restring.*

- E. FOR A SINGLE GPC FAILURE, RESTRINGING WILL NOT BE PERFORMED AFTER EI MINUS 5 MINUTES.

*EI minus 5 minutes was selected as the last time for which restringing would be performed as a result of a single GPC failure in order to allow recovery time prior to EI to regain PASS capability should the restring be unsuccessful.*

- F. RESTRINGING WILL NOT BE PERFORMED AFTER HAC INTERCEPT.

*Crew workload increases after HAC acquisition as concentration is directed towards the immediate landing tasks. Restringing will not be performed during this timeframe so as not to divert crew attention away from the critical landing phase tasks. Although no fault tolerance exists, the exposure to the next failure is minimized since the time between HAC intercept and touchdown is relatively short.*

- G. RESTRINGING WILL BE PERFORMED TO REGAIN CRITICAL CAPABILITY INDEPENDENT OF THE BFS STATUS. FOR CASES WHERE RESTRINGING IS ACCEPTABLE TO REGAIN FAULT TOLERANCE (REF. PARAGRAPH A), AN ENGAGEABLE BFS MUST BE AVAILABLE.

*The BFS is normally required when restringing is performed as a precaution against the low probability occurrence that the restring action may result in loss of the PASS set. However, when the vehicle has sustained failures such that less than critical capability remains (a capability which must be maintained or a loss of crew/vehicle will result), restringing will be performed to regain the needed capability independent of the BFS status in order to maintain the flying status of the orbiter.*

*If the BFS is not available and less than critical capability remains, restring is allowed to recover the PASS capability to control the orbiter. If the BFS is available and conditions are such that either a BFS engage or a dynamic restring will recover the critical capability, restring will be attempted if time permits completion of the restring while still maintaining the BFS engage option. ©[CR 7560 ]*

## FLIGHT RULES

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**12A\_A2-8**

**ORBITER ALONE SRMS/OBSS DAP CONSTRAINTS**

DURING PERIODS OF SRMS/OBSS OPERATIONS WHILE THE ORBITER IS IN FREE FLIGHT, THE DAP AND SRMS/OBSS SHALL BE CONFIGURED PER THE FOLLOWING CONSTRAINTS: @[CR 7590 ]

- A. DURING GENERAL SRMS/OBSS OPERATIONS, INCLUDING TPS DATA TAKES WITH OBSS MOUNTED SENSORS:

THE DAP SHALL BE CONFIGURED PER TABLE 12A\_A2-8-I.

**TABLE 12A\_A2-8-I - GENERAL SRMS/OBSS DAP CONSTRAINTS**

	VERN [2]	ALT [2]
ROT RATE	0.2	0.2
ATT DB	3.0	5.0
RATE DB	0.2	0.2
JET OPT		TAIL
# JETS		1 [1]
ON TIME		0.08
DELAY		6.00
CNTL ACC	9	9

NOTES:

- [1] DURING PERIODS WHEN OBSS MOUNTED SENSORS ARE NOT PERFORMING DATA TAKES, THE ALT NUMBER JETS MAY BE SET TO 2 TO IMPROVE MANEUVER RESPONSE.
- [2] DAP: FREE SHALL BE SELECTED WHEN CLEARANCE FROM STRUCTURE IS LESS THAN 2 FT FOR VERN, 5 FT FOR ALT.

- B. WITH RESPECT TO FLIGHT CONTROL PERFORMANCE, THE SRMS SHALL BE CONSIDERED LOADED WHILE THE OBSS IS ATTACHED DURING NOMINAL OPERATIONS. FOR CONTINGENCY OPERATIONS, THE SRMS SHALL BE CONSIDERED UNLOADED PROVIDED THE SRMS IS CONFIGURED PER RULE {12A\_C2-**TBD**}, CONTINGENCY SRMS/OBSS DAP CONSTRAINTS. @[CR 7590 ]

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**FLIGHT RULES**

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**12A\_A2-8****ORBITER ALONE SRMS/OBSS DAP CONSTRAINTS**  
**(CONTINUED)**

*Even though the total mass of the OBSS is less than the loaded SRMS definition in Rule {A12-6}, OMS/RCS CONSTRAINTS, the distribution of the mass results in a reduction of control authority margin for extreme SRMS positions. For this reason, a special CNTL ACCL (CA 9) was developed to compensate for the distributed mass. Under nominal operations, the DAP is optimized using the preferred CNTL ACCL; however, during contingencies, it is possible to use the standard DAP loads normally used in those operations (e.g., RCS burns, OMS burns, and rendezvous/proximity operations), provided the SRMS/OBSS is positioned in an analyzed location. These locations are defined in Rule {12A\_C2-**TBD**}, CONTINGENCY SRMS/OBSS DAP CONSTRAINTS. ©[CR 7590 ]*

*Reference CSDL Memorandum, STS-115 Mated Shuttle/ISS and OBSS Operations DAP Modes and Constraints. ©[CR 7590 ]*

## FLIGHT RULES

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12A\_A2-9

### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS

FOR FAILURES THAT REQUIRE EARLY MISSION TERMINATION TO THE PRIMARY LANDING SITE (PLS), THE FOLLOWING EXCEPTIONS AND CONSIDERATIONS APPLY. IN ALL CASES WHERE DOCKING OCCURS, CONSIDERATION WILL BE GIVEN TO SHORTENING THE DOCKED MISSION TO REDUCE THE WINDOW OF EXPOSURE FOR THE NEXT WORSE FAILURE. @[CR 7617 ]

NOTE THAT FOR NO CASES DOES THIS RULE PROVIDE THE GUIDANCE FOR INVOKING CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) OR LAUNCH-ON-NEED (LON), AS THAT WOULD BE A DECISION MADE BY THE MMT AFTER ALL APPROPRIATE RECOMMENDATIONS HAVE BEEN HEARD AND CONSIDERED.

A. FOR PURPOSES OF THIS RULE, THE ORBITER THERMAL PROTECTION SYSTEM (TPS) WILL BE CONSIDERED SUSPECT IF ANY SINGLE SYSTEM INDICATES A POTENTIAL ASCENT DEBRIS STRIKE OR DAMAGED AREA, UNTIL THE SUSPECT AREA HAS BEEN INSPECTED, ANALYZED, AND SHOWN TO BE CAPABLE OF SUPPORTING DEORBIT AND ENTRY. THE POTENTIAL DATA SYSTEMS INCLUDE THE FOLLOWING:

1. LAUNCH/ASCENT VIDEO TRACKING
2. LAUNCH/ASCENT RADAR TRACKING
3. WING LEADING EDGE (WLE) IMPACT SENSORS
4. ON-ORBIT INSPECTION

B. PRIOR TO DOCKING WITH THE ISS.

1. IF THE ORBITER TPS IS NOT SUSPECT, THE FOLLOWING APPLIES:
  - a. IF THE ORBITER IS NOT CAPABLE OF SUPPORTING RENDEZVOUS AND DOCKING, OR IF THE LAST REMAINING SYSTEM IS FAILING, THEN FLIGHT DAY 1 (FD1) OR NEXT PLS DEORBIT WILL BE PERFORMED.
  - b. IF AN ENTRY CRITICAL SYSTEM IS FAIL CRITICAL AND COMMON CAUSE OR GENERIC FAILURE MODE ARE SUSPECTED, THEN FD1 OR NEXT PLS DEORBIT WILL BE PERFORMED. @[CR 7617 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A2-9

**NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS**  
**(CONTINUED)**

c. FOR OTHER PLS CONDITIONS, MISSION DURATION WILL BE DETERMINED BY A RISK ASSESSMENT FOR DEORBIT AND ENTRY. THE OPTION TO RENDEZVOUS AND DOCK WILL BE MAINTAINED UNTIL THE APPROPRIATE RISK ASSESSMENTS ARE COMPLETED. @[CR 7617 ]

2. IF THE ORBITER TPS IS SUSPECT, THE FOLLOWING APPLIES:

a. IF THE ORBITER IS NOT CAPABLE OF SUPPORTING RENDEZVOUS AND DOCKING, OR IF THE LAST REMAINING SYSTEM IS FAILING, FD1 OR NEXT PLS DEORBIT WILL BE PERFORMED WITH THE FOLLOWING GUIDELINES:

(1) FOR SUSPECTED ORBITER TPS DAMAGE OTHER THAN RCC, TIME PERMITTING, BEST EFFORT TPS INSPECTION MAY BE PERFORMED PRIOR TO DEORBIT AT THE NEXT PLS.

(2) FOR SUSPECTED ORBITER RCC DAMAGE, DELAY SUCCESSIVE PLS OPPORTUNITIES AS REQUIRED TO INSPECT THE SUSPECT RCC AREA, WHILE MAINTAINING THE TIME AND CAPABILITY TO EXECUTE DEORBIT AND LANDING.

b. FOR OTHER PLS CONDITIONS, CONTINUE THE MISSION PAST NEXT PLS TO INSPECT THE SUSPECT ORBITER TPS AREA PRIOR TO COMMITTING TO PLS. MISSION DURATION WILL BE DETERMINED BY THE REQUIRED RISK ASSESSMENT FOR DEORBIT AND ENTRY. THE OPTION TO RENDEZVOUS AND DOCK WILL BE MAINTAINED UNTIL THE APPROPRIATE RISK ASSESSMENTS ARE COMPLETED. @[CR 7617 ]

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**FLIGHT RULES**

12A\_A2-9

**NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS  
(CONTINUED)**

**TABLE 12A\_A2-9-I - PRIOR TO DOCKING - SUMMARY TABLE**

PLS CONDITION	TPS NOT SUSPECT	TPS SUSPECT
ORBITER CANNOT SUPPORT RNDZ/DOCKING	FD1 OR NEXT PLS	TILE: FD1 OR NEXT PLS [1] RCC: PLS AFTER INSPECT SUSPECT RCC
LAST REMAINING SYSTEM IS FAILING	FD1 OR NEXT PLS	TILE: FD1 OR NEXT PLS [1] RCC: PLS AFTER INSPECT SUSPECT RCC
COMMON CAUSE OR GENERIC FAILURE MODE	FD1 OR NEXT PLS	NEXT PLS AFTER INSPECT SUSPECT TPS [2]
OTHER PLS CONDITIONS	RISK ASSESSMENT DETERMINES MISSION DURATION [2]	NEXT PLS AFTER INSPECT SUSPECT TPS [2]

@[CR 7617 ]

- [1] BEST EFFORT TPS INSPECTION PRIOR TO DEORBIT.
- [2] MISSION DURATION WILL BE DETERMINED BY A RISK ASSESSMENT FOR DEORBIT AND ENTRY. THE OPTION TO RENDEZVOUS AND DOCK WILL BE MAINTAINED UNTIL THE RISK ASSESSMENTS ARE COMPLETED.

C. AFTER DOCKING WITH THE ISS AND PRIOR TO THE COMPLETION OF PLANNED ASCENT DEBRIS TPS INSPECTIONS:

1. IF THE ORBITER TPS IS NOT SUSPECT, THE FOLLOWING APPLIES:
  - a. IF THE ORBITER CANNOT SUPPORT THE TIME OR CONFIGURATION REQUIRED TO COMPLETE THE PLANNED TPS INSPECTIONS, OR IF THE LAST REMAINING SYSTEM IS FAILING AND CSCS/LON IS NOT AVAILABLE, THEN NEXT PLS WILL BE PERFORMED. IF CSCS/LON IS VERIFIED TO BE AVAILABLE, TIME PERMITTING, PERFORM THE APPROPRIATE RISK ASSESSMENT TO DETERMINE IF DEORBIT AND ENTRY ARE VIABLE AS COMPARED TO CSCS/LON.
  - b. FOR OTHER PLS CONDITIONS, MISSION DURATION WILL BE DETERMINED BY THE REQUIRED RISK ASSESSMENT FOR DEORBIT AND ENTRY. @[CR 7617 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A2-9

### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

2. IF THE ORBITER TPS IS SUSPECT, THE FOLLOWING APPLIES:  
 @[CR 7617 ]
- a. IF THE ORBITER CANNOT SUPPORT THE TIME OR CONFIGURATION REQUIRED TO COMPLETE THE PLANNED TPS INSPECTIONS, OR IF THE LAST REMAINING SYSTEM IS FAILING AND CSCS/LON IS NOT AVAILABLE, THEN NEXT PLS WILL BE PERFORMED. IF CSCS/LON IS VERIFIED TO BE AVAILABLE, THEN THE SUSPECT ORBITER TPS AREA WILL BE INSPECTED PRIOR TO COMMITTING TO UNDOCK AND DEORBIT. TIME PERMITTING; PERFORM THE APPROPRIATE RISK ASSESSMENT TO DETERMINE IF DEORBIT AND ENTRY ARE VIABLE AS COMPARED TO CSCS/LON.
  - b. FOR OTHER PLS CONDITIONS, CONTINUE THE MISSION PAST NEXT PLS TO INSPECT THE SUSPECT ORBITER TPS AREA PRIOR TO COMMITTING TO PLS. MISSION DURATION WILL BE DETERMINED BY THE REQUIRED RISK ASSESSMENT FOR DEORBIT AND ENTRY.

**TABLE 12A\_A2-9-II - AFTER DOCKING - SUMMARY TABLE**

PLS CONDITION	TPS NOT SUSPECT	TPS SUSPECT
ORBITER CANNOT SUPPORT PLANNED TPS INSPECTIONS	NEXT PLS [1]	NEXT PLS IF NO CSCS/LON. IF CSCS/LON AVAILABLE, INSPECT SUSPECT TPS BEFORE UNDOCK. [1]
LAST REMAINING SYSTEM FAILING	NEXT PLS [1]	NEXT PLS IF NO CSCS/LON. IF CSCS/LON AVAILABLE, INSPECT SUSPECT TPS BEFORE UNDOCK. [1]
COMMON CAUSE OR GENERIC FAILURE MODE	RISK ASSESSMENT DETERMINES MISSION DURATION [2]	CONTINUE MISSION PAST NEXT PLS TO INSPECT SUSPECT TPS [2]
ALL OTHER PLS CONDITIONS	RISK ASSESSMENT DETERMINES MISSION DURATION [2]	CONTINUE MISSION PAST NEXT PLS TO INSPECT SUSPECT TPS [2]

[1] IF CSCS/LON IS AVAILABLE, TIME PERMITTING, PERFORM THE APPROPRIATE RISK ASSESSMENT TO DETERMINE IF DEORBIT AND ENTRY ARE VIABLE AS COMPARED TO CSCS.

[2] MISSION DURATION WILL BE DETERMINED BY A RISK ASSESSMENT FOR DEORBIT AND ENTRY. @[CR 7617 ]

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## FLIGHT RULES

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12A\_A2-9

**NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS**  
**(CONTINUED)**

- D. FOR LOSS OF OMS/RCS DELTA-V CAPABILITY PRIOR TO DOCKING, IF REMAINING CAPABILITIES RESULT IN EITHER RENDEZVOUS OR DEORBIT/ENTRY BEING POSSIBLE, AND NOT BOTH, THEN THE FOLLOWING APPLIES: @[CR 7617 ]
1. IF THE ORBITER TPS IS NOT SUSPECT, THEN FD1 OR NEXT PLS DEORBIT WILL BE PERFORMED. CONSIDERATION WILL BE GIVEN TO PERFORMING BEST EFFORT TPS INSPECTION PRIOR TO DEORBIT AT THE NEXT PLS.
  2. IF THE ORBITER TPS IS SUSPECT, CONTINUE THE MISSION PAST NEXT PLS TO INSPECT THE SUSPECT ORBITER TPS AREA PRIOR TO COMMITTING TO DEORBIT. PERFORM THE REQUIRED RENDEZVOUS BURNS AND MANEUVERS IN THE INTERIM TO PRESERVE A RENDEZVOUS OPTION, TO THE EXTENT POSSIBLE WHILE MAINTAINING DEORBIT STEEP CAPABILITY. IF INSPECTION AND ANALYSES INDICATE THAT THE ORBITER CANNOT SUPPORT SAFE DEORBIT/ENTRY, THEN DEORBIT CAPABILITY WILL BE GIVEN UP TO ALLOW FOR DOCKING.

*For STS-115, the exceptions and considerations in this rule apply for PLS failure scenarios as called for in the Rule {A2-102}, MISSION DURATION REQUIREMENTS, and the associated individual systems PLS rules in those respective sections of the Volume A rules. For all cases where docking has occurred or will occur, consideration will be given to shortening the docked mission in order to reduce the WOE to the NWF. That is, after the appropriate risk assessment is performed, and/or the required TPS inspection and analyses are completed, and the orbiter TPS is considered capable of supporting deorbit and entry, any remaining docked mission time will be evaluated to determine if it is appropriate to reduce the mission duration to protect for the NWF. @[CR 7617 ]*

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## FLIGHT RULES

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12A\_A2-9

### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

*In preparation for the RTF missions, numerous vehicle modifications have been implemented to minimize or eliminate the liberation of debris during launch and ascent that can cause critical orbiter TPS damage. For these missions, it is prudent to inspect the orbiter TPS whenever it is feasible prior to committing to deorbit and entry to verify the vehicle modifications, and to ensure that the TPS can support deorbit and entry. At the same time, it is prudent to reduce the WOE to a NWF for systems PLS cases. This rule requires actions that take into account the critical systems considerations as well as the status of the orbiter TPS to affect the most equitable balance of risks for the flight phase, either prior to docking or after docking, and prior to the completion of the planned TPS inspections. Furthermore, this rule considers the urgency of the system failure(s) for the given flight phase, while considering the status of CSCS and LON capabilities when docked. This rule does not provide the guidance for actually invoking CSCS and LON, as that will be a decision for the mission management team (MMT) after all appropriate recommendations have been made for any given scenario. ©[CR 7617 ]*

#### Suspect TPS Definition

*For purposes of this rule, the status of the orbiter TPS is defined as either suspect or not suspect. If any single system, including launch/ascent imagery, launch/ascent radar tracking, wing leading edge (WLE) sensors, or on-orbit inspections, indicates a potential ascent debris strike to the orbiter TPS or a damaged area, then orbiter TPS is considered suspect. The TPS will remain suspect until such time as the required inspections can be accomplished and the associated analyses are completed to exonerate the suspect TPS condition, showing that the TPS is capable of supporting deorbit and entry. Given the criticality of the TPS and flight experience showing that TPS damage has occurred on numerous missions, only a single data source will be required to make the TPS suspect. However, in any case, in order for the TPS to be declared suspect in a PLS scenario, the data is required to indicate a clear potential for damage, and it should do so without requiring extraordinary assumptions and extrapolation. For all other cases, the orbiter TPS will be considered not suspect. This includes cases when there is no data, such as is expected to be the case on flight day 1 (FD1). On FD1, the earliest imagery data will be transmitted to the three manned space flight centers (JSC, KSC, and MSFC) and available for analyses at approximately 2:00 hours Mission Elapsed Time (MET). These initial analyses are expected to be complete by approximately 8:00 hours MET. For FD1, the first PLS opportunity considered is normally REV 3, with a deorbit burn ignition time (TIG) of approximately 4:00 hours MET. A decision to commit to deorbit on REV 3 is required by approximately 3:30 MET. The REV 6 decision, normally the last one considered for a FD1 PLS, is required by approximately 7:30 MET. Therefore, except for an extraordinary circumstance, no data is expected to be available to indicate that the TPS is suspect on FD1. Additionally, the FD1 PLS cases are generally considered to be an extension of the ascent abort case, as it relates to the limitations of time and data. The basic RTF flight rationale supports treating the FD1 PLS cases similar to the ascent abort cases, where in the absence of data to the contrary, the TPS must be considered nominal in order to support the required abort scenario. The associated risk of unsuspected critical orbiter TPS damage for these ascent and FD1 abort scenarios is an accepted risk as part of the flight rationale for RTF. ©[CR 7617 ]*

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## FLIGHT RULES

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### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

*It is noted that the definition of suspect TPS is not the same as the definition of a compromised orbiter, as defined in Rule {A2-207}, LANDING SITE SELECTION [HC]. However, a compromised orbiter may be declared as a result of suspect TPS if sufficient TPS inspection data exists per Rule {A2-207}, LANDING SITE SELECTION [HC]. ©[CR 7617 ]*

#### Prior to Docking, Orbiter TPS is Not Suspect

*Prior to docking when the orbiter TPS is not suspect, the following guidelines apply. If the systems failure results in the orbiter not being capable of supporting rendezvous and docking, or if the last system is failing, or if an entry-critical system has lost all fault tolerance and generic or common cause failure mode are suspected, then FDI or next PLS will be performed. In these cases, the WOE to the NWF should be minimized to allow safe return of the orbiter and crew while the vehicle can still support deorbit and entry. This assumes that there are no indications of critical orbiter TPS damage; therefore, it is prudent to perform a PLS as soon as possible. With regard to the inability of the orbiter to support rendezvous and docking, this only applies when the orbiter does not have the systems capability to support a rendezvous and docking, without regard for redundancy. These cases do not include scenarios where the ability to rendezvous and dock remains, but redundancy requirements per Rule {C2-101}, ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC], are not satisfied. The generic failure mode and common cause considerations generally only apply for multiple systems failures, except for cases where a single system failure (e.g., Freon coolant loop) results in PLS, and the failure mode is identified as a previously known and understood failure mode that is considered generic, and thus more likely to affect the remaining good system(s). If the failure mode is isolated and understood, and not previously considered generic, then given only one failure has occurred, it will not be considered a generic failure unless data is available to suggest otherwise.*

*For other PLS failures, including those not considered to be generic in nature, the mission duration will be determined after performing the appropriate risk assessment for deorbit and entry, as well as rendezvous and docking. In the interim, rendezvous and docking capability will be maintained to the extent possible, while not compromising the ability to perform deorbit and entry. Because these failures are somewhat less urgent, it is prudent to take the time to perform the required risk assessment prior to committing to deorbit and entry. It may also be possible to perform some amount of TPS inspection if time allows and if it does not compromise the ability to perform deorbit and entry. ©[CR 7617 ]*

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## FLIGHT RULES

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### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

Prior to Docking, Orbiter TPS is Suspect ©[CR 7617 ]

*Prior to docking when the orbiter TPS is determined to be suspect, the following guidelines apply. If the systems failure results in the orbiter not being capable of supporting rendezvous and docking, or if the last system is failing, then the PLS requirements are driven by whether or not the suspect TPS is RCC. The rule distinguishes between suspect RCC and other TPS because in general RCC cannot sustain the same level of damage before it becomes critical as compared to the other TPS subsystems. If the suspect TPS is other than RCC, then prior to executing a next PLS, a best effort inspection may be performed depending on the condition of the orbiter systems and the time to support with available inspection techniques. If the suspect TPS is RCC, then the PLS will be delayed for successive PLS opportunities as required to accomplish inspection to the greatest extent possible while maintaining deorbit and entry capability. This provides the maximum mitigation for suspect RCC, while maintaining the ability to execute a PLS if no other option exists. This approach increases the WOE for the failing system(s); however, it does so in order to mitigate the risk of deorbit and entry with critical RCC damage.*

*For all other system failure scenarios that occur prior to docking, where the TPS is suspect, the TPS will be inspected and a risk assessment will be performed prior to commit to deorbit to determine the appropriate mission duration. By definition, these system failure cases are less urgent than the cases previously noted, and the risk of critical TPS damage is considered greater than the risk of the NWF. By remaining on orbit, the option to rendezvous and dock is preserved should the risk analysis deem that course of action necessary.*

Post Docking, Orbiter TPS is Not Suspect

*After docking when the orbiter TPS is not suspect, the following guidelines apply. If the orbiter is not capable of supporting the time or configuration required for the planned TPS inspections, or if the last remaining system is failing, and CSCS/LON is not available, then PLS will be performed. If CSCS/LON is available, then time permitting, the PLS will be delayed to perform the appropriate risk assessment prior to undocking and committing to deorbit and entry. In these cases, CSC/LON is not being invoked or declared; rather the availability of it is considered. If CSCS/LON is considered available, then it is prudent to take the time available to perform the appropriate risk trade to determine if deorbit and entry are viable as compared to CSCS/LON. If the failure mode will not support the time required to perform this analysis, then PLS will be performed. ©[CR 7617 ]*

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## FLIGHT RULES

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### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

*For all other scenarios where the orbiter is docked and the TPS is not suspect, the orbiter will remain docked until a deorbit and entry risk assessment has been completed. These cases are less urgent from an orbiter systems standpoint, and it is prudent to take the time required to determine the appropriate mission duration for the failure scenario. Given the comparatively safe configuration of being docked to the ISS, the risk of the NWF is considered reduced and is accepted in order to ensure the prudent course of action relative to mission duration. ©[CR 7617 ]*

#### Post Docking, Orbiter TPS is Suspect

*Post docking when the orbiter TPS is determined to be suspect, the following guidelines apply. If the orbiter is not capable of supporting the time or configuration required for the planned TPS inspections, or if the last remaining system is failing, and CSCS/LON is not available, then PLS will be performed. If CSCS/LON is available, then PLS will be delayed to perform the required focused TPS inspection and analyses, as well as the appropriate risk assessment prior to committing to undock and deorbit. The risk of executing a PLS with suspect TPS is considered greater than the risk of remaining docked and potentially requiring CSC/LON as a result. For these scenarios, if the TPS is still considered suspect after docking it likely means that the probability of having critical TPS damage is increased. More specifically, by definition, most of the planned TPS inspection will have been completed and at least partially analyzed by this time, including the FD1 data, the FD2 RCC inspections, and the rendezvous pitch maneuver data. Remaining docked to perform the required focused inspection and associated risk assessment for this scenario does not mean that CSCS/LON will be invoked; however, since it is available, the risk of invoking it becomes an accepted risk as compared to the risk of deorbit and entry with potentially critical TPS damage.*

*For all other system failure scenarios where the TPS is suspect and docking has occurred, the TPS will be inspected and a risk assessment will be performed prior to committing to undock and deorbit. These cases are less urgent from an orbiter systems standpoint, and it is prudent to take the time required to perform the required focused inspections and to determine the appropriate mission duration for the failure scenario. Given the comparatively safe configuration of being docked to the ISS, the risk of the NWF is considered reduced and is accepted in order to ensure the prudent course of action relative to the suspect TPS and mission duration. ©[CR 7617 ]*

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## FLIGHT RULES

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### NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

OMS/RCS Delta-V Loss ©[CR 7617 ]

*If the TPS is not suspect and OMS/RCS delta-V capability is lost prior to docking, such that either rendezvous and docking, or deorbit and entry may be performed, but not both, then FD1 or Next PLS will be performed. In these cases, a best effort TPS inspection may be considered if it is determined that the associated time and risks of performing the inspection(s) will not compromise the ability to execute deorbit and entry. In these cases, the associated risks of delaying the PLS to FD2 must be considered, since a FD2 deorbit and entry is generally much less desirable than FD3 for example, with regard to crew health and space adaptation.*

*If the TPS is suspect, the mission will continue past successive PLS opportunities as required in order to perform focused TPS inspections. In the interim time, all rendezvous burns and maneuvers will be executed as required to maintain a rendezvous and docking option to the extent possible without giving up deorbit steep and entry capability. These cases are generally not time critical, but rather critical to delta-V capability. The risk of sustaining the NWF while remaining on orbit is considered less than that of executing deorbit and entry with the potential for critical TPS damage. By maintaining the rendezvous profile, the contingency option to dock with ISS and invoke CSCS/LON is preserved in the event the TPS damage is deemed critical. If the TPS inspection and analyses reveal that the TPS damage may be critical, then the requirement to maintain deorbit capability will no longer be maintained if it precludes the ability to perform rendezvous and docking. Additionally, for these scenarios where rendezvous and docking becomes required, then maintaining the OMS/RCS delta-V to perform a controlled disposal deorbit and entry may not be possible and the rendezvous/docking will always take priority.*

*Reference Rules {A2-102}, MISSION DURATION REQUIREMENTS, and {A2-210} ENTRY THERMAL OPTIONS [HC].*

*Reference Ascent/Entry Flight Techniques Panel (A/EFTP) #206 on October 22, 2004, and A/EFTP #209B on January 25, 2005. ©[CR 7617 ]*

## FLIGHT RULES

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### 12A\_A2-10

### ET PHOTOGRAPHY

- A. THE ET UMBILICAL WELL PHOTOGRAPHY +X TRANSLATION MANEUVER WILL BE NO-GO FOR THE FOLLOWING: ©[CR 7601 ]
1. OMS/RCS PROPELLANT LEAKS, HELIUM SYSTEM LEAKS, OR TANK FAILURES THAT RESULT IN A PROPELLANT CRITICAL MISSION
  2. MECO UNDERSPEED THAT RESULTS IN AN INABILITY TO SUPPORT A FIRST DAY PLS DEORBIT
  3. ET PREDICTED TO BE IN DARKNESS FOR BOTH UMBILICAL WELL AND ET HANDHELD PHOTOGRAPHY
- B. THE +X TRANSLATION MAY BE PERFORMED AFTER A DELAYED ET SEPARATION, PROVIDED THAT THE MPS DUMP IS COMPLETE OR HAS BEEN DELAYED UNTIL AFTER THE +X MANEUVER.
- C. THE CREW HANDHELD ET PHOTOGRAPHY PITCH MANEUVER WILL BE NO-GO FOR THE FOLLOWING:
1. NO +X TRANSLATION MANEUVER PERFORMED
  2. FAILURES THAT RESULT IN A PROPELLANT CRITICAL MISSION:
    - a. LOSS OF AN OMS ENGINE
    - b. MECO UNDERSPEED GREATER THAN UNDERSPEED RECOVERY CAPABILITY
    - c. UNPLANNED PRE-MECO OMS DUMP
  3. BFS ENGAGED
  4. ET IN DARKNESS AT PHOTOGRAPHY TIME ©[CR 7601 ]

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## FLIGHT RULES

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**12A\_A2-10****ET PHOTOGRAPHY (CONTINUED)**

*There are two methods of photographing the External Tank. Method 1 utilizes automatic cameras in the ET umbilical wells of the orbiter and requires an 11-second +X translation immediately following the -Z separation burn. The +X maneuver requires about 120 pounds of RCS propellant. This propellant goes directly in-plane and is an aid to achieving the proper orbit for rendezvous flights, so it is not an impact to perform this translation maneuver for such missions. Method 2 utilizes crew handheld cameras and requires an orbiter pitch maneuver using moments provided by the MPS dump. Method 2, if not performed via the MPS dump, requires an additional 70 pounds of aft and 30 pounds of forward RCS propellant. Method 1 is considered primary and Method 2 is considered secondary for obtaining engineering analysis photography of the ET. Method 1 provides the highest resolution photographs of the ET. These priorities are reflected in the constraints of this rule. ©[CR 7601 ]*

**+X Translation Constraints:**

*Significant failures in the OMS and RCS systems (propellant or helium leaks or tank failures) result in a loss of delta-V capability, and the ET photography propellant may be needed to accomplish flight-critical maneuvers (e.g., OMS-1, deorbit) or for entry control. Each failure will be assessed independently, but in general, failures which severely impact OMS or RCS capabilities will be cause to NO-GO both photography methods so that a safe orbit may still be achieved. Consideration will be given to performing the +X translation maneuver if the failure does not result in a propellant critical mission.*

*Certain MECO underspeed/OMS remaining combinations result in an AOA shallow. For these cases, we are propellant critical and an uncertified abort is required. Therefore, it is not prudent to perform the +X translation in these cases. For the loss of comm case, the crew uses an HA cue for GO/NO-GO status on the +X. To be conservative, the HA will be based on the design MECO underspeed. Assuming a full ATO dump, if the underspeed is greater than the design MECO underspeed, the result would be an AOA shallow. If time allows, the ground can make the call based on the underspeed/OMS remaining resulting in an ATO/Min Hp or greater orbit.*

*ET photography typically is scheduled on all flights where at least part of the launch window allows sunlight for the photos. Photos of the ET in darkness are not useful. If lighting changes during the launch window, ET photography can be planned and trained for, but will be canceled if sunlight will not be present at the same time photos are to be taken. Each of the two methods will be evaluated on its own lighting conditions.*

*For the case of a delayed ET separation (i.e., time to recover separation jets) or MPS feedline disconnect fail, it is acceptable to perform the +X translation and pitch maneuver. However, it is prudent to wait until the MPS dump is complete prior to initiating the +X maneuver or keep the dump inhibited until after the +X has been performed. If the pitch maneuver is to be performed, then a minimum of 1:40 minutes after ET separation is required to provide enough separation distance between the orbiter and ET prior to initiation of the MPS dump and corresponding pitch maneuver. ©[CR 7601 ]*

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## FLIGHT RULES

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12A\_A2-10

ET PHOTOGRAPHY (CONTINUED)

*Pitch-Maneuver Constraints:* ©[CR 7601 ]

*Not performing the +X maneuver results in the relative distance between the orbiter and ET decreasing from 688 feet to 461 feet. The pitch maneuver will not be performed since a dispersed relative motion analysis of the ET and orbiter at this distance has not been performed.*

*The propellant used for the pitch maneuver does not benefit the rendezvous like the +X maneuver does. By not performing the pitch maneuver, approximately 10 fps delta V from the MPS dump can be utilized in plane and postgrade. For propellant critical missions resulting from loss of a single OMS, underspeeds that impact rendezvous capability, unplanned OMS dump, or loss of vernier attitude control for certain missions, it is prudent to utilize this propellant to protect for the rendezvous.*

*Loss of a single OMS engine results in having to redline propellant for a RCS steep deorbit. This could result in a propellant critical mission and, thus, it is prudent to not perform the pitch maneuver and save the corresponding delta V.*

*MECO underspeeds will be evaluated against the mission specific underspeed recovery capability to determine whether the pitch maneuver can be performed. This underspeed capability is computed using the mission specific prop priority table and protects for the nominal rendezvous profile, including three sigma dispersions, the rendezvous pitch maneuver, nominal undock and separation, and 2-2-2 deorbit costs. This value will be computed for both verns failed and verns available in order to assess whether the pitch maneuver should be performed if it is known that the vernier jets are failed post MECO.*

*An unplanned pre-MECO OMS dump results in loss of budgeted propellant and may result in a propellant critical mission. It is, therefore, prudent not to perform the pitch maneuver and save the corresponding delta velocity.*

*If the BFS were engaged prior to the pitch maneuver being performed, there are two reasons to delete the pitch maneuver. The first is that the BFS DAP will not allow the pitch to be performed via the MPS dump as it does not support a single axis in "free drift." The second is that the mission will more than likely become propellant critical at this point as the post insertion timeline on the BFS will have significantly greater propellant consumption until the PASS is recovered. ©[CR 7601 ]*

## FLIGHT RULES

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**12A\_A2-11**

**LATE RCC INSPECTION FOR MMOD DAMAGE**

- A. RE-RENDEZVOUS IS NOT A REQUIREMENT IN SUPPORT OF LATE INSPECTION. @[CR 7692 ]
1. NC-5 WILL BE PLANNED AND EXECUTED (IF RE-RENDEZVOUS PROFILE REQUIRES) TO RETAIN RE-RENDEZVOUS CAPABILITY.
  2. NC-6 WILL BE EXECUTED IN THE EVENT THAT IMAGERY REVIEW OR DAT ASSESSMENT IS NOT COMPLETED OR RCC DAMAGE DOES NOT MEET THE DAMAGE CRITERIA AND REQUIRES REPAIR TO SUPPORT ENTRY.

*Although re-rendezvous is not a requirement, in support of delayed imagery review, DAT assessment, or inability to repair RCC damage, a re-rendezvous plan has been developed for STS-115 that allows re-rendezvous to be performed covering 1, 1 deorbit opportunities based on nominal propellant usage. Propellant will not be explicitly budgeted to maintain a re-rendezvous capability should unforeseen propellant issues occur (e.g., MECO underspeed, etc.). @[CR 7704 ]*

The following table shows the pre-mission re-rendezvous plan for the August 28, 2006 launch:

MET	BURN	NOMINAL DELTA-V (FPS)	NOTES
8/18:00	SEP-2	1.0	POSIGRADE SEP (INSTEAD OF 3.0 FPS RETROGRADE)
9/01:30	NC-5	0.6	TARGET STATIONKEEP AT 40 NM
9/14:30	NC-6	1.0	BEGIN STATIONKEEP AT 40 NM
10/00:23	NC-7	0.0	MAINTAIN 40 NM STATIONKEEPING
10/14:27	NH	0.7	SET UP DELTA HEIGHT FOR RNDZ
10/15:00	NC-8	11.2	INITIATE RE-RENDEZVOUS PROFILE
10/16:31	TI	8.9	INITIATE FINAL TERMINAL PHASE
10/19:12	DEORBIT		NOMINAL EOM DEORBIT TO KSC
10/18:53			DOCKING

- B. THE NOMINAL LATE INSPECTION PLAN FOR STS-115 CONSISTS OF A DOCKED PORT SURVEY WITH THE LDRI, UNDOCKING WITH OBSS IN HANDOFF POSITION, AND STBD WLE AND NOSE CAP (POST UNDOCKING) WITH THE LDRI. @[CR 7692 ] @[CR 7704 ]

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## FLIGHT RULES

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### 12A\_A2-11      LATE RCC INSPECTION FOR MMOD DAMAGE (CONTINUED)

C. THE DAMAGE ASSESSMENT TEAM (DAT) WILL UTILIZE THE RCC DAMAGE INSPECTION REQUIREMENTS TO DETERMINE MMOD ENTRY CRITICAL DAMAGE FOR THE WLE AND NOSE CAP TO SUPPORT REPAIR/ENTRY GO/NO-GO CAPABILITY. @[CR 7692 ]

AS SOON AS VIOLATIONS HAVE BEEN IDENTIFIED, THE TPS IMAGERY COORDINATOR (TIC), PER DIRECTION FROM THE DAT, WILL INFORM THE FLIGHT CONTROL TEAM.

D. IN SUPPORT OF LATE INSPECTION ACTIVITIES, UNDOCKING WILL BE DELAYED FOR THE FOLLOWING:

1. TPS DAMAGE IS SUSPECTED AND HAS NOT BEEN DECLARED GO FOR ENTRY.
2. PORT WLE IMAGERY REVIEW OR DAT ASSESSMENT IS NOT COMPLETED BY SCHEDULED UNDOCKING TIME AND RE-RENDEZVOUS IS NOT AVAILABLE.

*A more robust EVA capability is available while docked (due to the availability of additional support hardware and repair tools).*

*It is prudent to remain docked in support of a possible port WLE repair due to the robust EVA capability and it is mandatory to remain docked if the RMS/OBSS cannot support standalone (undocked) RCC EVA repair.*

*For a delayed undocking scenario, procedures are available for docked nose cap and STBD WLE surveys and will be scheduled while EVA repair is being developed (for the port wing case). It should be noted that these procedures will require additional execution time since they have not been previously performed and the STBD WLE survey has reduced coverage to support clearance protection.*

E. LATE INSPECTION WILL NOT BE PERFORMED IN A PLS OR MDF CASE.

*Mission priority and timeline focus is changed to ensure the vehicle is in a safe configuration to support deorbit, entry, and landing due to the systems failure for which the PLS/MDF was invoked. Per existing rules and Program philosophy, deorbit is planned as soon as possible to reduce the window of exposure to the next worse failure. @[CR 7692 ]*

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## FLIGHT RULES

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### **12A\_A2-11            LATE RCC INSPECTION FOR MMOD DAMAGE (CONTINUED)**

- F. IN THE CASE OF THE LOSS OF THE LDRI SENSOR (PRIME) DURING LATE INSPECTION, THE SURVEY WILL BE SUPPORTED ON A BEST EFFORT BASES WITH AVAILABLE PROCEDURES. @[CR 7692 ]
1. ITVC (IF MODE 2 ILLUMINATION AVAILABLE FROM LDRI) - PORT WING AND NOSE CAP DOCKED, STBD UNDOCKED
  2. IDC WLE (7-11), NOSE CAP - UNDOCKED
  3. LCS - UNDOCKED
- G. NO PROACTIVE EFFORTS (VEHICLE POWERDOWN, ADDITIONAL H2O TRANSFER, ETC.) WILL BE PUT INTO PLACE DURING THE NOMINAL MISSION TO INCREASE PRE-MISSION CSCS CAPABILITY FOR LATE INSPECTION. @[CR 7704 ]

*Per Programmatic direction, re-rendezvous capability, post undocking, is not required in support of Late Inspection. Programmatic expectation is that the damage that may be caused by MMOD impact is small enough to require no repair or can be successfully repaired using NOAX via an undocked EVA repair.*

*Although not a requirement for STS-115, a plan has been developed that allows re-rendezvous with no impact to deorbit planning if re-rendezvous is not performed. The re-rendezvous plan utilizes stationkeeping at 40 nm in a stable orbit for which deorbit planning can easily be executed.*

*The nominal late inspection plan for STS-115 consists of using the LDRI sensor and performing the port WLE survey post MPLM berth (docked), undocking with the OBSS in the handoff position, and completing the STBD WLE and Nose Cap inspection after undocking. This provides the most optimal/efficient plan to support late inspection requirements and complete the planned mission objectives. The timeline option was concurred upon at the February 3, 2006; March 3, 2006; and April 6, 2006, PRCB's for the STS-121/ULF1.1 mission, and is being carried over to the STS-115/12A mission.*

*The DAT will provide a repair/entry GO/NO-GO based on the RCC damage inspection requirements.*

*Undocking will be delayed for the case where imagery detects damage on the port WLE. Undocking will also be delayed for at least 24 hours for the scenarios where re-rendezvous is not available and port WLE imagery review/DAT assessment is not complete at the scheduled undocking time. @[CR 7692 ]*

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## FLIGHT RULES

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### **12A\_A2-11      LATE RCC INSPECTION FOR MMOD DAMAGE (CONTINUED)**

*The docked configuration provides a more robust EVA capability utilizing ISS assets. Re-rendezvous is not without risks with the possibility (low probability) of not being able to re-dock due to an APDS problem, thus, losing the most optimal configuration for repair and/or CSCS options. ©[CR 7692 ]*

*Based on Program direction and philosophy, late inspection will not be performed for an MDF/PLS case. The mission priorities and timeline should focus on configuring the vehicle to support deorbit/entry. Deorbit will be planned as soon as practical to reduce the window of exposure to the next worse failure.*

*Additionally, with the loss of the LDRI sensor, a best effort survey will be performed utilizing the current procedures/capabilities. Mission lifetime (cryo) is the constraining factor and the best effort/risk tradeoff must be performed to ensure the capability to deorbit is protected (late inspection PRA versus deorbit).*

*Finally, CSCS assumptions were originally developed in support of damage caused by ascent debris. CSCS maximum duration is based on defined assumptions including powerdowns on FD5 (modified group C) and intrusive powerdowns on FD10. These early powerdowns have a major effect on planned mission activities and objectives. Therefore, to support mission objectives, the standard group B powerdown will be performed. Undocking without any proactive prep for CSCS reduces the overall CSCS capability.*

*Reference Rules {A2-102}, MISSION DURATION REQUIREMENTS; {A2-203}, DEORBIT DELAY GUIDELINES; and {A2-204}, MDF DEORBIT GUIDELINES. ©[CR 7692 ]*

## FLIGHT RULES

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### 12A\_A2-12

### TPS INSPECTION AND IMPACT DETECTION PRIORITIES

#### A. FD2 SURVEYS @[CR 7690 ]

1. FD2 INSPECTIONS WILL BE EXECUTED, AS PREFLIGHT PLANNED, TO EXPEDITE COLLECTION OF REINFORCED CARBON-CARBON (RCC) IMAGERY DATA REQUIRED TO DETERMINE INTEGRITY OF THERMAL PROTECTION SYSTEM (TPS) AFTER EXPOSURE TO THE ASCENT DEBRIS ENVIRONMENT.
2. FD2 INSPECTIONS WILL BE LIMITED TO DOCUMENTED/TRAINED PROCEDURES TO OPTIMIZE DATA COLLECTION AND MINIMIZE RISKS ASSOCIATED WITH THE EXTENSIVE SURVEY OPERATIONS.
3. THE FD2 PORT WLE SURVEY MAY BE REPLACED BY THE FD3 CREW CABIN END EFFECTOR (EE) SURVEY IF SUSPECTED TPS DAMAGE ON THE CREW CABIN AREA WARRANTS. THE PORT WING INSPECTION WILL BE RESCHEDULED AS SOON AS PRACTICAL POST DOCKING.
4. ORBITER CAMERAS WILL BE UTILIZED TO PROVIDE A BEST EFFORT INSPECTION FOR TPS AREAS OF CONCERN AT PLANNED PAUSE POINTS IN THE FD2 SURVEYS. NO CHANGES TO THE PROCEDURE PAUSE POINTS WILL BE MADE TO ACCOMMODATE ORBITER CAMERA VIEWS (SEE PARAGRAPH A.2).

*The goal of the planned FD2 inspection procedures is to efficiently and expeditiously collect the required RCC data for review. Any deviation from the pre-planned procedures delays collection of RCC data and has a major impact to the subsequent mission timeline to achieve the required data.*

*The planned FD2 LDRI RCC inspections have no timelined margin for the day. The inspections are sequenced in priority order (STBD WLE, nose cap, port WLE) due to the loss of full inspection capability on the STBD WLE and nose cap when docked to the ISS. While docked, the 5 feet clearance cannot be maintained for a Laser Dynamic Range Imager (LDRI) motion scan at the desired resolutions on starboard lower RCC panels 5-13 and starboard upper RCC panels 1-4, and an area on the lower, starboard side of the nose cap. The port LDRI survey can be completed docked. With ascent debris contributing 27.1 percent to the Space Shuttle Program probability risk assessment, it's imperative that the full suite of data (at the required resolution) be collected as quickly as possible on FD2 to analyze the health of the RCC. Delaying/moving the inspections from FD2 has major implications to the planned mission objectives (delay in docking to achieve required imagery resolution, or impact docked operation to complete surveys, with reduced resolution in the areas identified). @[CR 7690 ]*

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## FLIGHT RULES

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12A\_A2-12

### TPS INSPECTION AND IMPACT DETECTION PRIORITIES (CONTINUED)

*Due to the intensive/extensive crew support required to safely execute the FD2 RCC inspections, the inspections will be limited to the documented/trained LDRI procedures. Since the LDRI sensor provides the highest resolution on the RCC for initial damage detection (80 mil and 20 mil 2 inch crack) during the scan surveys, "focused" stop/stare inspection should not be required with either the LDRI or an alternate sensor. Doing so delays completing the RCC scan surveys and introduces additional risks to the inspection execution. Any changes to the planned RCC scan inspections require procedure verification and validation to ensure they can be safely performed. This cannot be sufficiently completed during real-time execution or prior to planned crew sleep. In addition, the preferred sensor of choice for RCC-focused inspection (Integrated Sensor Inspection System (ISIS) Digital Camera (IDC)) is constrained to daylight operations to achieve the required resolution (80 mil). ©[CR 7690 ]*

*For the scenario where there is suspect TPS damage (crew cabin, chin panel, etc.) which can be inspected as part of the crew cabin EE survey and is of immediate concern where inspection cannot wait until FD3, the FD2 port survey may be delayed until docking to allow this inspection data to be retrieved. The entire crew cabin EE survey will be executed in place of the port WLE survey to provide not only inspection of the area of concern, but the remainder of the TPS to clear it of ascent debris concerns. During the crew cabin EE survey, pause points in the procedure may be utilized to manually move the EE closer to the suspect damage to get better resolution of the damage. This is unique to Remote Manipulator System (RMS) only procedure and can be safely accommodated without impacting the planned execution.*

*Orbiter camera views, when available, will be used to provide initial inspection views of damaged area.*

B. IF THERMAL PROTECTION SYSTEM (TPS) INSPECTIONS ARE REPLANNED IN FLIGHT, THEY WILL BE PLANNED PER THE FOLLOWING PRIORITIES BEFORE ISS DOCKING:

1. STARBOARD WING LEADING EDGE "BLACK" AND LOW CLEARANCE AREAS
2. NOSE CAP
3. PORT WING LEADING EDGE "BLACK" AREAS
4. REMAINING WING LEADING EDGE AREAS
5. CHIN PANEL AND ARROW HEAD
6. TPS SITES WITH SUSPECTED IMPACT OR DAMAGE ©[CR 7690 ]

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**FLIGHT RULES**

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**12A\_A2-12****TPS INSPECTION AND IMPACT DETECTION PRIORITIES  
(CONTINUED)**

7. LOWER SURFACE DOOR SEALS @[CR 7690 ]
8. REMAINING ACREAGE AREA
9. REMAINING EXTERIOR SURFACES

*The planned FD2 reinforced carbon-carbon (RCC) inspections have no timeline margin for the day. While docked to ISS, 5 feet clearance cannot be maintained for an LDRI motion scan at the desired resolutions on starboard lower RCC panels 5-13 and starboard upper RCC panels 1-4 (0.25 inch and 1.0 inch resolution, respectively, and an area on the lower, starboard side of the nose cap). Further, there are areas around the orbiter that cannot be imaged at the desired resolutions with only the SRMS end effector camera. Thus, the OBSS must be used to inspect these areas for entry critical damage, or EVA digital still imagery is required with a high crew time and mission objective impact. These areas are referred to as the "black" areas, based on the black and white diagrams used to depict the SRMS end effector camera's ability to inspect TPS at Space Shuttle Vehicle Inspection and Repair OFTP #11. The nose cap "black" area can be seen in the STS-114 JOP #23 minutes dated May 24, 2005.*

*Based on the combination of these constraints, if the TPS inspections are replanned before docking, the revised plan will optimize obtaining the data most difficult to get after docking. The next priority before docking is on the least impact tolerant RCC, any areas with suspected impacts or damage (based on ascent video, ET imagery, or impact sensors), door seals, and tile.*

C. AFTER ISS DOCKING, TPS INSPECTION PRIORITIES ARE AS FOLLOWS:

1. TPS SITES WITH SUSPECTED IMPACT OR DAMAGE
2. WING LEADING EDGES, WITH AREAS HAVING THE SMALLEST ACCEPTABLE DAMAGE TOLERANCE ALSO HAVING THE HIGHEST RELATIVE PRIORITY
3. NOSE CAP, CHIN PANEL, AND ARROW HEAD
4. LOWER SURFACE DOOR SEALS
5. REMAINING ACREAGE AREA
6. REMAINING EXTERIOR SURFACES @[CR 7690 ]

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## FLIGHT RULES

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12A\_A2-12

**TPS INSPECTION AND IMPACT DETECTION PRIORITIES**  
**(CONTINUED)**

- D. IF THERE IS A CONFLICT, DATA WILL BE DOWNLINKED ACCORDING TO THE FOLLOWING PRIORITIES: ©[CR 7690 ]
1. FOCUSED INSPECTION DATA
  2. WLE IMPACT SENSOR ASCENT PEAKS
  3. WLE IMPACT SENSOR DETAILED DATA IF REQUIRED TO IDENTIFY A SUSPECTED ASCENT IMPACT LOCATION
  4. SCHEDULED INSPECTION DATA, WITH RELATIVE PRIORITIES PER PARAGRAPH B
  5. ET UMBILICAL PHOTOS
  6. CREW HAND HELD ET PHOTOS

*It is assumed that any focused inspection data was gathered due to a suspected impact or suspected TPS damage. Thus, once gathered, downlinking that data has the highest priority in order to maximize the ground analysis time. Similarly, WLE impact sensor data has a high relative priority since it may provide a cue for focused WLE inspections which have a higher probability of detecting small RCC damage than a scheduled inspection. ET photos are a lower priority since they are primarily intended to validate the ET certification. Since it is possible that foam loss seen in these photos may provide some cue not seen in any other source, there is still a goal to bring these photos down in flight.*

*These priorities were approved by the December 6, 2004 FOICB. ©[CR 7690 ]*

## FLIGHT RULES

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### 12A\_A2-13

### TPS INSPECTION SENSOR PRIORITIES

- A. FD2 RCC MOTION SCAN ©[CR 7691 ]
  - 1. LASER DYNAMIC RANGE IMAGER (LDRI)
  - 2. INTENSIFIED TELEVISION CAMERA (ITVC)
  - 3. ISIS DIGITAL CAMERA (IDC)
  - 4. LASER CAMERA SYSTEM (LCS)
  
- B. FD4 FOCUSED INSPECTION
  - 1. 3D - (TILE CAVITIES, GAP FILLER, THERMAL BARRIERS, ET DOOR CLOSURE)
    - a. LASER CAMERA SYSTEM (LCS)
    - b. LASER DYNAMIC RANGE IMAGER (LDRI)
    - c. ISIS DIGITAL CAMERA (IDC)
  
  - 2. 2D - (RCC, THERMAL BARRIERS)
    - a. ISIS DIGITAL CAMERA (IDC)
    - b. INTENSIFIED TELEVISION CAMERA (ITVC)

*The FD2 RCC motion survey priorities are based on the ability to maximize the data gathering as well the sensors resolution capabilities. The LDRI is the primary sensor for the FD2 RCC motion scans. The ITVC was selected as the second priority sensor due to the ability to get the complete RCC data set during the allotted FD2 inspection time (assuming that the LDRI Mode 2 capability is available to provide required illumination for the scan). The IDC is selected as the third priority due to the requirement for daylight operations to get the required resolution during a motion scan. Due to the daylight constraint for motion scans, the procedures were developed to support WLE 7-11 and nose cap surveys in the attempt to acquire as much inspection data on the critical RCC areas in the remaining FD2 allotted time. The LCS is the last priority due to its lack of resolution capability on the RCC.*

*The FD4 focused inspection priorities are based on the required data to thoroughly analyze the Area of Interest (AOI) identified during the FD2 RCC, FD2 digital still of OMS pod, FD3 EE, and FD3 RBAR pitchover maneuver (RPM) inspections.*

*Reference STS-121/ULF1.1 JOP#11 and the OBSS/ISIS Sensors Focused Inspection Template (Rosetta Stone) developed by the Focused Inspection Working Group. ©[CR 7691 ]*

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**FLIGHT RULES**

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**ISS ONLY RULES**

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**12A\_B2-1**      **CONTINGENCY EVA'S**

A STAGE CONTINGENCY EVA WILL BE CONSIDERED FOR ANY OF THE FOLLOWING:

- A. INSTALLATION OF USOS POWER SYSTEM JUMPERS REQUIRED TO PREVENT LOSS OF ISS HARDWARE (RACU, P6 SECONDARY FEEDBACK, Y BYPASS JUMPERS) @[DN 97 ]
- B. COMPLETE 12A ASSEMBLY TASKS.
- C. REPLACE AN EXTERNALLY LOCATED MDM (LOCATED ON PMA 1, SO, S1, P1, OR P3/P4)
- D. REPLACE SEQUENTIAL SHUNT UNIT (SSU).
- E. REMOVE/STOW BATTERY CHARGE/DISCHARGE UNIT (BCDU).
- F. REPLACE SSRMS ARM COMPUTER UNIT (ACU), CAMERA AND LIGHT ASSEMBLY (CLA), OR CAMERA, LIGHT, AND PAN/TILT ASSEMBLY (CLPA).
- G. REPLACE MBS ORU'S - CANADIAN REMOTE POWER CONTROL MODULE (CRPCM), MBS COMPUTER UNIT (MCU), CAMERA LIGHT PAN AND TILT UNIT (CLPA), CAMERA LIGHT ASSEMBLY (CLA).
- H. REPLACE ELECTRONICS CONTROL UNIT (ECU).
- I. REPLACE BEARING, MOTOR, ROLL RING MODULE (BMRRM).
- J. REPLACE LOWER IEA MDM.
- K. REPLACE DC SWITCHING UNIT (DCSU).
- L. REPLACE LAB HEAT EXCHANGER.
- M. REPLACE REMOTE POWER CONTROLLER MODULE (RPCM).
- N. REPLACE DC-DC CONVERTER UNIT (DDCU-E).
- O. REPLACE PUMP FLOW CONTROL SUBASSEMBLY (PFCS) ON PVTCS OR EEATCS.
- P. MANUAL POSITIONING OF SOLAR ARRAYS



## FLIGHT RULES

**12A\_B2-2**

**ISS STAGE ATTITUDE CONSTRAINTS [RC]**

THE ISS ORBITAL AVERAGE ATTITUDE MUST BE MAINTAINED WITHIN THE FOLLOWING ENVELOPES:

REFERENCE FRAME	BETA [2]	ATTITUDE NAME	APPROVED ATTITUDE RANGES		
			YAW	PITCH	ROLL
ISS LVLH	$\beta \leq -70$ [1] [3]	+ZLV +XVV	-5° TO +15°	-20° TO 0°	0° TO +15°
	$-70 < \beta < -52$ [1]	+ZLV +XVV	-5° TO +15°	-20° TO +15°	0° TO +15°
	$-52 < \beta < +52$	+ZLV +XVV	-15° TO +15°	-20° TO +15°	-15° TO +15°
	$\beta \geq +52$ [1]	+ZLV +XVV	-15° TO +5°	-20° TO +15°	-15° TO +5°
	$\beta \geq +40$	+ZLV -YVV [4] [8] [9] [10]	+75° TO +105°	-15° TO +15°	-15° TO +15°
	$\beta \leq -40$	+ZLV +YVV [4] [8] [9] [10]	-105° TO -75°	-15° TO +15°	-15° TO +15°
XPOP [5] [6] [7]	$\beta \leq -52$ [8]	+XPH +ZNN	-10° TO +10°	-10° TO +5°	-10° TO +10°
	$-52 < \beta < -45$	+XPH +ZNN	-10° TO +10°	-15° TO +5°	-10° TO +10°
	$-45 \leq \beta \leq -30$	+XPH +ZNN	-10° TO +10°	-15° TO +5°	-10° TO +10°
	$45 \geq \beta \geq 30$	-XPH +ZNN	170° TO 190°	-15° TO +5°	-10° TO +10°
	$52 > \beta > 45$	-XPH +ZNN	170° TO 190°	-15° TO +5°	-10° TO +10°
	$\beta \geq +52$ [8]	-XPH +ZNN	170° TO 190°	-10° TO +5°	-10° TO +10°

@[DN 116 ]

NOTE:

- [1] THE YAW AND ROLL RANGES FOR XVV ATTITUDES WHEN  $|\beta| > 52$  ARE CONSTRAINED BY NODE 1 MDM THERMAL LIMITS.
- [2] POWER GENERATION MUST BE SUFFICIENT TO SUSTAIN THE NECESSARY ISS SYSTEMS. ANY DEFICIENCIES SHALL BE MANAGED PER RULE {B9-453}, ENERGY MANAGEMENT [RC]. THIS INCLUDES TRANSITIONS BETWEEN LVLH AND XPOP REFERENCE FRAMES.
- [3] ISS PITCH IS CONSTRAINED TO -20 TO 0 DEG TO MITIGATE BGA COLD CONCERNS WHILE IN +ZLV +XVV. AT  $\beta < -70$  DEG. UNTIL P5 IS INSTALLED. PASSIVE THERMAL ANALYSIS SHOWS THE P4 BETA GIMBALS EXCEED LOWER LIMIT IN A NO SUN CONDITION, I.E., AT  $\beta < -70$  DEG.
- [4] FOR  $|\beta| \geq 40$  DEG, THE +ZLV ± YVV FLIGHT ATTITUDES ARE UNDER EVALUATION AS ALTERNATIVES TO THE XPOP FLIGHT ATTITUDE DUE TO: (A) STABLE CMG CONTROLLERS CANNOT BE DEVELOPED FOR XPOP THAT WILL KEEP THE ISS WITHIN ITS APPROVED XPOP ATTITUDE ENVELOPE, AND (B) HIGH TEMPERATURE CONDITIONS WILL BE EXPERIENCED BY THE P1 RBVM'S, S1 HRS. AND THE RUSSIAN PROGRESS VEHICLE BATTERIES WHILE FLYING XPOP AT  $|\beta| \geq 60$  DEG.
- [5] USE OF THE NOMINAL XPOP FLIGHT ATTITUDE REQUIRES THE FOLLOWING CONSTRAINT TO BE OBSERVED: P6-4B SAW: DUE TO THE SHADOWING OF THE P3 SARJ BY THE P6-4B SOLAR ARRAY, THE NOMINAL XPOP FLIGHT ATTITUDE CANNOT BE FLOWN FOR LONG PERIODS OF TIME AT  $|\beta| \leq 45$  DEG. IF THE XPOP FLIGHT ATTITUDE IS REQUIRED FOR  $|\beta| \leq 45$  DEG, IT MAY BE FLOWN FOR PERIODS OF TIME < 13 HOURS WITHOUT P6-4B SAW OFF-POINTING. IF THE XPOP FLIGHT ATTITUDE IS REQUIRED FOR PERIODS OF TIME > 13 HOURS, THE P6-4B SAW MUST BE OFF-POINTED PER PHALCON STANDARD CONSOLE PROCEDURE (SCP) 3.9 – SOLAR ARRAY QUIESCENT OPERATIONS (TBD) TO ALLOW SUNLIGHT ONTO THE P3 SARJ. THE ACTION OF OFF-POINTING MUST BE DONE IN CONJUNCTION WITH MANAGEMENT OF THE ENERGY BALANCE AS STATED IN NOTE [2] ABOVE. A THERMAL RECOVERY OF 1 HOUR IN THE +ZLV +XVV ATTITUDE IS REQUIRED FOR EVERY HOUR SPENT IN XPOP FLOWN BELOW  $|\beta| \leq 45$  DEG WITHOUT SUFFICIENT P6-4B SAW OFF-POINTING. ONCE THE RETRACTION OF THE P6-4B SOLAR ARRAY HAS TAKEN PLACE, THIS NOTE IS NO LONGER APPLICABLE.

@[DN 116 ]

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## FLIGHT RULES

### 12A B2-2                      ISS STAGE ATTITUDE CONSTRAINTS [RC] (CONTINUED)

- [6] USE OF THE NOMINAL XPOP FLIGHT ATTITUDE REQUIRES THE FOLLOWING CONSTRAINT TO BE OBSERVED: P6-2B SAW: TO PREVENT THE STARBOARD HRS RADIATOR INTEGRATED MOTOR CONTROLLER FROM OVERHEATING WHILE IN THE XPOP FLIGHT ATTITUDE, THE P6-2B SAW SHOULD BE OPERATED USING PHALCON SCP 3.9, "SOLAR ARRAY QUIESCENT OPERATIONS." @[DN 116 ]
- [7] CONSTRAIN PERIODS OF SARJ ROTATION TO LESS THAN 15 MINUTES WHEN IN XPOP WITH AT LEAST 3 HOURS BETWEEN EACH PERIOD OF ROTATION.
- [8] P4 BGA'S MUST BE IN OPEN LOOP OPERATION MODE WHEN SOLAR | BETA | > 70 WHILE IN XPOP OR ±YVV. THERMAL ANALYSIS SHOWS THAT P4 BETA GIMBALS EXCEED LOWER TEMPERATURE LIMITS WHEN SHADOWED BY THE BETA GIMBAL PLATFORM AND/OR P6-4B SOLAR ARRAY AT HIGH SOLAR BETA ANGLES. THIS ASSUMES THAT SARJ IS LOCKED AT ALPHA = 0.
- [9] SATURATION OF THE EEATCS IS PREDICTED FOR A SYSTEM HEAT LOAD OF 9.5 KW FOR |β| ± 60 DEGREES. ATTITUDE SPECIFICS AVAILABLE FROM ATCS.  
IF TELEMETRY OR PLANNING INDICATES SATURATION IS LIKELY, OPERATORS MUST BE PREPARED TO REDUCE SYSTEM HEAT LOAD OR MANEUVER TO A MORE BENIGN FLIGHT ATTITUDE. IF HEAT LOAD REDUCTION AND ALTERNATIVE ATTITUDE ARE DEEMED UNSAFE OR UNFEASIBLE, THEN IT MAY BE POSSIBLE TO INHIBIT THE EEATCS MAXIMUM OUTLET TEMPERATURE FDIR WITH THE SUPPORT OF ADDITIONAL ANALYSIS OF THE SPECIFIC CONDITIONS.  
OPERATORS MUST MONITOR EEATCS PFCS OUTLET TEMPERATURES AND FCV POSITIONS CLOSELY. IF TELEMETRY INDICATES EXCEEDING 50 DEG F (PFCS ATP LIMIT-SHORT SHEET) IS IMMINENT, OPERATORS MUST REDUCE THE EEATCS SYSTEM HEAT LOAD. EEATCS HIGH TEMPERATURE SHUTDOWN FDIR WILL SHUT DOWN THE AFFECTED EEATCS LOOP WHEN THE PFCS OUTLET TEMPERATURE REACHES 55 DEG F.
- [10] THE FOLLOWING MOBILE TRANSPORTER (MT) AND MOBILE SERVICING SYSTEM (MSS) CONSTRAINTS APPLY:  
 - MSS SHALL BE IN OPERATIONAL OR DUAL STRING KEEP ALIVE.  
 - BOTH STRINGS OF MT HEATERS MUST BE ENABLED.  
 - NO MCAS OPERATIONS  
 - PRIOR TO ANY POWERDOWNS, FLIGHT SPECIFIC ANALYSIS SHOULD BE PERFORMED. @[DN 116 ]

*Reference P3 PTCS verification analysis report - MDC99H0286A. SARJ components will remain within their temperature limits in XPOP if operated for 15 minutes continuously. Three hours between periods of rotation is sufficient to return components to an acceptable temperature.*

*Shadowing of the P3 SARJ by the P6 4B solar array while it is deployed requires operational constraints to be placed on the mated stack when flying the XPOP flight attitude. Failure to adhere to these constraints could result in some components on the P3 SARJ exceeding their low temperature limits while flying in this attitude.*

*Thermal analysis shows the P4 beta gimbals exceed the lower temperature limit in a no sun condition, i.e., at a high negative solar beta angle.*

*SARJ PIDS and SSODB flight attitude specification restrict XPOP flight attitude to less than 15 minutes with the SARJ rotating.*

*Source: SSPCB Briefing, SARJ Cold Temp. Violations Issue Resolution, June 12, 2001; and Boeing CER Presentation, CR # R-PCM-540, Flight Attitude Rev D+ Thermal Design Issue Resolution for Truss Segments P4 and S4, July 12, 2002.*

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## FLIGHT RULES

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### **12A\_B2-2**                    **ISS STAGE ATTITUDE CONSTRAINTS [RC] (CONTINUED)**

*Use of +ZLV±YVV: This attitude is needed as a replacement for XPOP at  $|\beta| \geq 40$  deg due to CMG Momentum Manager Controllers not being able to be designed such that the asymmetric ISS configuration could be kept within the design attitude envelope for that attitude. Also, the +ZLV±YVV attitudes keep the S1 HRS and P1 RBVM IMCA's within thermal limits, alleviate Progress hot and DC-1 cold temperature violations from occurring at  $|\beta| \geq 60$  deg. Lastly, in the event of loss of non-propulsive attitude control, the +ZLV±YVV attitudes reduce propellant consumption by a factor of 10 over XPOP.* ©[DN 116 ]

*Reference: SSP 50699-03: ISS Certification Baseline, Flight Attitudes and ISS Program SSCN 8559.*  
©[DN 116 ]

### **12A\_B2-3**                    **STAGE DRAG-THROUGH CABLES [RI]**

DRAG-THROUGH CABLES WITHIN THE ISS WILL BE USED AS FOLLOWS DURING STAGE 12A:

- A. TWO RUSSIAN HEADSET CABLES (FGB COMM PANELS TO SM) - CONNECTED FOR RPM AND PERIODICALLY FOR TRAINING PURPOSES
- B. OPS LAN DATA CABLE (LAB TO FGB) - CONNECTED AT ALL TIMES
- C. AIR DUCTS (THROUGHOUT RUSSIAN SEGMENT) - CONNECTED AT ALL TIMES
- D. VIDEO CABLE (NODE OR AIRLOCK TO FGB) - CONNECTED FOR UP TO 5 CONSECUTIVE DAYS FOR VIDEO ROUTING DURING PROGRESS/SOYUZ DOCKING AND UNDOCKING

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### PRELAUNCH

#### 12A\_C2-1

#### SHUTTLE LAUNCH WINDOW

- A. FOR STS-115, IF LIGHTING TO ACCOMMODATE ET UMBILICAL PHOTOGRAPHY POST MECO IS REQUIRED, ACCEPTABLE LAUNCH DAYS ARE EXPECTED TO BE AUGUST 28, 2006, TO SEPTEMBER 13, 2006.  
@[CR 7625A ]

*Onboard and ground cameras have photography lighting requirements that impact the launch window. Specifically, ground cameras (KSC-IT-6577) require daylight for both launch and ascent. The ET umbilical well and crew hand-held cameras (Enhanced Launch Vehicle Imaging System NSTS 37389) require lighting post MECO for ET photography. The ET lighting constraints are documented with NASA letter, MP31 (245-04), from MP31/Manager, External Tank Project, External Tank (ET)/Orbiter Separation Imagery/Lighting Requirements. If lighting for post MECO ET photography is required, it will be documented in NSTS 17462 STS-115 Flight Requirements Document (FRD).*

*In general, the daylight launch requirement is for the full sun disk to be above the horizon at launch, which corresponds to approximately 3 minutes after sunrise to 3 minutes prior to sunset. Lighting for the umbilical well camera photography, when required, is from 08:30 to 09:30 (mm:ss) Mission Elapsed Time (MET) and lighting for crew hand-held camera photography, when required, is from 11:30 to 13:30 MET. The acceptability of these images cannot be computed in any reasonable manner in real time and must be determined in the weeks prior to launch, based on an integrated flight design trajectory and SX image analysis.*

- B. FOR PRE-LAUNCH PLANNING PURPOSES, THE AUGUST 28, 2006, LAUNCH WINDOW OPENS AT APPROXIMATELY 19:59:04 GMT AND CLOSSES AT 20:09:04 GMT BASED ON THE PREDICTED ISS REFERENCE TRAJECTORY DELIVERED IN MAY 2006, AND STANDARD PLANAR CONSTRAINTS. THE LAUNCH PERIOD WILL BE DEFINED AS 10 MINUTES PRIOR TO THE WINDOW OPEN UNTIL 10 MINUTES AFTER WINDOW CLOSE, BASED ON THE MAXIMUM PRE-LAUNCH PREDICTED PLANAR WINDOW. IN GENERAL, THE LAUNCH WINDOW SHIFTS EARLIER BY APPROXIMATELY 24 MINUTES EACH DAY, REPEATING APPROXIMATELY EVERY 60 DAYS. @[CR 7625A ]

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## FLIGHT RULES

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### 12A\_C2-1

### SHUTTLE LAUNCH WINDOW (CONTINUED)

C. THE PHASE ANGLE AT OMS-2 WILL DETERMINE THE RENDEZVOUS PLAN FOR SUCCESSFUL DOCKING TO ISS. THE FOLLOWING RENDEZVOUS CONSTRAINTS WILL BE IN PLACE FOR STS-115: @[CR 7625A ]

1. NO PART OF THE LAUNCH WINDOW WILL BE USED THAT RESULTS IN A FLIGHT DAY (FD) 4 RENDEZVOUS.

*It is essential that the 12A mission dock on FD3 in order to accomplish all mission objectives. In the event of a FD4 rendezvous, it is likely that one entire day of docked operations will be deleted.*

2. THE MAXIMUM PHASE ANGLE AT OMS-2 FOR A FD3 RENDEZVOUS IS APPROXIMATELY 292 DEGREES.

*Since the ISS altitude is expected to be approximately 185 nm at launch, every day capability for FD3 rendezvous cannot necessarily be achieved. Due to the lower altitude, a FD3 rendezvous can only be accomplished when the phase angle at OMS-2 is less than 292 degrees. Beyond this value, only FD4 rendezvous operations are possible. This value is somewhat variable and will be recomputed at launch minus 2 days, if required. The maximum FD3 phase angle assumes that there are no expected retrograde maneuvers (including dispersions) in the rendezvous plan, a minimum perigee post OMS-2 (reference paragraph C4), and a FD1 posigrade NC maneuver of at least 6 fps. On launch days where the phase angle is slightly larger than 292 degrees, retrograde maneuvers (reference paragraph C4) and launch time adjustments (reference paragraph D) may be used to change an apparent FD4 rendezvous into a FD3 rendezvous.*

3. IF THE PHASE ANGLE SUPPORTS BOTH A FD2 AND FD3 RENDEZVOUS, A FD2 RENDEZVOUS OPTION WILL BE PRESERVED UNTIL POST INSERTION IS COMPLETE UNLESS THIS OPTION REQUIRES THREE BURNS ON FD1 TO CHANGE TO A FD3 RENDEZVOUS. THE MAXIMUM PHASE ANGLE AT OMS-2 THAT CAN SUPPORT FD2 RENDEZVOUS IS APPROXIMATELY 134 DEGREES.

*If an MDF is declared early on FD1, a FD2 rendezvous offers the only possibility of mated operations. On the other hand, a FD2 rendezvous timeline imposes schedule compression hardships, which are not warranted by nominal mission duration. Unless an MDF is declared first, FD2 phasing will, therefore, be performed until NC-1 targeting requires the phase rate be arrested to achieve a FD3 rendezvous without propellant penalty. Due to very tight timeline constraints on STS-115, FD2 phasing will not be protected if doing so requires a third burn on FD1. @[CR 7625A ]*

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**FLIGHT RULES****12A\_C2-1****SHUTTLE LAUNCH WINDOW (CONTINUED)**

4. TO PROVIDE MAXIMUM PHASING CAPABILITY, POST OMS-2 PERIGEE HEIGHT CAN BE AS LOW AS 85 NM AND RETROGRADE PHASING BURNS MAY BE CONSIDERED. ©[CR 7625A ]

*Phasing capability resulting in the earliest possible rendezvous is highly desirable for both nominal and MDF timeline options. Providing this capability in marginal cases equates to achieving the maximum possible phase rate. Retrograde burns can be used to lower mean orbit height to increase phase rate above that for a nominal, propellant-efficient rendezvous restricted to prograde burns if propellant margins permit. This propellant cost must be doubled, subsequently, when orbit height is raised to that of ISS. The lowest permissible perigee height, currently certified at 85 nm, should be achieved prior to planning retrograde burns, because some height-lowering is obtained without propellant cost through maximum aero drag.*

*For the expected altitude of ISS for STS-115, FD3 rendezvous capability exists for all launch days in the August-September launch period. With active trajectory control of the ISS, it is possible that FD3 rendezvous can be preserved for far greater periods. However, since the expected altitude of the ISS at shuttle launch is below an every other day phase repeating orbit altitude of 186 nm, it is possible that FD3 rendezvous capability will be lost every other day if the ISS trajectory is not optimized correctly for FD3 rendezvous.*

- D. THE PREFERRED LAUNCH TIME WILL BE DETERMINED AS DOCUMENTED IN RULE {A2-8}, LAUNCH TIME SELECTION FOR GROUND-UP RENDEZVOUS. FOR STS-115, THE FOLLOWING EXCEPTION TO RULE {A2-8D}.2, LAUNCH TIME SELECTION FOR GROUND-UP RENDEZVOUS, IS APPLICABLE:

ON THOSE LAUNCH DAYS WHERE THE PREDICTED PHASE ANGLE AT OMS-2 IS AT OR NEAR THE MAXIMUM PHASE ANGLE TO ACHIEVE A FD3 RENDEZVOUS (REFERENCE PARAGRAPH C2), THE PREFERRED LAUNCH TIME CAN BE MOVED EARLIER THAN THE IN-PLANE TIME BUT NO EARLIER THAN THE PLANAR WINDOW OPEN TIME.

*To achieve FD3 rendezvous capability, it may become necessary to move the preferred launch time earlier than the in-plane time in order to reduce the phase angle at OMS-2. This option would be exercised when the in-plane launch time is at or near the maximum FD3 rendezvous phase angle (reference paragraph C2) and can be used in addition to or instead of retrograde maneuvers (reference paragraph C4). In this scenario, the OMS-2 phase angle will be reduced by approximately 4 degrees for each minute the preferred launch time is moved earlier. ©[CR 7625A ]*

## FLIGHT RULES

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### 12A\_C2-2

### ISS DRIVEN SHUTTLE LAUNCH COMMIT CRITERIA [RI]

- A. IN ADDITION TO THE SYSTEMS LISTED IN RULE {C2-201}, ISS DRIVEN SHUTTLE LAUNCH COMMIT CRITERIA [RC] [E], THE ISS STAGE MUST MEET THE FOLLOWING CRITERIA AT T-9 MIN OR HAVE AN ETRO PRIOR TO WHEN THEY ARE REQUIRED. THE ETRO CAN BE MET EITHER BY SPARES FLOWN ON THE SHUTTLE OR BY ON-ORBIT SPARES INSTALLED BY THE ISS CREW. IF ANY OF THE CRITERIA IS NOT MET, THE RULE MAY BE WAIVED AFTER MANAGEMENT MEETS TO ASSESS THE CONDITION.
1. MOBILE TRANSPORTER (MT) AT WORKSITE 7
  2. SINGLE FAULT TOLERANT AIRLOCK SYSTEM FUNCTIONALITY TO PERFORM CAT 1 MISSION OBJECTIVES (DETERMINATION MAY BE BASED ON PREVIOUS USAGE).
  3. AT LEAST ONE STRING OF THE SSAS IMCA'S MUST BE OPERATIONAL.
  4. AT LEAST THREE OPERATIONAL CONTROL MOMENT GYROSCOPES (CMG'S)
- B. NON-ISS SHUTTLE CARGO ELEMENT LCC: NONE

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**FLIGHT RULES**

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PRIORITIES AND MISSION DURATION

**12A\_C2-11**      **ON-ORBIT PRIORITIES [RI]**

- A. THE INTERNATIONAL SPACE STATION PROGRAM OFFICE AND SPACE SHUTTLE PROGRAM OFFICE HAVE AGREED ON THE FOLLOWING JOINT PRIORITIES:
1. PERFORM FD2 TPS INSPECTIONS. @[DN 42 ]
  2. PERFORM RPM DURING RENDEZVOUS AND DOCKING FOR ORBITER TPS TILE INSPECTION USING ISS IMAGERY.
  3. INSTALL INTEGRATED TRUSS SEGMENT (ITS) P3/P4 TO ITS P1. (CAT 1)
  4. ACTIVATE ITS P3/P4 SYSTEMS TO RECEIVE SURVIVAL POWER FROM P6. (CAT 1)
  5. TRANSFER MANDATORY AND CRITICAL ITEMS PER 12A TRANSFER PRIORITY LIST. (CAT 1)
  6. CONFIGURE P4 FOR POWER GENERATION AND DISTRIBUTION AND DEPLOY P4 (CHANNEL 4A/2A) SOLAR ARRAY WINGS (SAW'S). (CAT 2) @[DN 42 ]
  7. DEPLOY SARJ DLA'S. (CAT 2)
  8. INSTALL FOUR OF FOUR AJIS STRUTS. (CAT 2)
  9. REMOVE LAUNCH LOCKS AND RESTRAINTS, ACTIVATE, AND CHECKOUT SARJ. (CAT 2)
  10. INSTALL ALL SARJ BRACE BEAMS. (CAT 2)
  11. DEPLOY P4 PHOTOVOLTAIC RADIATOR (PVR). (CAT 2)
  12. TRANSFER REMAINING ITEMS PER 12A TRANSFER PRIORITY LIST. (CAT 2)

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

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**12A\_C2-11            ON-ORBIT PRIORITIES [RI] (CONTINUED)**

13. COMPLETE EVA TASKS NECESSARY TO ENABLE MT TRANSLATION TO WORKSITE (WS)#8. (CAT 2)
  - a. ROTATE P1 MT STOP.
  - b. REMOVE P3 SPACE VISION SYSTEM (SVS) TARGET - FACE 1.
  - c. REMOVE AND STOW P3 KEEL PIN AND DRAG LINK. @[DN 42 ]
  - d. REMOVE P3 REMOTE POWER DISTRIBUTION ASSEMBLY (RPDA) COVERS.
  - e. POSITION APFR'S TO CLEAR FACE
14. REMOVE CID'S 6 AND 8.
15. RELOCATE MT TO WS#8 AND CHECKOUT MSS. (CAT 2)
16. PERFORM THE FOLLOWING EVA TASKS: (CAT 3)
  - a. REMOVE AND REPLACE STBD S-BAND BASE BAND PROCESSOR AND TRANSPONDER.
  - b. INSTALL EVA TEMP RAIL STOP (ETRS), STOW P3 MT STOP AND EVA SHUTTLE TETHER STOP.
  - c. PERFORM SHUTTLE DTO 851, EVA IR CAMERA OBJECTIVE 1.
  - d. P6 SHOULDER BOLT RETAINER INSTALLATION
  - e. INSTALL EWIS ANTENNAS AND CABLE ON U.S. LAB.
  - f. RETRIEVE MISSE-5.
17. TRANSFER MINIMUM OF 25 LBS O<sub>2</sub> TO ISS HPGT'S. @[DN 42 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C2-11      ON-ORBIT PRIORITIES [RI] (CONTINUED)**

18. PERFORM DAILY MIDDECK ACTIVITIES TO SUPPORT PAYLOAD OPERATIONS: @[DN 42 ]
  - a. SDBI 1490, PMZ - BIOAVAILABILITY AND PERFORMANCE EFFECTS OF PROMETHAZINE DURING SPACE FLIGHT
  - b. SDBI 1634, SLEEP - SLEEP WAKE ACTIGRAPHY AND LIGHT EXPOSURE DURING SPACE FLIGHT
  - c. SDBI 1493, LATENT VIRUS - MONITORING REACTIVATION AND SHEDDING IN ASTRONAUTS
19. PERFORM USOS/RUSSIAN DAILY ISS PAYLOAD STATUS CHECKS AS REQUIRED.
20. PERFORM ITCS SAMPLING.
21. PERFORM DEFIBRILLATOR CHECKOUT.
22. PERFORM THE FOLLOWING EVA TASKS: (CAT 3)
  - a. SET THE SOFT CAPTURE LATCHES FOR THE P5 INSTALL (12A.1 GET-AHEAD).
  - b. MODIFIED ROCKETDYNE TRUSS ATTACHMENT SYSTEM (MRTAS) VISUAL INSPECTION AND FOD CHECK (12A.1 GET-AHEAD)
  - c. POSITION APFRS FOR 12A.1 EVA 1 (12A.1 GET-AHEAD).
  - d. RELEASE P4 IEA MMOD SHIELD BOLT TORQUES.
  - e. ENGAGE P6 BGA HINGE LOCK.
23. REBOOST ISS WITH ORBITER, USING AVAILABLE PROPELLANT, TO MAINTAIN ALTITUDE AND RENDEZVOUS REQUIREMENTS. (CAT 4 )
24. INSTALL IWIS BATTERIES.
25. PERFORM IMAGERY SURVEY OF THE ISS EXTERIOR DURING ORBITER FLYAROUND, IF PROPELLANT AVAILABLE. (CAT 4)  
@[DN 42 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)

26. PERFORM RAMBO AND MAUI PAYLOADS OF OPPORTUNITY. @[DN 42 ]
  27. PERFORM SDTO 15003-U (MICROGRAVITY ENVIRONMENT DEFINITION) FOR THE SARJ CHECKOUT. (CAT 4)
  28. PERFORM SDTO 12004-U SHUTTLE BOOSTER FAN BYPASS.
  29. PERFORM SDTO 13005-U (ISS STRUCTURAL LIFE VALIDATION AND EXTENSION) FOR ISS REBOOST (IWIS REQUIRED).
  30. SDTO 13005-U (ISS STRUCTURAL LIFE VALIDATION AND EXTENSION) FOR P3/P4 INSTALLATION TO ISS (CAT 4)
  31. PERFORM SDTO 13005-U (ISS STRUCTURAL LIFE VALIDATION AND EXTENSION) FOR THE 12A ORBITER UNDOCKING (IWIS DESIRED, BUT NOT REQUIRED). (CAT 4)
  32. PERFORM PROGRAM-APPROVED EVA GET-AHEAD TASKS:
    - a. MBS CAMERA
    - b. INSTALL S1 CETA LIGHT.
    - c. INSTALL NON-PROPULSIVE VENT (NPV) ON LAB.
    - d. MATE P1/P3 FLUID UMBILICAL.
    - e. RELOCATE EWIS LAB HAND RAILS.
    - f. PERFORM DTO 851 IR CAMERA OBJECTIVE 2. @[DN 42 ]
- B. EVA PRIORITY MATRIX - THIS MATRIX IDENTIFIES WHAT EVA TASKS WOULD BE PERFORMED ON FLIGHT 12A BASED ON THE MISSION PRIORITIES IF ALL FOUR SCHEDULED EVA'S CANNOT BE EXECUTED.
- IF ONLY ONE EVA CAN BE PERFORMED, THE EVA OBJECTIVES ARE TO INSTALL P3/P4 ON P1 AND CONNECT POWER/DATA UMBILICALS.

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

12A\_C2-11

**ON-ORBIT PRIORITIES [RI] (CONTINUED)**

**TABLE 12A\_C2-11-I - EVA PRIORITIES MATRIX**

EVA TASK	NOMINAL EVA PERF	RATIONALE	TASK PERF IF 1 EVA	TASK PERF IF 2 EVA	TASK PERF IF 3 EVA
<u>CONNECT P3 TO P1 UTILITIES – UPPER/LOWER TRAY:</u> UMBILICAL HOOK UPS CLOSE CID 7. REMOVE CID 6 AND 8. MDM COVER REMOVAL	EVA 1 EVA 1 EVA 1 EVA 1	REQUIRED TO APPLY KEEP-ALIVE POWER AND ACTIVATE P3/P4  SCHEDULED FOR EFFICIENCY UPON ACTIVATION, ORU WILL OVERTEMP WITH SHROUD LOCATED OVER ORU.	1		
<u>SARJ PREPARATIONS:</u> DEPLOY DLA'S (2). INSTALL AJIS STRUTS. (4)	EVA 1 EVA 1	REQUIRED TO ALLOW SARJ ROTATION	2		
<u>SAW PREP TASKS:</u> RELEASE UPPER SABB RESTRAINTS. RELEASE LOWER SABB RESTRAINTS. RELEASE UPPER BETA GIMBAL RESTRAINTS. ROTATE P4 KEEL PIN. UNSTOW LOWER SABB. UNSTOW UPPER SABB. SET SOFT CAPTURE LATCHES FOR P5 INSTALL. MRTAS VISUAL INSPECTION AND FOD CHECK SSU AND ECU COVER REMOVAL	EVA 1 EVA 1 EVA 1 EVA 1 EVA 1 EVA 1 EVA 1 EVA 1 EVA 1 EVA 1/2	REQUIRED PRIOR TO DEPLOYING THE P4 SOLAR ARRAYS  SCHEDULED FOR EVA EFFICIENCY SCHEDULED FOR EVA EFFICIENCY REFERENCE RULE (12A_C2-53B), P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS, FOR COVER REMOVAL CONSTRAINTS.	3		
<u>SAW PREP TASKS:</u> SSU AND ECU COVER REMOVAL <u>SARJ PREPARATION:</u> REMOVE LAUNCH LOCKS. (16) REMOVE LAUNCH RESTRAINTS. (6) SWING OPEN MLI COVER LATCHES. (4 COVERS WITHOUT LL'S UNDERNEATH)	EVA 1/2  EVA 2 EVA 2 EVA 2	REFERENCE RULE (12A_C2-53B), P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS, FOR COVER REMOVAL CONSTRAINTS. REQUIRED TO ALLOW SARJ ROTATION		1	
RELEASE PV RADIATOR CINCHES AND WINCH.	EVA 3	REQUIRED PRIOR TO PVR DEPLOY			1
<u>CLEAR MT TRANSLATION PATH:</u> ROTATE P1 MT STOP. REMOVE P3 SVS TARGET-FACE 1. REMOVE AND STOW P3 KEEL PIN AND DRAG LINK. REMOVE P3 RPDA COVERS. POSITION APR'S CLEAR OF FACE 1.	EVA 3 EVA 3  EVA 3 EVA 3 EVA 3	MT STOP, SVS TARGET REMOVAL, KEEL PIN/DRAK LINK REMOVAL AND RPDA COVER REMOVAL REQUIRED TO CLEAR MT TRANSLATION PATH TO WORKSITE 8. WORKSITE 8 IS REQUIRED FOR P5 INSTALLATION ON FLIGHT 12A.1. REFERENCE RULE (12A_C2-53B), P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS, FOR COVER REMOVAL CONSTRAINTS.			2
DEPLOY	EVA 3	THE P3 SARJ BRACES MUST BE DEPLOYED PRIOR TO PERFORMING EVA TASKS AT THE P4 TIP (I.E., P5 INSTALLATION ON FLIGHT 12A.1) OR SARJ OPERATIONS OTHER THAN CHECKOUT (REF RULE (12A_C2_54), DOCKED LOADS CONSTRAINTS [RI] [C]).			3
EVA TEMP RAIL STOP (ETRS) INSTALLATION AND STOW P3 MT STOP	EVA 3	REQUIRED TO ALLOW A CETA CART TO BE LOCATED OUTBOARD OF THE MT WHILE AT WORKSITE 8 - SCHEDULED FOR EFFICIENCY			4
PERFORM SHUTTLE DTO 851, EVA IR CAMERA OBJECTIVE 1.	EVA 3	PLANNED FOR BEST ORBITER VIEWING ANGLE			5
RELEASE P4 IEA MMOD SHIELD BOLT TORQUE.	EVA 3	SCHEDULED FOR EVA EFFICIENCY			
P6 SHOULDER BOLT RETAINER INSTALLATION	EVA 3	SCHEDULED FOR EFFICIENCY			6
ENGAGE P6 BGA HINGE LOCK.	EVA 3	SCHEDULED FOR EFFICIENCY			7
RETRIEVE MISSE 5.	EVA 3	SCHEDULED FOR EFFICIENCY			8
INSTALL EWIS ANTENNAS AND CABLE ON U.S. LAB.	EVA 3	SCHEDULED FOR EFFICIENCY			9
REMOVE AND REPLACE STBD S-BAND BASE BAND PROCESSOR AND TRANSPONDER.	EVA 3	SCHEDULED FOR EFFICIENCY			10
REMOVE AND REPLACE MBS CAMERA.	EVA 3				11
PROGRAM APPROVED GET AHEADS					12

@[DN 12 ] @[DN 46 ] @[DN 78 ]

SCHEDULE FOR EVA EFFICIENCY - LOWER PRIORITY EVA TASK IS SCHEDULED AHEAD OF HIGHER PRIORITY TASK IN ORDER TO OPTIMIZE THE EVA TIMELINE.

SCHEDULE FOR EFFICIENCY - LOWER PRIORITY EVA TASK IS SCHEDULED AHEAD OF HIGHER PRIORITY TASK DUE TO CONSTRAINTS OF POWER OR COMMUNICATION CONFIGURATION. @[DN 46 ]

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**FLIGHT RULES**

**12A\_C2-12**

**ON-ORBIT PROPELLANT PRIORITIES [RI]**

A. PROPELLANT PRIORITIES FOR CONSUMABLES LIMITED SITUATIONS, HIGHEST PRIORITIES FIRST ARE:

PRIORITY	FLIGHT ACTIVITY	NOTES
1.	NOMINAL OMS/RCS REDLINES (PROTECTS 1-1 DEORBIT OPPORTUNITIES)	REF RULE {A2-108}, CONSUMABLES MANAGEMENT
2.	MINIMUM DURATION FLIGHT	
3.	RENDEZVOUS, UNDOCK, AND SEPARATE FROM ISS	INCLUDES PROPELLANT FOR A MEAN RENDEZVOUS, DOCK, AND CONTINGENCY UNDOCK/SEPARATION FROM THE ISS. DOES NOT INCLUDE PROPELLANT FOR ANY DOCKED ATTITUDE HOLD OR MANEUVERS.
4.	JOINT UNDERSPEED RECOVERY	IF RENDEZVOUS CANNOT BE ACHIEVED AT THE NOMINAL STATION ALTITUDE, THEN CONSIDERATION WILL BE GIVEN IN REAL TIME TO LOWERING THE STATION ALTITUDE TO PROVIDE RENDEZVOUS CAPABILITY.
5.	RBAR PITCH MANEUVER (RPM)	THE RPM IS LOWER PRIORITY THAN RENDEZVOUS WITH THE ISS. REF. RULE {A2-121M}, RNDZ/PROX OPS PROPULSION SYSTEMS MANAGEMENT.
6.	SHUTTLE CONTROL OF MATED STACK FOR SAW 2A DEPLOY AND POST DEPLOY MANEUVER TO TEA ATTITUDE	ISS IS UNABLE TO HOLD ATTITUDE FOR THE SAW 2A DEPLOY.
7.	ET PHOTOGRAPHY PITCH MANEUVER	PHOTOGRAPHY OF THE ET USING THE HANDHELD CAMERA IS HIGHLY DESIRABLE. THE +X TRANSLATION IS NOT INCLUDED AT THIS LEVEL AS THIS MANEUVER CONTRIBUTES TO THE OVERALL RENDEZVOUS BURN PLAN.
8.	WEATHER WAVE-OFF EXTENSION DAY (PROTECTS 2-1-1 DEORBIT OPPORTUNITIES)	THE WEATHER WAVE-OFF EXTENSION DAY IS LOWER PRIORITY THAN THE MINIMUM ALTITUDE REQUIRED FOR PRIMARY PAYLOAD ACTIVITIES. REF RULE {A2-108C}, CONSUMABLES MANAGEMENT.
9.	SHUTTLE CONTROL OF MATED STACK FOR WATER DUMPS AND ASSOCIATED MANEUVERS	CONSERVES ISS PROPELLANT
10.	SHUTTLE CONTROL OF MATED STACK FOR THE ODS LEAK CHECK, MANEUVER TO THE UNDOCK ATTITUDE, AND ATTITUDE CONTROL UNTIL UNDOCK	CONSERVES ISS PROPELLANT
11.	SHUTTLE CONTROL OF MATED STACK FOR THE MANEUVER POST DOCKING TO THE TEA ATTITUDE	CONSERVES ISS PROPELLANT
12.	NOMINAL MISSION DURATION	EXTEND MISSION DURATION IN FLIGHT DAY INCREMENTS PAST MDF, UP TO NOMINAL. REF RULE {A2-108}, CONSUMABLES MANAGEMENT. ASSUMES ISS ATTITUDE HOLD.

©[CR 7588 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

12A\_C2-12

ON-ORBIT PROPELLANT PRIORITIES [RI] (CONTINUED)

PRIORITY	FLIGHT ACTIVITY	NOTES
13	POST UNDOCK LATE INSPECTION	DELTA PROPELLANT REQUIRED FOR LATE INSPECTION MANEUVERS AND ATTITUDE HOLD ABOVE NOMINAL -ZLV, -XVV ATTITUDE HOLD
14.	FCS CHECKOUT WITH APU RUNNING	THE VENT FORCES FOR RUNNING AN APU SIGNIFICANTLY INCREASE PROPELLANT CONSUMPTION WHILE THE APU IS RUNNING WHILE AN FCS C/O WITHOUT AN APU HAS NO APPRECIABLE PROPELLANT COSTS.
15.	PROVIDE ADDITIONAL DEORBIT ATTEMPTS UP TO 2-2-2, INCLUDING ANY REQUIRED ORBIT ADJUST BURNS	TO PROVIDE 2-2-2 (TWO ATTEMPTS ON 3 CONSECUTIVE DAYS) WILL REQUIRE AN ADDITIONAL TWO REVS OF WAVEOFF ABOVE 2-1-1 CAPABILITY.
16.	CONTINGENCY SHUTTLE CONTROL OF MATED STACK FOR ATTITUDE HOLD	CONSERVES ISS PROPELLANT. CMG CONTROL WILL BE PRIME FOR ATTITUDE HOLDS. SHUTTLE CONTROL IS ONLY USED IF CMG ATTITUDE HOLD IS NOT AVAILABLE.
17.	OMS ENGINE FAIL	REF RULES {A6-303}, OMS REDLINES [CIL]; {A6-304}, FORWARD RCS REDLINES; AND {A6-305}, AFT RCS REDLINES [HC].
18.	ISS REBOOST	AVAILABLE SHUTTLE MARGIN WILL BE USED TO REBOOST THE ISS.
19.	ISS FLYAROUND	
20.	MAUI AND RAMBO	
21.	KU OPTIMIZATION FOR OBSS INSPECTION	KU OPTIMIZATION REDUCES THE AMOUNT OF PLAYBACK TIME REQUIRED FOR OBSS INSPECTION DATA.

©[DN 37 ] ©[CR 7588 ]

B. PAYLOAD RETURN PROPELLANT MAY BE RELEASED FOR LOWER PRIORITY ACTIVITIES AFTER SUCCESSFUL TRANSFER TO THE ISS.

*Returning station elements intended to remain with the ISS may increase the deorbit and ballast propellant requirements. Once these items have been successfully deployed and there is no possibility that they will be returned, then the propellant committed to their return and ballast can be allocated to lower priority activities.*

## FLIGHT RULES

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### 12A\_C2-13

### MISSION EXTENSION

- A. THE NOMINAL 12A MISSION DURATION IS 11+1 DAYS.
- B. IN THE EVENT OF A FD4 RENDEZVOUS, THE +1 DAY WILL BE USED AND A NORMAL MISSION TIMELINE WILL BE EXECUTED.
- C. IN THE EVENT THAT FOCUSED INSPECTIONS OF THE ORBITER ARE REQUIRED, THE +1 DAY WILL BE USED TO ACCOMPLISH THE INSPECTIONS. @[CR 7650 ]

*The pre-flight plan, if focused inspections are required, is to insert the +1 day NET FD5 for the inspections. The requirement for focused inspection will not be determined until after the P3/P4 truss has been removed from the payload bay following docking. Due to launch-to-activation thermal constraints, once the P3/P4 is removed from the payload bay, it must be installed on the ISS and activated the following day. This requires that EVA 1 be performed on FD4. Therefore, the earliest opportunity to perform focused inspection is FD5.*

- D. THE 12A MISSION HAS THE POTENTIAL OF EXTENDING THE DOCKED MISSION BY 1 ADDITIONAL DAY BEYOND THE NOMINAL 11-DAY DURATION FOR HIGH PRIORITY OBJECTIVES. THE PRIORITIES FOR ADDING AN ADDITIONAL DAY ARE:
  - 1. ADD CONTINGENCY EVA DAY IF REQUIRED FOR CAT 1 OBJECTIVES.
  - 2. ADD CONTINGENCY EVA DAY IF REQUIRED FOR CAT 2 OBJECTIVES.
  - 3. ADD EXTRA DAY WHILE DOCKED IF REQUIRED TO ACCOMPLISH CAT 2 IVA OBJECTIVES.
- E. IF CONSUMABLES ARE INSUFFICIENT TO SUPPORT AN ADDITIONAL DOCKED DAY TO ACCOMPLISH CAT 1 OBJECTIVES, THE DAY BETWEEN UNDOCKING AND LANDING WILL BE DELETED AND THE DOCKED MISSION WILL BE EXTENDED. @[CR 7650 ]

*The CAT 1 objectives should be accomplished if at all possible. Back-to-back EVA's will only be done to accomplish CAT 1 and 2 objectives. An additional day for other objectives can be added as long as these two items are preserved. If both a FD4 rendezvous and a contingency day were required, EVA 3 day would be given up (assuming all Cat 1 objectives were accomplished and consumables were not available for an extra day) in order to preserve the day between undock and landing.*

## FLIGHT RULES

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### 12A\_C2-14      CONTINGENCY EVA'S [RI]

- A. PRIOR TO P3/P4 UNBERTH FROM THE PAYLOAD BAY, EVA 1 AND P3/P4 INSTALLATION WILL BE DELAYED AND A CONTINGENCY EVA PERFORMED IF REQUIRED TO:

RECOVER REDUNDANCY FOR FUNCTIONS SUPPORTING MATING OF P3/P4 TO P1.

*Reference Rule {12A\_C15-2}, UNSCHEDULED/CONTINGENCY EVA.*

- B. CONTINGENCY EVA (AFTER P3/P4 INSTALLATION)

SEE SECTION 15 CONTINGENCY/UNSCHEDULED EVA'S.



## FLIGHT RULES

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### 12A\_C2-15

### SHUTTLE NON-PROPULSIVE CONSUMABLES MANAGEMENT

THE PRIORITIES FOR O<sub>2</sub>, H<sub>2</sub>, AND N<sub>2</sub> CONSUMABLE LIMITED SITUATIONS, HIGHEST FIRST, ARE:

- A. CONTINGENCY RESERVES, MEASUREMENT ERROR, ETC., FROM THE APPROPRIATE SHUTTLE REDLINE RULES IN VOLUME A

*Reference Rules {A9-257}, POWER REACTANT STORAGE AND DISTRIBUTION (PRSD) H2 AND O2 REDLINE DETERMINATION, and {A17-202}, PSIA CABIN CONTINGENCY 165-MINUTE RETURN CAPABILITY. These redlines include a 2-2-2 shuttle deorbit opportunity plus minimum power level requirements for a safe landing and other contingency reserve.*

- B. MINIMUM DURATION FLIGHT, INCLUDING UP TO 2 DAYS OF DOCKED OPERATIONS WITH ONE EVA FOR THE TRANSFER OF THE P3/4 TRUSS ASSEMBLY

*Minimum duration flight includes approximately 96 hours of on-orbit time, ascent, post-insertion, deorbit prep, and entry. Generally, there will be only 1 docked day's worth of activities on an MDF, but it is possible to achieve 2 docked days if the orbital mechanics are favorable. This includes orbiter thermal requirements. Currently, 4 lbm O<sub>2</sub> is being budgeted for this EVA. A total of 3.62 lbm of N<sub>2</sub> is being budgeted for the EVA. ©[CR 7402 ]*

- C. NOMINAL MISSION DURATION

*This includes orbiter thermal requirements.*

- D. TWO ADDITIONAL NOMINALLY PLANNED ISS BASED EVA'S NOT INCLUDED IN THE MINIMUM DURATION FLIGHT REQUIREMENT (REFERENCE PARAGRAPH B)

*Currently, 8 lbs of O<sub>2</sub> is being budgeted for the two scheduled EVA's. A total of 3.62 lbm of N<sub>2</sub> is being budgeted for each of the two scheduled EVA's. ©[CR 7402 ]*

- E. MISSION EXTENSION OF DOCKED PERIOD TO THE NOMINAL +1 DAY

*This includes orbiter thermal requirements.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-15

### SHUTTLE NON-PROPULSIVE CONSUMABLES MANAGEMENT (CONTINUED)

F. AN ADDITIONAL DAY ABOVE THE NOMINALLY PLANNED MISSION TO BE USED AS AN ADDITIONAL DOCKED DAY OR A WEATHER EXTENSION DAY WITH TWO DEORBIT OPPORTUNITIES.

*If shuttle consumable margins allow, an additional day will be protected. An additional day (docked or weather extension day) would require approximately 250 lbs O<sub>2</sub> and 30 lbs H<sub>2</sub>.*

G. ONE UNSCHEDULED ISS-BASED EVA

*Currently, 4 lbs of O<sub>2</sub> is being budgeted for the unscheduled EVA. A total of 3.62 lbm of N<sub>2</sub> is being budgeted for the unscheduled EVA. @[CR 7402 ]*

H. N<sub>2</sub> TO SUPPORT ORBITER 10.2 EVA BACKUP CAPABILITY

*44 lbm of N<sub>2</sub> is budgeted to support 179-minute emergency deorbit capability while orbiter is at 10.2 psia for backup EVA operations from shuttle.*

*DOCUMENTATION: SIA (NSTS 21458).*

I. O<sub>2</sub>/N<sub>2</sub> FOR TRANSFER TO THE ISS

*Line transfer of a minimum of 25 lbm O<sub>2</sub> will be budgeted. If shuttle consumable margins allow, additional O<sub>2</sub>/N<sub>2</sub> for line transfer will be supplied on an as-needed basis. @[DN 60 ]*

*DOCUMENTATION: SIA (NSTS 21458).*

J. EGRESS REPRESSURIZATION OF THE ISS TO THE MAXIMUM PRESSURE VALUES LISTED IN RULE {C17-4}, ISS ATMOSPHERE REPLENISHMENT [RC]

*In the event that ISS HPGT consumables are being used for metabolic demand (e.g., if Elektron is inoperable), this item may be placed above line transfers in priority. In this case, the oxygen transfer does not impact ORCA lifetime.*

K. ADDITIONAL SHUTTLE DEORBIT OPPORTUNITIES ABOVE 2-2-2

## FLIGHT RULES

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### 12A\_C2-16      MINIMUM DURATION FLIGHT [RI]

- A. AN MDF WILL BE CONSTRUCTED PER THE PRIORITIES SHOWN IN RULE {12A\_C2-11}, ON-ORBIT PRIORITIES [RI]. THIS LEADS TO THE FOLLOWING SEQUENCE OF EVENTS: @[CR 7667 ]
1. FD3 - RENDEZVOUS AND DOCK WITH ISS, ITS P3/P4 UNBERTH/HANDOFF
  2. FD4 - ITS P3/P4 INSTALL, EVA1 - CONNECT UMBILICALS BETWEEN P1 AND P3 TO PROVIDE SURVIVAL POWER FROM P1, ACTIVATE ITS P3/P4 SYSTEMS TO RECEIVE SURVIVAL POWER FROM P1.
  3. FD5 - TRANSFER MANDATORY AND CRITICAL ITEMS PER 12A TRANSFER LIST.
  4. FD6 - UNDOCK, CABIN STOW, FCS CHECKOUT, AND RCS HOT FIRE
  5. FD7 - DEORBIT
- THIS ACCOMPLISHES CAT 1 PRIORITY OBJECTIVES.
- B. UNDOCKING WILL BE DELAYED UNTIL THE TPS IS CLEARED FROM ASCENT DEBRIS AND GAP FILLER PROTRUSIONS, AND THE ET DOORS ARE VERIFIED IN THE PROPER CONFIGURATION TO SUPPORT RE-ENTRY.
- C. LATE RCC INSPECTION FOR MMOD WILL NOT BE PERFORMED IN AN MDF CASE:
1. DUE TO THE REDUCED ON-ORBIT EXPOSURE TIME TO THE MMOD ENVIRONMENT SINCE THE FD2 INSPECTION
  2. TO MINIMIZE WINDOW OF EXPOSURE OF THE NEXT ORBITER SYSTEMS FAILURE FOR WHICH THE MDF WAS INVOKED
  3. TO PROVIDE ADEQUATE TIME TO PERFORM ENTRY PREP AND ENTRY STOW ACTIVITIES TO SUPPORT DEORBIT, ENTRY, AND LANDING  
@[CR 7667 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-16

MINIMUM DURATION FLIGHT [RI] (CONTINUED)

*This plan recognizes the desire to terminate the mission early due to orbiter failures, install ITS P3/P4, and deliver the critical hardware to ISS. It assumes that TPS inspection data from the ascent debris environment, gap fillers, and ET doors has been reviewed and confirms TPS to be GO for entry. ©[CR 7667 ]*

*Numerous combinations of the MDF plans are possible depending on when the failure occurs, the time required to assess TPS inspection data, etc.*

*The goal will be to delay undocking until the TPS is cleared from ascent debris, gap filler protrusions, and proper ET door closure and is shown to be GO for entry since repair options are more robust at ISS as is the contingency safe haven capability. If undocking is delayed beyond FD8, consideration will be given to adding another EVA from the nominal plan per Rule {12A\_C2-**TBD**}, EVA TASK REPLANNING GUIDELINES. Undocking is expected to occur later in the crew day than usual to ensure post-EVA tasks are complete and middeck return items are stowed. All of this leads to this being a busy flight from launch through undocking, and it is, therefore, highly desired to preserve the day between undocking and deorbit to ensure the orbiter is ready and the crew is rested for entry.*

*For the MDF case, late RCC inspection for MMOD damage will not be performed. The MMOD exposure from the scheduled FD2 inspection to deorbit FD8 has similar PRA as the FD09/10 late inspection to deorbit on FD12. Additionally, delaying deorbit to perform the late inspection increases the window of exposure to the next worst orbiter systems failure for which the MDF was invoked. Late inspection requires approximately 2 days for execution of inspection and imagery review. Also, time is required to ensure the vehicle has been properly checked out and configured to safely support deorbit, entry, and landing.*

D. THE ITS P3/P4 WILL ONLY BE UNBERTHED AND INSTALLED ON ISS IF THERE IS 1 FULL DOCKED DAY TO PERFORM EVA1.

*Due to the components on the ITS P3/P4 requiring to stay above certain thermal limits, P3/P4 will not be unberthed from the shuttle PLB unless there is 1 full docked day available to perform the installation, umbilical mating, and activation of the ITS.*

*Reference Rules {12A\_C2-11}, ON-ORBIT PRIORITIES [RI]. ©[CR 7667 ]*

## FLIGHT RULES

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### SAFETY DEFINITION AND MANAGEMENT

#### 12A\_C2-31      ISS CARGO ELEMENT RETURN

- A. THE P3/P4 TRUSS WILL REMAIN ON THE ISS IF ALL THE FOLLOWING ARE MET:

THE P3/P4 IS INSTALLED WITH AT LEAST THREE OF FOUR MBA'S MEETING THE BOLT TIGHT CRITERIA. REFER TO RULE {12A\_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION. @[CR 7686 ]

*This config can support docking and undocking loads (shuttle, Soyuz, or Progress), ISS (SM and aft Progress) reboost, and shuttle (config 3 and 4) reboost. Inability to mate power and/or data connectors to the truss (which may result in loss of P3/P4 ORU's) will not dictate return of the cargo element. @[DN 38 ]*

- B. IN THE EVENT THAT THE P3/P4 MUST BE RETURNED, ALL FOUR PRLA'S CONFIRMED, CLOSED, AND LATCHED, AND THE TWO KEEL LATCHES MUST BE CLOSED AND LATCHED.

*No preflight structural analysis was performed to determine if payload return with a PRLA or AKA released would result in damage to the orbiter and/or P3/4, or any orbiter entry control concerns. Current analysis tools are not sufficient to perform a non-linear analysis as required for this case, preflight or real time.*

- C. IN THE EVENT THAT P3/P4 MUST BE RETURNED AFTER AN MET OF 100 HOURS, FOUR HOURS OF THERMAL CONDITIONING IN PLB TO EARTH ATTITUDE IS REQUIRED AFTER UNDOCKING. ADDITIONAL ORBITER PLB NO-SUN ATTITUDES WILL REQUIRE A 10-HOUR RECOVERY IN NOMINAL ATTITUDE ENVELOPE.

*The SLR material (Martensitic Steel) exhibits brittle failure characteristics at cold temperatures. Thermal Conditioning may be required before the SLR is subjected to descent/landing loads. Attitudes that place no Sun in the PLB could cause P3/P4 components to exceed their lower temperature limits.*

*Reference Analysis performed to close FCA Action 222280A-FCA-022.*

## FLIGHT RULES

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12A\_C2-32

### KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING LASER DYNAMIC RANGE IMAGER (LDRI) OPERATIONS [HC]

- A. PER OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OSHA) STANDARDS, CREWMEMBERS SHALL AVOID LOOKING AT THE LASER SOURCE. [CR 7494 ]
- B. IF THE LASER DYNAMIC RANGE IMAGER (LDRI) IS IN MODES 2 THROUGH 6:
1. IF LDRI IS > 2.7 METERS (9.0 FEET) FROM THE COCKPIT, SIDE HATCH, OR ISS WINDOWS: NO PROTECTION REQUIRED.
  2. IF LDRI IS BETWEEN 0.6-2.7 METERS (2.0-9.0 FEET) FROM THE COCKPIT, SIDE HATCH, OR ISS WINDOWS: EYEWEAR DESIGNATED TO PROTECT AGAINST LDRI RADIATION SHALL BE WORN.
  3. IF LDRI IS < 0.6 METERS (2.0 FEET) FROM THE COCKPIT, SIDE HATCH, OR ISS WINDOWS: WINDOW SHADE(S) OR WINDOW COVER SHALL BE INSTALLED.

*LDRI mode 1 is the standby mode, which has the laser turned off; therefore, this rule is only in effect for modes 2 through 6.*

*The LDRI is a non-visible laser. The LDRI contains an embedded Class IV laser. The LDRI contains 19 LED's emitting radiation at 805nm with a combined power of 8.9W. Optical attenuation limits individual laser beams to 0.21mW, which is Class I status. Due to beam overlap and overall system output, eye and skin hazards exist. The LDRI is eye and skin safe at a distance greater than 2.7 m (9.0 feet) from the cockpit windows. Distances less than or equal to 2.7 meters (9.0 feet) require additional protection. The cockpit and side hatch windows provide negligible protection at this wavelength. The required eyewear will be determined by NASA Medical Operations.*

*The PDRS console monitors arm position and distances. Flight Day 2, 10, and 11 scans are designed preflight and can be found in the PDRS Flight Supplement. INCO monitors the LDRI mode when scans are occurring after the RMS is in position. INCO monitoring is limited by LDRI system telemetry availability. PDRS reports distance violations to both shuttle and ISS Flight Directors if within any Keep-Out Zones and the MCC Surgeon will recommend the required personal protective equipment (PPE).*

*MOD recognizes this hazard and will use best effort in verifying LDRI direction and scan mode prior to removing window protection allowing the crew better situational awareness of SRMS/OBSS visuals for clearances between the orbiter hull to prevent physical contact. [CR 7494 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C2-32                    KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING  
LASER DYNAMIC RANGE IMAGER (LDRI) OPERATIONS [HC]  
(CONTINUED)**

C.    THERE ARE NO KOZ'S FOR AN UNPOWERED LDRI.    ©[CR 7494 ]

D.    THERE ARE NO KOZ'S FOR LDRI WHILE THE OBSS IS BERTHED.

*DOCUMENTATION:*

*Hazard Reports OBSS LCS 001, Rev E, Crew Eye or Skin Injury as a Result of Exposure to Laser Radiation, and LDRI-5, Pathological/Physiological/Psychological.*

*NASA Memorandum SD-06-034, Laser Safety Analysis of OBSS LCS and LDRI Lasers, May 30, 2006.*

*OSHA standards: 29 CFR 1910.133, Eye and Face Protection; 29 CFR 1926.54, Non-Ionizing Radiation; and 29 CFR 1926.102, Eye and Face Protection.    ©[CR 7494 ]*

**FLIGHT RULES**

**12A\_C2-33**

**KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING LASER CAMERA SYSTEM (LCS) OPERATIONS [HC]**

- A. PER OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OSHA) STANDARDS, CREWMEMBERS SHALL AVOID LOOKING AT THE LASER SOURCE. @[CR 7495 ]
- B. IF THE LASER CAMERA SYSTEM (LCS) INFRARED LASER IS POWERED ON AND ACTIVELY LASING, THE FOLLOWING PROTECTIVE EYE SHIELDING MUST BE WORN/INSTALLED IF THE KEEP-OUT ZONE DISTANCE(S) LISTED IN THE FOLLOWING CHART ARE BREACHED. THE KEEP-OUT ZONE IS PROJECTED OUT AS A RECTANGLE EXITING 30 DEG X 30 DEG PERPENDICULAR TO THE LCH OPTIC WINDOW. @[CR 7618 ]

LCC INTERFACE WITH LCH	NO PROTECTION REQUIRED	EYEWEAR DESIGNATED TO PROTECT AGAINST LCS RADIATION SHALL BE WORN	WINDOW SHADE(S) OR WINDOW COVER(S)
ORBITER SIDE HATCH WINDOW	>19.1 METERS ( > 67 FEET )	19.1 TO 10.7 METERS (67 TO 35.1 FEET)	< 10.7 METERS ( < 35.1 FEET )
ORBITER FLIGHT DECK WINDOWS	> 11 METERS ( > 37 FEET )	11 TO 6.7 METERS (37 TO 22 FEET )	< 6.7 METERS ( < 22 FEET )
ISS U.S. LAB WINDOW	> 14.6 METERS ( > 48 FEET )	14.6 TO 8.2 METERS (50 TO 27 FEET )	< 8.2 METERS ( < 27 FEET )

@[CR 7618 ]

*The nominal preflight procedures for LCS scanning are only used for focused tile inspections. Focused inspection procedures using the LCS sensor are developed real time based on flight data. The PDRS console operator in MCC monitors the LCS distance during in-flight scanning and will inform both shuttle and ISS Flight Directors if any Keep-Out Zones are determined and any safety precautions required. The INCO console operator reports any off-nominal scanning events to the FD on the Flight Loop. INCO, PDRS, SURGEON, and FD will have the responsibility to ensure crewmembers are instructed to don eye protection or install the window shade(s)/cover(s) if the scanning is projected to violate the constraints defined in this rule. @[CR 7495 ]*

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

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12A\_C2-33

### KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING LASER CAMERA SYSTEM (LCS) OPERATIONS [HC] (CONTINUED)

*The LCS is not visible to the human eye. The LCS is a Class IIIb laser with a source of 1500 nm, 360 mW (derated to a nominal power output of 252 mW), due to attenuation of the optical components of the Laser Camera Head (LCH) nominal output power from the LCH window is 200 mW. A potential hazard to the cornea of the eyes and skin could be present with this laser. The required eyewear will be determined by NASA Medical Operations. The distances listed in the rule are based on Adidas Model 124 sunglasses that are manifested for each STS crewmember. ©[CR 7495 ]*

*Hazard Report OBSS LCS 001, Rev F, Crew Eye or Skin Injury as a Result of Exposure to Laser Radiation, details an improbable but critical worst-case two-fault KOZ as 19.1 m. If the LCH is actively scanning/lasing and has two internal LCH hardware failures generating a stationary laser beam, this would produce a potential laser beam radiation hazard critical to a crewmember's eye if continually radiated for greater than 10 seconds. PDRS and INCO will use best effort to write LCS focused inspection procedures to ensure the SRMS/OBSS is in position with the LCH facing the inspection area prior to activating the LCH laser. The crew does have insight to laser operations and can quickly turn off the laser if a malfunction is encountered. PDRS will model this failure as a rectangle exiting 30 deg x 30 deg perpendicular to the LCS optic window. ©[CR 7618 ]*

*MOD and the crew will use best effort to adhere to the LCS KOZ while maintaining visuals on SRMS/OBSS clearances to the shuttle hull using the cabin windows.*

*The orbiter side hatch window has no protective coating and is modeled with 100 percent transmittance.*

*The orbiter cockpit, overhead, and aft flight deck windows contain protective coatings which have a transmittance of 30 percent or less, allowing for shorter KOZ by attenuating the LCH laser.*

*The ISS windows contain protective coatings which have a transmittance of 55 percent or less, allowing for shorter KOZ's by attenuating the LCH laser.*

C. THERE ARE NO KOZ'S FOR AN UNPOWERED LCS.

D. THERE ARE NO KOZ'S FOR AN LCS IN HEATERS-ONLY MODE.

E. THERE ARE NO KOZ'S FOR LCS WHILE THE OBSS IS BERTHED.

#### DOCUMENTATION:

*Hazard Reports OBSS LCS 001, Rev F; Crew Eye or Skin Injury as a Result of Exposure to Laser Radiation, June 16, 2006; and LDRI-5, Pathological/Physiological/Psychological. ©[CR 7618 ]*

*NASA Memorandum SD-06034, Laser Safety Analysis of OBSS LCS and LDRI Lasers, May 30, 2006.*

*OSHA standards: 29 CFR 1910.133, Eye and Face Protection; 29 CFR 1926.54, Non-Ionizing Radiation; and 29 CFR 1926.102, Eye and Face Protection. ©[CR 7495 ]*

## FLIGHT RULES

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### RENDEZVOUS/PROXIMITY AND DEPLOY/SEPARATION OPERATIONS

12A\_C2-41

#### STATION RENDEZVOUS/DOCKING PROPELLANT PRIORITIES

[RC] @[DN 98 ] @[DN 105 ] @[CR 7606A ]

- A. IN ORDER TO BE GO FOR STATION DOCKING, SHUTTLE PROPELLANT MUST BE AVAILABLE AS FOLLOWS TO PERFORM THE INDICATED OPERATIONS:
1. PROP REQUIRED FOR A NOMINAL APPROACH AND DOCKING
  2. PROP REQUIRED FOR THE GREATEST OF SHUTTLE ANY ATTITUDE SEPARATION VS SHUTTLE EMERGENCY SEPARATION VS BACKOUT/FAILED CAPTURE/BREAKOUT AS FOLLOWS:
    - a. PROP TO PERFORM SHUTTLE ANY ATTITUDE SEPARATION PER RULE {C4-156}, ANY ATTITUDE SEPARATION [HC] [RC]  
  
OR
    - b. PROP TO PERFORM SHUTTLE EMERGENCY SEPARATION PER RULE {C4-153}, SHUTTLE EMERGENCY SEPARATION [HC] [RC]  
  
OR
    - c. PROP TO PERFORM SHUTTLE OPERATIONS PER RULE {C4-452}, SHUTTLE BACKOUT/FAILED MECHANICAL CAPTURE [RC], AND A NON-TIME-CRITICAL SHORT RANGE PROX OPS BREAKOUT
  3. PROP REQUIRED PER RULE {A2-121A}, RENDEZVOUS/PROX OPS PROPULSION SYSTEMS MANAGEMENT, PARAGRAPHS 1-3
  4. PROP REQUIRED FOR SHUTTLE/STATION STACK ATTITUDE CONTROL FOR MINIMUM MATED OPS DURATION AS DEFINED IN THE ANNEX
  5. PROP REQUIRED FOR A POTENTIAL INCREASED DEORBIT COST RESULTING FROM SEPARATION/BREAKOUT WILL NOT BE PROTECTED.  
@[CR 7606A ]

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## FLIGHT RULES

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12A\_C2-41

### STATION RENDEZVOUS/DOCKING PROPELLANT PRIORITIES [RC] (CONTINUED)

*At a minimum, to dock with the station, propellant must be available to complete the nominal approach through docking, perform a shuttle any attitude separation or a shuttle emergency separation from station, and to protect deorbit and entry redlines, including a deorbit prep and 1 day of orbit maintenance to the PLS opportunity. If the station cannot control attitude through the docked phase, orbiter propellant is required for this activity. The greatest of any attitude separation versus emergency separation versus backout/failed capture/breakout is required. The any attitude separation would be used following a successful capture where hardmate cannot be accomplished such that neither vehicle can assume attitude control. Emergency separation would be used when the Joint Expedited Undocking and Separation (JEUS) is executed for a shuttle cabin leak, the loss of two Freon loops, or the loss of two water loops. Additionally, JEUS may be used for an unisolatable propellant leak, loss of two cabin fans, or loss of two fuel cells. The backout/failed capture provides for the orbiter to back out, fly the corridor, and perform a breakout if required. For all of these scenarios, no propellant is budgeted for increased deorbit costs, re-rendezvous attempts, or for stationkeeping. If the separation results in an increased deorbit cost but insufficient propellant margin exists to provide the increased steep deorbit cost, then a shallow deorbit must be performed. This additional risk was accepted by the JMICB in order to avoid having to load additional OMS propellant to cover the potential increased deorbit cost which could impact Ascent Performance Margin (APM). ©[CR 7606A ]*

- B. TI DELAY BURN VS RBAR STATIONKEEPING - IF A SINGLE REV POSTPONEMENT TO PROX OPS IS ANTICIPATED PRIOR TO TI, A TI DELAY BURN WILL BE PERFORMED AS A PROPELLANT CONSERVATION MEASURE.

*To perform a TI delay burn, a total of 6 fps is expended in addition to a nominal rendezvous (3 fps more than TI is required for TI delay itself plus 3 fps for the delayed TI burn). At 25 lbs of propellant per fps, this penalty equates to 150 lbs. The TI delay option also expends an additional 28 lbs of FRCS propellant if the 3 fps delayed TI is a multi-axis burn because TI is nominally a 9 fps single OMS burn.*

*The STS-74 approach database indicates that the mean penalty for LOW Z Rbar stationkeeping at 170 feet is 2.7 lbs/min of which 44 percent is FRCS usage (1.2 lbs/min). Thus, the TI delay penalty in total propellant usage is reached in about 55.5 min of Rbar stationkeeping while that for FRCS usage is reached in 23 min. A TI delay is, therefore, clearly more propellant efficient for any postponement to the approach of one orbit or more. ©[CR 7606A ]*

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## FLIGHT RULES

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12A\_C2-41

**STATION RENDEZVOUS/DOCKING PROPELLANT PRIORITIES**  
**[RC] (CONTINUED)**

- C. TI DELAY BURN VS VBAR STATIONKEEPING - IF A SINGLE REV POSTPONEMENT TO PROX OPS IS ANTICIPATED PRIOR TO TI, A TI DELAY BURN WILL BE PERFORMED AS A PROPELLANT CONSERVATION MEASURE. @[CR 7606A ]

*To perform a TI delay burn, a total of 6 fps is expended in addition to a nominal rendezvous (3 fps more than TI is required for TI delay itself plus 3 fps for the delayed TI burn). At 25 lbs of propellant per fps, this penalty equates to 150 lbs. The TI delay option also expends an additional 28 lbs of FRCS propellant if the 3 fps delayed TI is a multi-axis burn because TI is nominally a 9 fps single OMS burn.*

*The standard Vbar stationkeeping rule of thumb indicates that the mean penalty for Low Z Vbar stationkeeping is 2.5 lbs/min. Thus, the TI delay penalty in total propellant usage is reached in about 60 min of Vbar stationkeeping. A TI delay is, therefore, clearly more propellant efficient for any postponement to the approach of one orbit or more. @[CR 7606A ]*

## FLIGHT RULES

**12A\_C2-42**

**ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**

A. ISS APPENDAGE CONFIGURATION:

1. NOMINALLY, THE USOS SOLAR ARRAY ROTARY JOINTS (SARJ) AND THE BETA GIMBAL ASSEMBLIES (BGA) WILL BE FEATHERED DURING SEPARATION AS DEFINED IN THE FOLLOWING TABLE WHILE THE ORBITER IS WITHIN 600 FEET (400 FEET FOR P6 ARRAYS WHEN P6 IS ON Z1). @[DN 92 ]

**TABLE 12A\_C2-42-I - USOS FEATHER ANGLES FOR ORBITER UNDOCK**

STAGE CONFIGURATION	Z1-P6		PORT ARRAYS				STARBOARD ARRAYS					
	BGA (DEG)		SARJ (DEG)	BGA (DEG)				SARJ (DEG)	BGA (DEG)			
				INBOARD (P4)		OUTBOARD (P6)			INBOARD (S4)		OUTBOARD (S6)	
	UPR-2B	LWR-4B	UPR-4A	LWR-2A	UPR-2B	LWR-4B	LWR-1A	UPR-3A	LWR-3B	UPR-1B		
AFTER FLT 12A (4B DEPLOYED)	150	210	0 L	270 L	80 L							

L = LATCHED OR LOCKED  
R = ARRAY RETRACTED

*This Rule defines the SARJ and BGA positions for departure and undocking. A SARJ is defined to be feathered when it is positioned at its feather angle and its DLA is engaged and powered. (Analysis for an unlocked SARJ is still pending.) A BGA is defined to be feathered when it is positioned at its feather angle and the BGA motor is powered. A SARJ is defined to be locked when the DLA lock rack is engaged to the bull gear.*

*A BGA is defined to be locked when its anti-rotation pin is engaged and the BGA motor is off.*

2. SHUTTLE UNDOCKING WILL BE DELAYED FOR UP TO ONE ORBIT IF REQUIRED TO CONFIGURE THE U.S. ARRAYS.
  - a. IF THE 2A OR 4A ARRAY CANNOT BE ORIENTED TO THE CONFIGURATIONS DEFINED IN TABLE 12A\_C2-42-I, USOS FEATHER ANGLES FOR ORBITER UNDOCK, UNDOCKING MAY CONTINUE PROVIDED:
    - (1) ARRAY IS LOCKED AND NOT IN A RESTRICTED POSITION PER TABLE 12A\_C2-42-II - RESTRICTED ARRAY POSITIONS. @[DN 92 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

**12A\_C2-42                    ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**  
**(CONTINUED)**

**TABLE 12A\_C2-42-II - RESTRICTED ARRAY POSITIONS** ©[DN 92 ]

<u>P4 2A BGA: 290-40, 110-220</u>
<u>P4 4A BGA: 300-60, 120-240</u>

*Reference JSC 29791, July 2002 and Boeing ISS S&M Presentation to VCB, April 9, 2001 (P6 on Z1), J332-2002-142, December 6, 2002 (P4 arrays for 4B Deployed case).*

OR

- (2) ARRAY IS FEATHERED TO THE POSITION DEFINED IN TABLE 12A\_C2-42-I - USOS FEATHER ANGLES FOR ORBITER UNDOCK, AND UNLOCKED.

*The potential risk for damaging a P4 solar array during orbiter separation is much higher than for P6-on-Z1 arrays. If the P4 arrays can be feathered to 90/270 degrees, analysis has shown the BGA can maintain position at this angle while subjected to obiter and ISS plume loads in the event the arrays cannot be locked. However, in this configuration, the arrays are zero-fault tolerant for inadvertent rotation into a structural Keep-out Zone (KOZ). Alternatively, the arrays can be locked in any position not restricted in Table 12A\_C2-42-II - RESTRICTED ARRAY POSITIONS. Note that the BGA drive may not be able to maintain position while subject to plume loads at all angles.*

- b. IF THE 2B OR 4B ARRAY CANNOT BE ORIENTED TO THE CONFIGURATIONS DEFINED IN TABLE 12A\_C2-42-I - USOS FEATHER ANGLES FOR ORBITER UNDOCK, UNDOCKING MAY CONTINUE.

*There are no thermal or loads keep-out zones for the P6 solar arrays when undocking from PMA2 when on the Lab Forward CBM, so undocking may continue even if the P6 arrays cannot be positioned.* ©[DN 92 ]

- 3. NOMINALLY, THE FGB AND SM SOLAR ARRAYS WILL BE IN SOLAR ZONE 1 OR 9 WHILE THE ORBITER IS WITHIN 170 FEET. UNDOCKING WILL BE DELAYED UP TO ONE ORBIT TO ALLOW RS SOLAR ARRAYS TO BE ORIENTED TO THE POSITIONS DEFINED ABOVE.

*This Rule defines the SM and FGB array positions for departure and undocking. Array structural load limits will not be violated if the arrays are not in the proper sun zones; however, actual loading may be significant and structural fatigue could reduce solar array life.*

*Reference VAC 11A Orbiter/ISS On-Orbit Loads Report, JSC 29791, July 2002.*

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## FLIGHT RULES

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**12A\_C2-42**                    **ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**  
**(CONTINUED)**

- B. ANY EXPEDITED UNDOCKING MAY CONTINUE IF U.S. OR RUSSIAN SOLAR ARRAYS CANNOT BE POSITIONED OR STOPPED, PROVIDED: @[DN 92 ]
1. 2A AND 4A ARRAYS ARE LOCKED AND NOT IN A RESTRICTED ARRAY POSITION (SEE TABLE 12A\_C2-42-II - RESTRICTED ARRAY POSITIONS)
- OR
2. 2A AND 4A ARRAYS ARE FEATHERED TO 90/270 DEGREES AND UNLOCKED

*The potential risk for damaging a P4 solar array during orbiter separation is much higher than for P6-on-Z1 arrays. If the P4 arrays can be feathered to 90/270 degrees, analysis has shown the BGA can maintain position at this angle while subjected to orbiter and ISS plume loads in the event the arrays cannot be locked. However, in this configuration the arrays are zero-fault tolerant for inadvertent rotation into a structural KOZ. Alternatively, the arrays can be locked in any position not restricted in Table 12A\_C2-42-II - RESTRICTED ARRAY POSITIONS. Note that the BGA drive may not be able to maintain position while subject to plume loads at all angles.*

*There are no thermal or loads keep-out zones for the P6 solar arrays when undocking from PMA2 on the Lab Forward CBM, so undocking may continue even if the P6 arrays cannot be positioned. The risk of exceeding a P6 solar array load limit is considered lower than delaying an expedited undocking, since expedited undockings are the result of an unsafe condition requiring an orbiter separation and, in some cases, deorbit. Further, undocking plume loads are typically more benign than approach plume loads, which also reduces the overall risk of overloading the P6 solar arrays. @[DN 92 ]*

- C. SPACE STATION REMOTE MANIPULATOR SYSTEM (SSRMS) SHALL BE IN A PRE-ANALYZED UNDOCKING CONFIGURATION.

*Reference Hazard Report ISS-COLL-1003-4A, Hazards During Proximity Operations, Cause 7, Control 5.*

- D. REFER TO RULE {B2-19}, U.S. LAB WINDOW OPERATIONAL CONSTRAINTS, FOR MANAGEMENT OF THE LAB SHUTTER DURING SHUTTLE UNDOCKING.

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**FLIGHT RULES**

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**12A\_C2-42                    ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**  
**(CONTINUED)**

E. ACS MODING CONFIGURATION

1. AT LEAST ONE COMMAND SOURCE SHALL BE AVAILABLE TO MODE THE STATION INTO ATTITUDE CONTROL. THE LIST OF COMMAND SOURCES INCLUDES THE FOLLOWING, IN ORDER OF PRIORITY:

PRIORITY	COMMAND SOURCE
1	AUTOMATIC ACS MODING IN THE CCS
2	ISS CREW
3	GROUND (MCC-H OR MCC-M)

*The automatic ACS moding shall be considered a single, redundant command source, since the ACS moding status is not check pointed to the backup C&C MDM.*

THE PRIMARY COMMAND SOURCE SHALL HAVE THE NEXT HIGHEST AVAILABLE COMMAND SOURCE AS A BACKUP, IF AVAILABLE. THE BACKUP SHALL COMMAND THE ISS TO ATTITUDE CONTROL IF THE ISS IS STILL IN FREE DRIFT AT A TIME WHEN THE ISS WAS EXPECTED TO HAVE RESUMED ATTITUDE CONTROL.

*The backup command source options of the ISS crew and the ground (MCC-H or MCC-M) shall command after 100 seconds have elapsed from undocking and the automatic command sequence has failed to resume ISS attitude control. This still satisfies the constraint of a minimum separation distance of 9 ft (interface-to-interface). The ISS crew is the second priority command source, and a higher priority than the ground, to protect for a loss of communication condition.*

*The orbiter crew, using the UHF link, was not listed in the priority table because this method is many failures deep, there is not the time criticality for commanding the Motion Control System as there is at docking, and the orbiter crew's concern is separating from the ISS.*

*Reference Hazard Report ISS-GNC-701-4A, Loss of ISS attitude control due to integrated system failure, Cause 1, Control B.2.*

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## FLIGHT RULES

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12A\_C2-42

**ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**  
**(CONTINUED)**

2. THE AUTOMATIC ACS MODING'S LED CONTROL SOFTWARE SHALL REMAIN INHIBITED FOR UNDOCKING. THIS WILL ENSURE THAT THE LIGHTS REMAIN OFF AND DO NOT GIVE AN INCORRECT STATUS OF THE STATION ATTITUDE CONTROL SYSTEM.

*Certain failures may cause the LED control software (per SPN 285) to incorrectly reflect the usability of ACS moding and the attitude control of the station.*

3. IF, WITHIN 3 HOURS OF ORBITER UNDOCKING, A U.S. GNC FAILURE OCCURS SUCH THAT ACS MODING WILL BE UNABLE TO ESTABLISH U.S. ATTITUDE CONTROL AFTER UNDOCK, THE FOLLOWING MUST OCCUR POST-SEPARATION:
  - a. THE CCS "ORBITER DOCKED" FLAG WILL BE SET TO "NOT DOCKED."
  - b. CONTROL WILL BE HANDED OVER TO THE RUSSIAN SEGMENT.

*U.S. GNC is susceptible to multiple single failures (such as loss of the Primary GNC MDM) that render it unable to control attitude without at least 3 hours of reconfiguration by the ground. During unmated operations, such failures would lead to an automatic handover to the Russian Segment (which would snap and hold the current attitude). This software is normally inhibited during mated operations since the orbiter is available for control of the stack. The manual RS unconditional handover command is identical to that sent automatically by CCS, and provides MCC-H and the crew with the ability to directly re-establish stack attitude control manually following orbiter undock after time critical GNC failures. However, if the "RS Takeover without Handshake" response is inhibited, this off-nominal handover will not be successful. In that case, a nominal handover must occur, to give the Russians the master flag, prior to the orbiter departure.*

*Several actions in the Russian Segment are controlled by the "orbiter docked" flag (such as mass properties updates), and this flag must be verified as set for an undocked configuration prior to issuing the handover command.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C2-42**                    **ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]**  
**(CONTINUED)**

F. UNDOCKING DELAY CRITERIA:

SHUTTLE UNDOCKING WILL BE DELAYED FOR UP TO ONE ORBIT TO ASSESS ANY OF THE FOLLOWING ISS ANOMALIES. UNDOCKING MAY BE DELAYED FOR UP TO 1 DAY IF ASSESSMENT SHOWS THAT CONSUMABLES NECESSARY TO SUPPORT APPLICABLE REPAIR ACTIONS IN 1 EXTRA DAY ARE AVAILABLE.

NODE MDM

*Loss of either Node MDM will leave the ISS one failure away from loss of all insight into P6. A replacement MDM is onboard, but a stage EVA is more difficult than a shuttle-based EVA and will use ISS consumables to perform. The loss of the MDM and the difficulty of the ISS crew performing the R&R is considered risky enough that the shuttle should delay undock and perform an off-nominal EVA to effect replacement of the MDM.*

**12A\_C2-43**                    **RESERVED** ©[DN 9 ] ©[DN 104 ]

## FLIGHT RULES

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12A\_C2-44

ORBITER EQUIPMENT POWER VERIFICATION [HC]

- A. ORBITER EQUIPMENT THAT IS UNPOWERED DURING ASCENT AND PLANNED FOR USE DURING DOCKED OPERATIONS WILL BE POWERED ON PRIOR TO DOCKING, WHEN PRACTICAL, TO VERIFY NO POTENTIAL WIRE-TO-WIRE SHORT EXISTS THAT WOULD RESULT IN AN INADVERTENT RCS THRUSTER FIRING.
- B. THERE ARE NO POWER-UP RESTRICTIONS AS A RESULT OF SHUTTLE SYSTEM FAILURES.

*Inadvertent RCS thruster firings while mated to the ISS may have serious effects on ISS hardware. Wire-to-wire short is one failure mechanism that may result in an inadvertent RCS thruster firing. The ascent phase of flight is most likely to reveal wire-to-wire short for equipment that is powered during ascent. For orbiter systems that are unpowered during ascent but are required for docked operations, power must be applied to the equipment to verify a wire-to-wire short is not present. When practical, all unpowered equipment required for docked operations will be verified pre-docking. System failures that require powering unverified equipment or equipment that is not practical to verify pre-docking will be assumed good and powered while docked. RCS Auto Manifold Close software will minimize the effects of an inadvertent thruster firing while docked if caused by an undetected wire-to-wire short.*

*References: Hazard Report ORBI 055, Inadvertent Firing of a Forward/Aft Reaction Control Subsystem Jet Results in Death or Injury to Ground Personnel and/or Loss of Orbiter Crew and Vehicle.*

## FLIGHT RULES

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### 12A\_C2-45

### RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC]

- A. THE SHUTTLE WILL BE IN LOW Z MODE BETWEEN 305 AND 23 METERS (1000 AND 75 FEET), AND NORM Z BETWEEN 23 METERS (75 FEET) AND DOCK. EXCEPTIONS TO THIS MANAGEMENT ARE REQUIRED TO ADDRESS SPECIFIC CONTINGENCIES AND ARE DEFINED IN PARAGRAPH C. @[DN 54 ]

*Low Z is highly desired between 305 and 23 meters (1000 and 75 feet) in order to avoid plume impingement on the Station vehicle from the upfiring PRCS jets during attitude hold or +Z translations. Low Z transition at 305 meters (1000 feet) and back to Norm Z at 23 meters (75 feet) was determined to minimize shuttle plume impingement on Station at far ranges and to minimize thermal effects from shuttle plumes at close ranges.*

*Reference Rule {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], for additional constraints on the use of Norm Z depending on ISS appendage feathering. Reference Hazard Report PRIME-701-2A, Cause 2, Inadequate/Loss of Orbiter Attitude Control.*

*The minimum jets required for full Low Z capabilities (translation and rotation) are two forward-firing jets, one down-firing jet on each side in the forward pod, one aft-firing jet in each aft pod, and one down-firing jet in each aft pod. This mode supports Low Z translation and attitude control.*

*Low Z will override selection of the TAIL ONLY option for pitch selected on SPEC 20 and fire forward reaction control system (FRCS) downfiring jets in order to maintain pitch control.*

- B. INSIDE 23 METERS (75 FEET), ANY NORM Z BRAKING WILL BE PERFORMED USING A 0.01 FPS PULSE SIZE UNLESS A COLLISION THREAT EXISTS. IF REQUIRED TO MAINTAIN TRAJECTORY CONTROL OR TO AVOID COLLISION, NORM Z BRAKING USING A 0.05 FPS PULSE SIZE MAY BE PERFORMED AS NEEDED TO NULL CLOSING RATE OR PLACE THE SHUTTLE BACK ON A NOMINAL APPROACH PROFILE.

*Norm Z braking in DAP B (0.01 fps pulse size) is utilized to reduce loads on the ISS P6 solar arrays and the ISS starboard radiator until it is relocated during Flight STS-119/15A. For later configurations, this constraint protects the solar arrays of the Soyuz/Progress. Jet firing database analysis performed in the spring of 2002 confirmed that restricting +Z Norm Z firings to B DAP (0.01 fps pulse size assumed) within 75 ft sufficiently meets plume constraints (no +Z Norm Z pulse timing restrictions are necessary). (Refer to Orbiter V-bar Approach Jet Firing History Database, LM memo 2HEC-ES-2CX-115, and Comparison of VAC-9A Orbiter Approach Plume-Induced Loads Using V-bar and V-bar 2002 Jet Firing History Databases, LM memo 2HEC-ES-2CX-081.) This constraint will be followed as long as there is not a risk of collision due to following the constraint. If the approach cannot be safely performed with the constraint, Norm Z braking using the 0.05 fps pulse size can be performed as needed to place the shuttle back onto a safe trajectory. @[DN 54 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-45

RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC]  
(CONTINUED)

C. EXCEPTIONS TO THE LOW Z/NORM Z MANAGEMENT DEFINED IN PARAGRAPHS A AND B ARE ALLOWED IN THE FOLLOWING CASES. THESE EXCEPTIONS ARE ONLY ALLOWED IF THE U.S. AND RUSSIAN ARRAYS ARE FEATHERED AND ISS IS IN THE APPROACH ATTITUDE. @DN 54 ]

1. FOR THE LOSS OF BOTH AFT FIRING JETS IN THE SAME POD (DEGRADED +X):
  - a. FROM 1000 TO V-BAR ARRIVAL, THE DAP WILL REMAIN IN LOW Z AND +Z TRANSLATION IS NOT ALLOWED.
  - b. FROM V-BAR ARRIVAL (RANGE APPROXIMATELY 250 FEET) TO 75 FEET, NORM Z WILL BE SELECTED AND +Z TRANSLATION WILL BE PERFORMED USING A 0.01 FPS PULSE SIZE WITH 10-SECOND INTERVALS BETWEEN PULSES.
2. FOR THE LOSS OF VRCS AND ONE DOWN-FIRING JET IN THE FORWARD POD:

FROM V-BAR ARRIVAL (RANGE APPROXIMATELY 250 FEET) TO 75 FEET, NORM Z WILL BE SELECTED AND +Z TRANSLATION WILL BE PERFORMED USING A 0.01 FPS PULSE SIZE WITH 10-SECOND INTERVALS BETWEEN PULSES.
3. FOR THE LOSS OF TWO DOWN-FIRING JETS ON ONE SIDE OF THE FORWARD POD:
  - a. FROM 1000 TO V-BAR ARRIVAL, THE DAP WILL REMAIN IN LOW Z AND +Z TRANSLATION IS NOT ALLOWED.
  - b. FROM V-BAR ARRIVAL (RANGE APPROXIMATELY 250 FEET) TO 75 FEET, NORM Z WILL BE SELECTED AND +Z TRANSLATION WILL BE PERFORMED USING A 0.01 FPS PULSE SIZE WITH 10-SECOND INTERVALS BETWEEN PULSES. @DN 54 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-45

### RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC] (CONTINUED)

*Crew procedures have been developed to allow either a safe continued approach or safe separation for all two jet failure cases that result in degraded control or loss of control. The procedures that address two of these cases - degraded +X, and loss of two down-firing jets on the same side of the forward pod - involve a change to the standard Norm Z/Low Z management. In addition, an exception to the standard Norm Z/Low Z management rule is allowed in the event of both a VRCS and single forward down-firing jet failure. These three cases are more fully described below. (Reference presentation #7, Rendezvous Procedures Analysis and Action Status, to the Orbit Flight Technique Panel (OFTP) #215, October 15, 2004; the minutes for OFTP #215, October 15, 2004; presentation #2, Rendezvous Procedures Reviews and Analysis for RCS Jet Requirements, to the OFTP #218, February 25, 2005; and the minutes to the OFTP #218, February 25, 2005. These presentations addressed two specific OFTP Actions: 205-1 - Rendezvous Procedures and Monitoring Tools Updates Status, and 213-1 - Next Worse FWD Jet failure (FWD Down, FWD Yaw, FWD -X) during Rendezvous Operation Part II.) ©[DN 54 ]*

*Loss of both aft-firing jets in either aft pod (degraded +X): This case results in degraded +X translation and loss of Low Z +Z translation. The degraded +X procedures support continuing the approach to dock. Neither Norm Z or Low Z braking is allowed between 1000 feet and V-bar arrival, and from V-bar initiation to 75 feet, braking is performed in Norm Z vs. Low Z. Norm Z braking in this region is performed in DAP B with 10-second intervals between pulses. Plume loads for this procedure have been analyzed by a piloted database where Norm Z braking is allowed beyond the normal range (75 feet).*

*Loss of two forward down-firing jets on the same side: This case results in DAP lockout of ±Y translation, loss of Low Z PRCS attitude control, and -Z control that is seriously degraded. The loss of Low Z PRCS attitude control can rapidly impart a large closing and out-of-plane velocity on the orbiter. The loss of control, combined with the large velocities, creates collision concerns and/or the need for large separation burns which could cause structural failure of ISS elements. The single forward down-firing jet failure procedure modifies the nominal V-bar approach procedures to prevent the loss of Low Z PRCS attitude control and the associated hazard control issues. The main change is that for the loss of both verniers and a single forward down-firing jet, the approach from V-bar initiation to 75 feet is performed in Norm Z vs. Low Z. Braking in this region is done in DAP B with 10-second intervals between pulses. There may be real-time discussion, dependent on the specific nature of the failure case, and there may be specific reasons for taking precautionary action or accepting the risk of continuing without changing the procedures. ©[DN 54 ]*

## FLIGHT RULES

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### 12A\_C2-46

### FLYAROUND CONTROL REQUIREMENTS [RC]

- A. IF FULL TRANSLATIONAL CAPABILITY IN THE  $\pm X$ ,  $\pm Y$ ,  $-Z$ , OR LO Z +Z AXES IS NOT AVAILABLE (REF RULE {A2-117A}, RNDZ/PROX OPS GNC SYSTEMS MANAGEMENT), A FLYAROUND WILL NOT BE PERFORMED. @[DN 43 ]

*Full translation control in these axes is required to maintain the flyaround range and lateral control requirements. These translation requirements also ensure that full PRCS LO Z rotational control is available. Although Rule {C2-109}, RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC], states that approach may proceed without LO Z, it is required for flyaround because the risk to ISS solar arrays is not warranted for a lower priority activity.*

- B. IF A SINGLE SUBSEQUENT FAILURE COULD RESULT IN A LOSS OF BOTH PRCS LO Z ATTITUDE CONTROL AND VRCS, THE FLYAROUND WILL NOT BE PERFORMED.

*The loss of both PRCS LO Z attitude control and VRCS attitude control would result in PRCS attitude firings toward the ISS. These PRCS attitude firings could result in damage to ISS solar arrays.*

- C. IF THE FLYAROUND HAS ALREADY BEGUN AND THE REQUIREMENTS IN PARAGRAPHS A OR B ARE NO LONGER MET, THE SHUTTLE NOSE IN PLANE BREAKOUT WILL BE PERFORMED.

*In this case, it is prudent to immediately establish an opening rate and get to No LO Z range as quickly as possible.* @[DN 43 ]

## FLIGHT RULES

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### 12A\_C2-47

### DATA DUMP PIPE DURING ORBITER DOCKING

THE DATA DUMP PIPE SHOULD NOMINALLY BE DUMPING FROM THE PRIMARY C&C MDM FROM NO LATER THAN 10 MINUTES PRIOR TO DOCKING TO 5 MINUTES AFTER CONTACT. @[CR 7528 ]

*Dockings are performed using automated moding software to configure the ISS to free drift after contact, with the crew and the ground as backup methods to command the ISS to free drift. If the C&C dump pipe is directed to an MDM other than the primary C&C MDM, and that MDM were to fail around docking, the return S-band link to the ground would be lost, and the ground would not be able to confirm that the ISS is free drift after contact. This particular failure has no impact on the execution of the automatic moding software, so the concern is only with the verification of free drift. If the dump pipe were directed to the primary GNC MDM or the primary INT MDM, and that MDM were to fail, in addition to the loss of S-band return link, the ASCM LED's used by the orbiter crew to verify ISS free drift would also be turned off until the GNC MDM was recovered (60 sec to 5 minutes) or the LED's would not flash until the INT MDM was recovered. If the dump pipe is directed to the primary C&C MDM, S-band return link telemetry is only lost until the backup C&C becomes primary (1 - 5 seconds), and the ASCM LED's would be turned off because the LED software is default inhibited. Regardless of where the dump pipe is when any of these MDM's fail, the ISS crew display will be covered by the C&W summary page that will move to the front when the failure occurs, so the ISS crew will not have the correct display immediately available.*

*If the primary GNC MDM or the primary INT MDM is selected for the dump pipe, then the failure of either MDM effectively takes out two lines of redundancy (ASCM LED's and ground telemetry) for verification of free drift during the immediate window after contact and, potentially, also hinders the ability of the ISS crew to verify free drift (due to the C&W summary popup), which leaves no method for the shuttle crew to verify free drift within 65 seconds of contact. Due to structural concerns, the ISS must be verified to be in free drift within 65 seconds after contact, or the orbiter must depart. It is preferable that the dump pipe be directed to the primary C&C MDM to ensure availability of ground telemetry even though the ASCM LED's and crew C&W summary display issues still exist if the primary C&C MDM were to fail. The limited window to verify free drift (65 seconds) is driving the desire to prevent the loss of S-band return link due to a failure.*

*During this time period around docking, the dump pipe can be redirected from the C&C MDM to other MDM's to dump data if off-nominal events or failures occur that are considered higher priority, such as detection of CMG distress. @[CR 7528 ]*



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**FLIGHT RULES**

12A\_C2-48

ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC]

THIS RULE SUPERSEDES RULE {C2-101}, ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC]. @[CR 7534 ]

SYSTEM	FAILURE	NC FINAL	TI	PROX OPS	RPM [36]	R < 400 FT	R < 250 FT	R < 170 FT	DOCK
ISS	RS ARRAYS NOT IN REQUIRED POSITION FOR DOCKING	GO	GO	GO	GO	GO		GO [2]	GO [2]
	ATV ARRAYS NOT IN REQUIRED POSITION FOR DOCKING [44]	GO	GO	GO	GO	GO		GO	GO
	USOS ARRAYS NOT IN REQUIRED POSITION FOR DOCKING	GO	GO	GO	GO	DLY [2]		GO [2]	GO [2]
	ISS IS NOT IN DOCKING ATTITUDE	GO	GO	GO [3]	NO-GO [26]	ABT [1]		ABT [1]	ABT [1]
	ISS TRACKING LIGHT	GO	GO [3]	GO	GO	GO		GO	GO
	ISS VOICE, COMMANDING, TELEMETRY	GO	TI DLY [18]	GO	GO	GO		GO	ABT [43]
	ISS ATTITUDE CONTROL MODING COMMAND AND VERIFICATION	GO	GO	GO	GO	GO		GO	NO-GO[43]
	ISS TRANSLATIONAL JETS NOT INHIBITED	GO	TI DLY	ABT [19]	NO-GO [19]	ABT [19]		ABT [19]	ABT [19]
	ISS SYSTEM FAILURE [7]		TI DLY	ABT	NO-GO	ABT		ABT	ABT
	PRIMARY C&C MDM		TI DLY [23]	GO	GO	DLY [23]		DLY [23]	DLY [23]
	PRIMARY GNC MDM (WHILE UNDER RS THRUSTER CONTROL)		GO	GO	GO	GO		GO	GO
	PRIMARY INT MDM		GO	GO	GO	GO [21]		GO [21]	GO [21]
	LA1 AND LA2 MDM'S		GO	GO	GO	GO [21]		GO [21]	GO [21]
	LOSS OF ATTITUDE CONTROL	GO	TI DLY [22]	GO	NO-GO [27]	ABT [24]		ABT [24]	ABT [24]
DIGITAL STILL CAMERA (ALL ISS 400/800 MM↓)		GO	GO	NO-GO	GO		GO	GO	
PROP/RCS	VRCS	GO	GO	GO	GO	GO	GO	GO	GO
	LAST AFT FIRING JET (+X)	GO	TI DLY [8]	ABT [32]	NO-GO [28]	ABT [32]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD FIRING JET (-X)	GO	TI DLY [8]	ABT [32]	NO-GO [28]	ABT [32]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD OR AFT LEFT FIRING JET (+Y)	GO	TI DLY [8]	GO [37]	NO-GO [28]	GO [37]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD OR AFT RIGHT FIRING JET (-Y)	GO	TI DLY [8]	GO [37]	NO-GO [28]	GO [37]	ABT [4]	ABT [4]	ABT [4]
	LAST UP FIRING JET IN FORWARD OR EITHER AFT (+NZ)	GO	TI DLY [8]	GO	GO	GO	ABT [4]	ABT [4]	ABT [4]
	2 FORWARD FIRING JETS (DEGRADED -X, +LZ)	GO	GO [5]	GO [5]	GO [5]	GO [5]	GO [5]	GO [5]	GO [5]
	LAST AFT-FIRING JET IN EITHER POD (DEGRADED +X, +LZ)	GO	GO [5]	GO [5]	NO-GO [39]	GO [5]	GO [5]	GO [5]	GO [5]
	LAST DOWN FIRING JET ON EITHER SIDE OF FORWARD (+LZ PITCH AND PCT)	GO	TI DLY [8]	ABT [38]	[33]	ABT [38]	ABT[4] [6]	ABT[4] [6]	ABT [4] [6]
	LAST DOWN FIRING JET IN EITHER AFT POD (+LZ ROLL AND PCT)	GO	TI DLY [8]	GO [29]	NO-GO [34]	GO [29]	ABT [6]	ABT [6]	ABT [6]
	ANY SINGLE FWD DOWN FIRING JET OR ANY 2 DOWN FIRING JETS IN EITHER AFT POD	GO	GO	GO	NO-GO [38]	GO	GO	GO	GO
GNC	IMU'S	GO	TI-DLY [8]	GO [35]	NO-GO [30]	GO [35]	ABT	ABT	ABT
	CAMERAS	GO	GO	GO	GO [40]	GO	ABT	ABT	ABT
	TCS/IHL	GO	GO	GO	NO-GO [31]	GO	GO	ABT [20]	ABT [20]
	CAMERA A & D	GO	GO	GO	GO	GO	GO	GO	ABT [20]
	STAR TRACKER	GO	GO	GO	GO	GO	GO	GO	GO
	RNDZ RADAR	GO	GO	GO (IF VIS)	GO	GO	GO	GO	GO
	COAS	GO	GO	GO	GO	GO	GO	GO	GO
	ANGULAR ALIGN	GO	GO	GO	GO	GO	GO	GO	ABT
	AFT THC	GO	TI-DLY [8]	ABT	NO-GO	ABT	ABT	ABT	ABT
	CONTACTS	GO	TI-DLY [8]	GO	GO	GO	ABT[12] [42]	ABT[12] [42]	ABT[12] [42]
DPS	1 OF 3 GNC GPC'S	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]
	1 OF 2 GNC GPC'S	GO	TI-DLY	GO	NO-GO [30]	GO	ABT [10]	ABT [10]	ABT [10]
	ANY GPC'S	GO [15]	ABT [14]	ABT [14]	NO-GO [14]	ABT [14]	ABT [14]	ABT [14]	ABT [14]
	MDM (FF, FA, PL)	GO	GO	GO	GO [41]	GO	GO	GO	GO
	SM GPC	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]

@[CR 7534 ]

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## FLIGHT RULES

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12A\_C2-48

### ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC] (CONTINUED)

NOTES: @[CR 7534 ]

- [1] THE CORRIDOR APPROACH IS DESIGNED TO ENSURE PROXIMITY OPERATIONS ARE WITHIN THE LOADS DATABASE AND THAT TCS TARGETS ARE AVAILABLE. TO PROTECT THE RUSSIAN SOLAR ARRAYS, THE ORBITER CANNOT PROCEED CLOSER THAN 170 FT WITHOUT THE ISS BEING IN DOCKING ATTITUDE. STATIONKEEP AT OR BACK OUT TO 170 FT AND AWAIT THE ATTITUDE MANEUVER. TO PROTECT DEPLOYED U.S. SOLAR ARRAYS, THE ORBITER CANNOT PROCEED CLOSER THAN 400 FT. STATIONKEEP AT OR BACK OUT TO 400 FT AND AWAIT THE ATTITUDE MANEUVER IF U.S. SOLAR ARRAYS ARE DEPLOYED. WHEN U.S. SOLAR ARRAYS ARE DEPLOYED OUTBOARD OF S3 OR P3, THE U.S. CONSTRAINT IS EXPECTED TO INCREASE TO 600 FT. THIS WILL BE ASSESSED BEFORE 12A.1.
- [2] GO IF SHUTTLE LOW Z IS AVAILABLE.  
WITHOUT LOW Z:  
PROCEED WITHOUT RS SOLAR ARRAYS BEING FEATHERED.  
DELAY APPROACH WITHIN 400 FT UP TO AN ORBIT IF POSSIBLE TO POSITION U.S. SOLAR ARRAYS. OTHERWISE, PROCEED CLOSER WITHOUT ARRAYS BEING FEATHERED OR CONFIRMED NOT TO BE IN A KEEP-OUT ZONE.  
REF RULES {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], AND {C2-109}, RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC].
- [3] FOR FLIGHTS STARTING WITH 4A, IF THE TRACKING LIGHT FAILS, THEN THE ORBITER STAR TRACKERS WILL NOT BE AVAILABLE AS AN OPTIONAL SENSOR DURING THE RENDEZVOUS. THE USE OF THE STAR TRACKERS WITH THE TRACKING LIGHT ALSO REQUIRES THAT THE ISS IS IN AN ATTITUDE THAT ALLOWS USE OF THE TRACKING LIGHT BY TI + 28 MINUTES.
- [4] ORBITER WILL NOT PROCEED INSIDE OR CONTINUE INSIDE 250 FT IF CONTROL IS COMPLETELY LOST IN ONE AXIS.
- [5] SPECIAL CONDITIONS MUST BE MET TO CONTINUE INSIDE OF 1000 FT WITHOUT LOW Z BRAKING ABILITY. NO NORM Z BRAKING IS ALLOWED BETWEEN 1000 FT AND 75 FT. REF RULE {C2-109}, RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC].
- [6] THE ORBITER CAN PROCEED WITH LOSS OF LOW Z ATTITUDE CONTROL. THE ORBITER SHOULD STAY VRCS IF AVAILABLE AND MODE TO NORM Z TAIL ONLY (IF AVAILABLE) AND NORM Z NOSE/TAIL OTHERWISE. HOWEVER, THE ORBITER CANNOT ATTEMPT A DOCKING IF PCT IS LOST. A GMEM OVERWRITE MUST BE IMPLEMENTED BEFORE THE ORBITER IS GO TO ATTEMPT A DOCKING. IF IN A "LOSS OF LOW Z ATTITUDE" OR "LOSS OF PCT" CASE, THE CONTROL IN THE -Z AND/OR ±Y AXES WILL ALREADY BE LOST, SO THE ORBITER WILL BE NO-GO INSIDE OF 250 FT. REF RULE {C2-109}, RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC].
- [7] IF ANY ISS SYSTEMS FAIL (SUCH AS MCS, COMM, THERMAL, CDH, ETC.), WHICH WOULD PREVENT A SUCCESSFUL DOCKING OR VIOLATE DOCKING CONSTRAINTS, THE RENDEZVOUS WILL BE ABORTED. PRIOR TO TI, A TI DELAY MAY BE PERFORMED TO ALLOW TIME TO RECOVER THE FAILED SYSTEM. POST-TI, THE RENDEZVOUS WILL BE HALTED AT THE NEXT MOST CONVENIENT POINT. REFERENCE: HAZARD REPORT ISS-GNC-0701-9A, LOSS OF ISS ATTITUDE CONTROL.
- [8] GO FOR TI IF CAPABILITY CAN BE RECOVERED PRIOR TO 250 FT WITHOUT IMPACTING RENDEZVOUS OPERATIONS. TI DELAY MAY BE PERFORMED TO PROVIDE MORE TIME TO EVALUATE THE SYSTEM FAILURE AND RECOVERY EFFORTS.
- [9] WHEN POSSIBLE, RESTRING TO REMAINING TWO GNC GPC'S. A RESTRING IS REQUIRED PRIOR TO THE RPM IN ORDER TO REGAIN REQUIRED JET REDUNDANCY.
- [10] IF RANGE IS LESS THAN 250 FT, BACK OUT TO 250 FT AND RESUME APPROACH WHEN RECONFIGURED TO TWO GNC GPC'S.
- [11] INCLUDES STRINGING. IF REDUNDANCY RECOVERABLE PRIOR TO 250 FT.
- [12] GO IF THE FORWARD THC IS AVAILABLE FOR BRAKING INPUTS. LOSS OF TWO +Z CONTACTS IN THE AFT THC WILL REQUIRE THE FORWARD THC TO BE MANNED WITHIN 75 FEET OF ISS. IF ONE +Z CONTACT REMAINS IN EACH FORWARD AND AFT THC, THEY MUST BE PROTECTED AGAINST ANY SINGLE POINT FAILURES WHICH WOULD NO-OPT BOTH CONTACTS.
- [13] RESERVED @[CR 7534 ]

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## FLIGHT RULES

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12A\_C2-48

**ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC]**  
**(CONTINUED)**

- [14] THIS ABORT CRITERIA IS BASED ON THE ASSUMPTION THAT AN SM AND A BFS MACHINE ARE REQUIRED AND THEREFORE NOT ENOUGH GPC'S ARE LEFT TO GET REDUNDANT GNC GPC'S. WITHOUT REDUNDANT GNC GPC'S, THE ORBITER IS NO-GO TO BURN TI OR TO PROCEED INSIDE OF 250 FT, SO THERE IS NO REASON TO CONTINUE WITH THE RENDEZVOUS. IF THE SM OR BFS MACHINE COULD BE CONVERTED TO A GNC MACHINE, THEN THERE WOULD NOT BE ANY ABORT CRITERIA. (ADDITIONALLY, THIS FAILURE INVOKES AN MDF CONDITION ACCORDING TO THE FLIGHT RULES.) @[CR 7534 ]
- [15] THIS FAILURE INVOKES AN MDF CONDITION ACCORDING TO THE FLIGHT RULES.
- [16] WHEN POSSIBLE, GIVE UP ONE OF THE THREE GNC GPC'S AND FORM A NEW SM GPC.
- [17] RESERVED
- [18] PRIOR TO TI, IF THERE IS NO VOICE, COMMAND OR TELEMETRY COMMUNICATION BETWEEN THE GROUND AND ISS, TI DELAY CAN BE CONSIDERED WHILE THE ISS IS IN AN UNKNOWN CONFIGURATION. REF RULE {C2-113}, MINIMUM COMMUNICATION ASSETS FOR A SUCCESSFUL DOCKING [RI].
- [19] THE TRANSLATIONAL JETS ON THE ISS MUST BE INHIBITED TO PREVENT OVERPRESSURE OR THERMAL DAMAGE TO THE SHUTTLE DUE TO POTENTIAL ISS JET EXHAUST PLUME. IF THE TRANSLATIONAL JETS ON THE ISS CANNOT BE INHIBITED, THEN THE RENDEZVOUS WILL BE ABORTED. PRIOR TO TI, A TI DELAY COULD BE PERFORMED TO ALLOW TIME TO TRY TO INHIBIT THE JETS. POST-TI, THE RENDEZVOUS WILL BE HALTED PRIOR TO ENTERING PROXIMITY OPERATIONS.
- [20] TO CONTINUE THE APPROACH (BETWEEN 170 FT AND 10 FT) WITH NO TCS/HHL UNITS OR TO PROCEED INSIDE 10 FT WITHOUT CAMERAS A OR D WILL MEAN APPROACHING OUTSIDE THE BOUNDS OF PLUME, PROP AND CONTACT CONDITIONS ANALYSIS. CONSIDERATION CAN BE GIVEN TO CONTINUING THE APPROACH WITH THE ACCEPTANCE OF POTENTIALLY SEVERE IMPACTS TO PLUME LOADING ON THE STATION APPENDAGES, SHUTTLE PROPELLANT MARGINS, AND CONTACT CONDITIONS.
- [21] IF ACS AUTO-MODING SOFTWARE/LIGHTS CANNOT BE CONFIGURED TO SUPPORT AUTOMATIC MODING AT CONTACT, OR IF PRIMARY INT MDM FAILS, OR IF BOTH LA1 AND LA2 MDM'S FAIL, CONTINUE APPROACH WITH ISS CREW DESIGNATED PRIME AND MCC-H/M DESIGNATED BACKUP FOR COMMANDING ISS TO FREE DRIFT UPON "CAPTURE CONFIRMED."
- [22] "GO FOR TI" REQUIREMENTS DICTATE ISS MUST BE IN A KNOWN CONFIGURATION CAPABLE OF ACHIEVING THE DOCKING ATTITUDE WITH LVLH RATES OF 0.04 DEG/SEC PER AXIS OR LESS.
- [23] C&C MDM FAILURE TAKES DOWN ALL AUTOMATIC MODING (OF BOTH USOS AND RS) AND MANUAL USOS COMMANDING TO FREE DRIFT, AS WELL AS ALL USOS COMMAND AND TELEMETRY. IN THE CASE WHERE RUSSIAN MANUAL MODING IS REQUIRED, THE CREW SHALL HAVE ACCESS TO A RUSSIAN LAPTOP OR ISS MAY BE OVER A RUSSIAN GROUND SITE. REFER TO RULES {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], AND {C2-106}, COMMUNICATIONS COVERAGE REQUIREMENTS DURING DOCKING OF SHUTTLE [HC] [RC]. A C&C MDM SHOULD AUTOMATICALLY BE RECOVERED WITHIN 5 SECONDS, WHICH WILL PROVIDE TELEMETRY AND GROUND COMMANDING. THE ISS CREW WOULD HAVE TO RECONNECT THE PCS FOR COMMAND AND TELEMETRY CAPABILITY.
- [24] THE ORBITER WILL PERFORM A CORRIDOR BACKOUT TO 400 FT ON +VBAR TO MITIGATE SHUTTLE PLUME AND COLLISION CONCERNS IF ISS DRIFTS OUT OF ATTITUDE. THE ORBITER MAY CONTINUE IN FROM 400 FT ONCE ISS HAS ASSUMED ATTITUDE CONTROL AND IS BACK IN THE DOCKING ATTITUDE. REFERENCE: HAZARD REPORT ISS-GNC-0701-9A, LOSS OF ISS ATTITUDE CONTROL.
- [25] GO IF ATTITUDE CONTROL IS HANDED OVER TO THE SM. ACS MODING WILL STILL FUNCTION. IF TIME ALLOWS, PREPARE FOR MCC-M BACKUP COMMAND.
- [26] RELATIVELY SMALL EXCURSIONS FROM THE DOCKING ATTITUDE COULD OBSCURE THE VIEW FROM THE ISS WINDOW. IN ADDITION, PLUME LOADS ON ISS HAVE ONLY BEEN ANALYZED FOR THE DOCKING ATTITUDE.
- [27] CONTINUE TO 400 FT ON VBAR TO AWAIT TROUBLESHOOTING. @[CR 7534 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-48

### ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC] (CONTINUED)

- [28] POSITIVE CONTROL IS REQUIRED IN EACH AXIS IN ORDER TO SET UP THE INITIAL CONDITIONS FOR THE RPM. @[CR 7534 ]
- [29] LOSS OF PRCS LOW Z ROLL CONTROL. GO AS LONG AS VERNIS ARE AVAILABLE.
- [30] CRITICAL VEHICLE CONTROL SYSTEMS MUST BE REDUNDANT TO SAFELY PERFORM THE RPM.
- [31] USE OF TCS OR HHL IS REQUIRED TO MEET THE RANGE AND RANGE RATE CONDITIONS SPECIFIED FOR STARTING THE PITCH MANEUVER. ATTEMPTING THE MANEUVER WITHOUT MEETING THESE CONDITIONS COULD ALLOW LARGE TRAJECTORY DISPERSIONS TO BUILD DURING THE MANEUVER. RECOVERY FROM THESE DISPERSIONS COULD BE PROPELLANT-EXPENSIVE, AND WOULD BE FURTHER COMPLICATED BY THE UNAVAILABILITY OF THE TCS AND HHL SENSORS. SINCE HHL RAW RANGE RATE AT THE RPM RANGE HAS BEEN SHOWN TO BE HIGHLY DEPENDENT ON OPERATOR TECHNIQUES, CONSECUTIVE RANGE MARKS SHOULD BE USED TO ESTIMATE RANGE RATE. THE RPOP HHL/DT FUNCTION IS PREFERRED FOR THIS METHOD. (REFERENCE ORBIT FLIGHT TECHNIQUES PANEL #217, JANUARY 28, 2005.)
- [32] BOTH  $\pm X$  TRANSLATIONS ARE REQUIRED TO STABILIZE ON THE +RBAR, TO START AND STOP THE TWICE ORBITAL RATE VBAR APPROACH (TORVA), AND TO MAINTAIN THE VBAR.
- [33] THE RPM IS ALREADY NO-GO FOR LOSS OF THE FIRST FORWARD DOWN-FIRING JET (SEE NOTE [38]).
- [34] IF ALL DOWN-FIRING JETS IN THE SAME AFT POD ARE FAILED, THERE IS NOT ADEQUATE PRCS CONTROL AUTHORITY TO NULL THE PITCH RATE. THE TORVA IS FLYABLE IN LOW Z IN THIS CASE ONLY IF VERN JETS ARE AVAILABLE. OTHERWISE, ROLL CONTROL IS COMPLETELY LOST.
- [35] ONCE TI IS EXECUTED, A LOSS OF SYSTEMS REDUNDANCY IS NOT CAUSE TO ABORT/BREAKOUT IF THE SYSTEM CAN BE RECOVERED AT THE NEXT CONVENIENT HOLDING POINT (ALTHOUGH CERTAIN REDUNDANCY REQUIREMENTS EXIST FOR THE RPM).
- [36] THIS COLUMN DEFINES THE GO/NO-GO CRITERIA FOR STARTING THE RPM.
- [37] ALTHOUGH  $\pm Y$  CAPABILITY IS LOST, LARGE Y EXCURSIONS ARE NOT EXPECTED DURING THIS TIMEFRAME. ALSO, INCREASED CLOSURE FROM CROSS-COUPPLING WOULD NOT BE SIGNIFICANT IN THIS JET CONFIGURATION.
- [38] WITH TWO FORWARD DOWN-FIRING JETS LOST ON ONE SIDE,  $\pm Y$  AND LOW Z BRAKING CAPABILITY IS LOST. LARGE CLOSURE MAY DEVELOP DUE TO DEGRADED PRCS LOW Z ATTITUDE CONTROL. STARTING THE RPM WILL CAUSE A LARGE CLOSING RATE TOWARD ISS THAT WILL FORCE A BREAKOUT FROM THE RENDEZVOUS. WHILE THIS BREAKOUT TRAJECTORY PROVIDES ADEQUATE CLEARANCE BETWEEN THE ORBITER AND THE ISS (> 170 FT), THERE MAY NOT BE ENOUGH PROPELLANT TO PERFORM A RE-RENDEZVOUS. TO PRECLUDE THE POSSIBILITY OF A BREAKOUT, REDUNDANT FORWARD DOWN-FIRING JETS ARE REQUIRED FOR THE RPM. (REFERENCE ORBIT FLIGHT TECHNIQUES PANEL #216, NOVEMBER 19, 2004.)  
FAILURE OF THE REMAINING DOWN-FIRING AFT JET DURING THE RPM WOULD RESULT IN A LOSS OF LOW Z PRCS PITCH CONTROL (SEE NOTE [34]).
- [39] PERFORMING THE RPM WITH ONLY ONE +X JET COULD COMPLICATE THE TRANSITION FROM THE RPM INTO THE TORVA.
- [40] CAMERA A OR D CAN BE ALIGNED ALONG THE -Z AXIS TO BE USED AS A CENTERLINE CAMERA SUBSTITUTE FOR SETTING UP THE RPM INITIAL CONDITIONS.
- [41] THE OTHER SYSTEMS PORTIONS OF THE TABLE SHOULD BE CONSULTED TO DETERMINE RENDEZVOUS IMPACTS FROM LOSS OF SYSTEMS ASSOCIATED WITH THE AFFECTED MDM.
- [42] IF THE AFT THC HAS LOST TWO -Z CONTACTS, GO TO CONTINUE ONLY IF THE DAP REMAINS IN TRANSLATION PULSE WHILE AFT FLIGHT CONTROLLER POWER IS ON.
- [43] AT LEAST ONE COMMUNICATION PATH MUST BE AVAILABLE FOR EACH OF THE THREE CRITICAL PHASES OF DOCKING, (1) CAPTURE CONFIRMED, (2) DRIFT COMMANDING, AND (3) DRIFT VERIFICATION. REF RULE {C2-113}, MINIMUM COMMUNICATION ASSETS FOR A SUCCESSFUL DOCKING [RI].
- [44] THERE ARE NO CONSTRAINTS ON ATV SOLAR ARRAYS DURING SHUTTLE RENDEZVOUS AND DOCKING. NASA ANALYSIS SHOWS THAT THE MAXIMUM TORQUE ON THE ATV SOLAR ARRAYS DURING SHUTTLE DOCKING IS 3.14 NM. ATV SOLAR ARRAYS CAN TOLERATE A MAXIMUM OF 3.35 NM. EVEN IN THE WORST CASE, THE ATV SOLAR ARRAYS CAN ROTATE DURING SHUTTLE DOCKING. REFERENCE: EMAIL, ESA/DETLEF OTTO TO NASA/A. TABAKMAN, SUBJECT: ATV ARRAYS LOADS DUE TO THE ORBITER DOCKING, DATED FEBRUARY 23, 2005.

*Reference Hazard Report ISS-COLL-1003-11A, Hazards During Proximity Operations.* @[CR 7534 ]

## FLIGHT RULES

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**12A\_C2-49**

**A31P LAPTOP CONFIGURATION FOR RETURN**

THE ORBITER WILL UNDOCK WITH A MINIMUM OF THREE FULLY FUNCTIONAL A31P LAPTOPS. ©[CR 7669 ]

*STS-115 will launch with four A31p laptops as part of the shuttle complement. The nominal plan is to transfer one of the A31p's (STS6) to ISS toward the end of the docked mission. This will only occur if the remaining three A31p's are fully functional. Three A31p's on the shuttle allow one machine for KFX, and two machines for any LCS, IDC, DOUG, RPOP, and WLES operations.* ©[CR 7669 ]

## FLIGHT RULES

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### ISS DOCKED OPERATIONS

#### **12A\_C2-51      MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]**

THIS RULE SUPERSEDES PARAGRAPH A OF RULE {C2-11}, PERMISSIBLE MATED ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] [E]. ALL OTHER PARTS OF RULE {C2-11}, PERMISSIBLE MATED ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] [E], APPLY. @[DN 117 ]

- A. PRIOR REMOVAL OF TO P3/P4 FROM THE ORBITER PAYLOAD BAY, THE ALLOWABLE MATED STACK ATTITUDE ENVELOPE IS DEFINED IN TABLE 12A\_C2-51-I.

**TABLE 12A\_C2-51-I - ATTITUDE ENVELOPE PRIOR TO  
REMOVAL OF P3/P4 FROM PLB**

BETA ANGLES [1]	ATTITUDE REFERENCE FRAME [2]	ISS ATTITUDE NAME	PERMISSIBLE ATTITUDE ENVELOPE [3]		
			YAW	PITCH	ROLL
-50° < β < 0°	ISS LVLH	+ZLV +XVV	-15° TO +15°	0° TO +30°	-15° TO +15°
		+ZLV -XVV	-165° TO +165°	0° TO +30°	-15° TO +15°
0° < β < +50°		+ZLV +XVV	-15° TO +15°	0° TO +30°	-15° TO +15°
		+ZLV -XVV	-165° TO +165°	0° TO +30°	-15° TO +15°

NOTES:

- [1] BEFORE P3/P4 REMOVAL FROM THE ORBITER PAYLOAD BAY, LAUNCH-TO-ACTIVATION CONSIDERATIONS REQUIRE THE MATED STACK TO MAINTAIN THE +ZLV -XVV OR +ZLV +XVV FLIGHT ATTITUDES DEPENDING UPON THE SIGN OF THE SOLAR BETA ANGLE. THIS CONSTRAINT, COUPLED WITH THE NECESSITY TO MEET ENERGY BALANCE REQUIREMENTS DURING THE RENDEZVOUS & PROXIMITY OPERATIONS TIME PERIOD, REQUIRES THE FLIGHT SOLAR BETA ANGLE TO BE LIMITED TO ±50 DEG.
- [2] THE XPOP ATTITUDE IS NOT AN ACCEPTABLE ATTITUDE WITH THE P3/P4 ELEMENT IN THE ORBITER PAYLOAD BAY.
- [3] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E].

*+ZLV ±XVV must be flown prior to P3/P4 activation to provide sufficient thermal margin for P3/P4 ORU survival.*

Source: Phase III Launch to Activation, VSIP Presentation, September 20, 2001. @[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C2-51                    MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]**  
**(CONTINUED)**

B. FOR THE P3/P4 OVERNIGHT PARK TIME PERIOD, THE ALLOWABLE MATED STACK ATTITUDE ENVELOPE IS DEFINED IN TABLE 12A\_C2-51-II. @[DN 117 ]

**TABLE 12A\_C2-51-II - ATTITUDE ENVELOPE FOR P3/P4 OVERNIGHT PARK**

BETA ANGLES [1]	ATTITUDE REFERENCE FRAME [2]	ISS ATTITUDE NAME	PERMISSIBLE ATTITUDE ENVELOPE [3]		
			YAW	PITCH	ROLL
-50° < β < +10°	ISS LVLH	+ZLV -XVV	-165° TO +165°	0° TO +30°	-15° TO +15°
-10° < β < +50°		+ZLV +XVV	-15° TO +15°	0° TO +30°	-15° TO +15°

NOTES: **TBD** @[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

**12A\_C2-51                    MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]**  
**(CONTINUED)**

C. POST P3/P4 OVERNIGHT PARK TIME PERIOD, THE ALLOWABLE MATED STACK ATTITUDE ENVELOPE IS DEFINED IN TABLE 12A\_C2-51-III.  
 ©[DN 117 ]

**TABLE 12A\_C2-51-III - MATED ATTITUDE ENVELOPE**

BETA ANGLES	ATTITUDE REFERENCE FRAME [1]	ISS ATTITUDE NAME	PERMISSIBLE ATTITUDE ENVELOPE [2]		
			YAW	PITCH	ROLL
-50° < β < +15°	ISS LVLH	+XVV W/HIGH ROLL BIAS	-15° TO +15°	0° TO +30°	+30° TO +50° [5]
-10° < β < +50°			-15° TO +15°	0° TO +30°	-50° TO -30° [5]
-50° < β < +10°		-XVV W/HIGH	+165° TO +195°	0° TO +30°	-50° TO -30° [6]
-15° < β < +50°		ROLL BIAS	+165° TO +195°	0° TO +30°	+30° TO +50° [6]
-75° ≤ β < -50° [3]	ISS LVLH	+XVV W/HIGH ROLL BIAS	-15° TO +15°	0° TO +30°	+30° TO +50° [5]
+50° < β ≤ +75° [3]			-15° TO +15°	0° TO +30°	-50° TO -30° [5]
-75° ≤ β < -50° [3]		-XVV W/HIGH	+165° TO +195°	0° TO +30°	-50° TO -30° [6]
+50° < β ≤ +75° [3]		ROLL BIAS	+165° TO +195°	0° TO +30°	+30° TO +50° [6]
-60° ≤ β ≤ -50° [8]	ISS XPOP	+ZNN +XPH	-10° TO +10°	0° TO +30°	-10° TO +10°
-50° < β < -30° [8]			-10° TO +10°	0° TO +30°	-10° TO +10°
+30° < β < +50° [4]		+ZNN -XPH	+170° TO +190°	0° TO +30°	-10° TO +10°
+60° ≥ β ≥ +50° [4]			+170° TO +190°	0° TO +30°	-10° TO +10°
-50° < β < 0° [9]	ISS	+ZNN +YPH	-95° TO -85°	+20° ( <b>TBR</b> )	(β+25°) < ROLL < (β+50°) [7]
0° < β < +50° [9]	XPOP	+ZNN -YPH	+85° TO +95°	+20° ( <b>TBR</b> )	(-β+25°) < ROLL < (-β+50°) [7]

NOTES:

- [1] AFTER P3/P4 INSTALLATION BUT BEFORE ACTIVATION OF THE TRUSS SEGMENT, LAUNCH TO ACTIVATION CONSIDERATIONS REQUIRE THE MATED STACK TO MAINTAIN THE -XVV OR +XVV Z-NADIR FLIGHT ATTITUDE.
- [2] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E].
- [3] MATED ±XVV FLIGHT ATTITUDE ABOVE SOLAR BETA MAGNITUDE OF 50 DEG IS RESTRICTED TO CSCS SCENARIOS ONLY. ANALYSIS ASSUMES P4 AND P6 BGA'S ARE SOLAR TRACKING, SARJ AND TRRJ ARE LOCKED AT 0 DEG AND MT IS PARKED AT WS#4. REFERENCE SSCN 8559. ©[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

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12A\_C2-51

### MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC] (CONTINUED)

- [4] PRIOR TO P4 SAW DEPLOY, USE OF THE NOMINAL XPOP ATTITUDE IS PROHIBITED. POST P4 SAW DEPLOY, USE OF THE NOMINAL XPOP ATTITUDE IS NOT PLANNED AND HAS NOT BEEN ANALYZED FOR THE MATED 12A FLIGHT. ADDITIONALLY, NON-PROPULSIVE CMG MOMENTUM MANAGER CONTROLLERS, WHICH WOULD HOLD A TEA OUTSIDE THE CERTIFIED XPOP FLIGHT ATTITUDE ENVELOPE, WOULD NEED TO BE DEVELOPED (4-6 WEEKS FOR TASK COMPLETION). LASTLY, IF FLYING OUTSIDE THE XPOP CERTIFIED FLIGHT ATTITUDE ENVELOPE IS NOT ALLOWABLE, THE XPOP FLIGHT ATTITUDE COULD BE FLOWN PROPULSIVELY IF SUFFICIENT PROPELLANT RESOURCES ARE AVAILABLE. THE FOLLOWING CONSTRAINTS SHOULD BE OBSERVED: @[DN 117 ]
- P6-4B SAW: DUE TO THE SHADOWING OF THE P3 SARJ BY THE P6-4B SOLAR ARRAY, THE NOMINAL XPOP FLIGHT ATTITUDE CANNOT BE FLOWN FOR LONG PERIODS OF TIME AT  $|\beta| \leq 45^\circ$ . IF THE XPOP FLIGHT ATTITUDE IS REQUIRED FOR  $|\beta| \leq 45^\circ$ , IT MAY BE FLOWN FOR PERIODS OF TIME  $< 13$  HOURS WITHOUT P6-4B SAW OFFPOINTING. IF THE XPOP FLIGHT ATTITUDE IS REQUIRED FOR PERIODS OF TIME  $> 13$  HOURS, THE P6-4B SAW MUST BE OFF-POINTED PER PHALCON STANDARD CONSOLE PROCEDURE (SCP) 3.9 – SOLAR ARRAY QUIESCENT OPERATIONS (**TBD**) TO ALLOW SUNLIGHT ONTO THE P3 SARJ. THE ACTION OF OFF-POINTING MUST BE DONE IN CONJUNCTION WITH MANAGEMENT OF THE ENERGY BALANCE AS STATED IN NOTE [2] ABOVE. A THERMAL RECOVERY OF 1 HOUR IN THE +ZLV +XVV ATTITUDE IS REQUIRED FOR EVERY HOUR SPENT IN XPOP FLOWN BELOW  $|\beta| \leq 45^\circ$  WITHOUT SUFFICIENT P6-4B SAW OFF-POINTING. ONCE THE RETRACTION OF THE P6-4B SOLAR ARRAY HAS TAKEN PLACE, THIS NOTE IS NO LONGER APPLICABLE.
- P6-2B SAW: TO PREVENT THE STARBOARD HRS RADIATOR INTEGRATED MOTOR CONTROLLER ASSEMBLY (IMCA) FROM OVERHEATING WHILE IN THE XPOP FLIGHT ATTITUDE, THE P6-2B SAW SHOULD BE OPERATED PER PHALCON SCP 3.9, SOLAR ARRAY QUIESCENT OPERATIONS (**EFFECTS OF PITCH ATTITUDE ARE TBD**).
- [5] DUE TO THE ASYMMETRICAL CONFIGURATION OF THE MATED STACK DURING AND AFTER THE P3/P4 INSTALLATION AND UP UNTIL UNDOCKING, THE ROLL ATTITUDE ENVELOPE HAS BEEN EXPANDED TO ACCOMMODATE MOMENTUM MANAGER CONTROL OF THE MATED STACK WITHOUT THRUSTER FIRING. ANALYSIS ASSUMES P4 AND P6 BGA'S ARE SOLAR TRACKING, SARJ AND TRRJ ARE LOCKED AT 0 DEGREES. REFERENCE SSCN 8559.
- [6] ANALYSIS ASSUMES P4 AND P6 BGA'S ARE SOLAR TRACKING, SARJ AND TRRJ ARE LOCKED AT 0 DEGREES. REFERENCE SSCN 8699.
- [7] FOR P4 SAW DEPLOY THERMAL CONDITIONING, ANALYSIS ASSUMES P6 BGA'S ARE PARKED, 4A BGA IS PARKED AT 60 DEG DURING DEPLOY, 2A BGA IS PARKED AT 300 DEG DURING DEPLOY, SARJ AND TRRJ ARE LOCKED AT 0 DEG, AND THE MT IS PARKED AT WS#7. THESE ATTITUDES ARE INTENDED TO PROVIDE A SOLAR INCIDENCE ANGLE OF GREATER THAN 60 DEG TO THE P4 ARRAYS, WHILE MEETING REQUIREMENTS FOR CREW VISUALS AND P6 POWER GENERATION. REFERENCE SSCN 8559.
- [8] MATED XPOP FLIGHT ATTITUDE ABOVE SOLAR BETA MAGNITUDE OF 50 DEG IS RESTRICTED TO CSCS SCENARIOS ONLY.
- [9] FOR USE DURING P4 SAW DEPLOY ONLY

*With respect to the use of +XVV w/high roll bias, the installation of P3/P4 gives the ISS an asymmetric configuration whose mass properties do not allow the certified +ZLV +XVV attitude envelope to be maintained non-propulsively while the orbiter is present. To allow ISS assembly operations to take place under CMG non-propulsive momentum manager control, an expanded roll bias attitude is required.*

Reference: SSP 50699-03: ISS Certification Baseline, Flight Attitudes and ISS Program SSCN 8559.  
@[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-51

### MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC] (CONTINUED)

*With respect to the use of nominal -XVV and -XVV w/high roll bias, flying -XVV (low or high roll bias) reduces the orbiter's risk of Micrometeoroids and Orbital Debris (MMOD) impact as compared to flying the nominal +XVV (low or high roll bias) attitude. The -XVV high roll bias attitude is also flown for the same reasons as the +XVV high roll bias attitude. Note: ISS MMOD risk increases in the -XVV Z-Nadir flight attitude. ©[DN 117 ]*

*Reference: SSP 50699-03: ISS Certification Baseline, Flight Attitudes and ISS Program SSCN 8699.*

*Use of nominal XPOP ±90 deg Yaw for SAW deploy provides proper thermal conditioning to reduce stiction during the 12A P4 SAW deployment. Thermal conditioning requirements cannot be met while flying the +ZLV +XVV attitude.*

*Reference: SSP 50699-03: ISS Certification Baseline, Flight Attitudes and ISS Program SSCN 8559.*

*Analysis using the mass properties for the various STS-115/12A mated configurations showed that, due to the asymmetrical configuration of the mated stack, the roll attitude envelopes for both - and + solar beta angles would have to be expanded to allow for non-propulsive momentum manager operation while precluding thruster firings.*

D. DURING SAW DEPLOYMENT, REFER TO RULE {12A\_B9-12}, P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION, FOR FLIGHT ATTITUDE GUIDELINES TO THERMALLY CONDITION THE SAW DURING DEPLOYMENT OPERATIONS FOR A DURATION OF 5 HOURS.

AFTER THIS DURATION, THE VEHICLE ATTITUDE MUST REMAIN INSIDE THE ALLOWABLE ATTITUDE ENVELOPE, PER PARAGRAPH C ABOVE, FOR 10 HOURS BEFORE ADDITIONAL DEVIATIONS OCCUR.

E. TRANSITORY EXCURSIONS OUTSIDE APPROVED RANGES MAY BE UP TO AND INCLUDING 5 DEGREES PER AXIS.

*Although the instantaneous ISS attitude may deviate from the approved envelopes, the orbit average must still be within limits. Source: SSCN 3383B (January 2001) to D684-10198-06 DCN002, ISS Flight Attitudes (December 1, 1999). ©[DN 117 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

**12A\_C2-51                      MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]**  
**(CONTINUED)**

- F. MANEUVERS BETWEEN APPROVED ATTITUDE ENVELOPES SHALL BE PERFORMED WITH THE FOLLOWING CONSTRAINTS: @[DN 117 ]
1. THE MAXIMUM MANEUVER TIME SHALL BE ONE ORBITAL PERIOD.
  2. THE SOLAR POINTING VECTOR IN THE ISS BODY AXIS SHALL NOT BE STATIC DURING THE MANEUVER.

*Under extreme hot thermal conditions, analysis indicates a 12-minute thermal capability when the ISS transitions outside the attitude envelope. The above constraints prevent near continuous sun exposure on ISS hardware during maneuvers.*

- G. DURING SPECIAL OPERATIONS, ISS ATTITUDES MUST BE MAINTAINED WITHIN THE FOLLOWING ENVELOPE:

ATTITUDES FOR SPECIAL OPERATIONS [6]							
	REFERENCE FRAME	ISS ATTITUDE NAME	ALLOWABLE ATTITUDES [1]			TIME LIMIT [2][3]	RECOVERY TIME
			YAW	PITCH	ROLL		
REBOOST	ISS LVLH	+ZLV -XVV [4]	+175° TO +185°	+1° TO +11°	-5° TO +5°	5 HRS	<b><u>TBS</u></b>
REBOOST	ISS LVLH	-XVV W/+PITCH BIAS	+165° TO +195°	+45° TO +75°	-15° TO +15°	5 HRS	<b><u>TBS</u></b>

NOTE:

- [1] APPROVED RANGES AND VARIATIONS MUST FALL WITHIN THE NOMINAL ATTITUDE TABLE.
- [2] AFTER SPECIFIED OPERATIONS ARE COMPLETE, ADDITIONAL DEVIATIONS ARE THERMALLY PERMITTED PER RULE {C2-11B}.1, PERMISSIBLE MATED ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] [E], PRIOR TO THE RECOVERY TIME. THUS, THE TOTAL TIME OUTSIDE OF THE ENVELOPE, FOR THESE SPECIFIC ATTITUDES, CAN BE AS MUCH AS 8 HOURS BEFORE THE RECOVERY TIME IN PARAGRAPH B IS STARTED. THE RECOVERY TIME OF 10 HOURS WOULD THEN APPLY AND NOT THE RECOVERY VALUES CALLED OUT IN THIS TABLE.
- [3] THE TIME LIMIT COLUMN REFERS TO THE SPECIFIC PERIOD OF TIME SPENT IN THE SPECIAL OPERATIONS ATTITUDE, PLUS THE TIME PERIOD BETWEEN THE INITIAL ATTITUDE ENVELOPE VIOLATION AND WHEN THE VEHICLE REACHES THE SPECIAL OPERATIONS ATTITUDE.
- [4] ORBITER CONFIGURATION 3, REFERENCE FLIGHT SPECIFIC MATED REBOOST CONFIGURATION AND CONSTRAINTS RULE.
- [5] ATTITUDES ARE SPECIFIC TO SIGN OF SOLAR BETA ANGLE
- [6] POWER GENERATION MUST BE SUFFICIENT TO SUSTAIN THE NECESSARY ISS SYSTEMS. ANY DEFICIENCIES SHALL BE MANAGED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THIS INCLUDES TRANSITIONS BETWEEN LVLH AND XPOP REFERENCE FRAMES. @[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-51

### MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC] (CONTINUED)

- H. PREFERRED ATTITUDE FOR SHUTTLE MATED WASTE/WATER DUMPS  
 ©[DN 117 ]
1. WHILE DOCKED, WASTE/WATER DUMPS CAN BE PERFORMED ONLY IF THE PROJECTION OF ORBITER WASTE/WATER DUMP NOZZLE(S) ONTO THE LOCAL HORIZONTAL PLANE IS AT LEAST 15 DEGREES RETROGRADE. TBD ATTITUDE WILL BE USED WHEN FLYING +ZLV +XVV AND TBD ATTITUDE WILL BE USED WHEN FLYING +ZLV -XVV.  
 ©[DN 66 ]
  2. ORBITER PROPELLANT WILL BE USED TO HOLD ATTITUDE DURING WASTE/WATER DUMPS EVEN IF A MANEUVER TO ATTITUDE IS NOT PERFORMED.

*In order to assure that water/ice particles from the waste/water dump do not impinge on the orbiter, the centerline of the nozzle must point in a retrograde direction. All ISS hardware has been cleared of any mechanical damage from waste/water dumps with the centerline pointed in the pure out-of-plane direction per the ISS Environments Protocol dated November 1, 2004. However, the protocol does not include orbiter hardware. There is very little empirical data of damage potential to orbiter surfaces by these particles at these impact velocities other than windows. Therefore, to avoid recontact with the particles, the dump nozzle centerline must be oriented such that the centerline is greater than or equal to the expected water plume half cone angle in the retrograde direction. In this case, the plume half cone angle is expected to be 10 degrees. To account for attitude deadbanding (5 degrees using ALT), the minimum angle should be greater than or equal to 15 degrees. Maneuvering to this or a slightly larger biased attitude is also advantageous to crew timeline since it takes less time to maneuver instead of maneuvering to the attitude where the dump will be entirely retrograde. The actual total maneuver angle required is based on flight specific internal DAP parameters such that the DAP modes into the maneuver logic. For example, on STS-114 the minimum VERN (ALT) angle is 15 (25) degrees (including allowance for deadbanding). This time savings can then be used for other crew activities.*

*Reference Joint U.S./Russian Agreement on Recontact from Water Dump and Propellant Purge Particles, November 1, 2004. ©[DN 66 ] ©[DN 117 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

**12A\_C2-51                    MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]**  
**(CONTINUED)**

I. ORBITER REPAIR MANEUVER (ORM) & CSCS SEPARATION PERMISSIBLE ATTITUDES @[DN 117 ]

THE ALLOWABLE MATED STACK ATTITUDE ENVELOPES TO PERFORM ORM, ORM CONTINGENCY SEPARATION, AND CSCS CONTINGENCY SEPARATION ARE DEFINED IN TABLE 12A\_C2-51-IV.

**TABLE 12A\_C2-51-IV - MATED ATTITUDE ENVELOPES FOR ORM**

BETA ANGLES	REF FRAME	ISS ATTITUDE NAME	ORM EVENT	PERMISSIBLE ATTITUDE ENVELOPE		
				YAW	PITCH	ROLL
-50° < β < +10°	LVLH	+XVV W /ROLL BIAS [1]	WAYPOINT #1	+5° TO +25°	+5° TO +25°	+30° TO +50°
		+XVV W / ROLL & PITCH BIAS [2]	OVERNIGHT PARK POSITION	+5° TO +25°	+25° TO +45°	+20° TO +40°
		+ZLV +XVV [3]	REPAIR	-15° TO +5°	-10° TO +10°	-20° TO 0°
-10° < β < +50°	LVLH	-XVV W /ROLL BIAS [1]	WAYPOINT #1	-175° TO -155°	+5° TO +25°	+30° TO +50°
		-XVV W / ROLL & PITCH BIAS [2]	OVERNIGHT PARK POSITION	-175° TO -155°	+25° TO +45°	+20° TO +40°
		+ZLV -XVV [3]	REPAIR	+165° TO +185°	-10° TO +10°	-20° TO 0°
-50° ≤ β ≤ +50°	LVLH	+XVV W / - PITCH BIAS [4]	ORM CONTINGENCY SEPARATION (IN WAYPOINT #1 CONFIG.)	-5° TO +5°	-45°	-5° TO +5°
-50° ≤ β ≤ +50°			ORM CONTINGENCY SEPARATION (IN WAYPOINT #8 CONFIG.)	-5° TO +5°	-45°	-5° TO +5°
-75° ≤ β ≤ +75°	LVLH	-XLV +ZVV [5]	CSCS CONTINGENCY SEPARATION	-5° TO +5°	+90°	-5° TO +5°

NOTES:

- [1] ALLOWABLE TIME IN ATTITUDE IS 3 HOURS
- [2] ALLOWABLE TIME IN ATTITUDE IS 24 HOURS
- [3] ALLOWABLE TIME IN ATTITUDE IS 12 HOURS
- [4] ALLOWABLE TIME IN ATTITUDE IS 3 HOURS
- [5] ALLOWABLE TIME IN ATTITUDE IS 2.5 HOURS @[DN 117 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-51

### MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC] (CONTINUED)

*With respect to the use of Orbiter Repair Maneuver (ORM) attitudes, the duration of the ORM choreography, starting at Waypoint #1 and ending at the ORM Repair Position (and back again), requires the maneuver to be separated over multiple days. During the ORM choreography, the mated stack will remain in a stable attitude at three discrete points: (i) Orbiter undock - Waypoint #1, (ii) Orbiter Overnight Park (ONP) - Waypoint #8, and (iii) Orbiter Final Repair Position. To allow for non-propulsive attitude control at each of these three positions, an expanded set of flight attitude envelopes must be approved that violate the approved flight attitude envelopes for -XVV Z-Nadir and +XVV Z-Nadir mated operations. This is caused by the combination of orbiter position on the Shuttle Remote Manipulator System (SRMS) arm and the asymmetrical configuration of the ISS. ©[DN 117 ]*

*With respect to the use of ORM Contingency Separation attitude, in order to recover from an SRMS arm malfunction, the Shuttle Program would like to protect for the capability to perform a non-propulsive, orbiter separation from the ISS while in the ORM Orbiter Undock (Waypoint #1) configuration or ORM ONP (Waypoint #8) configuration.*

*With respect to the use of CSCS Contingency Separation attitude, the Shuttle Program has requested that an orbiter disposal attitude be flown (in the event that CSCS is declared) that allows orbital mechanics to provide the quickest separation distance between the ISS and the unrepairable, unmanned orbiter so it may be returned to Earth.*

*Reference: SSP 50699-03: ISS Certification Baseline, Flight Attitudes and ISS Program SSCN 9657.  
©[DN 117 ]*

## FLIGHT RULES

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### 12A\_C2-52 COMMUNICATIONS COVERAGE REQUIREMENTS @[CR 7680 ]

REAL-TIME TELEMETRY IS MANDATORY FOR THE FOLLOWING ACTIVITIES. IF COMMUNICATIONS ARE CURRENTLY LOS OR EXPECTED TO BE LOS AT THE TIME THESE TASKS ARE TO BE PERFORMED, THE CREW WILL WAIT FOR THE NEXT AOS.

- A. REFER TO RULE {12A\_C10-5}, COMMUNICATION REQUIREMENTS FOR SSAS OPERATIONS, FOR SPECIFIC COMMUNICATION REQUIREMENTS DURING SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS) OPERATIONS. @[CR 7680 ]

*These are key operations that require close monitoring by the ground.*

- B. REFER TO RULE {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], PARAGRAPH B.15, FOR COMMUNICATION COVERAGE REQUIREMENTS DURING SOLAR ARRAY DEPLOYMENT. @[DN 18 ]
- C. REFER TO RULE {12A\_B9-19}, PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS) RADIATOR DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], PARAGRAPH B.8, FOR COMMUNICATION COVERAGE REQUIREMENTS DURING PHOTOVOLTAIC RADIATOR DEPLOYMENT. @[DN 18 ]

## FLIGHT RULES

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**12A\_C2-53**

**P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**

A. P3/P4 TRUSS LTA TIME CONSTRAINTS ARE LISTED IN TABLES 12A-C2-53-I THROUGH 12A-C2-53-IV. LTA TIMES LISTED ARE DEPENDENT UPON SOLAR BETA, FLIGHT ATTITUDE, AND OVERNIGHT PARK POSITION OF THE P3/P4 ELEMENT. ©[DN 114 ]

1. OPTION A - FD3 UNBERTH, OVERNIGHT PARK AT SRMS/SSRMS HANDOFF LOCATION (ON EITHER SRMS OR SSRMS)

**TABLE 12A\_C2-53-I - OPTION A P3/P4 LTA TIME CONSTRAINTS**

ATTITUDE [3]	BETA [2]	TIME LIMIT [1]	CONSTRAINT
+ XVV	40 TO 60	34 HRS	P4 BATTERIES
	20 TO 40	34 HRS	P4 BATTERIES
	0 TO 20	34 HRS	P4 BATTERIES
	-20 TO 0	0 [5]	P4 BATTERIES
	-40 TO -20	0 [5]	P4 MDA [4]
	-60 TO -40	0 [5]	P4 MDA [4]
-XVV	40 TO 60	0 [5]	P4 MDA [4]
	20 TO 40	0 [5]	P4 MDA [4]
	0 TO 20	0 [5]	P4 BATTERIES
	-20 TO 0	34 HRS	P4 BATTERIES
	-40 TO -20	34 HRS	P4 BATTERIES
	-60 TO -40	34 HRS	P4 BATTERIES

©[DN 114 ]

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## FLIGHT RULES

**12A\_C2-53      P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**  
**(CONTINUED)**

2. OPTION B - FD3 UNBERTH, OVERNIGHT PARK AT HIGH HOVER  
 (APPROXIMATELY 5 FEET OFF P1) @[DN 114 ]

**TABLE 12A\_C2-53-II - OPTION B P3/P4 LTA TIME CONSTRAINTS**

ATTITUDE [3]	BETA [2]	TIME LIMIT [1]	CONSTRAINT
+ XVV	40 TO 60	34 HRS	P4 BATTERIES
	20 TO 40	34 HRS	P4 BATTERIES
	0 TO 20	34 HRS	P4 BATTERIES
	-20 TO 0	0 [5]	P4 MDA [4]
	-40 TO -20	0 [5]	P4 MDA [4]
	-60 TO -40	0 [5]	P4 MDA [4]
-XVV	40 TO 60	0 [5]	P4 MDA [4]
	20 TO 40	0 [5]	P4 MDA [4]
	0 TO 20	0 [5]	P4 MDA [4]
	-20 TO 0	34 HRS	P4 BATTERIES
	-40 TO -20	34 HRS	P4 BATTERIES
	-60 TO -40	34 HRS	P4 BATTERIES

@[CR 7665 ]

3. OPTION C - FD3 UNBERTH AND INSTALL

**TABLE 12A\_C2-53-III - OPTION C P3/P4 LTA TIME CONSTRAINTS**

ATTITUDE [3]	BETA [2]	TIME LIMIT [6]	CONSTRAINT
+ XVV	40 TO 60	34 HRS	P4 BATTERIES
	20 TO 40	34 HRS	P4 BATTERIES
	0 TO 20	34 HRS	P4 BATTERIES
	-20 TO 0	0	P4 MDA [4]
	-40 TO -20	0	P4 MDA [4]
	-60 TO -40	0	P4 MDA [4]
-XVV	40 TO 60	0	P4 MDA [4]
	20 TO 40	0	P4 MDA [4]
	0 TO 20	0	P4 MDA [4]
	-20 TO 0	34 HRS	P4 BATTERIES
	-40 TO -20	34 HRS	P4 BATTERIES
	-60 TO -40	34 HRS	P4 BATTERIES

@[DN 114 ]

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## FLIGHT RULES

12A\_C2-53

### P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS (CONTINUED)

4. OPTION D - FD4 UNBERTH, INSTALL AND ACTIVATION @[DN 114 ]

**TABLE 12A\_C2-53-IV - OPTION D P3/P4 LTA TIME CONSTRAINTS**

ATTITUDE [3]	BETA [2]	TIME LIMIT [6]	CONSTRAINT
+ XVV	40 TO 60	34 HRS	P4 BATTERIES
	20 TO 40	34 HRS	P4 BATTERIES
	0 TO 20	34 HRS	P4 BATTERIES
	-20 TO 0	14 HRS	P4 MDA [4]
	-40 TO -20	0	P4 MDA [4]
	-60 TO -40	0	P4 MDA [4]
-XVV	40 TO 60	0	P4 MDA [4]
	20 TO 40	0	P4 MDA [4]
	0 TO 20	14 HRS	P4 MDA [4]
	-20 TO 0	34 HRS	P4 BATTERIES
	-40 TO -20	34 HRS	P4 BATTERIES
	-60 TO -40	34 HRS	P4 BATTERIES

NOTES:

- [1] CLOCK BEGINS WHEN THE SSRMS TRANSLATION OF P3/P4 FROM THE OVERNIGHT PARK LOCATION IS INITIATED AND STOPS WHEN THERMAL CONDITIONING IS ESTABLISHED VIA COMPONENT POWER AND/OR HEATERS FOR BOTH P3/P4 STRINGS.
- [2] NOTE - BETA CONSTRAINED TO ±50 BY RULE {12A\_C2-51}, MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC].
- [3] LAUNCH-TO-ACTIVATION CONSIDERATIONS REQUIRE THE ISS TO MAINTAIN THE XVV Z-NADIR FLIGHT ATTITUDE PRIOR TO ACTIVATION OF THE P3/P4 TRUSS SEGMENT; THUS, THE XPOP ATTITUDE IS NOT PERMITTED DURING THIS TIMEFRAME. @[CR 7665 ]
- [4] ANALYSIS SHOWS THERE IS NOT A SIGNIFICANT DIFFERENTIATION IN TIME LIMITS BETWEEN MAST CANISTER MDA'S AND BLANKET BOX MDA'S; THUS, A SPECIFIC MDA IS NOT CALLED OUT.
- [5] IN CASES WHERE THE ANALYSIS SHOWED THAT THE AVAILABLE TIME LIMIT DID NOT SUPPORT THE NOMINAL ACTIVATION TIMELINE, A TIME LIMIT OF ZERO (0) IS SHOWN. IN THESE INSTANCES, THE ACTIVATION MARGIN IS LESS THAN ZERO AND IT IS REFLECTED AS N/A IN THIS TABLE. @[CR 7665 ]
- [6] CLOCK BEGINS WHEN P3/P4 IS REMOVED FROM THE ORBITER PLB AND STOPS WHEN THERMAL CONDITIONING IS ESTABLISHED VIA COMPONENT POWER AND/OR HEATERS FOR BOTH P3/P4 STRINGS. @[DN 114 ]

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## FLIGHT RULES

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12A\_C2-53

### P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS (CONTINUED)

*The thermal clocks in this rule are event-based. Thermal analysis shows that components on the P3/P4 truss will reach their lower limit by the times listed above in Tables 12A\_C2-53-I through 12A\_C2-53-IV. Times listed in these tables are for the most limiting component for each Beta range. The thermal analysis was performed assuming a nominal mission and attitude timeline for the major P3/P4 activities and that the P3/P4 is at the overnight park position prior to crew sleep on FD3. Minor timeline/attitude deviations, including FD2 orbiter inspections, are not considered to be an impact to the overall time constraints of this rule. However, significant changes in the MET of any of these activities will result in impacts to the time constraints, which must be assessed as part of the real-time operations. ©[DN 114 ] ©[CR 7665 ]*

*Source: Boeing JOP Presentation, 12A P3/P4 Overnight Park Action, May 12, 2005; and Boeing JOP Presentation, 12A and 13A LTA Constraints for FD3 Unberth Feasibility and 12A Thermal Profile, August 13, 2003.*

- B. UPON ACTIVATION OF THE P4 IEA, THE P4 PFCS'S MUST BE STARTED TO MAINTAIN BATTERY TEMPERATURES BELOW THE UPPER TEMPERATURE TRIP LIMIT OF 20 DEG C (68 DEG F).

*The IEA 2A and 4A channels must be powered in order to activate the beta gimbal and SAW hardware, thus adding a heat load to the IEA strongback. Thus, thermal conditioning is required to prevent exceeding IEA temperatures. Activating the PFCS and flowing ammonia through the PV radiator will establish the necessary thermal control. The limiting component is the IEA battery.*

- C. P3/P4 COMPONENT THERMAL COVER CONSTRAINTS ARE DEFINED IN TABLE 12A\_C2-53-V - P3/P4 MLI CONSTRAINTS. ©[DN 114 ]

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**FLIGHT RULES**

12A\_C2-53

**P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**  
**(CONTINUED)**

**TABLE 12A\_C2-53-V - P3/P4 MLI CONSTRAINTS** ©[DN 114 ]

MLI LOCATION	CONSTRAINT	COMMENTS
P4 SSU'S (2)	<p>THE SSU MUST BE ACTIVATED PRIOR TO SHROUD REMOVAL.</p> <p>THE SSU WILL BE DEACTIVATED IF TEMPERATURE LIMITS ARE EXCEEDED BEFORE THE SHROUDS CAN BE REMOVED.</p> <p>RETURN SHROUD TO ORBITER.</p>	<p>REFER TO RULES {B9-158}, SSU AND ECU OPERATIONS PRIOR TO THERMAL SHROUD REMOVAL, AND {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS, AND MINIMUM REQUIREMENTS.</p> <p>PRIOR TO ACTIVATION, ORU WILL UNDERTEMP IF SHROUD IS PREMATURELY REMOVED.</p> <p>UPON ACTIVATION, ORU WILL OVERTEMP WITH SHROUD LOCATED OVER ORU.</p> <p>SHROUD REQUIRED TO BE RETURNED FOR USE ON FLIGHT 15A, STS-119</p>
P4 ECU'S (2)	<p>THE ECU MUST BE ACTIVATED PRIOR TO SHROUD REMOVAL.</p> <p>THE ECU WILL BE DEACTIVATED IF TEMPERATURE LIMITS ARE EXCEEDED BEFORE THE SHROUDS CAN BE REMOVED.</p> <p>RETURN SHROUD TO ORBITER.</p>	<p>REFER TO RULES {B9-158}, SSU AND ECU OPERATIONS PRIOR TO THERMAL SHROUD REMOVAL, AND {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS, AND MINIMUM REQUIREMENTS.</p> <p>PRIOR TO ACTIVATION, ORU WILL UNDERTEMP IF SHROUD IS PREMATURELY REMOVED.</p> <p>UPON ACTIVATION, ORU WILL OVERTEMP WITH SHROUD LOCATED OVER ORU.</p> <p>SHROUD REQUIRED TO BE RETURNED FOR USE ON FLIGHT 15A, STS-119</p>
P3 MDM'S (1) []	<p>MAY BE REMOVED 1 HOUR PRIOR TO ACTIVATION</p> <p>IF ONLY 1 MDM BROUGHT OPERATIONAL, MUST BE REMOVED WITHIN 5 HOURS FOLLOWING ACTIVATION</p> <p>IF BOTH MDM'S BROUGHT OPERATIONAL, MUST BE REMOVED WITHIN 3 HOURS FOLLOWING ACTIVATION</p> <p>REMOVE PRIOR TO MT TRANSLATION TO WS8</p> <p>RETURN SHROUD TO ORBITER.</p>	<p>PRIOR TO ACTIVATION, ORU WILL UNDERTEMP IF SHROUD IS PREMATURELY REMOVED.</p> <p>UPON ACTIVATION, ORU WILL OVERTEMP WITH SHROUD LOCATED OVER ORU.</p> <p>SLATED TO BE REMOVED DURING 12A MATED MISSION</p> <p>MLI MAY INTERFERE WITH MT TRANSLATION.</p> <p>SHROUD IS NOT REQUIRED FOR A LATER FLIGHT (TRASH).</p>

©[DN 114 ] ©[CR 7665 ]

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## FLIGHT RULES

**12A\_C2-53      P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**  
(CONTINUED)

**TABLE 12A\_C2-53-V - P3/P4 MLI CONSTRAINTS (CONTINUED)**

MLI LOCATION	CONSTRAINT	COMMENTS
P3 RPDA'S (2) [2]	1. <u>MUST BE REMOVED BEFORE HIGH BETA PERIODS. ABOVE +60</u>  2. <u>REMOVE PRIOR TO MT TRANSLATION TO WS8</u>	<u>1 &amp; 2 SLATED TO BE REMOVED DURING 12A MATED MISSION</u>  1. <u>RPCM'S ARE AT LOW TO NOMINAL POWER DRAW DURING EARLY STAGES AND ANALYSIS SHOWS MLI SHROUD CAN REMAIN ON ORU.</u>  2. <u>MAY INTERFERE WITH MT TRANSLATION</u>
P3 RJMC'S (2)	REQUIRED FOR XPOP AND DEPLOYED P6-4B SOLAR ARRAY	1. INSTALLED TO PROTECT COLD CONCERN IN XPOP WHILE P6 PORT ARRAY SHADOWS THE P3 TRUSS. PLAN TO BE REMOVED DURING STAGE 12A.1 EVA  2. REMOVAL NECESSARY TO PREVENT HOT ISSUE IN XVV AT HIGH BETA AT FLIGHT 10A OR LAUNCH +3 YEARS
XPOP SHROUDS (2)	REQUIRED FOR XPOP AND YVV ATTITUDES	INSTALLED TO SHADOW P3 HARDWARE WHILE IN XPOP AND YVV. PLANNED TO BE REMOVED DURING STAGE 12A.1 EVA

@[DN 114 ]

NOTES:

- [1] P3 MDM'S SHARE ONE MLI COVER.
- [2] WPPR 48 DID NOT ADDRESS THE RPDA'S. THIS NEEDS TO BE ASSESSED AND THE CONSTRAINT NEEDS TO BE CONFIRMED. LEAVE CONSTRAINT UNDERLINED. @[DN 114 ]

*Source: Boeing JOP Presentation, MLI Removal Constraints on P3/P4 Truss Segments, November 1, 2002*

- D. THE S1 S-BAND BSP TRANSFER MUST BE COMPLETED WITHIN 2 HOURS INSIDE AN MLI EVA BAG AND INSTALLATION MUST BE COMPLETED WITHIN 2 HOURS AFTER IT IS REMOVED FROM THE EVA BAG. TRANSFER CLOCK STARTS WHEN THE BSP IS REMOVED FROM THE AIRLOCK AND STOPS WHEN THE BSP IS PULLED OUT OF THE MLI BAG. INSTALLATION CLOCK STARTS WHEN THE BSP IS PULLED OUT OF THE MLI BAG AND STOPS WHEN THE BSP IS MECHANICALLY INSTALLED.  
@[CR 7665 ]

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## FLIGHT RULES

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12A\_C2-53

**P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**  
**(CONTINUED)**

THE REMOVED BSP MUST BE PLACED IN AN EVA BAG WITHIN 1 HOUR AND TRANSFERRED TO THE AIRLOCK WITHIN 3.5 HOURS. THE "PLACE-IN-BAG" CLOCK STARTS WHEN THE BSP IS REMOVED AND STOPS WHEN THE BSP IS PLACED IN A MLI BAG. THE TRANSFER CLOCK STARTS WHEN THE BSP IS PLACED IN A MLI BAG AND STOPS WHEN THE BSP HAS BEEN BROUGHT INTO THE AIRLOCK. @[CR 7665 ]

*The S1 S-band BSP installation must be accomplished within the time limits specified above to prevent the components from violating their minimum temperature limits.*

*Source: Boeing Passive Thermal Analysis, July 13, 2006*

- E. THE S1 S-BAND XPDR TRANSFER MUST BE COMPLETED WITHIN 2 HOURS INSIDE AN MLI EVA BAG AND INSTALLATION MUST BE COMPLETED WITHIN 2 HOURS AFTER IT IS REMOVED FROM THE EVA BAG. TRANSFER CLOCK STARTS WHEN THE XPDR IS REMOVED FROM THE AIRLOCK AND STOPS WHEN THE XPDR IS PULLED OUT OF THE MLI BAG. INSTALLATION CLOCK STARTS WHEN THE XPDR IS PULLED OUT OF THE MLI BAG AND STOPS WHEN THE XPDR IS MECHANICALLY INSTALLED.

THE REMOVED XPDR MUST BE PLACED IN AN EVA BAG WITHIN 1 HOUR AND TRANSFERRED TO THE AIRLOCK WITHIN 3.5 HOURS. THE "PLACE-IN-BAG" CLOCK STARTS WHEN THE XPDR IS REMOVED AND STOPS WHEN THE XPDR IS PLACED IN A MLI BAG. THE TRANSFER CLOCK STARTS WHEN THE XPDR IS PLACED IN A MLI BAG AND STOPS WHEN THE XPDR HAS BEEN BROUGHT INTO THE AIRLOCK.

*The S1 S-band XPDR installation must be accomplished within the time limits specified above to prevent the components from violating their minimum temperature limits.*

*Source: Boeing Passive Thermal Analysis, July 13, 2006 @[CR 7665 ]*

# FLIGHT RULES

**12A\_C2-54**

**DOCKED LOADS CONSTRAINTS [RI] [C]**

A. LOADS CONSTRAINTS DURING P3/P4 INSTALLATION ARE DEFINED IN TABLE 12A\_C2-54-I, P3/P4 INSTALLATION LOADS CONSTRAINTS.

**TABLE 12A\_C2-54-I - P3/P4 INSTALLATION LOADS CONSTRAINTS**

P3/4 CONFIG		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [16]			OPERATIONS						
		VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UNISOLATED)	EVA OPS ON P3/P4	RE-BOOST (STS, SM, PROG)	UNDOCKING (STS/RS)	DOCKING (STS/RS)	PORT SARJ/P4 BGA ROTATION	MT TRANS/SRMS/SSRMS OPS
				MOM MGMT NO DESATS	USTO								
P3/4 BERTHED IN PAYLOAD BAY		A12/1	B12/2	OK	OK	OK	OK	OK	OK [9]	OK	OK	OK	
SRMS OPS	MNVR FROM BERTH TO LOW HOVER (CLEARANCE <2FT/5FT) [2]	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK					OK [12]	
	MNVR FROM BERTH TO LOW HOVER (CLEARANCE >2FT/5FT) [2]	NOT OK	NOT OK	OK	OK	OK	OK		NOT OK			OK [12]	
	AT P3/4 LOW HOVER	A15/1		OK	OK	OK	OK					OK [12]	
	MNVR TO AUTO SEQ START	NOT OK	NOT OK	OK	OK	OK	OK		NOT OK			OK [12]	
	AT P3/4 AUTO SEQ START	A15/1		OK	OK	OK	OK					OK [12]	
	MNVR TO HANDOFF POSITION	NOT OK	NOT OK	OK	OK	OK	OK		NOT OK			OK [12]	
	AT HANDOFF POSITION WITH SSRMS UNGRAPPLED	A15/5		OK	OK	OK	OK					OK [12]	
SIMO	AT HANDOFF WITH BOTH SRMS & SSRMS GRAPPLED			OK									
SSRMS OPS	AT HANDOFF WITH SRMS UNGRAPPLED	NOT OK		OK	OK	OK	OK		OK [15]	OK	NOT OK	OK [12]	
	MNVR TO INTERMEDIATE POSITION	NOT OK	NOT OK	OK	OK	NOT OK	OK		NOT OK			OK [12]	
	AT INTERMEDIATE POSN	A15/6		OK	OK	OK	OK		OK [15]	OK	NOT OK	OK [12]	
	MNVR TO PRE-INSTALL POSITION	NOT OK	NOT OK	OK	OK	OK	OK		NOT OK			OK [12]	
	AT P3/4 PRE-INSTALL	A15/6		OK	OK	OK	OK		OK [15]	OK	NOT OK	OK [12]	
	MNVR TO RTL POSITION	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK		NOT OK			OK [12]	

@[DN 22 ] @[CR 7698 ]

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**FLIGHT RULES**

12A\_C2-54

DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

**TABLE 12A\_C2-54-I - P3/P4 INSTALLATION LOADS CONSTRAINTS (CONTINUED)**

P3/4 CONFIG		ATTITUDE CONTROL & OPS [1]		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [16]			OPERATIONS					
		VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UNISOLATED)	EVA Ops on P3/P4	RE-BOOST (STS, SM, PROG)	UNDOCKING (STS/RS)	DOCKING (STS/RS)	PORT SARJ/P4 BGA ROTATION	MT TRANS/ SRMS/ SSRMS OPS	
				MOM MGMT NO DESATS	USTO									
SSAS OPS	AT READY TO LATCH POSITION	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	NOT OK [14]	NOT OK	NOT OK	NOT OK		OK [6] [13]	
	SECOND PHASE/THIRD STAGE CAPTURE COMPLETE (CLAW FULLY CLOSED)	A12/3	NOT OK	OK	NOT OK	NOT OK	OK [8]	OK [7]	NOT OK	NOT OK	NOT OK		OK [6] [13]	
	SSAS CLAW FULLY CLOSED & ANY SINGLE SSAS BOLT FULLY TIGHT [3]	A12/3	NOT OK	OK	NOT OK	NOT OK	OK [8]	OK [7]	NOT OK	NOT OK	NOT OK		OK [6] [13]	
	COMBINATION OF TWO BOLTS FULLY TIGHT (1-2, 1-4, OR 2-4) & CLAW FULLY CLOSED [3]	A12/3	NOT OK	OK	NOT OK	NOT OK	OK [8]	OK [7]	NOT OK	NOT OK	NOT OK		OK [6] [13]	
	COMBINATION OF TWO BOLTS FULLY TIGHT (3-1, 3-2, OR 3-4) & CLAW FULLY CLOSED [3]	A12/3	NOT OK	OK	OK [10]	OK [10]	OK [8]	OK [7]	NOT OK [11]	OK	NOT OK		OK [6]	
	ANY 3 FULLY TIGHT BOLTS [3] [4]	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK [6]	
	4 BOLTS FULLY TIGHT [3] [5]	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	

@[DN 22 ] @[CR 7698 ]

NOTES:

- [1] KEY:  – ACS OR OPS ALLOWED.  – ACS OR OPS NOT ALLOWED  – NOT ANALYZED.
- [2] MINIMUM DISTANCE CONSTRAINT IS 2 FT FOR VRCS AND SM THRUSTERS, 5 FT FOR PRCS.
- [3] REFERENCE RULE {12A\_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION. THE LOAD CONSTRAINTS CAN BE SUPPORTED BY MBA BOLTS OR EVA INSTALLED SSAS CONTINGENCY BOLT KITS. EACH SSAS INTERFACE IS CERTIFIED TO SUPPORT LOADS AS DOCUMENTED WITH UP TO TWO CONTINGENCY BOLT KITS INSTALLED.
- [4] THIS CONFIGURATION CAN TOLERATE ALL EXPECTED LOADS UNTIL THE MATING OF ADDITIONAL TRUSS SEGMENTS.
- [5] THE NOMINAL PLAN IS TO OPEN THE CAPTURE LATCH AFTER AT LEAST FOUR BOLTS ARE FULLY TIGHT. A FAILED CLOSED CAPTURE LATCH CAN SUPPORT NEAR TERM LOADS, BUT THE LONG TERM LOAD CARRYING CAPABILITY OF THE INTERFACE MAY BE AFFECTED. @[DN 22 ]
- [6] MT/CETA CANNOT TRANSLATE ACROSS SSAS INTERFACE UNTIL ALL FOUR BOLTS ARE CONSIDERED FULLY TIGHT PER RULE {12A\_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION.
- [7] CAN ONLY SUPPORT EVA LOADS ON P3/P4 TRUSS WHEN CREWMEMBER IS INBOARD OF SARJ. NO APFR BASED OPERATIONS ON P3.
- [8] ORBITER ERGOMETER NOT ALLOWED. ALL ISS EXERCISE OK
- [9] CONFIG 3 (VRCS) ONLY REBOOST ALLOWED
- [10] SM JETS ALLOWED, PROGRESS JETS NOT ALLOWED
- [11] SM MAIN ENGINE AND ORBITER REBOOST NOT ALLOWED. PROGRESS R&D IS ALLOWED.

**THIS RULE CONTINUED ON NEXT PAGE**



# FLIGHT RULES

## 12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

- [12] SRMS/SSRMS OPERATIONS ACCEPTABLE. MT TRANSLATION NOT ACCEPTABLE
- [13] SRMS OPERATIONS ACCEPTABLE, NOT APPLICABLE FOR SSRMS/MT OPERATIONS
- [14] EVA OPERATIONS FOR MANUAL SSAS CAPTURE LATCH CLOSURE AND PRD INSTALLATION ACCEPTABLE @[DN 22 ]
- [15] SM MAIN ENGINE NOT ALLOWED
- [16] REFERENCE RULE {12A\_C2-65}, MATED FES DUMP CONSTRAINTS, FOR TIMEFRAMES ON FD3 AND FD4 TO AVOID TERMINATING OR INITIATING FES DUMPS. THESE CONSTRAINTS ARE TO AVOID SIGNIFICANT INCREASES IN MOMENTUM WHEN MOMENTUM MANAGEMENT IS THE ONLY ALLOWABLE CONTROL MODE. @[CR 7698 ]

B. LOADS CONSTRAINTS FOR THE MOBILE TRANSPORTER ARE DEFINED IN TABLE 12A\_C2-54-II, MOBILE TRANSPORTER LOADS CONSTRAINTS.

**TABLE 12A\_C2-54-II - MOBILE TRANSPORTER LOADS CONSTRAINTS**

ATTITUDE CONTROL & OPS [1]  MT CONFIGURATION [3]	STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [4]			OPERATIONS						
	VRCS	PRCS	CMG - TA		THRUST -ERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	RE-BOOST [5]	UN-DOCK-ING [6]	DOCK-ING [6]	PORT SARJ/ P4 BGA ROTATION	SRMS/ SSRMS OPS
			MOM MGMT NO DESATS	USTO								
LATCHED AT WORKSITE (MIN 3 OF 4 LTU'S)	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
LATCH TRANSITION			OK			OK [9]	OK [7] [10]				OK	
UNLATCHED (BRAKES ON)	A12 [5]	NOT OK	OK	OK [8]	OK [8]	OK [9]	OK [7] [10]	OK [11]	OK	NOT OK	OK	
UMA TRANSLATING			OK			OK [9]	OK [7] [10]				OK	
TRANSLATING	A12 [2][5]	NOT OK	OK			OK [9]	OK [7] [10]			NOT OK	OK	

@[DN 22 ] @[CR 7698 ]

NOTES:

- [1] KEY:  - ACS OR OPS ALLOWED     - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] THRUSTER FIRINGS ARE NOT ALLOWED WHEN THE MT IS TRANSLATING ACROSS S0/S1, S0/P1, OR P1/P3 GAPS.
- [3] MT CONFIGURATION DESCRIPTIONS:  
LATCHED: MT SECURED AT WORKSITE WITH A MINIMUM OF THREE OUT OF FOUR LOAD TRANSFER UNITS LATCHED  
LATCH TRANSITION: ANY INTERMEDIATE CONFIGURATION BETWEEN FULLY LATCHED (WITH TRANSLATION DRIVE RAISED) AND FULLY UNLATCHED (WITH TRANSLATION DRIVE LOWERED). THIS ROW APPLIES WHETHER THE LATCHES (OR ENGAGEMENT DRIVE) ARE IN MOTION OR NOT.  
UNLATCHED (BRAKES ON): MT IS IN CONFIGURATION READY FOR TRANSLATION, BUT NOT IN MOTION: LTU'S UNLATCHED, MT RAISED 2.16 CENTIMETERS TO TRANSLATION HEIGHT, TRANSLATION DRIVE WHEEL ENGAGED, AND BRAKES ON.  
TRANSLATING: MT IN MOTION  
UMA TRANSLATING: UMA'S IN MOTION

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### **12A\_C2-54      DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)**

- [4] FOR CASES WHERE THRUSTER FIRINGS ARE NOT ALLOWED OR THE EFFECTS OF THRUSTER FIRINGS HAVE NOT BEEN ANALYZED, MULTIPLE INHIBITS WILL BE IMPLEMENTED WHICH PRECLUDE INADVERTENT THRUSTER FIRINGS. SPECIFICALLY, THE FOLLOWING FUNCTIONS WILL BE INHIBITED: DESAT REQUESTS, AUTO H/O TO RS, RS TAKE CONTROL W/O HANDSHAKE, AND RS TAKEOVER DUE TO TIER 1 LOSS OF COMM.
- [5] UNLOADED SSRMS ONLY
- [6] DOCKING AND UNDOCKING VEHICLES INCLUDE ORBITER, PROGRESS, AND SOYUZ
- [7] NO MAX EVA OR MODERATE EVA IS ALLOWED. MAX EVA INCLUDES APFR OPS. MODERATE EVA INCLUDES VIGOROUS BODY MOTIONS, QUICK GRABS, KICK OFFS, AND SHAKING MOTIONS. IN ADDITION, NO MAX IVA LOADS ARE ALLOWED. NOMINAL IVA ACTIVITIES DURING MT OPERATIONS, SUCH AS CREW TRANSLATION FROM MODULE TO MODULE, ARE NOT EXPECTED TO VIOLATE LOADS CONSTRAINTS.
- [8] SM THRUSTERS ONLY FOR CMG MANEUVER W/ PULSE ASSIST, ISS ALONE OR WITH ORBITER DOCKED THRUSTERS-ONLY ATTITUDE MANEUVER
- [9] EXERCISE: THE FOLLOWING ARE ALLOWED IN CONJUNCTION OR SEPARATELY:
  - TVIS/IRED/CEVIS OR @[CR 7698 ]
  - TVIS/IRED/SM ERGOMETERCREWMEMBER SQUATS AND HEEL RAISES USING THE UNISOLATED INTERIM RESISTIVE EXERCISE DEVICE (IRED) ARE LIMITED TO A MINIMUM TIME OF 3 SECONDS BETWEEN REPETITIONS.  
SM ERGOMETER RATE LIMITED TO 60 RPM'S TO AVOID STRUCTURAL TUNING  
NO ORBITER ERGOMETER ALLOWED  
CEVIS AND SM ERGOMETER NOT ALLOWED TOGETHER
- [10] EVA CREW IS NOT ALLOWED TO USE WORKSITES ON THE MT OR MBS. (USE OF MT OR MBS HANDRAILS AND INADVERTENT CONTACT ARE NOT ANALYZED.)
- [11] ONLY SHUTTLE VRCS REBOOST AND PROGRESS REBOOST OFF-PULSING ARE ALLOWED @[CR 7698 ]

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**FLIGHT RULES**

**12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)**

C. LOADS CONSTRAINTS FOR THE P4 SOLAR ARRAYS, PV RADIATOR, AND SARJ BRACE BEAMS/STRUTS ARE DEFINED IN TABLE 12A\_C2-54-III, SOLAR ARRAYS AND PV RADIATOR LOADS CONSTRAINTS. REFERENCE RULE {12A\_C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI], FOR FEATHERING REQUIREMENTS AND MORE DETAILED LOADS CONSTRAINTS FOR DEPLOYED P4 SOLAR ARRAYS.  
 @[CR 7698 ]

**TABLE 12A\_C2-54-III - SOLAR ARRAYS AND PV RADIATOR LOADS CONSTRAINTS**

ATTITUDE CONTROL & OPS [1]  P3/4 CONFIG		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL			OPERATIONS						
		VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (STS, SM, PROG)	UN-DOCK-ING (STS/RS)	DOCK-ING (STS/RS)	PORT SARJ/ P4 BGA ROTA-TION	MT TRANS/ SSRMS OPS
				MOM MGMT NO DESATS	USTO								
P4 SOLAR WING (*)	FULLY LATCHED	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOR/EVA DRIVEN DEPLOY/ RETRACT/LATCH OPS			OK				OK [7]					
	READY TO DEPLOY OR RELATCH [4] (UNLATCHED)	A12/3	NOT OK	OK	OK	OK	OK [13]	OK [7]	OK [14]	OK	NOT OK	OK	OK [8]
	PARTIALLY DEPLOYED < 1 MAST BAY EXTENDED (MOTOR STOPPED) [5]	A12/3	NOT OK	OK	NOT OK	NOT OK	OK [13]	[OK [7]	OK [14]	OK [15]	NOT OK	NOT OK [3]	OK [8]
	PARTIALLY DEPLOYED: >=1 MAST BAY EXTENDED (MOTOR STOPPED) [5]	A12/3 [19]	NOT OK	OK	OK [21]	OK [21]	OK	OK	OK [14] [19]	OK [15]	OK [15]	NOT OK [3]	OK [8]
	FULLY DEPLOYED [6]	A12/3 [19]	B12/4 [19]	OK	OK [21]	OK [21]	OK	OK	OK [19]	OK [15]	OK [15]	OK	OK
P4 RADIATOR OR (**)	FULLY CINCHED (6 CINCHES INSTALLED)	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOR/EVA DRIVEN DEPLOY/ RETRACT			OK				OK [7]					
	READY TO DEPLOY OR WINCH [16]	A12/3 [18]	NOT OK	OK	OK [11] [12] [18]	OK [11] [12] [18]	OK	OK [18]	OK [14]	OK	NOT OK [17]	OK	OK [8]
	PARTIALLY DEPLOYED (MOTOR STOPPED) [9]	A12/3	NOT OK	OK	OK [11] [12]	OK [11] [12]	OK	OK	OK [14]	OK	OK [10]	OK	OK [8]
FULLY DEPLOYED	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	

@[DN 22 ] @[CR 7698 ]

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## FLIGHT RULES

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### 12A\_C2-54      DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

NOTES:

- [1] KEY:  – ACS OR OPS ALLOWED     – ACS OR OPS NOT ALLOWED     – NOT ANALYZED.
- [2] DELETED
- [3] SARJ ROTATION FOR PARTIALLY DEPLOYED SOLAR ARRAY CONFIGURATIONS WILL BE ANALYZED DURING THE FLIGHT IF NECESSARY DEPENDING ON REASON FOR PARTIAL DEPLOY AND NEED TO ROTATE. BGA ROTATION IS ACCEPTABLE.
- [4] READY TO DEPLOY OR RELATCH IS DEFINED AS A SOLAR ARRAY THAT IS UNLATCHED AND MAST FULLY RETRACTED. THE SOLAR ARRAY IS SUBJECT TO DAMAGE IN THIS CONFIGURATION. EXTERNAL LOADS CAN RESULT IN A PINCHING OF THE STIFFENING RODS BETWEEN THE BLANKET BOX SKIRTS. THIS PINCHING COULD LEAD TO CUTS ALONG THE ALUMINUM DOUBLER THAT HOLDS THE STIFFENING RODS IN PLACE, RESULTING IN SHARP EDGES THAT COULD CUT INTO ADJACENT PANELS.
- [5] PARTIALLY DEPLOYED IS DEFINED AS A SOLAR ARRAY IN A STATE BETWEEN "READY TO DEPLOY OR RELATCH" (I.E., MAST IS NOT FULLY RETRACTED) AND "FULLY DEPLOYED" (I.E., BLANKETS ARE NOT FULLY TENSIONED). THE SOLAR ARRAY IS SUBJECT TO DAMAGE IN THIS CONFIGURATION. EXTERNAL LOADS CAN RESULT IN STRUCTURAL LOADING OF THE MAST AND BLANKET CONTAMINATION, BOTH OF WHICH CONTRIBUTES TO REDUCING ARRAY LIFE. ALSO, IF ONE MAST BAY OR LESS IS EXTENDED, THE CELLS COULD BE DAMAGED.
- [6] FULLY DEPLOYED REFERS TO A SOLAR ARRAY WITH A MAST THAT IS FULLY EXTENDED AND BLANKETS THAT ARE FULLY TENSIONED. REFER TO TABLE 12A\_C2-54-V - ROTATING MECHANISMS LOADS CONSTRAINTS, FOR PV ARRAY KOZ AND LOCKING CONSTRAINTS. @[DN 22 ]
- [7] NO MAX EVA ALLOWED. MAX EVA INCLUDES VIGOROUS BODY MOTION, QUICK GRAB, KICKOFF TETHER RESTRAINTS, AND PFR INGRESS. DUE TO THESE CONSTRAINTS, AN ISSUE EXISTS CONCERNING EVA DEPLOY OF THE SAW IF IT IS STUCK AT < 1 MAST BAY OUT.
- [8] LOADED SSRMS OPS AND MT TRANSLATIONS ARE ALLOWED WITH A MAXIMUM LOAD OF 550 LBS. EVA CREWMEMBER TRANSLATIONS ARE ACCEPTABLE. CONFIGURATIONS WILL BE ANALYZED DURING THE FLIGHT, IF NECESSARY.
- [9] PARTIALLY DEPLOYED IS DEFINED AS A RADIATOR THAT IS BETWEEN 2 FEET AND 99 PERCENT DEPLOYED.
- [10] RESERVED
- [11] THRUSTERS ONLY MANEUVER RATE MUST BE 0.1 DEGREES/SECOND OR LESS.
- [12] NO EVA OR EXERCISE DURING THRUSTERS-ONLY MANEUVER.
- [13] ISOLATED EXERCISE ALLOWED ONLY (TVIS, CEVIS). NO UNISOLATED EXERCISE ALLOWED (ORBITER ERGOMETER, RED, SM ERGOMETER).
- [14] STS VRCS, SM REBOOST, AND PROGRESS REBOOST ALLOWED. STS PRCS REBOOST NOT ALLOWED. PROGRESS ON DC-1 NADIR REBOOST NOT ANALYZED
- [15] ARRAYS MUST BE FEATHERED FOR ORBITER DOCKING/UNDOCKING TO REDUCE STRUCTURAL LOADING OF THE MAST AND BLANKET CONTAMINATION. WHEN THE ARRAY IS FULLY DEPLOYED AND THE BLANKETS ARE TENSIONED, THE MAST IS SLIGHTLY COMPRESSED, ADDING TO THE STRUCTURAL STABILITY OF THE ARRAY. REFERENCE RULE {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC]. @[DN 22 ]
- [16] READY TO DEPLOY OR WINCH IS DEFINED AS A RADIATOR THAT IS UNCINCHED, UNWINCHED, AND LESS THAN 2 FEET DEPLOYED. NOTE THAT IN THIS STATE, THE PVR IS VERY DIFFICULT TO MODEL ACCURATELY. ALSO, THE LOADS ANALYSIS MODELS FOR THE PVR IN THIS CONFIGURATION WERE NOT TEST VERIFIED AS THEY ARE FOR MOST NOMINALLY PLANNED OPERATIONS.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_C2-54                      DOCKED LOADS CONSTRAINTS [RI] [C]    (CONTINUED)

- [17] ORBITER DOCKING MAY INDUCE MOVEMENT OF THE RADIATOR IN THE DEPLOY DIRECTION THAT COULD RESULT IN SUDDEN CONTACT FORCES BETWEEN THE SCISSOR BEAMS, BASE, SHEAR FITTINGS, ETC. THIS DEFLECTION WILL NOT EXCEED THE 9.72-INCH EXTENSION OF THE WINCH MECHANISM. THEREFORE, IF THE RADIATOR EXTENDS BEYOND THE WINCH'S REACH, ORBITER DOCKING IS ALLOWED. IF THE RADIATOR IS EXTENDED LESS THAN THAT, THE RADIATOR MUST BE MANUALLY WINCHED. ONCE THE RADIATOR IS FULLY RETRACTED AND WINCHED, THE CINCHES MUST BE MANUALLY INSTALLED BEFORE ORBITER DOCKING IS ALLOWED. RUSSIAN DOCKING IS ALLOWED WITH A RADIATOR IN A READY-TO-DEPLOY-OR-WINCH STATE. ©[CR 7698 ]
- [18] MNVR/ATTITUDE JET FIRINGS (INCLUDING DESAT) NOT ALLOWED WHILE EVA CREWMEMBER IS WITHIN 1 FT FROM THE P4 PVR WHILE UNCINCHED AND UNWINCHED.
- [19] NO KOZ FOR 2A. CONFIG-3 AND CONFIG-4 REBOOST ALLOWED. FOR DEPLOYED PVA GREATER THAN ONE MAST BAY- 4A KOZ APPLY. REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI]. CONSTRAINTS RESULT IN ORBITER ATTITUDE CONTROL NOT ALLOWED DURING 4A SOLAR ARRAY DEPLOY GREATER THAN 1 MAST BAY SINCE ARRAY IS NOT MOVED TO FEATHER POSITION UNTIL AFTER DEPLOY IS COMPLETED. ©[DN 22 ]
- [20] RESERVED
- [21] NO KOZ OR LOCKING REQUIREMENTS FOR 4A. 2A OK IF ONLY ONE MAST BAY DEPLOYED. IF 2A GREATER THAN ONE MAST BAY DEPLOYED, REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. (REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI]) CONSTRAINTS RESULT IN ISS ATTITUDE CONTROL NOT ALLOWED DURING 2A SOLAR ARRAY DEPLOY GREATER THAN 1 MAST BAY SINCE ARRAY IS NOT MOVED TO FEATHER POSITION UNTIL AFTER DEPLOY IS COMPLETED. ©[DN 22 ] ©[CR 7698 ]

*\* The “ready to deploy or relatch” and “partially deployed” solar wing configurations were analyzed outside the design configuration using contingency methodology and non-test verified linear models. The analyses included all of the loading events in the table up through the next orbiter docking. It was performed to support flight operations and nominal deployment operations, and does not apply to prolonged unlatched or partially deployed configurations. The impacts of prolonged exposure to an unlatched or partially deployed configuration on solar array life have not been assessed.*

*\*\* The “ready to deploy or winch” and “partially deployed” radiator configurations were analyzed outside the design configuration using contingency methodology and non-test verified linear models. The analyses included all of the loading events in the table up through the next orbiter docking.*

*Source: Boeing Technical Memo A92-J332-STN-M-TSW-170, Mechanical Assessment of Free Drift vs CMG Momentum Manager Environment, December 11, 2002; AG-J332-STN-M-ER-2002-060- Dynamic Loads Assessment for the Partially Deployed Solar Array Study ; AG-J332-STN-M-ER-2002-078- Dynamic Loads Assessment for the Partially Deployed PV Radiator Study.*

D. LOADS CONSTRAINTS FOR ROTATING MECHANISMS ARE DEFINED IN TABLE 12A\_C2-54-IV, SARJ LOADS CONSTRAINTS.

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**FLIGHT RULES**

12A\_C2-54

DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

**TABLE 12A\_C2-54-IV - SARJ LOADS CONSTRAINTS**

ATTITUDE CONTROL & OPS [1]  P3/4 CONFIG	STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL			OPERATIONS						
	VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (STS, SM, PROG)	UN-DOCKING (STS/RS)	DOCKING (STS/RS)	PORT SARJ/ P4 BGA ROTATION	MT TRANS/ SRMS/ SSRMS OPS
			MOM MGMT NO DESATS	USTO								
NOMINAL CONFIG UP TO START OF EVA 2: 0-4 AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S INSTALLED, 0-4 BRACE BEAMS INSTALLED, P4 SAW'S & PVR STOWED OR DEPLOYED	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	NOT OK [2] [3]	OK
NOMINAL CONFIG IN EVA 2: ALL AJIS STRUTS RIGIDIZED, A PORTION OF SARJ LL/LR'S REMOVED, 0-4 BRACE BEAMS INSTALLED, P4 SAW'S AND PVR STOWED OR DEPLOYED [7] [10]	A12/3	NOT OK	OK	OK BUT [11]	OK BUT [11]	OK BUT [11]	OK	OK [5]	OK	OK	NOT OK [2] [3]	OK
NOMINAL CONFIG IN EVA 2 AFTER RELEASE OF LAST SLR: ALL AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S REMOVED, 0-4 BRACE BEAMS INSTALLED, P4 SAW'S AND PVR STOWED OR DEPLOYED "BOTH DLA'S PINION ENGAGED" WHILE EVA CREW NEAR SARJ [7]	A12/3	NOT OK	OK	OK	OK	OK	OK	OK [5]	OK	OK	NOT OK [3]	OK
POTENTIAL CONFIG AT THE END OF EVA 2: ALL AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S REMOVED, 0-3 BRACE BEAMS INSTALLED, P4 SAW'S AND PVR STOWED OR DEPLOYED. "1 DLA LOCKED" [7] [10]	A12/3	NOT OK	OK	OK	OK	OK	OK	OK [5]	OK	OK	NOT OK [3]	OK
NOMINAL CONFIG AT THE END OF EVA 2: ALL AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S REMOVED, ALL BRACE BEAMS INSTALLED, P4 SAWS AND PVR STOWED OR DEPLOYED. "1 DLA LOCKED"	A12/3	B12/4	OK	OK	OK	OK	OK	OK	OK	OK	NOT OK [3]	OK
DURING SARJ CHECKOUT ALL AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S REMOVED, 0-4 BRACE BEAMS INSTALLED, P4 SAWS AND PVR STOWED	A12/3	NOT OK	OK	OK BUT [12]	OK BUT [12]	OK BUT [12]	OK [8]	OK BUT [12]	NOT OK	NOT OK	OK [3] [9]	OK BUT [12]
OFF-NOMINAL CONFIG AT THE END OF EVA 2 OR 3: 3 OF 4 AJIS STRUTS RIGIDIZED, ALL SARJ LL/LR'S REMOVED, ALL BRACE BEAMS INSTALLED, P4 SAWS AND PVR STOWED OR DEPLOYED.	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

@[DN 22 ] @[CR 7698 ]

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## FLIGHT RULES

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### 12A\_C2-54                      DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

NOTES:

- [1] KEY:  – ACS OR OPS ALLOWED     – ACS OR OPS NOT ALLOWED     – NOT ANALYZED.
- [2] SARJ CANNOT BE ROTATED SINCE LL/LR'S ARE IN PLACE.
- [3] P4 BGA ROTATION ACCEPTABLE.
- [4] RESERVED @[CR 7698 ]
- [5] NO PRCS REBOOST ALLOWED.
- [6] RESERVED @[DN 22 ]
- [7] ALL FOUR AJIS STRUTS MUST BE DEPLOYED PRIOR TO THE FIRST LL/LR REMOVAL. IF ONE AJIS STRUT CANNOT BE RIGIDIZED, FOUR BRACE BEAMS MUST BE INSTALLED PRIOR TO THE FIRST LL/LR REMOVAL. IN THIS CONFIGURATION, THE SAME LOADS CONSTRAINTS APPLY. REFERENCE RULE {12A\_C2-55}, P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA.
- [8] NO EVA OPERATIONS OUTBOARD OF THE SARJ. REFERENCE RULE {B15-15}, EVA KEEPOUT ZONES [HC] [RI] [E].
- [9] SARJ CHECKOUT WITH P4 SAW'S AND PVR STOWED IS ACCEPTABLE. SARJ CANNOT BE OPERATIONAL OTHER THAN SARJ CHECKOUT UNTIL FOUR SARJ BRACE BEAMS ARE INSTALLED. IN THE NOMINAL 12A PLAN, SARJ WILL REMAIN LOCKED AFTER SARJ CHECKOUT UNTIL THE P6 PORT SAW IS RETRACTED ON MISSION 12A.1.
- [10] P5 TRUSS ELEMENT INSTALLATION WITHOUT ALL AJIS STRUTS DEPLOYED AND BRACE BEAMS INSTALLED HAS NOT BEEN ANALYZED.
- [11] NO STRUCTURAL LIMIT EXCEEDANCE, BUT WHILE LL'S OR LR'S ARE BEING REMOVED, LOADS IMPARTED BY THRUSTERS AND UNISOLATED EXERCISE PRECLUDE COMPLETION OF THESE TASKS.
- [12] NO STRUCTURAL LIMIT EXCEEDANCES, BUT THESE OPERATIONS (ISOLATED EXERCISE OKAY) VIOLATE SARJ C/O REQUIREMENTS. @[DN 22 ] @[CR 7698 ]

*Reference MDC 96H065D SARJ Reconfiguration with Brace Beams Out for Mission 12A (Draft, September 2003)*

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# FLIGHT RULES

## 12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

E. LOADS CONSTRAINTS FOR ROTATING MECHANISMS UNDER NOMINAL CONDITIONS (ARRAYS/RADIATORS ARE FULLY DEPLOYED, PRIMARY STRUCTURAL INTERFACES ARE NOMINALLY MATED, ETC) ARE DEFINED IN TABLE 12A\_C2-54-V, ROTATING MECHANISMS LOADS CONSTRAINTS. ©[CR 7698 ]

**TABLE 12A\_C2-54-V - ROTATING MECHANISMS LOADS CONSTRAINTS**

ATTITUDE CONTROL & OPS [1]  MECHANISM CONFIG		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL			OPERATIONS							
		VRCS	PRCS	CMG - TA		THRUSTERS ONLY [9]	CREW EXERCISE (ISOLATED OR UNISOLATED)	EVA OPS	RE-BOOST (STS, SM, PROG) [3]	UN-DOCK -ING (STS/RS) [2]	DOCK -ING (STS/RS) [2]	ELE-MENT BERTH-ING	SRMS & SSRMS OPS	MT OPS
				MOM MGMT NO DESATS	USTO [9]									
TRRJ	LOCKED	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	ROTATING	OK	OK	OK	OK	OK	OK	OK	OK	OK [2]	NOT OK	OK	OK	OK
	STOPPED	OK	OK	OK	OK	OK	OK	OK	OK	OK [2]	NOT OK	OK	OK	OK
SARJ	LOCKED	OK [6]	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	ROTATING [10]	OK [6]	NOT OK	OK	NOT OK	NOT OK	OK	OK [5]	OK [4]	NOT OK	NOT OK	OK	OK	OK
	STOPPED	OK [6]	NOT OK	OK	NOT OK	NOT OK	OK	OK	OK [4]	NOT OK	NOT OK	OK	OK	OK
BGA	LOCKED	OK [6]	OK [7]	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	ROTATING	OK [6]	NOT OK	OK	OK [9]	OK [9]	OK	OK	OK [4]	NOT OK	NOT OK	OK	OK	OK
	STOPPED	OK [6]	NOT OK	OK	OK [9]	OK [9]	OK	OK	OK [4]	OK	OK	OK	OK	OK

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- [1] KEY:  - ACS OR OPS ALLOWED  - ACS OR OPS NOT ALLOWED  - NOT ANALYZED.
- [2] ARTICULATING APPENDAGES MUST BE FEATHERED (SEE RULES {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], AND {C2-155}, ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]).
- [3] PROGRESS R&D REBOOST USING PROGRESS MID-RING JETS FOR PITCH AND YAW CONTROL NOT ALLOWED. ORBITER REBOOST CONFIG 1 NOT ALLOWED. SM MAIN ENGINE REBOOST ONLY ANALYZED FOR 2-ENGINE CASE.
- [4] ORBITER REBOOST CONFIGS 1 AND 2 NOT ALLOWED. PRCS Y-FIRING JETS MAY INDUCE SEVERE PLUME IMPINGEMENT LOADS ON OUTBOARD ARRAYS. IF CONFIG-3 OR CONFIG-4 REBOOST EMPLOYED, SEE CONSTRAINTS IN NOTE [6] FOR FEATHERING REQUIREMENTS. CONFIG-4 REBOOST PRCS TRANSLATION PULSES CONSTRAINED TO 80 MILLISECONDS (PAIRED PULSES OK).
- [5] EVA OUTBOARD OF ROTATING SARJ NOT PERMITTED.
- [6] VRCS OPERATIONS INCLUDE VRCS HOLD, MANEUVER, CONFIG-3 REBOOST, AND CONFIG-4 REBOOST ROTATIONAL CONTROL - WITH SARJ LOCKED AT 0 DEGREES, P4 BGA LOCKING IS NOT REQUIRED. 2A ARRAY HAS NO KOZ FOR VRCS OPERATIONS OR CONFIG-4 REBOOST. 4A KOZ'S APPLY; REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. (REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI].)
- [7] PRCS OPERATIONS - TO AVOID OVERLOADING OF ARRAY MAST, REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. (REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI].) ©[DN 22 ] ©[CR 7698 ]

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## FLIGHT RULES

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### **12A\_C2-54                      DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)**

- [8]      CMG DESATURATION – IF SM JETS USED FOR PITCH OR YAW CONTROL, ONLY 1 JET PER AXIS IS ALLOWED. IF SM JETS USED FOR ROLL CONTROL, 2 OR 4 JETS FOR SM ROLL ARE ACCEPTABLE ALTHOUGH 2 SM ROLL JETS PREFERRED. PROGRESS FOR PITCH, YAW, OR ROLL CONTROL IS ACCEPTABLE. THERE ARE NO STRUCTURAL KOZ'S IF BGA'S ARE UNLOCKED, HOWEVER THERE ARE STRUCTURAL KOZ'S FOR LOCKED BGA JOINTS. REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. (REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI].) @[DN 22 ] @[CR 7698 ]
- [9]      THRUSTERS ONLY MANEUVER – WHILE SARJ LOCKED AT 0 DEGREES, 4A MAY BE UNLOCKED WITH NO RESTRICTION ON ARRAY ANGLE. FOR 2A, REFER TO SOLAR ARRAY FEATHER REQUIREMENTS. (REF RULE {12A-C2-64}, SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [RI].) @[DN 22 ] @[CR 7698 ]
- [10]     SEE SARJ ACTIVATION RULE FOR CONSTRAINTS AGAINST SARJ ROTATION DURING CHECKOUT. SARJ WILL BE NOMINALLY LOCKED AT ALPHA=0 DEGREES AFTER SARJ CHECKOUT DUE TO CLEARANCE ISSUES WITH 4B SOLAR ARRAY.

*This Rule is intended to list allowable operational modes of the SARJ, TRRJ, and Beta Gimbal joints under nominal conditions (arrays/radiators are fully deployed, primary structural interfaces are nominally mated, etc.).*

*Operation of the SARJ and Beta joints during vehicle approach and separation is not recommended due to the possibility of the arrays moving into a structural or joint-control keep-out zone.*

*During VRCS operations and Configuration-4 orbiter reboost, the 2A and 4A arrays may remain unlocked, provided the SARJ is locked at 0 degrees, as there are no structural load exceedances for either array. There are no restrictions against the 2A array BGA angle. The 4A array should not be positioned at 0±30 degrees or 180±30 degrees to protect for structural lifetime limits.*

*There are no restrictions or structural KOZ for CMG desaturations for the 4A array. For the 2A array, there are no restrictions if the 2A BGA is unlocked. If the 2A array is locked at angle other than 90 or 270 degrees (±10 degrees), then DC-1 nadir jets may not be used for roll control.*

Reference **TBD**

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**FLIGHT RULES**

**12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)**

F. LOADS CONSTRAINTS FOR EVA ARTICULATING PORTABLE FOOT RESTRAINT (APFR) OPERATIONS ARE DEFINED IN TABLE 12A\_C2-54-VI - APFR LOADS CONSTRAINTS. IN GENERAL, PRCS AND IRED ARE PRECLUDED DURING ANY APFR OPERATIONS FROM A STRUCTURE-MOUNTED WORKSITE INTERFACE (WIF). APFR OPERATIONS FROM AN SRMS- OR SSRMS-MOUNTED WIF DO NOT CARRY THESE RESTRICTIONS UNLESS OCCURRING SIMULTANEOUSLY WITH STRUCTURE-MOUNTED APFR OPERATIONS. @[CR 7698 ]

Reference: EVAM-0250, Assessment of APFR Usage for STS-121, May 5, 2006.

EVAM-0272: Revised Assessment of APFR Usage on SRMS/OBSS for STS-121 IWIF DTO 849

**TABLE 12A\_C2-54-VI - APFR LOADS CONSTRAINTS**

EVA TASK APFR LOCATION (TOTAL INGRESSED MASS)	ATTITUDE CONTROL & OPS [1]		STS ATTITUDE CONTROL			ISS ATTITUDE CONTROL					OPERATIONS							
	VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST	UNDOCK-ING	DOCKING								
			MOM MGMT OR ATT HOLD	USTO														
<b>EVA 1</b>																		
CONNECT P1 TO P3 UTILITIES P3 TRUSS (1 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
SA PREP TASKS P4 TRUSS (1 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
SARJ DLA DEPLOYS P3 TRUSS (1 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
<b>EVA 2</b>																		
SARJ LAUNCH LOCK AND LAUNCH RESTRAINT REMOVALS [3] P3 & P4 TRUSSES (1 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
<b>EVA 3</b>																		
REMOVE AND STOW DRAG LINK AND KEEL BEAM P3 TRUSS (2 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
REMOVE SPARE SASA FROM Z1 Z1 TRUSS (2 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
HANDOFF SPARE AND OLD SASA S0 TRUSS (1 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											
STOW OLD SASA Z1 TRUSS (2 CREW)	A12/3	NOT OK	OK	OK	OK	OK [2]	OK											

@[CR 7698 ]

- [1] KEY:  - ACS OR OPS ALLOWED.  - ACS OR OPS NOT ALLOWED  - NOT ANALYZED.
- [2] IRED NOT ALLOWED DURING STRUCTURE-MOUNTED APFR OPS
- [3] REFERENCE TABLE C2-54-IV FOR ADDITIONAL OPERATIONAL LOADS CONSTRAINTS DURING SARJ LL/LR REMOVALS. @[CR 7698 ]

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**FLIGHT RULES**

**12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)**

G. LOADS CONSTRAINTS FOR ORBITER BOOM SENSING SYSTEM (OBSS) OPERATIONS ARE DEFINED IN TABLE 12A\_C2-54-VII, OBSS OPERATIONS LOADS CONSTRAINTS. @[CR 7698 ]

**TABLE 12A\_C2-54-VII - OBSS OPERATIONS LOADS CONSTRAINTS**

OBSS CONFIG [2]		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [6] [9] [11]			OPERATIONS				
		VRCS	PRCS	CMG - TA [5]		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED) [13]	EVA OPS [14]	REBOOST (STS, SM, PROG) [7] [11]	UNDOCKING (STS/RS) [8]	DOCKING (STS/RS) [8]
				MOM MGMT NO DESATS	USTO						
OBSS SSRMS UNBERTH/ BERTH	UNLOADED STATIC	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK
	UNLOADED MANEUVERING	A12	B12	OK	OK	OK	OK	OK	NOT OK	NOT OK	NOT OK
	MNVR TO LOW HOVER (CLEARANCE <2 FT)	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK
	MNVR TO LOW HOVER (CLEARANCE >2 FT)	A12	B12	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK
	LOW HOVER POSITION	A12	B12	OK	OK	OK	OK	OK	OK	OK	NOT OK
	OBSS MNVR TO HANDOFF POSITION	A12	B12	OK	OK	OK	OK	OK	NOT OK [12]	NOT OK [12]	NOT OK [12]
	OBSS AT HANDOFF POSITION	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK
	OBSS GRAPPLED TO SRMS AND SSRMS			OK							
	MNVR TO OBSS BERTHED POSITION (CLEARANCE > 2 FT)	A12	B12	OK	OK	OK	OK	OK	NOT OK	NOT OK	NOT OK
	MNVR TO OBSS BERTHED POSITION (CLEARANCE < 2 FT)	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK

@[DN 22 ] @[CR 7698 ]

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**FLIGHT RULES**

12A\_C2-54

DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

**TABLE 12A\_C2-54-VII - OBSS OPERATIONS LOADS CONSTRAINTS (CONTINUED)**

ATTITUDE CONTROL & OPS [1][3][4]  OBSS CONFIG [2]		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [6] [9] [11]			OPERATIONS				
		VRCS	PRCS	CMG - TA [5]		Thrusters ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED) [13]	EVA OPS [14]	REBOOST (STS, SM, PROG) [7] [11]	UNDOCK-ING (STS/RS) [8]	DOCK-ING (STS/RS) [8]
				MOM MGMT NO DESATS	USTO						
OBSS SRMS OPS	OBSS AT HANDOFF POSITION	A12	B12	OK	<u>OK</u>	<u>OK</u>		OK	OK	OK	OK
	OBSS MNVR TO PARK POSITION	A12	B12	OK	NOT OK	NOT OK		OK	NOT OK	NOT OK	NOT OK
	OBSS AT PARK POSITION	A12	B12	OK	<u>OK</u>	<u>OK</u>		OK	OK		
	MANEUVER TO OBSS DOCKED SURVEY POSITIONS (WITHOUT EVA CREWMEMBER)	A12	B12	OK	NOT OK	NOT OK		OK	NOT OK		
	IN DOCKED SURVEY POSITIONS (WITHOUT EVA CREWMEMBER)	A12	B12	OK	<u>OK</u>	<u>OK</u>		OK	OK		
	MANEUVER TO OBSS DOCKED SURVEY POSITIONS (W/ EVA CREWMEMBER)										
	IN DOCKED SURVEY POSITIONS (W/ EVA CREWMEMBER)										
	OBSS MNVR TO HANDOFF POSITION	A12	B12	OK	NOT OK	NOT OK		OK	NOT OK	NOT OK	NOT OK
AFTER OBSS LATCHING		A12	B12	OK	<u>OK</u>	OK	OK	OK	OK	OK	OK

@[DN 22 ] @[CR 7698 ]

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## FLIGHT RULES

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### 12A\_C2-54      DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

NOTES:

- [1] KEY:  - ACS OR OPS ALLOWED.  - ACS OR OPS NOT ALLOWED  - NOT ANALYZED.
- [2] SSRMS/OBSS POSITIONS DEFINED IN REF DATA.
- [3] REFERENCE CSA-SS-MOA-LF1-003, CSA-SS-MOA-LF1-004 REV C, CSA-SS-MOA-LF1-006 REV B, MOA.79103 REV A.
- [4] CONSTRAINTS APPLY TO BOTH BRAKES ON AND POSITION HOLD UNLESS OTHERWISE NOTED.
- [5] SINGLE PULSE MODE FOR CMG-TA.
- [6] REFERENCE RULE {B12-105}, SSRMS ATTITUDE CONTROL CONSTRAINTS FOR ISS [HC] [RC], FOR USE OF AUTOMATIC ATTITUDE CONTROL IN UNPLANNED CONTINGENCY.
- [7] SHUTTLE REBOOST (CONFIG 1-4), SM AND PROGRESS REBOOST.
- [8] DOCKING AND UNDOCKING VEHICLES INCLUDE ORBITER, SOYUZ, AND PROGRESS.
- [9] CONSTRAINTS APPLY TO ISS ATTITUDE HOLD AND MANEUVERS.
- [10] RESERVED @[DN 22 ]
- [11] SSRMS CONSTRAINTS APPLY TO MATED AS WELL AS STAGE OPERATIONS.
- [12] THESE OPERATIONS ARE PERMITTED IF THE SSRMS IS IN BRAKES ON AT THE UHF CLEAR OR AFT POSITIONS. @[DN 22 ]
- [13] IF THERE IS AN EVA WHILE THE ORBITER IS CONTROLLING ATTITUDE WITH PRCS JETS, ONLY TVIS EXERCISE IS ALLOWED DURING THE EVA.
- [14] MAXIMUM EVA LOADS ARE NOT PERMITTED DURING ORBITER PRCS MANEUVER OF THE ISS OR DURING PRCS TWO- OR THREE-JET ATTITUDE HOLD. MAXIMUM EVA LOADS INCLUDE APFR INGRESS, VIGOROUS APFR MOTIONS, AND CREW KICK-OFFS.
- [15] REFERENCE RULE {12A\_C2-~~TBD~~} CONTINGENCY SRMS/OBSS DAP CONSTRAINTS. @[CR 7698 ]

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# FLIGHT RULES

## 12A\_C2-54 DOCKED LOADS CONSTRAINTS [RI] [C] (CONTINUED)

H. LOADS CONSTRAINTS FOR ORBITER REPAIR MANEUVER (ORM) ARE DEFINED IN TABLE 12A\_C2-54-VIII, ORM LOADS CONSTRAINTS (CONTINGENCY). PER ORM WORKING GROUP CONFIGURATION SELECTION, THE 12A ORM CONTROLLERS WERE DESIGNED, ANALYZED, AND WILL BE CERTIFIED ONLY FOR THE CONFIGURATION WHERE P4 ARRAYS ARE RETRACTED. @[CR 7698 ]

**TABLE 12A\_C2-54-VIII - ORM LOADS CONSTRAINTS (CONTINGENCY)**

ORM CONFIG	STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [5]			OPERATIONS				
	VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (STS, SM, PROG)	UNDOCK-ING (STS/RS)	DOCK-ING (STS/RS)
			MOM MGMT NO DESATS	USTO						
SRMS MNVR TO SEPARATION POSITION (< 2 FEET)	NOT OK	NOT OK	OK [2]	NOT OK	NOT OK	OK [3]		NOT OK		
SRMS MNVR TO SEPARATION POSITION (> 2 FEET)	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK		
SRMS AT SEPARATION POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK	OK	
SRMS MNVR TO ORBITER UNDOCK POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK		
SRMS IN ORBITER UNDOCK POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK	OK	
SRMS MNVR TO ORBITER REPAIR POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK		
SRMS IN ORBITER REPAIR POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3] [4]	OK	NOT OK		
SRMS MNVR TO ORBITER OVERNIGHT PARK POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK		
SRMS IN ORBITER OVERNIGHT PARK POSITION	NOT OK	NOT OK	OK [2]	OK [2]	OK [2]	OK [3]		NOT OK	OK	

@[DN 22 ] @[CR 7698 ]

NOTES:

- [1] KEY:  - ACS OR OPS ALLOWED.  - ACS OR OPS NOT ALLOWED  - NOT ANALYZED.
- [2] ATTITUDE CONTROL ALLOWED USING ORM-SPECIFIC THRUSTER FIRING CRITERIA.
- [3] THE FOLLOWING EXERCISE EQUIPMENT MAY BE USED: CEVIS, TVIS, SM ERGOMETER, RUSSIAN RED, ORBITER ERGOMETER
- [4] EXERCISE NOT OK DURING EVA DUE TO EXCESSIVE VIBRATION. OK FOR CEVIS PRE-BREATHE ACTIVITY.
- [5] PER ORM WORKING GROUP CONFIGURATION SELECTION, THE 12A ORM CONTROLLERS WERE DESIGNED, ANALYZED, AND WILL BE CERTIFIED ONLY FOR THE CONFIGURATION WHERE P4 ARRAYS ARE RETRACTED. @[CR 7698 ]

## FLIGHT RULES

12A\_C2-55

**P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA**

THE FOLLOWING TASKS ARE PLANNED TO BE PERFORMED DURING STS-115/12A TO SUPPORT P3/P4 INSTALLATION, ACTIVATION AND CHECKOUT:

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA** @[DN 76 ]

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
1. INSTALLATION OF P3/P4 TO P1 (IVA)	A. ALLOWABLE MATED STACK ATTITUDES PRIOR TO, DURING, AND AFTER INSTALLATION OF P3/P4 TO P1 ARE DOCUMENTED IN RULE {12A_C2-51}, MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC]. B. CONSTRAINTS ON THRUSTER FIRINGS AND OTHER LOAD-INDUCING OPERATIONS DURING P3/P4 INSTALL ARE DOCUMENTED IN RULE {12A_C2-54A}, DOCKED LOADS CONSTRAINTS [RI] [C]. C. MANDATORY VIDEO SUPPORT DURING P3/P4 UNBERTH AND INSTALLATION IS DOCUMENTED IN RULE {12A_C2-59}, STS-115/12A VIDEO SUPPORT [HC]. D. MSS REDUNDANCY REQUIREMENTS ARE DOCUMENTED IN RULE {12A_C12-2}, MSS REDUNDANCY FOR ITS P3/4 HANDLING [HC] [C]. E. MANDATORY COMMUNICATION REQUIREMENTS DURING SSAS OPERATIONS ARE DOCUMENTED IN RULE {12A_C10-5}, COMMUNICATIONS REQUIREMENTS FOR SSAS OPERATIONS. F. DURING SSAS SECOND PHASE (SECOND/THIRD STAGE) CAPTURE LATCHING ACTUATION, NO NON-SSAS COMMANDS SHOULD BE SENT FROM THE CREW/GROUND TO THE EXT MDM OR TO LOWER TIER DEVICES UNDER EXT MDM PER RULE {12A_C2-61}, COMMANDING CONSTRAINTS DURING SSAS LATCHING OPERATIONS [HC].	1. EVA IS ALLOWED ON P3 (INBOARD OF SARJ) ONCE SSAS CAPTURE LATCH IS FULLY CLOSED. EVA IS ALLOWED ON ENTIRE P3/P4 ELEMENT ONCE ANY THREE SSAS BOLTS FULLY TIGHT. 2. CMG-ONLY OR SHUTTLE VERN ATTITUDE CONTROL ALLOWED ONCE SSAS CAPTURE LATCH FULLY CLOSED. SM THRUSTER FIRINGS ALLOWED ONCE ANY TWO SSAS BOLTS FULLY TIGHT AND CLA FULLY CLOSED. ALL SHUTTLE AND ISS THRUSTER FIRINGS ALLOWED ONCE ANY THREE BOLTS FULLY TIGHT. 3. TO BE CONSIDERED STRUCTURALLY SAFE FOR UNDOCKING, TWO OF FOUR BOLTS (WHERE ONE BOLT IS NO. 3) MUST BE FULLY TIGHT. (REF RULE {12A_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C])

@[DN 21 ] @[DN 62 ] @[CR 7699A ]

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## FLIGHT RULES

12A\_C2-55

### P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
2. MATE P3 TO P1 UTILITIES – UPPER AND LOWER TRAYS AND REMOVE CID'S 6 AND 8 (EVA)	<p>A. PRIOR TO ELECTRICAL CONNECTOR MATES OR CID REMOVALS, INHIBITS WILL BE VERIFIED IN PLACE PER THE REQUIREMENTS OF RULE {12A_C9-1}, POWER CONNECTION INHIBITS [HC]</p> <p>B. PRIOR TO POWERDOWNS FOR UTILITY MATING AND CID REMOVALS, THE P1 TRR/RADIATOR BEAM MUST BE AT A GAMMA ANGLE OF 0 DEGREES TO SUPPORT THERMAL TIME LIMITS FOR UNPOWERED ORU'S ON P1 TRUSS. (REF RULE {12A_C2-56D}, TRUSS POWERDOWN CONSTRAINTS)</p>	<p>ITS P3/P4 ACTIVATION CAN PROCEED IF AT LEAST THE FOLLOWING CONNECTORS ARE MATED:</p> <p>UPPER: P11, P13, P14, P15</p> <p>LOWER: P1, P3, P4, P5</p>
3. DEPLOY DLA'S (2) - (EVA)	THE DLA'S MUST BE COMMANDED FROM THEIR LAUNCHED "LOCK" POSITION TO THE "NEUTRAL" POSITION PRIOR TO EVA DEPLOY BY THE CREW.	<p>ONE OF TWO DLA'S DEPLOYED</p> <p><i>To rotate the SARJ, only one of the two DLA's is required. However, currently, two of two DLA's are required to be engaged prior to the last launch lock/launch restraint release.</i></p>
4. ACTIVATE ITS P3/P4 SYSTEMS TO RECEIVE SURVIVAL POWER (IVA)	<p>A. CID 7 – 2A MUST BE ON TO PROVIDE POWER FROM P6 TO P4.</p> <p>B. LTA THERMAL LIMITS AND RELATED SYSTEMS MANAGEMENT CONSTRAINTS ARE DOCUMENTED IN RULE {12A_C2-53} P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS.</p>	<ol style="list-style-type: none"> <li>1. ONE OF TWO P4 PVCU'S ACTIVE</li> <li>2. ONE OF TWO P3 MDM'S</li> <li>3. GOOD CHECKOUT OF THE P3/P4 ORU'S.</li> </ol>
5. SSU (2), ECU (2), RPDA (2), AND MDM (1) THERMAL SHROUD REMOVAL (EVA)	REFER TO RULES {12A_C2-53}, P3/P4 LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS; {B9-158}, SEQUENTIAL SHUNT UNIT (SSU) AND ELECTRONIC CONTROL UNIT (ECU) OPERATIONS PRIOR TO THERMAL SHROUD REMOVAL; AND {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS.	REMOVAL OF SEVEN SHROUDS
6. RELEASE OF INBOARD/OUTBOARD SABB RESTRAINTS (EVA)	NONE	<p>INBOARD (TWO BOLTS) AND OUTBOARD (SIX BOLTS) LAUNCH RESTRAINTS MUST BE CONFIRMED RELEASED FOR BOTH THE LEFT AND RIGHT SABB'S.</p> <p>(REF RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS)</p>

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## FLIGHT RULES

12A\_C2-55

**P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM  
CRITERIA (CONTINUED)**

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS  
AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
7. ROTATION OF THE IEA KEEL PIN (EVA)	NONE	HARD DOCK DETENT MUST BE CONFIRMED IN THE CAPTURED POSITION FOR THE KEEL TO BE CONFIRMED SECURED OR IEA KEEL PIN BOLT MUST BE RE-INSTALLED.  (REF RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS)
8. RELEASE OF BGA RESTRAINTS (EVA)	A. REFER TO RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS, FOR CONSTRAINTS ASSOCIATED WITH RELEASE OF BGA RESTRAINTS.  B. FOR EVA ACTIVITY NEAR THE BGA, THE BGA MUST BE MANAGED PER RULE {B9-305}, BGA/SOLAR ARRAY MANAGEMENT DURING EVA.	REFER TO RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS, FOR MINIMUM TASK CRITERIA ASSOCIATED WITH RELEASE OF BGA RESTRAINTS.
9. UNSTOW OF SABB'S (EVA)	RELEASE OF SAW BGA RESTRAINTS COMPLETED (FOUR BAR LINKAGE DEPLOYED)  (REF RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS)	1. TWO OF TWO ELBOW LOCKING STRUT SLEEVES MUST BE VERIFIED IN PLACE FOLLOWING SABB UNSTOW.  2. TWO OF TWO SABB SECURING PIP PINS MUST BE VERIFIED RE-INSTALLED.  3. THREE OF THREE MAST TIP FITTINGS MUST BE CONFIRMED RELEASED.  (REF RULE {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS)
10. BLANKET BOX (BB) UNLATCH	REFER TO RULE {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR CONSTRAINTS ASSOCIATED WITH BLANKET BOX UNLATCH.	REFER TO RULE {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR MINIMUM TASK CRITERIA ASSOCIATED WITH BLANKET BOX UNLATCH.
11. ACTIVATION OF P4 PVTCS (IVA)	REFER TO RULES {B9-703}, PFCS PUMP START CRITERIA, AND {12A_C9-3}, PVTCS PFCS THERMAL CONTROL ALGORITHMS FOR P4 ACTIVATION, FOR CONSTRAINTS ASSOCIATED WITH PVTCS PUMP ACTIVATION.	ONE OF TWO PUMPS IN A LOOP CONFIRMED OPERATING

@[DN 21 ] @[DN 62 ] @[DN 76 ] @[CR 7699A ]

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**FLIGHT RULES**

12A\_C2-55

**P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
12. BATTERY THERMAL CONDITIONING, CHARGING, AND CHANNEL CONFIG FOR NOMINAL OPS (IVA)	PRIOR TO THE NOMINAL START OF BATTERY CHARGING, BATTERY THERMAL CONDITIONING MUST BE COMPLETED (REF RULE {B9-455}, BATTERY ORU TEMPERATURE MANAGEMENT).	<ol style="list-style-type: none"> <li>1. BATTERY THERMAL CONDITIONING – COMPLETE WHEN EACH BATTERY’S AVERAGE TEMP IS BETWEEN 0 DEG TO 10 DEG C OR 32 DEG TO 50 DEG F (REF RULE {B9-455}, BATTERY ORU TEMPERATURE MANAGEMENT).</li> <li>2. BATTERY CHARGING – COMPLETE WHEN STATE OF CHARGE (SOC) VERIFIED &gt; 100 PERCENT.</li> </ol>
13. SARJ PREP FOR ROTATION - (EVA)  LAUNCH LOCKS, LAUNCH RESTRAINTS, MLI COVER LATCHES	<p>A. FOUR OF FOUR AJIS STRUTS MUST BE INSTALLED BEFORE REMOVAL/TORQUE RELIEF OF ANY SARJ LAUNCH LOCK OR SARJ LAUNCH RESTRAINT. IF ONLY THREE OF FOUR AJIS STRUTS CAN BE INSTALLED, FOUR OF FOUR SARJ BRACES MUST BE INSTALLED PRIOR TO REMOVAL/TORQUE RELIEF OF ANY SARJ LAUNCH LOCK OR SARJ LAUNCH RESTRAINT.</p> <p>B. BOTH DLA'S MUST BE "ENGAGED" BEFORE EITHER THE LAST LAUNCH LOCK OR LAUNCH RESTRAINT IS REMOVED.</p> <p>C. ALL SARJ LAUNCH LOCKS MUST BE REMOVED PRIOR TO REMOVAL/TORQUE RELIEF OF ANY SARJ LAUNCH RESTRAINT.</p>	<ol style="list-style-type: none"> <li>1. SIXTEEN OF SIXTEEN LAUNCH LOCKS, AND</li> <li>2. SIX OUTBOARD OF TEN LAUNCH RESTRAINTS, AND</li> <li>3. FOUR OF FOUR MLI COVER LATCHES MUST BE OPENED</li> </ol> <p><i>The SARJ cannot physically rotate until the Launch Locks/Restraints have been released and the MLI Cover Latches have been rotated out of the way.</i></p>

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**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

12A\_C2-55

**P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
14. SARJ ACTIVATION AND CHECKOUT (IVA)	<p>A. BGA'S MUST BE CONFIGURED SUCH THAT THE P4 2A AND 4A BLANKET BOXES WILL NOT BE WITH IN 5 FEET OF THE CONE OF ROTATION FOR THE P6 4B SAW BY FEATHERING P4 4A AT 60 DEGREES AND P4 2A AT 300 DEGREES. IF THE P4 BGA'S CANNOT BE FEATHERED, THE P6 4B ARRAY MUST BE FEATHERED BETWEEN 150 AND 210 DEGREES.</p> <p>B. SIXTEEN OF SIXTEEN LAUNCH LOCKS REMOVED</p> <p>C. SIX OUTBOARD OF TEN LAUNCH RESTRAINTS REMOVED</p> <p>D. FOUR OF FOUR MLI COVER LATCHES MUST BE OPENED.</p> <p>E. ONE OF TWO DLA'S DEPLOYED</p> <p>F. ONCE THE P4 SAW'S ARE DEPLOYED, THIS TASK CANNOT BE PERFORMED WHILE THE P6-4B SAW REMAINS DEPLOYED (SAFETY HAZARD REPORT BOEING ISS-COLL-1002-12A).</p> <p>G. REFER TO RULE {12A_C2-54} DOCKED LOADS CONSTRAINTS [RI] [C], FOR CONSTRAINTS ASSOCIATED WITH SARJ CHECKOUT.</p>	<p>WHILE THE P6 ARRAYS ARE RETRACTED, THE SARJ MUST BE ROTATED 180 DEG TO SUPPORT SARJ CHECKOUT, WITH THE FINAL POSITION SARJ AT 0 DEG (PVR POINTED TO NADIR). (REF RULE {12A_B9-12}, P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION.)</p>
15. MAST EXTENSION (IVA)	<p>REFER TO RULES {B9-206}, SOLAR ARRAY WING DEPLOY PREPARATION, CONSTRAINTS AND MINIMUM REQUIREMENTS; {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC]; {12A_B9-12}, P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION; AND {12A_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR CONSTRAINTS ASSOCIATED WITH MAST EXTENSION.</p>	<p>REFER TO RULE {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR MINIMUM TASK CRITERIA ASSOCIATED WITH MAST EXTENSION.</p>
16. SAW TENSIONING OPS (IVA)	<p>REFER TO RULE {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR CONSTRAINTS ASSOCIATED WITH SAW TENSIONING OPS.</p>	<p>REFER TO {RULE B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR MINIMUM TASK CRITERIA ASSOCIATED WITH SAW TENSIONING OPS.</p>

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## FLIGHT RULES

12A\_C2-55

### P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
17. PVR PREP FOR DEPLOY (EVA)	<p>A. THE INBOARD AND OUTBOARD CINCHES MUST BE RELEASED PRIOR TO THE OTHER CINCHES.</p> <p><i>If the side cinches are released prior to the end cinches, structural deformation of the radiator could occur, preventing a successful deployment.</i></p> <p>B. THRUSTER FIRINGS ARE NOT ALLOWED WHILE EVA CREW IS WITHIN 1 FOOT OF PVR WHILE THE PVR IS RETRACTED AND THE PIP PINS ARE REMOVED FROM THE WINCH BARS. (REF RULE {12A_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C])</p> <p><i>After the winch pip pins are released, the PV radiator panels are free to move. To prevent EVA crew from unexpected PVR motion, thruster firings are prohibited when these pip pins are removed.</i></p>	<p>SIX OF SIX CINCHES AND TWO OF TWO WINCH BARS MUST BE RELEASED TO CONSIDER EACH PVR PREPARED FOR DEPLOY.</p> <p><i>To allow successful PVR deployment, all of the cinches (six per radiator) and both of the winch bars (two per radiator) must be released.</i></p>
18. DEPLOY/RETRACT PVR (IVA)	<p>REFER TO RULES {12A_B9-19}, PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS) RADIATOR DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC]; {B9-701}, PHOTOVOLTAIC RADIATOR (PVR) DEPLOYMENT; AND {12A_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR CONSTRAINTS ASSOCIATED WITH PVR DEPLOY.</p>	<p>REFER TO RULE {12A_B9-19}, PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS) RADIATOR DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], FOR MINIMUM TASK CRITERIA ASSOCIATED WITH PVR DEPLOY.</p>
19. P3 KEEL PIN AND DRAG LINK REMOVAL (EVA)	NONE	REQUIRED TO BE REMOVED FROM THE PATH OF THE MT BEFORE TRANSLATING TO WS#8.
20. EVA TEMP RAIL STOP INSTALLATION (EVA)	NONE	
21. RIGIDIZE P4 SARJ AJIS STRUTS (4) – (EVA)	NONE	FOUR OF FOUR AJIS STRUTS.
22. DEPLOY P3 SARJ BRACES (4) – (EVA)	NONE	THREE OF FOUR P3 SARJ BRACES TO ALLOW SARJ ROTATION.

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**FLIGHT RULES**

12A\_C2-55

**P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

**TABLE 12A\_C2-55-I - P3/P4 INSTALLATION CONSTRAINTS AND MINIMUM CRITERIA (CONTINUED)**

TASK	CONSTRAINTS	MINIMUM TASK CRITERIA
23. ROTATE P1 MT STOP (EVA)	P3/P4 INSTALL MUST HAVE BEEN COMPLETED.	REQUIRED TO BE REMOVED FROM THE PATH OF THE MT BEFORE TRANSLATING TO WS#8
24. REMOVE P3 SVS TARGET-FACE 1 (EVA)	NONE	REQUIRED TO BE REMOVED FROM THE PATH OF THE MT BEFORE TRANSLATING TO WS#8
25. TRANSFER MT TO P3-B1, WS#8 AND CHECKOUT MSS (IVA)	<p>A. MT STOP ON P1 MUST BE ROTATED DOWN.</p> <p>B. SVS TARGET MUST BE REMOVED.</p> <p>C. P3 KEEL PIN AND DRAG LINK MUST BE REMOVED.</p> <p>D. ETRS INSTALLED AND TETHER SHUTTLE STOP STOWED REQUIRED AND P3 MT STOP ROTATED DOWN IF CETA CART ON PORT SIDE OF THE MT.</p> <p>E. THE P3 MDM AND THE RPDA THERMAL SHROUDS MUST BE REMOVED PRIOR TO TRANSLATING OVER THESE ORU'S.</p> <p>F. IF THE CETA HAS BEEN POSITIONED OUTBOARD OF THE MT, THE SARJ MUST BE LOCKED IN PLACE, THE ETRS INSTALLED, AND THE P3MT STOP ROTATED DOWN FOR THE MT TO BE TAKEN TO WS#8 (REF RULE {B2-23}, MT/CETA CONFIGURATION CONSTRAINTS [HC]).</p> <p>G. TO TRANSLATE ACROSS THE P1/P3 INTERFACE FOUR OF FOUR BOLTS REQUIRED (REF RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION).</p>	

@[DN 21 ] @[DN 62 ] @[DN 77 ] @[CR 7699A ]

## FLIGHT RULES

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### 12A\_C2-56      TRUSS POWERDOWN CONSTRAINTS

POWERDOWNS OF TRUSS COMPONENTS WILL BE MANAGED PER THE FOLLOWING GUIDELINES:

- A. S0 TRUSS COMPONENTS CANNOT BE WITHOUT OPERATIONAL OR HEATER POWER FOR LONGER THAN THE TIMES IDENTIFIED IN THE TABLE BELOW:

**TABLE 12A\_C2-56-I - S0 TRUSS POWERDOWN TIME CONSTRAINTS**

REFERENCE FRAME	ATTITUDE	BETA	TIME LIMIT (HOURS)
XPOP QUASI-INERTIAL	XPOP	-60 TO -30 OR +30 TO +60	2
LVLH	+ZLV +XVV	-60 TO -40	1.5
		-40 TO +40	10
		+40 TO +60	6
LVLH	+ZLV -XVV	+40 TO +60	1.5
		-40 TO +40	10
		-60 TO -40	6

©[DN 83 ]

*During truss installation missions, it may be necessary to remove operational/heater power from activated truss components. During these transition phases, truss components must be maintained above the minimum temperature limits. To ensure these limits are not violated, components must regain operational and/or heater power within the time limits defined above.*

*Source: Segment S0 LTA Thermal Analysis Results, MDC 97H0588 rev. A, May 1, 1999 and SIR7-0018 Thermal Analysis, January 2002.*

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## FLIGHT RULES

12A\_C2-56

**TRUSS POWERDOWN CONSTRAINTS (CONTINUED)**

B. TO INCREASE THE TIME LIMITS FOR S0 IN PARAGRAPH A FOR XPOP, BETA < -40 IN +ZLV +XVV, OR BETA > +40 IN +ZLV -XVV, IT IS NECESSARY TO PREHEAT SOME TRUSS COMPONENTS. ONLY THE COMPONENTS LISTED IN THE TABLE BELOW REQUIRE PREHEATING. A 5-HOUR PREHEAT IMMEDIATELY PRIOR TO THE POWERDOWN PROVIDES A 4-HOUR POWERDOWN TIME LIMIT. @[DN 83 ]

**TABLE 12A\_C2-56-II - S0 COMPONENTS REQUIRING PREHEATING FOR XPOP +ZLV ±XVV FOR HIGH BETA ANGLES**

REFERENCE FRAME	ATTITUDE	BETA	COMPONENT	PREHEAT DURATION (HOURS)	CORRESPONDING POWERDOWN DURATION (HOURS)
XPOP QUASI-INERTIAL	XPOP	$\beta > +40$ or $\beta < -40$	DDCU S03B	5	4
			DDCU S04B	5	4
			MBSU 2A2B	5	4
			MBSU 3A3B	5	4
		$+30 < \beta \leq +40$ or $-40 \leq \beta < -30$	DDCU S03B	5	4
LVLH	+ZLV +XVV	$\beta < -40$	DDCU S04B	5	4
			MBSU 1A1B	5	4
			MBSU 4A4B	5	4
LVLH	+ZLV -XVV	$\beta > +40$	DDCU S04B	5	4
			MBSU 1A1B	5	4
			MBSU 4A4B	5	4

*Thermal analysis was performed for Mated XPOP and Mated +ZLV +XVV at the MPA. Betas from -60 to +60 were analyzed. The only components that required preheating during these attitude/beta combinations are listed in the table above. Deviating from the MPA and the given tolerance band will require further assessment. @[DN 83 ]*

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**FLIGHT RULES**

**12A\_C2-56**

**TRUSS POWERDOWN CONSTRAINTS (CONTINUED)**

*Capability exists to preheat the MBSU's and DDCU's. The recommended preheating time of 5 hours protects for a 4-hour powerdown. All other S0 truss components can survive a 4-hour powerdown without preheating either by redundant power feeds or the predicted temperature after 4 hours was not shown to violate the lower non-operational temperature limit.*

*Manual Heater Operations of the DDCU and MBSU coldplate heaters via RPC commands will be used to accomplish the preheating task. If telemetry indicates the MBSU and/or DDCU coldplate temp exceeds 4.4 deg C (40 deg F) during the preheating timeframe, the preheating is considered complete and the RPC to the coldplate heater can be opened. The component will remain above the non-operational limit for the remainder of the powerdown, up to 9 hours. Thermal analysis also indicates no upper limit temperatures are approached by leaving the RPC closed for the 5-hour preheat timeframe.*

*Source: SIR7-0018 Thermal Analysis, January 2002*

C. ONCE ACTIVATED, S1 TRUSS COMPONENTS CAN SURVIVE A CHANNEL POWERDOWN FOR UP TO 4 HOURS AT BETA ANGLES < +40 DEG IN +ZLV +XVV OR BETA ANGLES > -40 IN +ZLV -XVV. FOR BETA ANGLES OUTSIDE THESE RANGES, CERTAIN COMPONENTS MUST BE PREHEATED PER TABLE 12A\_C2-56-III - S1 COMPONENTS PREHEAT REQUIREMENTS. S1 TRUSS COMPONENTS CANNOT SURVIVE A POWERDOWN ON EITHER POWER CHANNEL IN XPOP. @[DN 83 ]

**TABLE 12A\_C2-56-III - S1 COMPONENTS PREHEAT REQUIREMENTS**

REFERENCE FRAME	ATTITUDE	BETA	COMPONENT	PREHEAT DURATION (HOURS)	CORRESPONDING POWERDOWN DURATION (HOURS)
LVLH	+ZLV +XVV	$\beta < +40$	ALL	N/A	4.0
		$\beta > +40$	BBC S1-1	1.5	4.0
			BBC S1-2	1.5	4.0
			DDCU S1-4B	5.0	4.0
LVLH	+ZLV -XVV	$\beta > -40$	ALL	N/A	4.0
		$\beta < -40$	BBC S1-1	1.5	4.0
			BBC S1-2	1.5	4.0
			DDCU S1-4B	5.0	4.0

@[DN 83 ]

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**FLIGHT RULES****12A\_C2-56****TRUSS POWERDOWN CONSTRAINTS (CONTINUED)**

*Thermal analysis was performed for Mated XPOP and Mated +ZLV +XVV at the MPA with the TRRJ packed at an angle of 0 Deg. Betas from -60 to +60 were analyzed. The only components that required preheating during these attitude/beta combinations are listed in the table above. Deviating from the MPA and the given tolerance band or changing the TRRJ Angle will require further assessment. @DN 83 ]*

*All other S1 truss components can survive a 4-hour powerdown in +ZLV +XVV without preheating either by using survival heaters on the redundant power string, using operational power on the redundant power string, or the predicted temperature after 4 hours was not shown to violate the lower non-operational temperature limit. Camera and light equipment with survival heaters on the channel being powered down must use operational power to maintain thermal limits. Analysis assumes the DDCU S1-4B thermal cover is installed. During preheating, ORU temperatures will be monitored and preheating will discontinue if upper temperature limits are reached.*

*If the S1 truss is powered down while in XPOP, several components that do not have redundant heater or operational power available will reach their lower thermal limits within minutes. The most constraining equipment includes the Thermostat Boxes, the RBVM IMCA's and the S-Band ORU's.*

*Source: SIR7-0018 Thermal Analysis, July 2002.*

- D. ONCE ACTIVATED, P1 TRUSS COMPONENTS CAN SURVIVE A CHANNEL POWERDOWN FOR UP TO 4 HOURS AT BETA ANGLES > -40 DEG IN +ZLV +XVV OR BETA ANGLES < +40 IN +ZLV -XVV. FOR OTHER BETA ANGLES AND ATTITUDE REFERENCES FRAMES, CERTAIN COMPONENTS MUST BE PREHEATED PER TABLE 12A\_C2-56-IV, P1 COMPONENTS PREHEAT REQUIREMENTS. @DN 83 ]

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## FLIGHT RULES

12A\_C2-56

**TRUSS POWERDOWN CONSTRAINTS (CONTINUED)**

**TABLE 12A\_C2-56-IV - P1 COMPONENTS PREHEAT REQUIREMENTS**

REFERENCE FRAME	ATTITUDE	BETA	COMPONENT	PREHEAT DURATION (HOURS)	CORRESPONDING POWERDOWN DURATION (HOURS)
LVLH	+ZLV +XVV	$\beta > -40$	ALL	N/A	4.0
		$\beta < -40$	BBC P1-1	1.5	4.0
			BBC P1-2	1.5	4.0
			DDCU P1-3A	5.0	4.0
			THERMOSTAT BOXES W/MLI	N/A	2.5
			RBVM IMCA	N/A	2.0
LVLH	+ZLV -XVV	$\beta < +40$	ALL	N/A	4.0
		$\beta > +40$	BBC P1-1	1.5	4.0
			BBC P1-2	1.5	4.0
			DDCU P1-3A	5.0	4.0
			THERMOSTAT BOXES W/MLI	N/A	2.5
			RBVM IMCA	N/A	2.0
XPOP QUASI-INERTIAL		$+60 > \beta > +40$ $-60 < \beta < -40$	DDCU P1-3A	5.0	4.0
			BBC P1-1	2.0	2.0
			BBC P1-2	2.0	2.0
			RBVM IMCA	N/A	2.0
			THERMOSTAT BOXES W/MLI	N/A	2.4
		$-40 < \beta < -30$ $+40 > \beta > +30$	DDCU P1-3A	5.0	4.0
			BBC P1-1	1.5	3.0
			BBC P1-2	1.5	4.0
			RBVM IMCA	N/A	2.0

©[DN 83 ]

*Thermal analysis was performed for Mated XPOP and Mated +ZLV +XVV at the MPA with the TRRJ packed at an angle of 0 Deg. Betas from -60 to +60 were analyzed. The only components that required preheating during these attitude/beta combinations are listed in the table above. Deviating from the MPA and the given tolerance band or changing the TRRJ Angle will require further assessment.* ©[DN 83 ]

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## FLIGHT RULES

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### 12A\_C2-56      TRUSS POWERDOWN CONSTRAINTS (CONTINUED)

*All other P1 truss components can survive a 4-hour channel powerdown without preheating either by using survival heaters on the redundant power string, using operational power on the redundant power string, or the predicted temperature after 4 hours was not shown to violate the lower non-operational temperature limit. During preheat operations, temperatures will be monitored to ensure components do not go above their max operational temperature. Camera and light equipment with survival heaters on the channel being powered down must use operational power to maintain thermal limits. Analysis assumes the DDCU P1-4B thermal cover is installed. During preheating, ORU temperatures will be monitored and preheating will discontinue if upper temperature limits are reached.*

*The thermostat boxes on P1 do not have redundant heaters, nor do they have a pre-heat capability. However, these boxes do have MLI unlike the S1 thermostat boxes.*

*Source: SIR7-0018 Thermal Analysis, July 2002*

E. ONCE ACTIVATED, P3 TRUSS COMPONENTS CAN SURVIVE A CHANNEL POWERDOWN FOR UP TO 4 HOURS IN +ZLV ±XVV AND XPOP. ©[DN 83 ]

*Thermal analysis was performed for Mated XPOP and Mated +ZLV +XVV at the MPA with the TRRJ packed at an angle of 0 Deg. Betas from -60 to +60 were analyzed. Deviating from the MPA and the given tolerance band or changing the TRRJ angle will require further assessment. ©[DN 83 ]*

*All P3 components can survive a 4-hour channel powerdown by using survival heaters on the redundant string, operational power on the redundant power string, or the predicted temperature after 4 hours was not shown to violate the lower non-operational temperature limit.*

*Source: SIR7-0018 Thermal Analysis, December 2002*

### 12A\_C2-57      SARJ CONSTRAINT FOR MT AND CETA CART AT WS#8

©[DN 110 ]

DUE TO CLEARANCE PROBLEMS WITH THE SARJ AND THE CETA CART, THE SARJ KEEP-OUT ZONE IS BETWEEN 68 DEG AND 114 DEG WITH THE MT AT WS#8 IN THE C-MT-C CONFIGURATION. SARJ ROTATION IS PROHIBITED WHILE THE MT REMAINS AT WS#8 IN THE C-MT-C CONFIGURATION.

*Reference SARJ to CETA Clearance Analysis performed by DX24/Robotics Analysis, which shows the following clearance problems:*

- a. Launch Lock to PFR, 68 to 84 deg (min at 78 deg), clearance from 0.23 to 3 inches
- b. Launch Lock to EVA WIF, 86 to 94 deg (min at 91 deg), clearance from 1.06 to 3 inches
- c. Launch Lock to EVA WIF, 105 to 114 deg (min at 110 deg), clearance from 1.09 to 3 inches

©[DN 110 ]

## FLIGHT RULES

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### 12A\_C2-58

### EXERCISE CONSTRAINTS WHILE DOCKED [RC]

- A. WHILE THE SHUTTLE IS DOCKED TO STATION, THE CONSTRAINTS ON CREW EXERCISE ARE AS FOLLOWS [1]:
1. CREWMEMBER SQUATS AND HEEL RAISES USING THE UNISOLATED INTERIM RESISTIVE EXERCISE DEVICE (IRED) ARE LIMITED TO A MINIMUM TIME OF 3 SECONDS BETWEEN REPETITIONS.
  2. CREWMEMBER TORSO BENDING AND ROWING EXERCISES USING THE RUSSIAN FORCE LOADER HC-1 ARE LIMITED TO A MINIMUM TIME OF 3 SECONDS BETWEEN REPETITIONS.
  3. CREWMEMBER HAMMER THROW AND FOREARM BENDING EXERCISES USING THE RUSSIAN FORCE LOADER HC-1 ARE LIMITED TO A MINIMUM TIME OF 2 SECONDS BETWEEN REPETITIONS.

*Unisolated IRED and HC-1 use can create loads that alone will create fatigue issues and may shorten the life of the station. When combined with other loads due to shuttle/ISS mated ops, these loads can result in load levels exceeding constraints. To avoid these issues, the period between the start of each squat or heel raise should be at least 3 seconds.*

- B. DURING ORBITER ATTITUDE CONTROL AND MANEUVERS, WITH ALT 2-JET OR 3-JET OPTION, SHUTTLE BICYCLE ERGOMETER EXERCISE IS ACCEPTABLE BUT SHALL NOT EXCEED 67.5 RPM (1.13 HZ).

*ALT PRCS 2-jet and 3-jet attitude control loads due to multiple bi-polar PRCS jet firings combined with other shuttle/ISS mated loads result in unacceptable load levels on shuttle and ISS components. Loads due to the shuttle bicycle ergometer are a major contributor. During ALT PRCS 2-jet and 3-jet attitude holds, limiting the shuttle bicycle ergometer use to a maximum pedal frequency of 67.5 rpm alleviates the loads issues.*

- C. DURING SHUTTLE BASED REBOOST CONFIG 1, SHUTTLE BICYCLE ERGOMETER EXERCISE IS ACCEPTABLE BUT SHALL NOT EXCEED 67.5 RPM (1.13 HZ).

*Loads due to shuttle automated reboost config 1 combined with other shuttle/ISS mated loads result in unacceptable load levels on shuttle and ISS components. Loads due to the shuttle bicycle ergometer are a major contributor. Limiting the shuttle bicycle ergometer use to a maximum pedal frequency of 67.5 rpm alleviates the loads issues.*

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## FLIGHT RULES

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**12A\_C2-58**                    **EXERCISE CONSTRAINTS WHILE DOCKED [RC]**  
**(CONTINUED)**

D. REFER TO RULE {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR EXERCISE CONSTRAINTS DURING SOLAR ARRAY DEPLOYMENT AND SRMS/SSRMS OPERATIONS. @[DN 4 ]

NOTE: IF A SPECIFIC PIECE OF EXERCISE EQUIPMENT IS NOT IDENTIFIED WITH A CONTROL MODE, IT IS IMPLIED THAT NO RESTRICTION ON SAID EQUIPMENT IS IMPOSED.

## FLIGHT RULES

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12A\_C2-59

STS-115/12A VIDEO SUPPORT [HC] @[DN 109 ]

A. INTEGRATED TRUSS SEGMENT (ITS) P3/4 UNBERTH

1. IF THE ORBITER BOOM SENSOR SYSTEM (OBSS) REMAINS BERTHED FOR ITS P3/4 UNBERTH, THE U.S. LAB CAMERA (CP13) AND PAYLOAD BAY CAMERA C ARE CRITICAL FOR STARBOARD CLEARANCE VIEWING, WHILE PAYLOAD BAY CAMERA B AND SRMS ELBOW ARE CONSIDERED CRITICAL FOR PORT CLEARANCE VIEWING.
2. UNBERTH OPERATIONS MAY CONTINUE WITH THE LOSS OF ONE CRITICAL STARBOARD VIEWING CAMERA AND ONE CRITICAL PORT VIEWING CAMERA.
3. IN THE EVENT THAT THE CONDITIONS OF PARAGRAPHS 1 AND 2 OF THIS RULE CANNOT BE MET, THE SSRMS MAY BE REPOSITIONED TO PROVIDE ADDITIONAL UNBERTH CAMERA VIEWS.

*The nominal procedures call for unberthing the P3/4 truss while the OBSS is cradled and latched in the starboard Manipulator Positioning Mechanisms (MPM's). This creates a close clearance (approximately 3 inches) between the P3/4 starboard trunnions and the OBSS after the truss is above the V-guides. Crew simulator runs have identified certain cameras that are considered critical to monitor the close clearances on the port and starboard sides of the payload bay.*

*In the event that a critical camera is lost, the SSRMS, based on the Local Area Bus (LAB) Power/Data Grapple Fixture (PDGF), may be used to provide additional clearance views. Alternatively, the SSRMS may be considered to grapple and maneuver the OBSS clear until the P3/4 truss is unberthed. To use the SSRMS for viewing operations or OBSS handling, a double walkoff would be required from WS7/PDGF-3 to PDGF-1, then to the LAB PDGF. Once the P3/4 unberth is completed, a double walkoff back to WS7/PDGF-3 is required for P3/4 handoff and installation.*

B. ITS P3/4 INSTALLATION

1. THE ARTIFICIAL VISION UNIT (AVU) IS THE PRIMARY INSTALLATION CUE. THE PRIME CAMERA TO PROVIDE AVU DATA IS THE RMS SIDEVIEW CAMERA (RSC). THE BACKUP CAMERA IS THE SRMS ELBOW CAMERA.
2. PRIMARY DIRECT CAMERA VIEWS ARE PAYLOAD BAY CAMERA A, PAYLOAD BAY CAMERA B, RSC, SRMS ELBOW, SSRMS BASE ELBOW, SSRMS TIP ELBOW, AND P1 LOWER OUTBOARD CAMERA (CP9). @[DN 109 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-59

STS-115/12A VIDEO SUPPORT [HC] (CONTINUED)

3. IN THE UNLIKELY EVENT THAT A SOLUTION IS NOT AVAILABLE FROM EITHER AVU, P3/4 INSTALLATION MAY CONTINUE USING AVAILABLE CAMERA CUES, SSRMS DIGITALS, AND/OR EVA GROUND CONTROLLED APPROACH (GCA). @[DN 109 ]

*Given the highly constrained nature of the SASS capture envelope, it is preferable to utilize the AVU for the install to allow the SSRMS operator to use the Remote Manipulator System (RMS) Situational Awareness Display (RSAD) Mating Corridor Display to insure the capture corridor is maintained.*

*The robotics tasks can be accomplished with the loss of the prime cues; however, additional time will be required to complete the tasks. The crew has determined that the following will likely be their downmoding sequence for installation cues: (1) AVU for position and attitude, (2) AVU for attitude only and visual cues for position in the event that the AVU position solution is noisy, (3) SSRMS digitals for attitude and visual cues for position in the unlikely event that the AVU solution is not available, and (4) visual cues only for position and attitude in the extremely unlikely event that both the AVU solution and the SSRMS digitals are not available.*

*Reference Space Vision System (SVS) Hazard Report 97011-8, Incorrect Display of Target Position or Motion; Operational Control Agreement Document (OCAD) 4916;, and Rule {B12-6}, SSRMS FIELD OF VIEW CONSTRAINT [HC] [C].*

### C. ELECTRICAL POWER SYSTEM (EPS) ARTICULATING HARDWARE

1. TO SUPPORT MANDATORY VISUAL CUES DURING THE P4 SOLAR ARRAY DEPLOYMENTS, PVR DEPLOY, AND PORT SARJ CHECKOUT, CAMERAS INDICATED AS PRIME WILL BE INCLUDED IN THE NOMINAL PLAN.
2. FOR LOSS OF ANY PRIME CAMERA VIEWS, OPERATIONS WILL CONTINUE USING BEST BACKUP CAMERA VIEW AVAILABLE.
3. ORBITER AND ISS KU-BAND SYSTEMS WILL BE USED TO PROVIDE VIDEO TO THE GROUND DURING ALL OPERATIONS WHEN FEASIBLE.
4. THE CAMERAS/SSRMS/SRMS WILL BE PRECONFIGURED BY THE CREW PRIOR TO SLEEP TO SUPPORT THE FOLLOWING ACTIVITIES:
  - a. UNLATCH OF EACH P4 SOLAR ARRAY BLANKET BOX (SABB)  
(IF UNABLE TO VERIFY DURING EVA 1)
  - b. PORT SARJ CHECKOUT
  - c. P4 PVR DEPLOY @[DN 109 ]

**THIS RULE CONTINUED ON NEXT PAGE**

# FLIGHT RULES

12A\_C2-59

STS-115/12A VIDEO SUPPORT [HC] (CONTINUED)

Certain visual cues are required to provide adequate measure of the SARJ/SAW deploy/PVR deploy operations. The following camera assessments were performed by ROBO in July 2005.

The SAW deploy and PVR deploy can be accomplished with the loss of their respective prime cues; however, additional time may be required to reconfigure backup views to complete the tasks.

The Port SARJ checkout will occur during crew sleep. Camera commanding during SARJ checkout will be performed from MCC-H.

**TABLE 12A\_C2-59-I - CAMERA USAGE FOR 12A VIEWING OPERATIONS**

CAMERA [1]		TRUSS P1_LOOB (PORT 9)	SSRMS/MBS [2]				EVA (WVS)	SHUTTLE PLB			SRMS [4]			
			LEE	TIP ELBOW	BASE ELBOW	POA		A	B [3]	C	EE	ELB		
ACTIVITY	P4 BRS PIN RELEASE [5] [6] [7]	2A LATCH MOTION [8]	RBB											
			LBB	B/U [9]										
		4A LATCH MOTION [8]	RBB	B/U [9]										
			LBB			PRI								
		2A BRS PIN VERIFICATION	RBB											
			LBB	PRI [9]										
		4A BRS PIN VERIFICATION	RBB	B/U [9]										
		LBB												
INITIAL P4 BGA ROTATION [5]		PRI												
PORT SARJ CHECKOUT (180 TO 0 DEGREES)		PRI												
P4 SAW DEPLOY [11] [12] [14]	4A LATCH MOTION & 1 MAST BAY DEPLOY [7]	PRI												
	2A LATCH MOTION & 1 MAST BAY DEPLOY [7]	B/U RBB												
	FULL WING VIEW MAST BAY COUNT/TENSION BAR	B/U												
	4A DEPLOY													
	4A DEPLOY													
P4 SAW DEPLOY [11] [12] [14]	4A DEPLOY													
	2A DEPLOY													
P4 PVR DEPLOY [11]	FULL PVR VIEW	PRI												

©[CR 7553 ]

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## FLIGHT RULES

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12A\_C2-59

STS-115/12A VIDEO SUPPORT [HC] (CONTINUED)

## NOTES:

- [1] KEY:  – USEFUL VIEW (PRI = PRIMARY CAMERA; B/U = BACKUP CAMERA);  – UNABLE TO VIEW  
THE MBS MAST IS CONSIDERED FAILED AND THE SHUTTLE PLB CAMERA D, LAB EXTERNAL, AND S1\_LO CAMERAS ARE BLOCKED BY STRUCTURE FOR THE ENTIRE MISSION.
- [2] ASSUMES MSS IS AT WS#7 (P1-B5), AND THAT THE SSRMS IS ON PDGF 3 AND IS IN POSITION PER THE FLIGHT SPECIFIC ROBOTICS CHECKLIST. FOR THE PVR DEPLOY, THE SSRMS IS BASED ON THE LAB PDGF.
- [3] THE SRMS MUST BE UNSTOWED OR CRADLED BUT ROLLED OUT, BEFORE THIS CAMERA IS USEFUL.
- [4] NON-PROPULSIVE CRYO LIMITED ON ORBITER, DO NOT USE ORBITER RESOURCES UNLESS CAMERA IS DESIGNATED AS PRIME OR IF CIRCUMSTANCES REQUIRE IT. ASSUMES SRMS IS NOT STOWED, AND IN POSITION PER FLIGHT SPECIFIC PDRS CHECKLIST.
- [5] ASSUMES PORT SARJ POSITION = 180 DEGREES
- [6] ASSUMES BGA 2A/4A AT 0 DEGREES (INITIAL CONFIG) UNTIL AT LEAST THE START OF EVA 2. IF BGA'S CAN BE ROTATED TO 180 DEGREES AT THE END OF EVA1, MANY MORE CAMERAS ARE AVAILABLE TO VERIFY THE RELEASE OF THE BRS PINS. UNTIL ANALYSIS SHOWS OTHERWISE, THE ECU/SSU THERMAL SHROUDS MUST BE REMOVED BEFORE THE BGA CAN BE ROTATED.  
VIEW CONSIDERED USEFUL IF IT CAN VIEW ALL 7 BRS PINS OR AT LEAST 1 BANK OF LATCHES ON THE IDENTIFIED SABB.
- [7] NEED TO VERIFY AT LEAST ONE BANK OF LATCHES UNLATCHED.
- [8] THE FIRST UNLATCHING OF EACH SABB MUST BE VIEWED IN REAL TIME BY THE GROUND. DUE TO VIDEO TRUNK LINE LIMITATIONS DURING THE SECOND HALF OF THE P3 ACTIVATION, ONLY 1 MSS CAMERA AND 1 ORBITER CAMERA ARE AVAILABLE AT ANY ONE TIME.
- [9] SINCE SABB UNLATCHING WILL OCCUR DURING DDCU LA4A POWERDOWN (P1\_LO CAMERA IS WITHOUT POWER), IT CAN BE USED FOR LATCH MOTION AND BRS PIN VERIFICATION ONLY AFTER POWER IS RESTORED AT THE END OF THE P3 ACTIVATION PROCEDURE.  
P1\_LO CAMERA CAN SEE ALL REQUIRED ITEMS EXCEPT FOR POSSIBLY THE 2A LBB BRS PIN 6. IF UNABLE TO VISUALLY CONFIRM RELEASE OF THIS PIN, AN EVA CREWMEMBER MUST CONFIRM THE STATUS OF THIS PIN OR BGA 2A MUST BE REPOSITIONED TO 180 DEGREES TO CONFIRM THE STATUS OF THIS PIN USING THE P1\_LO CAMERA. @[DN 109 ]
- [10] THE BASE ELBOW CAMERA CAN ONLY VIEW THE 2A LEFT LATCH MOTION IF THE SSRMS IS IN THE CONTINGENCY 4A SABB VIEWING POSITION
- [11] ASSUMES PORT SARJ POSITION = 0 DEGREES
- [12] ASSUMES BGA 4A IS 60 DEGREES AND BGA 2A IS 300 DEGREES  
ASSUMES THREE RWS MONITORS AVAILABLE AND ONE ISS RWS MONITOR IS CONFIGURED FOR ORBITER VIDEO ROUTING  
LATCH MOVEMENT VERIFICATION REQUIRES ONE SIMULTANEOUS VIEW (ONE PER BLANKET BOX). ONE BAY DEPLOY REQUIRES ONE SIMULTANEOUS VIEW (ONE PER ARRAY). 49 PERCENT DEPLOY AND 100 PERCENT DEPLOY BOTH REQUIRE 4 SIMULTANEOUS VIEWS (A VIEW OF EACH INBOARD TENSION MECHANISM, A VIEW TO COUNT MAST BAYS, AND A FULL VIEW OF THE ARRAY).
- [13] THE 2A LBB LATCHES ARE BLOCKED WHEN THE SRMS IS AT THE PRE-CRADLE POSITION. IF SP IS MOVED TO +30 DEGREES, CAMERA C HAS A CLEAR VIEW OF THE 2A LBB.
- [14] SOME OF THESE ACTIVITIES REQUIRE MULTIPLE CAMERAS TO BE AVAILABLE TO THE CREW DURING CRITICAL ACTIVITIES. THE CAMERA PRIORITY FOR DOWNLINK MAY BE DIFFERENT FROM THE CREW'S CAMERA PRIORITY. IF ONLY ONE OF THESE CAMERAS CAN BE DOWNLINKED, THE PREFERRED CAMERA IS SPECIFIED WITH AN ASTERISK. THIS PREFERRED CAMERA SHOULD ALSO BE RECORDED ON A VTR. @[CR 7553 ]  
CAMERA DOWNLINK PRIORITIES FOR 4A SAW DEPLOYMENT: 1) SRMS ELBOW (FULL VIEW), 2) P1 LOOB (MAST BAY COUNT), 3) TIP LEE (LBB), 4) TIP ELBOW (RBB). AT A MINIMUM, THE SRMS ELBOW CAMERA SHOULD BE DOWNLINKED VIA THE ORBITER KU AND ISS KU, AND CAPTURED ON THE VTR WHEN SAW 4A MECHANISMS ARE IN MOTION. IF A SECOND VTR IS AVAILABLE, RECORD THE P1 LOOB CAMERA WHEN SAW 4A MECHANISMS ARE IN MOTION.  
CAMERA DOWNLINK PRIORITIES FOR 2A SAW DEPLOYMENT: 1) PLB B (FULL VIEW), 2) P1 LOOB (MAST BAY COUNT), 3) TIP LEE (RBB), 4) BASE ELBOW (LBB). AT A MINIMUM, THE PLB B CAMERA SHOULD BE DOWNLINKED VIA THE ORBITER KU AND ISS KU, AND RECORDED ON AN ISS VTR WHEN SAW 2A MECHANISMS ARE IN MOTION. IF A SECOND VTR IS AVAILABLE, RECORD THE P1 LOOB CAMERA WHEN SAW 2A MECHANISMS ARE IN MOTION. @[CR 7553 ]

## FLIGHT RULES

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### 12A\_C2-60

### PORT SARJ POSITION AND ROTATION CONSTRAINT [HC]

WHILE THE P6-4B SOLAR ARRAY, P4 SOLAR ARRAYS, AND P4 PV RADIATOR ARE DEPLOYED, PORT SARJ POSITION IS LIMITED TO THE RANGE OF 307 TO 360 DEGREES (OR 0 DEGREES). WHEN THE PORT SARJ IS NOT POSITIONED AT 0 DEGREES, THE P4-4A SOLAR ARRAY WILL BE POSITIONED AT 270 DEGREES OR WITHIN AN APPROPRIATE ANGLE RANGE TO PROVIDE A MINIMUM OF 5 FEET CLEARANCE BETWEEN SOLAR ARRAYS P6-4B AND P4-4A. ©[DN 118 ]

*Rotation of the port SARJ after the P4 SAW's and P4 PVR are deployed is restricted to prevent inadvertent contact and damage to the P4 and the P6-4B SAW's under a runaway SARJ hazard condition. The SARJ is positioned at a 0 deg (equivalent to 360 deg) Alpha angle for P4 SAW deployments. When the port SARJ is parked at the 0 deg position, the full range of BGA motion for the P4 and the P6-4B SAW's is permitted. When the SARJ is at any position other than 0 deg, P4 and P6 BGA operations may be limited. The SARJ position Keep-Out Zones (KOZ's) for initial P4 SAW deployment with the P6 SAW's deployed are defined in EPS SODF Reference 5.107. Analysis assumes P4 BGA's are at worst-case position or at 0 deg and protects for a 5-ft clearance between structures and other rotating hardware.*

*When a collision hazard exists, SARJ rotation may be performed under carefully controlled conditions incorporating small incremental motion and additional hazard controls. Continuous monitoring (by ground and/or crew) will be provided during such rotation. Direct commanding to the Rotary Joint Motor Controller (RJMC) hardware may be implemented to provide direct hardware control (vs software control) of the rotation angle. This technique prevents a runaway joint hazard after a single P3 MDM Failure.*

*In the event of runaway joint conditions, the operator may implement one or more of several methods to terminate SARJ rotation. These include (1) issuance of an abort command to the RJMC to remove voltage from motor windings, (2) RPC open command to remove power from the RJMC, (3) upstream RPC open command to remove power from the electrical bus supporting the RJMC, and (4) deactivation of the upstream DC to DC Converter Unit (DDCU). Boeing analysis indicates that the SARJ will coast to a stop within approximately 10 degrees of power removal at nominal (4 deg/min) rotation rate.*

*Source: Boeing Safety Hazard Analysis, ISS-COLL-1002-12A, ISS collision; and Graphics Research Analysis Facility (GRAF) Memo FUR # 61.2002, Port SARJ Clearance Angles for ISS/F12A, August 16, 2002.*

*Hazard Reports are still pending. ©[DN 118 ]*

## FLIGHT RULES

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12A\_C2-61

### COMMANDING CONSTRAINTS DURING SSAS LATCHING OPERATIONS [HC]

DURING SSAS SECOND PHASE (SECOND/THIRD STAGE) CAPTURE LATCHING ACTUATION, NO NON-SSAS COMMANDS SHOULD BE SENT FROM THE CREW/GROUND TO THE EXT MDM OR TO LOWER TIER DEVICES UNDER EXT MDM.

*This is required per OCAD 19452 for 12A. After an SSRMS brakes-on event, the CCS safing software sends commands to the SSAS software (STOP and PAUSE commands) and to the SEP's s/w (IMCA RPC Open commands) to stop IMCA motion in under 6.98 seconds or a catastrophic structural hazard could occur (ISS-Mech-109 Cause 50). The Boeing Safety concern is that if other commands are being processed by the EXT DSM software at this moment, then the processing of the commands could be slowed down. While this is very unlikely, unless this failure were to occur at the same moment another command is being processed, it is still theoretically possible. This risk is acceptable, since there is no planned commanding nor need to command during the 5+ minutes of Capture Latch actuation. Note: This only applies during the timeframe where the hazard is evident (from Topological Capture until the SSAS is fully seated). ©[CR 7688 ]*

*Reference: 12A/13A Mechanism Safing Software HSI Test Result presented at EBIT, June 18, 2003.  
©[CR 7688 ]*

## FLIGHT RULES

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### 12A\_C2-62      DRAG THROUGH CABLES [RI]

A. DRAG-THROUGH CABLES FROM THE SHUTTLE WILL BE USED AS FOLLOWS DURING ASSEMBLY MISSION 12A:

1. PMA/ODS INTERFACE AIR DUCT (SHUTTLE ODS TO PMA2) - CONNECTED ENTIRE DOCKED MISSION
2. O<sub>2</sub> SUPPLY LINE (SHUTTLE ODS TO PMA2) - CONNECTED ENTIRE DOCKED MISSION @[DN 115 ]
3. DRAG THROUGH QUICK DISCONNECT (QD) (AT PMA2/LAB HATCH) :  
@[ED ]
  - a. BATTERY POWERED SPEAKER MIKE UNIT (BPSMU) (SHUTTLE ODS TO LAB) - CONNECTED ENTIRE DOCKED TIME
  - b. TWO RWS V10 CABLES (SHUTTLE FLT DECK TO LAB) - CONNECTED ENTIRE DOCKED TIME

*The drag through QD is capable of connecting and disconnecting two video cables and two BPSMU cables, and was installed on STS-121. For mission 12A, the crew will bring one BPSMU cable across to ISS.*

4. TWO PHA HOSES (ISS AIRLOCK TO SHUTTLE MIDDECK) - AS REQUIRED DURING EVA CREW HYGIENE BREAKS ON MORNINGS OF EVA DAYS @[CR 7694 ]

*To maintain EVA pre-breathe protocol, EVA crewmembers will don masks and breathe O<sub>2</sub> supplied via PHA hoses connected in the ISS Airlock during their morning hygiene break (approximately 1.5 hrs in duration). EVA crew may translate to orbiter middeck during this time as required.*

5. N<sub>2</sub> SUPPLY LINE (SHUTTLE ODS TO PMA2) - CONNECTED FOR DURATION OF N<sub>2</sub> TRANSFER OPS

*N<sub>2</sub> transfer is not planned for STS-115, but margins may allow some transfer capability. Including the N<sub>2</sub> transfer configuration in this rule is the conservative approach, allowing the config to be assessed for safety compliance pre-flight in order to maximize real-time flexibility.*

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## FLIGHT RULES

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**12A\_C2-62                      DRAG THROUGH CABLES [RI] CONTINUED**

B. THE DAY-BY-DAY CONFIGURATION OF THE CABLES BETWEEN THE SHUTTLE AND ISS WILL BE MANAGED AS INDICATED IN THE FOLLOWING TABLE (FD = FLIGHT DAY):

	AIR DUCT	DRAG THRU QD (1 BPSMU, 2 V10)	O2 SUPPLY	PHA HOSES (2)	N2 SUPPLY
FD03	X	X	X		[2]
FD04 EVA	X	X	X	[1]	[2]
FD05 EVA	X	X	X	[1]	[2]
FD06	X	X	X		[2]
FD07 EVA	X	X	X	[1]	[2]
FD08	X	X	X		[2]
FD09	X	X	X		[2]
FD10	X	X	X		[2]

@[CR 7694 ]

NOTES:

- [1] PHA HOSES ONLY USED FOR APPROX. 1.5 HRS BY TWO EVA CREWMEMBERS ON MORNINGS OF EVA DAYS PER PARAGRAPH A.4 ABOVE
- [2] N<sub>2</sub> SUPPLY LINE NOT PLANNED FOR CONNECTION, BUT INCLUDED FOR CONSERVATISM TO MAXIMIZE REAL-TIME FLEXIBILITY PER PARAGRAPH A.5 ABOVE @[CR 7694 ]

*This Rule is a flight specific explanation of Rule {B2-402}, CONSTRAINTS ON CABLES, HOSES, DUCTS, ETC. THROUGH HATCHES [RC] [E], documenting the plan for Flight 12A. @[DN 115 ]*

**12A\_C2-63                      RESERVED @[DN 66 ]**

## FLIGHT RULES

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### 12A\_C2-64

### SYSTEMS MANAGEMENT DURING EETCS SATURATION PERIODS

IF TELEMETRY OR PLANNING INDICATES SATURATION OF THE EARLY EXTERNAL THERMAL CONTROL SYSTEM (EETCS) IS LIKELY, THE FOLLOWING ACTIONS WILL BE TAKEN: ©[CR 7635 ]

- A. IF SATURATION HAS ALREADY OCCURRED OR IS IMMINENT AND THE DURATION OR MAGNITUDE OF THE SATURATION IS SIGNIFICANT OR EETCS PFCS OUTLET TEMPERATURES HAVE OR WILL EXCEED 10 DEGREES C (50 DEGREES F) :

GROUND OR CREW WILL EXECUTE A MANUAL EPS LOADSHED TO REDUCE EPS LOADS. EPS LOADS WILL BE REDUCED UNTIL BOTH THE EETCS IS NO LONGER SATURATED AND PFCS OUTLET TEMPERATURES ARE BELOW 10 DEGREES C (50 DEGREES F) .

*Thermal analysis has shown for worse case scenarios, usually associated with inertial attitudes, EETCS system saturation is possible. EETCS system saturation is defined as the EETCS PFCS FCV valve going to full flow through the radiators (FCV = 90 degrees). For non-transitory cases, a saturated EETCS may eventually lead to loss of ITCS temperature control and possibly EETCS loop shutdown due to overtemp. Thermal Loadshed Tables are not populated during the 12A timeframe, thus EPS Load Shed must be utilized to rapidly reduce system load. In a time critical situation, it is more efficient to execute the powerdown utilizing the EPS Loadshed capabilities in the onboard software versus issuing multiple RPC (or similar device) open commands.*

*The EETCS PFCS Max Outlet Temperature FDIR will automatically shut down a PFCS if outlet temperature exceeds 12.7 degrees C (55 degrees F). This FDIR is nominally enabled.*

*Reference Rule {B2-5}, LOAD MANAGEMENT [HC] [RC] [E].*

- B. IF SATURATION IS PREDICTED TO OCCUR AND THE DURATION OR MAGNITUDE OF SATURATION IS EXPECTED TO BE SIGNIFICANT OR PFCS OUTLET TEMPERATURES ARE PREDICTED TO EXCEED 10 DEGREES C (50 DEGREES F) , ONE OR MORE OF THE FOLLOWING ACTIONS WILL BE PERFORMED :

1. GROUND OR CREW WILL MANUALLY REDUCE SYSTEM LOADS.
2. ISS WILL MANEUVER TO A MORE THERMALLY BENIGN ATTITUDE.

IF SYSTEM LOAD REDUCTION OR MANEUVERING TO AN ALTERNATE ATTITUDE ARE NOT POSSIBLE, WITH THERMAL MER CONCURRENCE, IT MAY BE ACCEPTABLE TO INHIBIT THE EETCS PFCS MAX OUTLET TEMPERATURE FDIR. ©[CR 7635 ]

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## FLIGHT RULES

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12A\_C2-64

### SYSTEMS MANAGEMENT DURING EETCS SATURATION PERIODS (CONTINUED)

*With time available, the most effective means to reduce loading on the EETCS is for the ground to identify non-critical loads to be unpowered. The current EPS Loadshed Table may be used as a guide in load selection, but it should be noted that only loads powered via internal LAB DDCU's (excluding LA2A and LA4A) impact EETCS system loading, thus only these loads should be unpowered. ©[CR 7635 ]*

*Maneuvering to a more benign attitude (nominally XVV or YVV) will lower the effective sink temperature of the EETCS and should relieve the saturation condition.*

*EETCS PFCS Max Outlet Temperature FDIR may be inhibited if analysis shows that temperature exceedance will not cause hardware damage. In this scenario, it is better to leave the EETCS operational, providing degraded cooling to internal loads rather than to have it shutdown providing no cooling.*

*Reference Rule {B2-5}, LOAD MANAGEMENT [HC] [RC] [E].*

C. NO ACTION IS REQUIRED IF SATURATION IS PREDICTED TO OCCUR BUT BE TRANSITORY IN DURATION OR MAGNITUDE AND EETCS PFCS OUTLET TEMPERATURES WILL NOT EXCEED 10 DEGREES C (50 DEGREES F) .

*EETCS saturation nominally occurs prior to hardware temperature exceedances; thus, for transitory saturation events, no action is required as no temperatures limits will be exceeded.*

*DOCUMENTATION: Boeing ISS-HOU-ATCS-MBS-050035, Rev A, February 27, 2006. ©[CR 7635 ]*

## FLIGHT RULES

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### 12A\_C2-65

### MATED FES DUMP CONSTRAINTS

FES DUMPS MAY OCCUR AT ANY TIME DURING THE MATED MISSION EXCEPT FOR THE FOLLOWING TIME PERIODS. TO PROTECT FOR ATTITUDE CONTROL DISTURBANCES, FES DUMPS SHOULD NOT BE INITIALIZED OR TERMINATED DURING THESE WINDOWS: ©[CR 7660C ]

- A. FLIGHT DAY 3, FROM 2 HOURS PRIOR TO MOMENTUM MANAGEMENT STARTUP THROUGH COMPLETION OF THE P3/4 HANDOFF TO THE SSRMS
- B. FLIGHT DAY 4, FROM 2 HOURS PRIOR TO MOMENTUM MANAGEMENT STARTUP THROUGH COMPLETION OF BOLT DRIVE

*In order to avoid significant increases in momentum when momentum management is the only allowable control mode, as specified in Rule {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FES initiation and FES termination activities should be avoided. Nominal topping FES ops or FES dumps that extend through the window are not an issue as the momentum transients are tied to starting or stopping FES dumps only. ©[CR 7660C ]*

- C. FLIGHT DAY 6, DURING THE FREE DRIFT PERIODS FOR SAW DEPLOY

*FES dumps should not be conducted at all through the free drift periods as no control system will be able to counteract the torque. Nominal topping FES ops are allowed. ©[CR 7706 ]*



## FLIGHT RULES

12A\_C2-66

SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS  
[HC] [RI]

WHEN THE USOS SOLAR ARRAYS ARE FULLY DEPLOYED, THE ARRAYS ARE FEATHERED TO MINIMIZE STRUCTURAL LOADING, EROSION/CONTAMINATION FROM THRUSTER FIRINGS, CONTAMINATION AND IMPACT DAMAGE DUE TO WATER DUMP/PROPELLANT PURGE OPERATIONS, AND TO SUPPORT KURS COMMUNICATION COVERAGE. @[CR 7593A ]

- A. NOMINALLY, THE USOS SOLAR ARRAY ROTARY JOINTS (SARJ) AND THE BETA GIMBAL ASSEMBLIES (BGA) WILL BE FEATHERED AS DEFINED IN TABLES 12A\_C2-66-I AND 12A\_C2-66-II.

NOTE: THE FOLLOWING TABLES ASSUME THE P4 SOLAR ARRAYS ARE DEPLOYED AFTER THE PORT SARJ IS LOCKED AT 0 DEGREES.

**TABLE 12A\_C2-66-I -FEATHER ANGLES FOR NOMINALLY PLANNED MISSION EVENTS DURING 12A MATED OPERATIONS**

	NOMINALLY PLANNED MISSION EVENTS- 12A MATED OPS	P4			P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>DOCKING</b>						
1	STATION MANEUVER TO/FROM ORBITER DOCKING ATTITUDE (THRUSTERS)	N/A	N/A	N/A	ANY	ANY
2	12A ORBITER DOCKING (THRUSTERS) [1]	N/A	N/A	N/A	150* [2]	210* [2]
<b>WATER DUMP</b>						
3	12A ORBITER VRCS MANEUVER TO/FROM WATER DUMP ATTITUDE (THRUSTERS) [5]	0 L	ANY	270* [2] L&D: 40-120 OR 220-300; ENV: 80-100 OR 260-280	ANY	ANY
4	12A ORBITER WATER DUMP (WATER AND THRUSTERS) [6]	0 L	ANY	270* ENV: 270 - 272 OR 102 -104	ANY	223* ENV: 213 - 223

@[CR 7593A ]

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**FLIGHT RULES**

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**  
**[HC] [RI] (CONTINUED)**

NOMINALLY PLANNED MISSION EVENTS- 12A MATED OPS		P4			P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>ORBITER REBOOST</b>						
5	12A ORBITER REBOOST CONFIG 3 (THRUSTERS)	0 L	ANY	270* [2] L&D: 30-150 OR 210-330; ENV: 80-100 OR 260-280	ANY	ANY
6	12A ORBITER REBOOST CONFIG 4 (THRUSTERS)	0 L	ANY	270* [2] L&D: 40-120 OR 220-300; ENV: 80-100 OR 260-280	ANY	ANY
<b>ORBITER ATTITUDE MANEUVERS &amp; HOLD</b>						
7	12A ORBITER ATTITUDE MANEUVERS, & ATTITUDE HOLD (THRUSTERS) (VRCS ONLY)	0 L	ANY	270* [2] L&D: 40-120 OR 220-300; ENV: 80-100 OR 260-280	ANY	ANY
8	12A STATION ATTITUDE MANEUVERS, & ATTITUDE HOLD (USTO CONTROL AND THRUSTER CONTROL) SAME AS 12A STAGE OPERATIONS CONSTRAINTS (SEE TABLE_12A_C2-66-II)					
<b>SAW DEPLOY</b>						
9	12A P4 - 4A SAW DEPLOY (THERMAL CONDITIONING & VISUAL CUES) [7]	0 L	N/A	60* L	ANY	ANY
10	12A P4 - 2A SAW DEPLOY (THERMAL CONDITIONING & VISUAL CUES) [8]	0 L	300* L	270* (ATTITUDE HOLD CONSTRAINT - SEE ITEM 7)	ANY	ANY
<b>EVA</b>						
11	12A EVA 3 - INSTALLATION OF P6 BGA RETAINERS (EVA SAFETY & POWER GENERATION)	0 L	ANY	ANY	180* L (±20)	ANY L
12	12A EVA 3 - MISSE 5 (EVA SAFETY & POWER GENERATION)	0 L	ANY	ANY	ANY	ANY
13	12A EVA'S PLASMA MITIGATION (VOLTAGE POTENTIAL) [9]	0 L	ANY	ANY	ANY	ANY

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**FLIGHT RULES**

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**

**[HC] [RI] (CONTINUED)**

NOMINALLY PLANNED MISSION EVENTS – 12A MATED OPS		P4			P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>ORBITER UNDOCKING</b>						
14	STATION MANEUVER TO/FROM ORBITER UNDOCKING ATTITUDE (THRUSTERS)	0 L	80* L [3] [4]	ANY	ANY	ANY
15	12A ORBITER UNDOCKING (THRUSTERS) [10]	0 L	80* L [3] [4]	270* L [3]	150* [2]	210* [2]

@[CR 7593A ]

\* PREFERRED ANGLE

L=LOCKED, R=RETRACTED, L&D=PLUME LOADS CONSTRAINT, ENV=PLUME EROSION CONSTRAINT

NOTES:

- [1] THE FEATHERING ANGLE FOR 12A ORBITER DOCKING PROTECTS SOLAR ARRAYS FOR ORBITER THRUSTER PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION)
- [2] FEATHERING PROTECTS FOR STRUCTURAL LIFE. NO STRUCTURAL HAZARD AT WORST CASE BGA ANGLE
- [3] FEATHERING PROTECTS FOR STRUCTURAL LOADS EXCEEDANCES – LOCKING REQUIRED TO PRECLUDE INADVERTENT BGA SHUTDOWN AND ROTATION TO WORST CASE ANGLE.
- [4] FROM AN L&D PERSPECTIVE, 90 DEGREES IS OPTIMAL FOR UNDOCKING LOADS; HOWEVER, 80 DEGREES AND LOCKED IS OPTIMAL FOR MANEUVERS AND WITHIN THE ACCEPTABLE RANGE TO SUPPORT UNDOCKING LOADS. ALTHOUGH DOCKING MAY PROCEED IF THE P4-2A IS AT 80 DEGREES AND UNLOCKED, THE P4-2A ARRAY WILL BE LOCKED THROUGHOUT UNDOCKING ACTIVITIES TO SUPPORT RUSSIAN SEGMENT THRUSTER MANEUVERS TO AND FROM THE UNDOCKING ATTITUDE.
- [5] THE P4-4A BGA FEATHERING ANGLE FOR 12A ORBITER MANEUVER TO WATER DUMP ATTITUDE PROTECTS SOLAR ARRAYS FOR ORBITER THRUSTER PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION). THE FEATHERING ANGLE OF P4-2A=270 WAS SELECTED SINCE IT MEETS BOTH LOADS AND EROSION REQUIREMENTS AND IS CONSISTENT WITH THE ALLOWABLE WATER DUMP FEATHERING ANGLES (SEE ITEM 4).
- [6] THE P4-4A AND P6-4B SOLAR ARRAYS MUST BE FEATHERED DURING ORBITER WATER DUMPS TO MITIGATE DAMAGE DUE TO IMPACTS OF LIQUID/ICE PARTICLES. REFER TO RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS, FOR MORE INFORMATION.
- [7] ISS ATTITUDE CONTROL WILL BE USED DURING P4-4A SAW DEPLOY TO PROTECT FOR PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION). REF. RULES {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC], AND {12A\_B9-12}, POWER TRANSFER FROM THE USOS TO RS.
- [8] ORBITER ATTITUDE CONTROL WILL BE USED DURING P4-2A SAW DEPLOY TO PROTECT FOR PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION). P4-4A MUST BE FEATHERED FOR ORBITER ATTITUDE CONTROL (SEE ITEM 7). REF. RULES {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC] AND {12A\_B9-12}, POWER TRANSFER FROM THE USOS TO RS.
- [9] ASSUMES TWO PLASMA CONTACTOR UNITS (PCU'S) ARE IN DISCHARGE. SOLAR ARRAYS CAN BE FEATHERED, UPON PCU FAILURE, IF NECESSARY TO MINIMIZE RISK OF SHOCK TO EVA CREW DUE TO STATIC DISCHARGE. REFER TO RULE {12A\_B9-5}, PLASMA HAZARD MITIGATION [HC] [RI], FOR MORE INFORMATION.
- [10] THE FEATHERING ANGLE FOR 12A ORBITER UNDOCKING PROTECTS SOLAR ARRAYS FOR ORBITER AND ISS THRUSTER PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION). REFER TO RULE {12A\_C2-42}, ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC], FOR MORE INFORMATION. @[CR 7593A ]

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## FLIGHT RULES

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**  
**[HC] [RI] (CONTINUED)**

**TABLE 12A\_C2-66-II -FEATHER ANGLES FOR NOMINALLY PLANNED MISSION EVENTS DURING 12A STAGE OPERATIONS**

NOMINALLY PLANNED MISSION EVENTS – 12A STAGE OPS		PORT SARJ (DEG)	P4		P6 (ON Z1)	
			2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>STAGE REBOOST</b>						
1	12A STAGE STATION MANEUVER TO/FROM REBOOST ATTITUDE (THRUSTERS) [1] [4]	0 L	80* [13] MANEUVER CONSTRAINT; L MAY BE REQUIRED (SEE ITEMS 3 & 4)	ANY	ANY	ANY
2	12A STAGE STATION REBOOST WITH PROGRESS ON SM AFT OFF-PULSING OR SM MAIN ENGINE (THRUSTERS) [1] [4]	0 L	80* ATTITUDE HOLD CONSTRAINT (SEE ITEM 5)	ANY	ANY	ANY
<b>ATTITUDE MANEUVERS</b>						
3	12A STAGE STATION ATTITUDE MANEUVERS [2] [4]					
<b>USTO CONTROL</b>						
3A	ROLL CONTROL: PROGRESS ON DC-1 NADIR PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [5]	0 L	80* [14] L&D: 50-90 OR 230-270 ENV: 50-80 OR 230-260	ANY	ANY	ANY
3B	ROLL CONTROL: PROGRESS ON DC1 NADIR PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [5]	0 L	80* [14] L&D: 60-90 OR 240-270 ENV: 70-80 OR 250-260	ANY	ANY	ANY
3C	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [5]	0 L	80* [14] [15] L&D: 60-100 OR 240-280 ENV: 50-100 OR 230-280	ANY	ANY	ANY
3D	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [5]	0 L	80* [14] [15] L&D: 60-100 OR 240-280 ENV: 70-90 OR 250-270	ANY	ANY	ANY

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**FLIGHT RULES**

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**

**[HC] [RI] (CONTINUED)**

NOMINALLY PLANNED MISSION EVENTS – 12A STAGE OPS			P4		P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>ATTITUDE MANEUVERS (CONTINUED)</b>						
4	12A STAGE STATION ATTITUDE MANEUVERS [2] [4]					
<b>THRUSTER CONTROL</b>						
4A	ROLL CONTROL: PROGRESS ON DC-1 NADIR PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [5]	0 L	<b>80* L</b> [13] L&D: 60-90 L OR 240-270 L ENV: 50-80 OR 230-260	ANY	ANY	ANY
4B	ROLL CONTROL: PROGRESS ON DC1 NADIR PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [5]	0 L	<b>80* L</b> [13] L&D AND ENV: 70-80 L OR 250-260 L	ANY	ANY	ANY
4C	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [5]	0 L	<b>80*[14] [15]</b> L&D: 60-90 OR 240-270 ENV: 50-100 OR 230-280	ANY	ANY	ANY
4D	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [5]	0 L	<b>80* L</b> [13] L&D: 60-90 L OR 240-270 L ENV: 70-90 OR 250-270	ANY	ANY	ANY

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**FLIGHT RULES**

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**

**[HC] [RI] (CONTINUED)**

NOMINALLY PLANNED MISSION EVENTS – 12A STAGE OPS			P4		P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>ATTITUDE HOLD</b>						
5	12A STAGE STATION ATTITUDE HOLD		[2] [10]			
<b>USTO CONTROL / THRUSTER CONTROL</b>						
5A	ROLL CONTROL: PROGRESS ON DC-1 NADIR PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [6]	0 L	80* ENV: 50-80 OR 230-260 L&D: NO CONSTRAINTS	ANY	ANY	ANY
5B	ROLL CONTROL: PROGRESS ON DC1 NADIR PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [6]	0 L	80* ENV: 70-80 OR 250-260 L&D: NO CONSTRAINTS	ANY	ANY	ANY
5C	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: PROGRESS ON SM AFT  (THRUSTERS) [6]	0 L	80* ENV: 50-100 OR 230-280 L&D: NO CONSTRAINTS	ANY	ANY	ANY
5D	ROLL CONTROL: SERVICE MODULE PITCH & YAW CONTROL: SERVICE MODULE  (THRUSTERS) [6]	0 L	80* ENV: 70-90 OR 250-270 L&D: NO CONSTRAINTS	ANY	ANY	ANY
<b>PROGRESS/SOYUZ DOCKING</b>						
REFER TO RULE {D2-2}, ISS APPENDAGE CONFIGURATION FOR SOYUZ/PROGRESS RENDEZVOUS [HC] [RC]						
<b>PROGRESS/SOYUZ UNDOCKING</b>						
REFER TO RULE {D2-302}, ISS APPENDAGE CONFIGURATION FOR SOYUZ/PROGRESS UNDOCKING AND SEPARATION FROM A NADIR PORT [HC] [RC]						
<b>PROGRESS/SOYUZ RELOCATION</b>						
REFER TO RULE {D2-17}, USOS APPENDAGE CONFIGURATION FOR SOYUZ RELOCATION [HC] [RC]						
<b>RUSSIAN SEGMENT THRUSTER TEST</b>						
REFER TO RULE {D2-TBD}, USOS APPENDAGE CONFIGURATION FOR RUSSIAN SEGMENT THRUSTER TEST						
<b>RUSSIAN SEGMENT PROPELLANT PURGE</b>						
REFER TO RULE {D2-TBD}, USOS APPENDAGE CONFIGURATION FOR RUSSIAN SEGMENT PROPELLANT PURGE						

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**FLIGHT RULES**

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**

**[HC] [RI] (CONTINUED)**

NOMINALLY PLANNED MISSION EVENTS – 12A STAGE OPS			P4		P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>WATER DUMP</b>						
6	MANEUVER TO/FROM USL WATER DUMP ATTITUDE (THRUSTERS) [11]	0 L	<b>80* OR 260*</b> MANEUVER CONSTRAINT; L MAY BE REQUIRED (SEE ITEMS 3 & 4)	ANY	ANY	ANY
7	12A STAGE ISS WATER DUMP USL STARBOARD NOZZLE (THRUSTERS) [8] [11]	0 L	<b>80*</b> ATTITUDE HOLD CONSTRAINT (SEE ITEM 5)	ANY	ANY	ANY
8	12A STAGE ISS WATER DUMP USL PORT NOZZLE (WATER AND THRUSTERS) [9] [11]	0 L	<b>260*</b> ENV: 252-260 [7]	ENV: 264-274 OR 96-104 [3]	ENV: 125 OR 295 (±5) [3]	ENV: 62 OR 232 (±2) [3]
<b>PLASMA MITIGATION</b>						
9	12A STAGE EVA'S PLASMA MITIGATION (VOLTAGE POTENTIAL) [12]	0 L	ANY	ANY	ANY	ANY
<b>STAGE NOMINAL OPERATIONS</b>						
10	12A STAGE NOMINAL OPERATIONS	0 L	ANY	ANY	FOR XVV - DUAL ANGLE TRACKING. FOR XPOP & YVV - FIXED OR AUTO-TRACKING	FOR XVV - DUAL ANGLE TRACKING. FOR XPOP & YVV - FIXED OR AUTO-TRACKING

@[CR 7593A ]

\* PREFERRED ANGLE

L=LOCKED, R=RETRACTED, L&D=PLUME LOADS CONSTRAINT, ENV=PLUME EROSION CONSTRAINT, KURS=CONSTRAINT FOR KURS COMMUNICATION COVERAGE

NOTES:

- [1] NO FEATHER CONSTRAINTS ARE ASSOCIATED WITH THE REBOOST ITSELF; HOWEVER, THE STANDARD FEATHER CONSTRAINTS APPLY FOR THE MANEUVER TO/FROM THE REBOOST ATTITUDE AND ATTITUDE HOLD FIRINGS DURING THE REBOOST.
- [2] APPROPRIATE FEATHERING ANGLES ARE DEPENDENT ON ISS ATTITUDE CONTROL CONFIGURATION.
- [3] PREFERRED ANGLE SELECTION IS DEPENDENT ON ATTITUDE AND SOLAR BETA, AND SHOULD MAXIMIZE POWER GENERATION CAPABILITY THROUGHOUT THE ACTIVITY.
- [4] P4-2A FEATHERING IS REQUIRED TO PROTECT FOR ISS THRUSTER PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION). @[CR 7593A ]

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## FLIGHT RULES

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12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS****[HC] [RI] (CONTINUED)**

- [5] THE COMPLETE ALLOWABLE P4-2A FEATHERING ANGLE RANGES FOR MANEUVERS WITH USTO CONTROL AND RS THRUSTER CONTROL ARE PROVIDED FOR BOTH PLUME LOADS AND EROSION MITIGATION. THE PREFERRED FEATHERING ANGLE OF P4-2A=80 DEGREES SATISFIES BOTH CONSTRAINTS. @[CR 7593A ]
- [6] THE COMPLETE ALLOWABLE P4-2A FEATHERING ANGLE RANGES FOR ATTITUDE HOLD WITH USTO CONTROL/RS THRUSTER CONTROL ARE PROVIDED FOR PLUME EROSION MITIGATION (NO LOADS CONSTRAINT).
- [7] A POWERDOWN MAY BE REQUIRED IN ORDER TO FEATHER THE 2A ARRAY TO 260 DEGREES. FEATHERING THE 2A ARRAY TO 80 DEGREES IN AN ATTEMPT TO IMPROVE POWER GENERATION COULD RESULT IN LIQUID/ICE PARTICLE IMPACTS TO THE ACTIVE SIDE OF THE ARRAY. THE FEATHERING ANGLE RANGE IDENTIFIED PROTECTS P4 FOR IMPINGEMENT FROM THE LAB WATER DUMP AS WELL AS RUSSIAN SEGMENT THRUSTER FIRINGS FOR ATTITUDE HOLD. THERE ARE ACTUALLY TWO SETS OF FEATHERING ANGLE RANGES FOR WATER DUMP MITIGATION ALONE. SINCE WATER DUMPS ARE NOT ALLOWED ON THE ACTIVE SIDE OF THE ARRAY, THESE RANGES ARE SLIGHTLY LESS THAN 180 DEGREES APART. WHEN OVERLAPPED WITH THE CONSTRAINTS FOR PLUME EROSION MITIGATION, THERE IS ONLY ONE RANGE OF ALLOWABLE ANGLES.
- [8] THE USL STARBOARD WATER VENT NOZZLE HAS NO VIEW TO THE P4 OR P6 PV SOLAR ARRAYS. P4-2A FEATHERING ANGLES ARE REQUIRED FOR MANEUVERING AND ATTITUDE HOLD THRUSTER FIRINGS. REFER TO RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS, FOR MORE INFORMATION.
- [9] THE P4 AND P6 SOLAR ARRAYS MUST BE FEATHERED DURING USL PORT WATER DUMPS TO MITIGATE DAMAGE DUE TO IMPACTS OF LIQUID/ICE PARTICLES. THE P4 SOLAR ARRAY MUST ALSO BE FEATHERED TO MITIGATE THRUSTER PLUME IMPINGEMENT FOR ISS MANEUVER AND ATTITUDE HOLD FIRINGS. THE GIVEN FEATHERING ANGLES REPRESENT AN INTEGRATION OF BOTH CONSTRAINTS. THERE ARE NO OTHER ALLOWABLE FEATHERING ANGLES BECAUSE WATER DUMPS ARE NOT PERMITTED ON THE ACTIVE SIDE OF SOLAR ARRAYS. REFER TO RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS, FOR MORE INFORMATION.
- [10] ATTITUDE HOLD INCLUDES ANY ISS THRUSTER FIRINGS FOR ATTITUDE HOLD, REBOOST, CMG DESAT REQUEST, AND CMG THRUSTER ASSIST.
- [11] FEATHERING REQUIRED FOR MANEUVER TO/FROM WATER DUMP ATTITUDE AND ATTITUDE HOLD FIRINGS DURING THE WATER DUMP. P4-2A BGA=260 DEGREES SELECTED AS PREFERRED ANGLE SINCE THIS PROTECTS FOR PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION) AND IS CONSISTENT WITH THE ALLOWABLE WATER DUMP FEATHERING ANGLES FOR THE USL PORT NOZZLE (SEE ITEM 9). IF WATER WILL ONLY BE DUMPED FROM THE USL STARBOARD NOZZLE, P4-2A BGA=80 DEGREES IS THE PREFERRED ANGLE TO MITIGATE PLUME IMPINGEMENT EFFECTS (SEE ITEM 7). SEE ITEMS 3 AND 4 FOR MANEUVER LOCKING REQUIREMENTS.
- [12] ASSUMES TWO PLASMA CONTACTOR UNITS (PCU'S) ARE IN DISCHARGE. SOLAR ARRAYS CAN BE FEATHERED, UPON PCU FAILURE, TO MINIMIZE RISK OF SHOCK TO EVA CREW DUE TO STATIC DISCHARGE. REFER TO RULE {12A\_B9-5}, PLASMA HAZARD MITIGATION [HC] [RI], FOR MORE INFORMATION.
- [13] FEATHERING PROTECTS FOR STRUCTURAL LOADS EXCEEDANCES – LOCKING REQUIRED TO PRECLUDE INADVERTENT BGA SHUT-DOWN AND ROTATION TO WORST CASE ANGLE.
- [14] FEATHERING PROTECTS FOR STRUCTURAL LIFE. NO STRUCTURAL HAZARD AT WORST CASE BGA ANGLE. BGA MAY NOT BE ABLE TO MAINTAIN POSITION DUE TO PLUME INDUCED TORQUE LOADS AT NON-FEATHERED POSITION.
- [15] STRUCTURAL KOZ'S EXIST FOR A LOCKED 2A ARRAY – DO NOT LOCK P4-2A 121-179 AND 301-359 DEGREES. LOCKING THE ARRAY CHANGES THE LOAD PATH AND THRUSTER LOADS CAN EXCEED THE LOAD CAPABILITY OF THE BGA ANTI-ROTATION PIN. WITH THE ARRAY UNLOCKED, STRUCTURAL LOADS WILL NOT BE EXCEEDED; HOWEVER, THE BGA WILL LIKELY BE OVERTORQUED, AND THE BGA MOTOR WILL TRIP OFF. THE ARRAY COULD BE FREE-SPINNING IN THIS EVENT. @[CR 7593A ]

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## FLIGHT RULES

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12A\_C2-66

### SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [HC] [RI] (CONTINUED)

*Prior to the P6-4B retraction, the port SARJ position will nominally remain at 0 degrees to prevent structural interference between the P4 and P6-4B SAW's. ©[CR 7593A ]*

*Structural limit loads may be exceeded by ISS and/or orbiter thruster plume impingement loads on the U.S. PV arrays. Feathering the arrays minimizes the projected surface area to the thrusters, significantly reducing structural loads to acceptable levels. If analysis shows the array limit loads are exceeded at the worst case orientation, the arrays must be locked at the feathered position. BGA locking precludes the possibility of a BGA shutdown, which would allow subsequent thruster firings to rotate the array to a worst case angle and create an immediate structural hazard. In some cases, the loads at the worst case BGA angles do not exceed structural limits, but may cause excessive structural fatigue life consumption. In these cases, the BGA does not need to be locked, since no structural hazard exists in the event of a BGA shutdown. Please note, the BGA controller may not be capable of reacting plume-induced torque loads at non-feathered orientations. If the BGA is positioned outside the feathered range, thruster firings may exceed the BGA FDIR limits and force a BGA shutdown, at which point the array could rotate to virtually any position. While not a structural hazard, this could lead to significant loss in power generation until the BGA can be restarted.*

*There are cases in which no structural KOZ's exist for the 2A array in an unlocked configuration, but do exist if the 2A array is locked. There is no true structural load path between the BGA and the ISS in torsion (aside from the BGA motor and bearing friction) when unlocked. There are no plans to lock the arrays in these orientations once the arrays are fully deployed.*

*The USOS Solar Array Wings (SAW's) must be feathered to mitigate thruster plume-induced erosion/pitting of solar array surface coating materials resulting from particle impacts associated with thruster firings. Allowable feathering angles are dependent on thruster selection. An allowable feathering angle may be selected to improve energy balance for the flight attitude and solar beta angle. In addition, solar array feathering may be required to mitigate impact damage (or erosion) from water dumps and propellant purges. Contamination in the form of deposition from thruster plumes, water dumps, or propellant purges is also mitigated by solar array feathering.*

B. FOR OFF-NOMINAL EVENTS, THE SARJ AND BGA'S WILL BE FEATHERED AS DEFINED IN TABLES 12A\_C2-66-III AND 12A\_C2-66-IV.

NOTE: THE FOLLOWING TABLES ASSUME THE P4 SOLAR ARRAYS ARE DEPLOYED AFTER THE PORT SARJ IS LOCKED AT 0 DEGREES. ©[CR 7593A ]

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## FLIGHT RULES

12A\_C2-66

### SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [HC] [RI] (CONTINUED)

**TABLE 12A\_B9-66-III -FEATHER ANGLES FOR OFF-NOMINAL  
EVENTS DURING 12A MATED OPERATIONS**

OFF- NOMINAL EVENTS- 12A MATED OPS			P4		P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>ORBITER ATTITUDE MANEUVERS &amp; HOLD</b>						
1	12A ORBITER ATTITUDE MANEUVERS AND ATTITUDE HOLD (THRUSTERS) (PRCS ONLY)	0 L	90* L [6]	270* L [6]	ANY	ANY
<b>ORBITER REPAIR MANEUVER</b>						
2	12A ORBITER REPAIR MANEUVER (ORM) (THRUSTERS) [4]	0 L	RETRACTED	RETRACTED	ANY	ANY
3	12A ORBITER REPAIR MANEUVER (ORM) EMERGENCY SEPARATION AFTER P4 ARRAYS DEPLOYED. (THRUSTERS) [2] [3] [4]	0 L	80* [6] (L IF TIME PERMITS)	270* [6] (L IF TIME PERMITS)	150* [7]	210* [7]
<b>CONTINGENCY SHUTTLE CREW SUPPORT</b>						
4	12A ORBITER CSCS SEPARATION AFTER P4 ARRAYS DEPLOYED (A NO-BURN SEP) (THRUSTERS FOR MANEUVER AND ATTITUDE HOLD)	0 L	80* L MAY BE REQUIRED (SEE TABLE II, ITEMS 3, 4, & 5)	ANY	ANY	ANY
<b>OFF-NOMINAL VENTS</b>						
5	12A ORBITER FREE FLUID DISPOSAL (WATER AND THRUSTER) [1]	0 L	ANY	270* SEE TABLE I, ITEMS 3 & 4	ANY	223* SEE TABLE I, ITEM 4
6	12A ORBITER DEPRESS VIA VACUUM VENT LINE (THRUSTERS ONLY, AIR HAS NO IMPACT) ATTITUDE CONTROL IS HANDED OVER TO ORBITER [5]	0 L	ANY	270* ATTITUDE HOLD CONSTRAINT (SEE TABLE I, ITEM 7)	ANY	ANY
7	12A ORBITER DEPRESS VIA EXTERNAL A/L DEPRESS VLV - ORBITER BASED EVA (THRUSTERS ONLY, AIR HAS NO IMPACT) ATTITUDE CONTROL IS HANDED OVER TO ORBITER [5]	0 L	ANY	270* ATTITUDE HOLD CONSTRAINT (SEE TABLE I, ITEM 7)	ANY	ANY
<b>PLASMA MITIGATION</b>						
8	12A STAGE EVA'S PLASMA MITIGATION - PCU FAILURE (VOLTAGE POTENTIAL)[8]	0 L	90 OR 270	270 OR 90	ANY	ANY
<b>JEUS THRUSTERS</b>						
9	12A ORBITER JEUS (THRUSTERS) [3]	0 L	80* [2] [6] (L IF TIME PERMITS)	270* [6] (L IF TIME PERMITS)	150* [7]	210* [7]

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## FLIGHT RULES

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12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**  
**[HC] [RI] (CONTINUED)**

\* PREFERRED ANGLE WITHIN RANGES @[CR 7593A ]  
L=LOCKED, R=RETRACTED, L&D=PLUME LOADS CONSTRAINT, ENV=PLUME EROSION CONSTRAINT

NOTES:

- [1] FREE FLUID DISPOSAL HAS SAME CONSTRAINTS AS NOMINAL ORBITER WATER DUMP. CLEANUP OF A WATER LEAK INTO CABIN WILL BE DUMPED OUT THE ORBITER WATER VENTS. FEATHERING REQUIRED FOR MANEUVER TO/FROM WATER DUMP ATTITUDE AND ATTITUDE HOLD FIRINGS DURING THE WATER DUMP. P4-2A BGA=260 SELECTED AS PREFERRED ANGLE SINCE THIS PROTECTS FOR PLUME IMPINGEMENT EFFECTS (I.E., LOADS AND EROSION) AND IS CONSISTENT WITH THE ALLOWABLE WATER DUMP FEATHERING ANGLES. SEE TABLE 12A\_C2-66-I, ITEMS 3 AND 4.
- [2] FROM AN L&D PERSPECTIVE, 90 DEGREES IS OPTIMAL FOR UNDOCKING LOADS; HOWEVER, 80 DEGREES AND LOCKED IS OPTIMAL FOR MANEUVERS AND WITHIN THE ACCEPTABLE RANGE TO SUPPORT UNDOCKING LOADS. ALTHOUGH DOCKING MAY PROCEED IF THE P4-2A IS AT 80 DEGREES AND UNLOCKED, THE P4-2A ARRAY WILL BE LOCKED THROUGHOUT UNDOCKING ACTIVITIES TO SUPPORT RUSSIAN SEGMENT THRUSTER MANEUVERS TO AND FROM THE UNDOCKING ATTITUDE.
- [3] DUE TO THE RAPID RESPONSE TIME OF THESE EVENTS AND THE LENGTH OF TIME IT TAKES TO LOCK THE BGA, UTILIZING A PARAFFIN ACTUATOR, ALL ARRAYS WILL FIRST BE FEATHERED. IF TIME PERMITS, MCC-H WILL ATTEMPT TO LOCK THE BGA'S IN ORDER OF THE HIGHEST LOAD POTENTIAL TO THE LOWEST LOAD POTENTIAL. IF THE ORBITER HAS NOT YET SEPARATED, AND THE ARRAYS ARE FEATHERED, BGA 4A WILL BE LOCKED FIRST, THEN BGA 2A.
- [4] NOTE: PER ORM WORKING GROUP CONFIGURATION SELECTION, THE 12A ORM CONTROLLERS WERE DESIGNED, ANALYZED, AND WILL BE CERTIFIED ONLY FOR THE CONFIGURATION WHERE P4 ARRAYS ARE RETRACTED.
- [5] NO EROSION OR CONTAMINATION CONCERNS FOR ORBITER AIR DEPRESS VENT. FEATHERING REQUIREMENTS FOR ORBITER ATTITUDE HOLD APPLY. SEE TABLE 12A\_C2-66-I, ITEM 5.
- [6] FEATHERING PROTECTS FOR STRUCTURAL LOADS EXCEEDANCES – LOCKING REQUIRED TO PRECLUDE INADVERTENT BGA SHUTDOWN AND ROTATION TO WORST CASE ANGLE
- [7] FEATHERING PROTECTS FOR STRUCTURAL LIFE. NO STRUCTURAL HAZARD AT WORST CASE BGA ANGLE. REFER TO RULE {12A\_C2-42}, ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC], FOR MORE INFORMATION ON UNDOCKING CONSTRAINTS.
- [8] IF A PCU SHOULD FAIL DURING EVA, THE P4 SOLAR ARRAYS WILL BE FEATHERED SO THE ACTIVE SURFACE OF THE ARRAY IS POINTED 105 DEGREES AWAY FROM THE VELOCITY VECTOR, TO MINIMIZE RISK OF SHOCK TO EVA CREW DUE TO STATIC DISCHARGE. ONCE THE CREW HAS INGRESSED, ARRAY FEATHERING IS NO LONGER REQUIRED. FEATHER POSITIONS ARE EDGE ON TO THRUSTER INDUCED LOADS. P4 ARRAY POSITION IS DEPENDENT ON ISS ATTITUDE AND PITCH. REFER TO RULE {12A\_B9-5}, PLASMA HAZARD MITIGATION [HC] [RI], FOR MORE INFORMATION. @[CR 7593A ]

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## FLIGHT RULES

12A\_C2-66

**SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS**  
**[HC] [RI] (CONTINUED)**

**TABLE 12A\_B9-66-IV -FEATHER ANGLES FOR OFF-NOMINAL  
EVENTS DURING 12A STAGE OPERATIONS**

	OFF- NOMINAL EVENTS- 12A STAGE OPS	P4			P6 (ON Z1)	
		PORT SARJ (DEG)	2A BGA (DEG)	4A BGA (DEG)	2B BGA (DEG)	4B BGA (DEG)
<b>DAM MANEUVERS</b>						
1	12A STAGE STATION DEBRIS AVOIDANCE MANEUVER (DAM) USING PROGRESS ON SM AFT OFF-PULSING OR SM MAIN ENGINE (THRUSTERS) [1]	0 L	80* MANEUVER & ATTITUDE HOLD CONSTRAINT; L MAY BE REQUIRED (SEE TABLE II, ITEMS 3, 4, & 5)	ANY	ANY	ANY
2	12A STAGE STATION DEBRIS AVOIDANCE MANEUVER (DAM) USING PROGRESS ON DC-1 NADIR (THRUSTERS) [2] [3] [6]	0 L	80* L L&D AND ENV: [4] 80* (+/- 10) L OR 260* (+/-10) L	ANY	30* OR 210* L&D: 0 - 90 OR 180 - 270 ENV: NO CONSTRAINT [5]	330* OR 150* L&D: 90 - 180 OR 270 - 360 ENV: NO CONSTRAINT [5]
<b>PLASMA MITIGATION</b>						
3	12A STAGE EVA'S PLASMA MITIGATION - PCU FAILURE (VOLTAGE POTENTIAL) [7]	0 L	90 OR 270	270 OR 90	ANY	ANY
<b>XPOP</b>						
4	12A STAGE XPOP SUN ON PORT SARJ (THERMAL) IF IN XPOP MORE THAN 13 HOURS	0 L	ANY	ANY	ANY	PER PHALCON SCP 3.9
5	12A STAGE XPOP SHADE STARBOARD IMCA (THERMAL)	0 L	ANY	ANY	PER PHALCON SCP 3.9	ANY

©[CR 7593A ]

\* PREFERRED ANGLE WITHIN RANGES

L=LOCKED, R=RETRACTED, L&D=PLUME LOADS CONSTRAINT, ENV=PLUME EROSION CONSTRAINT

NOTES:

- [1] NO FEATHER CONSTRAINTS ARE ASSOCIATED WITH THE DAM MANEUVER ITSELF; HOWEVER, THE STANDARD FEATHER CONSTRAINTS APPLY FOR THE MANEUVER TO THE DAM ATTITUDE.
- [2] IF THE P6 ARRAYS CANNOT BE CONFIGURED TO THESE POSITIONS, THE DAM MAY CONTINUE WITH THE ACCEPTED RISK THAT SOLAR ARRAY LIFE WILL BE IMPACTED. NO STRUCTURAL LOAD LIMIT WILL BE EXCEEDED. HOWEVER, THERE MAY BE A FATIGUE LIFE CONCERN, BUT THIS IS ACCEPTABLE FOR RARE EVENTS. ©[CR 7593A ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-66

### SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [HC] [RI] (CONTINUED)

*Due to the large offset between the DAM thrust vector and the ISS center of mass, the SM pitch jets will be firing an unusually large number of long pulses. The exhaust plume on the P6 arrays is significant enough to drive the P6 array loads to significant levels if unfeathered. Feathering the arrays keeps all structural loads within pre-flight structural fatigue life allocation. The arrays should remain unlocked to reduce torque loads. ©[CR 7593A ]*

- [3] IF THE P4-2A ARRAY CANNOT BE CONFIGURED AS DEFINED IN THIS TABLE, THERE IS A RISK OF CATASTROPHIC SOLAR ARRAY WING FAILURE. IN THE EVENT AN SM YAW THRUSTER FIRING SHOULD OCCUR DURING THE DAM, LOADS ON THE P4-2A ARRAY EXCEED THE RATED BENDING LOAD OF THE ARRAY BY 2.5 TIMES. THE P4-2A FEATHERING ANGLES REPRESENT AN INTEGRATED SOLUTION FOR PLUME LOADS AND PLUME EROSION MITIGATION.

*The ±10 deg angle range will only be used if the P4 2A array cannot be positioned nominally as a result of a BGA positioning problem. The loads on the array will be below the 30 percent limit value when positioned between the ±10 deg of the optimal feather position.*

*For 12A DC-1 Progress DAM's, a 16-second minimum delay time for thruster firings was built into the control logic. The thrusters may fire immediately after that delay time or seconds later. If the firings occur after a delay of 23 seconds and the array is not positioned and locked, there is a risk that the solar array wing will fail. The 23-second firing delay hits the second multiple of the US PV array. The 16-second delay in the valley between first and second multiples of array bending frequency. Note there is no protection against the RS MCS firing at delay times longer than 16 seconds. DC1 Progress DAM's have not been analyzed for any off-nominal ISS structural configurations (such as partial SSAS bolt-up, partially deployed arrays, etc). Structural analysis to certify DAM under these conditions is necessary before the DAM could be performed.*

- [4] FEATHERING PROTECTS FOR STRUCTURAL LOADS EXCEEDANCES – LOCKING REQUIRED TO PRECLUDE INADVERTENT BGA SHUT-DOWN AND ROTATION TO WORST CASE ANGLE
- [5] PLUME LOADS FROM A SINGLE FIRING ARE MINIMAL, BUT THE STRUCTURAL RESPONSE BUILDS UP OVER TIME UNTIL STEADY STATE REACHED. THIS IS A FATIGUE ISSUE.
- [6] PREFERRED ANGLE SELECTION IS DEPENDENT ON ATTITUDE AND SOLAR BETA, AND SHOULD MAXIMIZE POWER GENERATION CAPABILITY THROUGHOUT THE ACTIVITY.
- [7] IF A PCU SHOULD FAIL DURING EVA, THE P4 SOLAR ARRAYS WILL BE FEATHERED SO THE ACTIVE SURFACE OF THE ARRAY IS POINTED 105 DEGREES AWAY FROM THE VELOCITY VECTOR TO MINIMIZE RISK OF SHOCK TO EVA CREW DUE TO STATIC DISCHARGE. ONCE THE CREW HAS INGRESSED, ARRAY FEATHERING IS NO LONGER REQUIRED. FEATHER POSITIONS ARE EDGE ON TO THRUSTER INDUCED LOADS. P4 ARRAY POSITION IS DEPENDENT ON ISS ATTITUDE AND PITCH. REFER TO RULE {12A\_B9-5}, PLASMA HAZARD MITIGATION [HC] [RI], FOR MORE INFORMATION. ©[CR 7593A ]

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## FLIGHT RULES

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12A\_C2-66

### SOLAR ARRAY FEATHER REQUIREMENTS AND CONSTRAINTS [HC] [RI] (CONTINUED)

*DOCUMENTATION: Boeing ISS Environments Memo 2005-061, Feathering Angle Tables for Attitude Control - Stages 12A - 15A: Progress on DCI Providing Roll Control and Progress on SM Aft Providing Pitch and Yaw Control, Oct. 7, 2005; Boeing ISS Environments Memo 2005-062, Attitude Control - Stages 12A - 15A : Progress on DCI Providing Roll Control and ATV on SM Aft Providing Pitch and Yaw Control, Oct. 7, 2005; ISS Environments Memo 2005-063 Feathering Angle Tables for Attitude Control - Stages 12A - 15A: Progress on DCI Providing Roll Control and Service Module Providing Pitch and Yaw Control, Oct. 7, 2005; ISS Environments Memo 2005-064, Feathering Angle Tables for Attitude Control - Stages 12A - 15A: Service Module Providing Roll Control and Progress on SM Aft Providing Pitch and Yaw Control; Boeing ISS Environments, Memo 2005-065, Attitude Control - Stages 12A - 15A: Service Module Providing Roll Control and ATV on SM Aft Providing Pitch and Yaw Control, Oct. 7, 2005; Boeing ISS Environments Memo 2005-066, Attitude Control - Stages 12A - 15A: Orbiter Approach to PMA 2 on U.S. Lab, Nov.18, 2005; Boeing ISS Environments Memo 2005-067, Attitude Control - Stages 12A - 15A: Orbiter Separation from PMA 2 on U.S. Lab, Nov.18, 2005; Boeing ISS Environments Memo, Feathering Angle Tables for Soyuz/Progress Mated Thruster Tests; Boeing ISS Environments Memo 2003-009, U.S. Lab Port Side Condensate Water Releases: P4-2A and P4-4A Feathering Angle Requirements During Dump Operations; Boeing ISS Environments Memo 2003-014, U.S. Lab Condensate Water Dumps: Allowable Beta Angles for P6 SAW on ZI Truss (Stages 11A - 13A); ISS Environments Memo 2006-015, Propellant Purge Feathering Angle Requirements; Boeing ISS ISS Environments Memo 2006-002, P4 PV Array Feathering angles for Flight 12A Orbiter Mated Operations, Jan. 6, 2006; Devitis, Boeing SE&I VIPeR, 12A and 12A.1 Attitudes, Jan, 2006; RS memo F-1/106-6650, RS Array Feathering Requirements for Vehicle Docking to ISS, Dec. 27, 2004. Master Analysis Plan & Schedule (MAPS) 2004, Dec. 1, 2004; Joint U.S./RS Agreement on Recontact from CY 2006 U.S. Lab Water Dumps, January 2006; SARJ/BGA Constraints for Shuttle Docking/Undocking, Dave York, July 29, 2003; Viper web page: Solar Array and Radiator Feathering Index; DAM Source documentation **TBS**; Devitis, Boeing SE&I VIPeR, 12A and 12A.1 Attitudes, Jan, 2006; and RS memo F-1/106-6650. ©[CR 7593A ]*

*Reference Rules {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC]; {12A\_C2-42}, ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]; {12A\_B9-12}, P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION; {12A\_B9-5}, PLASMA HAZARD MITIGATION [HC] [RI]; and {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS. ©[CR 7593A ]*

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**FLIGHT RULES**

CONTINGENCY SCENARIOS

**12A\_C2-101**      **STS-115 ISS-12A RAPID SAFING [HC] [RI] [C]** @[ED ]

IF IT IS DETERMINED THAT THE ORBITER CAN SAFELY PERFORM A SUCCESSFUL ENTRY WITH A LOW RISK OF LOSS OF CREW IN AN EMERGENCY, RAPID SAFING WILL BE PERFORMED PER THE TABLE BELOW. IF THE ORBITER CANNOT PERFORM A SUCCESSFUL ENTRY WITHOUT A HIGH RISK OF LOSS OF CREW, THE CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) WILL BE DECLARED PER RULE {12A\_C2-103}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI] @[CR 7663 ]

RAPID SAFING PHASE	TASK COMPLETED	ACTION	TIME TO COMPLETE (HH:MM)[1]
NOMINAL CONFIG	ALL CASES WHERE THE ISS AND ORBITER ARE IN A NORMAL CONFIGURATION FOR PERFORMING DEORBIT OPS (NO RMS, EVA, OR ISS INGRESS PREP)	UNDOCK FROM PMA 2	00:30 [2]
INGRESS ONLY	ISS INGRESS (IN PROGRESS OR COMPLETE)	<ul style="list-style-type: none"> <li>• STOP/SAFE INGRESS OPS</li> <li>• IF OBSS UNBERTHERED AND ATTACHED TO SRMS, MNVR OBSS TO HANDOFF POSITION</li> <li>• STS CREW EGRESS ISS</li> <li>• CLOSE PMA 2/ODS HATCHES</li> <li>• UNDOCK FROM PMA 2</li> </ul>	01:00 [2]
P3/P4 HANDOFF TO ISS (W/SRMS AND SSRMS)	P3/P4 GRAPPLED	<ul style="list-style-type: none"> <li>• UNGRAPPLE P3/P4</li> <li>• MNVR SRMS TO PRE-CRADLE</li> </ul>	00:10
	PRLA'S OPENED	<ul style="list-style-type: none"> <li>• CLOSE PRLA'S</li> <li>• UNGRAPPLE P3/P4</li> <li>• MNVR SRMS TO PRE-CRADLE</li> </ul>	00:15
	P3/P4 MNVR STARTED	<p><u>OPTIONS:</u></p> <ul style="list-style-type: none"> <li>A. RETURN TO ORBITER (RTO)</li> <li>B. HANDOFF TO ISS AND MNVR SSRMS TO INTERMEDIATE POSN</li> </ul>	00:40 01:35
	P3/P4 IN LOW HOVER	<p><u>OPTIONS:</u></p> <ul style="list-style-type: none"> <li>A. JETTISON P3/P4</li> <li>B. RETURN TO ORBITER (RTO)</li> <li>C. HANDOFF TO ISS AND MNVR SSRMS TO INTERMEDIATE POSN</li> </ul>	00:30 00:50 01:15
	P3/P4 AT HANDOFF POSITION	<ul style="list-style-type: none"> <li>• COMPLETE HANDOFF TO ISS AND MNVR SSRMS TO INTERMEDIATE POSN</li> <li>• MNVR SRMS TO PRE-CRADLE</li> </ul>	00:50
OVERNIGHT CONFIG	P3/P4 AT HANDOFF POSITION	PERFORM MSS POWERUP AND MNVR P3/P4 TO INTERMEDIATE POSN	01:20

@[CR 7663 ]

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

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**STS-115 ISS-12A RAPID SAFING [HC] [RI] [C]**  
**(CONTINUED)**

RAPID SAFING PHASE	TASK COMPLETED	ACTION	TIME TO COMPLETE (HH:MM) [1]
P3/P4 INSTALLATION (W/SSRMS)	INITIATED MNVR TO PRE-INSTALL POSITION	CONTINUE TO PRE-INSTALL POSITION	00:30
	INITIATED MNVR TO RTL POSITION	RETURN P3/P4 TO PRE-INSTALL POSN	00:15
	SSAS FIRST STAGE CAPTURE	PROCEED WITH SSAS LATCHING AND BOLTING UNTIL 2 OF 4 BOLTS COMPLETE (ONE OF WHICH MUST BE BOLT 2)	00:40
	SSAS THIRD STAGE CAPTURE	PROCEED WITH SSAS BOLTING UNTIL 2 OF 4 BOLTS COMPLETE (ONE OF WHICH MUST BE BOLT 2)	00:30
EVA 1	CREW STILL IN JOINT A/L	<ul style="list-style-type: none"> <li>• REPRESS</li> <li>• EMERGENCY DOFF</li> <li>• HATCH OPEN</li> </ul>	00:30
	CREW EGRESS FROM JOINT A/L	TRANSLATE TO STS A/L	00:10 [3]
	CONNECT LOWER/UPPER TRAY UMBILICALS	<b>OPTIONS:</b> A. COMPLETE CURRENT CONNECTOR MATING, DO NOT CONNECT REMAINING CONNECTORS, TRANSLATE TO STS A/L B. COMPLETE ALL CONNECTIONS AND TRANSLATE TO STS A/L	00:25  01:15
	RELEASE SABB RESTRAINTS	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:15
	RELEASE SAW BGA RESTRAINTS	<b>OPTIONS:</b> A. REINSERT PIP PIN AND TRANSLATE TO STS A/L B. COMPLETE RESTRAINT REMOVAL AND TRANSLATE TO STS A/L	00:20  01:00
	ROTATE IEA KEEL PIN	COMPLETE KEEL PIN ROTATION AND TRANSLATE TO STS A/L	00:25
	UNSTOW SABB	<ul style="list-style-type: none"> <li>• COMPLETE ROTATION OF CURRENT BLANKET BOX</li> <li>• REINSERT PIP PIN</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:20
	SARJ PREPARATION	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:20
EVA 2	SARJ PREPARATION	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:20
EVA 3	P6 BGA SHOULDER BOLT CLIP INSTALLATION	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:15
	RELEASE PVR CINCHES AND WINCHES	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:20
	REMOVAL OF DRAG LINK	COMPLETE DRAG LINK STOWAGE AND TRANSLATE TO STS A/L	00:30
	KEEL BEAM REMOVAL	COMPLETE STOWAGE OF KEEL BEAM AND TRANSLATE TO STS A/L	00:45
	P3 CLEANUP	<ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:20

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**THIS RULE CONTINUED ON NEXT PAGE**



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**FLIGHT RULES**

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**STS-115 ISS-12A RAPID SAFING [HC] [RI] [C]**  
**(CONTINUED)**

RAPID SAFING PHASE	TASK COMPLETED	ACTION	TIME TO COMPLETE (HH:MM) [1]
EVA 3 (CONTINUED)	SASA R&R	<u>IF SPARE SASA ATTACHED TO Z1 / FAILED SASA ATTACHED TO S1:</u> <ul style="list-style-type: none"> <li>• SAFE WORKSITE</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:10
		<u>IF SPARE SASA UNATTACHED (CREW ON Z1) / FAILED SASA ATTACHED TO S1:</u> <ul style="list-style-type: none"> <li>• ATTACH FAILED SASA TO Z1</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:30
		<u>IF SPARE SASA UNATTACHED (CREW ON S0 OR S1) / FAILED SASA ATTACHED TO S1:</u> <ul style="list-style-type: none"> <li>• ATTACH SPARE SASA TO S1 INBOARD ZENITH LIGHT STANCHION</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:30
		<u>IF SPARE SASA ATTACHED TO S1 / FAILED SASA TEMP STOWED:</u> <ul style="list-style-type: none"> <li>• ATTACH SPARE SASA TO S1 INBOARD ZENITH LIGHT STANCHION</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:30
	S1 S-BAND BSP AND XPDR R&R	<u>IF OLD BSP OR XPDR HAVE NOT BEEN REMOVED:</u> <ul style="list-style-type: none"> <li>• TIGHTEN OLD BSP OR XPDR</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:25
		<u>IF OLD BSP OR XPDR HAS BEEN REMOVED:</u> <ul style="list-style-type: none"> <li>• INSTALL NEW BSP OR XPDR</li> <li>• TRANSLATE TO STS A/L</li> </ul>	00:25
OBSS UNBERTH (W/SRMS AND SSRMS)	SSRMS AT PRE-GRAPPLE POSN	MNVR SSRMS CLEAR OF PL BAY	00:05
	SSRMS WITH OBSS GRAPPLED	<ul style="list-style-type: none"> <li>• IF NECESSARY, REACQUIRE RTL AND LATCH MRL</li> <li>• UNGRAPPLE OBSS</li> <li>• MNVR SSRMS TO PRE-GRAPPLE POSITION</li> </ul>	00:25
	SSRMS WITH OBSS AT LOW HOVER	<u>OPTIONS:</u> A. LEAVE OBSS ON ISS AND UNDOCK B. RETURN TO ORBITER (RTO)	00:00 00:50
	SSRMS WITH OBSS AT CLEAR UHF ANTENNA POSITION	<u>OPTIONS:</u> A. ATTACH TO ISS (ATI) B. RETURN TO ORBITER (RTO)	00:40 00:55
	SSRMS WITH OBSS AT AFT POSITION	<u>OPTIONS:</u> A. ATTACH TO ISS (ATI) B. RETURN TO ORBITER (RTO)	00:30 01:10

@[CR 7663 ]

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## FLIGHT RULES

12A\_C2-101

STS-115 ISS-12A RAPID SAFING [HC] [RI] [C]  
(CONTINUED)

RAPID SAFING PHASE	TASK COMPLETED	ACTION	TIME TO COMPLETE (HH:MM)[1]
OBSS UNBERTH (W/SRMS AND SSRMS) (CONT'D)	SSRMS WITH OBSS AT HANDOFF POSITION	<u>OPTIONS:</u> A. LEAVE OBSS ON ISS AND UNDOCK B. RETURN TO ORBITER (RTO)	00:00 01:20
	SRMS GRAPPLED OBSS	<ul style="list-style-type: none"> <li>• UNGRAPPLE OBSS WITH SSRMS</li> <li>• MNVR SSRMS TO CLEARANCE POSN</li> </ul>	00:20
	OBSS RELEASED BY SSRMS	MNVR SSRMS TO CLEARANCE POSITION	00:05
OVERNIGHT CONFIG	OBSS ON SRMS IN PARK POSITION	<ul style="list-style-type: none"> <li>• PERFORM RMS POWERUP</li> <li>• MNVR SRMS TO HANDOFF POSN</li> </ul>	01:20
LATE INSPECTION	OBSS PORT SURVEY	MNVR SRMS WITH OBSS TO HANDOFF POSN	<u>00:30</u>

@[CR 7663 ]

NOTES:

- [1] TIMES SHOWN IN THIS COLUMN REFLECT THE TIME TO COMPLETE ISS SAFING ACTIONS. PROGRAM SAFETY POLICY REQUIRES THE TIME FROM THE START OF A RAPID SAFING EVENT UNTIL A DEORBIT BURN TIG TO BE LESS THAN 1:55. CONTROLLING PROCEDURE IS THE JOINT EXPEDITED UNDOCKING AND SEPARATION (JEUS) PROCEDURE. ACTIVITIES CALLED FROM THE JEUS INCLUDE:
- (A) JOINT EMERGENCY EGRESS
  - (B) ISS SAFING
  - (C) RECOVER EVA CREW
  - (D) UNDOCK
  - (E) PL SAFING
  - (F) SHUTTLE EMERGENCY SEPARATION
  - (G) STOW/JETTISON OBSS
- [2] TIME DETERMINED AT GENERIC JOP #135 (OCTOBER 2001).
- [3] ADD 0:15 IF EVA CREW CLOSSES JOINT AIRLOCK HATCH PRIOR TO TRANSLATING TO PL BAY. CLOSING AIRLOCK HATCH NOT REQUIRED FOR SAFING; HOWEVER, IT IS USEFUL FOR FUTURE ISS BASED EVA'S.

*Rule {A2-205}, EMERGENCY DEORBIT, requires that systems and payload be configured to support an emergency deorbit burn within 1 hour and 55 minutes. The overhead of the JEUS procedure (30 minutes or 50 minutes if EVA crew), and the Emergency Separation (30 minutes) must be added to the ISS Safing time to determine the TIG time of the deorbit burn. In addition, the rapid safing path must be single fault tolerant and additional time must be included to protect for next-worst failures during rapid safing. These additional times cause the rapid safing TIG time to violate the 1 hour and 55 minute constraint in some cases. This deviation is documented in the ISS/SSP Safety Accepted Risk Repot (ARR-ISS-179).*

*Safing times shown are the maximum times for a given phase. Actual times may vary depending on how far within a phase the crew has progressed at the time the emergency is declared. The times do not account for next-worst failures during safing. @[CR 7663 ]*

## FLIGHT RULES

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12A\_C2-102

ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE  
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON) @ED ]

- A. CSCS/LON WILL BE CONSIDERED IN SUPPORT OF THE FOLLOWING ORBITER FAILURE SCENARIOS: @[CR 7661 ]
1. ORBITER SYSTEMS FAILURES THAT RESULT IN THE INABILITY OF THE ORBITER TO PERFORM A SUCCESSFUL ENTRY AND LANDING
  2. ORBITER SYSTEMS FAILURES THAT RESULT IN A LOW PROBABILITY OF A SUCCESSFUL ENTRY, LANDING, AND CREW SURVIVAL
  3. IN A FAIL CRITICAL SCENARIO AS MITIGATION TO PROVIDE TIME TO PROPERLY ASSESS AND EVALUATE THE ORBITER SYSTEMS FAILURES AND ASSOCIATED RISKS OF ENTRY AND LANDING
  4. IN SUPPORT OF A SUSPECT TPS SCENARIO UNTIL THE TPS DAMAGE AND, IF REQUIRED, TPS REPAIR HAVE BEEN CLEARED TO SUPPORT ENTRY
- B. THE CSCS/LON OPTION IS CONSIDERED AVAILABLE IF THE CAPABILITY OF THE COMBINED ORBITER AND ISS ASSETS CAN SUPPORT THE ISS CREW AND STRANDED STS CREW UNTIL ARRIVAL OF THE LON RESCUE VEHICLE.
- C. CSCS/LON CONSIDERATION CRITERIA:
1. PRE-DOCKING:  
  
THE CSCS/LON OPTION WILL BE CONSIDERED PROVIDED THE ORBITER CAN ACHIEVE A SAFE DOCKING WITHOUT PUTTING THE ISS AT UNACCEPTABLE RISK AND DOES NOT IMPACT THE CAPABILITY OF RETURNING THE ISS CREW SAFELY TO EARTH VIA SOYUZ. @[CR 7661 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C2-102      ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE  
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)  
(CONTINUED)

2. DOCKED: @[CR 7661 ]

THE CSCS/LON OPTION WILL BE CONSIDERED PROVIDED THAT REMAINING DOCKED DOES NOT IMPACT THE CAPABILITY OF RETURNING THE ISS CREW SAFELY TO EARTH VIA SOYUZ.

3. POST-UNDOCKING:

THE CSCS/LON OPTION WILL NOT BE PROTECTED AFTER A PLANNED UNDOCKING (PROPELLANT WILL NOT BE REDLINED FOR RE-RENDEZVOUS ATTEMPT). HOWEVER, IF PROPELLANT IS AVAILABLE FOR A RE-RENDEZVOUS ATTEMPT, CSCS BECOMES AN OPTION PROVIDED IT CAN MEET THE PRE-DOCKING CONSTRAINTS DEFINED ABOVE.

D. ORBITER SYSTEMS FAILURE RESPONSE CSCS/LON

1. TIME PERMITTING, THE MMT WILL HAVE THE FINAL DECISION IF CSCS/LON SHOULD BE INVOKED.
2. IF THE ORBITER SYSTEM FAILURE REQUIRES IMMEDIATE RESPONSE, THE FLIGHT CONTROL TEAM WILL EVALUATE THE ORBITER FAILURE, SYSTEMS CAPABILITIES, CURRENT MISSION ACTIVITIES, AND AVAILABLE LANDING OPPORTUNITIES, AND WEIGH THE ASSOCIATED RISKS TO SELECT THE PROPER COURSE OF ACTION TO SAFELY RETURN THE CREW.

*With an operational ISS, additional operational flexibility and options become available. CSCS/LON is one of those options.*

*In the event that an orbiter failure(s) occurs that does not permit a safe reentry and landing of an orbiter, there are limited options to pursue. Although it has risks in itself, the CSCS/LON provides the opportunity and some finite time to allow a rescue mission to be attempted versus committing to an unsurvivable entry (or doing nothing at all). @[CR 7661 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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12A\_C2-102

**ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE  
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)  
(CONTINUED)**

*For the cases where the orbiter failure(s) results in a low probability of a safe landing or crew survival, consideration will be given to invoking CSCS/LON if the rescue mission improves upon the probability of survival. The risks of returning versus the risks of invoking the CSCS/LON will need to be weighed dependent upon the extent of the orbiter failure(s), the CSCS support duration/reliability, and LON rescue mission readiness. ©[CR 7661 ]*

*The CSCS/LON capability may also be considered as a mitigation option to provide additional time to properly assess and evaluate the orbiter systems failures and associated risks of entry and landing. For the fail-critical scenario, although the orbiter is one failure away from losing deorbit/entry capability, the prudent option would be to fully understand the failure mechanisms/causes and to evaluate the risks and probabilities of the next failure to ensure that the vehicle can support deorbit and entry.*

*For the TPS-suspect scenario, there is a concern that the TPS cannot safely support a nominal deorbit and entry of the orbiter. Until the TPS damage or repair is cleared for entry, the CSCS/LON option will be considered.*

*The CSCS/LON capability is considered available if the capability of the ISS and orbiter resources can support the ISS and shuttle crews until arrival of the LON rescue vehicle.*

*Although the orbiter may be in an unsafe entry configuration, consideration must be given to ensure that continuing to docking does not put the ISS at unacceptable risk or impact the capability of the ISS crew returning to Earth via the Soyuz. The capability to safely dock must be available. The concern is that if docking is continued, knowing that the required systems capability is unavailable, ISS crew safety could be jeopardized. This is a tough call, but all risks and consequences must be weighed.*

*While docked, the same considerations must be evaluated.*

*Re-rendezvous to the ISS post undocking is not nominally protected or redlined. Redlining this propellant would be an impact to the nominal planning of the mission. Post undocking, if propellant is available that would support a re-rendezvous, the same pre-docking constraints must be met for the second docking attempt. Since the orbiter failure requiring CSCS/LON does not permit a safe reentry and landing of the orbiter, deorbit and entry propellant can be used as part of the re-rendezvous propellant requirements since it will not be used to attempt an unsurvivable entry. Loss of the deorbit propellant would prohibit a disposal burn but would provide the opportunity to rendezvous and dock with the ISS. ©[CR 7661 ]*

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## FLIGHT RULES

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**12A\_C2-102      ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE  
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)  
(CONTINUED)**

*It should also be noted that the CSCS/LON duration would also be impacted since a nominal docked shuttle mission was flown prior to the orbiter failure post undocking. At this point in the mission, there are minimal orbiter consumables that remain, thus providing minimal contribution to the CSCS stay. Although the rescue vehicle has had 10-11 days of processing time since the launch of the current mission, the available CSCS duration may not be sufficient to support the rescue flight. Again a tough call, but the number one goal is to use all available options to provide the opportunity to get the shuttle crew safely home (versus doing nothing). ©[CR 7661 ]*

*The requirement to protect an unmanned undocking capability is not considered as mandatory and is not included as part of the rule. The CSCS/LON scenario is invoked because the orbiter has sustained a failure that does not permit a safe reentry and landing of the orbiter. If the orbiter can get safely docked, the opportunity exists to get the stranded crew safely home.*

*The optimal unmanned undocking procedure would include the disposal burn. If the orbiter failure is such that you have achieved docking (or are already docked), but does not provide a CSCS undocking/separation capability, there are other undocking options available that were reviewed at the ISS Safe Haven JOP's. For instance, a +Rbar docking could be performed that does not require any active attitude control and Orbital Mechanics takes care of separating the vehicles. The drawback is that a disposal burn cannot be performed. For the scenario where the orbiter cannot be undocked, once the cryo consumables are depleted, the Orbiter Docking System (ODS), Pressurized Mating Adapter (PMA), and Lab hatches will be closed.*

*Time permitting, the MMT will have the final decision in invoking CSCS/LON option. If the orbiter system failure requires immediate response, the Flight Control Team will use the available data to determine the proper course of action to safely return the crew (Emergency D/O or CSCS).*

*The bottom line is, all that can be done will be done to improve the probabilities and risks to provide the opportunity to get the stranded shuttle crew safely home.*

*Reference Rules {A2-101}, VEHICLE SYSTEMS REDUNDANCY DEFINITIONS; {12A1\_C2-103}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI]; and {12A\_C2-104}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) DECLARATION ACTIONS [RI]. ©[CR 7661 ]*

## FLIGHT RULES

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### 12A\_C2-103

### CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI]

CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) IS A NON-CERTIFIED CAPABILITY THAT WILL BE USED TO SUSTAIN A STRANDED STS CREW ON BOARD THE ISS IN SUPPORT OF AN STS RESCUE MISSION. ALL AVAILABLE ISS AND ORBITER RESOURCES ARE UTILIZED TO PROVIDE AN ON-ORBIT SAFE HAVEN UNTIL RESCUE MISSION ARRIVAL. ©[CR 7641 ]

*The ISS is certified to support three crewmembers based on the Soyuz return capability. The CSCS is a non-certified capability that is utilized as part of an “All out Effort” to provide the opportunity to safely return the STS crew home (up to seven crewmembers) via an STS rescue mission in the event that the orbiter has been declared “unflyable” and cannot perform a successful entry and landing.*

*The CSCS “Safe Haven” duration is dependent upon available orbiter and ISS consumables and resources to achieve the maximum duration possible. The orbiter is powered down to levels that maximize the docked duration while still supporting the STS crewmembers’ life support and hygiene needs and protecting the critical equipment required for unmanned undock and disposal. Although water, food, LiOH, etc. will be transferred from the orbiter prior to the unmanned undocking, the duration relies on critical ISS equipment (that may not have redundancy) and waste management supplies and food that are nominally manifested and scheduled for three-crew support. It is assumed that the orbiter has not sustained damage that would prevent it from supporting the STS crew while docked or prevent water, food, O<sub>2</sub>, etc. to be transferred to the ISS.*

*Additionally, rescue mission success relies on a successful launch of the rescue STS (high probability based on launch history) and the commitment to possibly launch without resolving the failure which caused the previous orbiter to become “unflyable.”*

*To provide the maximum duration possible, the ISS consumables are used to “zero” remaining. Using the ISS consumables to “zero” will result in de-manning of the ISS until a resupply is performed. For the CSCS contingency scenario, the demanning of the ISS is of a small consequence if there is any chance of returning the stranded STS crew safely home.*

*Reference Rule {12A\_C2-104}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) DECLARATION ACTIONS [RI], and NSTS 21519, LON Crew Rescue Flight MIP. ©[CR 7641 ]*

## FLIGHT RULES

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12A\_C2-104

CONTINGENCY SHUTTLE CREW SUPPORT (CSCS)  
DECLARATION ACTIONS [RI]

ONCE IT IS DETERMINED THAT THE ORBITER IS "UNFLYABLE" AND CANNOT PERFORM A SUCCESSFUL ENTRY AND LANDING, THE CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) WILL BE DECLARED. ©[CR 7641 ]

IN SUPPORT OF THE CSCS, THE FOLLOWING ACTIONS WILL BE INVOKED:

- A. ORBITER CSCS GROUP C+ POWERDOWN
- B. THE LAUNCH ON NEED (LON) RESCUE MISSION
- C. TRANSFER OF MANDATORY ITEMS TO THE ISS PRIOR TO CLOSEOUT/UNDOCKING OF ORBITER AS DEFINED IN NSTS-21519, LAUNCH ON NEED CREW RESCUE FLIGHT MIP
- D. CONSUMABLES MANAGEMENT OPTIMIZATION TO MAXIMIZE CSCS CAPABILITIES
- E. STS CREWMEMBER FOOD RATIONING AS REQUIRED
- F. TRANSFER OF ISS TRASH AND DISPOSAL ITEMS TO THE ORBITER AS THE AVAILABILITY EXISTS
- G. UNMANNED ORBITER UNDOCKING AND DISPOSAL BURN AT CSCS UNDOCKING REDLINE

*All efforts will be made to repair the orbiter for a safe deorbit, entry, and landing. The CSCS scenario will only be declared when it is determined that the orbiter is "unflyable" and cannot support a successful entry and landing. Once the CSCS is declared, multiple activities are invoked in support of the CSCS scenario.*

*The CSCS Group C+ is performed to power down the orbiter to levels that maximize the docked duration while still supporting the STS crewmembers' life support and hygiene needs and protecting the critical equipment required for unmanned undock and disposal.*

*The Launch on Need Rescue mission is put in motion and processing is initiated.*

*Critical consumables, equipment, and crew comfort items are transferred over to the ISS to maximize CSCS duration and maintain crew health. The critical transfer items have been identified in NSTS-21519, Launch on Need Crew Rescue Flight MIP. ©[CR 7641 ]*

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## FLIGHT RULES

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12A\_C2-104

**CONTINGENCY SHUTTLE CREW SUPPORT (CSCS)**  
**DECLARATION ACTIONS [RI] (CONTINUED)**

*Although for RTF missions, a prelaunch assessment of CSCS duration will be performed, all efforts will be made to maximize CSCS duration by optimizing real-time consumables management. Assumptions for pre-flight assessment are included in NSTS-21519, Launch on Need Crew Rescue Flight MIP. ©[CR 7641 ]*

*Food rationing for the STS crew will begin as determined by available food at CSCS declaration.*

*As the capability exists, ISS trash and crew disposal items will be transferred over to the orbiter to aid in ISS cleanup. Exact locations of the transferred items are not required since the CG impacts will not effect the disposal burn/shuttle breakup.*

*The damaged orbiter will be undocked prior to violating the cryogenic redline requirements to perform an unmanned undocking and disposal burn. The redline assumptions are included in NSTS-21519, Launch on Need Crew Rescue Flight MIP. A backup opportunity for the disposal burn will be planned to be available on undock day.*

*Reference Rule {12A\_C2-103}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI], and NSTS-21519, Launch on Need Crew Rescue Flight MIP. ©[CR 7641 ]*

## FLIGHT RULES

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### 12A\_C2-105

### POWERDOWNS FOR SAFE HAVEN RISK

- A. A MODIFIED GROUP C POWERDOWN WILL BE MAINTAINED TO THE EXTENT PRACTICAL IF ENTRY CRITICAL TPS DAMAGE IS SUSPECTED AND BEFORE IT HAS BEEN CLEARED FOR DEORBIT. ©[CR 7641 ]

*The orbiter is typically in a Group B powerdown while docked to ISS. A modified Group C powerdown will conserve more cryogenics and add margin for docked operations, end of mission, and an unmanned undocking scenario. Although this is not likely to add days of capability, it is prudent to add as much margin as possible.*

- B. THE CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) GROUP C+ POWERDOWN WILL ONLY BE IMPLEMENTED AFTER A MANNED DEORBIT HAS BEEN GROUND RULED OUT.

*The CSCS Group C+ powerdown protects the critical orbiter equipment and hardware required to perform unmanned undocking and disposal burn while providing maximum docked duration. The powerdown does not protect critical equipment/hardware required to preserve entry capability. Once the orbiter has been determined to be "unflyable," the CSCS scenario will be declared and the Group C+ power-down actions performed to maximize CSCS capability in support of the rescue mission.*

*The CSCS Group C+ powerdown will not be used until that decision is made to avoid prematurely losing the deorbit capability.*

*Reference: ISS Safe Haven JOP#4 and #6 for Group C+, unmanned undocking, and LON. ©[CR 7641 ]*

# FLIGHT RULES

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## SECTION 3 - GROUND INSTRUMENTATION

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# FLIGHT RULES

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## FLIGHT RULES

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### SECTION 3 - GROUND INSTRUMENTATION

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#### SHUTTLE ONLY RULES

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#### 12A\_A3-1

#### EDWARDS AIR FORCE BASE TACAN UTILIZATION

FOR SPACE SHUTTLE LANDINGS AT EDWARDS AIR FORCE BASE, THE EDWARDS 111X TACTICAL AIR COMMAND AND NAVIGATION SYSTEM (TACAN) OPERATING AT 1.0 KW POWER WILL BE USED AS THE PRIME TACAN. @[CR 7442A ]

*As part of an Air Force Material Command effort to upgrade their TACAN systems, the Edwards 111X TACAN was replaced in February 2006. The old Edwards TACAN was operated at 3.0 kW transmit power, while the new TACAN is only 1.0 kW transmit power. Rule {A3-201}, TACAN REDUNDANCY REQUIREMENTS AND ALTERNATE TACAN SELECTION PHILOSOPHY [HC], defines the minimum power level requirement as 1.5 kW. For ascending end of mission (EOM) continental United States (CONUS) landings, 1.5 kW provides greater than 30 seconds for evaluation and incorporation of TACAN data before 3-sigma navigation downtrack errors will exceed guidance constraints. Reference A/EFTP #216, December 16, 2005.*

*Based on Spacecraft Trajectory Analysis and Mission Planning System (STAMPS) analysis, the three most preferred alternate Edwards area TACAN's (Lake Hughes 21X, Gorman 108X, and Pomona 41X) showed good navigation performance at high altitudes/early Mach numbers (above 50 kft), but experienced brief exceedance of downtrack and/or crosstrack guidance constraints by 3-sigma nav errors between 45 kft and 20 kft. Although the new 1.0 kW EDW 111X is below the 1.5 kW power level requirement, the on-field Edwards TACAN provides the best navigation performance in the Terminal Area Energy Management (TAEM), Heading Alignment Cone (HAC), and Approach and Land (A&L) regions. It is more important to have accurate navigation in these regions because of the limited time and capacity to correct for energy problems that can be caused by inaccurate navigation in these final guidance phases.*

*Based on Dynamic Environment Communications Analysis Testbed (DECAT) radio frequency (RF) analysis, delayed lock-on is expected for the lower power level, with 2-LRU lock expected by 133 kft. STAMPS predicts that 3-sigma nav errors will exceed guidance constraints if TACAN's are not processed by 126 kft. So, based on DECAT and STAMPS, there would be approximately 26 seconds (7 kft altitude) to evaluate and incorporate TACAN's on a 3-sigma nav day before guidance constraints are exceeded. However, based on flight history, 3-sigma nav errors do not exceed guidance constraints (if TACAN's are not processed) until 116 kft. So, based on DECAT and flight history, there would be approximately 63 seconds (17 kft altitude) to evaluate and incorporate TACAN's on a 3-sigma nav day before guidance constraints are exceeded. The primary difference between STAMPS and flight history nav error estimates is that STAMPS assumes inertial measurement unit (IMU) accuracy according to specification drift rates while IMU flight performance is significantly better than spec. @[CR 7442A ]*

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## FLIGHT RULES

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12A\_A3-1

**EDWARDS AIR FORCE BASE TACAN UTILIZATION**  
**CONTINUED**

*For STS-115 Deorbit/Entry this rule allows the use of the Edwards TACAN at a 1.0 kW transmit power and supersedes the 1.5 kW minimum TACAN power defined in Rule {A3-201}, TACAN REDUNDANCY REQUIREMENTS AND ALTERNATE TACAN SELECTION PHILOSOPHY [HC]. This annex rule applies only to the Edwards 111X TACAN for ascending approaches and these results cannot be extrapolated to other TACAN's. The Edwards 111X TACAN utilizes improved technology that reduces line losses between the antenna and the transmitter and provides for a more effective antennae pattern allowing for lock on at longer range. ©[CR 7442A ]*

*Reference: A/EFTP #220, May 19, 2006, for analysis details. ©[CR 7442A ]*

## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS

FOR STS-115/12A, HIGH-SPEED TRACKING FOR LAUNCH AND DEORBIT/ENTRY IS MANDATORY AS FOLLOWS: @[CR 7629 ]

A. ASCENT AND FD1 ABORTS:

1. ASCENT RADAR TRACKING: DUAL SOURCE HIGH-SPEED GROUND TRACKING FROM KSC AREA ASSETS IS MANDATORY FROM LIFTOFF THROUGH 7:30 MET. DUAL SOURCE HIGH-SPEED GROUND TRACKING FROM THE WALLOPS AREA RADARS IS HIGHLY DESIRABLE FROM AOS THROUGH MECO PLUS 1 MINUTE.

*Powered Flight Tracking: Dual source high-speed tracking from one S-band system and one C-band radar or from two C-band radars is required during powered flight to provide confirmation of a good MCC ground Kalman filter solution. The MCC ground filter provides the real-time capability to monitor onboard navigation health during powered flight and to perform delta state uplinks for correction of extreme onboard navigation errors which could result in unsafe or mission-limiting MECO conditions for nominal ascent or aborts. Ground tracking also provides an independent navigation source to assess ascent performance for abort boundary calls and public safety.*

*Range Safety: Upon removal of the ET Range Safety destruct package, the flight crew/MCC assumes responsibility for public safety during second stage ascent. The tracking based navigation state precludes limit line violation due to severe onboard navigation problems (state vector update or manual MECO) and prevents loss of External Tank Impact Point (ETIP) prediction due to telemetry loss/data dropouts. The ETIP no longer endangers North American landmasses or islands at 7:30 MET, so tracking beyond this time is not required. Note that the Eastern Range has a similar tracking requirement for public safety purposes ending at the same time.*

*Wallops Tracking: Wallops area high speed C-band tracking is highly desirable for ascent trajectory evaluation near the northeast coastline after 7:30 MET. Although dual source Wallops tracking is highly desirable, a good MCC ground filter solution can be maintained on a single Wallops radar if confirmed on dual sources prior to KSC area radar LOS. Dual source Wallops C-band tracking will normally be scheduled for ascent support, but the launch shall not be scrubbed for loss of Wallops C-band tracking capability. @[CR 7629 ]*

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## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

*Post MECO Tracking: Dual source Wallops C-band tracking is highly desirable through MECO plus 1 minute to provide an accurate post-MECO ground filter vector. A minimum of 1 minute of post-MECO high-speed tracking is required for processor convergence after the powered flight ascent phase ends. An accurate post-MECO ground filter vector may be used to update onboard navigation before OMS-2 if required to significantly decrease planar delta-V for ground-up rendezvous missions, or before OMS-1 or OMS-2 if the delta-V capability gain would prevent ascent capability downmoding. ©[CR 7629 ]*

2. RTLS ENTRY RADAR TRACKING: DUAL SOURCE HIGH-SPEED GROUND TRACKING IS MANDATORY FROM RTLS MECO THROUGH TOUCHDOWN.

*Similar to the powered flight and post MECO timeframes, dual source high-speed ground tracking is required to provide an independent ground-based navigation source for MCC real-time operations, post-flight analysis capability, and trajectory reconstruction. Dual source tracking from either one S-band system and one C-band radar or two C-band radars, is required to provide confirmation of a good MCC ground Kalman filter solution. The MCC ground filter provides the real-time capability to monitor onboard navigation health, to perform delta state uplink for correction of navigation error exceeding delta state limits, and to perform Ground Controlled Approaches (GCA) for off-nominal trajectory dispersions. The dual source tracking requirement for RTLS entry can be satisfied with the same S-band systems and C-band radars required for ascent support.*

3. AOA/FIRST DAY PLS/NEXT PLS: FOR LAUNCH COMMIT, DUAL SOURCE HIGH-SPEED GROUND TRACKING IS HIGHLY DESIRABLE FROM 130 KFT TO TOUCHDOWN.

*For the purposes of launch commit, scheduling high-speed tracking support for AOA, FD1, or next PLS is only highly desirable due to the low probability of failures requiring an AOA or FD1 PLS and the associated complexity and additional launch constraints created by scheduling two additional ranges (Western Test Range (WTR) and White Sands Missile Range (WSMR)) for the required support. When tracking is highly desirable, there is a high probability of obtaining support for KSC or EDW area radars on a best effort basis if the ranges are given more than 3 hours advance notice. There is little chance of obtaining such support for a NOR AOA or PLS unless the request is made during normal duty hours. Additionally, for other PLS opportunities tracking support is virtually assured at all three CONUS sites, given 24 hours notice. ©[CR 7629 ]*

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## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

*C-band radars located within about 25 miles of the landing site can provide tracking capability from 130 Kft to touchdown. For Edwards landing, tracking from one Vandenberg and one Dryden radar satisfies the requirement for dual source tracking to touchdown, even though the Vandenberg radars are capable of tracking to only an altitude of approximately 40 Kft. For this situation, the MCC ground filter solution would be confirmed on dual sources prior to the Vandenberg tracking LOS, and a confirmed Dryden single source solution could be maintained until touchdown. This is applicable for any landing at Edwards including FDI PLS, next PLS, or EOM. ©[CR 7629 ]*

*KSC: Although dual source tracking is not specifically required for AOA, tracking for a KSC AOA will be available since the Eastern Range C-band radars and MILA S-band are already scheduled to support launch. They are effectively scheduled for AOA since they are not released until the "Go for orbit OPS." Thus support would be extended for a KSC AOA landing and could be extended for a KSC Rev 5 or 6 FDI deorbit.*

*EDW: For a FDI PLS to Edwards AFB, the Dryden C-band radars are already scheduled for on-orbit tracking in this timeframe. With pre-launch scheduling of the associated Western Range support, the Dryden C-band radars will be available to provide high speed tracking for a Rev 3 PLS for little additional cost. Thus, although not required for launch commit, the EDW radars will be scheduled for FDI PLS support.*

*NOR: Due to the low probability of AOA or FDI NOR PLS, and the significant scheduling costs for the WSMR C-band radars, these radars will not normally be scheduled pre-launch. The additional cost is not warranted since high-speed tracking will be available at KSC and EDW.*

*The specific redundant tracking requirement and benefits of high-speed tracking for an AOA, FDI PLS, or next PLS entry are the same as those discussed for RTLS entry.*

4. FDI PLS ONLY: AT LEAST ONE TDRS OR TWO C-BAND RADAR PASSES ARE REQUIRED TO SUPPORT PRE-DEORBIT STATE VECTOR ACCURACY.

*Post MECO, tracking is required for FDI deorbit in order to ensure the onboard state vector meets deorbit burn accuracy requirements. For high inclination launches (57 deg and 51.6 deg), at least one TDRS is required for orbit 3 deorbit because the ground track does not permit adequate C-Band coverage (ref. Rules {A4-101}, ONBOARD NAVIGATION MAINTENANCE, and {A3-102}, INTEGRATED NETWORK FAILURE DECISION MATRIX). ©[CR 7629 ]*

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## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

5. EOM RADAR TRACKING FOR LAUNCH COMMIT: FOR LAUNCH COMMIT AND SCHEDULING PURPOSES, EOM DUAL SOURCE HIGH-SPEED TRACKING CAPABILITY FROM 130K FEET TO TOUCHDOWN IS MANDATORY. ©[CR 7629 ]

*For launch commit, confirmation of the availability of the required tracking resources for the planned nominal End-of-Mission (EOM) site is required. The required tracking resources include the radars, the ER Range Operations Control Center, and other resources required for the transmission of the high-speed tracking data.*

*Test Vehicle Considerations For Ascent Tracking: In general, the orbiter is considered a developmental flight vehicle. For these reasons alone, redundant high-speed tracking systems are required to provide the necessary independent source for re-constructing the vehicle trajectory and navigation state for post flight ascent analyses, as well as for providing the MCC with independent real-time navigation state and energy determination for off-nominal operations.*

*These STS-115 flight specific high-speed tracking requirements for ascent and FDI intact aborts supersede those in Rule {A3-3}, GROUND AND NETWORK DETAILED REQUIREMENTS, Paragraph A4, Ascent Trajectory Processing.*

B. DEORBIT/ENTRY:

1. DUAL SOURCE HIGH-SPEED TRACKING FROM 130 KFT TO TOUCHDOWN IS MANDATORY FOR COMMIT TO DEORBIT.

*Dual source high-speed ground tracking is required to provide an independent ground-based navigation source for MCC real-time operations, post-flight analysis, and trajectory reconstruction. Real-time operations may include onboard navigation monitoring, delta state uplink for correction of extreme navigation errors, and GCA's for off-nominal trajectory dispersions. Redesignation to another landing site or wave-off to a later deorbit opportunity will be considered to gain dual source tracking for landing.*

*The specific redundant tracking requirement and benefits of high-speed tracking for an EOM entry are the same as those discussed for RTLS entry. ©[CR 7629 ]*

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## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

2. FOR PLANNED DEORBIT OPPORTUNITIES, THE SCHEDULING OF GROUND C-BAND TRACKING SUPPORT TO MAXIMIZE THE DURATION OF TRACKING COVERAGE FROM DEORBIT TO 130 KFT IS HIGHLY DESIRABLE. FOR TRACKING COVERAGE BELOW 300 KFT, DUAL SOURCE HIGH-SPEED TRACKING IS HIGHLY DESIRABLE. ©[CR 7629 ]

*C-band tracking along the entry ground track is highly desirable to provide an independent ground-based navigation source for MCC real-time operations, post-flight analysis and trajectory reconstruction. In real time, the C-band tracking data processing provides additional capability to evaluate the accuracy of other navigation sources (e.g., Primary Avionics Software System (PASS), BFS, GPS, ground ephemeris).*

*The MCC on-orbit tracking data processor is capable of processing either high-speed or low-speed tracking data to minimum altitude of 300K feet. Below 300K feet, the MCC ground Kalman filter provides the capability to process high-speed tracking data.*

*For scheduling purposes, only C-band tracking passes with an expected maximum elevation greater than 5 degrees will be scheduled in order to provide a reasonable assurance that the radar will be capable of acquiring valid tracking. Efforts will be made to schedule C-band radars to provide additional tracking coverage following deorbit and prior to the acquisition of the landing area C-band radars, but deorbit delay will not be considered to gain the additional tracking coverage.*

*RTF Considerations For Entry Tracking: In general, the orbiter is considered a developmental flight vehicle and in many respects every shuttle mission is a flight test since only 114 flights have transpired in the life of the Program. For these reasons alone, redundant high-speed entry tracking is required to provide the necessary independent source for re-constructing the vehicle trajectory and navigation state for post flight analyses, as well as for providing the MCC with an independent real-time navigation state and energy determination for off-nominal operations.*

*For STS-115 these flight specific high speed tracking requirements for deorbit/entry supersede those in Rule {A3-3B}.3, GROUND AND NETWORK DETAILED REQUIREMENTS, Entry Trajectory Processing. ©[CR 7629 ]*

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## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

C. THE FOLLOWING ADDITIONAL HIGH-SPEED TRAJECTORY DETERMINATION CAPABILITIES ARE REQUIRED FOR BOTH LAUNCH AND LANDING: ©[CR 7629 ]

1. HIGH-SPEED S-BAND - HIGHLY DESIRABLE. WILL BECOME MANDATORY FOR LOSS OF REDUNDANT C-BAND CAPABILITY.
2. HIGH-SPEED C-BAND - MANDATORY
3. KALMAN FILTER PROCESSING - MANDATORY

*These flight specific high speed trajectory requirements supersede those in Rule {A3-51}, TRAJECTORY PROCESSING REQUIREMENTS.*

D. THE FOLLOWING ADDITIONAL NETWORK CAPABILITIES ARE REQUIRED TO ROUTE HIGH HIGH-SPEED TRACKING DATA TO THE MCC:

1. MCC/KSC/45 SPACE WING INTERFACE: 7.2-KB LAUNCH/LANDING RADAR CIRCUIT - ONE OF TWO MANDATORY.

*These circuits provide launch/landing C-band tracking data from the 45th Space Wing Range Operations Control Center to the MCC. These are redundant circuits providing backup capability, each one capable of carrying the total traffic.*

2. FOR KSC LANDINGS (AOA, PLS, EOM): MIL 9.6-KB S-BAND HIGH SPEED TRACKING DATA CIRCUIT-HIGHLY DESIRABLE. WILL BECOME MANDATORY FOR LOSS OF REDUNDANT C-BAND TRACKING CAPABILITY.

*This circuit routes MILA high speed S-band tracking data to GSFC so that it can transmitted to the MCC.*  
©[CR 7629 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A3-2

### MANDATORY HIGH-SPEED TRACKING LAUNCH AND LANDING REQUIREMENTS (CONTINUED)

3. FOR EDW LANDINGS (PLS OR EOM): 9.6-KB VAFB AND 2.4-KB DFRC LANDING RADAR CIRCUITS-EITHER ONE OF TWO VAFB OR ONE OF ONE DFRC CIRCUITS MANDATORY IF TWO DRYDEN RADARS SCHEDULED FOR SUPPORT. IF EITHER DRYDEN RADAR IS UNAVAILABLE, ONE OF TWO VAFB CIRCUITS MANDATORY. ©[CR 7629 ]

*Each of two VAFB circuits is capable of providing high-speed tracking data from four Western Range and/or Dryden C-band radars. The DFRC circuit is capable of providing high speed tracking from only the two Dryden C-band radars. If both Dryden C-band radars are scheduled for support, any of the three circuits is capable of providing mandatory dual source high-speed tracking support for Edwards AOA/PLS. If both Dryden C-band radars are not available, then one of two of the VAFB circuits is required to provide dual source tracking support.*

4. FOR NORTHRUP LANDINGS (PLS OR EOM) - WSMR 2.4-KB LANDING RADAR CIRCUIT - ONE OF TWO MANDATORY.

*Each of these two circuits is capable of providing high-speed tracking data from two WSMR C-band radars. A single circuit is capable of providing mandatory dual source high-speed tracking support for Northrup AOA/PLS.*

*For STS-115, these flight specific high speed tracking requirements and associated network capabilities supersede those in Rules {A3-151}, MCC/KSC/45 SPW INTERFACE; {A3-152}, GSFC/STDN INTERFACE; {A3-153}, 45 SPW/VAFB INTERFACE; and {A3-154}, 45 SPW/WSMR INTERFACE. ©[CR 7629 ]*

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## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

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## FLIGHT RULES

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JOINT SHUTTLE/ISS RULES

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THERE ARE NO STS-115/12A JOINT SHUTTLE/ISS RULES FOR THIS SECTION

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 4 - TRAJECTORY AND GUIDANCE

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# FLIGHT RULES

## SECTION 4 - TRAJECTORY AND GUIDANCE

### SHUTTLE ONLY RULES

#### 12A\_A4-1

#### SHUTTLE TRAJECTORY AND GUIDANCE PARAMETERS

STS-115 FLIGHT-SPECIFIC TRAJECTORY AND GUIDANCE PARAMETERS AS THEY RELATE TO THE GENERIC RULES ARE LISTED IN THE FOLLOWING TABLE:

RULE REFERENCE	PARAMETER	VALUE
ALL	NOMINAL THROTTLE	104%
ALL	ABORT THROTTLE	104%
ALL	MAX THROTTLE	109%
ALL	THRUST BUCKET	72%
{A4.1.2-6}	DELTA V ABOVE AFT PRESS QTY	87.4 FT/SEC
{A4.1.1-1A}	2 SIGMA + MEAN INFLT FPR	2096 LBS
{A4.1.1-1B}	3 SIGMA + MEAN INFLT FPR	3098 LBS
{A2.1.2-2}, {A4.1.2-6}	MINIMUM HP	85 NM
{A4.1.2-6}	DESIGN MECO UNDERSPEED	160 FT/SEC
{A4.1.2-6}	CRITICAL MECO UNDERSPEED 1 ENGINE OUT CRITICAL MECO UNDERSPEED 2 ENGINES OUT	562 FT/SEC 542 FT/SEC
{A4.1.2-8A}	NOMINAL	40 FT/SEC
{A2.1.4-5B}	UNDISPERSED CROSSRANGE ASCENDING LEFT ASCENDING RIGHT DESCENDING LEFT DESCENDING RIGHT	838 NM 893 NM 849 NM 887 NM
{A4.1.3-7E}	DISPERSED CROSSRANGE ASCENDING LEFT ASCENDING RIGHT DESCENDING LEFT DESCENDING RIGHT	779 NM 826 NM 785 NM 823 NM
{A4.1.4-9}	CONT PAYLOAD RETURN AFTER ORBIT 3	N/A

©[CR 7626 ]

## FLIGHT RULES

**12A\_A4-2**

**SHUTTLE MANEUVER DEFINITION**

- A. STS-115 FLIGHT CYCLE MANEUVERS FOR THE NOMINAL FD3 (BACKUP FD4) DOCKING RENDEZVOUS PROFILE ARE CLASSIFIED AS "CRITICAL" OR "NONCRITICAL" PER THE FOLLOWING TABLE. APPROPRIATE VGO TRIMS ARE ALSO INCLUDED.

MANEUVER	CRITICALITY	VGO TRIMS (FPS)
OMS-2	CRITICAL FOR CREW SAFETY	$ VGOX  < 0.2;  VGOY/Z  < 2$
NC-1	NONCRITICAL	$ EACH VGO  < 0.2$
NC-2	NONCRITICAL	$ EACH VGO  < 0.2$
NPC	NONCRITICAL (IF REQUIRED)	$ EACH VGO  < 0.2$
NC-3	CRITICAL	$ EACH VGO  < 0.2$
NC-4	CRITICAL FOR MISSION SUCCESS (FD3 RNDZ); NONCRITICAL FOR FD4 RNDZ	$ EACH VGO  < 0.2$
NC-5	NONCRITICAL AND ONLY REQUIRED FOR FD4 RNDZ	$ EACH VGO  < 0.2$
NH	CRITICAL FOR MISSION SUCCESS (IF REQUIRED)	$ EACH VGO  < 0.2$
NC-6	CRITICAL FOR MISSION SUCCESS AND ONLY REQUIRED FOR FD4 RNDZ	$ EACH VGO  < 0.2$
NCC	CRITICAL FOR MISSION SUCCESS	$ EACH VGO  < 0.2$
TI	CRITICAL FOR MISSION SUCCESS	$ EACH VGO  < 0.2$
SEP	CRITICAL FOR CREW SAFETY	N/A
ORBIT ADJUST	NONCRITICAL (IF REQUIRED)	$ EACH VGO  < 0.2$
DEORBIT	CRITICAL FOR CREW SAFETY	$  VGOX/Z  < 2; DO NOT TRIM VGOY$

©[CR 7627 ]

- B. A PROP, GNC, OR DPS SYSTEM FAILURE ENCOUNTERED DURING A NONCRITICAL BURN WILL BE CAUSE FOR IMMEDIATE BURN TERMINATION AND VGO'S WILL NOT BE TRIMMED.

*A critical burn is one that cannot be rescheduled while non-critical burns can be rescheduled without major impact to the mission. This distinction affects crew procedures during the burn as far as continuing the burn after a systems failure and it affects the number of downmode options that are protected. Generally, noncritical phasing and plane change burns can be slipped at least one orbit without impact to crew safety or mission success. However, each such burn possesses an optimal TIG for propellant consumption and relative motion during a given orbit. In addition, any two phasing burns should be separated by a period of time sufficient to permit post-burn tracking of the first burn to be reflected in targeting of the second. Perturbations due to attitude maneuvers, water dumps, etc., should also be minimized for the phasing burn prior to crew sleep preceding day-of-rendezvous. In this way, target range deviations from 40 nm at the final phasing burn can be minimized to standardize subsequent relative motion.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A4-2

### SHUTTLE MANEUVER DEFINITION (CONTINUED)

*OMS-2, SEP, and deorbit are always critical to crew safety because they may result in uncontrolled atmospheric entry or orbiter/ISS recontact if TIG is slipped or an underburn is performed (ref Rule {A4-158}, MANEUVER EXECUTION MATRIX). On a ground-up rendezvous, OMS-2 is also considered the first rendezvous burn. All OMS-2 VGO's should ideally be trimmed to < 0.2 fps in magnitude (reference Rule {A2-124}, RENDEZVOUS MANEUVER EXECUTION), but ascent navigation accuracy does not generally support this. However, trim error magnitude < 0.2 fps in each VGO axis is assumed by rendezvous burn sequence design such that navigation errors will not drive any burn retrograde. This design is particularly sensitive to VGOX residuals. Covering greater VGOX residuals by design would result in a smaller rendezvous launch window maximum phase angle limit.*

*NC-3 is classified critical for this flight because it occurs in pre-sleep. If it slipped one rev, it would interfere with crew sleep. ®[CR 7627 ]*

*Day-of-rendezvous burns are classified "critical for mission success" because major flight objectives would be in jeopardy if they slipped one orbit. Although these burns are part of a rigidly scheduled sequence of events, this sequence may be slipped by one or two orbits early in the mission such that lighting at the corresponding Ti burn is preserved. There are generally at most a few minutes of TIG slip for day-of-rendezvous burns, and any TIG slip which occurs can lead to non-standard relative motion entailing increased propellant usage for subsequent burns.*

*All rendezvous burns will trim each VGO < 0.2 fps in magnitude per Rule {A2-124}, RENDEZVOUS MANEUVER EXECUTION. This includes crew-safety-critical rendezvous and prox ops breakout burns. Note that Sep is an exception because it is completed based on time; not VGO's. Another exception is OMS-2, as previously noted. Noncritical orbit adjusts will also trim each VGO < 0.2 fps in magnitude because tight margins on end-of-mission landing or payload objectives are typically targeted, and orbit navigation generally supports this precision.*

## FLIGHT RULES

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12A\_A4-3

### SHUTTLE EOM ORBIT ADJUST BURNS

- A. IF PROPELLANT IS AVAILABLE, ORBIT ADJUSTS MAY BE PERFORMED TO INCREASE THE NUMBER OF DEORBIT OPPORTUNITIES AVAILABLE. IF AN ELLIPTIC ORBIT IS TARGETED FOLLOWING THE ADJUST, STEEP DEORBIT CAPABILITY SHALL BE RETAINED TO SATISFY RULE {A4-103A}.3, OFF-NOMINAL ORBITAL ALTITUDE RECOVERY PRIORITIES.
- B. THE ORBIT ADJUST PLAN WILL ATTEMPT TO ACHIEVE THE FOLLOWING COMBINATIONS OF LANDING OPPORTUNITIES STATED IN ORDER OF DECREASING PRIORITY. ONLY OPPORTUNITIES WHICH SATISFY THE CREW DAY CONSTRAINTS (REF RULE {A4-107A}.7, PLS/EOM LANDING OPPORTUNITY REQUIREMENTS), WILL BE CONSIDERED (7 HRS < AWAKE TIME BEFORE LANDING < 16 HRS). AN ORBIT ADJUST PLAN WHICH WOULD RESULT IN LOSS OF OPPORTUNITIES AT A HIGHER PRIORITY THAN THOSE GAINED WILL NOT BE PERFORMED EVEN IF DAYLIGHT OPPORTUNITIES ARE PROVIDED BY THE PLAN.

PRIORITY	SITE	EOM	EOM + 1	EOM + 2
1	KSC	1	1	1
	EDW	1	1	1
2	KSC	2		
3	KSC		2	
4	EDW		2	
5	KSC			2
6	EDW			2

- C. ORBIT ADJUST BURN TIG'S WILL BE SCHEDULED SUCH THAT SUBSEQUENT CLOSEST APPROACH TO ISS IS GREATER THAN HALF THE DISTANCE ACHIEVED ONE ORBIT FOLLOWING TERMINATION OF ACTIVE PROXIMITY OPERATIONS PILOTING.

*Since no propellant is budgeted for orbit adjust burns, they are limited in magnitude to predicted margins above mission completion following ISS operations. Due to trajectory dispersions arising from ISS departure, prudent orbit adjust burn planning will avoid subsequent ISS approaches according to the "Rule of Halves" (ref Level B Ground rules & Constraints, Section 4.5.2.6, Postrelease Requirements, Paragraph (3)). This criterion is considered conservative even if ground tracking in support of orbit adjust targeting is unavailable.*

## FLIGHT RULES

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### 12A\_A4-4

### EOM ENTRY DTO/RUNWAY SELECTION PRIORITIES

DTO 805, CROSSWIND LANDING PERFORMANCE, WILL BE EXECUTED AS A DTO OF OPPORTUNITY. DTO 805 WILL NOT BE A CONSIDERATION IN SELECTING LANDING SITES OR RUNWAYS. IF CROSSWINDS ARE OBSERVED TO BE 10 KNOTS OR GREATER AS THE ORBITER APPROACHES THE HAC, DRAG CHUTE DEPLOY WILL BE DELAYED UNTIL POST NOSE GEAR TOUCHDOWN TO ACCOMPLISH DTO 805.

*No drag chute, braking, or nosewheel DTO's are scheduled. Drag chute deploy will be per nominal flight rules (ref Rules {A10-143}, DRAG CHUTE DEPLOY TECHNIQUES and {A10-144}, DRAG CHUTE DEPLOY CONSTRAINTS), unless the crosswind DTO is likely to be performed. In that case, drag chute deploy will be delayed until post nose gear touchdown to allow for pilot handling evaluation of the orbiter alone without any complications that drag chute dynamics may induce. Nominal touchdown speed is 195 keas with derotation performed using the beep trim switch at 185 keas or manually (if beep trim fails) at 175 keas. Drag chute nominal deploy is immediately prior to the initiation of derotation. However, the drag chute DTO program has cleared drag chute deploy as early as 15 keas prior to the initiation of derotation.*

*All ISS rendezvous flights have a probability of a night landing which would mean that the crosswind limit is 12 knots. Therefore, DTO 805, Crosswind Landing Performance Evaluation, which requires a crosswind of 10 knots or greater at touchdown, is not likely to be achieved, especially at night. With this small window of environmental conditions, it is not prudent to change landing sites (e.g., from KSC to EDW) to attempt DTO 805. Additionally, changing landing sites to EDW to achieve DTO 805 would be of benefit primarily if multiple, lakebed runways could be used to enhance the probability of achieving crosswind conditions. Lakebed landings, however, are undesirable at night due to possible dust obscuration problems (ref Rule {A2-207}, LANDING SITE SELECTION). Finally, night landings require xenon lights (ref Rule {A3-203B}, LANDING AID REQUIREMENTS). There is enough equipment at EDW to support only one lakebed runway in addition to concrete EDW 22 (and this would mean removing the xenon lights from EDW 04). Also, programmatic priorities make it highly desirable to land at KSC to avoid the cost and risk associated with ferry operations. Since a decision to change from KSC to EDW would have to be made approximately 2 to 4 hours before landing, it is unlikely that confidence in wind forecasts would be such that landing at EDW solely to achieve DTO 805 is prudent.*

### 12A\_A4-5

### OMS-2 TARGETING

THE ONBOARD OMS-2 TARGET HEIGHT WILL BE ADJUSTED POST-MECO FOR AN OPTIMUM OMS-2 PHASING BURN. @[CR 7628 ]

*OMS-2 is used for both orbital insertion as well as the first rendezvous phasing maneuver. In order to accomplish this, orbital perigee post OMS-2 can range from 105 nm to 307 nm. OMS-2 can also compensate for small MECO underspeeds and still preserve the rendezvous. With Space Shuttle Program approval, post OMS-2 perigee can go as low as 85 nm in order to improve launch window duration, but with a propellant penalty due to drag. @[CR 7628 ]*

## FLIGHT RULES

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### ISS ONLY RULES

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#### 12A\_B4-1 JETTISONED HARDWARE DURING EVA [RC] [E]

- A. THIS RULE SUPERSEDES RULE {B4-104}, JETTISONED HARDWARE [RC] [E] [J]. ©[CR 7659A ]
- B. ALL OBJECTS THAT ARE PLANNED TO BE JETTISONED DURING AN EVA ARE EXPECTED TO BE IDENTIFIED BY THE RESPONSIBLE CONTROL CENTER PRIOR TO THE EVA.
- C. DURING THE EVA, IF A NEW OBJECT IS IDENTIFIED TO BE JETTISONED, THE CONTROL CENTER RESPONSIBLE FOR THE ITEM WILL NOTIFY THE FLIGHT DIRECTOR OF THE OTHER CONTROL CENTER AND PROVIDE THE OBJECT'S MASS AND DIMENSIONS PRIOR TO JETTISON.
- D. HARDWARE WILL BE JETTISONED FROM THE SPACE STATION IN A RETROGRADE DIRECTION.

*Any objects jettisoned must not pose a collision hazard to the ISS. If the hardware is jettisoned retrograde in an orbit below that of the vehicle, relative motion will keep the debris away from the ISS. In any case, relative motion will be analyzed by the Station Trajectory Operations Officer for a possible collision hazard. U.S. Strategic Command (USSTRATCOM) will be notified of the jettisoned object and, if available, a state vector will be provided.*

*Hardware jettisoned from the Space Station prior to any non-shuttle Earth-to-Orbit-Vehicle (ETOV) rendezvous may pose a hazard to the visiting vehicle.*

*Documentation: Rule {C4-1}, JETTISONED HARDWARE [HC] [RC] [E].*

*Reference Rule {C4-1}, JETTISONED HARDWARE [HC] [RC] [E].*

- E. IT IS PREFERRED THAT THE HARDWARE BE JETTISONED DURING AN EVA DAY PASS.

*The jettison of hardware during an EVA day pass will provide the crew with the visual aids needed to determine the direction in which to jettison the object. Using the vehicle as a reference, the crew can determine the velocity vector and ensure the object is jettisoned in a retrograde direction. It also allows the crew to avoid striking the structure of the ISS as the object is released. ©[CR 7659A ]*

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## FLIGHT RULES

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12A\_B4-1

**JETTISONED HARDWARE DURING EVA [RC] [E]**  
**(CONTINUED)**

F. IF AN OBJECT IS LOST DURING THE EVA, THE RESPONSIBLE CONTROL CENTER WILL PROVIDE THE FLIGHT DIRECTOR OF THE OTHER CONTROL CENTER WITH THE OBJECT'S MASS, DIMENSIONS. ©[CR 7659A ]

*The relative motion between the ISS and the lost object will be analyzed by the Station Trajectory Operations Officer for a possible collision hazard. USSTRATCOM will be notified of the lost object, and if available, a state vector will be provided. ©[CR 7659A ]*

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## FLIGHT RULES

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JOINT SHUTTLE/ISS RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

# FLIGHT RULES

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## SECTION 5 - BOOSTER

### SHUTTLE ONLY RULES

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### JOINT SHUTTLE/ISS RULES

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 5 - BOOSTER

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#### SHUTTLE ONLY RULES

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12A\_A5-1

#### MANUAL THROTTLEDOWN FOR LO<sub>2</sub> NPSP PROTECTION AT SHUTDOWN [HC]

MANUAL THROTTLING TO THE MINIMUM SSME POWER LEVEL WILL BE PERFORMED TO PROTECT MECO LO<sub>2</sub> NET POSITIVE SUCTION PRESSURE (NPSP) REQUIREMENTS, IF REQUIRED. MANUAL THROTTLING WILL BE PERFORMED WHEN THE ONBOARD PROPELLANT REMAINING COMPUTATION REACHES 2 PERCENT AND THE FOLLOWING CONDITIONS ARE MET: ©[CR 7621 ]

A. TWO OR THREE ENGINES ON:

MCC FLIGHT DYNAMICS OFFICER (FDO) IS PREDICTING A VELOCITY UNDERSPEED AT MECO WHICH IS GREATER THAN 500 FT/SEC.

B. ONE ENGINE ON:

THE CREW WILL ALWAYS PERFORM THE SSME THROTTLEDOWN FOR THE ONE ENGINE-ON CASE EXCEPT FOR CERTAIN CONTINGENCY ABORT CASES THAT ARE DOCUMENTED ON THE CONTINGENCY ABORT CUE CARDS IN THE ASCENT CHECKLIST FLIGHT DATA FILE.

ONCE MANUAL THROTTLING IS INITIATED FOR NPSP PROTECTION, THE CREW WILL MAINTAIN MANUAL THROTTLES AND THEN PERFORM A MANUAL MECO AT THE DESIRED CUTOFF VELOCITY.

*If FDO is predicting a low-level cutoff prior to the guidance software issuing the fine count command for two or three engines running (ref. rationale of Rule {A4-59G}, MANUAL THROTTLE SELECTION [HC]), the engine(s) will shut down from an unsafe power level because the LO<sub>2</sub> NPSP will be below the required value to avoid cavitation. This violation may cause uncontained engine damage at shutdown. For the two or three engine running cases, analysis indicates that the vehicle acceleration near MECO will be sufficient to prevent SSME shutdown prior to fine count as long as the predicted underspeed is no greater than 500 ft/sec, based on 2 sigma MPS propellant protection. The two/three engine-on case assumes a vehicle mass of 379,000 lbs at MECO minus 10 seconds and a single engine thrust at 104 percent of 488,800 lbf. The 500 ft/sec cue is derived from the  $F = M * A$  equation, as well as those used by the fine count throttle logic in the guidance software (reference NASA memorandum DF6-94-08, dated May 11, 1994). If the predicted underspeed is greater than 500 ft/sec for the two or three engine running cases, manual throttling will be performed to the minimum power level, thereby reducing the NPSP requirements prior to reaching a low-level cutoff (LLCO) condition. ©[CR 7621 ]*

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## FLIGHT RULES

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12A\_A5-1

### MANUAL THROTTLEDOWN FOR LO<sub>2</sub> NPSP PROTECTION AT SHUTDOWN [HC] (CONTINUED)

*The only acceptable power level for an LLCO on the single engine running case is 67 percent (reference A/EFTP #211, March 23, 2005). As of this A/EFTP meeting, analysts within Rocketdyne and the SSME Project had not reached a consensus on the relative risk between a single engine LLCO at 91 percent versus 67 percent. Hence, to minimize power level related LLCO risk, the A/EFTP recommended that when in the single engine running scenario, the remaining engine should always be commanded to minimum power level for MECO. ©[CR 7621 ]*

*After throttledown, the crew will stay in manual throttles and be prepared to perform a manual MECO at the desired MECO velocity should it be reached prior to propellant low-level cutoff.*

*The minimum throttle level was selected for ease of training and to provide the best LO<sub>2</sub> NPSP shutdown conditions. The throttledown cue of 2 percent propellant remaining was selected to allow sufficient time to perform the manual throttling while minimizing performance impacts. Analysis (reference Ascent/Entry Flight Techniques Panel #91, July 17, 1992) shows that most of the error in the onboard propellant remaining computation occurs on the two-engine-out press-to-MECO abort when no OMS dump is performed. Engine performance problems also contribute to the propellant remaining error. The worst case engine problem is low specific impulse (lsp). Worst-on-worst analysis with two engines out simultaneously at the press-to-MECO boundary and the third engine running with an lsp which is 10 seconds below nominal shows that the 2 percent cue still provides sufficient time to throttle the engine down before low-level cutoff occurs.*

*The crew will not always throttle down for the one engine running case. For certain contingency aborts, it is not expected that a low-level cutoff will occur; therefore, manual throttle control is not required in these cases and is documented on the contingency abort cue cards in the Ascent Checklist Flight Data File.*

*Reference Hazard Report IMPS-08, Underpressurization of the Integrated MPS O<sub>2</sub> System. ©[CR 7621 ]*

## FLIGHT RULES

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12A\_A5-2

LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND  
MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]

- A. MAIN ENGINE LIMIT SHUTDOWN SOFTWARE WILL BE MANUALLY ENABLED UPON RECOGNITION OF EITHER AN LH<sub>2</sub> ULLAGE LEAK OR FOR ANY ORBITER GH<sub>2</sub> PRESSURIZATION SYSTEM ANOMALY EXCEPT ONE GH<sub>2</sub> FLOW CONTROL VALVE FAILED CLOSED. @[CR 7622 ]
- B. MAIN ENGINES SHALL NOT BE ALLOWED TO RUN BELOW A MINIMUM NPSP OF 3.5 PSI AT 104.5 PERCENT POWER LEVEL AND 3.0 PSI AT 67 PERCENT POWER LEVEL. THE MAIN ENGINES WILL BE THROTTLED DOWN OR SHUT DOWN TO AVOID RUNNING BELOW THE MINIMUM ALLOWABLE NPSP.

*If the LH<sub>2</sub> pressure at the inlet of the SSME falls below ICD values, the low pressure fuel pump (LPFP) and high pressure fuel pump (HPFP) in the SSME will eventually cavitate and overspin, potentially causing catastrophic damage to the SSME. In the Block II SSME, the LPFP typically cavitates earlier than the HPFP, resulting in critical low pressure fuel turbopump (LPFT) speeds prior to the high pressure fuel turbopump (HPFT) turbine discharge temperature (TDT) redline exceedance (based on analysis of Block II engine tests 904-317 and 904-321). It was determined at the AEFTP #220, May 19, 2006, that the HPFT TDT redline does not provide adequate protection for the Block II SSME from low LH<sub>2</sub> inlet pressure. To prevent a catastrophic failure, AEFTP recommended that the SSME's be prevented from running to a low NPSP value by manually throttling down the SSME to recover NPSP and/or by shutting down the SSME's. The minimum acceptable NPSP value is power level specific, and is slightly lower than the minimum ICD NPSP value.*

*Although the HPFT TDT redline may not provide protection to the SSME from low LH<sub>2</sub> NPSP, the main engine limit shutdown switch will be taken to ENABLE in this case to ensure the SSME limits are in the best configuration to handle low LH<sub>2</sub> inlet pressure. @[CR 7622 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

12A\_A5-2

**LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND  
MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]  
(CONTINUED)**

C. ORBITER GH<sub>2</sub> PRESSURIZATION SYSTEM ANOMALY @[CR 7622 ]

IF ULLAGE PRESSURE IS STEADILY DECAYING BELOW THE CONTROL BAND AND IS NOT THE RESULT OF AN ULLAGE LEAK (PER RULE {A5-9}, LH<sub>2</sub> ULLAGE LEAK [HC]), THE ENGINES WILL BE MANUALLY THROTTLED PER THE STEPS GIVEN BELOW. THE MANUAL THROTTLE STEPS WILL BE BASED ON THE SETTINGS LISTED IN THE TABLE BELOW WHEN THE LH<sub>2</sub> NPSP DROPS BELOW 3.5 PSI OR THE HPFT TDT'S INCREASE TO WITHIN 75 DEG R OF THEIR REDLINES. TO PREVENT THE VEHICLE ACCELERATION FROM EXCEEDING 3.0 G'S AFTER MANUAL THROTTLING IS INVOKED, THE CREW WILL MANUALLY THROTTLE BACK TO MAINTAIN 3.0 G'S.

STEP	THROTTLE SETTING (PERCENT)
1	95
2	80
3	67

ONCE INITIATED, MANUAL THROTTLES WILL BE MAINTAINED UNTIL MECO. A MANUAL MECO WILL BE REQUIRED.

*A GH<sub>2</sub> pressurization system anomaly could be caused by either multiple flow control valves failed closed or a plugged GH<sub>2</sub> pressurization leg. Coverage of the highly unlikely GH<sub>2</sub> plugged pressurization leg failure mode is a result of PRCB Directive S050270DP, Main Propulsion System (MPS) Critical Items List (CIL) Submittal Waiver Request, November 9, 1998.*

*Underspeeds resulting from two GH<sub>2</sub> flow control valves failed closed or a plugged GH<sub>2</sub> pressurization leg or three GH<sub>2</sub> flow control valves failed closed will potentially result in loss of crew and vehicle due to either early engine shutdowns (due to LH<sub>2</sub> NPSP) or ET structural failure. Manually throttling to a lower throttle setting increases the supplied NPSP by lowering LH<sub>2</sub> pressure losses across the LH<sub>2</sub> manifolds and lines, and also reduces the SSME NPSP requirement for engine operation. The combination of higher supplied NPSP and reduced NPSP requirement enables continued engine operation. Once initiated, manual throttles are maintained until MECO in order to prevent the auto throttleup to the mission power level that would occur following an SSME failure. Since the NPSP drops with this throttleup, maintaining manual throttles protects against the potential loss of additional SSME(s). @[CR 7622 ]*

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## FLIGHT RULES

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12A\_A5-2

**LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND  
MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]  
(CONTINUED)**

*The severity of the LH<sub>2</sub> NPSP loss is not only dependent upon the GH<sub>2</sub> pressurization system failure mode, but also upon the engine configuration and power level for a particular mission. Analysis shows that two GH<sub>2</sub> flow control valves failed closed on a nominal, ATO, or AOA mission using three Block II SSME's may require manual throttling to increase engine operation time. Additionally, manual throttling may also be required if one of the SSME's pressurization legs becomes plugged such that there is 0 percent flow from that leg (reference February 19, 1997 PSIG, Action Item 970205-01).*

©[CR 7622 ]

*A GH<sub>2</sub> pressurization leg refers to the series of hardware in the GH<sub>2</sub> pressurization line that carries flow from each SSME's LPFT turbine outlet to the 2-inch pressurization line that provides ullage pressure to the ET LH<sub>2</sub> tank. Each engine contains a check valve, a filter, and a flow control valve (reference SSSH 10-12). The hardware in these lines could potentially fail closed or, in the most extreme case, become plugged by contamination.*

*There are three possible scenarios resulting in a plugged GH<sub>2</sub> pressurization system leg. The first scenario involves the filter upstream of the flow control valve becoming plugged, resulting in 0 percent flow to the associated valve. The second and third scenarios are an obstruction or mechanical failure of the check valve upstream of the flow control valve or an obstruction of the flow control valve itself. This would result in 0 percent flow being provided from that engine to the 2-inch pressurization line. Since flow from all three pressurization legs is required to maintain ullage pressure above 32.6 psia, all three flow control valves will be commanded open as the system attempts to maintain pressure in the ET LH<sub>2</sub> tank. However, since flow in a single leg is obstructed, ullage pressure will steadily decay below the control band as the fuel volume in the ET LH<sub>2</sub> tank decreases.*

*The throttling cue of 3.5 psi for the LH<sub>2</sub> NPSP was chosen as the primary cue to avoid LH<sub>2</sub> NPSP regions where severe cavitation occurs and HPFT turbine temperatures increase exponentially. The ground LH<sub>2</sub> NPSP computation assumes a 3 sigma worst case LH<sub>2</sub> inlet temperature of 37.2 deg R from liftoff until MECO. The use of this worst case temperature provides for 2 sigma protection (i.e., a 0.8 psi bias) in the ground NPSP computation. The ground computation uncertainties are a result of measurement inaccuracies in ullage pressure, head pressure, frictional losses, and vapor pressure used in the derivation of NPSP. On average, the actual vehicle NPSP will be 0.8 psi higher than the NPSP value displayed by the MCC ground computation. HPFT TDT's were selected as a backup cue in case an HPFT starts to severely cavitate at a higher LH<sub>2</sub> NPSP value than expected. Both temperature limits (channels A and B) are calculated by subtracting 75 deg R from the redlines. Larger margins from the redline may overlap the nominal operating temperature range and provide false cues for action (ref. PSIG flight rule reviews on February 25, 1988; March 2, 1988; and November 17, 1993).* ©[CR 7622 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A5-2

**LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND  
MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]  
(CONTINUED)**

*The cue of 3.0 g's of acceleration was selected to ensure protection of vehicle acceleration limits (3.0 g). Various vehicle configurations or GH<sub>2</sub> pressurization system failure modes may or may not result in exceedance of vehicle acceleration limits. However, if a 3.0 g acceleration limit is used as an auto or manual throttling cue for all cases, vehicle structural limits are protected at all times. Reference Rule {A2-61}, Q-BAR/G-CONTROL. Three-g is not used as a cue for the first manual throttle step since leaving throttles in auto will throttle at 3.0 g's. Once manual throttles are taken for an NPSP or HPFT TDT cue, throttles will remain in manual and 3.0 g's will be protected in addition to the NPSP and HPFT TDT cues. The shuttle crews are trained that after selecting manual throttles, if the vehicle acceleration exceeds 3.0 g's, they will need to manually throttle to maintain 3.0 g's. ©[CR 7622 ]*

*Throttling in three steps was selected to minimize crew/MCC impact and workload. The steps approximately divide the action equally into thirds. The first step, 95 percent, was originally chosen to avoid the Rocketdyne HPFT impeller resonance region (i.e., 88 to 92 percent). This is no longer a concern as a result of a redesign of the impeller. The throttle setting of 95 percent was retained for training simplicity. The second step, 80 percent, is midway between the first step and the minimum power level. The last step, 67 percent, is the minimum power level and further commanded power reduction is not possible.*

#### D. LH<sub>2</sub> ULLAGE LEAK

A DELAYED TAL ABORT WILL BE PERFORMED (REF. RULE {A2-70}, DELAYED TRANSATLANTIC LANDING (TAL) ABORT). PRIOR TO TAL SELECTION, MANUAL THROTTLES WILL BE SELECTED. AFTER TAL SELECTION, THE THROTTLES WILL BE RETURNED TO AUTO.

ENGINES SHALL NOT BE THROTTLED TO 109 PERCENT.

*Throttling for low LH<sub>2</sub> NPSP due to an LH<sub>2</sub> ullage leak (reference Rule {A5-9}, LH<sub>2</sub> ULLAGE LEAK [HC]) or an open LH<sub>2</sub> vent/relief valve delivers less ullage pressurization gas, causing LH<sub>2</sub> NPSP to decay faster than keeping the engines at 104 percent.*

*Throttling the engines to 109 percent to achieve an abort boundary shall not be attempted because the repress rate and NPSP requirement does not support the ullage pressure decay rate, and will make the ullage situation worse when compounded with a leak condition. ©[CR 7622 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A5-2

LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND  
MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]  
(CONTINUED)

*Since the leak rate could increase at any time, it is important to reach multiple engine-out capability and an acceptable MECO as soon as possible. Performing a Delayed TAL maintains East Coast Abort Landing (ECAL) opportunities and improves bailout survival/recovery probabilities, while maintaining intact TAL performance margins to no less than a 3-sigma confidence level (reference Rule {A2-70}, DELAYED TRANSATLANTIC LANDING (TAL) ABORT). ©[CR 7622 ]*

*GPC software automatically throttles the engines down if TAL is selected above an I-loaded inertial velocity. To prevent the software from throttling the engines down when there is an LH<sub>2</sub> ullage leak, manual throttles are selected prior to selecting TAL. Once TAL is selected, the throttles will be returned to AUTO where they will stay at 104 percent until 3 g's are reached. Three-g throttling may exacerbate the NPSP decay necessitating earlier engine shutdowns, but this is an accepted risk to avoid vehicle structural damage.*

*Reference Hazard Report IMPS-06, Underpressurization of the Integrated MPS H2 System. ©[CR 7622 ]*

## FLIGHT RULES

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### 12A\_A5-3

### ABORT PREFERENCE FOR SYSTEMS FAILURES [HC]

A. LH<sub>2</sub> ULLAGE LEAK @[CR 7623 ]

IF LOW LH<sub>2</sub> NPSP OCCURS DUE TO AN EXTERNAL TANK LH<sub>2</sub> ULLAGE LEAK, A DELAYED TAL ABORT WILL BE PERFORMED TO PROVIDE THE EARLIEST MULTIPLE ENGINE-OUT CAPABILITY. REFERENCE RULE {A2-70}, DELAYED TRANSATLANTIC LANDING (TAL) ABORT.

B. GH<sub>2</sub> PRESSURIZATION SYSTEM ANOMALIES

IF THE LOW LH<sub>2</sub> NPSP OCCURS DUE TO THREE GH<sub>2</sub> FLOW CONTROL VALVES FAILED CLOSED, A DELAYED TAL ABORT WILL BE PERFORMED TO PROVIDE THE EARLIEST MULTIPLE ENGINE-OUT CAPABILITY. THIS IS THE ONLY GH<sub>2</sub> PRESSURIZATION SYSTEM ANOMALY FOR WHICH AN ABORT WILL BE PERFORMED. REFERENCE RULES {12A\_A5-2}, LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND MANUAL SHUTDOWN FOR LOW LH<sub>2</sub> NPSP [CIL] [HC], AND {A2-70}, DELAYED TRANSATLANTIC LANDING (TAL) ABORT.

*A TAL abort is preferred over RTLS because TAL MECO conditions are satisfied sooner than RTLS MECO conditions. If an LH<sub>2</sub> ullage leak occurs, throttling will not be performed for low LH<sub>2</sub> NPSP (see rationale for Rule {12A\_A5-2C}, LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND MANUAL SHUTDOWN FOR LOW LH<sub>2</sub> NPSP [CIL] [HC]). Once an ullage leak occurs, it is possible for the leak to worsen. In this case, the NPSP may deteriorate much faster than the failed closed flow control valve case. For ullage leaks, the time of each engine shutdown may be determined by predicting when the engines will reach the minimum allowable NPSP value. Since the leak rate could increase at any time, it is important to reach multiple engine-out capability and MECO conditions as soon as possible. Performing a Delayed TAL maintains East Coast Abort Landing (ECAL) opportunities and improves bailout survival/recovery probabilities, while maintaining intact TAL performance margins to no less than a 3 sigma confidence level (reference Rule {A2-70}, DELAYED TRANSATLANTIC LANDING (TAL) ABORT). @[CR 7623 ]*

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## FLIGHT RULES

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12A\_A5-3

### ABORT PREFERENCE FOR SYSTEMS FAILURES [HC] (CONTINUED)

*An abort will not be performed for two flow control valves failed closed or for a plugged GH<sub>2</sub> pressurization system leg. The flow control valves are normally open valves (must be powered closed). The close power will cycle the valves as required to satisfy the ullage pressure control band (reference Rule {A5-154}, LH2 TANK PRESSURIZATION [CIL] [HC]). It is assumed that the failure will occur during power cycling. With two valves failed closed, the third valve will not be power-cycled. Therefore, the third valve will remain open (unpowered) and nominal MECO conditions may be achieved by implementing Rule {12A\_A5-2}, LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]. For a plugged GH<sub>2</sub> pressurization leg, the other two flow control valves will operate and nominal MECO conditions may be achieved by implementing Rule {12A\_A5-2}, LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND MANUAL SHUTDOWN FOR LOW LH2 NPSP [CIL] [HC]. If three flow control valves are failed closed, a Delayed TAL abort will be performed. ©[CR 7623 ]*

#### C. ENGINE-TO-ENGINE HELIUM INTERCONNECT

A TAL ABORT TO EITHER A TAL SITE OR AUGMENTED CONTINGENCY LANDING SITE (ACLS), BASED ON WHICHEVER PROVIDES THE EARLIEST MULTIPLE ENGINE-OUT CAPABILITY, WILL BE PERFORMED IF THE HELIUM SYSTEM FROM A RUNNING ENGINE IS INTERCONNECTED TO A LEAKING ENGINE HELIUM SUPPLY IN ORDER TO ACHIEVE INTACT ABORT CAPABILITY (REF. RULE {A5-152B}, PRE-MECO MPS HELIUM SYSTEM INTERCONNECTS [CIL])

*Because of the severity of the helium leak which requires the implementation of Rule {A5-152B}, PRE-MECO MPS HELIUM SYSTEM INTERCONNECTS [CIL] [HC], adequate helium may not be available to support a nominal MECO. In this case, it is possible that a non-leaking engine as well as the leaking engine could shut down due to inadequate helium. Therefore, it is important to reach multiple engine-out capability and MECO conditions as soon as possible. This will be accomplished by performing a TAL abort or an abort to an ACLS.*

*Reference Hazard Report IMPS-06, Underpressurization of the Integrated MPS H2 System. ©[CR 7623 ]*

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## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

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## FLIGHT RULES

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JOINT SHUTTLE/ISS RULES

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## **FLIGHT RULES**

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## **FLIGHT RULES**

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### **SECTION 6 - PROPULSION**

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## **FLIGHT RULES**

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## **FLIGHT RULES**

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### **SECTION 7 - DATA SYSTEMS**

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## **FLIGHT RULES**

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# FLIGHT RULES

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## SECTION 8 - GNC

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## FLIGHT RULES

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### SECTION 8 - GNC

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#### SHUTTLE ONLY RULES

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#### 12A\_A8-1

#### GPS OPERATIONAL RAMP-UP GUIDELINES

- A. POST UNDOCKING DURING OPS 201 STATE VECTOR INCORPORATION OF GPS TO NAV IN AUTO MODE FOR A MINIMUM OF 6 HOURS WHILE THE CREW IS AWAKE IS HIGHLY DESIRABLE. @[CR 7639 ]

*This orbit incorporation will provide the MCC the opportunity to assess the performance of the onboard navigation system when incorporating GPS state vectors prior to the entry operations.*

- B. FOR END OF MISSION ONLY, THE FOLLOWING OPERATIONAL RAMP-UP OBJECTIVE SPECIFIED FOR SINGLE STRING GLOBAL POSITIONING SYSTEM WILL BE PERFORMED DURING ENTRY:
1. IN THE PASS PRIOR TO THE DEORBIT BURN, GPS TO NAV STATE VECTOR INCORPORATION IN AUTO MODE (MM301 ONLY)
  2. IN THE PASS POST CONFIRMATION WITH HIGH SPEED TRACKING, GPS TO NAV STATE VECTOR INCORPORATION IN AUTO MODE (MM 304 - LANDING)
  3. IN THE BFS GPS TO NAV INHIBITED (MM301 - LANDING)
- C. ACCEPTABLE GPS AND NOMINAL PASS AND BFS NAV CONFIGURATION SHOULD BE CONFIRMED BY THE MCC PRIOR TO GPS INCORPORATION.
- D. GPS INCORPORATION WILL OCCUR BASED ON AN MCC GO AND WILL ONLY BE PERFORMED PROVIDED THAT THERE ARE NO OTHER SIGNIFICANT ORBITER, MCC, LANDING SITE, OR GROUND NETWORK ANOMALIES.

*This operational test will provide a check of the overall integrated system under actual flight conditions to ensure acceptable incorporation of the GPS state vector into the baseline navigation system. The crew will require a GO from the MCC prior to performing the GPS to Auto. GPS will not be processed in the BFS so that an adequate state vector will be available in the BFS should incorporation of the GPS vector adversely impact the PASS navigation system. @[CR 7639 ]*

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## FLIGHT RULES

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12A\_A8-1

### GPS OPERATIONAL RAMP-UP GUIDELINES (CONTINUED)

*Acceptable GPS performance (no hardware problems, power failures, or commfaults, low FOM ( $\leq 5$ ), tracking four satellites), and a nominal PASS and BFS nav configuration are required before auto incorporation of GPS to nav. There is no need to perform the ramp up on this flight if the GPS system or Nav configuration is not in its normal state. ©[CR 7639 ]*

*Finally, there is no need to perform the ramp up on this flight if the GPS system or Nav configuration is not in its normal state or if there are significant orbiter, MCC, landing site, or ground network issues being worked by the MCC entry team or the flight crew. ©[CR 7639 ]*



## FLIGHT RULES

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### ISS ONLY RULES

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#### STAGE OPERATIONS

#### **12A\_B8-1                    INHIBITING DATA SELECT MODE FOR PRIMARY U.S. ATTITUDE SOURCE PRIOR TO CRITICAL OPERATIONS**

FOR OPERATIONS THAT REQUIRE A STABLE U.S. ATTITUDE SOURCE, THE DATA SELECT MODE (DSM) FOR THE HIGHEST PRIORITY GPS WILL BE SET TO "INHIBIT." DEPENDING ON THE OPERATION, BOTH GPS DSM'S MAY BE SET TO INHIBIT. @[CR 7530 ]

*The GPS DSM will be inhibited for the primary attitude source to prevent any large attitude reference transients from occurring during operations due to a bad GPS attitude being accepted (reference Station Program Note (SPN) 4222). This configuration may be applicable for operations including, but not limited to, entire mated shuttle missions, specific flight days, and/or mated or stage activities when a stable attitude source is needed. This configuration of the primary GPS DSM inhibited and the backup GPS enabled retains all short term system redundancy with attitude propagation and allows longer term redundancy with attitude filter resets. This configuration is intended to be used for a length of time on the order of hours or many days.*

*It is considered good practice to inhibit both GPS DSM's during docking and undocking operations using CMG attitude control. The ADCO also will determine if the backup GPS DSM needs to be inhibited based on but not limited to the following factors: if docking on thrusters, when the maneuver from XPOP to docking attitude occurs, how many Antenna Assemblies (AA) are operating, and upcoming timelined activities such as SM software loads, activities where thrusters are disabled, and stage RS EVA's occurring on the large diameter. Note that the period of time where both GPS DSM's will be inhibited should be on the order of hours because attitude redundancy is not as robust in this configuration because the U.S. attitude filters will be propagating and they will go degraded over time unless action is taken such as a filter reset off the Russian attitude data. This is applicable while SPN 4222 is active, as well as after it is retired. @[CR 7530 ]*

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### ASSEMBLY OPERATIONS

#### 12A\_C8-1

#### ORBITER DAP MODES AND PRIORITIES

- A. ORBITER DAP MODE PRIORITY DURING PERIODS OF ORBITER CONTROL OF THE MATED STACK WILL BE BASED ON PROPELLANT MARGINS. WHEN POSSIBLE, THE FOLLOWING DAP MODE PRIORITIES WILL BE USED:
1. VRCS FOR ATTITUDE HOLD AND MANEUVERS
  2. PRCS, ALT DAP, LOW Z, XJET ROT ENA FOR ATTITUDE HOLD, AND VRCS FOR MANEUVERS. PRCS JET GROUPS 2 AND 3 (FXL AND FXR) WILL BE DESELECTED FOR LOADS CONCERNS.
  3. PRCS, ALT DAP, LOW Z, XJET ROT ENA FOR ATTITUDE HOLD AND MANEUVERS. PRCS JET GROUPS 2 AND 3 (FXL AND FXR) WILL BE DESELECTED FOR LOADS CONCERNS.

*The orbiter propellant margins may not allow the orbiter to provide attitude control and attitude maneuvers for the whole mated stack time period with vernier reaction control (VRCS) only or with primary reaction control (PRCS) only control. To get the maximum time of orbiter attitude control, both VRCS and PRCS will be required. VRCS can be used during crew sleep. PRCS ALT DAP use results in ISS structural lifetime issues and degraded maneuver performance.*

*Simultaneous use of PRCS jet groups 1, 2 and 3 (FxF, FxL and FxR) is undesirable from a loads standpoint and can be avoided by deselecting either group 1 or groups 2 and 3, with the latter option preferred for 12A.*

- B. THE MATED VRCS AND PRCS ALT DAP MODES WILL BE CONFIGURED WITH THE FOLLOWING PARAMETERS:

*Reference CSDL Memorandum, STS-115 Mated Shuttle/ISS DAP Modes and Constraints (TBS).*

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## FLIGHT RULES

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**12A\_C8-1                      ORBITER DAP MODES AND PRIORITIES (CONTINUED)**

1. NON-SRMS/SSRMS LOADED OPERATIONS:

	ALT	VRCS
ROT RATE (DEG/SEC)	≤ 0.1	≤ 0.1
ATTITUDE DB (DEG)	[1]	[1]
RATE DB (DEG/SEC)	[1]	[1]
JET OPTION	3 (TAIL)	
NUMBER OF JETS	3 [2]	
ON TIME (SEC)	0.08	
DELAY (SEC)	11.04 [3]	
Z OPTION	LOW Z	
X JETS	ENABLED	
NOTCH FILTERS	ENABLED	
CNTL ACC	2,4 [4]	1,3,8 [4]

NOTES:

- [1] ATTITUDE AND RATE DB IS DEPENDENT ON ODS PRESSURIZATION (SEE PARAGRAPH C).
- [2] ONE OR TWO JET ALT CONTROL ALLOWED FOR ATTITUDE HOLD ONLY (NO MANEUVERS). TWO IS AVAILABLE FOR OVERALL PROPELLANT SAVINGS, ONE IS AVAILABLE FOR FORWARD PROPELLANT SAVINGS WITH INCREASED AFT USAGE.
- [3] AUTO REBOOST DELAY TIME IS 12.0 SEC.
- [4] CNTL ACCL 1 OR 2 ARE FOR INITIAL CONFIGURATIONS. CNTL ACCL 3 OR 4 ARE FOR FINAL CONFIGURATIONS. CNTL ACC 1-7 ARE REQUIRED FOR ODS PRESSURE ≥ 2.44 PSI, AND CNTL ACC 8 IS REQUIRED FOR ODS PRESSURE < 2.44 PSI.

2. LOADED SRMS/SSRMS OPERATIONS:

	ALT	VRCS
ROT RATE (DEG/SEC)	NOT CERTIFIED	≤ 0.1
ATTITUDE DB (DEG)		≥ 5.0
RATE DB (DEG/SEC)		0.15
JET OPTION		
NUMBER OF JETS		
ON TIME (SEC)		
DELAY (SEC)		
Z OPTION		
X JETS		
NOTCH FILTERS		
CNTL ACC		1,3,5-7 [1]

NOTES:

- [1] REFERENCE RULE {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR CONTROL ACCEL APPLICABILITY.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

### 12A\_C8-1      ORBITER DAP MODES AND PRIORITIES (CONTINUED)

C. THE MATED VRCS AND PRCS ALT DAP RATE DEADBANDS SHALL BE CONFIGURED AS NOTED TO ACCOUNT FOR ODS FREEPLAY:

ISS AND RMS CONFIGURATION	ODS PRESSURE	DAP MODE	ATTITUDE DEADBAND	RATE DEADBAND
12A INITIAL AND FINAL CONFIGS	PRESSURIZED [1]	VRCS	≥ 3.0	0.05
		ALT	≥ 5.0	0.07
	UNPRESSURIZED	VRCS	≥ 3.0	0.08
		ALT	NOT CERTIFIED	
12A SRMS/SSRMS LOADED OPS	PRESSURIZED [1]	VRCS	≥ 5.0	0.15
		ALT	NOT CERTIFIED	
	UNPRESSURIZED	VRCS		
		ALT		

NOTES:

[1] ODS PRESSURE MUST BE ≥ 2.44 PSI.

*Structural flex due to difference in the ODS pressure on STS-92 resulted in decreased DAP control margins and increased propellant usage. Mitigation of these concerns will require the DAP VERN attitude deadband and VERN and ALT rate deadbands to be increased when the ODS is depressurized for EVA (Reference **TBD**).*

D. THE REBOOST DAPS WILL BE CONFIGURED WITH THE FOLLOWING OPTIMIZED PARAMETERS:

REBOOST DAP CONFIG											
CONFIG NO. [1]	ROT. CNTL MODE	CA/NOTCH FILTERS [2]	RBST INTVL	ATT DB	RATE DB	MNVR RATE	JET OPT	NO. JETS	LOW Z	DELAY	X JET ROT CNTL
1	ALT	2,4/ENA	24.0	15.0 (PRI)	0.07	0.10	TAIL	3	YES	12.0	DISABLED
2	ALT	2,4/ENA	24.0	15.0 (PRI)	0.07	0.10	TAIL	3	YES	12.0	DISABLED
3	VRCS	1,3/ENA	2.0	5.0 (VRCS)	0.05	0.10					
4	VRCS	1,3/ENA	24.0	5.0 (VRCS)	0.05	0.10					

NOTES:

[1] SEE RULE {C2-12}, MATED REBOOST CONFIGURATION AND CONSTRAINTS [RC], FOR AUTO REBOOST CONFIGURATION DEFINITIONS.

[2] CNTL ACCEL 1 OR 2 PRE-INSTALL, CNTL ACCEL 3 OR 4 POST-INSTALL

## FLIGHT RULES

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### ASSEMBLY MISSION CONTINGENCY SCENARIOS

**THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION**

# FLIGHT RULES

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## SECTION 9 - ELECTRICAL

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### ISS ONLY RULES

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## FLIGHT RULES

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### SECTION 9 - ELECTRICAL

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#### SHUTTLE ONLY RULES

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#### 12A\_A9-1

#### PAYLOAD BAY FLOODLIGHTS

##### A. PAYLOAD BAY FLOODLIGHT CONSTRAINTS

OPERATION OF THE PAYLOAD BAY FLOOD LIGHTS IS LIMITED TO THE FOLLOWING CONSTRAINTS: MAXIMUM DUTY CYCLE.

ORBITER ATTITUDE	LIGHTS 1 AND 2	LIGHTS 3 AND 4	LIGHTS 5 AND 6
P3/P4 INTEGRATED TRUSS SEGMENT IS IN THE PAYLOAD BAY: ALL ATTITUDES	OFF AT ALL TIMES	OFF AT ALL TIMES	OFF AT ALL TIMES
P3/P4 INTEGRATED TRUSS SEGMENT NOT IN THE PAYLOAD BAY: ALL ATTITUDES	NO CONSTRAINTS	NO CONSTRAINTS	NO CONSTRAINTS

*The Payload Bay Flood Light (PLBFL) operational constraints are based on PLBFL system thermal limitations. These constraints result from the floodlight solder joint temperature limit of 350 deg F. No payload constraints have been identified.*

*Source: STS-115 Boeing Tech. Memo No. TS-TM-02-034, dated August 9, 2002.*

B. PAYLOAD BAY FLOODLIGHTS SHOULD BE OFF 15 MINUTES BEFORE THROUGH 5 MINUTES FOLLOWING MAUI DATA TAKE ACTIVITIES.  
 ©[CR 7599A ]

*The Payload Bay Lights could be a source of contamination to the optical data taken during a MAUI experiment. It is desirable for the lights to be off during MAUI experiment activities.*

*DOCUMENTATION: NSTS 21530, MAUI Payload Integration Plan, Basic + CHG 1, paragraph 4.2.2.4, March 29, 2006. ©[CR 7599A ]*

## FLIGHT RULES

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### 12A\_A9-2

### FUEL CELL PURGE CONSTRAINTS

FUEL CELL PURGES SHOULD NOT BE PERFORMED 15 MINUTES BEFORE THROUGH 5 MINUTES FOLLOWING MAUI DATA TAKE ACTIVITIES. @[CR 7599A ]

*The fuel cell purges could be a source of contamination to the optical data taken during a MAUI experiment. It is desirable that fuel cells are not purged during this time period.*

*DOCUMENTATION: MAUI Payload Integration Plan, Basic + CHG 1, paragraph 4.2.2.4, March 29, 2006. @[CR 7599A ]*

### 12A\_A9-3

### FUEL CELL (FC) LOSS [CIL]

A FUEL CELL (FC) IS CONSIDERED LOST IF: @[CR 7609 ]

THE STARTUP HEATER IS FAILED ON.

*Thermal analysis by IFC indicates that a failed-on startup heater would result in marginal operation for a FC with a nominal on-orbit load of 5 kW. Thermal equilibrium should be reached in approximately 15 minutes. The stack inlet temperature will rise from 182 to 212 degrees F, and the stack outlet temperature will rise from 204 to 228 degrees F. This results in calculated electrolyte concentrations of 47.6, 42.0, and 44.8 percent for the inlet, exit, and average cell conditions respectively. Operating the FC at higher power levels will drive the electrolyte concentration even higher and raise stack temperatures close to loss limits. The FC will not be useable as a single FC for entry and will be marginal or out of limits operating as a second FC, even after the loss of one FC powerdown steps are performed. Taking further powerdown steps to keep the FC operating as a second FC will result in reducing the vehicle fault tolerance, possibly taking it to the loss of second FC powerdown fault tolerance level.*

*DOCUMENTATION: SODB 4.4.1.1.1*

*If a FC startup heater can be disabled by taking the FC controller power to off, a FC which has been shut down in this manner may be reusable for a short period of time as a contingency only.*

*DOCUMENTATION: Engineering judgment. @[CR 7609 ]*

## FLIGHT RULES

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### 12A\_A9-4

### FC HEATER MANAGEMENT

- A. OPERATION OF A FC WITH A FAILED-ON HEATER IS PERMISSIBLE, PROVIDED KOH CONCENTRATION AND FC STACK TEMPERATURES ARE WITHIN OPERATIONAL LIMITS. @[CR 7609 ]

*Thermal analysis by International Fuel Cells (IFC's) indicates that a failed-on sustainer heater does not overheat a FC and that the FC would be usable for external loads up to 12 kW continuously.*

*Thermal analysis by IFC indicates that a failed-on startup heater would result in marginal operation for a FC with a nominal on-orbit load of 5 kW. Thermal equilibrium should be reached in approximately 15 minutes. The stack inlet temperature will rise from 182 to 212 degrees F, and the stack outlet temperature will rise from 204 to 228 degrees F. This results in calculated electrolyte concentrations of 47.6, 42.0, and 44.8 percent for the inlet, exit, and average cell conditions respectively.*

*Subsequent failure of the fuel cell coolant pump will require fuel cell safing actions be performed as soon as possible to prevent localized heating, heater element damage, breakdown of the fuel cell coolant, FC stack over-pressurization, and potentially catastrophic overheating of the stack (ref. Rule {A9-60}, FC COOLANT PUMP/H2 PUMP/H2O SEPARATOR FAILURE MANAGEMENT [CIL] [HC]: Shutdown within 9 minutes.)*

DOCUMENTATION: SODB 4.4.1.1.1

- B. IF A FC HAS A FAILED-ON HEATER, THE FOLLOWING WILL BE PERFORMED:
1. INHIBIT THE STARTUP HEATER LOGIC (FAILED-ON STARTUP HEATER ONLY) .

*If failed electronics has caused the heater to fail on, inhibiting the heater logic will disable the electronics.*

DOCUMENTATION: Engineering judgment.

2. MANAGE LOADS TO KEEP KOH/TEMPS WITHIN OPERATIONAL LIMITS.

*Managing loads may not be possible for the failed on startup heater (see paragraph A above).*

DOCUMENTATION: SODB 4.4.1.1.1 @[CR 7609 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A9-4

### FC HEATER MANAGEMENT (CONTINUED)

FOR A FAILED-ON STARTUP HEATER, OR IF THE ABOVE STEPS ARE UNSUCCESSFUL, OR IF MARGINS WILL NOT PERMIT RUNNING THE FC WITH FAILED-ON HEATERS, OR IF THE FC MUST BE SHUT DOWN FOR ANY OTHER REASON, CONTINUE WITH THE FOLLOWING:  
@[CR 7609 ]

3. TAKE THE FC TO STANDBY, THEN TAKE THE FC CONTROLLER POWER OFF, THEN BACK ON IN AN ATTEMPT TO REMOVE POWER FROM THE HEATER. IF THIS DISABLES THE HEATER, THE FC MAY BE RESTARTED OR IF FC SHUTDOWN IS REQUIRED FOR OTHER REASONS, THE SHUTDOWN WILL BE COMPLETED BY CLOSING THE REACTANT VALVES.
4. IF THE ABOVE STEPS WERE UNSUCCESSFUL, AND IF DATA SHOWS TAKING THE FC CONTROLLER POWER TO OFF DISABLES THE HEATER, THE FC SHUTDOWN WILL BE COMPLETED BY TAKING THE FC CONTROLLER POWER TO OFF AND CLOSING THE REACTANT VALVES.
5. IF ALL THE ABOVE STEPS WERE UNSUCCESSFUL, THE FC WILL BE SAFED BY TAKING THE FC TO START AND CLOSING THE REACTANT VALVES.

*All reasonable attempts to disable heaters should be performed to preserve consumables margins, lower FC operating temperatures to nominal, and preserve FC lifetime. Disabling the heater by taking the FC controller power off will prevent having to safe an otherwise good FC.*

*If all attempts to disable the heater are unsuccessful, but the fuel cell is able to continue operation without violating temperature or KOH limits, the fuel cell may be left running to provide redundancy and to allow more time to gather data.*

*If the FC must be shut down and the failed-on heater cannot be disabled, the reactants will be depleted ASAP to prevent excessive localized heating, damage to the heater element, thermal breakdown of the FC coolant, FC stack over-pressurization, and ultimately over-heating of the stack. With the increased heating associated with a failed-on heater, FC cooling problems, or high power levels, the time-to-effect for overheating and potential overpressure will be reduced, and a more timely response is required. (Ref. Rule {A9-60}, FC COOLANT PUMP/H2 PUMP/H2O SEPARATOR FAILURE MANAGEMENT [CIL] [HC]: Shutdown within 9 minutes.)*

DOCUMENTATION: SODB 4.4.1.1.1 and Engineering judgment. @[CR 7609 ]

## FLIGHT RULES

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12A\_A9-5

### FC COOLANT PUMP/H2 PUMP/H2O SEPARATOR FAILURE MANAGEMENT [CIL] [HC]

- A. THE FC MUST BE SHUT DOWN WITHIN 9 MINUTES (AT 7 KW) FOR LOSS OF COOLING. FC SAFING IS NOT REQUIRED. ©[CR 7609 ]

*After the loss of cooling, the FC must be shut down to preclude catastrophic failure due to overheating. Overheating will result in expansion of the stack, leaking of reactants into the PBD, and uncontrolled mixing of O<sub>2</sub> and H<sub>2</sub>, resulting in potential explosion. Testing and analysis indicate that the FC will reach the redline stack temperature of 250 deg F in approximately 9 minutes at 7 kW.*

DOCUMENTATION: SODB, 3.4.4.1.15.

- B. FUEL CELL OPERATION WITHOUT COOLING MAY BE EXTENDED BEYOND 9 MINUTES IF THE MCC CALCULATED FC STACK TEMPERATURE IS PREDICTED TO BE LESS THAN 250 DEG F. FC OPERATIONS BEYOND 9 MINUTES WILL ONLY BE ALLOWED DURING CRITICAL MISSION PHASES TO:
1. MAINTAIN TWO FUEL CELLS, OR
  2. MAINTAIN THREE MAIN BUSES (I.E., BUS TIE CAPABILITY LOST)

*At the FC power load of 7 kW, a FC can be operated for 9 minutes before the FC stack temperature reaches 250 deg F. However, if the power level can be reduced quickly after the loss of FC cooling, FC operation may be extended beyond 9 minutes, since a lower power level lowers the heating rate. FC operations would be extended when absolutely necessary to maintain two FC's or three main buses to allow critical equipment to remain powered, provide extra time to reconfigure safely, or to get past a critical event (i.e., ascent/entry). The 250 deg F limit of the FC stack temperature is required to maintain integrity of the FC power stack. Based on analysis and testing conducted by UTC and JSC E&D, the predicted FC stack temperature can be calculated from the FC stack temperature at the time of the failure and the affected FC subsequent power levels. (Reliable FC stack temperature measurement is lost following the loss of coolant flow.)*

*With the increased heating associated with a failed-on heater, FC cooling problems, or high power levels, the time-to-effect for overheating and potential overpressure will be reduced, and a more timely response is required.*

DOCUMENTATION: RI Internal Letter, 287-EPS-88-074, FC Operating Time Following Loss of Coolant, May 24, 1988; JSC-23091, Internal Note for FC X708 Thermal System Off-Limits Test, November 25, 1988; and SODB, 3.4.4.1.15.

*If the affected FC has previously experienced a failed-on heater that cannot be disabled, the reactants will be depleted to preclude potential catastrophic failure due to overheating. (Ref. Rule {A9-58}, FC SUSTAINER HEATER) ©[CR 7609 ]*

## FLIGHT RULES

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12A\_A9-6

ELECTRICAL GO/NO-GO CRITERIA [HC]

SYSTEM/COMPONENTS/FUNCTIONS	CONTINUE NOMINAL ASCENT IF:	INVOKE MDF IF:	ENTER NEXT PLS IF:
FUEL CELLS: FC STARTUP HEATER - FAILED ON		[1]	[2]
FC SUSTAINING HEATER - FAILED ON @[CR 7609 ]			[3]

- [1] WITH A FAILED-ON STARTUP HEATER, VI PERFORMANCE IS NOT EXPECTED TO MEET MINIMUM REQUIRED PERFORMANCE LEVEL FOR ENTRY AND WOULD NOT BE ACCEPTABLE AS A SECOND FUEL CELL. MARGINAL OR INADEQUATE ABILITY TO SUPPORT BUS VOLTAGE REQUIREMENTS FOR CONTINGENCY OPERATIONS (LOSS OF ONE FUEL CELL). MARGINAL OR INADEQUATE ABILITY TO MAINTAIN TEMPERATURE OR KOH CONCENTRATIONS WITHIN ACCEPTABLE LIMITS FOR HIGH POWER LEVEL OPERATIONS (ENTRY, LOSS OF ONE FC). CONSUMABLES IMPACT MAY DRIVE EARLIER MISSION TERMINATION IF FUEL CELL IS ALLOWED TO CONTINUE TO OPERATE.
- [2] WITH A FAILED-ON STARTUP HEATER AND ANOTHER FUEL CELL FAILED, ENTER NEXT PLS. WITH A FAILED-ON STARTUP HEATER, VI PERFORMANCE IS NOT EXPECTED TO MEET MINIMUM REQUIRED PERFORMANCE LEVEL FOR ENTRY AND WOULD NOT BE ACCEPTABLE AS A SECOND OR LAST FUEL CELL. MARGINAL OR INADEQUATE ABILITY TO SUPPORT BUS VOLTAGE REQUIREMENTS FOR CONTINGENCY OPERATIONS (LOSS OF TWO FUEL CELLS). MARGINAL OR INADEQUATE ABILITY TO MAINTAIN TEMPERATURE OR KOH CONCENTRATION WITHIN ACCEPTABLE LIMITS FOR HIGH POWER LEVEL OPERATIONS (LOSS OF TWO FUEL CELLS). RA-05 FAILURE MODES AND EFFECTS ANALYSIS, SEPT 30, 1983, AND SHUTTLE INFORMATION MEMORANDUM (SIM) # 33B, JUNE 13,1990.
- [3] WITH A FAILED-ON SUSTAINING HEATER AND ANOTHER FUEL CELL FAILED, ENTER NEXT PLS. VI PERFORMANCE IS NOT EXPECTED TO MEET MINIMUM ACCEPTABLE PERFORMANCE LEVEL FOR ENTRY IF USED AS A LAST FUEL CELL. CONSUMABLES IMPACT MAY DRIVE EARLIER MISSION TERMINATION IF FUEL CELL IS ALLOWED TO CONTINUE TO OPERATE. RA-05 FAILURE MODES AND EFFECTS ANALYSIS, SEPT 30, 1983, AND SHUTTLE INFORMATION MEMORANDUM (SIM) # 33B, JUNE 13,1990. @[CR 7609 ]



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## **FLIGHT RULES**

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**FLIGHT RULES**

**ISS ONLY RULES**

GENERAL

**12A\_B9-1      POWER TRANSFER TO THE RSOS FROM THE USOS [RC]**

A. NOMINAL ARCU/CHT CONFIGURATION BASED ON EXPECTED POWER TRANSFER TO THE RSOS IS SHOWN IN THE FOLLOWING TABLES. TABLE 1 GIVES THE PLANNED ARCU/CHT CONFIGURATION FOR A GIVEN ATTITUDE AND BETA ANGLE. TABLE 2 GIVES THE EXPECTED RS POWER DRAW FROM THE ACTIVE ARCU/CHT'S. POWER TRANSFER TO THE FGB INCLUDES 228 WATTS TRANSFERRED TO THE NODE THROUGH A RACU. ALL POWER NUMBERS IN THE TABLE ARE IN KW AND ARE APPLICABLE AT THE ARCU/CHT INPUT. THE FGB ARCU'S DRAW UP TO 1.6 KW AT THE ARCU INPUT (1.28 KW AT THE CONVERTER OUTPUT). THE SM CHT'S DRAW UP TO 1.9 KW AT THE CHT INPUT (1.5 KW AT THE CONVERTER OUTPUT).

**TABLE 12A\_B9-1-I - NOMINAL ARCU/CHT CONFIGURATION**

SOLAR BETA		0	10	20	30	37	40	50	52	60	65	70	75
FGB # OF ARCU'S	LVLH	0	0	0	1	1	1	1	1	1	1	1	1
	XPOP OR YVV	0	0	0	0	0	0	0	0	0	0	0	0
SM # OF CHT'S	LVLH W/O ROLL	2	2	2	3	3	3	3	3	3	3	4	4
	LVLH 30 DEG ROLL	2	2	2	2	2	2	2	2	2	2	2	2
	LVLH 40 DEG ROLL	3	3	2	2	2	2	2	2	2	2	2	1
	XPOP OR YVV	2	2	2	2	2	1	1	1	1	1	0	0

©[DN 107 ]

NOTES:

ONE FGB ARCU FOR SOLAR BETAS |30 DEG| TO |52 DEG| ONLY REQUIRED WHEN SOYUZ IS DOCKED TO FGB. TIME OF USE WILL DEPEND ON SOYUZ POWER CONSUMPTION. WILL LIKELY ONLY BE REQUIRED FOR 5 TO 6 HOURS PER DAY.

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

**12A\_B9-1                      POWER TRANSFER TO THE RSOS FROM THE USOS [RC]**  
**(CONTINUED)**

**TABLE 12A\_B9-1-II - ORBIT-AVERAGED NOMINAL POWER  
TRANSFER USOS TO RS**

SOLAR BETA		0	10	20	30	37	40	50	52	60	65	70	75
FGB PWR RQMT	LVLH	0.0	0.0	0.0	0.06	0.06	0.06	0.06	0.06	0.23	0.34	0.36	0.8
	XPOP OR YVV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SM PWR RQMT	LVLH W/O ROLL	3.20	3.26	3.42	3.72	4.10	4.12	4.39	4.46	4.76	5.28	5.53	5.66
	LVLH 30 DEG ROLL	3.58	3.28	3.26	3.24	3.23	3.20	3.24	3.26	3.26	3.24	2.98	2.82
	LVLH 40 DEG ROLL	3.80	3.62	3.56	3.14	3.00	2.98	2.98	2.98	2.89	2.52	1.91	1.21
	XPOP OR YVV	1.98	1.98	1.98	1.86	1.86	1.74	1.39	1.39	0.94	0.94	0.0	0.0

©[DN 107 ]

PLANNED EXCEEDENCES OF THE RS POWER DRAW IN TABLE 2 MUST BE COORDINATED WITH MCC-H AT LEAST 48 HOURS IN ADVANCE OF THE EXCEEDANCE SO THAT US POWER BALANCE CAN BE VERIFIED.

*In the event of a contingency, the RS is allowed to draw maximum power from activated ARCU/CHT's to resolve the situation. MCC-H must be notified within 30 minutes of the failure so that actions can be taken on the USOS to preserve power balance with the increased load. If additional ARCU/CHT's are required, they will be provided as power margin permits.*

*The kW values in the above tables are the predicted amount of power each Russian module needs to maintain energy balance for the given attitudes and beta ranges. The Russian EPS is designed to first draw power from the solar arrays, then the ARCU's, and finally from the batteries. There is no way to limit the ARCU load to the minimum required amount; therefore, the actual power transfer will be greater than the values listed in the table.*

DOCUMENTATION: RSC-E/Galina Lifanova, November 20, 2002, U.S.-RS EPS teleconference; RSC-E/S Yaroshenko. ©[DN 107 ]

B. IF THE 2B OR 4B BGA MUST BE PARKED, ONE SM CHT WILL BE PROVIDED FOR THE DURATION OF MATED OPS. IF POWER MARGINS SUPPORT THE ADDITIONAL LOAD, AN ADDITIONAL SM CHT WILL BE PROVIDED IF REQUIRED. IF BOTH 2B AND 4B BGA'S MUST BE PARKED SIMULTANEOUSLY, ONE SM CHT WILL BE PROVIDED, IF POWER MARGINS SUPPORT THE ADDITIONAL LOAD. ©[DN 2 ]

*If either BGA is placed in a parked position, solar array power generation is reduced such that powerdowns are required. The depth of the powerdowns is dependent on the beta angle and ISS attitude and will be determined real time.*

DOCUMENTATION: DF75 Power Analysis as reported to 9A/11A JOP, September 3, 2002.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-1

**POWER TRANSFER TO THE RSOS FROM THE USOS [RC]**  
**(CONTINUED)**

- C. POWER TRANSFER TO THE RSOS FROM THE USOS DURING DOCKING WILL BE LIMITED TO ONE SM CHT AND NO FGB ARCU'S. AN ADDITIONAL ARCU/CHT WILL BE PROVIDED, IF REQUIRED, ASSUMING POWER MARGINS SUPPORT THE ADDITIONAL LOAD. EACH FGB ARCU OUTPUT DRAWS UP TO 1.28 KW AND EACH SM CHT OUTPUT DRAWS UP TO 1.5 KW.

*Preflight energy balance assessment shows that for most beta angles, up to one SM CHT can be supported from the USOS during docking while protecting a one-rev docking delay. The nominal expected duration for this constraint is 1.5 hours, with a maximum duration of 4 hours. There is no way to limit the ARCU load to the minimum required amount; therefore, the actual power transfer will vary.*

- D. POWER TRANSFER TO THE RSOS FROM THE USOS DURING EVA'S WILL BE BASED ON AVAILABILITY OF POWER GENERATION FROM THE USOS ARRAYS AND THE REQUIRED U.S. SEGMENT LOAD CONFIGURATION. NOMINALLY, POWER TRANSFER TO THE RSOS FROM THE USOS DURING EVA WILL BE AS SPECIFIED IN PARAGRAPH A. FOR PLASMA CONTACTOR LOSS, POWER TRANSFER TO THE RSOS FROM THE USOS DURING EVA WILL BE LIMITED TO A MAXIMUM OF ONE SM CHT AND NO FGB ARCU'S. AN ADDITIONAL ARCU WILL BE PROVIDED, IF REQUIRED, ASSUMING POWER MARGINS SUPPORT THE ADDITIONAL LOAD.

*The latest power balance analysis indicates that USOS power generation will not be capable of supporting USOS loads and all of the SM CHT's and FGB ARCU's specified in paragraph A, while a Sequential Shunt Unit (SSU) is being shunted due to a Plasma Contactor Unit loss, at all of the possible beta angles and ISS attitudes that may be encountered during EVA's. Determinations of the actual powerdown required will be made real time.*

*DOCUMENTATION: DF75 USOS Energy Balance Analysis, August 2002.*

- E. FOR THE OFF NOMINAL CASE OF BEING CONSTRAINED, BY A FAILURE, TO ATTITUDE CONTROL BY TWO CMG'S, POWER TRANSFER FROM THE USOS TO THE RSOS WILL BE LIMITED TO A MAXIMUM OF TWO ARCU'S WHEN ALL OF THE CONDITIONS BELOW ARE MET. THE PREFERRED CONFIGURATION IF TWO ARCU'S ARE ACTIVE IS ONE SM CHT AND ONE FGB ARCU.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_B9-1                    POWER TRANSFER TO THE RSOS FROM THE USOS [RC] (CONTINUED)

1. A ROLL BIASED LVLH ATTITUDE WHICH ALLOWS ADEQUATE POWER GENERATION BY THE USOS TO SUPPORT THE POWER TRANSFER AMOUNTS SPECIFIED IN PARAGRAPH A IS NOT ALLOWABLE OR CANNOT BE MAINTAINED.
2. AN XPOP ATTITUDE WHICH ALLOWS ADEQUATE POWER GENERATION BY THE USOS TO SUPPORT THE POWER TRANSFER AMOUNTS SPECIFIED IN PARAGRAPH A IS NOT ALLOWABLE OR CANNOT BE MAINTAINED.
3. THE BETA ANGLE IS LESS THAN -44 OR GREATER THAN +38 DEGREES.

*Power analysis indicates that at high betas an XPOP attitude, or an LVLH attitude which is roll biased towards the Sun, must be maintained in order for the USOS to generate enough energy to allow for power transfer to the RSOS as defined in paragraph A. It is assumed that a nominal TEA attitude will be flown if such power favorable attitudes cannot be maintained due to CMG loss.*

*DOCUMENTATION: DF75 USOS Energy Balance Analysis, August 2002.*

F. WHEN THE ORBITER IS MATED TO ISS, THE NOMINAL FGB ARCU CONFIGURATION IN LVLH, BASED ON EXPECTED POWER TRANSFER TO THE RSOS, CHANGES TO 1 FGB ARCU POWERED ON AT EFFECTIVE BETAS > -10 AND < +23.

*Russian power analysis has shown that the orbiter, when mated to ISS, negatively impacts FGB power generation by shadowing the FGB solar arrays in the planned LVLH attitude. Effective beta is calculated as "beta + roll" (e.g., for beta angle of 47 deg and an ISS roll of -10 deg, effective beta is 37 deg). Power transfer to the FGB during EVA timeframes will be evaluated on a case-by-case basis as per Paragraph D. The nominal ARCU configuration does not extend to attitude excursion events outside the nominal LVLH attitude, which are also analyzed on a case-by-case basis.*

### 12A\_B9-2                    POWER TRANSFER TO THE USOS FROM THE RSOS [RC]

POWER TRANSFER TO THE USOS FROM THE RSOS WILL BE AS FOLLOWS:

NOMINAL RSOS TO USOS POWER TRANSFER WILL BE 400W (AVERAGE).

*USOS loads drawn from the RACU are expected to be around 290W on average. A 400-Watt allocation was agreed to with FGB managers to provide the required power through RACU 6 plus margin. ©[DN 73 ]*

*DOCUMENTATION: EPS TIM in Moscow, November 2004 ©[DN 73 ]*

## FLIGHT RULES

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### 12A\_B9-3

### RBI MANAGEMENT

- A. DCSU RBI'S MUST BE CLOSED IN THE FOLLOWING ORDER FOR POWER CHANNEL ACTIVATION FROM AN EXTERNAL POWER SOURCE.

RBI 6

RBI 5

RBI'S 2, 3, AND 4 IN ANY ORDER

RBI 1

*After RBI 6 has been successfully closed, this RBI close sequence must be followed to avoid a DCSU undervoltage brownout. A DCSU undervoltage brownout results in all DCSU RBI's transitioning to the open (default) state. The IEA DDCU-E source bus capacitance is sized small enough to prevent a DCSU undervoltage brownout upon closing RBI 5. If another switch (RBI 1, 2, 3, or 4) is closed before RBI 5, the DCSU will experience an undervoltage brownout due to the large inrush currents into the Battery Charge/Discharge Unit (BCDU) or SSU source bus capacitors. The IEA DDCU-E source bus capacitance provides enough voltage hold-up capability to enable closure of RBI's 2, 3, or 4 into the BCDU source bus capacitance. The SSU has the largest source bus capacitance and thus RBI 1 should be closed last.*

1. THE EXTERNAL SOURCE MUST PROVIDE VOLTAGE IN EXCESS OF 136.5 VOLTS TO THE DCSU RBI 6 INPUT PORT.

*Providing power of less than 136.5 Volts risks losing loads already powered up when additional RBI's are closed because of voltage droop during capacitor charging.*

2. IF THE EXTERNAL SOURCE IS ANOTHER POWER CHANNEL, ALL RBI CLOSURES MUST BE PERFORMED WHILE THE SOURCE CHANNEL'S SSU IS SHUNTING AT LEAST 5 AMPS OF TOTAL SHUNT CURRENT.

*If the source channel's SSU is shunting some power, then it is clear that there will be enough surge margin to handle capacitor charging inrush. Closing RBI's in the dependent channel's DCSU while the source channel's SSU is fully loaded and not shunting power risks tripping of the source channel's BCDU's leading immediately to the loss of the source channel.*

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## FLIGHT RULES

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12A\_B9-3

### RBI MANAGEMENT (CONTINUED)

- B. DCSU RBI'S MUST BE CLOSED IN THE FOLLOWING ORDER FOR A POWER CHANNEL ACTIVATION USING THE CHANNEL'S OWN SOLAR ARRAY POWER:

RBI 1

RBI'S 2, 3, 4, AND 5, IN ANY ORDER

RBI 6

*RBI 1 is closed to provide power to the DCSU primary power bus. The remaining RBI's (RBI 5, 2, 3, or 4) may be closed in any order. RBI 5 is usually closed before 2, 3, or 4, because it powers the PV module DDCU, which in turn provides power to the PFCS. RBI 6 should be closed last.*

- C. AFTER A DCSU RBI 2, 3, OR 4 HAS BEEN OPENED, RECLOSURE MUST BE PERFORMED DURING INSOLATION WHILE THE SSU REGULATES BUS VOLTAGE AND IS SHUNTING AT LEAST 5 AMPS OF TOTAL SHUNT CURRENT. RBI'S 5, AND 6 MAY BE RECLOSED AT ANY POINT IN THE ORBIT. RBI 1 MUST BE CLOSED IN INSOLATION WHILE THE SSU GENERATES POWER.

*If not done this way, the inrush caused by the capacitance on the BCDU's input might undervolt the bus. If the SSU is generating power, then its capacitor is already charged, and the BCDU's will not trip trying to charge it.*

- D. MBSU RBI'S MAY BE CLOSED OR RECLOSED IN ANY ORDER.

- E. THE FOLLOWING RESTRICTIONS APPLY TO RBI'S THAT EXPERIENCE TRIPS OR THAT UNEXPECTEDLY OPEN FOR OTHER REASONS:

1. WHERE ANY RBI TRIP IS ACCOMPANIED BY INDICATION OF A FAILED CURRENT SENSOR, AND WHERE THE REST OF THE PRIMARY HARDWARE ON THAT POWER CHANNEL (SSU, BCDU, DDCU, MBSU) CONTINUES TO OPERATE AS EXPECTED, THE TRIP FUNCTION FOR THE AFFECTED RBI WILL BE INHIBITED, AND THE RBI WILL BE RECLOSED.

*When there is a true fault anywhere in the Primary EPS, the expected signature is that the SSU will LFDP trip, and all DDCU's that maintain input power will suffer Input Undervoltage Trips. This all occurs because during the trip, the BCDU's limit their output current, causing the bus voltage to drop below the 100 Volt LFDP limit. When this signature is not present, and the tripped RBI still shows a high current, this can be viewed as two independent indications that there was no real fault, and the RBI can be safely reclosed.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_B9-3

### RBI MANAGEMENT (CONTINUED)

- a. IF THE RBI TRIP HAS CONFIRMING CUES AND THE RBI PROVIDES POWER TO THE LAST REMAINING STRING OF A CRITICAL FUNCTION, THE RBI MAY BE RECLOSED ONE TIME.

*If power to the only remaining string of a critical system must be restored, the risk caused by reclosing the RBI is worth the risk of closing the RBI into a fault. The operation of the trip function was verified in the first trip and there is no reason to believe that it would have stopped working before the reclosure. To reduce the risk during the reclosure even further, it can be attempted with a reduced DCSU bus voltage during eclipse. Doing so reduces the energy available during the fault and reduces the fault current that the RBI is required to break, should the reclosure result in a subsequent trip.*

- b. IF THE RBI TRIP HAS CONFIRMING CUES BUT IS NOT REQUIRED TO REGAIN THE LAST REMAINING STRING OF A CRITICAL FUNCTION, THE RBI WILL NOT BE RECLOSED UNLESS RECOMMENDED AFTER ADDITIONAL TROUBLESHOOTING BY MCC.

*The RBI closure is allowed if an RBI inadvertently opens without evidence of an overcurrent condition. Due to the fast response time of RBI overcurrent tripping (40 to 312 ms), risk of fire or arcing is minimal; therefore, reclosure will be attempted once. If there is evidence of an overcurrent trip, but the downstream loads are required to provide power to the last remaining string of a critical function, then reclosure will also be tried once. If neither of these are the case, then MCC will perform additional troubleshooting to determine the cause of the trip and if it is safe to attempt reclosure.*

2. ANY RBI THAT HAS UNEXPECTEDLY OPENED WITHOUT A TRIP MAY BE RECLOSED ONCE.
3. FOR ALL OTHER CASES, RECLOSE WILL NOT BE ATTEMPTED WITHOUT ANALYSIS OF ALL FACTORS THAT MIGHT HAVE CONTRIBUTED TO THE TRIP.

*If there is any question about what might have caused an RBI to open, it should be left open until a full troubleshooting effort can be performed. To do otherwise risks loss of a power channel.*

4. ANY RBI IS LIMITED, WITHIN ITS LIFETIME, TO A MAXIMUM OF 25 OPENINGS DUE TO AN OVERCURRENT TRIP.

### 12A\_B9-4

RESERVED ©[DN 15 ]



## FLIGHT RULES

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**12A\_B9-5**      **PLASMA HAZARD MITIGATION [HC] [RI]**    ©[DN 99 ]

- A. PCU'S ARE NOT REQUIRED TO BE ACTIVE DURING NON-EVA PERIODS.
- B. PRIOR TO P4 ARRAY DEPLOY, DURING NOMINAL EVA ACTIVITIES:  
©[CR 7608B ]
1. THE USOS WILL CONTROL PLASMA ARCING WITH TWO ACTIVE PCU'S IN DISCHARGE MODE.
  2. IN THE EVENT THAT ONE OR TWO PCU'S FAIL DURING THE EVA, THE EVA MAY CONTINUE.    ©[DN 99 ]
  3. IN THE EVENT THAT ONE OR TWO PCU'S FAIL PRIOR TO THE EVA, THE EVA MAY BE PERFORMED WITH NO PLASMA CONTROL.

*Hazard Report ISS-EVA-0312-12A identifies a catastrophic hazard to EVA crewmembers due to plasma arcs through the EMU. Early shock hazard analysis indicates that an ISS structural potential more negative than -40 V with respect to the ambient plasma was sufficient to create a charging concern for EVA crewmembers. Detailed analysis of all relevant ionospheric variability data (ISS Ionospheric Environment Specification) combined with validated charging models shows that the likelihood of violating the -40 V FP requirement remains negligible ( $\ll 10^{-6}$ ) before the P4 arrays are deployed.*

*Retracted solar arrays do not require any plasma hazard control actions.*

*Reference Hazard Reports NCR-ISS-062-12A, Fault Tolerance of Floating Potential Control During EVA, and ISS-EVA-0312-12A, Electric Shock to EVA Crew Resulting from EMU/Orlan Arcing in Plasma.*

- C. AFTER P4 ARRAY DEPLOY, DURING NOMINAL EVA ACTIVITIES:
1. HAZARD CONTROLS ARE REQUIRED AS FOLLOWS:
    - a. TWO ACTIVE PCU'S IN DISCHARGE MODE
    - b. ONE OF THE FOLLOWING:
      - (1) CCS PCU EVA HAZARD CONTROL ENABLED
      - (2) NO MORE THAN TWO ARRAYS UNSHUNTED
      - (3) NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR    ©[CR 7608B ]

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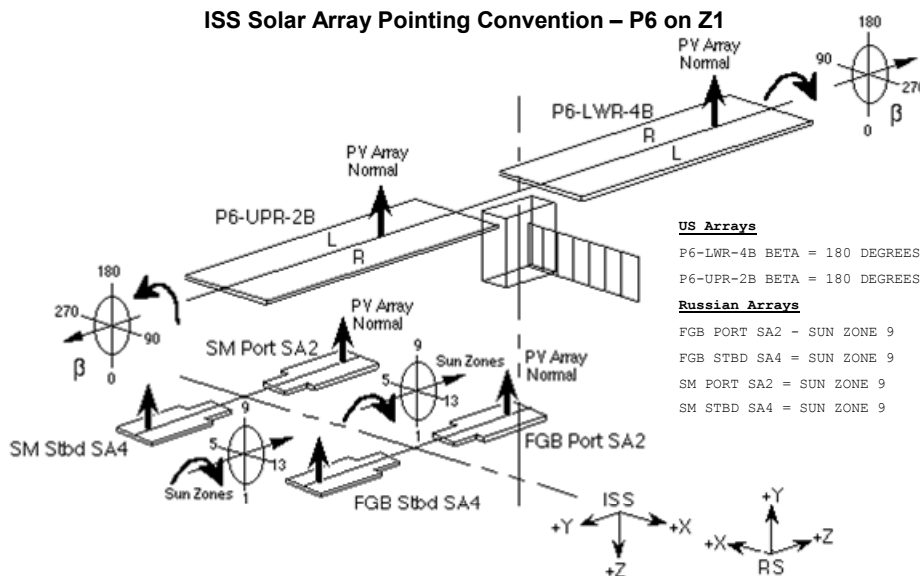
# FLIGHT RULES

12A\_B9-5

**PLASMA HAZARD MITIGATION [HC] [RI] (CONTINUED)**

2. IN THE EVENT THAT A PCU FAILS DURING THE EVA, THE CCS PCU EVA HAZARD CONTROL, IF ENABLED, WILL SHUNT ALL ACTIVE SOLAR ARRAYS. THE EVA MAY CONTINUE WITH ONE OF THE FOLLOWING CONFIGURATIONS: @[CR 7068B ]
  - a. NO MORE THAN TWO ARRAYS UNSHUNTED
  - b. NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR
  
3. IN THE EVENT THAT ONE OR TWO PCU'S FAIL PRIOR TO THE EVA, THE USOS WILL CONTROL PLASMA ARCING WITH ONE OF THE FOLLOWING METHODS:
  - a. NO MORE THAN TWO ARRAYS UNSHUNTED.
  - b. NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR

*The definition of Array Orientation is the angle normal to the active side of the solar array relative to the velocity vector. See Below:*



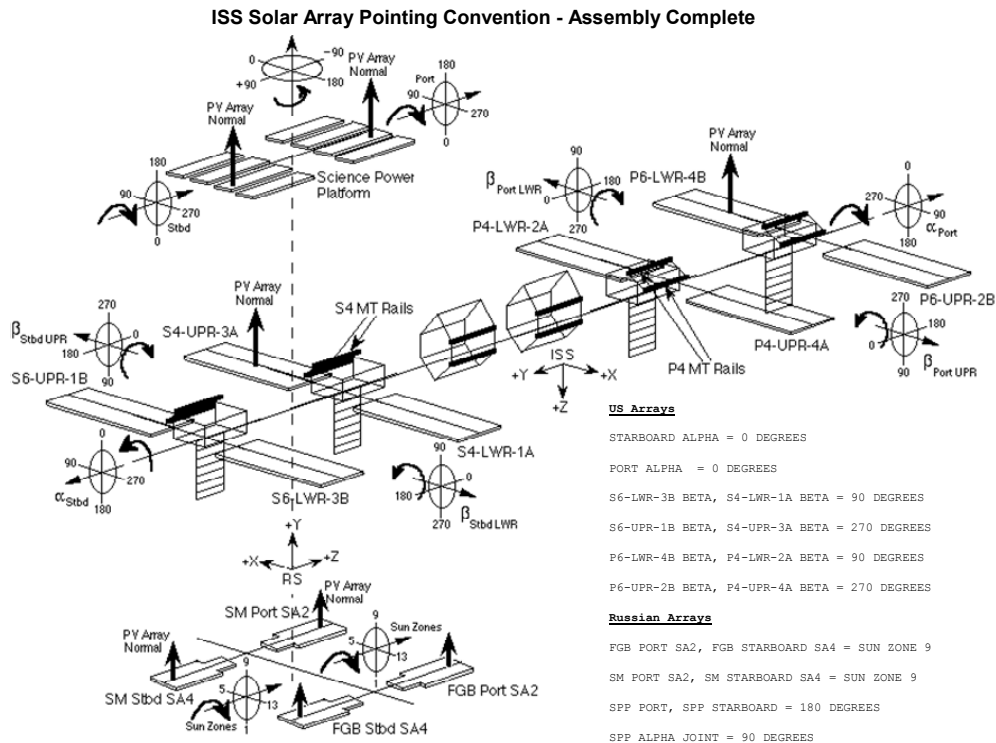
@[CR 7608B ]

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**FLIGHT RULES**

12A\_B9-5

**PLASMA HAZARD MITIGATION [HC] [RI] (CONTINUED)**



©[CR 7608B ]

Three hazard controls are required during EVA activities if floating potential magnitudes exceed 40V. If both PCU's are available and functional, then one additional control is required. CCS PCU EVA Hazard Control may provide the third control for the nominal case. In the event of PCU failure or shutdown, the CCS PCU EVA Hazard Control detects the loss and immediately shunts all solar arrays, maintaining plasma protection until further action is taken.

Per the CCS PCU EVA Hazard Control as documented in the CCS SRS paragraph 3.2.3.2.9, in the event of a PCU failure, having all solar arrays shunted provides the required controls until the ground takes additional action. Analysis has shown that no -40V violation exists if only two active solar arrays are pointed to ram or less than 15 degrees to ram at one time, regardless of the number of active PCU's. Once all arrays are shunted, the operator has the option of either shunting all but two active solar arrays, or placing any additional arrays greater than 15 degrees to wake. As long as no more than two unshunted arrays are facing ram at any one time, no -40V violation exists and the hazard is properly controlled. ©[CR 7608B ]

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## FLIGHT RULES

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12A\_B9-5

PLASMA HAZARD MITIGATION [HC] [RI] (CONTINUED)

*Hazard Report ISS-EVA-312-12A identifies a catastrophic shock hazard to EVA crewmembers due to vehicle electrical discharge through the EMU suit. Electrical currents enabled by dielectric breakdown arcing of exposed EMU suit materials may pass through an EMU suit and crewmember when the vehicle floating potential is more negative than -40V. ©[CR 7608B ]*

*Retracted solar arrays do not require any plasma hazard control actions.*

*Reference Hazard Report ISS-EVA-312-12A, Electric Shock to EVA Crew or EMU Fire Resulting from EMU Arcing to Plasma, February 14, 2003; and ISS Environments Memorandum 2006-045, John W. Alred, P4 Solar Array Wing RAM Angle Definition for Plasma Hazard Mitigation during Flight 12A/Stage 12A EVA's, July 12, 2006.*

4. IN THE EVENT AN EVA CREWMEMBER IS REQUIRED TO TRANSLATE OUTBOARD OF THE SARJ WHEN A PCU IS FAILED, AND PRE-FLIGHT ANALYSIS SHOWING THE ENVIRONMENTAL CONDITIONS DURING THE EVA MAY VIOLATE THE -40V REQUIREMENT THEN THE USOS WILL CONTROL PLASMA ARCING WITH ONE OF THE FOLLOWING METHODS:
  - a. NO MORE THAN ONE ARRAY UNSHUNTED ONLY WHEN THE EVA CREWMEMBER IS OUTBOARD OF THE SARJ
  - b. NO MORE THAN ONE ARRAY ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR ONLY WHEN THE EVA CREWMEMBER IS OUTBOARD OF THE SARJ

*Worst case analysis shows that floating potentials near -40V are possible outboard of the SARJ with two solar array wings unshunted and in the velocity vector.*

*Reference VIPer Working Group Presentation, Effect of Active Solar Array Configurations on ISS Charging, Brandon Reddel and Leonard Kramerl, August 9, 2005. ©[CR 7608B ]*

## FLIGHT RULES

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12A\_B9-6      RESERVED    ©[DN 17 ]

12A\_B9-7      RESERVED    ©[DN 17 ]

12A\_B9-8      RESERVED    ©[DN 1 ]

12A\_B9-9      RESERVED    ©[DN 1 ]

12A\_B9-10     RESERVED    ©[DN 1 ]

12A\_B9-11     RESERVED    ©[DN 1 ]

## FLIGHT RULES

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### 12A\_B9-12

### P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION

- A. DURING MAST DEPLOYMENT OPERATIONS, THE ISS ATTITUDE AND ALPHA AND BETA GIMBALS WILL BE CONFIGURED TO PROVIDE AN ACCEPTABLE THERMAL ENVIRONMENT DURING SOLAR ARRAY PANEL UNFOLDING. ©[CR 7555A ]

*Structural and thermal analysis of the Solar Array Wings (SAW's) indicates that there is a risk of improper or unsuccessful deployment if minimum thermal conditions are not met. During SAW deployment, a solar incident angle of 90 degrees ( $\pm 30$  degrees) must be maintained to the back side of the SAW. This incident angle may be met with a combination of Beta Gimbal Assembly (BGA) positioning and ISS attitude adjustment.*

- B. THE PORT SOLAR ALPHA ROTARY JOINT (SARJ) WILL BE LOCKED AT 0 DEGREES THROUGHOUT SOLAR ARRAY DEPLOYMENT.

*Due to the potential for collision, port SARJ rotation is restricted while Solar Array 4B is deployed and any P4 mechanisms are deployed. A SARJ position of 0 degrees provides adequate positioning for viewing of SAW deployment, as well as post-deployment power generation for P4 power channels.*

- C. BGA 2A WILL BE LOCKED AT 300 DEGREES AND BGA 4A WILL BE LOCKED AT 60 DEGREES THROUGHOUT SOLAR ARRAY DEPLOYMENT.

*This BGA positioning provides the maximum anticipated solar incident angle (to the back side of the array) while preserving adequate crew viewing capability during deployment. The crew must have visual monitoring capabilities to confirm proper operation of SAW hardware. BGA's may be positioned no more than 60 degrees from the launch position (0 degrees). While mechanisms are in motion, the BGA is subject to a possible motor trip when the motor is on and the anti-rotation pin is not engaged. This would result in a free-spinning array and subject to worst case loads while deployment is underway. This constraint only applies to the BGA associated with the array to be deployed.*

*Reference Rule {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC]. ©[CR 7555A ]*

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## FLIGHT RULES

12A\_B9-12

**P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ AND BGA CONFIGURATION (CONTINUED)**

D. ISS ATTITUDE WILL BE MAINTAINED PER THE TABLE BELOW:

@[CR 7555A ]

**TABLE 12A\_B9-12-I - SAW DEPLOY ATTITUDE ENVELOPE**

BETA ANGLES	EVENT	ATTITUDE [1] [5]	ATTITUDE REFERENCE FRAME	PERMISSIBLE ATTITUDE ENVELOPE				
				YAW	PITCH	ROLL [3]	TIME IN ATTITUDE [2]	RECOVERY TIME [2]
$-50^\circ \leq \beta \leq 0^\circ$	2A DEPLOY	XPOP W/-90° YAW	ISS XPOP [2]	-90°	+20°	$40^\circ -  \beta $	3 INSOLATION PERIODS	6 TO 10 HOURS
$0^\circ \leq \beta \leq +50^\circ$		XPOP W/+90° YAW		$40^\circ -  \beta $		3 INSOLATION PERIODS	6 TO 10 HOURS	
$-50^\circ \leq \beta \leq 0^\circ$	4A DEPLOY	XPOP W/-90° YAW	ISS XPOP [2]	-90°	+20°	$30^\circ -  \beta $	3 INSOLATION PERIODS	6 TO 10 HOURS
$0^\circ \leq \beta \leq +50^\circ$		XPOP W/+90° YAW		$30^\circ -  \beta $		3 INSOLATION PERIODS	6 TO 10 HOURS	

NOTES:

- [1] SUN IS REQUIRED ON THE STARBOARD SIDE OF ISS FOR 12 HOURS PRIOR TO MANEUVER TO SAW DEPLOY ATTITUDE.
- [2] THE ALLOWABLE TIME IN THE SAW DEPLOYMENT ATTITUDES IS LIMITED TO A DURATION OF THREE FULL INSOLATION PERIODS. AFTER THIS DURATION, THE VEHICLE ATTITUDE MUST RETURN TO AND REMAIN INSIDE THE NOMINAL ATTITUDE ENVELOPE FOR 6 HOURS PRIOR TO RETURNING TO THE SAW DEPLOY ATTITUDE FOR TWO FULL INSOLATION PASSES. THE SUN MUST BE ON THE STARBOARD SIDE OF THE STATION DURING THIS 6-HOUR PERIOD. TEN HOURS IN THE NOMINAL ATTITUDE ENVELOPE IS REQUIRED PRIOR TO RETURNING TO THE SAW DEPLOY ATTITUDE FOR THREE FULL INSOLATION PASSES. AGAIN, THE SUN MUST BE ON THE STARBOARD SIDE OF THE STATION DURING THIS 10-HOUR PERIOD.
- [3] THE VALUES OF 30 DEGREES AND 40 DEGREES IN THESE EQUATIONS ARE THE EFFECTIVE BETA (EB) ANGLES. THE EFFECTIVE BETA ANGLES FOR SAW DEPLOY PROVIDE CLOSE TO IDEAL CONDITIONS FOR THERMAL CONDITIONING OF THE P4 SAW'S TO SUPPORT THEIR DEPLOYMENT. THE EFFECTIVE BETA ANGLE IS THE COMBINATION OF THE ABSOLUTE VALUE OF THE SOLAR BETA ANGLE PLUS THE ROLL VALUE THAT WILL PROVIDE IDEAL THERMAL CONDITIONING.  
 2A:  $EB = 40 \text{ DEGREES} = |\beta| + \text{ROLL}$  (IDEAL THERMAL CONDITIONING). NOTE: 2A SOLUTION ENVELOPE IS DARK GREEN AS SHOWN IN FIGURE 12A\_B9-12-I.  
 4A:  $EB = 30 \text{ DEGREES} = |\beta| + \text{ROLL}$  (IDEAL THERMAL CONDITIONING). NOTE: 4A SOLUTION ENVELOPE IS LIGHT GREEN AS SHOWN IN FIGURE 12A\_B9-12-I.  
 FOR P4 SAW DEPLOY THERMAL CONDITIONING, ANALYSIS ASSUMES P6 BGA'S ARE TRACKING, 4A BGA IS LOCKED AT 60 DEGREES DURING DEPLOY, 2A BGA IS LOCKED AT 300 DEGREES DURING DEPLOY, AND PORT SARJ IS LOCKED AT 0 DEGREES. THESE ATTITUDES ARE INTENDED TO PROVIDE A SOLAR INCIDENCE ANGLE OF 90 DEGREES ( $\pm 30$  DEGREES) TO THE P4 ARRAYS, WHILE MEETING REQUIREMENTS FOR CREW VISUALS AND P6 POWER GENERATION. REFERENCE SSCN 8559. @[CR 7555A ]

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## FLIGHT RULES

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12A\_B9-12

### P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ AND BGA CONFIGURATION (CONTINUED)

- [4] MATED STACK ATTITUDE CONTROL DURING THE P4 SOLAR ARRAY WING (SAW) DEPLOYS WILL BE HANDLED IN THE FOLLOWING MANNER: ISS WILL MANEUVER TO THE 4A SAW DEPLOY ATTITUDE AND CONTROL THE ATTITUDE WHILE THE 4A SAW IS IN THE PARTIALLY DEPLOYED AND FULLY DEPLOYED POSITIONS. THE MATED STACK WILL BE IN FREE DRIFT WHILE THE MAST IS IN MOTION. AT THE COMPLETION OF THE 4A SAW DEPLOY, ISS WILL MANEUVER TO THE 2A SAW DEPLOY ATTITUDE. AFTER THE 4A SAW IS FEATHERED TO 270 DEGREES, TO SUPPORT ORBITER JET FIRINGS, ISS WILL HAND OVER MATED CONTROL TO THE ORBITER. THE ORBITER WILL CONTROL THE ATTITUDE WHILE THE 2A SAW IS IN THE PARTIALLY DEPLOYED AND FULLY DEPLOYED POSITIONS. THE MATED STACK WILL BE IN FREE DRIFT WHILE THE MAST IS IN MOTION. AT THE COMPLETION OF THE 2A SAW DEPLOY, THE ORBITER WILL MANEUVER BACK TO LVLH. AFTER THE 2A SAW IS FEATHERED TO 80 DEGREES, TO SUPPORT ISS JET FIRINGS, THE ORBITER WILL HAND OVER MATED CONTROL TO ISS. ©[CR 7555A ]
- [5] USE AN ECLIPSE PERIOD MANEUVER TO AND FROM SAW DEPLOY ATTITUDE USING U.S. THRUSTERS ONLY (USTO) AT EITHER 0.084 OR 0.1 DPS.

*Difficulties with SAW deploy during STS-97/4A demonstrated the impact of a cold thermal environment on SAW blanket deploy characteristics. An even, warm thermal environment is highly desirable to minimize stiction between blanket panel elements. Stiction becomes a concern when deploying the array from 49 percent (15.5 mast bays) to 100 percent, and there is a potential for damaging the hardware due to tension bar rise and slap back. However, the ability to visually identify deploy anomalies must be provided regardless of the thermal environment. Thermal conditioning can only take place during an insolation period. The length of time it takes to thermally condition the blanket is dependant on attitude, solar beta, BGA position, and which surface of the array is being illuminated. The inactive side of the array warms faster when in sun than the active side of the array when it is in sun. Therefore, the nominal plan is to illuminate the inactive surface of the array and maintain a solar incidence angle near 90 degrees for approximately 30 minutes, to achieve adequate thermal conditioning. Severity of array stiction is directly proportional to the time the panels have been stored inside of the blanket boxes and temperature of panels at deployment.*

*Thruster plume on a partially deployed array can cause structural damage and contaminate the array. For arrays to be deployed forward of the main truss, attitude control should be maintained with ISS thrusters. For arrays to be deployed aft of the main truss, attitude control should be maintained with orbiter thrusters. While P6 is located on Z1, attitude control can be maintained with ISS thrusters for array deploy operations. ©[CR 7555A ]*

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**FLIGHT RULES****12A B9-12****P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ AND BGA  
CONFIGURATION (CONTINUED)**

- E. IF THE SOLAR ARRAY IS PARTIALLY DEPLOYED, AND ISS THERMAL LIMITS ARE EXCEEDED WHILE IN THE SOLAR ARRAY DEPLOY THERMAL CONDITIONING ATTITUDE, MANEUVER TO LVLH, THEN RESUME SOLAR ARRAY DEPLOY UTILIZING THE CREEP RELEASE TECHNIQUE. ©[CR 7555A ]

*If required to return to an LVLH attitude due to thermal limit exceedance, it may take 6+ hours before another attitude transition is possible. Therefore, it is preferable to proceed with solar array deployment, even if thermal conditions are not optimal to minimize blanket panel stiction forces. Difficulties with P6-2B SAW deploy during STS-97/ISS-4A demonstrated the impact of a cold thermal environment on SAW blanket deploy characteristics while in low tension mode. However, the P6-4B SAW was placed in high tension mode and successfully deployed in LVLH, by using the creep release technique to minimize risk of damage due to stiction. The creep release technique may take more time than deploying an array in a thermal conditioning attitude, however a wait time of 6+ hours between array deploy attempts is not required. Thermal conditioning can only take place during an insolation period. Once in LVLH, resume array deploy when sun vector is optimal (as close to 90 deg to the back surface of the array as possible). An even, warm thermal environment is highly desirable to minimize stiction between blanket panel elements. When deploying the array from 49 percent (15.5 mast bays) to 100 percent, there is a potential for damaging the hardware due to tension bar rise and slapback. The creep release technique minimizes the risk to the hardware during this phase of solar array deployment.*

*Thruster plume on a partially deployed array can cause structural damage and contaminate the array. For arrays to be deployed forward of the main truss, attitude control should be maintained with ISS thrusters. For arrays to be deployed aft of the main truss, attitude control should be maintained with orbiter thrusters. While P6 is located on Z1, attitude control can be maintained with ISS thrusters for array deploy operations.*

*Reference Rule {B9-207}, SOLAR ARRAY WING DEPLOY CONSTRAINTS AND MINIMUM REQUIREMENTS [HC].*

*Documentation: Boeing ISS Environments Memo 2005-061, Feathering Angle Tables for Attitude Control - Stages 12A-15A: Progress on DC1 Providing Roll Control and Progress on SM Aft Providing Pitch and Yaw Control; ISS Environments Memo 2005-063, Feathering Angle Tables for Attitude Control - Stages 12A-15A: Progress on DC1 Providing Roll Control and Service Module Providing Pitch and Yaw Control; ISS Environments Memo 2005-064, Feathering Angle Tables for Attitude Control - Stages 12A-15A: Service Module Providing Roll Control and Progress on SM Aft Providing Pitch and Yaw Control; and Viper Team Orbiter/ISS Thruster Plume Analysis(LOADS) and Impacts On USOS Arrays. ©[CR 7555A ]*

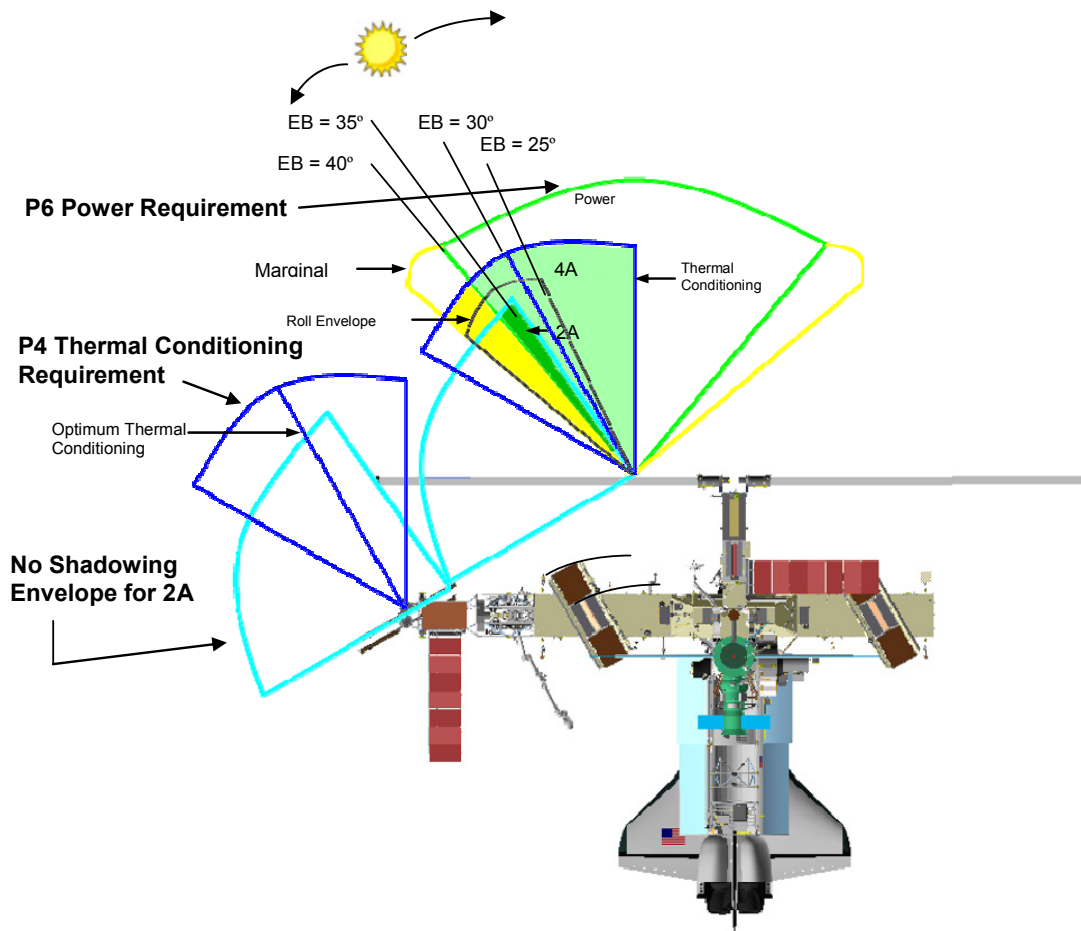
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# FLIGHT RULES

12A\_B9-12

## P4 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ AND BGA CONFIGURATION (CONTINUED)

FIGURE 12A\_B9-12-I - SAW DEPLOY ATTITUDE ENVELOPE VISUALIZATION ©[CR 7555A ]



©[CR 7555A ]

## FLIGHT RULES

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12A\_B9-13

SARJ DRIVE LOCK ASSEMBLY (DLA) CONFIGURATION  
MANAGEMENT [HC] [RI] ©[DN 16 ] ©[CR 7654 ]

- A. THE FOLLOWING ARE THE NOMINAL SOLAR ALPHA ROTARY JOINT (SARJ) DLA CONFIGURATIONS:
1. DURING SARJ ROTATION, THE PRIMARY DLA WILL BE IN THE ENGAGED POSITION AND THE CROSS-STRAPPED DLA WILL BE IN THE NEUTRAL POSITION.
  2. WHILE THE SARJ IS PARKED, THE PRIMARY DLA WILL BE PLACED IN THE ENGAGED POSITION AND THE CROSS-STRAPPED DLA WILL BE PLACED IN THE LOCKED POSITION.

*While the SARJ is rotated or configured for rotation, the primary DLA will be engaged in order to provide a motor for rotating the SARJ. The cross-strapped DLA will be placed in neutral so that it does not restrict SARJ movement. The primary DLA is defined as the DLA on the same string as the P3/S3 MDM in commanded mode. The primary DLA must be the engaged DLA for this configuration, since it is the only DLA capable of moving the SARJ.*

*When the SARJ is parked, one DLA must be locked in order to prevent inadvertent SARJ motion. The other DLA will be engaged in order to prevent both DLA's from being placed in neutral during DLA reconfigurations. The primary DLA is engaged and the cross-strapped DLA is locked to minimize DLA reconfiguration. The primary DLA is the only one capable of driving the SARJ to the parked position. Once the SARJ is in the parked position, the cross-strapped DLA is locked.*

- B. IN CONDITIONS WHERE ANTICIPATED LOADS MAY CAUSE SARJ FREE ROTATION, BOTH DLA'S MAY NOT BE IN THE NEUTRAL POSITION.

*When the DLA's are in the neutral-neutral configuration, the associated outboard truss is susceptible to rotation due to external loads. There is no analysis to define which loads could damage hardware when the DLA's are in this configuration; therefore, the neutral-neutral configuration should be avoided.*

- C. DURING EVA'S IN THE PROXIMITY OF THE SARJ, THE SARJ DLA'S WILL BE CONFIGURED TO PREVENT HARDWARE MOTION HAZARDS TO EVA CREWMEMBERS.
1. ONE DLA WILL BE LOCKED TO HOLD THE SARJ STATIONARY WHEN EVA CREWMEMBERS TRANSLATE PAST AND/OR WORK OUTBOARD OF THE SARJ. ©[CR 7654 ]

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## FLIGHT RULES

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12A\_B9-13

**SARJ DRIVE LOCK ASSEMBLY (DLA) CONFIGURATION  
MANAGEMENT [HC] [RI] (CONTINUED)**

2. IF EVA CREWMEMBERS ARE WORKING WITHIN 2 FEET OF SARJ HARDWARE, THE DLA'S WILL BE PLACED IN ONE OF THE FOLLOWING CONFIGURATIONS: @[CR 7654 ]
  - a. ONE DLA WILL BE LOCKED, ALL MOTOR SETPOINTS WILL BE SET TO ZERO, AND ALL MOTORS WILL BE DESELECTED.
  - b. BOTH DLA'S WILL BE LOCKED.
3. DURING SARJ INSTALLATION, WHILE THE LAST LAUNCH LOCK OR RESTRAINT IS REMOVED, BOTH DLA'S MUST BE ENGAGED WITH ALL MOTOR SETPOINTS SET TO ZERO AND ALL MOTORS DESELECTED.

*During EVA operations in the proximity of the SARJ or outboard structure, the SARJ must be held stationary. For nominal operations, this is accomplished by locking a SARJ DLA, setting the motor setpoints to zero, and deselecting all motors. For SARJ assembly operations, prior to the removal of the last launch lock or restraint, the DLA's cannot be locked due to alignment of the lock rack and race ring teeth. Both DLA's are engaged with all motor setpoints set to zero and all motors deselected in order to hold the joint in place while the last launch lock or restraint is being removed. All motor setpoints are set to zero and motors are deselected to prevent inadvertent rotation of the SARJ. Inadvertent rotation may result in physical contact with, and damage to, the EMU.*

*12A FOR RJMC/DLA EVA Ops Constraints Splinter, March 1, 2006.*

*Documentation: Hazard Report ISS-MCH-0051-AC, Rev 1, Collision with Orbiter, ISS Component or EVA Crewmember Due to Inadvertent Mechanism Operation, May 31, 2001 @[CR 7654 ]*

## FLIGHT RULES

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### 12A\_B9-14                    P4 BETA GIMBAL ASSEMBLY (BGA) OPERATION DURING HIGH SOLAR BETA ANGLES

WHEN SOLAR  $|\text{BETA}| > 70$  WHILE IN XPOP OR YVV ATTITUDES, THE P4 BGA'S WILL BE OPERATED IN OPEN LOOP MODE.

*Thermal analysis shows the P4 beta gimbals exceed the lower temperature limit when shadowed by the beta gimbal platform and/or the P6-4B solar array at a high solar beta angle,  $|\text{beta}| > 70$  while in XPOP or  $\pm\text{YVV}$  attitudes. The analysis assumed the SARJ was locked at  $\alpha = 0$ .*

WHEN SOLAR BETA IS  $< -70$  WHILE IN +XVV ATTITUDES, THE P4 BGA'S WILL BE OPERATED NOMINALLY. @DN 8 ]

*Reference Rule {12A\_B2-2}, ISS STAGE ATTITUDE CONSTRAINTS [RC], for pitch constraints.*  
@DN 8 ]

*Source: Boeing CER Presentation, CR # R-PCM-540, Flight Attitude Rev D+ Thermal Design Issue Resolution for Truss Segments P4 and S4, July 12, 2002.*

### 12A\_B9-15                    INITIAL ENGAGE VISUAL INSPECTION OF SOLAR ALPHA ROTARY JOINT (SARJ) DRIVE LOCK ASSEMBLIES (DLA'S)

AFTER INITIAL INSTALLATION, IT IS HIGHLY DESIRED, BUT NOT REQUIRED, FOR THE CREW TO VISUALLY CONFIRM THE DLA POSITION AFTER THE DLA IS ENGAGED.

*Visual confirmation of the DLA pinion gear in contact with the SARJ race ring when the DLA is engaged will help ensure the DLA was installed properly.*

## FLIGHT RULES

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12A\_B9-16

### P4 PHOTOVOLTAIC RADIATOR (PVR) HEAT REJECTION CAPABILITIES

- A. WHILE THE P4 PVR IS STOWED, THE P4 PVTCS WILL BE UTILIZED TO SUPPORT THE FOLLOWING PRIORITIZED LIST OF LOADS AS LONG AS THE BATTERY OPERATING TEMPERATURES DEFINED IN RULE {B9-455}, BATTERY ORU TEMPERATURE MANAGEMENT, ARE NOT VIOLATED:
1. DCSU WITH ALL SIX RBI'S CLOSED
  2. ACTIVE P4 DDCU (CONVERTER ON) AND SSU
  3. THREE ACTIVE BCDU/BATTERY SETS (INITIAL CHARGING AND NOMINAL CHARGE/DISCHARGE CYCLES)
  4. ECU AND PFCS LOADS ON RPCM 4A-A/2A-A (RPC'S ONE, TWO, THREE ONLY)

*The true limitation on the number of loads the PVTCS can support is the temperature of the batteries. Thermal analyses performed by Canoga Park indicate the maximum heat load that a stowed PVR can reject is approximately 1600 watts per EPS channel. The expected heat load during nominal battery charge/discharge cycles is approximately 1425 watts per power channel. The analysis was performed for a worst-case hot thermal environment: XPOP YPR 0/25/0, solar beta = 0, altitude = 180 nm.*

*DOCUMENTATION: Assessment of 4A JOP Start-Up Scenario; 4A JOP, December 12, 1997; and consultation with Boeing-Canoga Park Thermal Analyst/Gyan Hajela.*

- B. A 50 PERCENT DEPLOYED PVR WILL SATISFY ALL P4 EPS HEAT REJECTION DEMANDS.

*DOCUMENTATION: 4A JOP #26, May 18, 1999.*

## FLIGHT RULES

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12A\_B9-17

### SEAMLESS POWER CHANNEL HANDOVER (SPCH) REQUIREMENTS

THE FOLLOWING REQUIREMENTS WILL BE USED TO PERFORM SEAMLESS POWER CHANNEL HANDOVER (SPCH) BETWEEN ISS POWER CHANNELS: [DN 23 ]

1. ESTABLISH MASTER AND SLAVE CHANNELS WHERE THE MASTER CHANNEL ALWAYS HAS THE HIGHER BUS VOLTAGE SETPOINT THROUGHOUT THE SPCH.

*In general, the master and slave channel selection should be made to minimize instantaneous load transfer during cross tie/bus tie and channel isolation events.*

2. PRIMARY BUS VOLTAGE REGULATION SETPOINT OF THE SLAVE CHANNEL BATTERY CHARGE/DISCHARGE UNITS (BCDU'S) SHALL BE SET TO 147 VOLTS.

*Nominally, the BCDU mode of regulation is set at 151V and the Sequential Shunt Unit (SSU) is set at 160V for every power channel operational on orbit. During the SPCH, the voltage regulation of the BCDU's of the slave channel will be changed to 147V. The master channel will be kept at 151V. A 4V (or 13V) difference between the master and slave channels will be maintained if the cross tie/bus tie action occurs during eclipse or insolation, respectively. Once the master and the slave channels are cross tied/bus tied, the slave channel primary bus voltage will be regulated at the master channel regulation setpoint minus the line losses between the channels.*

3. BATTERY CHARGE CURRENT SETPOINT OF THE SLAVE CHANNEL SHALL BE SET TO 1 AMP.

*Once the master and the slave channels are cross tied/bus tied, the slave channel will act as a load to the master channel. Therefore, reducing battery charge current of the slave channel to 1 amp will reduce the load on the master channel.*

4. SSU OF THE SLAVE CHANNEL WILL BE SHUNTED. IF NOT POSSIBLE, OPEN RBI 1 TO ISOLATE FROM MAIN POWER BUS.

*The SSU of the slave channel must be shunted prior to the hot cross tie/bus tie to prevent tying two sources together. If the slave SSU is not shunted, it might result in tripping both channels.*

5. CROSS TIE/BUS TIE OF THE MASTER AND SLAVE CHANNELS IS ALLOWED DURING ISOLATION OR ECLIPSE.

*The SPCH can be performed in eclipse or insolation; however, it is desirable to perform the hot crosstie/bus tie during insolation since SSU with solar array can withstand load transient better than batteries. [DN 23 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-17

**SEAMLESS POWER CHANNEL HANDOVER (SPCH)**  
**REQUIREMENTS (CONTINUED)**

6. CALCULATION OF THE MAXIMUM TRANSFER LOAD SHALL BE BASED ON THE FOLLOWING: ©[DN 23 ]
- a. MAXIMUM LOAD IS DEFINED AS THE CUMULATIVE LOAD OF DIRECT CURRENT SWITCHING UNIT (DCSU) REMOTE BUS ISOLATORS (RBI'S) 5 AND 6 OF THE MASTER CHANNEL AND DCSU RBI'S 5 AND 6 OF THE SLAVE CHANNEL.
  - b. WHEN BUS TIE OCCURS BETWEEN TWO CHANNELS, WITH CIRCUIT INTERRUPT DEVICES (CID'S) IN THE CIRCUIT PATH, THE MAXIMUM LOAD OF PRIMARY POWER AT THE INSTANT OF TYING MASTER AND SLAVE CHANNELS SHALL NOT EXCEED 9.5 KW.
  - c. WHEN BUS TIE OCCURS BETWEEN TWO CHANNELS, AFTER CIDS ARE REMOVED FROM THE CIRCUIT PATH, THE MAXIMUM LOAD OF PRIMARY POWER AT THE INSTANT OF TYING MASTER AND SLAVE CHANNELS SHALL NOT EXCEED 12.2 KW FOR THREE BCDU'S AND 9.5 FOR TWO BCDU'S ON THE MASTER CHANNEL.

*The limit of the maximum load that can be transferred from one channel to another is based on the power consumption of DCSU RBI's 5 and 6 of both master and slave channels. The master channel with three or two operating BCDU's can carry a maximum transient load of 9.5 kW. Since there is a CID in the power feed circuitry, which is the limiting factor for the maximum transient load of 9.5 kW, there is a possibility of damaging the CID contactor if the transient load across the CID is greater than 9.5 kW. For 12A electrical power system configuration, SPCH can only be performed between channels 4B and 4A or between channels 2B and 2A.*

7. AT THE INSTANCE OF CROSS TIE/BUS TIE IN ECLIPSE, THE BATTERY STATE OF CHARGE (SOC) OF THE MASTER CHANNEL SHALL BE ABOVE 65 PERCENT SOC.

*When SPCH is performed during eclipse, the master channel battery SOC should be above 65 percent. If battery SOC of the master channel is below 65 percent, the load transient might undervolt the master channel. ©[DN 23 ]*



## FLIGHT RULES

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### 12A\_B9-18

### SEAMLESS POWER CHANNEL HANDOVER (SPCH) PHILOSOPHY

SPCH METHODOLOGY CAN BE PERFORMED WHEN ANY OF THE FOLLOWING PHOTOVOLTAIC MODULE (PVM) SYSTEM/ORU FAILURES OCCUR: ©[DN 24 ]

A. THE PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS) IS LOST.

*The power channel cannot operate without active cooling.*

B. THE SEQUENTIAL SHUNT UNIT (SSU) VOLTAGE REGULATION IS LOST.

C. THE BETA GIMBAL ASSEMBLY (BGA) BEARING, MOTOR, AND ROLL RING MODULE (BMRRM) FAILS TO TRANSFER PRIMARY POWER.

D. THE DIRECT CURRENT SWITCHING UNIT (DCSU) RBI 1 IS LOST (FAILED OPEN) .

E. THE SOLAR ALPHA ROTARY JOINT (SARJ) FAILS TO TRANSFER POWER (FLIGHTS 12A AND SUBS) .

F. THE PHOTOVOLTAIC MODULE (PVM) DIRECT CURRENT-DIRECT CURRENT CONVERTER UNIT (DDCU) IS LOST.

*Failure of the PVM DDCU removes power to the Pump and Flow Control System (PFCS), which is integral to the operation of the PVTCS.*

G. THE BATTERY CHARGE/DISCHARGE UNIT (BCDU) IS LOST DUE TO POWER SUPPLY FAILURE WHICH LIMITS THE CHANNEL TO 3 KW AND THE CHANNEL LOAD CANNOT BE POWERED DOWN BELOW 3 KW WITH THE LOADSHED FUNCTION.

*When a BCDU power supply has failed, the charging capability for the other two BCDU's is limited to 16 amps (approximately 3 kW). Prior to SPCH, the loads of the affected channel will be reduced (using loadshed function) to a level of 3 kW in order to maintain an energy balance of the failed channel. Unless the severe loadshed function cannot reduce the channel loads to a 3 kW total load without performing additional manual powerdown, then SPCH can be utilized. ©[DN 24 ]*

## FLIGHT RULES

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12A\_B9-19

PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)  
RADIATOR DEPLOY CONSTRAINTS AND MINIMUM  
REQUIREMENTS [HC]

A. P4 PVTCS RADIATOR DEPLOY PREPARATION VERIFICATION ©[DN 20 ]

TO BE GO FOR DEPLOY, ALL EVA PREPARATION TASKS RELATED TO THE RADIATOR MUST BE VERIFIED COMPLETE. NOMINALLY, THE RADIATOR WILL BE DEPLOYED AS SOON AS THE CINCHES AND WINCHES ARE REMOVED.

*Loads analysis models for the PVTCS radiator are only test-verified in the fully deployed and fully retracted (cinched and winched) positions. To minimize the amount of time in an unverified configuration, the radiator will nominally be deployed as soon as the cinches and winches are removed.*

B. RADIATOR DEPLOY OPERATIONS WILL INCORPORATE THE FOLLOWING PRIORITIZED CONSTRAINTS:

1. SARJ AND THERMAL RADIATOR ROTARY JOINT (TRRJ) ROTATION CONSTRAINTS DURING RADIATOR DEPLOY OPERATIONS.

a. FOR DEPLOY OF THE P4 PVTCS RADIATOR, ROTATION OF THE PORT TRRJ BE STOPPED ONLY IF THE ETCS RADIATOR OBSTRUCTS THE VIEW OF P4 RADIATOR.

*Dynamic loads due to TRRJ rotation are minimal, and therefore not a concern during radiator deploy operations.*

b. FOR DEPLOY OF THE P4 PVTCS RADIATOR, ROTATION OF THE PORT SARJ, WILL BE STOPPED AND LOCKED AT 0 DEGREES.

*Prior to deploy operations, rotation of the nearest SARJ will be stopped and locked in order to minimize dynamic loads and support visual verification requirements. While mechanisms are in motion, the hardware could be damaged when subjected to external forces (e.g., thruster firings, SARJ rotation).*

*Prior to deploy operations, all applicable articulated mechanisms will be positioned to ensure significant structural clearance during the entire activity. If the PVR is deployed prior to P4 SAW deploy, this avoids collision between the P4 PVR and SAW 4B. ©[DN 20 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-19

**PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)**  
**RADIATOR DEPLOY CONSTRAINTS AND MINIMUM**  
**REQUIREMENTS [HC] (CONTINUED)**

*Documentation: MAGIK Lab Analysis: Assessment of Max Port and Stbd Rotation Before P6 Solar Array Collision, AI# 1521, Jana Rebmann/Nancy Rustemeyer, May 9, 2002, and GRAF Lab analyses: Port SARJ Clearance Angles for ISS/F12A, August 16, 2002, and Stbd SARJ Clearance Angles for ISS/F13A, August 20, 2002, Kim Tran. ©[DN 20 ]*

*The following Hazard Reports are pending approval: Boeing Safety Hazard Analysis ISS-MCH-109, Inability to Gain/Maintain Structural Integrity Using Attachment Mechanisms (12A September 1, 2005 and 13A/15A, December 17, 2001), and Boeing Safety Hazard Analysis ISS COL-1002, ISS Collision (12A September 1, 2005 and 13A/15A, December 17, 2001).*

2. THERE ARE NO CONSTRAINTS TO BGA ROTATION DURING RADIATOR DEPLOY OPERATIONS.
3. DURING RADIATOR DEPLOY, THE ISS/ORBITER MUST BE IN FREE DRIFT OR ISS CONFIGURED FOR CONTROL MOMENT GYROSCOPE (CMG) CONTROL WITH THRUSTERS INHIBITED DURING PERIODS OF MECHANICAL MOTION. MAXIMUM EVA LOADS AND CREW EXERCISE ARE ALSO RESTRICTED DURING THIS PERIOD.

*While mechanisms are in motion, the hardware could be damaged when subjected to external forces (e.g., thruster firings). As long as the mechanisms are not in motion, nominal attitude control can be maintained within the limitations of the flight specific Docked Load Constraints rule. Consideration must be given to propellant usage during non-free drift/thruster inhibited periods. The nominal plan is to implement CMG control with thrusters inhibited to support this constraint. Free drift will be used in the event CMG control is unavailable. The maximum duration, for which the thrusters must remain inhibited or free drift would be required, is not expected to exceed 15 minutes.*

*Documentation: Boeing Technical Memo A92-J332-STN-M-TSW-170, Mechanical Assessment of Free Drift vs CMG Momentum Manager Environment, December 11, 2002.*

4. RADIATOR WILL NOT BE DEPLOYED IF THE PFCS INLET OR OUTLET PRESSURE IN EITHER LOOP EXCEEDS 250 PSI/1725 KPA.

*The radiator is designed to deploy/retract with a maximum pressure of 250 psi/1725 kPa in the radiator plumbing. At pressures higher than this, there is the potential for damage to the flexhoses that connect the radiator panels. The nominal operating pressure of the PVTCS is approximately 1350 kPa (195 psi).*

©[DN 20 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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**PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)**  
**RADIATOR DEPLOY CONSTRAINTS AND MINIMUM**  
**REQUIREMENTS [HC] (CONTINUED)**

- 5. NOMINALLY, ONE OF TWO LOOPS IN THE RADIATOR SHOULD BE ACTIVE DURING DEPLOY OPERATIONS. @[DN 20 ]

*In order to ensure that temperatures and pressures are uniform throughout the radiator during deploy/retract activities, at least one of the two loops should be actively flowing ammonia. Radiator deploy/retract operations can still be performed without an active loop (i.e., PFCS powered, but no pumps running), but the preference is to have at least one loop up and running.*

*DOCUMENTATION: Assembly and Operations Support Plan, Book 4, Revision C, June 1998; Deployable Radiator Subassembly Specification, RC1894, April 1997; ISS Loads Analysis EID-03878, Rev B; and engineering judgment.*

- 6. DIRECT (LINE OF SIGHT) OR INDIRECT (VIA CAMERA) CREW VISUAL INSIGHT IS REQUIRED DURING ALL RADIATOR DEPLOY OPERATIONS.

*The crew must have sufficient visual cues to assess the success or failure of the deploy operation. Failure modes may not be detected without visual monitoring of deploy progress. Once detected, such failures require immediate crew-initiated abort of PVR motion. Due to limited visual capability during eclipse periods, visual monitoring can only take place during insolation periods. PVR deployment should be stopped upon entering eclipse. Deploy operations may resume once sufficient light is available to determine visual cues.*

**TABLE 12A\_B9-19-I - PVR DEPLOY VISUAL REQUIREMENTS**

VIEWING REQUIREMENT	USED TO MONITOR
FULL RADIATOR VIEW	OFF-NOMINAL RADIATOR DEFLECTION
RADIATOR MECHANISMS	STRIKER ARM AND PULLEY HARD STOP POSITIONS.

- 7. ONCE THE ABOVE CONSTRAINTS/PRIORITIES HAVE BEEN MET, RADIATOR DEPLOY OPERATIONS WILL BE PLANNED SUCH THAT MCC-H WILL HAVE TELEMETRY INSIGHT FOR THE DURATION OF THE MECHANISM OPERATION. VIDEO DOWNLINK OF MECHANISM MOTION IS HIGHLY DESIRABLE, BUT NOT REQUIRED FOR NOMINAL DEPLOY OPERATIONS. @[DN 20 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-19

**PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)**  
**RADIATOR DEPLOY CONSTRAINTS AND MINIMUM**  
**REQUIREMENTS [HC] (CONTINUED)**

- a. PRIOR TO THE START OF A DEPLOY SEQUENCE, IF DOWNLINK TELEMETRY IS LOST, THE DEPLOY WILL BE DELAYED UNTIL THE COMM LINK IS REGAINED. @[DN 20 ]

*MCC-H must verify PVR position and supporting RPCM health at the beginning of mechanism motion.*

- b. IF THE PHYSICAL DEPLOY HAS BEEN INITIATED AND DOWNLINK TELEMETRY OR VIDEO IS LOST, THE DEPLOY WILL BE ALLOWED TO CONTINUE UNTIL COMPLETION.
- c. TELEMETRY AND VIDEO DOWNLINK ARE REQUIRED PRIOR TO AND DURING THE IMPLEMENTATION OF ANY PVR CONTINGENCY.

*To ensure a nominal deploy, it is considered prudent to halt operations until the ground can monitor the PVR deploy. Once the PVR deploy has been initiated, it is better to allow the deploy to proceed rather than to halt and restart. Note: only downlink telemetry is required for the PVR deploy. Video downlink is highly desired, during nominal PVR deployment, however, it is required for all contingency operations.*

C. RADIATOR DEPLOYMENT

1. TASK CONSTRAINTS/DEPENDENCIES

- a. CONFIRM NO EVA CREW WITHIN THE DEPLOY ENVELOPE OF THE RADIATOR.

*To avoid injury, the EVA crew must remain clear of the PVR until it is deployed 100 percent.*

- b. TO BE GO FOR RADIATOR DEPLOY, CINCHES AND WINCHES MUST BE CONFIRMED RELEASED.

*If the PVR cinches and winches are not fully released, the PVR could be damaged.*

- c. INSTALLATION OF SARJ BRACES/AJIS STRUTS IS NOT REQUIRED FOR RADIATOR DEPLOYMENT. @[DN 20 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-19

**PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)**  
**RADIATOR DEPLOY CONSTRAINTS AND MINIMUM**  
**REQUIREMENTS [HC] (CONTINUED)**

2. MINIMUM REQUIREMENTS FOR TASK COMPLETION @[DN 20 ]

A RADIATOR IS CONSIDERED FULLY DEPLOYED WHEN ONE OF THE FOLLOWING CONDITIONS OCCURS:

- a. THE DEPLOY MICROSWITCH INDICATES DEPLOYED AND THE RADIATOR MOTOR HAS BEEN RUN FOR 1 ADDITIONAL MINUTE.
- b. VISUAL CUES CONFIRM THAT THE STRIKER ARM ON ONE OF TWO PULLEYS ON THE TORQUE ARM AND ONE OF TWO PULLEYS ON THE TORQUE PANEL HAVE REACHED THE HARD-STOP POSITION.
- c. THE AUTO TIMEOUT FAULT DETECTION, ISOLATION, AND RECOVERY (FDIR) EXECUTES, NO OTHER ANOMALIES HAVE OCCURRED, AND THE RADIATOR APPEARS FULLY EXTENDED.

*The radiator deploy microswitch is zero fault tolerant and does not provide an indication that the radiator is fully deployed. Hardware testing has shown that in order for the cables to be properly tensioned, the radiator motor must be run for 1 additional minute after the deploy indicator becomes active. If the deploy indicator fails, then a fully deployed radiator status can only be confirmed by visual cues. The fully deployed visual cues consist of viewing the four cable pulleys and identifying when the striker arm has rotated against the hard-stop position. If the striker arm on one of two pulleys on the torque arm and one of two pulleys on the torque panel have reached the hard-stop position, then the radiator is fully deployed.*

*If the deploy indicator is not available and the visual cues in Paragraph 2 cannot be made, then the radiator motor will be run until the Auto Timeout FDIR algorithm executes. The FDIR sends commands to Stop and Power Off the motor if the radiator state does not match the commanded position within 13 minutes. If the radiator appears fully extended and no additional anomalies occurred during the deploy operation, then the radiator can be considered fully deployed until the visual cues in Paragraph 2 can be made. Furthermore, the radiator deploy activity has consistently taken less than 10 minutes during ground testing. @[DN 20 ]*

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## FLIGHT RULES

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PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)  
RADIATOR DEPLOY CONSTRAINTS AND MINIMUM  
REQUIREMENTS [HC] (CONTINUED)

3. FAILURE RESPONSE @[DN 20 ]
  - a. IF THE RADIATOR MOTOR STALLS DURING DEPLOYMENT, STOP DEPLOY OPERATIONS. IF THE STALL IS ISOLATED TO THE MOTOR ONLY, THE MOTOR IS CONSIDERED FAILED AND THE FOLLOWING PARAGRAPH APPLIES.
  - b. IF THE RADIATOR MOTOR FAILS, THE RADIATOR WILL BE DEPLOYED MANUALLY BY THE CREW USING THE EVA OVERRIDE WITH A PGT MAX TORQUE SETTING AS DESIGNATED IN SSCN 1819. IF THE PGT STALLS, STOP DEPLOY OPERATIONS.

*The malfunction procedure "PVR Deploy/Retract Failure" includes steps to isolate fault, recover from fault, and proceed with deploy. If the deploy motor stalls during array deployment, the root cause (i.e., binding, motor failure) must first be determined before re-attempting to deploy. The radiator could be damaged if deploy is attempted after a stall condition resulting from a binding condition.*

*The SSCN 1819 is released approximately 3 months before the mission and contains specific torque values for the radiator hardware. @[DN 20 ]*

## FLIGHT RULES

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### CONTINGENCY SCENARIOS

#### **12A\_B9-41      EPS HARDWARE SCAVENGE**

A. WHERE FAILURES OF DIFFERENT ORU TYPES CAUSE THE LOSS OF MULTIPLE POWER CHANNELS BECAUSE SPARE ORU'S ARE UNAVAILABLE, SWAPS WILL BE PERFORMED TO CONSOLIDATE ENOUGH HARDWARE TO PROVIDE WORKING POWER CHANNELS IN THE FOLLOWING PRIORITY ORDER:

1. CHANNEL 2B
2. CHANNEL 4B @ [DN 13 ]
3. CHANNEL 4A
4. CHANNEL 2A

*Channel 2B is recovered as the highest priority in order to provide power to critical internal equipment powered from the Lab aft endcone DDCU LA2B, as well as S-band (mounted on P6) communication. Channels 4B and/or 4A are recovered next to provide critical systems redundancy where possible and to provide survival power to truss equipment.*

*Channel 2A is recovered After Channel 4A and/or 4B to provide power to truss equipment.*

B. UPON FAILURE OF A CRITICAL RPCM, WHEN A SPARE IS NOT AVAILABLE, AN EXISTING RPCM WILL BE SCAVENGED FOR USE. CRITICAL RPCM'S ARE DEFINED AS ONES THAT POWER MDM'S, LAB AND AIRLOCK SHELL HEATERS, ITCS, S-BAND, FIRE DETECTION, CMG'S, MBSU AND DDCU COLDPLATE HEATERS, SSAS'S, AND CBM'S REQUIRED FOR THIS AND LATER ASSEMBLY FLIGHTS. RPCM'S THAT APPEAR IN THE FOLLOWING TABLE ARE SCAVENGE CANDIDATES. @ [DN 13 ]

1. IF REQUIRED, AN INTERNAL RPCM CAN BE PLACED INTO AN EXTERNAL SPDA.
2. THE RPCM THAT IS SCAVENGED IS SELECTED FROM THE SAME BUS AS THE RPCM THAT REQUIRES REPLACEMENT, WHEN PRACTICAL, TO MINIMIZE THE NUMBER OF BUS POWERDOWNS.

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**FLIGHT RULES**

12A\_B9-41

**EPS HARDWARE SCAVENGE (CONTINUED)**

RPCM	LOCATION	TYPE	POWER SOURCE	COMMENT	NOTE
LA1B_A	INT (LAB)	V	DDCU LA1B	LIGHTS	2
LA2B_A	INT (LAB)	V	DDCU LA2B	LIGHTS + RACK FLOW CONTROL	2
LA1A4A_A	INT (LAB)	III	DDCU LA1A	LAP2 ISPR (EXPRESS RACK 4 AUX PWR), LAP1 ISPR (NOT POWERED)	1 & 2
LA1A4A_B	INT (LAB)	III	DDCU LA1A	LAS2 ISPR (HRF AUX POWER), LAS3 ISPR (MSG USER PWR)	1 & 2
LA1A4A_G	INT (LAB)	III	DDCU LA1A	LAO3 ISPR (EXPRESS RACK 3 PWR, ARIS)	1 & 2
LA2A3B_A	INT (LAB)	III	DDCU LA3B	LAP4 ISPR (NOT POWERED), LAP2 ISPR (EXPRESS RACK 4 USER PWR)	1 & 2
LA2A3B_B	INT (LAB)	III	DDCU LA3B	LAO4 ISPR (NOT POWERED), LAO3 ISPR (EXPRESS RACK 3 PWR, ARIS)	1 & 2
LA2A3B_G	INT (LAB)	III	DDCU LA3B	LAS3 ISPR (MSG AUX POWER), LAS4 ISPR (EXPRESS RACK 5 USER PWR)	1 & 2
N14B_A	INT (NODE 1)	V	DDCU Z14B	FWD CBM CONTROLLER (AFTER LAB INSTALL ONLY) + IMV VLV + FWD ELPS	2
S02B_D	EXT (S0)	V	DDCU LA2A	S0-2 MDM SDO CARD A11, A12 CH 00-15, SO/S1 ATTACH HW	2
S03A_C	EXT (S0)	II	DDCU LA2A	NODE 2/NODE 3 PDGF FEED	2
S12B A	EXT (S1)	V	DDCU LA2A/ RPCM S02B A		2
S13A E	EXT (S1)	IV	DDCU LA2A	MOBILE SERVICING CENTER (MSC) UTILITY PORT	2 & 3
S13A F	EXT (S1)	IV	DDCU LA2A	MSC UTILITY PORT	2 & 3
S01A_D	EXT (S1)	V	DDCU LA4A	S0-1 MDM SDO CARD A11. A12 CH 00-15, SO/P1 ATTACH HW + CMG-1	2
S04B_C	EXT (S0)	II	DDCU LA4A	NODE 2/NODE 3 PDGF FEED	2
S11A A	EXT (S1)	V	DDCU LA4A/ RPCM S01A A		2
S14B E	EXT (S1)	IV	DDCU LA4A	MSC UTILITY PORT	2 & 3
S14B F	EXT (S1)	IV	DDCU LA4A	MSC UTILITY PORT	2 & 3
S14B G	EXT (S1)	V	DDCU LA4A		2
P11A A	EXT (S1)	V	DDCU LA4A/ RPCM S01A A	VIDEO CAMERA SUPPORT ASSEMBLY (VCSA), EXTERNAL TELEVISION GROUPS (ETVCG)	2 & 3
P14B E	EXT (P1)	IV	DDCU LA4A	MSC UTILITY PORT	2 & 3
P14B F	EXT (P1)	IV	DDCU LA4A	MSC UTILITY PORT	2 & 3
P13A E	EXT (P1)	IV	DDCU LA2A	MSC UTILITY PORT	2 & 3
P13A F	EXT (P1)	IV	DDCU LA2A	MSC UTILITY PORT	2 & 3
P34B C	EXT (P3)	V	DDCU LA2A	P3-2 MDM HEATER AND P3 RAIL HEATERS	2
P34B F	EXT (P3)	IV	DDCU LA2A	MSC UTILITY PORT 8, UMA 1	2
P33A C	EXT (P3)	V	DDCU LA4A	P3-1 MDM HEATER AND P3 RAIL HEATERS	2
P33A F	EXT (P3)	IV	DDCU LA4A	MSC UTILITY PORT 8, UMA 2 POWER	2

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## FLIGHT RULES

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12A\_B9-41

EPS HARDWARE SCAVENGE (CONTINUED)

NOTES:

- [1] THE TYPE III INTERNAL RPCM'S AVAILABLE FOR SCAVENGE IN THE LAB ARE NOT CERTIFIED FOR EXTERNAL OPERATIONS. HOWEVER, USING THESE RPCM'S EXTERNALLY IS THE ONLY VIABLE METHOD FOR POWERING S1/P1 TRUSS CORE POWER BUS HARDWARE IF AN EXTERNAL TYPE III RPCM FAILS. USING AN INTERNAL RPCM EXTERNALLY IS A LIFETIME LIMITING IMPACT TO THE ORU.
- [2] INTERNAL AND EXTERNAL RPCM'S OF THE SAME TYPE MAY BE SWAPPED FOR USE IN CASES OF AN RPCM FAILURE.
- [3] THE UTILITY PORT PROVIDES ELECTRICAL POWER FOR SSRMS OPERATIONS VIA THE MOBILE TRANSPORTER (MT) AND IS PART OF THE (MOBILE SERVICING SYSTEM (MSS).

*The scavenge list is not in priority order. The most convenient RPCM is selected.*

## FLIGHT RULES

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**12A\_B9-42**

**BCDU FAILURE RESPONSE**

IF A BCDU FAILS SUCH THAT THE MAXIMUM CHARGE RATES FOR THE REMAINING BCDU'S ARE LIMITED, THE FAILED BCDU WILL BE REMOVED AS SOON AS PRACTICAL.

*Removing the failed BCDU allows the remaining operational BCDU's on the channel to charge batteries at nominal currents defined by the Battery Current Setpoint PPL resident in the PVCU MDM's. The channel's power capability is limited to approximately 2.5 kW if the failed BCDU is not removed. If the BCDU is removed, nearly full channel capability can be restored. There is no spare BCDU available for changeout.*

*DOCUMENTATION: 4A JOP #27, June 22, 1999.*

## FLIGHT RULES

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**12A\_B9-43**

**PVCU LOSS RESPONSE**

THE FOLLOWING ACTIONS ARE REQUIRED FOR THE AFFECTED PVM AFTER LOSS OF A SINGLE PVCU: @[DN 6 ]

- A. PV ARRAY MANAGEMENT POSITIONS SHOULD BE CONSTRAINED TO ENSURE THAT UPON LOSS OF COMM TO THE REMAINING PVCU, THE P6 OR P4 ARRAYS WILL BE PLACED WITHIN THE FOLLOWING RANGE OR PARKED AT THE FOLLOWING ANGLE:

P6 PVCU	P6 PVCU	P4 PVCU	P4 PVCU
2B	4B	2A	4A
205° - 260°	155° - 100°	90°	270°

THIS MAY BE ACCOMPLISHED AS FOLLOWS:

1. FOR P6 PVCU LOSS IN XVV, IMPLEMENT ONE OF THE FOLLOWING:
  - a. FIRST COMMAND TO DIRECTED POSITION WITHIN THIS RANGE AND THEN COMMAND TO RATE MODE BUT SELECT ANGLE HOLD AS THE CONTINGENCY MODE (THIS UTILIZES THE LAST COMMANDED ANGLE SETPOINT FEATURE OF THE CONTINGENCY MODE), OR
  - b. A MODIFIED DUAL ANGLE MODE THAT KEEPS THE ARRAYS WITHIN THIS RANGE
2. FOR P6 PVCU LOSS IN XPOP, USE AUTOTRACK AND ADJUST THE BIAS ANGLE OF THE ARRAYS AS NECESSARY TO REMAIN WITHIN THIS RANGE.
3. FOR P6 PVCU LOSS IN YVV, THE ARRAYS SHOULD BE IN A DIRECTED POSITION WITHIN THIS RANGE.
4. FOR P4 PVCU LOSS, ARRAYS WILL BE PARKED AND LATCHED AT THE ANGLE SPECIFIED.
5. IN ALL CASES, THE BGA CONTINGENCY MODE SHALL BE SET TO ANGLE HOLD. @[DN 6 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_B9-43****PVCU LOSS RESPONSE (CONTINUED)**

*The loss of two Photovoltaic Controller Units (PVCU's) on a single power module causes the loss of both power channels. This is because both sets of BCDU's transition to a very low charge current. These actions are intended to be taken after the loss of one PVCU in order to provide a reasonable chance of PVM hardware survival (and possibly some level of U.S. segment survival for the P6 case) in the event the second MDM also fails. These actions must be implemented in advance as a preventive measure since, once the second MDM fails, all command capability to power channel hardware will be lost. ©[DN 6 1*

*Capability exists to replace cards within the MDM and this option should be exercised as soon as practical. Two EVA's will be required – one EVA to remove the failed MDM and bring it inside for card replacement and a second EVA to re-install the MDM.*

*Spare PVCU's are not kept on orbit. If a spare MDM is needed, the vehicle may be operating for an extended duration until an orbiter arrives with a replacement. The upper and lower PVCU MDM's have different mounting brackets (they are not interchangeable) and have been classified as launch on need rather than maintaining two spare MDM's on orbit.*

*Until the MDM can be fixed or replaced, the vehicle will be at risk for a second PVCU failure. The planning and implementation of these actions should occur within a reasonable timeframe. The intent of this rule is to minimize the amount of time, to the greatest extent possible, that the vehicle is operating under a single PVCU. If these actions are not implemented and the second P6 PVCU fails, the consequences will be a complete loss of USOS electrical power.*

*Reference Rule {B7-51}, UNRECOVERABLE MDM DEFINITION [RC].*

*After the second PVCU loss, there is no way to command the position of the solar arrays. Constraining the arrays to operate within this range and selecting angle hold as the contingency mode will guarantee that the arrays will stop within this range following the loss of the second PVCU. Assuming that the arrays are in this range and that all other actions in this rule have also been implemented, there is a reasonable chance of achieving some level of U.S. Segment survival.*

*Note that flying as much XPOP as possible provides the additional benefit of conditioning the P6 BGA motor current, reducing the likelihood of stalls during periods of XVV and thereby increasing the likelihood that the arrays will be able to be positioned into the prescribed range upon failure of the second PVCU when using rate mode in XVV. ©[DN 6 1*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES****12A\_B9-43****PVCU LOSS RESPONSE (CONTINUED)**

*Also note that if a second PVCU failure does occur, solar array feathering will not be possible. Catastrophic hazards exist for unfeathered outboard arrays mounted on the truss. Therefore, the P4 arrays will be parked and the beta gimbals latched at the listed angles to protect for 12A undocking and/or 12A.1 docking. SARJ feathering on the alpha axis will still be possible with no operational PVCU's. The listed locations for the P6 arrays will violate solar array feather requirements. However, while P6 is on Z1, structural load limits will not be exceeded and there is no catastrophic hazard. Solar array life may be impacted due to structural fatigue. Plume loads during vehicle arrival and separation may cause a divergence trip of the BGA motor(s) causing them to turn off and rotate to an undesirable power generation position. @[DN 6 ]*

- B. FOR P6 PVCU FAILURE, ATTITUDES FOR NOMINAL OPERATIONS SHOULD BE FLOWN THAT SUPPORT POWER BALANCE WITH NOMINAL LOADS (I.E., NO POWERDOWNS) USING THE ARRAY POSITIONING CONSTRAINTS IN PARAGRAPH A AND WITH THE FOLLOWING PREFERENCES: @[DN 6 ]
1. FLY XPOP AS MUCH AS FEASIBLE IN BETA MAGNITUDES BETWEEN 0 AND 60 DEGREES WITHOUT VIOLATING THE LOW BETA XPOP CONSTRAINT REQUIRING THAT  $PITCH < |BETA| - 5 \text{ DEG}$ .
  2. FLY YVV AS NEEDED FOR THERMAL CONDITIONING IN BETA RANGES ABOVE 40 DEG MAGNITUDE.
  3. FLY XVV AS NECESSARY FOR SPECIAL EVENTS AND IF NECESSARY FOR THERMAL PROTECTION IN LOW BETAS.
- C. THE VEHICLE AND SOLAR ARRAYS MAY TEMPORARILY BE REMOVED FROM THESE CONFIGURATIONS TO SUPPORT SHORT TERM EVENTS SUCH AS DOCKING, UNDOCKING, REBOOST, AND WATER DUMPS WHERE ARRAY FEATHERING IS REQUIRED.

*Feathering the solar arrays for temporary events may be required. The risk of a second PVCU failure during these events is considered low. Paragraphs A and B should be implemented again as soon as practical.*

- D. REVISE THE LOSS OF COMM SETTINGS FOR THE BATTERY HEATERS TO "ON" AT -5 DEG C AND "OFF" AT -4.5 DEG C.

*This is recommended to reduce the duty cycle of the battery heaters to improve the chances that power balance will be sustained if the second PVCU fails. Lower than -5 deg C may cause water to collect on the battery contacts and result in shorts and associated damage/failure of the battery.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B9-43

### PVCU LOSS RESPONSE (CONTINUED)

E. FOR THE POWER CHANNEL THAT DID NOT SUFFER THE PVCU FAILURE,

1. OPEN THE DC RBI IN THE BCDU FED BY DCSU RBI 2.

*This will remove DC control power from the SSU and BCDU1 on the channel with the PVCU failure. In the event that both PVCU's are lost, this will allow the first PVCU to be repowered following an R&R. Prior to this R&R, the power channel will need to be powered down to isolate the DCSU bus and its power source to the PVCU. If control power is not removed from the SSU, it will see an undervoltage condition at its output during eclipse and latch in the shunted state. If both PVCU MDM's have failed and the SSU has latched, there would be no way to repower the DCSU bus during insolation. Opening the CP RBI will allow the SSU to power cycle each insolation pass and automatically enter voltage regulation mode, thereby providing power to the DCSU bus.*

2. OPEN THE DC RBI IN THE BCDU FED BY DCSU RBI 3.

*This will remove DC control power from the DCSU and BCDU2 on the channel with the PVCU failure. In addition to the channel powerdown that will occur prior to PVCU R&R, this step allows the DCSU power supply to be isolated, removing all input sources to the PVCU. Additionally, it allows for a coldstart of the DCSU after it receives input power from the SSU following entry into voltage regulation mode. Whenever the DCSU performs a coldstart, it automatically closes the power supply switch to the PVCU allowing the MDM to be powered.*

F. FOR THE POWER CHANNEL THAT SUFFERED THE PVCU FAILURE, OPEN THE PVCU POWER SUPPLY SWITCH IN THE DCSU.

*Performing E and F allows for a deadfaced removal and replacement, and then a successful recovery for the failed PVCU, should the second PVCU fail before completing the R&R for the first failed PVCU. Following replacement with a working PVCU, the PVCU power supply switch in the DCSU can be reclosed by power cycling the DCSU power supply. This can be accomplished by overloading the power channel, causing the batteries to trip off and subsequent loss of the DCSU. When the ISS next enters insolation, the SSU will undergo a coldstart, causing power to flow to the DCSU and activating its power supply. A DCSU startup includes closing of the power switch feeding the PVCU.*

*There are two options for overloading the power channel. One option takes the channel out of energy balance, eventually depleting the batteries. The second option requires that enough load be applied to the power channel that the BCDU's overcurrent trip. The second option leaves energy in the batteries and results in a faster power channel recovery.*

*If the R&R for the failed PVCU is completed before a failure of the power module's remaining PVCU, power can be reapplied to the new PVCU by simply closing the switch that feeds the MDM. Once full redundancy is established, all control power RBI's, setpoints, and solar arrays can be returned to their nominal configurations.*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_B9-43      PVCU LOSS RESPONSE (CONTINUED)

- G. PERFORM PREEMPTIVE REFRESHES OF ALL POWER CHANNEL HARDWARE (INCLUDING DDCU'S AND RPCM'S) THAT DOES NOT HAVE EEPROM'S WITH ERROR CORRECTION ENABLED.

*Unexpected power channel losses might occur with little warning. The ORU's with susceptible EEPROM's should be kept refreshed as time allows.*

- H. FOR P6 PVCU LOSS, INHIBIT CLOSED LOOP CONTROL OF EEATCS LINE HEATERS AND OPEN THE RPC'S TO BOTH OF THE HEATERS FOR EACH LOOP. DURING RECONFIGURATIONS THAT WOULD NORMALLY CAUSE EEATCS LINE HEATERS TO CYCLE, THE SMALLER LINE HEATER CAN BE RE-ENABLED FOR SHORT DURATIONS. @[DN 6 ]

*During reconfigurations (i.e., CCAA swaps, ITCS mode transitions, ITCS setpoint changes, etc.), the smaller line heater can be re-enabled until thermal transients settle out (typically < 15 minutes; note that the line heater would not be on for this entire period). After the second PVCU is lost, however, there will be no other opportunity to reconfigure the line heater RPC's, and the heater will be controlled by its thermostat. The smaller line heater for each loop consumes approximately 600 W. To avoid the case where a line heater cycles on as the second PVCU fails and its status is never annunciated to the ground, and to avoid the need to book keep a 600-Watt heater on a power channel with 3 kW capability, the heaters should be disabled as much as is practical.*

- I. DEFINE A LOAD SHED AND SAFING STRATEGY THAT COULD BE IMPLEMENTED WITHIN 30 MINUTES IN THE EVENT THE SECOND PVCU FAILS.

- J. FOR P6 PVCU LOSS, IF NO STRATEGY HAS BEEN DEFINED PRIOR TO FAILURE OF THE REMAINING PVCU, COMMAND LOOP B BYPASS OF THE ITCS HEAT EXCHANGER PRIOR TO OVERTEMP OF LAB HARDWARE AND POWER DOWN ALL LAB DDCU'S AND ALL Z1 COMPONENTS. (THE REMAINING LOADS WILL BE ONLY THE P6 LOADS.) @[DN 6 ]

*It is preferred that USOS audio and command and telemetry be available while powerdown and safing actions are performed upon failure of the second PVCU. With the EEATCS FCV LoC set at 0 degrees, the internal C&T components in the Lab Module will begin to reach their temperature limits in approximately 30 to 60 minutes, causing loss of all USOS S-band and Ku-band.*

*To improve the likelihood of maintaining power balance with the current BCDU charge rate LoC setting of 2 amps, all unnecessary loads should be removed.*

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

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### 12A\_B9-43      PVCU LOSS RESPONSE (CONTINUED)

- K. PERFORM THE FOLLOWING ASSESSMENT TO DETERMINE WHETHER TO REVISE THE BCDU CHARGE RATE AND PVTCS FCV LOC VALUES UNTIL EXPECTED RECOVERY OF THE FIRST FAILED PVCU:

GROUND RULE THAT THE EEATCS FCV LOC SET POINT REMAINS AT 0 DEGREES (THE LAB WILL BE POWERED DOWN IF THE SECOND PVCU FAILS) .

CONSTRAIN THE ASSESSMENT BY THE BETA REGIME UP TO THE PROJECTED DATE OF RECOVERY OF THE FIRST FAILED PVCU.

ESTABLISH AND PRE-COORDINATE AN ATTITUDE, POWER MANAGEMENT, AND REPAIR STRATEGY THAT WOULD SUPPORT RUSSIAN SEGMENT AND CRITICAL TRUSS AND Z1 SURVIVAL LOADS UNTIL RECOVERY OF A PVCU SHOULD THE SECOND PVCU FAIL.

FOR THIS BETA, ATTITUDE, AND POWER STRATEGY, RE-ANALYZE BCDU AND PVTCS FCV LOC VALUES THAT WOULD SUPPORT CRITICAL COMPONENTS SUCH AS CMG'S AND IMPROVE THE CHANCE OF MAINTAINING POWER BALANCE WITHOUT UNDULY RISKING THE HEALTH OF P6 PV BATTERIES.

IF THE EXPECTED RECOVERY OF THE FIRST FAILED PVCU SLIPS, ITERATE ACCORDINGLY.

*The current LoC settings for the BCDU charge rate and the PVTCS FCV would likely result in loss of both channels of the module. It is expected that these settings could be revised if the beta regime were constrained such that power balance could be achieved without jeopardizing the life of the batteries. It is also expected that critical truss and Z1 loads may be supported - Z1 loads by increasing the BCDU charge rate slightly and truss loads by installing IVA jumpers to feed power to one string of the truss with Russian Segment power via RACU, although this would depend on the attitude strategy. It is not recommended that a nonzero EEATCS FCV setting be assessed due to the complexity of the analysis and the likelihood that a nonzero value would significantly increase risk of catastrophic leakage, battery damage, and loss of both power channels.*

12A\_B9-44      RESERVED @[DN 1 ]

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**FLIGHT RULES**

**JOINT SHUTTLE/ISS RULES**

GENERAL

**12A\_C9-1            POWER CONNECTION INHIBITS [HC]**

WHILE CREWMEMBERS ARE MATING OR DEMATING POWER CONNECTORS, AT LEAST ONE MONITORED UPSTREAM INHIBIT SHALL BE USED TO PREVENT POWERING EXPOSED CONNECTORS. THE TABLES BELOW SPECIFY REQUIRED POWER INHIBITS IF A PHYSICAL POWER PATH TO THE CONNECTION EXISTS. ITEMS MARKED AS "NONE REQUIRED" INDICATE THAT THERE IS NO POWER PATH TO THE CONNECTION AT THE 12A TIMEFRAME. NOTE THAT CID'S ARE EQUIVALENT BY DESIGN TO ONE INHIBIT. SAFETY INHIBITS WILL BE APPLIED PER RULE {B2-1}, POWER CONNECTION INHIBITS [HC] [RC] [E] [A].

EVA MATED CONNECTORS

A. CONNECT P3/P4 TO P1 UPPER TRAY UMBILICALS

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	DOWNSTREAM LOADS <180 W	SOCKET ON PWR SIDE?	1ST INHIBIT	2ND INHIBIT	NOTE
W5002	P1 P11 TO P3 J11	P6 4B PRI PWR TO P4 CH 4A DCSU	Y	N	CID 8 OPEN	NONE REQUIRED	[1] [2]
W5004	P1 P12 TO P3 J12	P6 4B PRI PWR (WHEN P6 ON P5) TO MBSU DUMMY RECEPTACLE	Y	N/A	NONE REQUIRED	NONE REQUIRED	
W5104	P1 P13 TO P3 J13	RPCM S01A B SEC PWR TO P3 TRUSS	Y	Y	RPCM S01A B RPC 1 OPEN	DDCU LA4A CONVERTER OFF	[3]
W5102	P1 P14 TO P3 J14	DDCU LA4A SEC PWR TO P1 TRUSS	Y	Y	DDCU LA4A CONVERTER OFF	NONE REQUIRED	
W5260	P1 P15 TO P3 J15	1553 CH B	N/A	N/A	NONE REQUIRED	NONE REQUIRED	[4]
W5452	P1 P16 TO P3 J16	VIDEO/SYNC-3, HRDL (UCCAS-2)	N/A	N/A	NONE REQUIRED	NONE REQUIRED	[4]
W5354	P1 P17 TO P3 J17	INSTM	N/A	N/A	NONE REQUIRED	NONE REQUIRED	[4]

NOTES:

[1] AT 12A, CONNECTS P6 CH 4B PRIMARY POWER TO P4 CH 4A DCSU FOR P4 CH 4A STARTUP. AFTER 12A.1, PROVIDES CH 4A PRIMARY POWER TO MBSU BUS 4A.

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

**12A\_C9-1**

**POWER CONNECTION INHIBITS [HC] (CONTINUED)**

- [2] CABLE W5002 HAS PINS ON THE POWER SIDE OF THE CONNECTOR, WHICH DOES NOT MEET THE REQUIREMENTS OF THE SAFETY LETTER. NCR-ISS-134, APPROVED ON JULY 8, 2004, ALLOWS HAVING ONE UPSTREAM INHIBIT (CID 8 OFF) AND ONE DOWNSTREAM INHIBIT (LOAD <180 W).
- [3] DURING THE EVA, ONCE DDCU LA4A IS POWERED OFF FOR THE W5102 CONNECTION, THE FIRST UPSTREAM INHIBIT CAN NO LONGER BE MONITORED, SO THE SECOND INHIBIT IS REQUIRED.
- [4] 1553 AND SIGNAL CABLES MEET THE LOW POWER CONNECTOR REQUIREMENTS OF THE SAFETY LETTER AND, THEREFORE, DO NOT REQUIRE POWER INHIBITS.

B. CONNECT P3/P4 TO P1 LOWER TRAY UMBILICALS

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	DOWNSTREAM LOADS <180 W	SOCKET ON PWR SIDE?	1ST INHIBIT	2ND INHIBIT	NOTE
W5001	P1 P1 TO P3 J1	P6 2B PRI POWER TO P4 CH 2A DCSU	Y	N	CID 7 OPEN	NONE REQUIRED	[1] [2]
W5003	P1 P2 TO P3 J2	P6 2B PRI PWR (WHEN P6 ON P5) TO MBSU DUMMY RECEPTACLE	Y	N/A	NONE REQUIRED	NONE REQUIRED	
W5101	P1 P3 TO P3 J3	RPCM S02B B SEC PWR TO P3 TRUSS	Y	Y	RPCM S02B B RPC 1 OPEN	DDCU LA2A CONVERTER OFF	[3]
W5103	P1 P4 TO P3 J4	DDCU LA2A SEC PWR TO P1 TRUSS	Y	Y	DDCU LA2A CONVERTER OFF	NONE REQUIRED	
W5259	P1 P5 TO P3 J5	1553 CH A	N/A	N/A	NONE REQUIRED	NONE REQUIRED	[4]
W5451	P1 P6 TO P3 J6	HRDL (UCCAS-1)	N/A	N/A	NONE REQUIRED	NONE REQUIRED	[4]

NOTES:

- [1] AT 12A, CONNECTS P6 CH 2B PRIMARY POWER TO P4 CH 2A DCSU FOR P4 CH 2A STARTUP. AFTER 12A.1, PROVIDES CH 2A PRIMARY POWER TO MBSU BUS 2A.
- [2] CABLE W5001 HAS PINS ON THE POWER SIDE OF THE CONNECTOR, WHICH DOES NOT MEET THE REQUIREMENTS OF THE SAFETY LETTER. NCR-ISS-134, APPROVED ON JULY 8, 2004, ALLOWS HAVING ONE UPSTREAM INHIBIT (CID 7 OFF) AND ONE DOWNSTREAM INHIBIT (LOAD <180 W).
- [3] DURING THE EVA, ONCE DDCU LA2A IS POWERED OFF FOR THE W5103 CONNECTION, THE FIRST UPSTREAM INHIBIT CAN NO LONGER BE MONITORED, SO THE SECOND INHIBIT IS REQUIRED.
- [4] 1553 AND SIGNAL CABLES MEET THE LOW POWER CONNECTOR REQUIREMENTS OF THE SAFETY LETTER AND, THEREFORE, DO NOT REQUIRE POWER INHIBITS.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

**12A\_C9-1                      POWER CONNECTION INHIBITS [HC] (CONTINUED)**

C. REMOVE CID'S 6 AND 8

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	POWER INHIBIT	NOTE
U27-W08C	Z1J430 FROM Z1 CID 6 P230	CID 6 REMOVAL	CID 6 - OFF DCSU 4B RBI 6 - OPEN DCSU 4A RBI 6 - OPEN OR CID 8 - OFF	[1] [2]
W4035	S0 P230 FROM Z1 CID6 J430	CID 6 REMOVAL	CID 6 - OFF DCSU 4B RBI 6 - OPEN DCSU 4A RBI 6 - OPEN OR CID 8 - OFF	[1] [2]
W4035 U27-W08C	S0 P230 TO Z1 J430	P6 CH 4B PRI POWER TO P4 CH 4A	DCSU 4B RBI 6 - OPEN DCSU 4A RBI 6 - OPEN OR CID 8 - OFF	[1] [2]
W4035	S0 J484 FROM S0 CID8 P485	CID 8 REMOVAL	CID 8 - OFF DCSU 4B RBI 6 - OPEN OR CID 6 - OFF DCSU 4A RBI 6 - OPEN	[3] [4]
W4005	S0 P485 FROM S0 CID8 J484	CID 8 REMOVAL	CID 8 - OFF DCSU 4B RBI 6 - OPEN OR CID 6 - OFF DCSU 4A RBI 6 - OPEN	[3] [4]
W4005 W4035	S0 P485 TO S0 J484	P6 CH 4B PRI POWER TO P4 CH 4A	DCSU 4B RBI 6 - OPEN OR CID 6 - OFF DCSU 4A RBI 6 - OPEN	[3] [4]

@[CR 7646 ]

NOTES:

- [1] AT 12A, PRIOR TO CHANNEL 4A ACTIVATION, THE UPSTREAM INHIBIT IS OBTAINED BY OPENING DCSU 4B RBI 6. THE DOWNSTREAM LOADS CONSIST OF DDCU LA4A AND, IF CID 8 IS NOT OPEN, DCSU 4A AND PVCU 4A. THE COMBINED LOAD OF THE POWER SUPPLIES FOR THESE ORU'S IS LESS THAN 180W.
- [2] AFTER CHANNEL 4A ACTIVATION, CID 6 MUST BE ISOLATED FROM TWO SOURCES BY OPENING DCSU 4B RBI 6 AND DCSU 4A RBI 6 OR CID 8. THE ONLY LOAD IS DDCU LA4A WHICH IS LESS THAN 180W.
- [3] AT 12A, PRIOR TO CHANNEL 4A ACTIVATION, THE UPSTREAM INHIBIT IS OBTAINED BY OPENING DCSU 4B RBI 6 OR OPENING CID 6. THE DOWNSTREAM LOADS CONSIST OF DCSU 4A AND PVCU 4A. THE COMBINED LOAD OF THE POWER SUPPLIES FOR THESE ORU'S IS LESS THAN 180W.
- [4] AFTER CHANNEL 4A ACTIVATION, CID 8 MUST BE ISOLATED FROM TWO SOURCES BY OPENING DCSU 4B RBI 6 OR CID 6 AND DCSU 4A RBI 6. THE ONLY LOAD IS DDCU LA4A WHICH IS LESS THAN 180W.

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C9-1

POWER CONNECTION INHIBITS [HC] (CONTINUED)

D. UPGRADE S1 S-BAND ORU'S

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	POWER INHIBIT	NOTE
W5127	P636D - BSP J1D	BSP OPS POWER  BSP HEATER POWER	RPCM S11A B RPC 11 OPEN AND CLOSE COMMAND INHIBITED  RPCM S11A B RPC 2 OPEN AND CLOSE COMMAND INHIBITED	[1]
W5206	P636B - BSP J1B	1553 CH A	N/A	[1] [2]
W5208	P636C - BSP J1C	1553 CH B	N/A	[1] [2]
W5208	P636A - BSP J1A	RS-422	N/A	[1] [2]
W5127	P637D - XPDR J1D	XPDR OPS POWER  XPDR HEATER POWER	RPCM S11A B RPC 10 OPEN AND CLOSE COMMAND INHIBITED  RPCM S11A B RPC 15 OPEN AND CLOSE COMMAND INHIBITED	[1]
W5206	P637B - XPDR J1B	1553 CH A	N/A	[1] [2]
W5208	P637C - XPDR J1C	1553 CH B	N/A	[1] [2]
W5208	P637A - XPDR J1A	RS-422	N/A	[1] [2]

©[CR 7646 ]

NOTES:

[1] BSP AND XPDR HAVE BLIND MATE CONNECTORS.

[2] 1553 AND SIGNAL CABLES MEET THE LOW POWER CONNECTOR REQUIREMENTS OF THE SAFETY LETTER AND, THEREFORE, DO NOT REQUIRE POWER INHIBITS.

**THIS RULE CONTINUED ON NEXT PAGE**

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**FLIGHT RULES**

**12A\_C9-1                      POWER CONNECTION INHIBITS [HC] (CONTINUED)**

E. S1 SASA REMOVE AND REPLACE @[CR 7646 ]

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	DOWNSTREAM LOADS < 180 W?	SOCKET ON PWR SIDE?	1ST INHIBIT	2ND INHIBIT	NOTE
W200A	P33 – J3 (SASA)	SPARE SASA HEATER POWER	Y	Y	RPCM Z14B B RPC 1 OPEN WITH CLOSE COMMAND INHIBITED	NONE REQUIRED	[1]
W5208	P2 TO J2	XPDR S1 RF RECEIVER TRANSMITTER	N/A	N/A	NOT REQUIRED	NONE REQUIRED	[2]
W5151	P3 TO J3	ACRFG S1 HTR	Y	Y	RPCM S11A B RPC 12 OPEN WITH CLOSE COMMAND INHIBITED	NONE REQUIRED	
W5150	P4 TO J4	ACRFG S1	Y	Y	RPCM S11A B RPC 16 OPEN WITH CLOSE COMMAND INHIBITED	NONE REQUIRED	

NOTES:

- [1] THIS RPC ALSO POWERS THE EARLY AMMONIA SERVICER THROUGH CABLE W200B.
- [2] 1553 AND SIGNAL CABLES MEET THE LOW POWER CONNECTOR REQUIREMENTS OF THE SAFETY LETTER AND, THEREFORE, DO NOT REQUIRE POWER INHIBITS.

F. AVIONIC RACK JUMPER FROM LAB105 TO AVIONICS RACK 2 (LAB1D1)

CABLE	CONNECTION/ DISCONNECTION	FUNCTION	1ST INHIBIT	2ND INHIBIT	NOTE
W8250C	P1 TO J1 (AV 2 UIP)	AV RACK 2 120VDC	RPCM LA1B D RPC 04 OPEN AND CLOSE COMMAND INHIBITED	NONE REQUIRED	[1]
W8226	AV JUMPER P1 TO J1(AV 2 UIP)	AVIONICS RACK POWER JUMPER TO AV2	RPCM LA1B D RPC 04 OPEN AND CLOSE COMMAND INHIBITED	NONE REQUIRED	[1]
W8226	AV JUMPER P2 TO J1(O5 STANDOFF UIP)	AV RACK POWER JUMPER TO O5 SECONDARY POWER	RPCM LA2A3B F RPC 01 OPEN AND CLOSE COMMAND INHIBITED	NONE REQUIRED	[2]

NOTES:

- [1] THE UPSTREAM DDCU LA1B WILL CURRENT LIMIT TO PREVENT MORE THAN 65A.
- [2] THE UPSTREAM DDCU LA3B WILL CURRENT LIMIT TO PREVENT MORE THAN 65A.

*Medical Operations has set 32 Vdc as the threshold for posing a shock hazard to an IVA crewmember. The risk can be controlled by use of an inhibit that is verified at the time of the mate/demate operation. Connector design should mitigate the molten metal hazard at the lower currents. Above 65 amps, sustained electrical arcs and the molten metal hazard require an additional inhibit. For the ISS, most internal cables that will be mated/demated will be downstream of a DC to DC Converter Unit (DDCU) which has current limiting circuitry that prevents currents above 63 amps. @[CR 7646 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

12A\_C9-1

**POWER CONNECTION INHIBITS [HC] (CONTINUED)**

G. CLASS 1 EVA CONTINGENCY TASKS @[CR 7646 ]

ORU	POWER INHIBIT	NOTE
DDCU 4B	DCSU 4B RBI 5 OPEN	[1]
DDCU 2B	DCSU 2B RBI 1 OPEN	[1]
PFCS 4B	RPCM 4B A RPC 03 OPEN AND CLOSE COMMAND INHIBITED	[2]
PFCS 2B	RPCM 2B A RPC 03 OPEN AND CLOSE COMMAND INHIBITED	[2]
DCSU 4B	1. SSU 4B SHUNTED 2. BCDU 4B1 CONVERTER OFF AND FI OPEN 3. BCDU 4B2 CONVERTER OFF AND FI OPEN 4. BCDU 4B3 CONVERTER OFF AND FI OPEN 5. BCDU 2B2 CP RBI OPEN 6. DDCU 4B CONVERTER OFF	[3]
DCSU 2B	1. SSU 2B SHUNTED 2. BCDU 2B1 CONVERTER OFF AND FI OPEN 3. BCDU 2B2 CONVERTER OFF AND FI OPEN 4. BCDU 2B3 CONVERTER OFF AND FI OPEN 5. BCDU 4B2 CP RBI OPEN 6. DDCU 2B CONVERTER OFF	[3]
SSU 4B	1. DCSU 4B RBI 1 OPEN 2. BCDU 2B1 CP RBI OPEN 3. IF POSSIBLE, SSU 4B SHUNTED 4. IN ECLIPSE 5. W118 P21 J1 DISCONNECTED	[4]
SSU 2B	1. DCSU 2B RBI 1 OPEN 2. BCDU 4B1 CP RBI OPEN 3. IF POSSIBLE, SSU 2B SHUNTED 4. IN ECLIPSE 5. W111 P11 J1 DISCONNECTED	[4]

NOTES:

- [1] ONE UPSTREAM REQUIRED, THE DDCU POWER SUPPLY DRAWS LESS THAN 180W WHEN POWERED ON.
- [2] ONE UPSTREAM REQUIRED, THE PFCS POWER SUPPLY DRAWS LESS THAN 180W WHEN POWERED ON.
- [3] SHUNTING THE SSU, TURNING OFF THE BCDU CONVERTERS, AND OPENING THE CPI REMOVES POWER INPUTS DIRECTLY TO THE DCSU. THE PVM RPCM'S ARE WITHIN THE DCSU AND MUST BE DEACTIVATED AND SAFED AS WELL. THIS IS DONE BY TURNING THE PVM DDCU CONVERTER OFF.
- [4] THE UPSTREAM CONNECTION FOR THE SSU CONNECTS DIRECTLY TO THE SOLAR ARRAY. THE ONLY WAY TO REMOVE POWER FROM THE ARRAY IS TO BE IN ECLIPSE OR RETRACT THE SOLAR ARRAY.

*Reference Hazard Report Prime-207-2A, Electrical Shock of IVA Crewmember, causes 2 and 3; and safety interpretation memorandum MA2-99-170, Crew Mating/Demating of Powered Connectors.*

## FLIGHT RULES

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### 12A\_C9-2

### USOS ARRAY FEATHERING DURING WATER DUMPS

- A. FOR ORBITER WASTE WATER, SUPPLY, PAYLOAD WATER RESERVOIR (PWR), OR CONTINGENCY WATER CONTAINER (CWC) DUMPS, THE USOS SOLAR ARRAYS MUST BE FEATHERED AS FOLLOWS: ©[DN 108 ]
1. FOR THE P6 ARRAYS ON Z1:
    - a. THE P6 4B ARRAY MUST BE FEATHERED BETWEEN 213 DEGREES AND 223 DEGREES. 223 DEGREES IS PREFERRED. IF THE P6 4B ARRAY CANNOT BE FEATHERED, THE WATER DUMP SHOULD BE DELAYED.
    - b. THE P6 2B ARRAY IS NOT REQUIRED TO BE FEATHERED.

*For the P6 4B Array, 223 degrees is preferred because it exposes the least surface area on the backside to the water dump plume. The arrays are feathered to mitigate damage to the optical coatings on the active side and the SiOx protective coating on the back side due to impacts of ice particles. The feather angles keep the arrays out of the plume core and orient the arrays such that the edge of the array is in plane with the dump nozzle with a 5-degree bias to the back of the array. In-plane refers to the edge of the solar array pointing directly at the dump nozzle.*

*The dump should be delayed to allow consideration of alternate feathering angles or other options (such as offloading the water into a CWC).*

2. FOR THE P4 ARRAYS:
  - a. THE PREFERRED PORT SARJ, P4 2A ARRAY, AND P4 4A ARRAY FEATHERING ANGLES ARE LISTED IN TABLE 12A\_C9-2-I. ©[DN 108 ]

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

12A\_C9-2

### USOS ARRAY FEATHERING DURING WATER DUMPS (CONTINUED)

**TABLE 12A\_C9-2-I - PREFERRED FEATHER ANGLES FOR ORBITER DUMPS**  
@[DN 108 ]

PORT SARJ ALPHA ANGLE [1] [2] [3]	P4-4A BGA BETA ANGLE [1] [2]	P4-2A BGA BETA ANGLE [1] [4]
0±5	(270-272) OR (102-104)	ANY
10±5	(266-268) OR (098-100)	(90-102) OR (254-268)
20±5	(262-264) OR (94-96)	(94-102) OR (260-268)
30±5	(258-260) OR (90-92)	(98-102) OR (264-268)
40±5	(254-256) OR (86-88)	(100-106) OR (268-272)
50±5	(250-254) OR (82-84)	(104-110) OR (270-276)
60±5	(246-250) OR (78-82)	(106-114) OR (274-280)
70±5	(244-248) OR (74-80)	(110-116) OR (276-284)
80±5	(240-248) OR (72-78)	(110-118) OR (278-286)
90±5	(238-246) OR (70-78)	(112-120) OR (280-288)
100±5	(236-246) OR (68-78)	(112-122) OR (280-290)
110±5	(236-246) OR (68-78)	(112-122) OR (280-290)
120±5	(236-246) OR (68-78)	(112-122) OR (280-290)
130±5	(238-246) OR (70-78)	(112-120) OR (280-288)
140±5	(238-248) OR (70-80)	(110-118) OR (280-286)
150±5	(238-248) OR (70-82)	(110-114) OR (278-284)
160±5	ANY	(108-112) OR (276-280)
170±5	ANY	(104-108) OR (272-276)
180±5	ANY	(102-104) OR (270-272)
186 TO 354 [3]	NOT ALLOWED	NOT ALLOWED

NOTES:

- [1] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [2] PORT SARJ ANGLES BETWEEN 186 AND 354 DEGREES ARE NOT PERMITTED IN ORDER TO PREVENT WATER CONTAMINATION OR PARTICLE DAMAGE TO THE P4 PVR FROM EXPOSURE TO THE SHUTTLE WATER PLUME.
- [3] FOR A SARJ ANGLE WITH OVERLAPPING ROWS (E.G., 5, 15, 25, ETC.) IN THE TABLE, EITHER SET OF BGA ANGLES MAY BE USED. FOR EXAMPLE, FOR A SARJ ANGLE OF 5 DEGREES, THE BGA ANGLES MAY BE CHOSEN FROM EITHER THE SARJ ROW FOR 0±5 OR 10±5.
- [4] FOR BETA ANGLES LISTED AS ANY, THE BGA IS NOT REQUIRED TO BE FEATHERED AND MAY REMAIN IN THE NOMINAL ARRAY MODE. @[DN 108 ]

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## FLIGHT RULES

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12A\_C9-2

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

*The feather angles protect the optical coatings on the active side and the SiOx protective coating on the back side of the P4 arrays and the PV radiator from damage due to ice particle impacts. The angles allow no impacts on the active side of the arrays. For the back side of the arrays, impact angles are restricted to be greater than 75 degrees from the normal to the back of the array, since no damage will result from impacts above this angle. The P4 radiator is kept out of a 20-degree cone from the centerline of the ice plume. ©[DN 108 ]*

- b. IF FEATHERING PER TABLE 12A\_C9-2-I CANNOT BE PERFORMED, NEW ANGLE COMBINATIONS MAY BE CHOSEN BASED ON THE TABLES BELOW. ©[DN 108 ]

**THIS RULE CONTINUED ON NEXT PAGE**





## FLIGHT RULES

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12A\_C9-2

### USOS ARRAY FEATHERING DURING WATER DUMPS (CONTINUED)

NOTES: @[DN 108 ]

- [1] SHADED POSITIONS ARE ACCEPTABLE ANGLE PAIRS.
- [2] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}. ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [3] PORT SARJ ANGLES BETWEEN 186 AND 354 DEGREES ARE NOT PERMITTED IN ORDER TO PREVENT WATER CONTAMINATION OR PARTICLE DAMAGE TO THE P4 PVR FROM EXPOSURE TO THE SHUTTLE WATER PLUME.
- [4] FOR PORT SARJ POSITIONS WITH ALL BETA ANGLES SHADED, THE BGA IS NOT REQUIRED TO BE FEATHERED AND MAY REMAIN IN THE NOMINAL ARRAY MODE.

*Source Data: Boeing Environments Team 12A FOR Presentation, January 28, 2003, and Boeing Environments Team Memo 2003-001, Orbiter Water Dumping onto ISS – P4 SAW Feathering Angle Requirement with 4B Retraction, February 20, 2003.*

- c. IF THE PORT SARJ CANNOT BE FEATHERED OUTSIDE OF ANGLES BETWEEN 186 AND 354 DEGREES OR AN ALLOWABLE COMBINATION OF PORT SARJ AND P4 BGA ANGLES CANNOT BE ACHIEVED, THE WATER DUMP SHOULD BE DELAYED.

*Port SARJ angles between 186 and 354 degrees are not permitted in order to prevent water contamination or particle damage to the P4 PVR from exposure to the shuttle water plume.*

*The dump should be delayed to allow consideration of alternate feathering angles or other options (such as offloading the water into a CWC).*

- B. FOR U.S. LAB PORT SIDE CONDENSATE WATER DUMPS, THE USOS ARRAYS MUST BE FEATHERED AS FOLLOWS:
  - 1. FOR THE P6 ARRAYS ON Z1:
    - a. THE P6 4B ARRAY MUST BE FEATHERED BETWEEN 60-65 DEGREES OR BETWEEN 230-235 DEGREES.
    - b. THE P6 2B ARRAY MUST BE FEATHERED BETWEEN 120-130 DEGREES OR 290-300 DEGREES.
    - c. IF THE P6 ARRAYS CANNOT BE FEATHERED, THE WATER DUMP SHOULD BE DELAYED. @[DN 108 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C9-2

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

*The arrays are feathered to mitigate damage to the optical coatings on the active side and the SiO<sub>x</sub> protective coating on the back side due to impacts of ice particles. The feather angles keep the arrays out of the plume core and orient the arrays such that the edge of the array is in plane with the dump nozzle with a 5-degree bias to the back of the array. In-plane refers to the edge of the solar array pointing directly at the dump nozzle. ©[DN 108 ]*

*The dump should be delayed to allow consideration of alternate feathering angles or other options (such as offloading the water into a CWC).*

*Source: Boeing Environments Memo, 2003-014, U.S. Lab Condensate Water Dumps: Allowable Beta Angles for P6 Solar Array Wing (SAW) on Z1 Truss (Stages 11A – 13A).*

2. FOR THE P4 ARRAYS:

- a. THE PREFERRED PORT SARJ, P4 2A ARRAY, AND P4 4A ARRAY FEATHERING ANGLES ARE LISTED IN TABLE 12A\_C9-2-IV.  
©[DN 108 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

12A\_C9-2

### USOS ARRAY FEATHERING DURING WATER DUMPS (CONTINUED)

**TABLE 12A\_C9-2-IV - PREFERRED FEATHER ANGLES FOR  
PORT LAB DUMPS** ©[DN 108 ]

PORT SARJ ALPHA ANGLE [1] [3]	P4-4A BGA BETA ANGLE [1] [2]	P4-2A BGA BETA ANGLE [1] [2] [4]
0±5	(264-274) OR (96-104)	(84-94) OR (252-262)
10±5	(264-270) OR (94-102)	(84-96) OR (252-262)
20±5	(262-268) OR (94-100)	ANY
30±5	(260-266) OR (92-98)	ANY
40±5	(258-264) OR (90-96)	(94-106) OR (262-272)
50±5	(256-262) OR (88-94)	(96-106) OR (262-272)
60±5	(254-262) OR (86-94)	(96-106) OR (262-272)
70±5	(252-260) OR (84-92)	(98-106) OR (264-274)
76-304	NOT ALLOWED	NOT ALLOWED
310±5	(268-278) OR (100-110)	(78-90) OR (246-258)
320±5	(268-278) OR (100-110)	(80-90) OR (248-258)
330±5	(268-276) OR (100-108)	(80-90) OR (248-258)
340±5	(268-276) OR (100-108)	(82-90) OR (250-258)
350±5	(266-274) OR (98-106)	(84-92) OR (252-262)

NOTES:

- [1] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [2] PORT SARJ ANGLES BETWEEN 76 AND 305 DEGREES ARE NOT PERMITTED BECAUSE THE SOLAR ARRAYS ARE WITHIN THE HIGH IMPACT ZONE OR THE HIGH IMPACT ZONE IS BETWEEN THE SOLAR ARRAY AND THE PV RADIATOR.
- [3] FOR A SARJ ANGLE WITH OVERLAPPING ROWS (E.G., 5, 15, 25, ETC.) IN THE TABLE, EITHER SET OF BGA ANGLES MAY BE USED. FOR EXAMPLE, FOR A SARJ ANGLE OF 5 DEGREES, THE BGA ANGLES MAY BE CHOSEN FROM EITHER THE SARJ ROW FOR 0±5 OR 10±5.
- [4] FOR BETA ANGLES LISTED AS ANY, THE BGA IS NOT REQUIRED TO BE FEATHERED AND MAY REMAIN IN THE NOMINAL ARRAY MODE.

*The feather angles protect the optical coatings on the active side and the SiOx protective coating on the back side of the P4 arrays and the PV radiator from damage due to ice particle impacts. The angles allow no impacts on the active side of the arrays. For the back side of the arrays, impact angles are restricted to be greater than 75 degrees from the normal to the back of the array, since no damage will result from impacts above this angle. The P4 radiator is kept out of a 20-degree cone from the centerline of the ice plume.* ©[DN 108 ]

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# FLIGHT RULES

**12A\_C9-2**

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

Source: Boeing Environments Memo, 2003-009, U.S. Lab Port Side Condensate Water Releases: P4-4A and P4-2A Feathering Angle Requirements During Dump Operations, ISS Flights 12A and beyond. ©[DN 108 ]

- b. IF FEATHERING PER TABLE 12A\_C-2-IV CANNOT BE PERFORMED, NEW ANGLE COMBINATIONS MAY BE CHOSEN BASED ON TABLE 12A\_C9-2-V.

**TABLE 12A\_C9-2-V - ALLOWABLE P4 SOLAR ARRAY 4A ALPHA/BETA ANGLE COMBINATIONS (BETA 0-238) FOR PORT LAB WATER DUMPS**

Port SARJ Alpha Angle	P4-4A BGA Beta Angle																										
	0 to 72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122 to 238	
0																											
10																											
20																											
30																											
40																											
50																											
60																											
70																											
80																											
90																											
100																											
110																											
120																											
130																											
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170																											
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230																											
240																											
250																											
260																											
270																											
280																											
290																											
300																											
310																											
320																											
330																											
340																											
350																											
360																											

Unacceptable Region: Solar arrays are within high impact zone or high impact zone is between solar array and PV radiator during condensate water dumps

Color Key:  = Allowable SAW Positions for US Lab Port Side Condensate Vent

NOTES:

- [1] SHADED POSITIONS ARE ACCEPTABLE ANGLE PAIRS.
- [2] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [3] PORT SARJ ANGLES BETWEEN 76 AND 305 DEGREES ARE NOT PERMITTED, BECAUSE THE SOLAR ARRAYS ARE WITHIN THE HIGH IMPACT ZONE OR THE HIGH IMPACT ZONE IS BETWEEN THE SOLAR ARRAY AND THE PV RADIATOR. ©[DN 108 ]

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# FLIGHT RULES

12A\_C9-2

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

**TABLE 12A\_C9-2-VI - ALLOWABLE P4 SOLAR ARRAY 4A ALPHA/BETA ANGLE COMBINATIONS (BETA 240-360) FOR PORT LAB WATER DUMPS @[DN 108 ]**

Port SARJ Alpha Angle	P4-4A BGA Beta Angle																											
	240	242	244	246	248	250	252	254	256	258	260	262	264	266	268	270	272	274	276	278	280	282	284	286	288	290 to 360		
0																												
10																												
20																												
30																												
40																												
50																												
60																												
70																												
80																												
90																												
100																												
110																												
120																												
130																												
140																												
150																												
160																												
170																												
180																												
190																												
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280																												
290																												
300																												
310																												
320																												
330																												
340																												
350																												
360																												
Color Key:	= Allowable SAW Positions for US Lab Port Side Condensate Vent																											

*Unacceptable Region: Solar arrays are within high impact zone or high impact zone is between solar array and PV radiator during condensate water dumps*

NOTES:

- [1] SHADED POSITIONS ARE ACCEPTABLE ANGLE PAIRS.
- [2] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [3] PORT SARJ ANGLES BETWEEN 76 AND 305 DEGREES ARE NOT PERMITTED, BECAUSE THE SOLAR ARRAYS ARE WITHIN THE HIGH IMPACT ZONE OR THE HIGH IMPACT ZONE IS BETWEEN THE SOLAR ARRAY AND THE PV RADIATOR. @[DN 108 ]

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# FLIGHT RULES

12A\_C9-2

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

**TABLE 12A\_C9-2-VII - ALLOWABLE P4 SOLAR ARRAY 2A ALPHA/BETA ANGLE COMBINATIONS (BETA 0-232) FOR PORT LAB WATER DUMPS @[DN 108 ]**

Port SARJ Alpha Angle	P4-2A BGA Beta Angle																										
	0 to 72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122 to 232	
0																											
10																											
20																											
30																											
40																											
50																											
60																											
70																											
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310																											
320																											
330																											
340																											
350																											
360																											

*Unacceptable Region: Solar arrays are within high impact zone or high impact zone is between solar array and PV radiator during condensate water dumps*

Color Key:  = Allowable SAW Positions for US Lab Port Side Condensate Vent

NOTES:

- [1] SHADED POSITIONS ARE ACCEPTABLE ANGLE PAIRS.
- [2] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [3] PORT SARJ ANGLES BETWEEN 76 AND 305 DEGREES ARE NOT PERMITTED, BECAUSE THE SOLAR ARRAYS ARE WITHIN THE HIGH IMPACT ZONE OR THE HIGH IMPACT ZONE IS BETWEEN THE SOLAR ARRAY AND THE PV RADIATOR.
- [4] FOR PORT SARJ POSITIONS WITH ALL BETA ANGLES SHADED, THE BGA IS NOT REQUIRED TO BE FEATHERED AND MAY REMAIN IN THE NOMINAL ARRAY MODE. @[DN 108 ]

**THIS RULE CONTINUED ON NEXT PAGE**

# FLIGHT RULES

12A\_C9-2

**USOS ARRAY FEATHERING DURING WATER DUMPS**  
**(CONTINUED)**

**TABLE 12A\_C9-2-VIII - ALLOWABLE P4 SOLAR ARRAY 2A ALPHA/BETA ANGLE COMBINATIONS (BETA 234-360) FOR PORT LAB WATER DUMPS**  
 ®[DN 108 ]

Port SARJ Alpha Angle	P4-2A BGA Beta Angle																									
	234	238	238	240	242	244	248	248	250	252	254	256	258	260	262	264	266	268	270	272	274	278	278	280	282	284 to 360
0																										
10																										
20																										
30																										
40																										
50																										
60																										
70																										
80																										
90																										
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320																										
330																										
340																										
350																										
360																										
Color Key:	= Allowable SAW Positions for US Lab Port Side Condensate Vent																									

*Unacceptable Region: Solar arrays are within high impact zone or high impact zone is between solar array and PV radiator during condensate water dumps*

NOTES:

- [1] SHADED POSITIONS ARE ACCEPTABLE ANGLE PAIRS.
- [2] ENERGY BALANCE WILL BE MAINTAINED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E]. THE APPROPRIATE FEATHERING ANGLES ARE SELECTED TO MAINTAIN ENERGY BALANCE FOR THE FLIGHT ATTITUDE AND SOLAR BETA ANGLE DURING THE SHUTTLE VENT EVENT.
- [3] PORT SARJ ANGLES BETWEEN 76 AND 305 DEGREES ARE NOT PERMITTED, BECAUSE THE SOLAR ARRAYS ARE WITHIN THE HIGH IMPACT ZONE OR THE HIGH IMPACT ZONE IS BETWEEN THE SOLAR ARRAY AND THE PV RADIATOR.
- [4] FOR PORT SARJ POSITIONS WITH ALL BETA ANGLES SHADED, THE BGA IS NOT REQUIRED TO BE FEATHERED AND MAY REMAIN IN THE NOMINAL ARRAY MODE. ®[DN 108 ]

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## FLIGHT RULES

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12A\_C9-2

USOS ARRAY FEATHERING DURING WATER DUMPS  
(CONTINUED)

- c. IF THE PORT SARJ CANNOT BE FEATHERED OUTSIDE OF ANGLES BETWEEN 76 AND 305 DEGREES OR AN ALLOWABLE COMBINATION OF PORT SARJ AND P4 BGA ANGLES CANNOT BE ACHIEVED, THE WATER DUMP SHOULD BE DELAYED. ©[DN 108 ]

*The dump should be delayed to allow consideration of alternate feathering angles or other options (such as offloading the water into a CWC).*

- C. FOR U.S. LAB STARBOARD SIDE CONDENSATE WATER DUMPS THE USOS ARRAYS MUST BE FEATHERED AS FOLLOWS:
1. FOR THE P6 ARRAYS ON Z1, THERE IS NO REQUIREMENT TO FEATHER.
  2. FOR THE P4 ARRAYS, THERE IS NO REQUIREMENT TO FEATHER THE PORT SARJ, P4 4A ARRAY, OR P4 2A ARRAY.

*Source: Boeing Environments Memo, 2003-014, U.S. Lab Condensate Water Dumps: Allowable Beta Angles for P6 Solar Array Wing (SAW) on Z1 Truss (Stages 11A - 13A), and Boeing Environments Memo, 2003-009, U.S. Lab Port Side Condensate Water Releases: P4-4A and P4-2A Feathering Angle Requirements During Dump Operations, ISS Flights 12A and beyond. ©[DN 108 ]*

## FLIGHT RULES

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12A\_C9-3

### PVTCS PFCS THERMAL CONTROL ALGORITHMS FOR P4 ACTIVATION

THE PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS) PUMP AND FLOW CONTROL SYSTEM (PFCS) THERMAL CONTROL ALGORITHMS IN THE PHOTOVOLTAIC CONTROL ASSEMBLY (PVCA) WILL BE COMMANDED TO THEIR NOMINAL STATES AS DEFINED IN THE VOLUME B FLIGHT RULES WITH THE FOLLOWING EXCEPTIONS: @[DN 76 ]

- A. THE FLOW CONTROL VALVE (FCV) CONTROL FUNCTION WILL BE INHIBITED (FI ACTIVATED) IN BOTH PHOTOVOLTAIC CONTROLLER UNIT (PVCU) MDM'S PRIOR TO APPLYING POWER TO THE PFCS. THE FCV CONTROL FUNCTION WILL BE ENABLED (FI DEACTIVATED) AFTER PFCS PUMP ACTIVATION.

*Inhibiting the automated PVCA FCV control function prior to PFCS activation and checkout will prevent the PVCA from repeatedly attempting to reposition the FCV during checkout operations.*

- B. THE FCV BATTERY WARM RECAL (FCV FAILURE RECOVERY) FUNCTION WILL BE INHIBITED (FI ACTIVATED) IN BOTH PVCU MDM'S PRIOR TO APPLYING POWER TO THE PFCS.

*On-orbit thermal environments may create conditions in which the P4 batteries are warmer than 20 deg C/68 deg F prior to PVTCS activation. Inhibiting the automated PVCA FCV Battery Warm Recal function prior to PFCS activation and checkout will prevent the PVCA from repeatedly attempting to recalibrate the FCV due to possible warm battery temperatures.*

- C. THE PFCS MIN INLET TEMP SAFING (UNDERTEMP LIMIT SHUTDOWN) FUNCTION WILL BE INHIBITED (FI ACTIVATED) IN BOTH PVCU MDM'S PRIOR TO APPLYING POWER TO THE PFCS. ONCE THE PFCS UNIT HAS BEEN INITIALIZED, PUMP OPERATIONS ARE VERIFIED NOMINAL, AND THE PFCS OUTLET TEMPERATURE REMAINS ABOVE -42.8 (-39.8) DEG C/-45 (-40) DEG F, THE PFCS MIN INLET TEMP SAFING FUNCTION WILL BE ENABLED (FI DEACTIVATED).

*On-orbit thermal environments may create conditions in which the PFCS outlet temperature is less than -42.8 deg C/-45 deg F prior to PVTCS activation. The FDIR protection is required to prevent damage to the PFCS Hall Effect sensor. Inhibiting the automated PVCA PFCS Min Inlet Temp Safing function prior to PFCS activation and checkout will prevent inadvertent PFCS pump shutdown during the activation sequence. Once the PFCS pump is active, the PFCS outlet temperature should remain greater than -42.8 deg C/-45 deg F as long as the PVTCS is functioning nominally. @[DN 76 ]*

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## **FLIGHT RULES**

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### SECTION 10 - MECHANICAL

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#### SHUTTLE ONLY RULES

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#### 12A\_A10-1 VENT DOOR MANAGEMENT [HC]

- A. ON ORBIT, ALL VENTS WILL NOMINALLY BE OPEN EXCEPT FOR THE FOLLOWING: ©[CR 7560 ]
1. IF REDUNDANT CLOSE CAPABILITY IS LOST, THE AFFECTED VENT(S) WILL BE CLOSED ASAP. IF BOTH FORWARD OR AFT COMPARTMENT VENTS HAVE LOST CLOSE REDUNDANCY, ONE VENT MAY REMAIN OPEN:
    - a. IF IFM CAPABILITY EXISTS TO RESTORE CLOSE REDUNDANCY, OR
    - b. FOR A KNOWN OR SUSPECTED NON-ISOLATED RCS OXIDIZER, OMS OXIDIZER, OR OMS HE LEAK

*For loss of close redundancy, the affected door is closed to limit the exposure to the next failure that would leave the door failed open. Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that vent box 3, if left open, is predicted to reach a temperature of 1100 deg F during the entry profile. Since the melting point of 2024 aluminum is 935 deg F, a breach of the box is expected to occur, possibly resulting in loss of crew and vehicle. Because the new thermal analysis data shows temperatures very similar to the old thermal analysis, the previous temperature predictions for vent doors 1/2, 5, 6, and 8/9 will be used until the new thermal analysis is complete. Currently, if left open during entry, vent box 1/2 is expected to reach a temperature of 1200 deg F, vent boxes 5 and 6 will experience 600 to 700 deg F heating, and vent box 8/9 will experience up to 550 deg F heating. Based on these temperatures, vent box 1/2 will surpass the melting point of 2024 aluminum and would result in a breach and possible loss of crew and vehicle. The reusability temperature limit of 2024 aluminum is 350 deg F and soon after reaching this temperature, the aluminum starts to lose structural integrity (around 400 deg F). Therefore, 400 deg F was chosen as the temperature limit for which to protect the vent doors. Even though vent doors 5, 6, and 8/9 do not reach the melting point of 2024 aluminum, they do exceed the structural integrity limit if left open during entry. Additionally, it is important that these doors are closed during entry heating above 400 deg F to protect various components in close proximity to the vent openings from failing, such as electrical wires, Freon lines, hydraulic lines, and APU hydrazine lines. ©[CR 7560 ]*

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**FLIGHT RULES****12A\_A10-1      VENT DOOR MANAGEMENT [HC] (CONTINUED)**

*If redundancy is lost on both left and right vents 1/2 (8/9), closing both doors to protect against the next failure will leave the forward (aft) compartment unvented. If an RCS oxidizer, OMS oxidizer, or OMS helium leak subsequently develops, the affected compartment can overpressurize. If IFM capability can restore close redundancy to at least one of the compartment vents, that vent may remain open. If IFM capability does not exist, it is acceptable to close off the forward (aft) compartment because the probability of an RCS oxidizer, OMS oxidizer, or OMS helium leak is substantially less than that for a failure that affects vent door drive. However, one vent from the forward (aft) compartment will be opened, regardless of IFM capability, in order to vent the forward or aft compartment due to a known or suspected RCS oxidizer, OMS oxidizer, or OMS helium leak. If the vents are not opened, the compartment could overpressurize, causing structural damage that would lead to loss of crew and vehicle during entry. Unless the IFM close capability criteria is met, if the leak is subsequently isolated, the vent will be closed. ©[CR 7560 ]*

2. VENTS MAY BE CLOSED/OPENED IN ORDER TO TROUBLESHOOT ELECTRICAL OR COMMAND PATH PROBLEMS. THE AFFECTED VENT(S) MAY BE LEFT IN THE POST-TEST CONFIGURATION UNLESS REPOSITIONING IS NECESSARY TO SATISFY PARAGRAPH A.1 OF THIS RULE.

*Sending real-time commands to drive vent doors can be used to determine the status of a suspect AC bus, to verify the state of a motor control assembly relay, or to verify proper GPC-FF/FA MDM function. There is no requirement to reposition a vent door to its previous configuration following the test unless the flight rules dictate a different configuration due to failures.*

- B. ENTRY WILL BE PERFORMED AT THE NEXT PLS OPPORTUNITY FOR LOSS OF VENT DOOR REDUNDANCY WHERE THE NEXT FAILURE RESULTS IN INABILITY TO MEET ENTRY VENT OPERATION CONSTRAINTS, UNLESS IFM CAPABILITY EXISTS TO RESTORE REDUNDANCY.

*“Entry vent operation constraints” refers to paragraph E of this rule.*

*Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that adequate venting margins could be maintained if at least one side of the forward compartment, one side of the aft compartment, and any four midbody vent doors are opened by 70,000 ft. If only three midbody vents are open by 70,000 ft, adequate venting margins can be maintained if at least one of the midbody vents open is left or right vent 3. Failures resulting in loss of open capability on both sides of the forward or aft compartments would result in structural failure and loss of crew and vehicle. Additionally, failures resulting in more than three midbody vent doors failed closed would also result in structural failure and loss of crew and vehicle. It is prudent to shorten the mission to minimize the time of exposure to any additional on-orbit failure that would result in insufficient venting. ©[CR 7560 ]*

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## FLIGHT RULES

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### 12A\_A10-1 VENT DOOR MANAGEMENT [HC] (CONTINUED)

*If failure(s) requires both left and right vents 1/2 (8/9) to be closed, closing the vents will remove the potential for a single failure causing a vent to be failed open, and it will take two additional failures to cause loss of venting capability. However, with both vents closed, the forward (aft) compartment is subject to catastrophic failure if an RCS oxidizer, OMS oxidizer (aft only), or OMS helium (aft only) leak occurs. Such a leak is considered to have a remote probability of occurrence, especially when compared to the probability of failures affecting vent door drive capability. ©[CR 7560 ]*

C. IF IFM CAPABILITY EXISTS AND IS NEEDED TO MEET ENTRY VENT OPERATION CONSTRAINTS:

*“Entry vent operation constraints” refers to paragraph E of this rule.*

1. TO REGAIN REDUNDANCY FOR ZERO FAULT TOLERANCE, CONSIDERATION WILL BE GIVEN TO PERFORMING THE IFM IF THE FAILURE OCCURS ANY TIME PRIOR TO THE DEORBIT BURN.

*Consideration will be given to performing an IFM to regain vent door redundancy when zero fault tolerant to the next worse failure. However, increasing this fault tolerance will be weighed against deorbit consumables (i.e., propellant, water, O<sub>2</sub>, and N<sub>2</sub>), available deorbit opportunities, and landing site weather. After the deorbit burn has been initiated, it is not warranted to stop the burn to regain fault tolerance.*

2. TO REGAIN CAPABILITY, THE IFM WILL BE PERFORMED IF THE FAILURE OCCURS AT ANY TIME PRIOR TO ACHIEVING SAFE HP.

*The deorbit burn will be terminated if necessary to regain critical capability.*

D. FOR ENTRY, LEFT VENTS 1/2 AND 8/9 WILL NOMINALLY REMAIN OPEN UNTIL THE MM 304 TRANSITION AND ALL OTHER VENTS WILL BE CLOSED PRIOR TO THE DEORBIT BURN. IF CLOSE REDUNDANCY IS LOST ON LEFT VENT 1/2 OR 8/9, THE AFFECTED VENT WILL BE CLOSED ASAP (PRIOR TO THE DEORBIT BURN, IF APPLICABLE).

*No vents will remain open to protect against the next worst failure.*

*Leaving the forward and aft compartments vented until MM 304 minimizes exposure to an OMS/RCS oxidizer or OMS helium leak, which can lead to overpressurization. However, this means committing to the deorbit burn with a forward vent open - if it cannot be closed, then burn-through will occur. Since it takes two failures for the vent door to fail open and only one for the leak, it is important to protect for the leak when able. ©[CR 7560 ]*

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**FLIGHT RULES****12A\_A10-1      VENT DOOR MANAGEMENT [HC] (CONTINUED)**

*With redundancy lost on left vent 1/2 or 8/9, the vehicle is one failure away from either burn-through (if the vent fails open) or overpressurization (if the vent fails closed). This assumes protecting against burn-through since one failure has already occurred to the vent and a similar one will lose capability.*  
 ©[CR 7560 ]

E. DURING ENTRY/ABORTS, THE FOLLOWING CONSTRAINTS FOR VENT OPERATIONS APPLY POST MECO:

1. ALL VENTS MUST BE CLOSED BETWEEN MACH 24 AND MACH 3.5.

*For loss of close redundancy, the affected door is closed to limit the exposure to the next failure that would leave the door failed open. Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that vent box 3, if left open, is predicted to reach a temperature of 1100 deg F during the entry profile. Since the melting point of 2024 aluminum is 935 deg F, a breach of the box is expected to occur, possibly resulting in loss of crew and vehicle. Because the new thermal analysis data shows temperatures very similar to the old thermal analysis, the previous temperature predictions for vent doors 1/2, 5, 6, and 8/9 will be used until the new thermal analysis is complete. Currently, if left open during entry, vent box 1/2 is expected to reach a temperature of 1200 deg F, vent box 5 and 6 will experience 600 to 700 deg F heating, and vent box 8/9 will experience up to 550 deg F heating. Based on these temperatures, vent box 1/2 will surpass the melting point of 2024 aluminum and would result in a breach and possible loss of crew and vehicle. The reusability temperature limit of 2024 aluminum is 350 deg F and soon after reaching this temperature, the aluminum starts to lose structural integrity (around 400 deg F). Therefore, 400 deg F was chosen as the temperature limit for which to protect the vent doors. Even though vent doors 5, 6, and 8/9 do not reach the melting point of 2024 aluminum, they do exceed the structural integrity limit if left open during entry. Additionally, it is important that these doors are closed during entry heating above 400 deg F to protect various components in close proximity to the vent openings from failing, such as electrical wires, Freon lines, hydraulic lines, and APU hydrazine lines. The Mach number limits are based on the thermal analysis for vent door 3; between Mach 24 (approximately 7.5 min after EI) and Mach 3.5 (approximately 24 min after EI, or approximately 1 min prior to Vrel = 2400), the vent temperature is predicted to exceed 400 deg F.*

2. PRIOR TO REACHING AN ALTITUDE OF 70,000 FT, THE MINIMUM NUMBER OF VENTS THAT MUST BE OPEN ARE AS FOLLOWS:
  - a. FORWARD AND AFT COMPARTMENTS: THE LEFT OR RIGHT SIDE VENTS (SINGLE SIDE) FOR EACH COMPARTMENT, AND
  - b. MIDBODY: ANY FOUR VENTS, OR ANY THREE VENTS IF AT LEAST ONE OF THESE IS LEFT OR RIGHT VENT 3 ©[CR 7560 ]

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**FLIGHT RULES****12A\_A10-1      VENT DOOR MANAGEMENT [HC]      (CONTINUED)**

*Data presented at the Ascent/Entry Flight Techniques Panel (A/E FTP) #218, March 2006, showed that adequate venting margins could be maintained if at least one side of the forward compartment, one side of the aft compartment, and any four midbody vent doors are opened by 70,000 ft. If only three midbody vents are open by 70,000 ft, adequate venting margins can be maintained if at least one of the midbody vents open is left or right vent 3. Failures resulting in loss of open capability on both sides of the forward compartment would result in significantly exceeding Performance Enhancement (PE) certification limits for compartment pressures and structural loading resulting in loss of crew and vehicle. Failures resulting in loss of open capability on both sides of the aft compartment would result in compartment pressures very close to the PE certification limits. Therefore, entry with all aft vent doors closed depends on all other vents to open nominally and on the 1307 bulkhead check valve to repressurize the aft compartment. As a result, it is not recommended to enter with all aft vent doors closed due to venting tolerances. Additionally, failures resulting in more than three midbody vent doors failed closed would also result in structural failure and loss of crew and vehicle. ©[CR 7560 ]*

3. FOR A NON-ISOLATED OMS OXIDIZER, RCS OXIDIZER, OR OMS HELIUM LEAK, LEFT VENTS 1/2 AND 8/9 WILL BE OPENED IF PRIOR TO MACH 24 OR AFTER MACH 3.5. BETWEEN MACH 24 AND MACH 3.5, LEFT VENT 1/2 AND 8/9 MUST BE CLOSED.

*Left vents 1/2 and 8/9 will be opened if prior to Mach 24 or after Mach 3.5 in order to vent the forward and aft compartments due to an OMS/RCS oxidizer or OMS helium leak. If the vents are not opened, the compartment could overpressurize and cause a loss of crew and vehicle. Per Hazard Reports ORBI-108, Overpressurization of the Orbiter Aft Fuselage Caused by the Failure of an MPS Helium Regulator or Relief Valve, and ORBI-111, Structural/TPS Damage from Overpressurization Due to Rupture/Leakage of OMS/RCS HE and/or GN2 Pressurization Systems, MPS helium, RCS helium, and OMS nitrogen can also cause overpressurization leading to possible LOCV. For an MPS helium leak, procedures are in place to isolate the leak; therefore, no vent door action is required. Reference Rule {A5-208}, POST-MECO AND ENTRY HELIUM ISOLATION [HC]. Additionally, no vent door action is required for an RCS helium or OMS nitrogen leak because a massive leak rate is required to overpress the compartment and this is considered unlikely. Left vent 1/2 and 8/9 must be closed between Mach 24 and Mach 3.5 to protect for burn-through, which would lead to a loss of crew and vehicle. The onboard software does not allow driving left vents 1/2 and 8/9 separately; however, if time and access allow, the crew can take steps to allow only the affected compartment to be vented if prior to Mach 24 or after Mach 3.5.*

4. FOR A MIDBODY H<sub>2</sub> LEAK > 1.0 LB/HR, ALL VENTS WILL REMAIN OPEN UNTIL THE MM 304 TRANSITION UNLESS CLOSE REDUNDANCY IS LOST ON ANY VENT DOOR. FOR LOSS OF CLOSE REDUNDANCY AND IF TIME PERMITS, ACTION WILL BE TAKEN TO LEAVE OPEN, UNTIL THE MM 304 TRANSITION, AS MANY MIDBODY VENTS AS PRACTICAL THAT STILL HAVE CLOSE REDUNDANCY. ©[CR 7560 ]

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**FLIGHT RULES**

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**12A\_A10-1      VENT DOOR MANAGEMENT [HC] (CONTINUED)**

*Leaks of H<sub>2</sub> greater than 1 lb/hr can lead to H<sub>2</sub> concentrations in the midfuselage that exceed the H<sub>2</sub> flammability limit during entry (ref. informal note, DF7/84-126, dated June 20, 1984). Delaying the closure of the vent doors until the MM 304 transition will reduce the amount of time that is available for H<sub>2</sub> to build up within the midfuselage while providing the maximum amount of time prior to the high heating phase of entry that H<sub>2</sub> has the opportunity to escape. If close redundancy is lost on any vent door, the affected vent must be closed regardless of hydrogen build-up concerns to protect for the next failure that would leave the vent door failed open and result in loss of crew and vehicle.*

©[CR 7560 ]

*The current vent door software will automatically close any vent doors at the MM 304 transition that might have been left open prior to that time. Additionally, the capability does not exist in the current software to open any midbody vent door prior to the MM 305 transition, which occurs well below the 100,000 foot altitude. Therefore, the latest the midbody vent doors can be left open for H<sub>2</sub> venting is MM 304, and the earliest the doors can be opened is MM 305 (Mach 2.4). ©[CR 7560 ]*

## FLIGHT RULES

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### 12A\_A10-2

### PLBD CLEARANCE CONSTRAINTS

THE OBSS MANIPULATOR POSITIONING MECHANISMS (MPM'S) CAN BE DEPLOYED ONLY IF THE STBD PLBD PUSHRODS HAVE AT LEAST SIX STRIPES VISIBLE. @[CR 7613 ]

*The starboard payload bay door (PLBD) must be open greater than 75 degrees in order to allow the MPM's to be deployed without any interference with the PLBD structure. If the starboard PLBD is open less than 75 degrees, the bottom of the forward OBSS MPM pedestal will interfere or drive against a PLBD avionics bracket. Each PLBD pushrod has 10 stripes; six stripes indicate that the door is at a minimum angle of 84 degrees. A PLBD position of 75 degrees is indicated between the fifth and sixth stripes. Intermediate positions prior to the sixth stripe cannot be accurately measured for adequate clearance margins. Therefore, in order to provide acceptable clearance capability prior to performing any OBSS MPM deploy operations, six PLBD pushrod stripes must be visible.*

*The starboard EVA slidewire is not manifested and is, therefore, not an interference concern with the OBSS. The six-stripe requirement is valid as long as the OBSS MPM's are flown, whether the OBSS is present or not.*

*Reference STS-115 PLBD Flight Rule with OBSS, Boeing CATIA Kinematic Analysis, Hai Pham & Ed Zadorozny, February 24, 2005; and UCN/MCR: 19755, PCIN: S164599D, RHFA of Retention Pedestal Mechanism Assembly Used for OBSS Modal Survey Testing, October 1, 2004. @[CR 7613 ]*

## FLIGHT RULES

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12A\_A10-3

### KU-BAND ANTENNA/OBSS CLEARANCE CONSTRAINTS

IN ORDER TO PRECLUDE CONTACT BETWEEN THE KU-BAND ANTENNA AND THE OBSS, THE FOLLOWING CONSTRAINTS APPLY TO KU ANTENNA DEPLOY AND STOW OPERATIONS: ©[CR 7614 ]

- A. WITH THE OBSS CRADLED, THE OBSS MPM'S MUST BE IN THE STOWED POSITION PRIOR TO KU ANTENNA DEPLOY OR STOW.
- B. WITH THE OBSS UNCRADLED, STOWING OR DEPLOYING OF THE KU ANTENNA CAN BE PERFORMED, AS NEEDED, REGARDLESS OF OBSS MPM POSITION.

*With the OBSS cradled, contact between the Ku-band antenna and the OBSS can occur during antenna deploy or stow operations, depending on the OBSS MPM position. Approximately 2.6 inches of clearance exists with the antenna stowed and the OBSS cradled and stowed, so no concern exists for this configuration (including during launch and entry). However, this clearance decreases as the antenna moves past the OBSS during Ku stow and deploy operations. KSC testing showed that, with the OBSS MPM's in the deployed position, contact will occur. With the MPM's stowed, clearance exists, but is very small (minimum clearance was measured at 0.688 inches on OV-103, and 0.469 inches on OV-104; the point of contact is between the antenna dish and an OBSS thermal blanket). Thermal effects (material expansion, contraction, bending, and rotation) and OBSS positioning in the MPM's can decrease this clearance by 0.371 inches (reference Boeing technical memorandum TM-SJ00-SJC0D-2005-014, Maximum Thermal Deflections Between Ku-band Antenna and OBSS, April 19, 2005). Imagery, Science, and Analysis Group performed a photogrammetric analysis during STS-114 (STS-114 Ku Deployment - Measured Linear Clearance Between the Edge of Ku Dish and Forward Edge of the OBSS, D. Liddle/D. Bretz, August 3, 2005), which indicated a positive clearance of  $0.8 \pm 0.1$  inches between the Ku dish and the OBSS (MPM's stowed). All the analysis and photogrammetry was validated with a successful Ku stow on STS-114. For STS-121, both the Ku Deploy (FD1) and Ku Stow were performed with the OBSS cradled and MPM's stowed. ©[CR 7614 ]*



## FLIGHT RULES

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### 12A\_A10-4 APU LOSS DEFINITIONS [HC]

THIS RULE SUPERSEDES RULE {A10-1A}.10, APU LOSS DEFINITIONS [HC]:  
©[CR 7615 ]

AN APU IS CONSIDERED LOST IF THE FUEL PUMP INLET PRESSURE IS < 30 (49) PSIA PRIOR TO OPENING THE FUEL ISOLATION VALVES WHEN THE APU FUEL TANK PRESSURE IS > 150 (141) PSIA. LOSS OF INSTRUMENTATION WILL NOT BE CAUSE FOR DECLARING AN APU LOST.

*If a large delta pressure exists across the Fuel Isolation Valves (FIV's), a hazardous surge pressure could result at dead-ends in the lines when the valves are opened. At low fuel pump inlet pressures, cycling of the FIV's could result in rapid compression of froth bubbles formed at the interface between hydrazine and ullage gasses in the fuel line. This rapid compression can result in localized adiabatic heating of hydrazine fuel and subsequent detonation. The presence of ullage gasses in the APU fuel lines is a nominal condition. When the pressure in the fuel line is less than 15 psia prior to opening the FIV's, surge pressures over 2500 psia can act on these ullage bubbles (WSTF Report 96-30335, November 14, 1996). White Sands straight tube and U-tube testing showed that hydrazine becomes unstable above 2500 psia and Adiabatic Bubble Compression Detonation (ABCD) could occur (RD-WSTF-0002, February 20, 1990). Reference SODB, Vol. I, 3.4.4.3, and Rule {A10-22}, APU START/RESTART LIMITS [HC].*

*As a result of Aging Vehicle Assessment Mid Life Cert observation AVF-001802 and Shuttle Safety Review Panel action 0423-005, the APU PRT reviewed the rationale for opening a FIV on an APU with a low fuel pump inlet pressure (FPIP). The review prompted the APU community to raise the fuel pump inlet pressure limit from 15 psia to 30 psia. The 30 psia lower limit is based on the KSC history of safe FIV openings with fuel tank pressures greater than 150 psia and the FPIP between 30 psia and 40 psia. Reference OPO tagup presentation APU FIV Opening with Low Manifold Pressure, B. Irlbeck, December 1, 2004. The 150 psia value is based on an analysis performed by the Propulsion and Fluid Systems Branch with 2 psia of ullage downstream of the FIV's. ©[CR 7615 ]*

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## FLIGHT RULES

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### 12A\_A10-4      APU LOSS DEFINITIONS [HC] (CONTINUED)

*During STS-73, STS-75, and STS-78, a gross static fuel pump carbon seal leak on APU 2 into the seal cavity drain system caused the FPIP to decay below 30 psia. After these flights, a manufacturing flaw was discovered. The manufacturing process was changed to eliminate the suspected cause of the leakage anomalies. Subsequent flights have shown static seal leakage of only trace amounts of hydrazine into the seal cavity drain lines. These trace amounts of hydrazine leakage are likely insufficient to create a pressure differential across the FIV's such that ABCD is a concern. ©[CR 7615 ]*

*Loss of the FPIP transducer results in loss of pressure monitoring of the portion of fuel line between the FIV's and the shutoff valve (SOV). Loss of instrumentation alone is insufficient cause to declare an APU lost, but other factors (rising drain line pressure, history of leakage, leakage trend prior to transducer loss, etc.) in conjunction with loss of instrumentation may be enough to declare loss of a system.*

*The 49 psia fuel pump inlet pressure and the 141 psia fuel tank pressure limits account for transducer inaccuracies. Actual transducer biases are given for each mission based on data from KSC and should be taken into account for each system.*

*Reference Hazard Reports ORBI 031, Inability of the APU Turbine Housing to Contain a Disintegrating Turbine Wheel due to Hub Failure or an Overspeed Condition; ORBI 121, Hydrazine (N<sub>2</sub>H<sub>4</sub>) Detonation and Bubble Compression in the APU; and ORBI 250, External Leakage from the APU Fuel Supply System. ©[CR 7615 ]*

## FLIGHT RULES

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### 12A\_A10-5 APU START/RESTART LIMITS [HC]

THIS RULE SUPERSEDES RULE {A10-22H}, APU START/RESTART LIMITS [HC]: @[CR 7616 ]

FOR AN APU WITH FUEL TANK PRESSURE:

- A. > 150 (141) PSIA,
1. AND FOR LOSS OF FUEL PUMP INLET PRESSURE MONITORING, THE APU WILL BE (RE)STARTED ONLY IF REQUIRED.
  2. THE FUEL ISOLATION VALVES MAY BE OPENED, AS NEEDED, IF:
    - a. FUEL PUMP INLET PRESSURE > 30 (49) PSIA.
    - b. FUEL PUMP INLET PRESSURE IS BETWEEN 15 (34) PSIA AND 30 (49) PSIA AND THE APU IS REQUIRED.
    - c. FUEL PUMP INLET PRESSURE < 15 (34) PSIA, AND THE APU IS NEEDED TO MAINTAIN TWO APU/HYDRAULIC SYSTEMS FOR AEROSURFACE ACTUATOR OPERATION, A LAST METHOD OF GEAR DEPLOY, A LAST METHOD OF BRAKING, OR TO REGAIN NWS IF A KNOWN DIRECTIONAL CONTROL PROBLEM EXISTS.
    - d. EXTERNAL LEAKAGE IS NOT SUSPECTED AND THE BURST DISK HAS NOT RUPTURED, IN AN ATTEMPT TO MAINTAIN FUEL PUMP INLET PRESSURE > 30 (49) PSIA. FOR CONFIRMED LEAKS INTO THE SEAL CAVITY DRAIN SYSTEM, SEAL CAVITY DRAIN LINE PRESSURE WILL BE USED TO VERIFY AN EQUALIZATION PRESSURE > 30 (32) PSIA HAS BEEN ACHIEVED BETWEEN THE APU FUEL LINE AND SEAL CAVITY DRAIN LINE.
- B. < 150 (141) PSIA, THE FUEL ISOLATION VALVES MAY BE CYCLED OPEN, AS NEEDED, REGARDLESS OF THE FUEL PUMP INLET PRESSURE.  
@[CR 7616 ]

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**FLIGHT RULES****12A\_A10-5      APU START/RESTART LIMITS [HC]      (CONTINUED)**

*Loss of the FPIP transducer results in loss of pressure monitoring of the portion of fuel line between the FIV's and the SOV. Leakage externally into the aft compartment, into the seal cavity drain, or past the SOV could lead to Adiabatic Bubble Compression Detonation (ABCD). Leaving one of the fuel isolation valves open for the APU shutdown would allow monitoring via the fuel tank pressure transducers for such leakages, but would also feed an external leak if present. The unacceptable risk of hydrazine leakage into the aft compartment is cause to forgo attempts at gaining additional insight into the fuel pump inlet manifold and restrict the use of the APU. In this case, the risk of ABCD occurring at the entry startup, in addition to feeding an external leak if present, must be accepted when the system is required. System data may determine the presence of system leakages, though not necessarily. Current available methods may only provide for the detection of gross leakage. Provided the data shows no signs of leakage, coupled with the fact that the APU is essentially quiescent during orbit, the risk of running the system as required for entry is justified. ©[CR 7616 ]*

*Starting an APU with a low FPIP may result in high surge pressures and introduces the possibility of ABCD. Reference SODB, vol. I, 3.4.4.3, and Rules {A10-1}, APU LOSS DEFINITIONS [HC], and {A10-33}, APU DEFINITIONS. The APU FIV's have been opened on the pad and on orbit with fuel tank pressures greater than 150 psia and fuel pump inlet pressures between 15 and 30 psia on more than 15 occasions without any occurrences of ABCD. Due to uncertainties in an actual ABCD event occurring at fuel pump inlet pressures between 15 and 30 psia, the risk of an ABCD event occurring at these pressures is outweighed by the risk of entry without a required APU running. Therefore, at this pressure range, the FIV's may be opened if the APU is required. With a FPIP below 15 psia on a particular APU fuel system, the risk of an ABCD event occurring will be accepted only to regain critical capability.*

*As a result of Aging Vehicle Assessment Mid Life Cert observation AVF-001802 and Shuttle Safety Review Panel action 0423-005, the APU PRT reviewed the rationale for opening a FIV on an APU with a low Fuel Pump Inlet Pressure (FPIP). The review prompted the APU community to raise the fuel pump inlet pressure limit from 15 psia to 30 psia. The 30-psia value is based on the KSC history of safe FIV openings with fuel tank pressures greater than 150 psia and the FPIP between 30 psia and 40 psia. Reference OPO tagup presentation APU FIV Opening with Low Manifold Pressure, B. Irlbeck, December 1, 2004. The 150 psia value is based on an analysis performed by the Propulsion and Fluid Systems Branch with 2 psia of ullage downstream of the FIV's.*

*If a corresponding increase in drain line pressure is noted, the fuel isolation valves may be opened to repressurize the fuel line to prevent reaching the loss limit. ©[CR 7616 ]*

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## FLIGHT RULES

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### 12A\_A10-5      APU START/RESTART LIMITS [HC]      (CONTINUED)

*The 34 psia and 49 psia fuel pump inlet pressure limits account for transducer inaccuracies. Actual transducer biases are given for each mission based on data from KSC and should be taken into account for each system. ©[CR 7616 ]*

*Reference Hazard Reports ORBI 031, Inability of the APU Turbine Housing to Contain a Disintegrating Turbine Wheel Resulting in Loss of Crew/Vehicle; ORBI 040, Premature Shutdown of Second APU Due to Electrical Circuit, Lube Oil or Fuel Systems Failures After One APU Lost; ORBI 121, Hydrazine (N<sub>2</sub>H<sub>4</sub>) Adiabatic Bubble Compression Detonation (ABCD) in the APU System; and ORBI 265, Overheating of Hydrazine in the APU Due to Controller or Injector Cooling Failures Could Result in Fire/Explosion. ©[CR 7616 ]*

NASA - JOHNSON SPACE CENTER

## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS) OPERATIONS

#### **12A\_C10-1**      **SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS)** **READY TO LATCH (RTL) INDICATION REQUIREMENTS** **[HC]**    ©[DN 40 ]

THREE OF THREE POSITIVE RTL INDICATIONS ARE REQUIRED TO INITIATE CAPTURE LATCH CLOSURE. A POSITIVE RTL CAN BE OBTAINED FROM ANY OF THE FOLLOWING METHODS:

*If the mating truss element remains in the SSAS Hardware Safe Zone (as defined in Rule {12A\_C10-3}, SSAS CAPTURE CORRIDOR CONSTRAINTS) and three of three positive RTL indications are achieved, then SSAS Berthing Analysis guarantees that the Coarse Alignment Guides are properly meshed and the Capture Bar is within the Latch Claws, thus allowing Capture Latch closure. Within the SSAS Hardware Safe Zone, any positive RTL indication achieved is a valid RTL.*    ©[CR 7666 ]

- A. POSITIVE RTL SENSOR INDICATION FROM EITHER ONE OR BOTH INTEGRATED MOTOR CONTROLLER ACTUATORS (IMCA'S)

*A positive RTL indication consists of the RTL switch physically opening as the RTL plunger on the S1/P1 SSAS is depressed. Each IMCA is wired to one of two available switches housed in each RTL. Positive feedback is provided to the operator as a green light on the PCS display when the RTL is depressed at least 2.03 cm (0.08 in.) – 0.41 cm (0.16 in.).*

- B. VISUAL CONFIRMATION THAT THE COURSE ALIGNMENT PIN CROSSES THE ENTRY PLANE OF THE COURSE ALIGNMENT CUP

*SSAS Berthing Analysis has shown that when the Course Alignment Pin crosses the Coarse Alignment Entry Plane of the Course Alignment Cup (see figure below), then the RTL plunger on the S1/P1 SSAS should be contacting the RTL Striker Plate. Neither SVS/RMS Digitals, due to inaccuracies, nor SVS, shown to have lateral errors in excess of 3.55 cm, are an acceptable backup to a failed RTL sensor. Only an IVA (via camera views) or EVA crewmember who has a good view of the Course Alignment Pin entering the Course Alignment Cup can be used to verify the mating element is at the RTL position.*    ©[CR 7666 ]

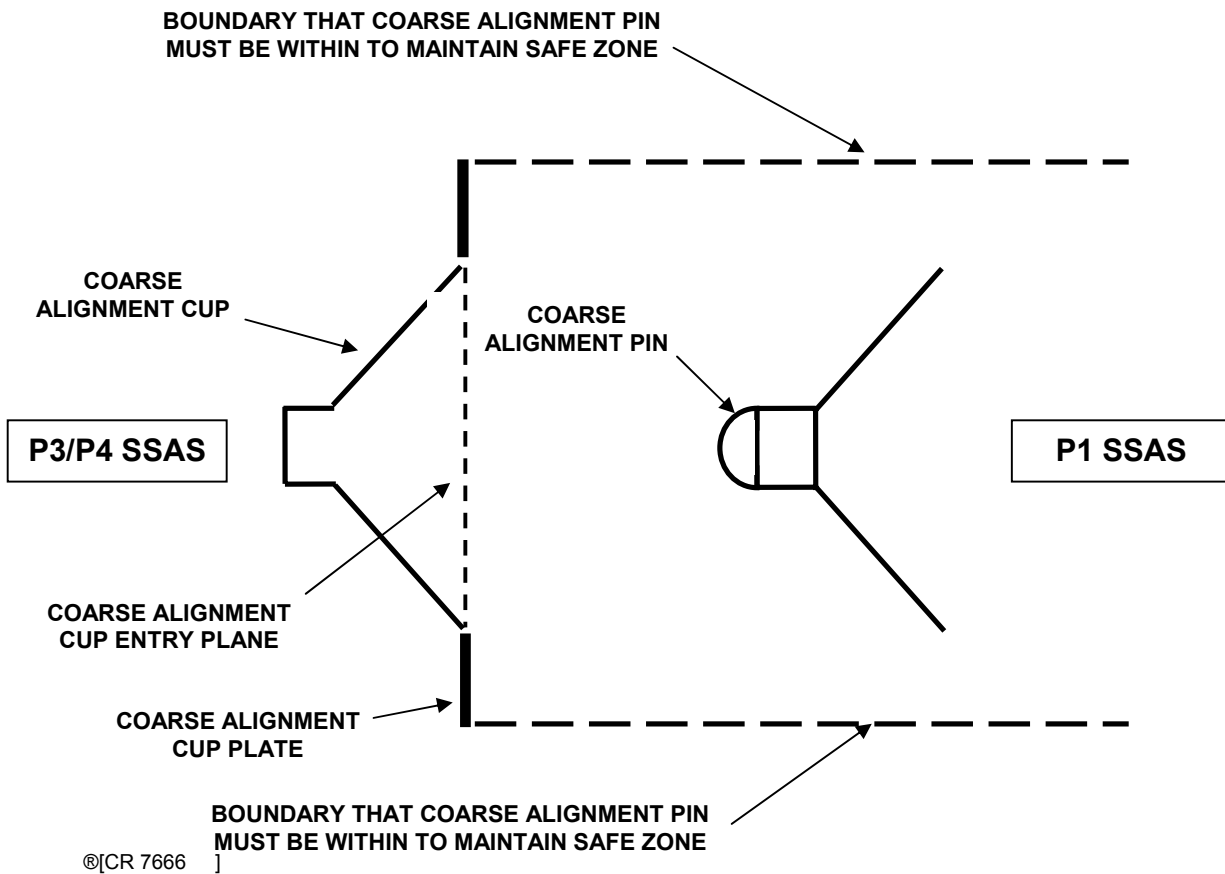
*DOCUMENTATION: Hazard Report ISS-MCH-0109-9A, Inability to Gain/Maintain Structural Integrity Using Attachment Mechanisms*    ©[DN 40 ]

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# FLIGHT RULES

12A\_C10-1

SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS) READY TO LATCH (RTL) INDICATION REQUIREMENTS [HC]  
(CONTINUED)



©[CR 7666 ]



## FLIGHT RULES

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12A\_C10-2

### SSAS BOLT FULLY TIGHT DEFINITION

AN SSAS BOLT (CONSISTING OF MOTORIZED BOLT ASSEMBLY (MBA), CONTINGENCY BOLT KIT, OR COMBINATION OF BOTH) IS CONSIDERED TO BE FULLY TIGHT IF IT MEETS ANY OF THE FOLLOWING CRITERIA: @[CR 7668 ]

A. A MOTORIZED BOLT WITH

1. BOTH BOLT TIGHT SWITCHES (BTS'S) CLOSED

*Each MBA has two Bolt Tight Switches (BTS's) that close (depress) when the MBA calibrated spring stack is compressed, as the bolt tightens, to its required minimum load of 10800 lbf. Nominal operation expects both switches to close when the bolt is tight.*

2. ALL OF THE FOLLOWING ARE TRUE: ONE OF THE TWO BOLT TIGHT SWITCHES CLOSED, THE REPORTED NOMINAL CURRENT FOR THAT BOLT WHILE TIGHTENING EXCEEDED 350 MILLI-AMPS, AND THE MBA ON TIME EXCEEDED 8 MINUTES.

*In SSAS Normal State, if two Bolt Tight Switch (BTS) indications are not seen within 2 seconds of each other, then software will pull power to the bolt, stopping bolt motion. In SSAS Manual State, a failure of one (BTS) will not cause software to pull power to the bolt. The operator will have to command the bolt to power off upon closure of either BTS if the other BTS failed open. If powering the bolt with the Limit Switch Cutoff Override activated in SSAS Manual State, the bolt will not power off at all, regardless of either BTS position. In any case, if both BTS's do not indicate a closed position, then logged current data can be used to estimate the final bolt preload. Recorded current plots for each bolt during ground testing and/or on-orbit checkout are available to allow for a comparison between test data and observed current data that could result in an approximate determination of the bolt's final preload. Typically, each MBA reaches a bolt tight condition after 8-9 minutes of "MBA On Time." This parameter, along with an assessment of bolt current data showing gradual increases in current until reaching a minimum of 350 mAmps, could be used to determine if a bolt is tight and, therefore, did not jam prematurely.*

3. EVA MANUAL OVERRIDE DRIVEN UNTIL BOTH BOLT TIGHT SWITCHES CLOSED WITH PGT TORQUE LESS THAN OR EQUAL TO 250 IN-LBS @[CR 7668 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_C10-2      SSAS BOLT FULLY TIGHT DEFINITION (CONTINUED)

*Each MBA has a backup capability to manually drive the bolt via a 7/16-inch hex stub that the EVA Pistol Grip Tool can attach to. This allows an EVA crewmember to drive each bolt in case multiple failures prevent remote operation of the bolts. Final torquing of the EVA Override will achieve the required final preload on the bolt. The final torque sequence will be documented in the EVA MBA Bolt Actuation procedure and will require verification of both Bolt Tight Switches closing as the bolt is incrementally driven via the override. The bolt is expected to be driven at 100 in-lbs torque for at least 460 bolt turns and then checked for both BTS's to be closed. If still open, the PGT torque will be increased by 20 percent and repeated until both BTS's close, up to the maximum permissible input torque of 250 in-lbs. Note that this method would require a functioning Bolt Bus Controller for BTS feedback and that the MBA may have to be preheated in accordance with Rule {12A\_C10-4}, SSAS HEATER REQUIREMENTS, prior to driving the MBA with the override. ©[CR 7668 ]*

4. EVA MANUAL OVERRIDE DRIVEN TO SPECIFIED TORQUE VALUE WITHOUT BOLT TIGHT SWITCH FEEDBACK AFTER FIRST USING ONE CONTINGENCY BOLT TO FULLY SEAT THE MBA.

*If Bolt Tight Switch (BTS) feedback is unavailable due to a Motorized Bolt Assembly (MBA) and/or Bolt Bus Controller(s) failure, then the bolt may be torqued to a final preload via the EVA Manual Override without BTS feedback. Before the override is driven in this case, one of two available Contingency Bolts is installed to fully seat the MBA fine alignment cone (P1 SSAS) in the MBA fine alignment cup (P3/P34 SSAS). This minimizes the gap between the mating elements that the MBA will have to pull together. The individual bolt-specific torque values will be documented in EVA procedures and are supplied by Engineering in SSCN 1819 for SSAS Contingencies. Note that the MBA may have to be preheated in accordance with Rule {12A\_C10-4}, SSAS HEATER REQUIREMENTS, prior to driving the MBA with the override.*

- B. AN EVA INSTALLED CONTINGENCY BOLT KIT, CONSISTING OF TWO BOLTS TORQUED TO THE SPECIFIED FINAL TORQUE VALUE (EACH SSAS INTERFACE IS ONLY CERTIFIED FOR A MAXIMUM OF TWO INSTALLED CONTINGENCY BOLT KITS.)

*Each SSAS mechanism has four Motorized Bolt Assemblies (MBA's) used to permanently attach two Integrated Truss Segments together. Contingency Bolt kits provide a backup capability for failure of a Motorized Bolt Assembly.*

*Each MBA location has an additional backup capability to allow EVA installation of contingency bolts. Two structural attachment points, adjacent to each MBA location, allow for two contingency bolts (two bolts per Contingency Bolt Kit) to be installed as a backup to the Motorized Bolt Assembly. The Contingency Bolts are installed in a particular order and each torqued to an initial setting that is dependent upon MBA location. Each bolt is then torqued to a final torque setting. Upon completion of torquing both contingency bolts to their required final torque, the composite bolt (MBA with Contingency Bolts) will satisfy the requirements of a fully tight bolt. The order of installation and complete torque settings is found in the EVA SSAS Contingency Bolt Installation procedure. The specific torque values for each contingency bolt will be documented in EVA procedures and are supplied by Engineering in SSCN 1819 for SSAS Contingencies. ©[CR 7668 ]*

## FLIGHT RULES

### 12A\_C10-3 SSAS CAPTURE CORRIDOR CONSTRAINTS

- A. THE SSAS HARDWARE SAFE ZONE CORRIDOR IS DEFINED BY THE EQUATIONS: @[DN 111 ]
1.  $R + 0.41L \leq 4.7$  AND
  2.  $W \leq 4$  DEG.
- B. THE SAFE ZONE WILL BE MAINTAINED WHENEVER THE DISTANCE BETWEEN THE P1 AND P3/P4 TRUSS SEGMENTS IS 50 CM OR LESS. IF THE SAFE ZONE IS VIOLATED, THE OPERATOR WILL BACK OUT IN THE ISS - Y DIRECTION UNTIL THE TRUSSES ARE SEPARATED BY 50 CM OR THE SAFE ZONE IS RE-ESTABLISHED.

*The safe zone guarantees the following: proper coarse alignment guide meshing will occur, hardware contact will be limited to hardware capable of withstanding 3.05 cm/sec impact, the mating elements will not become "bound-up" and thus will be able to be separated if required, and no "false-positive" RTL indications are possible. The safe zone does not guarantee that positive RTL will be achieved. It does, however, provide for a larger "zone" in which the operator may perform methodical P1 and P3/P4 alignment adjustments while attempting to acquire three positive RTL indications.*

*The basic hardware safe zone corridor is defined by the equation:  $R + 0.41L \leq 4.7$  and  $W \leq 4$ . This represents the allowable hardware limit and is evaluated for the various cue systems. In the equations, R is the roll error in degrees about the approach axis (ISS +Y); L is the lateral offset in cm (RSS of X and Z errors); and W is the wobble in degrees (RSS of relative angular errors about X and Z axes).*

- C. ANY OF THE FOLLOWING BERTHING CUES AND ASSOCIATED SAFE ZONE CORRIDOR CRITERIA MAY BE USED TO VERIFY THE SAFE ZONE IS MAINTAINED:
1. SVS: THE CONSTRAINT IS DEFINED BY THE EQUATIONS IN THE SSAS HARDWARE SAFEZONE CORRIDOR PLOT. THE FOLLOWING CRITERIA WILL BE USED FOR IMPLEMENTATION:
 

(12A):  $W < 3.69$  DEG,  $R \leq 1.0$  DEG, AND  $L \leq 5.0$  CM

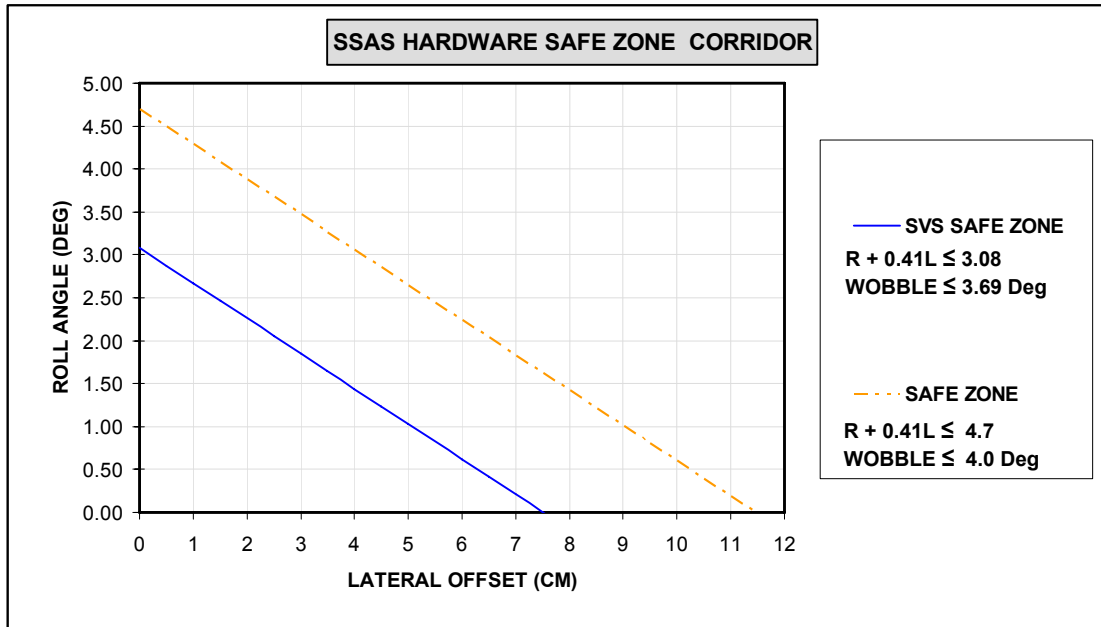
*When using SVS, the errors associated with the SVS system must be "subtracted" from the basic hardware safe zone corridor equation:  $R + 0.41L \leq 4.7$ . For 12A, the worst case SVS lateral inaccuracy via SAAP analysis is  $L = 3.55$  cm with a corresponding roll inaccuracy of  $R = 0.16$  degrees. These errors result in a SSAS hardware safe zone equation value = 3.08. The largest wobble error shown in the 12A SAAP results is 0.31 degrees resulting in a wobble allowance  $\leq 3.69$  degrees. Thus, the "fly to" Hardware Safe-Zone corridor equation when using SVS is:  $R + 0.41L \leq 3.08$  with wobble  $\leq 3.69$  degrees. Refer to Figure 12A\_C10-3-I. Note that this analysis assumes that all SVS targets and required cameras are available. @[DN 111 ]*

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# FLIGHT RULES

12A\_C10-3

SSAS CAPTURE CORRIDOR CONSTRAINTS (CONTINUED)



©[DN 111 ]

**FIGURE 12A\_C10-3-I - SSAS HARDWARE AND SVS SAFE ZONE CORRIDOR.**

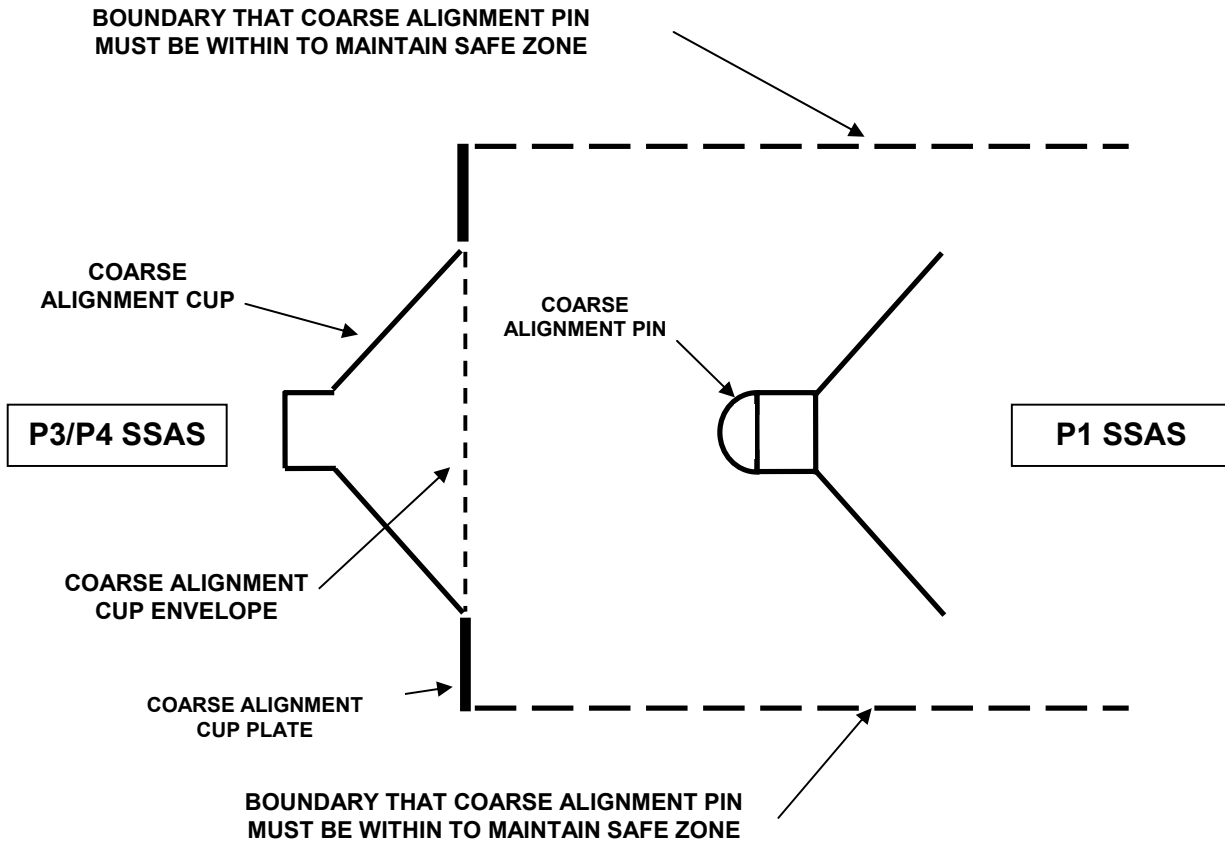
2. VISUALS: THE CONSTRAINT IS DEFINED BY THE SSAS HARDWARE SAFE ZONE CORRIDOR EQUATION. AT LEAST ONE OF THE FOLLOWING THREE CRITERIA MUST BE MET AND ARE LISTED IN PREFERRED ORDER TO MAINTAIN THE SAFEZONE.
  - a. EACH P1 SSAS COARSE ALIGNMENT PIN MUST BE WITHIN THE ASSOCIATED P3/P4 COARSE ALIGNMENT CUP ENVELOPE. REFER TO FIGURE 12A\_C10-3-II.
  - b. EACH P1 SSAS COARSE ALIGNMENT PIN IS IN CONTACT WITH THE ASSOCIATED P3/P4 COARSE ALIGNMENT CUP PLATE ASSEMBLY. REFER TO FIGURE 12A\_C10-3-II.
  - c. THE POSITION OF EACH P1 SSAS COARSE ALIGNMENT PIN IS SUCH THAT DURING SUBSEQUENT SSRMS OR PAYLOAD RETENTION DEVICES (PRD) OPERATIONS, THE CRITERIA AS SPECIFIED IN PARAGRAPHS 2a OR 2b ABOVE IS MET. REFER TO FIGURE 12A\_C10-3-II. ©[DN 111 ] ©[CR 7670 ]

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**FLIGHT RULES**

12A\_C10-3

SSAS CAPTURE CORRIDOR CONSTRAINTS (CONTINUED)



**FIGURE 12A\_C10-3-II - COARSE ALIGNMENT CUP, PIN, AND PLATE ASSEMBLY.**

*When using visuals (camera views or EVA), the entire hardware safe zone corridor is given to the crew and no error sources are accounted for. For the case where EVA is used as the method of maintaining the hardware safe zone corridor, EVA visuals of the hardware will be the primary cue. The EVA crew must account for the potential judgment errors in visually confirming the approach corridor and in the maintaining of the hardware safe zone corridor during berthing. The safe zone can be assured by verifying that all of the P1 coarse alignment pins are over the P3/P4 coarse alignment cups or over/in contact with the P3/P4 plate assemblies surrounding the coarse alignment cups. Per discussion at the 12A FOR, EVA is not typically trained to assist in maneuvering the berthing element to the RTL position, thus this rationale is provided as guidance only. See Figure 12A\_C10-3-II. ©[DN 111 ] ©[CR 7670 ]*

*Reference: Boeing Memorandum ISS-HOU-MSER-CFE-060009, SSAS Mechanism Corridor and SVS Error Analyses Input to Operational Corridor for Flight 12A, January 9, 2006. ©[DN 111 ]*

## FLIGHT RULES

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### 12A\_C10-4 SSAS HEATER REQUIREMENTS ©[DN 19 ] ©[CR 7697 ]

HEATER CONSTRAINTS FOR EACH SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS) SITE ARE LISTED BELOW. CONSTRAINTS APPLY UNTIL A TRUSS IS FULLY MATED TO THIS SITE. AFTER SUCH TIME, ONLY THE INTEGRATED MOTOR CONTROLLER ACTUATOR (IMCA) HEATERS MAY BE DEACTIVATED IMMEDIATELY. BOLT BUS CONTROLLER (BBC) AND MOTORIZED BOLT ASSEMBLY (MBA) HEATERS WILL STAY ACTIVATED PENDING APPROVED CHIT THAT OUTLINES PERMISSIBLE TIMETABLE FOR BBC AND MBA HEATER DEACTIVATION.

*Each SSAS site has a total of 12 heaters as part of the Passive Thermal Control System: Two for both the Integrated Motor Controller Actuators (IMCA's) and Capture Latch (two total), two for each Motorized Bolt Assemblies (MBA) (eight total) and one for each BBC (two total).*

*Once SSAS latching operations are complete, the need for IMCA heater power is no longer required since this requirement was to prevent damage to the IMCA's prior to the mating and/or to provide operational heat to the latch during the mating.*

*The BBC contains two of the three safety inhibits which prevent an inadvertent retraction of the MBA. Discontinuing the BBC heaters could potentially result in one or both inhibits failing, leaving only a single inhibit to prevent a catastrophic hazard. Ultimately, the power connection to the BBC will be disconnected. Until the connectors are physically demated, the BBC heater system shall remain activated or if deactivation is directed per chit. Historically, the BBC heaters have been left activated for at least 6 months post the SSAS mating flight on which they were used to allow for assured monitoring of the MBA Bolt Tight Limit Switches.*

*The Motorized Bolt Assembly (MBA) heaters shall remain activated after their use on an SSAS mating flight. Historically, the MBA heaters have been left activated for at least 2 weeks until deactivation is directed per chit.*

- A. AT LEAST ONE OF THE TWO HEATER STRINGS FOR THE IMCA'S AND MBA'S MUST REMAIN ACTIVATED.

*Having IMCA's/MBA's go below their allowed thermal limits can cause loss of the IMCA/MBA and possibly loss of the MBA EVA backup capability (since common gears are kept warm also by heaters). The IMCA's and MBA's all have operational limits of -42.8 deg C (-45 deg F). The heaters are designed to keep these components above this limit.*

- B. THE HEATER STRING SHALL REMAIN ACTIVATED FOR EACH BBC.

*Each BBC has only one heater. The BBC's have operational limits of -42.8 deg C (-45 deg F), and the heater is designed to keep the BBC above this limit. Temperatures below the limit can cause damage to the avionics inside the BBC. ©[CR 7697 ]*

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**FLIGHT RULES**

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**12A\_C10-4      SSAS HEATER REQUIREMENTS (CONTINUED)**

- C. BEFORE OPERATION OF THE MBA EVA MANUAL OVERRIDE CAN OCCUR, THE MBA GEAR TRAIN SHALL BE HEATED TO A MINIMUM TEMPERATURE OF +15.6 DEG C (+60 DEG F) AS MEASURED BY THE MBA HEATER RESISTIVE TEMPERATURE DETECTOR (RTD) SENSORS. ©[CR 7697 ]

*This constraint is required to ensure that the MBA gear train is at the proper temperature, thus allowing sufficient output torque to the bolt when driven using the EVA Manual Override. The MBA utilizes a set of four planetary gear assemblies that greatly enhances the mechanical advantage of the system to overcome gearing loads, such as friction or viscous forces, due to cold lubricant (Braycote or dry lube). The EVA Manual Override utilizes the fourth planetary gear set, thus effectively driving the bolt through one gear set. This lessens the amount of mechanical advantage due to the smaller gear ratio and thus requires higher input torque than when using the MBA motor.*

*Note that the MBA heater-off setpoints are -37.2 deg C (-35 deg F), which will require inhibiting the Closed Loop Control of the MBA heaters and manually closing both heater RPC's. This will bring the MBA gearing up to the required temperature before using the EVA Manual Override. The Resistive Temperature Detector (RTD) sensors will provide temperature feedback as to the progress of the preheat, which may take less than 1 hour with both heaters on. Shuttle assembly missions flying ±XVV attitude put the hardware in good thermal condition. During 8A for example, the SSAS heaters were not required at all since the MBA's were warmer than the "Heater-On" setpoint.*

*The preheat could be started when the need to drive a bolt(s) manually is first determined during the assembly mission. This could be performed in parallel with the EVA crew egressing the airlock and getting set up for this operation. Operations Support Officer (OSO) will then use the heater temperature feedback as a GO when ready for the EVA crew to manually drive the bolt. The nominal plan is to power on both MBA heaters, which may be required to provide enough heat to get the MBA temperature above 60 deg F. Analysis has shown that at the worst-case cold environment (at -100 deg F), one operational MBA heater may only be able to attain a temperature of +22 deg F. ©[CR 7697 ]*

## FLIGHT RULES

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### 12A\_C10-5 COMMUNICATION REQUIREMENTS FOR SSAS OPERATIONS

- A. THE FOLLOWING CMD'S WILL ONLY BE INITIATED WHEN THE COMPLETE SSAS SYSTEM RESPONSE CAN OCCUR DURING A PLANNED AOS PERIOD: ©[CR 7671 ]
1. ANY SSAS NORMAL OR MANUAL BOLT ACTUATION COMMANDS
  2. ANY SSAS BOLT/LATCH ACTUATION COMMANDS SENT AS A MALFUNCTION RESPONSE
- B. IT IS HIGHLY DESIRED FOR THE FOLLOWING COMMANDS TO BE INITIATED WHEN THE COMPLETE RESPONSE CAN OCCUR DURING A PLANNED AOS PERIOD:
1. ANY SSAS NORMAL OR MANUAL CAPTURE LATCH ACTUATION COMMANDS
  2. ANY SSAS COMMANDS SENT AS A MALFUNCTION RESPONSE

*The SSAS operations involving the mating of truss elements are very time critical and important to be completed successfully to allow for the activation and subsequent survival of truss components. SSAS telemetry is selected for downlink in S-band (SC) and OIU (4CC) format.*

- a. *The timeframe in which all four SSAS Motorized Bolt Assemblies (MBA's) are driven to permanently attach the truss segments together is the most critical operation of the mating event. Timely resolution of any anomalies may depend on analysis of real-time data. In particular, the Limit Switch Cutoff Flag is an important indication of bolt tight success and will only appear on the crew PCS SSAS display for approximately 1 second whereas the ground can log the successful setting of this flag in ELOG.*

*Additionally, driving bolt current feedback is an important parameter. MBA specific current plots exist from ground testing that could also be used to validate the level of current, hence load, seen on each bolt when compared to the MBA current data as recorded on RTPLOT. The actuation time required to fully tighten each MBA is approximately 8-9 minutes.*

- b. *Any and all CMD's sent to actuate SSAS Latching or Bolting hardware as part of a malfunction response requires telemetry data to allow for operations/system experts to determine the status of the system and success of the malfunction response. ©[CR 7671 ]*

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## FLIGHT RULES

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12A\_C10-5

**COMMUNICATION REQUIREMENTS FOR SSAS OPERATIONS**  
**(CONTINUED)**

- c. *Any or all commands involved in actuation of the Capture Latch are important to be monitored for the successful mating of the truss elements. Telemetry data to the ground during Capture Latch actuation can be extremely useful in providing precise insight into the progress of the truss mating and state/health of the SSAS and ROBO systems. The latching portion of the mating event requires good coordination between both the robotics and mechanism operators and, thus, adequate insight into system status is highly desired. ©[CR 7671 ]*
- d. *Any or all CMD's, sent as part of a malfunction response, require good telemetry data for system experts and the MER to determine the status of the system and the success of the malfunction response.*

*General Note: In the event of unexpected LOS with the ISS via S-band and OIU when driving a bolt forward, the following guidance is provided: Before 8 minutes of "MBA On Time," it is preferred to PAUSE/STOP bolt actuation and wait until AOS is achieved with MCC-H. If the bolt is in its final tightening phase such that "MBA On Time" is greater than 8 minutes, then it is preferred to let the bolt reach its fully tight position rather than pausing bolt actuation to wait for AOS with MCC-H. Instructions have been provided via the SSAS mate procedures to hold until AOS with MCC-H before proceeding with the next bolt forward tightening in this case. ©[CR 7671 ]*

## FLIGHT RULES

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### 12A\_C10-6 P3/4 UNGRAPPLE REQUIREMENTS [HC] @[DN 41 ]

THE SSRMS WILL REMAIN GRAPPLED TO THE P3/4 TRUSS UNTIL A MINIMUM SET OF BOLTS HAS BEEN TIGHTENED TO SUPPORT ISS ATTITUDE CONTROL (HOLD AND MANEUVER). ACCEPTABLE SSAS BOLT CONFIGURATIONS TO SUPPORT LOADS ARE INDICATED IN RULE {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C]. @[CR 7672 ]

*The SSRMS shall stay attached to the mating element until a good structural interface between both truss elements can be confirmed and that sustain induced loads during active attitude control (RS thrusters). The nominal plan after three bolts are fully tight is for MCC-H to take over SSAS operations and allow the crew to ungrapple the SSRMS to support EVA operations.*

*An earlier SSRMS ungrapple is acceptable after the Capture Latch is fully closed with two bolts fully tight (as long as one of the two is Bolt 3) and only if Service Module jets are used (no Progress jets) as defined in Rule {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], Note 10. @[CR 7672 ]*

*DOCUMENTATION: Hazard Report ISS-MCH-0050-9A, Collision with Orbiter, ISS Component or EVA Crewmember Due to Mechanism Failure. @[DN 41 ]*

## FLIGHT RULES

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12A\_C10-7

### SSAS CAPTURE LATCH FULLY CLOSED DEFINITION

AN SSAS CAPTURE LATCH IS CONSIDERED TO BE FULLY CLOSED IF IT MEETS ANY OF THE FOLLOWING CRITERIA: ©[CR 7674 ]

AN INTEGRATED MOTOR CONTROLLER ACTUATOR (IMCA) WITH

- A. CORRECT TURNCOUNT AND CLOSED LATCH SWITCH CLOSED
- B. LATCH EVA MANUAL OVERRIDE TORQUED TO CORRECT TURNCOUNT AND CLOSED LATCH SWITCH CLOSED

IF NO INTEGRATED MOTOR CONTROLLER ACTUATOR(S) (IMCA) AVAILABLE

- C. LATCH EVA MANUAL OVERRIDE TORQUED TO CAPTURE LATCH HARDSTOP AT MAXIMUM TORQUE SETTING

*Each SSAS mechanism has a Capture Latch, which is driven by an IMCA and performs the function of pulling the truss elements together with a force of approximately 2500 lbf to force proper alignment of the elements during mating. There are two redundant IMCA's for each SSAS Capture Latch. Note: To perform SSAS Normal State Bolting operations, the Closed Latch Switch indication on the IMCA selected in the SSAS Path must be closed.*

- a. *Each IMCA has a Closed Latch switch that provides positive feedback when the Capture Latch reaches the closed position (the latch drive screw depresses the switch as it reaches the closed position). The nominal SSAS Capture Latch initframes do not have the "Stop On Switch" parameter set as a Stop On condition (meaning IMCA will NOT stop actuating when this switch closes). The IMCA turn count was chosen, however, such that both Closed Latch switches (one for each IMCA) should close when the IMCA is driven to a final position of 3110 turns. The IMCA Backup Initframe commands, used in the case of latching malfunctions, do have both the "Stop On Switch" and "Stop On Position" parameters set. In this case, the selected IMCA will stop when the Closed Latch switch is closed or when the IMCA reaches its final position, whichever comes first.*
- b. *If both IMCA's are degraded such that the Capture Latch cannot be remotely driven, but Closed Latch switch sensor feedback is available, then the Capture Latch can be driven closed via the 7/16-inch Hex EVA Manual Override to the specified Pistol Grip Tool (PGT) turncount with a Closed Latch switch from at least one of two available IMCA's indicating the Latch is closed.*
- c. *If both IMCA's are failed with no capability to remotely drive the Capture Latch and/or limit switch position (Closed Latch switch) sensor feedback is unavailable, then the EVA Manual Override is driven via the 7/16-inch Hex EVA Manual Override until the maximum allowable Pistol Grip Tool (PGT) torque and expected PGT turns are achieved after the Capture Latch reaches its hardstop.*  
©[CR 7674 ]

## FLIGHT RULES

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### 12A\_C10-8      RESPONSE TO SSRMS/SSAS SAFING DURING CAPTURE [C]

SHOULD SSRMS/SSAS SAFING OCCUR DURING CAPTURE OPERATIONS, THE FOLLOWING SSRMS CONSTRAINTS APPLY BEFORE SSAS CAPTURE MAY CONTINUE:

NOTE: FOR EACH SCENARIO, THE APPROPRIATE SSRMS AND SSAS MALS WILL BE RUN TO RECOVER THE NORMAL SYSTEMS FUNCTIONALITY PRIOR TO BEING ABLE TO CONTINUE CAPTURE. IF TOPOLOGICAL CAPTURE (TC) HAS NOT BEEN ACHIEVED YET, THE SSAS MAL WILL GENERALLY REPOWER THE SYSTEM, THEN REQUIRE A TEMPLATE BE BUILT TO DRIVE THE LATCH TO A 1034 HARDWARE POSITION. ONCE PAST TC (1034 IMCA TURNS), THE MAL WILL DRIVE THE LATCH CLOSED USING A BACKUP THIRD STAGE CAPTURE COMMAND THAT WILL CLOSE THE LATCH AND STOP LATCH MOTION WHEN THE LATCH CLOSED SWITCH CLOSSES (WHICH SHOWS THAT LATCH SHOULD BE FULLY CLOSED).

A. SAFING OCCURS DURING FIRST STAGE CAPTURE.

1. IF IMCA TURNS  $\leq 600$ , THE SSRMS WILL TRANSITION BACK TO POSITION HOLD AND SSAS OPERATIONS CAN CONTINUE.

*If SSRMS brakes engage while the SSAS CLA is driving during first stage capture, the response is different based on loads that may have built up in the SSRMS. If IMCA turns are less than or equal to 600, the CLA will not have made contact with the capture bar. Therefore, SSAS operations can continue once the SSRMS is in position hold.*

2. IF IMCA TURNS  $> 600$ , CYCLE SSRMS BRAKES OFF/ON FIVE TIMES, THEN CONTINUE WITH SSAS OPERATIONS (EVEN IF ANY RTL'S ARE LOST DURING BRAKE CYCLING).

*After 600 turns on the IMCA, there is a possibility that the CLA has engaged the capture bar of the passive SSAS. In order to release SSRMS loads, the brakes must be cycled off and on five times (cycle the brakes-off, wait 10 seconds, cycle the brakes-on, and wait 10 seconds, ending with the brakes-off).*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C10-8      RESPONSE TO SSRMS/SSAS SAFING DURING CAPTURE [C]**  
**(CONTINUED)**

*Analysis has shown that if, at any time during the above operations, any SSAS RTL's are lost due to RTL plungers pushing the elements apart, there is not enough movement by the SSRMS to move the P3 element out of the RTL envelope. In worst case, the P3 element will be pushed back such that the tips of the RTL plungers will be over the RTL striker plate but not depressing the plunger. More importantly, the tips of the Coarse Alignment Guides will be aligned with the Coarse Alignment Cups and, thus, there is no potential for misalignment of the two mating halves. For this case, the End-to-End Berthing Integration Team (EBIT) recommended continuing SSAS operations without reacquiring RTL's.*

*Reference 12A SSRMS Brakes Cycling Analysis presented to EBIT June 18, 2003.*

B. SAFING OCCURS DURING SECOND OR THIRD STAGE CAPTURE (IMCA TURNS > 1034 BUT < 1737) .

SSRMS MUST BE LIMPED PRIOR TO CONTINUING .

*If IMCA turns are greater than TC (1034 turns) but less than Full Seat position (1737 turns), the mechanism is not fully seated. Until the mechanism is fully seated, there exists potential for motion of mating elements, which could potentially build loads on the arm, thus requiring transition of the SSRMS back to Limp to release the loads acquired on the arm.*

C. IF SAFING OCCURS DURING THIRD STAGE CAPTURE (IMCA TURNS ≥ 1737)

NO CONSTRAINTS ON SSRMS MODE

*After Full Seat position (1737 turns), the SSAS no longer significantly moves the SSRMS. Operations past full seat mainly preload the mating interface; thus, SSRMS mode is unconstrained.*

*Reference 12A SSRMS Brakes Cycling Analysis presented to EBIT June 18, 2003.*

## FLIGHT RULES

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12A\_C10-9

APDS RULE REFERENCE MATRIX

THIS RULE SUPERSEDES RULE {C10-101J}, APDS RULE REFERENCE MATRIX [RC]:

FAILURE MODE	WHEN FAILURE OCCURRED			DETECTION METHOD
	PRE-DOCKING	WHILE DOCKING	PRE-UNDOCKING	
1. LOSS OF ALL DAMPING	ABORT DOCKING	CONTINUE FLIGHT AS PLANNED		VISUALLY (DYNAMICS), DAMPING BUS, AND TELEMETRY
2. LOSS OF PARTIAL DAMPING	CONTINUE FLIGHT AS PLANNED			VISUALLY (DYNAMICS), AND DAMPING BUS

- a. *Analysis has shown that with the loss of all damping, large misalignments are likely. The differential centering springs will reach their hardstops and mechanism damage is possible. Docking should not continue in this situation. For the loss of damping post-capture, docking should continue as planned. It is unknown whether the Failed Capture/Any Attitude Separation procedure can be performed safely for large misalignments due to loads concerns and potential contact between the shuttle and ISS. Therefore, the best way to separate safely would be to do so immediately if the damping indication is not received 5 seconds after capture. However, without any confirming cues, separation may be performed unnecessarily and rendezvous would have to be performed again (if possible). It is also unknown exactly if/what damage will occur when the APDS hardstops are reached. Test reports from NPO-E and analysis performed by Boeing indicate that the forces/moments experienced during a loss of damping are within the ultimate loads of the APDS that were tested. According to analysis performed by the CAMMP lab, vehicle-to-vehicle contact does not occur when the APDS is rotated to its design limits. This rule assumes that the risks incurred to perform a second rendezvous and the risk of vehicle-to-vehicle contact associated with performing the Failed Capture procedure are more likely than the risk of hardware damage that may occur when APDS hardstops are reached. Additionally, the one single-point failure for loss of damping post-capture that is addressed in the FMEA/CIL's is a capture sensor that fails to depress. This is highly unlikely due to the large mass of the two vehicles. Additional single-point failures include loss of a connector either in the external airlock or on the docking module.*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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12A\_C10-9

**APDS RULE REFERENCE MATRIX (CONTINUED)**

*Modifying the rendezvous/docking procedures to find a more benign way to dock without damping was not pursued due to the low probability of occurrence. Additionally, the failures that affect damping pre-docking are electrical bus or fuse failures. If both electrical buses are down, in addition to the loss of damping, both ring drive motors and hook motors would be lost, and docking could not be performed without an IFM. Reference OFTP #206, April 25, 2003; OFTP #215, October 15, 2004; OFTP #216, November 19, 2004; OFTP#218, February 25, 2005; and NPO-E reports P31373-745, P33726-044, and P31478-745.*

- b. *Analysis has shown that docking with partial damping within the allowable piloting constraints is not a concern. For these cases, the docking will continue. Reference OFTP #216, November 19, 2004. Analysis presented at OFTP #211 indicated that for contact conditions with severe angular rates and lateral velocities 4.5 times higher than seen in flight, APDS mechanism hardstops were reached. Additionally, at OFTP #216, it was shown that APDS hardstops can be reached by stacking 3 sigma values for contact conditions. Therefore, when docking with partial damping, it is important to follow the piloting guidelines and to keep angular rates at a minimum.*

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**FLIGHT RULES**

SSAS CONTINGENCY OPERATIONS

**12A\_C10-21**

**SSAS FAILURE IMPACT MATRIX**

FAILURE	TIME OF FAILURE	
	PRIOR TO CAPTURE LATCH CLOSURE	AFTER CAPTURE LATCH CLOSURE
A. FAILURE OF A SINGLE READY TO LATCH (RTL) SWITCH INDICATION PER RTL ASSEMBLY OR SWITCH CONNECTOR AT IMCA	CONTINUE IF CAN MEET RTL REQUIREMENTS IN PARAGRAPH A OF {12A_C10-1}, SEGMENT TO SEGMENT ATTACHMENT SYSTEM (SSAS) READY TO LATCH (RTL) INDICATION REQUIREMENTS	NO IMPACT – CONTINUE OPS
B. FAILURE OF RTL PLUNGER, RTL STRIKER PLATE, OR BOTH RTL SWITCHES	CONTINUE BY MEETING RTL REQUIREMENTS IN PARAGRAPH B OF {12A_C10-1}, SEGMENT TO SEGMENT ATTACHMENT SYSTEM (SSAS) READY TO LATCH (RTL) INDICATION REQUIREMENTS	NO IMPACT – CONTINUE OPS
C. FAILURE OF INTEGRATED MOTOR CONTROLLER ACTUATOR (IMCA) INCLUDING ABIT, PBIT, OPEN/CLOSED SWITCH FAILURE, OR PWR/DATA FAILURE TO PREVENT NOMINAL OPERATION OF IMCA	TROUBLESHOOT AND RECOVER FROM FAILURE IF POSSIBLE, OTHERWISE CONTINUE OPS ON ALTERNATE IMCA, IF AVAILABLE	SELECT ALTERNATE IMCA AND CONTINUE WITH MATE
D. FAILURE OF BOTH IMCA'S OR FAILURE OF CAPTURE LATCH (CLA) TO FULLY CLOSE (PROVIDE PRELOAD)	TROUBLESHOOT AND RECOVER FROM FAILURE IF POSSIBLE, DEVELOP WORKAROUND TO GET AT LEAST ONE IMCA OPERATIONAL, IF POSSIBLE	PERFORM EVA SSAS CAPTURE LATCH ACTUATION TO SATISFY CAPTURE LATCH FULLY CLOSED CRITERIA IN {12A_C10-8}, SSAS CAPTURE LATCH FULLY CLOSED DEFINITION
E. FAILURE OF EVA MANUAL OVERRIDE TO FULLY CLOSE CLA (PROVIDE PRELOAD)	N/A	USE PAYLOAD RETENTION DEVICES (PRD) TO PULL TRUSS SEGMENTS TOGETHER TO ALLOW BOLTING VIA MBA'S
F. FAILURE OF BOLT BUS CONTROLLER (BBC) INCLUDING DIRECTION RELAY, PWR RELAY(S), LIMIT SWITCH RETURN, BOLT TIGHT SWITCH(ES), OR PWR/DATA FAILURE TO PREVENT NOMINAL OPERATION OF BBC	TROUBLESHOOT AND RECOVER FROM FAILURE IF POSSIBLE, OTHERWISE CONTINUE OPS ON ALTERNATE BBC, IF AVAILABLE	SELECT ALTERNATE BBC AND CONTINUE WITH MATE
G. DEGRADATION OF BOTH BBC'S SUCH THAT BOLT TIGHT SWITCH INDICATIONS ARE STILL AVAILABLE	TROUBLESHOOT AND RECOVER FROM FAILURE IF POSSIBLE, DEVELOP WORKAROUND TO GET AT LEAST ONE BBC OPERATIONAL, IF POSSIBLE	PERFORM EVA SSAS MBA BOLT ACTUATION TO SATISFY BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A3 OF RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION

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## FLIGHT RULES

12A\_C10-21

**SSAS FAILURE IMPACT MATRIX (CONTINUED)**

FAILURE	TIME OF FAILURE	
	PRIOR TO CAPTURE LATCH CLOSURE	AFTER CAPTURE LATCH CLOSURE
H. FAILURE OF ANY SINGLE MBA TO MEET BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A1 OR A2 IN RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION	N/A	CONTINUE OPS TO GET ANY THREE MBA'S TO MEET BOLT FULLY TIGHT CRITERIA. WHEN TIME ALLOWS PERFORM EVA SSAS MBA BOLT ACTUATION ON FOURTH MBA TO SATISFY BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A3 OF RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION
I. FAILURE OF MULTIPLE MBA'S TO MEET BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A1 OR A2 IN RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION	N/A	CONTINUE OPS TO GET AS MANY MBA'S AS POSSIBLE TO MEET BOLT FULLY TIGHT CRITERIA. PERFORM EVA SSAS MBA BOLT ACTUATION ON REMAINING MBA'S TO SATISFY BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A3 OF RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION
J. FAILURE OF EVA SSAS MBA BOLT ACTUATION TO DRIVE ONE OR TWO BOLTS TO MEET BOLT FULLY TIGHT CRITERIA IN PARAGRAPH A1, A2, OR A3 IN RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION	N/A	PERFORM EVA SSAS CONTINGENCY BOLT KIT INSTALLATION TO INSTALL CONTINGENCY BOLT KIT CONSISTING OF TWO EVA INSTALLED BOLTS AT ASSOCIATED FAILED MBA LOCATION TO SATISFY BOLT FULLY TIGHT CRITERIA IN PARAGRAPH B OF RULE {12A_C10-2}, SSAS BOLT FULLY TIGHT DEFINITION, – NOTE: ONLY 2 CONTINGENCY BOLT KITS ARE CERTIFIED FOR USE ACROSS EACH SSAS INTERFACE
K. FAILURE OF CAPTURE LATCH TO OPEN AFTER BOLTING COMPLETE (REMOVE PRELOAD)	N/A	NO IMMEDIATE IMPACT. LATCH CAN REMAIN LOADED AND DRIVEN OPEN AT FIRST POSSIBLE OPPORTUNITY (IVA OR EVA)
L. DEGRADATION OF BOLT BBC SUCH THAT NEITHER ARE CAPABLE OF SENSING THE MBA BOLT TIGHT SWITCHES	TROUBLESHOOT AND RECOVER FROM FAILURE, IF POSSIBLE. DEVELOP WORKAROUND TO GET AT LEAST ONE BBC OPERATIONAL, IF POSSIBLE.	PERFORM EVA SSAS MBA BOLT ACTUATION TO SATISFY BOLT FULLY TIGHT CRITERIA IN RULE {12A_C10-2A}.4, SSAS BOLT FULLY TIGHT DEFINITION.

- a. *If a single RTL switch for each RTL Assembly were to fail prior to the mating event (during Prep for Mate) such that the RTL constraints documented in Rule {12A\_C10-1A}, SEGMENT TO SEGMENT ATTACHMENT SYSTEM (SSAS) READY TO LATCH (RTL) INDICATION REQUIREMENTS, can be met. As long as at least one RTL switch signal per RTL Assembly is available, then can continue with capture. This protects for three independent switch failures or a failure of the entire connector/cable feeding sensor data to an IMCA.*

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**FLIGHT RULES**

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**12A\_C10-21      SSAS FAILURE IMPACT MATRIX (CONTINUED)**

- b. *If an RTL Plunger has failed to prevent ability to be depressed, or if an RTL Striker Plate fails such that it cannot depress an RTL Plunger, or if both switches in an RTL Assembly fail, then Rule {12A\_C10-1A}, SEGMENT TO SEGMENT ATTACHMENT SYSTEM (SSAS) READY TO LATCH (RTL) INDICATION REQUIREMENTS, cannot be met. This requires visual cues, either camera or EVA to backup RTL sensor indications to determine if the element is in the Capture Envelope.*
- c. *If a failure of an IMCA occurs such as an Active Built In Test Error (ABIT), Passive Built In Test Error (PBIT), latch open/closed switch failure, or some other failure that prevents the IMCA to be used to nominally drive the Capture Latch, then the affected IMCA should be considered degraded. If such a failure occurs during the Prep for Mate, adequate time may exist to try and troubleshoot failure and recover functionality of the device. However, even if errors were transient and were cleared, the error could re-occur during the mate causing considerably more difficulty in completing capture. For this reason, the IMCA that had such failures during the Prep for Mate should not be used as the primary operational IMCA during the Mate. In addition, if such an IMCA failure occurs during the Mate, the operator should switch operation of the Capture Latch to the secondary IMCA and press ahead with the Mate due to time critical nature of the mating event.*
- d. *If both IMCA's fail to operate the Capture Latch during the mating event due to the same failure or independent failures, then the EVA crew should be prepared to operate the Capture Latch Manual Override in order to drive the Capture Latch to the fully closed position as determined by closed latch switch sensor data if available, or by input torque and turns on Manual Override. The probability that both IMCA's can fail due to the same failure or independent failures is very low; however, the capability exists for EVA to drive the latch closed.*
- e. *If the EVA Manual Override for the Capture Latch fails to drive the Capture Latch closed, say in the event of a mechanical binding of the latch mechanism, then a workaround exists to use Payload Retention Devices (PRD's), basically "come-alongs", to pull both elements close enough together to allow bolting operations using the Motorized Bolt Assemblies to begin. The PRD procedure uses two PRD's attached to handrails to pull the segments reasonably close together. In addition, two Contingency Bolts will be used to pull the segments completely together and help hold the segments together until the MBA's can be driven to permanently attach the two truss segments.*

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### 12A\_C10-21      SSAS FAILURE IMPACT MATRIX (CONTINUED)

- f. *If a failure of a BBC occurs such as the direction will not default to Forward, any of the bolt relays fail to close and provide power output to bolt(s), any Bolt Back Switch (BBS) or Bolt Tight Switch (BTS) failures to provide proper condition, or some other failure that prevents the BBC to be used to nominally drive the Motorized Bolt Assemblies, then the affected BBC should be considered degraded. If such a failure occurs during the Prep for Mate, adequate time may exist to try and troubleshoot failure and recover functionality of the device. However, even if errors were transient and were cleared, the error could re-occur during the mate causing considerably more difficulty in completing bolting. For this reason, the BBC that had such failures during the Prep for Mate, should not be used as the primary operational BBC during the Mate. In addition, if such a BBC failure occurs during the Mate, the operator should switch operation of the bolts to the secondary BBC and press ahead with the Mate due to time critical nature of the mating event.*
- g. *If failure of BBC's happens before/during Prep for Mate, then time is available to do some troubleshooting to correct the problem and try to get at least one BBC available and healthy enough to drive MBA's. If failure(s) occur during the Mate, then due to the time critical nature of the mating event, the quickest alternative to a lengthy troubleshooting approach is to prepare for EVA crew to drive the MBA's via the EVA Manual Override located on each MBA.*
- h. *If a failure of any single Motorized Bolt Assembly occurs such that it cannot meet the both Bolt Tight Switch closed constraint, or the one BTS with good current plot and long enough drive time constraints as documented in Rule {12A\_C10-2A}.1 or .2, SSAS BOLT FULLY TIGHT DEFINITION, then continue bolting operations to get three remaining bolts fully tight. Once three bolts are fully tight, all expected load conditions for the assembly flight can be met with a factor of safety of 1.5, thus no immediate action is required. When time allows, perform EVA SSAS MBA Bolt Actuation to drive the failed MBA's via the EVA Manual Override until each bolt meets the tight requirements as defined in Rule {12A\_C10-2A}.3 or .4, SSAS BOLT FULLY TIGHT DEFINITION, or, if Manual Override fails to drive the bolt to meet requirements, then EVA SSAS Contingency Bolt Kit Installation will be required. The EVA Manual Override procedure for the MBA's has the details of how the bolts are driven EVA to ensure final required bolt preload is achieved.*
- i. *If more than one Motorized Bolt Assembly fails to meet the both Bolt Tight Switch closed constraint, or the one BTS with good current plot and long enough drive time constraints as documented in Rule {12A\_C10-2A}.1 or .2, SSAS BOLT FULLY TIGHT DEFINITION, then continue bolting operations to get as many fully tight bolts as possible. Then perform EVA SSAS MBA Bolt Actuation to drive the failed MBA's via the EVA Manual Override until each bolt meets the tight requirements, or if Manual Override fails to drive bolt to meet requirements, then EVA SSAS Contingency Bolt Kit Installation will be required.*

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**12A\_C10-21      SSAS FAILURE IMPACT MATRIX (CONTINUED)**

- j. *If the use of the EVA Manual Override to drive one or two of the Motorized Bolt Assemblies fails to meet any of the criteria in Rule {12A\_C10-2A}, SSAS BOLT FULLY TIGHT DEFINITION, then a contingency bolt kit will be required to be installed in the failed MBA location. Without any BTS switch indications, there is not a way to verify what load the bolt has achieved using the EVA Manual Override. The current feedback data that is valuable in helping estimate the load when a bolt is driven via the MBA motor is unavailable; therefore, the only course of action left to meet the bolt fully tight criteria is the installation of a Contingency Bolt Kit.*
- k. *If any IMCA or Capture Latch failure occurs during the Mating event, the opening of the Capture Latch to remove the preload on the Capture Bar is not a requirement to completing any activation or EVA events. The SSAS interface was designed with the loads being carried by the Motorized Bolt Assemblies or combination of MBA's with up to two composite MBA's/Contingency Bolt Kits. At the conclusion of bolting operations, the Capture Latch is still putting a fair amount of load on the bar and not meeting the design requirement. Thus, it is important but not imperative that the Capture Latch be opened to remove the built up loads across the interface. This contingency configuration has been analyzed for strength using peak loading conditions, but life analysis will be performed as required to assess consequences during future build sequences/configurations.*
- l. *If both BBC's fail such that all capability to sense Bolt Tight Switch positions is lost, then perform EVA SSAS MBA Bolt Actuation to drive the bolts to final torque value after first using a Contingency Bolt to fully seat each bolt as documented in Rule {12A\_C10-2A}.4, SSAS BOLT FULLY TIGHT DEFINITION. If EVA cannot drive bolt(s) via the EVA Manual Override, then EVA SSAS Contingency Bolt Kit Installation will be required. Torque values for EVA Manual Override without benefit of Bolt Tight Switch feedback, as well as Contingency Bolt installation torques, were supplied to EVA in SSCN 1819.*

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## **FLIGHT RULES**

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### SECTION 11 - COMMUNICATIONS

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#### SHUTTLE ONLY RULES

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##### 12A\_A11-1      ORBITER S-BAND LOW FREQUENCY FOR ASCENT

- A. ENHANCED LAUNCH VEHICLE IMAGING SYSTEM (ELVIS) REQUIRES THE ORBITER OPERATE IN LOW FREQUENCY DURING ITS OPERATIONAL PERIOD TO PREVENT ADVERSELY EFFECTING THE EXTERNAL TANK (ET) REAL-TIME DOWNLINK VIDEO.

*The ELVIS component located on the ET which downlinks real-time images of the underside of the orbiter and the ET, operates from about L-2 minutes to shortly after ET separation at about MET 9:00 minutes. This system operates at 2272.5 MHz. The orbiter S-Band high frequency at 2287.5 MHz will degrade the image quality from the ET real-time camera downlink so the orbiter should operate in low frequency (2217.5 MHz) to prevent this problem. Ref: EV7-04-3065 Radio Frequency Interference from the Space Shuttle Orbiter S-band High Frequency Link to the External Tank Camera System Downlink.*

- B. THE ORBITER MAY USE S-BAND HIGH FREQUENCY FOR ASCENT IF LOW FREQUENCY IS FAILED.

*ET real-time video downlink is considered crit 3. Orbiter S-Band is a crit 1 system so, if S-Band low frequency is lost, the orbiter may use S-Band High frequency to recover this crit 1 capability. ET real-time video will be degraded in this case.*

##### 12A\_A11-2      LOSS OF ELVIS REAL-TIME DOWNLINK

LOSS OF THE REAL-TIME DOWNLINK FROM THE ET CAMERA WILL NOT TERMINATE ASCENT PHASE.

*ET camera downlink is considered a crit 3 function and cannot be used to prevent launch or termination of ascent.*

##### 12A\_A11-3      LOSS OF OBSS SENSORS

FAILURE OF THE ORBITER BOOM SENSOR SYSTEM (OBSS) SENSORS WILL RESULT IN CONTINUING TO NOMINAL END OF MISSION (EOM) .

*The LDRI, ITVC, and LCS sensors located on the end of the boom cannot cause a hazard to closing the Payload Bay doors if they are failed. Should the OBSS sensors fail to function, the backup plan for inspection includes images from ISS as well as EVA digital camera images.*

## FLIGHT RULES

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### 12A\_A11-4      LOSS OF LDRI

LASER DYNAMIC RANGE IMAGER (LDRI) IS CONSIDERED FAILED WHEN IMAGES FROM THE CAMERA ARE NOT RECEIVED AT THE CCTV SYSTEM.

*LDRI has a single failure which could cause the images from the camera to not be transmitted to the CCTV system. If flown, the Laser Camera System (LCS) is a backup to LDRI.*

### 12A\_A11-5      LOSS OF OBSS ITVC

OBSS INTENSIFIED TELEVISION CAMERA (ITVC) IS CONSIDERED FAILED WHEN IMAGES FROM THE CAMERA ARE NOT RECEIVED AT THE CCTV SYSTEM.

*The Orbiter Boom Sensor System (OBSS) ITVC is used for situational awareness and as backup to the LDRI imaging. It decodes and forwards the commands that move the Pan Tilt Unit (PTU).*

### 12A\_A11-6      LOSS OF LCS

THE LASER CAMERA SYSTEM (LCS) IS CONSIDERED FAILED WHEN COMMUNICATION BETWEEN THE LASER CAMERA HEAD (LCH) AND THE LASER CAMERA CONTROLLER (LCC) IS PERMANENTLY LOST.

*The LCS requires communications between its components. The LCH is the sensor located at the end of the OBSS. If the LCH cannot communicate across the ethernet link to the LCC located in a laptop computer on the flight deck of the orbiter, it will not be able to scan because the laser will turn off.*

### 12A\_A11-7      LOSS OF RSC

THE ROBOTIC MANIPULATOR SYSTEM (RMS) SIDE VIEW CAMERA (RSC) IS CONSIDERED FAILED WHEN IMAGES FROM THE CAMERA ARE NO LONGER AVAILABLE TO THE CCTV MONITORS. LOSS OF THE RSC WILL REQUIRE MORE TIME FOR OBSS SURVEYS, AND POSSIBLY RESULT IN TERMINATION OF OBSS SURVEYS IF SUPPLEMENTAL VIEWS ARE NOT AVAILABLE (I.E., ISS CAMERAS) .

*Without the RSC, the crew will not have a critical view of the position of the OBSS relative to the area of Thermal Protection System (TPS) that is being surveyed. The time to complete the survey will increase due to the fact that other views, if available, will have to be used to supplement the loss of the RSC. If other views are not available, it may not be possible to safely position the OBSS for surveys.*



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12A\_A11-8

INTEGRATED SENSOR INSPECTION SYSTEM (ISIS) DIGITAL  
CAMERA (IDC) SUN EXPOSURE PREVENTION [HC]

THE INTEGRATED SENSOR INSPECTION SYSTEM (ISIS) DIGITAL CAMERA (IDC) SHALL NOT BE POINTED TOWARD THE SUN WHILE THE IDC IS POWERED ON. @[CR 7493 ]

*Failure analysis was conducted at the “black box” level due to the IDC being fabricated primarily from commercial-off-the-shelf (COTS) components for which no failure data was available and due to there being no redundancy within the IDC system. The IDC does not have a commandable shutter.*

*Hazard Report IDC-022, Provides Degraded Image, describes the damage that occurs when the sun is in the IDC’s field of view (FOV) during powered operation. During testing following sun exposure, the center pixels of the image were non-functional (“stuck” white). The damage compromises the ability of the sensor to meet performance requirements.*

*The IDC is designed to meet all performance requirements with the sun not in the FOV. Testing has verified IDC pixel failure does not occur when the IDC electronics are powered off or in a heater-only mode.*

*PDRS shall use best effort to prevent IDC sun exposure by ensuring the IDC is turned off when the IDC FOV is potentially facing toward the sun. The IDC 50mm lens FOV is modeled as a cone leaving the IDC lens with a 20-degree angle. @[CR 7493 ]*

## FLIGHT RULES

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### ISS ONLY RULES

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**12A\_B11-1**      **RESERVED** @[DN 106 ]

**12A\_B11-2**      **S-BAND HIGH GAIN ANTENNA (HGA) CALIBRATION**

- A. AN S-BAND RADIO FREQUENCY GROUP (RFG) HIGH GAIN ANTENNA (HGA) CALIBRATION WILL BE PERFORMED IN CONJUNCTION WITH THE FOLLOWING OPERATIONS: @[CR 7636 ]
1. AFTER AN S-BAND RFG POWER CYCLE, BUT BEFORE THE HGA POINTING IS ENABLED.
  2. AFTER THE S-BAND RFG IS RECONFIGURED FROM LOW DATA RATE (LDR) TO HIGH DATA RATE (HDR), BUT BEFORE THE HGA POINTING IS ENABLED.
- B. DURING NOMINAL S-BAND HIGH DATA RATE OPERATIONS, AN HGA ANTENNA CALIBRATION WILL BE PERFORMED AT LEAST ONCE EVERY 6 WEEKS DURING NON-CRITICAL OPERATIONS.

*Following a powerup, the S-band RFG assumes its default configuration. Per the default configuration, the RFG's estimated azimuth and elevation position of the high gain antenna, i.e., where the RFG thinks its high gain antenna is positioned, is reset to (0 degrees, 0 degrees). The actual azimuth and elevation position of the high gain antenna will be whatever the position was prior to being powered off. This position can be something other than (0 degrees, 0 degrees) causing a discrepancy between the estimated position and the actual position of the high gain antenna after powerup. This discrepancy is resolved by commanding the RFG to perform its high gain antenna calibration after powerup. If left unresolved, the discrepancy between the estimated and actual positions will result in inaccurate pointing of the high gain antenna, unpredictable communications coverage, and possible damage to the Sequential Shunt Unit (SSU) due to inadvertent radiation.*

*When switching from LDR to HDR, a HGA calibration will be performed to ensure that the estimated and actual HGA positions are correct.*

*During nominal operations, the azimuth or elevation position can drift. During the 5A increment operations, an HGA calibration was performed after 4 weeks and the calibration passed. An HGA calibration every 6 weeks or sooner will ensure that the estimated and actual positions do not differ more than 1.3 degrees. @[CR 7636 ]*

## FLIGHT RULES

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12A\_B11-3

ISS S-BAND OPERATIONS DURING EVA [HC] [RI]

THERE ARE NO RESTRICTIONS TO THE USE OF THE S-BAND SYSTEM WHEN EVA ASTRONAUTS ARE WORKING OUTSIDE THE DEFINED S-BAND KEEP-OUT ZONES. IF AN ASTRONAUT MUST VIOLATE THE KEEP-OUT ZONE OF A POWERED S-BAND RADIO FREQUENCY GROUP (RFG), THE FOLLOWING ACTIONS WILL BE TAKEN UNTIL THE ASTRONAUT IS CLEAR OF THE KEEP-OUT ZONE:  
©[CR 7637B ]

1. THE HIGH GAIN ANTENNA (HGA) WILL BE PARKED (EL = 0 AND AZ = 0) AND THE POINTING MODE INHIBITED.
2. THE SOLID STATE POWER AMPLIFIER (SSPA) WILL BE COMMANDED TO MUTE.
3. THE TRANSMITTER WILL BE COMMANDED TO OFF.
4. THE TRANSPONDER WILL BE POWERED OFF.

*The field strength of the S-band system requires EVA crewmembers to observe appropriate keep-out zones if they are to be working in a region within the EVA keep-out zone. The keep-out zones associated with the S-band antennas are defined in Rule {B15-15}, EVA KEEPOUT ZONES [HC] [RC] [E]. Removing power from the transponder, combined with parking the HGA, turning the transmitter off and muting the HGA provides the required failure tolerance for crew safety within the keep-out zone. ©[CR 7637B ]*

## FLIGHT RULES

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12A\_B11-4

### S-BAND DECRYPTION INDEX MANAGEMENT

- A. THE LEGACY S-BAND DECRYPTION INDEX NOMINALLY WILL BE CHANGED EVERY 24 HOURS. THE TIME BETWEEN ANY TWO CONSECUTIVE INDEX CHANGES SHALL NOT BE SCHEDULED TO EXCEED 25 HOURS WITHOUT PRIOR APPROVAL OF THE CONTROLLING AUTHORITY. @[CR 7711A ]
- B. THE UPGRADED S-BAND DECRYPTION INDEX NOMINALLY WILL BE CHANGED ONCE A WEEK WITHIN A 16-HOUR WINDOW. THE TIME BETWEEN ANY TWO CONSECUTIVE INDEX CHANGES SHALL NOT BE SCHEDULED TO EXCEED 1 WEEK WITHOUT PRIOR APPROVAL OF THE CONTROLLING AUTHORITY.
- C. THE DECRYPTION INDEX WILL NOT BE CHANGED DURING CRITICAL OPERATIONS. IF A SCHEDULED INDEX CHANGE CONFLICTS WITH CRITICAL OPERATIONS, THEN THE INDEX CHANGE WILL BE RESCHEDULED TO OCCUR PRIOR TO THE CRITICAL OPERATIONS. SUBSEQUENT INDEX CHANGES WILL THEN CONFORM TO PARAGRAPH A (FOR LEGACY S-BAND) AND B (FOR UPGRADED S-BAND) OF THIS RULE.

*The controlling authority and the positions responsible for changing the decryption index are identified in the International Space Station (ISS) S-Band Uplink Encryption Key Management Plan (KMP) for the Mission Control Center (MCC), #LOR-TR2053. The controlling authority is ultimately responsible for when the index is changed.*

*Reference MSOC Memo, ISS Command Encryption System Operations, July 8, 2004. @[CR 7711A ]*

## FLIGHT RULES

### JOINT SHUTTLE/ISS RULES

#### 12A\_C11-1      ORBITER KU-BAND CONFIGURATION

- A. THERE ARE NO CONSTRAINTS TO KU-BAND HIGH POWER RADIATION (COMM MODE OR RADAR HIGH POWER MODE), WHEN THE DISTANCE BETWEEN THE ORBITER AND ISS IS GREATER THAN 765 FT OR WHEN THE KU MAIN BEAM RADIATION IS GREATER THAN 5 DEGREES AWAY FROM THE ISS STRUCTURE. NOMINAL KU CONFIGURATION WILL BE A "BETA PLUS MASK" MODE WITH A BETA VALUE OF 21 DEGREES, EXCEPT DURING SPECIFIC SRMS OPERATIONS WHEN THE FOLLOWING RF PROTECT BOXES WILL BE ADDED: @[CR 7633 ]

BOX	AZ/EL	CORRESPONDING ACTIVITY
A1	26<AZ<110    -90<EL<-30	SRMS POWER UP, POWER DOWN, AND CHECKOUT
A2	-27<AZ<110    -90<EL<0	OBSS UNBERTH, PORT WING SCAN, AND OBSS BERTH
A3	-81<AZ<110    -67<EL<-10	FLAT FIELD SURVEY
A4	-122<AZ<110   -90<EL<45	STARBOARD WING SCAN
A5	-32<AZ<110    -50<EL<30	NOSE CAP SCAN
A6	-93<AZ<110    -90<EL<32	SRMS UPPER SURFACE SURVEY
A7	-149<AZ<44    32<EL<83	SRMS UPPER SURFACE SURVEY

- B. WHILE THE ISS IS WITHIN 8 DEGREES OF THE ORBITER -Z AXIS (APPROACH CORRIDOR) AND THE RANGE IS LESS THAN 765 FT BUT GREATER THAN 105 FT, THE KU SYSTEM WILL BE OPERATED IN THE "BETA ONLY" MODE WITH A BETA VALUE OF +21 DEGREES IN ADDITION TO THE FOLLOWING RF PROTECT BOX:

BOX	AZ/EL	ELEMENT PROTECTED
B1	-35<AZ<45    -35<EL<40	MODULES, ISS STRUCTURE, AND SSRMS

@[CR 7633 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

**12A\_C11-1                    ORBITER KU-BAND CONFIGURATION (CONTINUED)**

C. WHILE THE ISS IS WITHIN THE APPROACH CORRIDOR AND THE RANGE IS LESS THAN 105 FT, OR WHILE THE SHUTTLE IS DOCKED TO THE ISS AND NO EVA OR SSRMS OPERATIONS ARE OCCURRING, THE KU SYSTEM WILL BE OPERATED IN THE "BETA ONLY" MODE WITH A BETA VALUE OF +21 DEGREES IN ADDITION TO THE RF PROTECT BOXES BELOW:

BOX	AZ/EL		ELEMENT PROTECTED
C1	-18<AZ<52	-68<EL<75	ISS CORE STRUCTURE
C2	-41<AZ<-10	-25<EL<39	S0 & ISS AIRLOCK
C3	-72<AZ<-36	-4<EL<33	S1

@[CR 7633 ]

IF THE ISS IS NOT WITHIN THE 8-DEGREE APPROACH CORRIDOR DURING PROX OPS, THE KU WILL REMAIN IN, OR WILL BE TAKEN TO, STBY UNTIL THE APPROPRIATE CORRIDOR CONDITIONS ARE MET.

D. TO PROTECT THE SSRMS AND SRMS DURING SPECIFIC MATED OPERATIONS, THE KU SYSTEM WILL BE OPERATED AS DEFINED IN PARAGRAPH C, WITH THE FOLLOWING RF PROTECT BOXES USED IN CONCERT WITH OR IN LIEU OF ONE OR MORE OF THE RF PROTECT BOXES LISTED IN PARAGRAPH C:

BOX	AZ/EL		CORRESPONDING ACTIVITY
D1	-18<AZ<70	-68<EL<75	P3/P4 UNBERTH/INSTALL OPERATIONS
D2	-120<AZ<6	-89<EL<-45	OBSS OPERATIONS

E. DURING EVA ACTIVITY, THE KU SYSTEM WILL BE OPERATED IN THE "BETA ONLY" MODE WITH A BETA VALUE OF 0 DEGREES, ALONG WITH PROTECT BOXES C1, C2, AND C3 DEFINED IN PARAGRAPH C ABOVE, AND ADDITIONAL BOXES AS NEEDED: @[CR 7633 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C11-1                      ORBITER KU-BAND CONFIGURATION (CONTINUED)**

F. TO PROTECT THE SSRMS DURING SPECIFIC MATED OPERATIONS, THE KU SYSTEM WILL BE OPERATED AS DEFINED IN PARAGRAPH C, WITH THE FOLLOWING RF PROTECT BOXES USED IN CONCERT WITH OR IN LIEU OF ONE OR MORE OF THE RF PROTECT BOXES LISTED IN PARAGRAPH C:  
 ©[CR 7633 ]

BOX	AZ/EL		CORRESPONDING ACTIVITY
F1	-92<AZ<5	-82<EL<4	SSRMS WALKOFF
F2	-129<AZ<10	-10<EL<42	SRMS SURVEY SUPPORT

G. DURING ALL OTHER SSRMS OR SRMS OPERATIONS, THE SHUTTLE KU SYSTEM WILL BE IN STBY OR TRAVELING WAVE TUBE (TWT) INHIBIT.

AT THE DISCRETION OF THE FLIGHT DIRECTOR, BASED ON REAL-TIME OPERATIONAL ASSESSMENT, KU COMM MAY BE ENABLED USING AN ALTERNATE MASKING SCHEME.

*The SRMS radiation limit, as defined in ER-06-012, Shuttle Remote Manipulator System (SRMS) Electromagnetic Interference (EMI) Exposure, is 200 V/m. Since the orbiter Ku main beam operates at 350 V/m, the SRMS must be protected from exposure to orbiter Ku radiation. ©[CR 7633 ]*

*The ISS radiation limit, as defined in NSTS 21497, is 125 V/m. The ISS Ku antenna boresight radiation limit, as defined in NSTS 21497, is 13.2 V/m. The EVA radiation exposure level, as defined in Rule {A11-7}, KU-BAND OPERATIONS DURING EVA, is 20 V/m that is established by the Extravehicular Maneuvering/Mobility Unit (EMU) specifications. Thirteen point two V/m is reached at 765 ft away from the Ku antenna, and 125 V/m is reached at 105 ft away from the Ku antenna. The masks in this rule protect the shuttle Ku antenna from reflected radiation off the ISS solar arrays; however, the masks do not protect the entire arrays from Ku radiation impingement, nor do they protect any part of the ISS radiators from such impingement.*

*Changes to the masking schemes and/or Ku-band system configuration beyond what is contained herein may be necessary to respond to real-time situations.*

*Unplanned SRMS or SSRMS motion creates risk of direct Ku radiation in excess of SRMS or SSRMS limits while the shuttle Ku-band system is operated in the comm mode.*

## FLIGHT RULES

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12A\_C11-2

### KU-BAND OPERATIONS DURING AN ISS BASED EVA

THERE ARE NO RESTRICTIONS TO THE USE OF THE KU-BAND SYSTEM WHEN EVA CREWMEMBERS ARE WORKING AND TRANSLATING OUTSIDE THE KU-BAND EVA KEEPOUT ZONE DEFINED IN RULE {B15-15}, EVA KEEPOUT ZONES [HC] [RC] [E]. IF AN EVA CREWMEMBER MUST VIOLATE THE KU-BAND EVA KEEPOUT ZONE, THE SGANT WILL BE PARKED IN A LOCATION THAT PROVIDES THE EVA CREWMEMBER MAXIMUM CLEARANCE FROM PHYSICAL CONTACT. THE KU BAND AUTOTRACK CONTINUOUS RETRY WILL BE INHIBITED, TRANSMITTER/RECEIVER CONTROLLER (TRC) POWER LEVEL CONTROLLER (PLC) WILL BE RESET, AND THE TRC POINTING MODE WILL BE INHIBITED. THE SGANT AND TRC WILL REMAIN POWERED. WHEN THE EVA CREWMEMBER HAS CLEARED THE KEEPOUT ZONE, THE NOMINAL KU-BAND OPERATIONS CAN RESUME.

*The EMU/Space to Space EVA/EMU Radio (SSER) certification limit for the Sgant Ku-band System (15 Ghz) is 250 V/m RMS. The physiological limit is 194 V/m RMS for the ISS Ku-band. ISS Ku-band transmits 10 W RF power nominally and 20 W in the failure mode. Maximum predicted e-field strength for the 10 W and 20 W modes is 87 V/m RMS and 125 V/m RMS, respectively. Therefore, no keepout zone should technically be required. However, a keepout zone of 3.3 ft (1.0 m) is maintained to preclude the possibility of EMU or equipment contact with the antenna*

*DOCUMENTATION: ISS USOS and SSO Antenna RF Exposure Keepout Zone Data Book, JSC 29045 - Volume I, EV4-01-906, December 2000. Physiology RF Exposure Keepout Distance From ISS USOS, SSO, and Russian Antennas, EV4-01-937, August 2001.*



## FLIGHT RULES

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### 12A\_C11-3

### LCS RADIATION RESTRICTIONS

A. SHUTTLE COMMUNICATIONS SYSTEMS RESTRICTIONS DURING LASER CAMERA SYSTEM (LCS) SCANNING OPERATIONS: @[CR 7518 ]

1. SHUTTLE S-BAND PM WHILE IN HIGH FREQUENCY SHALL NOT RADIATE LCS WHILE LCS IS SCANNING AND IS WITHIN 33.8 FEET (10.3 METERS) OF AN ACTIVE S-BAND PM ANTENNA.
2. SHUTTLE S-BAND PM WHILE IN LOW FREQUENCY SHALL NOT RADIATE LCS WHILE LCS IS SCANNING AND IS WITHIN 12.5 FEET (3.8 METERS) OF AN ACTIVE S-BAND PM ANTENNA.
3. SHUTTLE S-BAND FM SHALL NOT RADIATE LCS WHILE LCS IS SCANNING AND IS WITHIN 5.4 FEET (1.64 METERS) OF AN S-BAND FM ANTENNA.
4. THERE ARE NO RESTRICTIONS FOR THE KU-BAND.
5. SHUTTLE MICROWAVE SCANNING BEAM LANDING SYSTEM (MSBLS) SHALL NOT RADIATE WHEN LCS IS WITHIN 11.8 FEET (3.61 METERS) OF THE MSBLS ANTENNAS.
6. SHUTTLE TACAN SHALL NOT RADIATE WHEN LCS IS WITHIN 5.74 FEET (1.75 METERS) OF THE TACAN ANTENNAS.

*These radiation restrictions have been modified from STS-114; the new distances are the result of a window coating on the LCS optic window which decreases its radiation susceptibility.*

B. ISS COMMUNICATIONS SYSTEMS RESTRICTIONS DURING LCS SCANNING OPERATIONS:

1. THERE ARE NO OPERATIONAL RESTRICTIONS FOR ISS KU-BAND DURING LCS SCANNING OPERATIONS.
2. THERE ARE NO RESTRICTIONS FOR S1 AND P6 S-BAND LOW GAIN ANTENNAS (LGA'S) USAGE DURING LCS SCANNING OPERATIONS.
3. THERE ARE NO RESTRICTIONS FOR S-BAND STRING 2 (P6) USAGE DURING LCS SCANNING OPERATIONS. @[CR 7518 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

**12A\_C11-3                      LCS RADIATION RESTRICTIONS (CONTINUED)**

4. S-BAND STRING 1 HIGH DATA RATE SYSTEM SHALL NOT RADIATE LCS WHEN IT IS SCANNING AND IS WITHIN 14.8 DEGREES OFF BORESIGHT AND WITHIN 44.0 FEET (13.41 METERS) OF THE HGA. ©[CR 7518 ]

*S-band string 2 (P6) is the planned primary string during the STS-115/12A mission. S-band string 1 may be utilized during the joint mission timeframe. If S-band string 1 is used, the following methods will be implemented to preclude ISS S-band string 1 HDR radiation of LCS while it is scanning:*

- a. *Use of time tag commands to control S-band pointing, thus implementing a masking capability to preclude radiation of the LCS with the S-band High Gain Antenna (HGA) during the periods LCS is in scan mode. Early TDRS handovers may be utilized to improve S-band coverage and minimize masking impacts. Based on a -XVV mated attitude, this strategy will result in very little impact to S-band HDR coverage.*

- 1) *The following are the KOZ for S-band string 1 (S1) to protect LCS in all possible scan locations: Mask 1 is designed to protect the shuttle nose cone area and mask 2 is designed to protect the shuttle wing area. Both masks are needed to protect the entire shuttle body.*

ZONE	AZ LOWER (DEGREES)	AZ UPPER (DEGREES)	EL LOWER (DEGREES)	EL UPPER (DEGREES)
STRING 1 MASK 1	-42	84	122	180
STRING 1 MASK 2	-38	55	56	180

- 2) *Based on actual LCS scan locations, smaller mask zones may be implemented to increase S-band coverage.*
- b. *Command S-band string 1 to use the low gain antenna during periods that LCS is in scan mode and within high gain antenna KOZ.*
- c. *Command the S-band system Solid State Power Amplifier (SSPA) to mute during periods when the LCS is in scan mode and within the high gain antenna KOZ. Use of time tag commands or real-time command, per OIU or S-band, in the blind will be used to configure SSPA back to transmit when LCS is no longer projected to be in the KOZ.*

*The S-band string 1 RFG Critical Failure Caution will be annunciated when the SSPA is muted.*

*Reference: Engineering Analysis Report, EV7-06-4143, LCS Keep Out Distances for the SSO, ISS USOS, and ISS Russian Segment Antennas During LCS Scanning Operations. ©[CR 7518 ]*

**FLIGHT RULES**

**12A\_C11-4      ISS KU-BAND OPERATIONS FOR APPROACH AND DOCKING [HC]**

- A. THE ISS KU-BAND RENDEZVOUS MASK MUST BE ENABLED NO LATER THAN THE ORBITER REACHING A RANGE TO ISS OF 173 METERS (568 FEET).  
 ©[CR 7709 ]

*Per NSTS 21000-IDD-ISS, the ISS Ku-band subsystem cannot impart direct beam radiation above 20 V/m within 5 degrees of orbiter structure. This constraint is levied upon the ISS Ku-band subsystem to protect the pyrotechnics on the orbiter. For the ISS Ku-band subsystem, the 20 V/m level corresponds to a range of 173 meters (568 feet). During a nominal ISS rendezvous and Vbar docking, the orbiter reaches a range of 173 meters (568 feet) shortly after arriving on the +Rbar. Although the orbiter is within the ISS Ku-band antennas 20 V/m range at this time, it is not yet within the antennas' gimbal limits. Therefore, it is technically still safe to operate the ISS Ku-band system, but not for long. Within approximately 12 minutes or less of arriving on the +Rbar and just before arriving on the +Vbar, the orbiter will be within the ISS Ku-band gimbal limits. Instead of tracking when the orbiter arrives within the ISS Ku-band gimbal limits, it is safer to track when the orbiter reaches a range of 173 meters (568 feet) since the range data is more readily available. This rule, therefore, references the range of 173 meters (568 feet) as the no-later-than time for the ISS Ku-band rendezvous mask to be enabled. Typically, the start of the manual phase is used as a general reference mark for planning purposes as to when the mask will be enabled. Nominally, the start of the manual phase occurs after the Midcourse Correction (MC) 4 burn is performed. In an off-nominal case (i.e., radar-failed), the start of the manual phase occurs after the MC 3 burn. At the start of the manual phase, the orbiter is at an approximate range of at least 457 - 609 meters (1500-2000 feet), thus providing adequate margin before the orbiter reaches a range of 173 meters (568 feet).*

1. THE RENDEZVOUS MASK IS DEFINED IN THE ISS KU-BAND ELEVATION-CROSS ELEVATION COORDINATE SYSTEM AS FOLLOWS:

ELEVATION LOWER	ELEVATION UPPER	X ELEVATION LOWER	X ELEVATION UPPER
-180 DEGREES	-70 DEGREES	-45 DEGREES	+18 DEGREES

*These mask values are applicable for CCS R3.4.1 and subs.*

2. THE ISS KU-BAND RENDEZVOUS MASK IS ONLY VALID WHEN ALL OF THE FOLLOWING ARE TRUE:
- a. THE ODS IS IN THE FORWARD LOCATION OF THE ORBITER.
  - b. THE ORBITER IS DOCKING NOSE-UP (TAIL DOWN) TO PMA-2.
  - c. PMA-2 IS ON THE FORWARD END OF THE U.S. LAB.

THESE THREE CONSTRAINTS CONSTITUTE THE NOMINAL AND ONLY PLANNED ORBITER DOCKING ORIENTATION FOR ISS. ©[CR 7709 ]

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## FLIGHT RULES

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**12A\_C11-4**                    **ISS KU-BAND OPERATIONS FOR APPROACH AND DOCKING**  
**[HC] (CONTINUED)**

- B. DURING THE FOLLOWING OFF-NOMINAL CIRCUMSTANCES, THE ISS KU-BAND OPERATIONS MUST BE TERMINATED BY INHIBITING CONTINUOUS RETRY, RESETTING THE TRC PLC, AND INHIBITING THE POINTING MODE. @[CR 7709 ]
1. IF THE ORBITER IS OUTSIDE THE ISS KU-BAND RADIATION MASK'S ZONE OF PROTECTION AS DEFINED USING THE FOLLOWING TWO CONDITIONS:
    - a. FOR A RELATIVE RANGE ALONG THE CENTERLINE OF THE APPROACH CORRIDOR  $\leq$  76 METERS (250 FEET), IF THE ORBITER IS NOT WITHIN THE APPROACH CORRIDOR DEFINED IN RULE {C2-102}, RENDEZVOUS (RNDZ)/PROXIMITY OPERATIONS (PROX OPS) DEFINITIONS [HC] [RC]
    - b. FOR A RELATIVE RANGE ALONG THE CENTERLINE OF THE APPROACH CORRIDOR  $>$  76 METERS (250 FEET) IF THE ORBITER'S ELEVATION ABOVE THE CENTERLINE OF THE APPROACH CORRIDOR EXCEEDS 8 DEGREES OR THE ORBITER'S AZIMUTH EXCEEDS  $\pm$ 8 DEGREES

*The ISS Ku-band rendezvous radiation mask protects a zone as defined in Rule {C2-102}, RENDEZVOUS (RNDZ)/PROXIMITY OPERATIONS (PROX OPS) DEFINITIONS [HC] [RC], plus an extended cone of 8 degrees in radius for relative ranges  $>$  76 meters (250 feet).*

*The ISS Ku-band rendezvous mask extends all the way to the ISS Ku-band gimbal limits (in the +RBar direction). Therefore, the combination of the mask and the gimbal limits protects the orbiter during its +RBar to +VBar maneuver. The rendezvous mask protects the orbiter once this maneuver is completed and the orbiter is along the centerline of the approach corridor.*

2. IF DATA TO DETERMINE THE POSITION OF THE ORBITER WITHIN THE ISS KU-BAND RENDEZVOUS MASK IS NOT AVAILABLE ON THE GROUND

*Without data on the ground, the ISS Flight Control Team (FCT) cannot accurately monitor the range and relative position of the orbiter during the rendezvous. The ISS FCT will not be able to monitor the conditions documented in paragraph B.1 of this rule.*

3. IF THE ISS KU-BAND RENDEZVOUS MASK, DEFINED IN PARAGRAPH B.1 OF THIS RULE, IS NOT AND CANNOT BE ENABLED WHEN THE ORBITER IS AT OR WITHIN 173 METERS (568 FEET) OF THE ISS  
@[CR 7709 ]

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## FLIGHT RULES

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**12A\_C11-4**                    **ISS KU-BAND OPERATIONS FOR APPROACH AND DOCKING**  
**[HC] (CONTINUED)**

- C. ONCE THE ORBITER IS DOCKED TO THE ISS AND THE ISS KU-BAND DOCKED ORBITER MASKS HAVE BEEN ENABLED, THE RENDEZVOUS MASK CAN BE DISABLED. @[CR 7709 ]

*The ISS Ku-band docked orbiter masks are typically enabled at the same time as the rendezvous mask. Since the rendezvous mask encompasses the docked orbiter masks, this simultaneous enabling is not technically required. Nonetheless, the rendezvous and docked orbiter masks are enabled simultaneously as a matter of operator efficiency and task organization. Once the orbiter is docked, the rendezvous mask is disabled, leaving only the docked orbiter masks.*

*Reference: NSTS 21000-IDD-ISS sections 10.7.3.2.2 and S.10.5; EV4-01-906 ISS USOS and SSO Antenna RF Exposure Keep-Out Zone Databook; Rule {C2-102}, RENDEZVOUS (RNDZ)/PROXIMITY OPERATIONS (PROX OPS) DEFINITIONS [HC] [RC]; Hazard Report C&T-1101-6A Cause 4; Rule {C11-1}, ISS KU-BAND OPERATIONS WITH THE ORBITER [HC]; JSC-48072-114 Rendezvous Flight Data File STS-114, Basic, July 22, 2002; and EV4-04-3006 ISS Ku-band Masks for SSO Protection During Rendezvous. @[CR 7709 ]*

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 12 - ROBOTICS

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#### ISS ONLY RULES

THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION....12-12

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### VIDEO SYSTEM MANAGEMENT

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#### SPACE VISION SYSTEM MANAGEMENT

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## FLIGHT RULES

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### SECTION 12 - ROBOTICS

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#### SHUTTLE ONLY RULES

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#### **12A\_A12-1      SPARE MANIPULATOR CONTROL INTERFACE UNIT (MCIU)**

FOR A MANIPULATOR CONTROLLER INTERFACE UNIT (MCIU) FAILURE, THE SPARE MCIU WILL BE INSTALLED AS TIME PERMITS. ©[CR 7701 ]

*Computer-supported modes (Single, Auto, and manual-augmented) are preferred to ease operations. For a failed MCIU, direct and backup are the remaining methods of driving the RMS. Replacing the MCIU will regain computer-supported modes and considerably simplify operations. The typical time allocated to attain operational status of the replacement MCIU and stow the failed MCIU is 2.5 hours. Pending crew availability and aft flight deck (AFD) activity, a trade must be made real time as to whether sufficient time exists to replace the MCIU and proceed with nominal RMS operations (versus proceeding with single joint RMS, which will take longer and may be more complex) and still retain the ability to meet the mission objectives. Deferring the stowing of the failed MCIU may be considered to resume RMS operations sooner.*

*During the time that the MCIU is disconnected, only backup mode is available (end effector release only, no SPEE power). ©[CR 7701 ]*

## FLIGHT RULES

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**12A\_A12-2**

**ORBITER BOOM SENSOR SYSTEM (OBSS) THERMAL CONSTRAINTS**

- A. BOTH STBD RMS HEATERS SHALL BE ACTIVATED AS EARLY AS PRACTICAL AFTER ASCENT. @[CR 7701 ]

*While berthed in the MPM, the OBSS heaters are powered using STBD RMS assets. Activating both heater strings provides system redundancy from the power source to the base of the OBSS.*

- B. BOTH STBD RMS HEATERS SHALL BE DEACTIVATED DURING DEORBIT PREP.

*Thermal analysis shows that the OBSS can survive with the heaters unpowered for 2 hours. Currently, the STBD RMS heaters are scheduled to be activated at Launch +2:30 and deactivated at Landing -3:51. These specific cases have been determined to be acceptable times to power and unpower the heaters.*

*If a landing attempt is waved off after the deactivation of the OBSS heaters, the STBD RMS heaters shall be reactivated during DEORBIT PREP BACKOUT.*

- C. WHILE THE OBSS IS BERTHED, SENSOR TEMPERATURES WILL BE MANAGED TO STAY WITHIN OPERATING LIMITS AS DEFINED IN THE FOLLOWING TABLE:

SENSOR	OPERATING LIMITS (°F)	
	LOW	HI
AVIONICS BOX 1 & 2	-31° (-10°)	131° (128°)
LCS	32° (15°)	122° (119°)
LDRI	32° (39°)	158° (156°)
ITVC	-4° (8°)	140° (138°)
PTU	-4° (-10°)	140° (138°)
IDC	32° (14°)	131° (122°)

*The OBSS thermal limits are defined at the component level for each sensor. The sensor limits in the table are defined by the component limit that bounds the sum of all the components. @[CR 7701 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A12-2

**ORBITER BOOM SENSOR SYSTEM (OBSS) THERMAL  
CONSTRAINTS (CONTINUED)**

*Reference LDRI Orbiter Inspection System Critical Design Review Presentation, Thermal Design & Analysis, June 7, 2004; NDG006275, Rev. 1, Laser Camera Head Thermal Analysis, July 23, 2004; MDR-RMS-R.7684, Rev. 2.0, IBA Thermal Analysis Report, March 2, 2004; Addendum for IBA Thermal Report Post CDR, SRMS.71465, Two Sensor Design Thermal Report, October 20, 2004; ITVC Critical Design Review Presentation, May 19, 1992; MSAD-04-0197, Integrated Sensor Inspection System (ISIS) String 1 Thermal Analysis, May 25, 2004; TH-95-162, Rev. A, ITVC Camera Thermal Balance Report, October 14, 1995; MS-410-2 A-18, Revised ITVC Thermal Analysis, June 16, 1992; and Jacobs Sverdrup memo ESCG-4470-06-TEAN-DOC-0028, Updated Thermal Analysis of ISIS (Integrated Shuttle Inspection System) Digital Camera (IDC), March 8, 2006. ©[CR 7701 ]*

*With the exception of the Laser Camera System (LCS), ISIS Digital Camera (IDC), and the Pan Tilt Unit (PTU) low limits, the numbers in parentheses reflect the limit set in software, assuming a 1-3/4 count potential error in the thermistor readings. The LCS and PTU low limits are set to protect against false alarms due to thermal gradients between the heater and thermistor locations. The IDC Temperature thresholds are as set in the DCCS.ini file for caution and warning.*

- D. THE OBSS SHALL REMAIN BERTHED IF THE SENSOR TEMPERATURES ARE NOT WITHIN OPERATING LIMITS.

*When the OBSS is unberthed, insight into the sensor temperatures is not readily available. Therefore, the temperatures must be verified to be within the acceptable operating limits prior to unberth. For any violation of the operating limits, the SSP MER must provide concurrence prior to continuing OBSS operations.*

- E. SENSOR SURVIVAL TIME

1. SENSOR PACKAGE 1 (ITVC, LDRI, AND PTU) SHALL NOT BE LEFT WITHOUT POWER FOR LONGER THAN 90 MINUTES AND SENSOR PACKAGE 2 (LCS, IDC) SHALL NOT BE LEFT WITHOUT POWER FOR LONGER THAN 105 MINUTES.

*Periods longer than 90 minutes without power will result in certain Sensor Package 1 components falling below non-operational limits. The most sensitive component is the pan motor which is used to point the ITVC/LDRI for scanning. Reference ES3-95-007, Integrated Sensor Inspection System Sensor Package 1 (SP1) Handover Capabilities memorandum, April 14, 2005. Periods longer than 105 minutes without power will result in certain Sensor Package 2 components falling below non-operational limits. The most sensitive component is the Y-axis galvanometer which is used to direct the laser during scanning operations. Reference Laser Camera Head Thermal Analysis, NDG006275 Rev. May 4, 2005. ©[CR 7701 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A12-2

ORBITER BOOM SENSOR SYSTEM (OBSS) THERMAL  
CONSTRAINTS (CONTINUED)

2. IN THE EVENT THAT SENSOR PACKAGE 1 IS LEFT WITHOUT POWER FOR LONGER THAN 90 MINUTES AND/OR SENSOR PACKAGE 2 IS LEFT WITHOUT POWER FOR LONGER THAN 105 MINUTES, REAL-TIME ANALYSIS SHALL BE PERFORMED TO DETERMINE WARM-UP TIME(S) REQUIRED TO RETURN THE COMPONENT(S) TO OPERATIONAL TEMPERATURES SO THAT THEIR HEALTH CAN BE VERIFIED. @[CR 7701 ]

*The thermal analysis performed pre-flight covered a range of betas and various attitudes. The 90-minute and 105-minute survival times are based on the worst of the cases run for the limiting components. Thermal analysis done with the actual on-orbit conditions during the period the OBSS is without power can determine the time required to return the component(s) to operational temperatures. Once the warm-up times have elapsed, the health of the component(s) can be verified.*

F. SENSOR WARM-UP TIMES

1. AFTER SRMS OBSS UNBERTH, THE LDRI SHALL HAVE POWER APPLIED FOR 15 MINUTES PRIOR TO BEING MODED TO MODES 3, 4, 5, OR 6, AND THE LCS SHALL HAVE POWER APPLIED FOR 15 MINUTES PRIOR TO ANY SCANNING ACTIVITY. THE IDC SHALL HAVE (HEATER OR CAMERA) POWER APPLIED FOR 15 MINUTES PRIOR TO PHOTOGRAPHIC ACTIVITIES.
2. AFTER OBSS HANDOFF TO THE SRMS, THE LDRI SHALL HAVE POWER APPLIED FOR 2 HOURS PRIOR TO BEING MODED TO MODES 3, 4, 5, OR 6, AND THE LCS SHALL HAVE POWER APPLIED FOR 30 MINUTES PRIOR TO ANY SCANNING ACTIVITY. THE IDC SHALL HAVE (HEATER OR CAMERA) POWER APPLIED FOR 90 MINUTES PRIOR TO PHOTOGRAPHIC ACTIVITIES.

*Since insight into the LDRI, LCS, and IDC temperatures is not readily available once the OBSS is unberthed or handed off, power must be applied for a certain period of time before applying operational power to the electronics. LDRI modes 1 and 2 are acceptable modes without any warm-up time. @[CR 7701 ]*

## FLIGHT RULES

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### 12A\_A12-3 SRMS AND ORBITER BOOM SENSOR SYSTEM (OBSS) PARK

- A. THE SRMS MAY BE PARKED AT PRE-CRADLE FOR DOCKING. ©[CR 7701 ]

*Analysis has shown that Pre-cradle is an acceptable configuration to withstand docking loads. Reference SFOC Transmittal Form D43230-05-013, Docking Assessment with OBSS Attached to SRMS and SRMS at Pre-cradle, June 2005.*

- B. FOR A CONTINGENCY WHERE THE CONDITIONS OF RULE {12AA12-12}, STARBOARD MRL CONSTRAINTS, CANNOT BE MET PRIOR TO DOCKING, THE SRMS WITH THE OBSS MAY BE PARKED AT THE HANDOFF POSITION FOR DOCKING.

*Analysis has shown that the SRMS with the OBSS in the Handoff position is an acceptable configuration to withstand docking loads. Reference SFOC Transmittal Form D43230-05-013, Docking Assessment with OBSS Attached to SRMS and SRMS at Pre-cradle, June 2005. Docking with the OBSS on the SRMS is considered a contingency capability. Docking in this configuration would only be done if the OBSS cannot be cradled and latched per Rule {12A\_A12-12}, STARBOARD MRL CONSTRAINTS. The Handoff position is not an acceptable position for OMS burns. For OMS burns, the SRMS would remain grappled to the OBSS while berthed with as many latches as possible. OMS burn with OBSS grappled by SRMS with one MRL latched has not yet been analyzed.*

- C. FOR A CASE WHERE THE OBSS CANNOT BE BERTHED PRIOR TO UNDOCKING, THE SRMS WITH THE OBSS MAY BE PARKED AT THE HANDOFF POSITION FOR UNDOCKING.

*Analysis has shown that the SRMS with the OBSS in the Handoff position is acceptable configurations to withstand undocking loads including expedited undocking. Reference SFOC Transmittal Form D43230-05-012 and D43230-05-018, Dynamics Undocking and Rapid Safing Assessment with OBSS Attached to SRMS, June 2005 and August 2005. ©[CR 7701 ]*

- D. THE SRMS WITH THE OBSS MAY BE PARKED OVERNIGHT UNATTENDED AT THE OBSS PARK (SRMS AT PRE-CRADLE WITH OBSS GRAPPELLED) WHILE DOCKED. ©[CR 7701 ]

*In order to save time and reduce the amount of complex operations required during the docked mission, the OBSS may be left parked overnight unattended at the OBSS PARK position. Rule {A12-2}, UNATTENDED RMS CONSTRAINTS, allows a loaded SRMS to be parked overnight unattended for high priority payloads. ©[CR 7701 ]*

### 12A\_A12-4 THROUGH 12A\_A12-10 RULES ARE RESERVED

## FLIGHT RULES

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### STARBOARD MPM/MRL SYSTEMS MANAGEMENT

#### 12A\_A12-11

#### STARBOARD MPM DEPLOY/STOW CONSTRAINTS

- A. FOR LOSS OF STARBOARD MPM STOW REDUNDANCY, THE STARBOARD MPM'S WILL REMAIN DEPLOYED UNTIL OPERATIONS ARE COMPLETE. IF FAILURE OF THE REMAINING MPM STOW SYSTEM OCCURS WHILE DEPLOYED, OPERATIONS WILL CONTINUE UNTIL AN EVA CAN BE PERFORMED OR JETTISON IS REQUIRED. @[CR 7701 ]

*The starboard MPM's must be deployed to achieve mission success. Termination of activities due to loss of stow capability during operations will be of no benefit. A subsequent failure of the second MPM drive system would require an EVA to roll in the MPM or jettison of the MPM. EVA may be viable for electrical failures only (mechanical jam may result in jettison). Due to the priority of the mission objectives, the risk is acceptable.*

- B. FOR THE COMPLETE LOSS OF STARBOARD MPM MOTOR DRIVE CAPABILITY, AN EVA TO DEPLOY AND/OR STOW THE MPM'S WILL BE PERFORMED.

*The MPM must be deployed to achieve mission success. Electrical failures which prevent driving the MPM can be worked around via IFM or EVA; mechanical failures cannot. Due to the priority of the mission objectives, EVA support for these contingencies has been preflight planned.*

- C. THE STARBOARD MPM MUST BE FULLY DEPLOYED FOR OBSS UNBERTH/BERTH AND PAYLOAD UNBERTH/BERTH OPERATIONS.

*There are clearance concerns with OBSS grapple and unberth/berth with the starboard MPM's stowed. There are also clearance concerns during payload unberth/berth with the starboard MPM's stowed even if the OBSS is unberthed.*

- D. ONCE THE MPM'S ARE DEPLOYED, THEY MAY REMAIN DEPLOYED UNTIL MISSION OPERATIONS ARE COMPLETED. REFERENCE PARAGRAPHS A AND B FOR THE LOSS OF DUAL-MOTOR STOW CAPABILITY.

*With two-motor stow capability, there is no problem with leaving the MPM's deployed. Paragraphs A and B of this rule address the loss of dual-motor stow capability. The intent of this rule is to not require stowing the MPM's at the end of each day.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule. @[CR 7701 ]*

## FLIGHT RULES

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### 12A\_A12-12 STARBOARD MRL CONSTRAINTS

- A. OBSS OPERATIONS WILL BE ALLOWED TO CONTINUE WITH A COMPLETE LOSS OF STARBOARD MRL LATCH CAPABILITY. @[CR 7701 ]

*Two of three MRL's are required to be latched to allow the orbiter to dock and undock with the OBSS berthed. Three of three MRL's are required to be latched to allow the orbiter to enter with the OBSS berthed. Due to the importance of the OBSS operations, operations will be permitted to continue if the ability to latch three of three MRL's has been lost. The OBSS can be left on the SRMS for docking and undocking. The OBSS may be able to be left on the ISS or OBSS jettison is available as an alternative means to save the orbiter for entry.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule.*

- B. THE OBSS MUST HAVE TWO OF THREE MRL'S SECURED FOR DOCKING AND UNDOCKING AND OMS BURNS.

- C. THE OBSS MUST HAVE THREE OF THREE MRL'S SECURED FOR ENTRY.

*Each of the three MRL's have two independent drive motors, and either a mechanical jam would have to occur or both drive systems would have to fail to cause loss of latch capability for an MRL pedestal. IBA Strength Assessment: 2 of 3 MRL's latched + OMS Burn Condition (SRMS 83258) has shown that any two of three MRL's are acceptable for OMS burns, docking and undocking with no safety or loads concerns. OBSS Loads Analysis Report (NS04HB00) has shown that three of three MRL's must be secured during entry to prevent OBSS/radiator contact.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule. @[CR 7701 ]*

### 12A\_A12-13 STARBOARD MPM/MRL CYCLING

CYCLING OF THE STARBOARD MPM OR MRL SHALL ONLY BE PERFORMED WHILE THE OBSS IS BERTHED. @[CR 7701 ]

*There are two intentions for this rule. The first is to prevent MPM motion with the OBSS unberthed since there are clearance issues while berthing the OBSS with the starboard MPM's stowed. In particular, while the P3/P4 is berthed in the payload bay, it is not possible to berth the OBSS with the starboard MPM's stowed. The other is to prevent the latches from failing closed when the OBSS is unberthed. If this occurred, the OBSS could not be berthed with three of three latches, and would have to be jettisoned or left on ISS. @[CR 7701 ]*

### 12A\_A12-14 THROUGH 12A\_A12-20 RULES ARE RESERVED

## FLIGHT RULES

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### SRMS DRIVE SYSTEM MANAGEMENT

#### **12A\_A12-21      RATE SELECTION [CIL]**

DURING SRMS MANEUVERS OF THE ORBITER BOOM SENSOR SYSTEM (OBSS) USING THE PAYLOAD ID'S DESIGNED FOR SENSOR SCANS, COARSE RATE SELECTION IS PERMITTED EVEN WITHIN 10 FEET OF STRUCTURE. @[CR 7701 ]

*These rates are set based on sensor specifications, not through the typical implementation of the Marks formula for a payload with the mass of the OBSS. Rates calculated using the Marks formula would be higher. Therefore, the intent of Rule {A12-114}, ORBITER PROXIMITY CONSTRAINTS [CIL], will be maintained. @[CR 7701 ]*

#### **12A\_A12-22      AUTO MODE AVAILABILITY**

SRMS OPERATIONS IN SUPPORT OF THE ORBITER REPAIR MANEUVER (ORM) OR DAMAGE ASSESSMENT/REPAIR WITH THE OBSS CAN BE PERFORMED WITHOUT AUTO MODE AVAILABLE. @[CR 7701 ]

*Auto Mode is the preferred mode for performing the ORM and detection surveys with the OBSS, i.e., FD2 RCC surveys. However, the ORM and damage assessment/repair with the OBSS are extremely high priority tasks, and would therefore be performed with the best SRMS mode available.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule. @[CR 7701 ]*

#### **12A\_A12-23 THROUGH 12A\_A12-30 RULES ARE RESERVED**



## FLIGHT RULES

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### OBSS JETTISON SYSTEM MANAGEMENT

#### **12A\_A12-31      STARBOARD JETTISON SYSTEM CONSTRAINT**

- A. OBSS OPERATIONS SHALL BE ALLOWED TO CONTINUE IF EITHER OF THE STARBOARD JETTISON SYSTEM BUSES MNA ML86B OR MNC ML86B IS LOST, PROVIDED STARBOARD MPM STOW REDUNDANCY EXISTS.  
@[CR 7701 ]
- B. AN IFM WILL BE PERFORMED TO REGAIN A LOST STARBOARD JETTISON SYSTEM BUS WHEN CONVENIENT. THE IFM ONLY NEEDS TO BE PERFORMED UP TO THE POINT OF BEING INVASIVE TO THE ORBITER PANELS AND OTHER ORBITER SYSTEMS (I.E., RCS HEATERS) .

*With a starboard MPM redundancy failure and loss of a jettison system, the system is two failures away from a catastrophic situation in the event of an emergency deorbit. However, there is no means of verifying the current health of the alternate pyro system even though load and resistance tests were performed on turnaround. Therefore, if operations are allowed to continue in this posture, as much of the IFM should be performed as possible without impacting RCS heaters and by removing all but two of the panel A14 fasteners. With loss of RCS heaters, hotfiring of the affected RCS jets is the primary method to maintain thermal conditioning. A PRCS hotfire, if required, would be at odds with RMS operations. An additional 5 minutes will be required to complete the IFM should jettison subsequently be required.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule.*

- C. IF A STARBOARD JETTISON SYSTEM BUS IS LOST PRIOR TO COMPLETION OF OBSS OBJECTIVES, OPERATIONS WILL CONTINUE WITHOUT JETTISON SYSTEM REDUNDANCY.

*Operations may continue with the loss of a jettison system due to mission objective priorities. An IFM is available to restore a failed (short or open) jettison bus. This IFM will restore the jettison capability for any detected loss, but will impact other orbiter systems.*

*Rule {12A\_A12-41}, ORBITER BOOM SENSORY SYSTEM (OBSS) GO/NO-GO CRITERIA, references this rule. @[CR 7701 ]*

#### **12A\_A12-32 THROUGH 12A\_A12-40 RULES ARE RESERVED**

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**FLIGHT RULES**

GO/NO-GO CRITERIA

**12A\_A12-41 ORBITER BOOM SENSOR SYSTEM (OBSS) GO/NO-GO CRITERIA**

	CONTINUE OPERATIONS IF:					FLT RULE REF
	DAMAGE DETECT GRAPPLE UNBERTH	DAMAGE DETECT SURVEY	DAMAGE ASSESS/REPAIR GRAPPLE (HANDOFF) (HIGH PRIORITY)	CONTINUE DAMAGE ASSESS/REPAIR (HIGH PRIORITY)	ENTRY	
A. STBD MPM STOW MOTORS (2)	2 ↓ [1]	2 ↓ [1]	2 ↓ [1]	2 ↓ [1]		{12A_A12-11}
B. STBD MPM (3) STOWED INDICATIONS (6)					[2]	{12A_A12-11}
C. STBD MPM (3) DEP INDICATIONS (6)	FORWARD 1 ↓	FORWARD 1 ↓	FORWARD 1 ↓	FORWARD 1 ↓		{12A_A12-11}
D. STBD MRL LAT CAP (3)	1 ↓ [6]	3 ↓ [6]	3 ↓ [7]	3 ↓ [7]	0 ↓ [6]	{12A_A12-12}
E. STBD JETTISON (2)	1 ↓ [10]	1 ↓ [10]	1 ↓	1 ↓		{12A_A12-31}
F. PORT MPM STOW MOTORS (2)	2 ↓ [1]	2 ↓ [1]	2 ↓ [1]	2 ↓ [1]		{A12-72}
G. PORT MPM (4) DEP INDICATIONS (8)	SHOULDER 1 ↓	SHOULDER 1 ↓	SHOULDER 1 ↓	SHOULDER 1 ↓		{A12-72}
H. PORT MRL LAT CAP (3)	[8]	[8]	[9]	[9]		{A12-73}
I. PORT JETTISON (2)	1 ↓ [10]	1 ↓ [10]	1 ↓	1 ↓		{A12-181}
J. AUTO MODE (1)			1 ↓	1 ↓		{12A_A12-22}
K. MANUAL AUG MODE (1)			2 ↓ [3]	3 ↓ [3]		{A12-111}
L. DIRECT MODE (1)	1 ↓	1 ↓				{A12-111}
M. SINGLE MODE (1)						
N. BACKUP MODE (1)	0 ↓	0 ↓	0 ↓			{A12-111}
O. BRAKES (6)	0 ↓	0 ↓	0 ↓	0 ↓		{A12-115}
P. AUTO BRAKES (1)	0 ↓ [4]	0 ↓ [4]	0 ↓ [4]	0 ↓ [4]		{A12-116}
Q. CAPTURE & RIGIDIZE (2)	1 ↓		1 ↓			{A12-161}
R. DERIGIDIZE (2)	1 ↓	1 ↓	2 ↓	2 ↓		{A12-161}
S. RELEASE (2)	1 ↓ [1]	1 ↓ [1]	3 ↓ [1]	3 ↓ [1]		{A12-161}
T. BACKUP RELEASE (1)	0 ↓ [1]	0 ↓ [1]				{A12-161}
U. SRMS THERMAL	REQUIRED	REQUIRED	REQUIRED	REQUIRED		{A12-3}
V. SENSOR THERMAL	REQUIRED	REQUIRED	REQUIRED [5]	REQUIRED [5]		{12A_A12-2}

@[CR 7701 ]

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## FLIGHT RULES

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12A\_A12-41

ORBITER BOOM SENSOR SYSTEM (OBSS) GO/NO-GO  
CRITERIA (CONTINUED)

NOTES: @[CR 7701 ]

- [1] EVA CAPABILITY EXISTS FOR THE FOLLOWING CONTINGENCIES:
  - MPM DEPLOY/STOW
  - SRMS STRAPDOWN
  - OBSS BERTHING
  - GRAPPLE FIXTURE (GF) RELEASE
- [2] ONE AT THE FORWARD AND ONE AT EITHER THE MID OR AFT PEDESTAL IS REQUIRED.
- [3] ONE OF MANUAL, SINGLE, DIRECT, OR BACKUP REQUIRED FOR POSITIONING FOR DAMAGE ASSESSMENT/REPAIR AND JETTISON.
- [4] COMPUTER-SUPPORTED MODES UNAVAILABLE WITH LOSS OF AUTOBRAKES, BUT OPERATIONS IN DIRECT AND BACKUP CAN CONTINUE WITH THE LOSS OF AUTOBRAKES.
- [5] SENSOR THERMAL NOT REQUIRED FOR REPAIR OR HANDOFF FOR SSRMS CLEARANCES.
- [6] THREE MRL'S LATCHED REQUIRED FOR ENTRY. TWO MRL'S LATCHED REQUIRED FOR DOCK/UNDOCK (ONE OF WHICH MUST BE THE FWD MRL) OR OBSS LEFT ON SRMS DURING DOCK/UNDOCK. GO IF THERE IS A CONFIRMED CAPABILITY TO DOCK AND UNDOCK WITH THE OBSS ON THE SRMS. (THIS IS OPEN WORK THROUGH THE STS-114 JOP AT FOR BUT WILL BE CLOSED BEFORE FLIGHT.)
- [7] WITH THREE MRL'S FAILED, BOOM JETTISON OR CONTINGENCY STOW ON ISS WILL BE REQUIRED.
- [8] CONTINUE OPERATIONS IF ONE FAILURE WILL NOT RESULT IN THE INABILITY TO LATCH AT LEAST TWO MRL'S.
- [9] CONTINUE OPERATIONS EVEN IF ONE FAILURE WILL RESULT IN THE INABILITY TO LATCH AT LEAST TWO MRL'S (ASSUMES CURRENTLY HAVE TWO-LATCH CAPABILITY). EVA CAPABILITY REQUIRED.
- [10] SYSTEM REDUNDANCY OR JETTISON REDUNDANCY IFM REQUIRED. @[CR 7701 ]

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## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

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12A/STS-115  
12A-12A.1 STAGE

07/31/06

FINAL

ROBOTICS 12-12

Verify that this is the correct version before use.

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**FLIGHT RULES**

**JOINT SHUTTLE/ISS RULES**

GENERAL

**12A\_C12-1      ATTITUDE CONTROL CONSTRAINTS [RC] [C]**

STS AND ISS ATTITUDE CONTROL CONSTRAINTS FOR THE PLANNED MSS AND SRMS ATTACHED PAYLOAD OPERATIONS ARE SUMMARIZED IN TABLE 12A\_C2-54-I, P3/P4 INSTALLATION CONTROL CONSTRAINTS. USE OF AUTOMATIC ATTITUDE CONTROL MODES AT OTHER SSRMS CONFIGURATIONS IS ONLY PERMITTED PER RULES {A12-6}, OMS/RCS CONSTRAINTS, AND {B12-105}, SSRMS ATTITUDE CONTROL CONSTRAINTS FOR ISS [HC] [RC].

**12A\_C12-2      MSS REDUNDANCY FOR ITS P3/4 HANDLING [HC] [C]**

THE FOLLOWING TABLE DESCRIBES THE REAL-TIME RESPONSE TO MSS FAILURES AND DOCUMENTS 12A SPECIFIC EXCEPTIONS TO RULES {C12-1}, JOINT ISS-SHUTTLE MSS ACTIVITY PRE-CONFIGURATION AND TERMINATION [HC], AND {C12-3}, JOINT ISS-SHUTTLE MSS REDUNDANT WORKSTATION REQUIREMENT [HC].

TASK	REDUNDANCY LOST BEFORE:	REDUNDANCY LOST AFTER TASK IS IN PROGRESS:
P3/4 GRAPPLE AT HANDOFF	GO [1]	CONTINUE [1]
MANEUVER P3/4 FROM HANDOFF TO PRE-INSTALL	GO [1]	CONTINUE [1]
TRANSLATE P3/4 FROM PRE-INSTALL TO SSAS CAPTURE	GO [2]	CONTINUE [2]
CETA CART HANDLING	NO-GO [3]	CONTINUE

NOTES:

- [1] IF THE FAILURE SIGNATURE DOES NOT INDICATE A PROBLEM THAT WOULD AFFECT THE ALTERNATE STRING OR INDICATE A GENERIC SSRMS PROBLEM, THEN PROCEED ON THE ALTERNATE STRING. FOR P3/4 OPS, NOTE THAT END EFFECTOR OPERATIONS MAY PROCEED ON SINGLE STRING SINCE EVA PERSONNEL ARE AVAILABLE TO RELEASE THE GRAPPLE PIN IF NECESSARY.
- [2] REFERENCE RULE {12A\_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR SSRMS POSITIONS ACCEPTABLE FOR VARIOUS LOADS INCLUDING SHUTTLE UNDOCKING AND PROPULSIVE ATTITUDE CONTROL.
- [3] IF THE FAILURE SIGNATURE DOES NOT INDICATE A MECHANICAL JOINT PROBLEM AFFECTING BOTH STRINGS OR AN UNRECOVERABLE LOSS OF ONE STRING (DJOPS NOT AVAILABLE), OR AN ELBOW JOINT FAILURE, THEN PROCEED. @[DN 103 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C12-2

MSS REDUNDANCY FOR ITS P3/4 HANDLING [HC] [C]  
(CONTINUED)

*The risk to proceeding with P3/4 operations after the first failure is that the P3/4 truss element could be left on the SSRMS for an extended period of time and that the SSRMS could become stranded in a position difficult to service (after a second failure resulting in loss of SSRMS functionality).*

*Component thermal limits may be exceeded in this case. @[DN 103 ]*

*If the first failure is a joint failure, as long as it is not a mechanical problem (SSRMS is zero fault tolerant for mechanical problems), the other string is available to proceed nominally. The degraded joint ops (DJOPS) is available to provide a degraded backup string. For failures which are not recoverable via DJOPS, the concern is a second failure, which would put the other string at risk during the window of operations from SRMS handoff through install. If after discussion there is agreement that there is not a significant probability of another failure in this time window, then it is better to proceed so that the P3/4 truss element can be installed. The EVA crew is available to manually drive joints if required and shown to be feasible. If the failure is something other than those listed in note 3, a second failure would still allow the SSRMS to get the CETA cart to structure where it can be attached safely. @[DN 103 ]*

*Reference ISS Hazard Report CSA/SPAR-004-III, Loss of SSRMS Function Results in Either Loss of EVA Crew on End of SSRMS or Prevention of Safing of Orbiter Cargo Bay Door Closure and Deorbit; causes 1-3 refers to the possibility that the orbiter can be flown away despite an encroaching SSRMS. In this event, in order to be able to clear the SSRMS/payload combination away from the orbiter docking interface after the orbiter's departure, there must be ISS-based EVA capability.*

## FLIGHT RULES

**12A\_C12-3**

**MSS THERMAL CONSTRAINTS**

- A. DURING MT TRANSLATIONS BETWEEN WORKSITES, ALL COMPONENTS ON THE MSS CAN SURVIVE WITHOUT HEATER POWER FOR AT LEAST 24 HOURS WITH THE FOLLOWING EXCEPTIONS: @[DN 64 ]

**TABLE 12A\_C12-3-I - MBS COMPONENTS**

COMPONENT	WS [1]	+/-XVV [2]	MIN TIME (HOURS)	BETA ANGLE(S) [2]
MBS CLPA	4, 4-6, 4-7, 4-8	+XVV	4.8	+5
		-XVV	5.1	0, -5, -10
	6, 6-7, 6-8, 6-4	+XVV	8.1	-60
		-XVV	12.9	0, +60
	7, 7-8, 7-6, 7-4	+XVV	8.1	0
		-XVV	8.1	-35
8, 8-7, 8-6, 8-4	+XVV	6.6	+30, -20	
	-XVV	5.1	-35	
CRPCM	4, 4-6, 4-7, 4-8	+XVV	20.4	+60
		-XVV	18.9	-60
POA CLA	4, 4-6, 4-7, 4-8	+XVV	22.2	0
		-XVV	22.2	0
	8, 8-7, 8-6, 8-4	+XVV	22.2	0

NOTES:

- [1] THE ONLY WORKSITE LOCATIONS PLANNED TO BE UTILIZED FOR 12A ARE WS 4, WS 7, AND WS 8. WS 6 IS SHOWN FOR COMPLETENESS. THE ONLY PLANNED TRANSLATIONS FOR 12A ARE WS 4 TO WS 7, WS 7 TO WS 4, WS 4 TO WS 8, AND WS 8 TO 4. ALL OTHER TRANSLATION COMBINATIONS ARE SHOWN FOR COMPLETENESS.
- [2] +XVV ATTITUDE FOR POSITIVE SOLAR BETA ANGLES (YPR): -13, 15, -48. +XVV ATTITUDE FOR NEGATIVE SOLAR BETA ANGLES (YPR): 13, 17, 30. -XVV ATTITUDE FOR POSITIVE SOLAR BETA ANGLES (YPR): 193, 17, 30. -XVV ATTITUDE FOR NEGATIVE SOLAR BETA ANGLES (YPR): 167, 17, -48. @[DN 64 ]

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**FLIGHT RULES**

12A\_C12-3

**MSS THERMAL CONSTRAINTS (CONTINUED)**

**TABLE 12A\_C12-3-II - SSRMS COMPONENTS [3]**

COMPONENT	WS [1]	+/-XVV [2]	MIN TIME (HOURS)	BETA ANGLE(S) [2]
CLPA 1 (TIP ELB)	4, 4-6, 4-7	+XVV	4.8	-45
		-XVV	5.1	+35, +40, +45, +50
	6, 6-7, 6-4	+XVV	8.1	-25, -30
		-XVV	19.2	+15, +20, +25, +30
	7, 7-6, 7-4	+XVV	5.1	+30
		-XVV	6.6	-30
CLPA 2 (BASE ELB)	7, 7-6, 7-4	-XVV	14.4	-30
VDU 1 (TIP ELB)	7, 7-6, 7-4	+XVV	21.9	+30
		-XVV	18.9	-30
ACU 1 (BASE)	7, 7-6, 7-4	+XVV	14.9	+35
		-XVV	21.9	-35

NOTES: @[DN 64 ]

- [1] THE ONLY WORKSITE LOCATIONS PLANNED TO BE UTILIZED FOR 12A ARE WS 4, WS 7, AND WS 8. WS 6 IS SHOWN FOR COMPLETENESS. THE ONLY PLANNED TRANSLATIONS FOR 12A ARE WS 4 TO WS 7, WS 7 TO WS 4, WS 4 TO WS 8, AND WS 8 TO 4. ALL OTHER TRANSLATION COMBINATIONS ARE SHOWN FOR COMPLETENESS.
- [2] +XVV ATTITUDE FOR POSITIVE SOLAR BETA ANGLES (YPR): -13, 15, -48. +XVV ATTITUDE FOR NEGATIVE SOLAR BETA ANGLES (YPR): 13, 17, 30. -XVV ATTITUDE FOR POSITIVE SOLAR BETA ANGLES (YPR): 193, 17, 30. -XVV ATTITUDE FOR NEGATIVE SOLAR BETA ANGLES (YPR): 167, 17, -48.
- [3] ANALYSIS FOR WS4 AND WS7 DID INCLUDE THE SSRMS IN THE FOLLOWING CONFIGURATION: BASED ON MBS PDGF 3, LEE A AS BASE, SR = -60, SY = +90, SP = -225.7, EP = -140, WP = -63.7, WY = -45.3, WR = -114.3. THE ANALYSIS FOR WORKSITE (WS) 8 DID NOT INCLUDE SSRMS.

*During any MT translations, if the MT stops anywhere between worksites, and the MSS components remain without keep-alive power, the components listed in Tables 12A\_C12-3-I and 12A\_C12-3-II will violate their lower limits if heater power is not applied within the minimum time specified in the tables. In a contingency case, where the MT is failed between worksites, alternate methods may be employed to restore heater power, e.g., EVA-installed jumper cables. Note that the time starts at the beginning of MT translation, since that is when the MBS and SSRMS are unpowered.*

*The data presented in the above tables are the minimum times for each component to violate its lower thermal limits and the associated solar beta angles for both +XVV and -XVV for each worksite or translation. The times and associated solar beta angles shown are not the only instances in which these components have less than 24 hours survival time. For detailed survival times for all MSS components at specific solar beta angles, reference 12A Thermal Screening Analysis, HTR-1263, Revision B, September 9, 2005, and Revision A, October 14, 2004, performed by MacDonald, Dettwiler, and Associates Ltd. (MDA). @[DN 64 ]*

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**FLIGHT RULES**

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**12A\_C12-3            MSS THERMAL CONSTRAINTS (CONTINUED)**

B. MSS WARM-UP TIMES FOLLOWING TRANSLATIONS: @[DN 64 ]

1. AFTER PERIODS WITHOUT KEEP-ALIVE POWER, MSS COMPONENTS SHALL HAVE KEEP-ALIVE POWER APPLIED FOR SPECIFIC MINIMUM DURATIONS AS LISTED BELOW, PRIOR TO GOING OPERATIONAL OR BEING COMMANDED ON.

**TABLE 12A\_C12-3-III - MSS COMPONENT WARM-UP TIMES**

PERIOD WITHOUT POWER	MBS MCU	SSRMS ACU	MBS VDU	SSRMS VDU
15 MINUTES - 1 HOUR	---	---	---	6 MINUTES
2 HOURS	---	---	6 MINUTES	6 MINUTES
3 HOURS	---	6 MINUTES	6 MINUTES	12 MINUTES
4 HOURS	---	6 MINUTES	12 MINUTES	36 MINUTES
5 HOURS	---	12 MINUTES	18 MINUTES	42 MINUTES
6 HOURS	6 MINUTES	18 MINUTES	24 MINUTES	60 MINUTES
7 HOURS	12 MINUTES	18 MINUTES	36 MINUTES	78 MINUTES

2. AFTER PERIODS WITHOUT KEEP-ALIVE POWER, MSS CAMERAS SHALL HAVE KEEP-ALIVE POWER APPLIED UNTIL COMPONENT TEMPERATURES ARE AT ACCEPTANCE LIMITS, PER RULE {B12-104}, MSS THERMAL CONSTRAINTS [C], PARAGRAPH C, PRIOR TO BEING COMMANDED ON.

IF TEMPERATURE DATA IS UNAVAILABLE, MSS CAMERAS SHALL HAVE KEEP-ALIVE POWER APPLIED FOR SPECIFIC MINIMUM DURATIONS, AS SHOWN BELOW, PRIOR TO BEING COMMANDED ON. @[DN 64 ]

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**FLIGHT RULES**

12A\_C12-3

**MSS THERMAL CONSTRAINTS (CONTINUED)**

**TABLE 12A\_C12-3-IV - MSS CAMERA WARM-UP TIMES**

PERIOD WITHOUT POWER	MBS CLPA	SSRMS CLPA	SSRMS CLA
15 - 30 MINUTES	6 MINUTES	18 MINUTES	6 MINUTES
45 MINUTES	21 MINUTES	30 MINUTES	24 MINUTES
1 HOUR	30 MINUTES	36 MINUTES	24 MINUTES
2 HOURS	42 MINUTES	66 MINUTES	24 MINUTES
3 HOURS	72 MINUTES	84 MINUTES	36 MINUTES
4 HOURS	84 MINUTES	144 MINUTES	36 MINUTES
5 HOURS	84 MINUTES	156 MINUTES	78 MINUTES
6 HOURS	84 MINUTES	180 MINUTES	78 MINUTES
7 HOURS	90 MINUTES	210 MINUTES	78 MINUTES

©[DN 64 ]

*In keep-alive mode, the MSS component thermistors and heaters are self-regulating based on pre-set set-point temperatures. However, component temperatures can only be monitored when the MBS/SSRMS is in Operational. MCU/ACU, VDU, and camera temperatures can only be monitored when VDU's are on. The MSS avionics boxes should not be powered up unless and until the cards are above the specified minimum acceptance temperature. Failure to comply could result in thermal damage to components. Therefore, the only means to mitigate the risk of permanent damage to the avionics is to leave the MBS and SSRMS in keep-alive mode for long enough to ensure (via analysis) that all components will be within the acceptable temperature ranges before being operated. For periods without power between those listed in the table, a linear increase in required warm-up times will be assumed. Warm-up times assume both MSS strings in keep-alive mode, additional analysis is required for single-string keep-alive cases.*

*Reference 12A Thermal Screening Analysis, HTR-1263, Revision B, September 9, 2005, and Revision A, October 14, 2004, performed by MacDonald, Dettwiler, and Associates Ltd. (MDA). ©[DN 64 ]*

## FLIGHT RULES

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12A\_C12-4

ORBITER BOOM SENSOR SYSTEM (OBSS) POWER  
CONSTRAINTS [HC]

- A. KEEP-ALIVE POWER THROUGH THE STARBOARD FORWARD MANIPULATOR POSITIONING MECHANISM (MPM) WILL BE REMOVED PRIOR TO UNBERTH UNTIL AFTER REBERTH OF THE ORBITER BOOM SENSOR SYSTEM (OBSS). ©[CR 7701 ]

*The OBSS avionics and sensors receive keep-alive heater power through contacts on the forward end of the OBSS and the starboard forward MPM. Removing power through the starboard forward MPM during unberth and reberth will prevent arcing and sparking through the contacts. Keeping the power removed while the OBSS is unberthed from the starboard MPM's will prevent shorts due to debris and prevent the starboard forward MPM contacts from being an EVA hazard.*

- B. SPECIAL PURPOSE END EFFECTOR (SPEE) CONNECTOR POWER WILL BE REMOVED PRIOR TO GRAPPLING THE OBSS ELECTRICAL FLIGHT-RELEASABLE GRAPPLE FIXTURE (EFGF), DURING UNBERTH OF THE OBSS, PRIOR TO BERTH IN THE STARBOARD MPM'S, AND DURING UNGRAPPLE OF THE OBSS EFGF.

*The OBSS sensors receive operational and heater power through the interface of the SPEE connector on the SRMS EE and the ERGF. Removing SPEE connector power will prevent arcing and sparking during grapple and ungrapple, and prevent power from flowing into the starboard forward MPM contacts during unberth and berth. Grapple and ungrapple includes during handoff from/to the SSRMS. ©[CR 7701 ]*

## FLIGHT RULES

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12A\_C12-5

SSRMS/OBSS REBERTH CONSTRAINTS [HC] [C]

THE FOLLOWING CONSTRAINTS SHALL BE APPLIED TO THE SSRMS BERTHING OF THE OBSS INTO THE PAYLOAD BAY: @[CR 7701 ]

- A. THE OBSS CAN BE LATCHED IN THE PLB IF THE FOLLOWING MINIMUM CONDITIONS ARE MET:
  - 1. ALL THREE MRL'S INDICATE READY FOR LATCH.
  - 2. ROLL AXIS MISALIGNMENT IS LESS THAN 2 DEG.
- B. DURING LATCHING, THE MRL'S SHALL BE DRIVEN IN SINGLE MOTOR TIME.
- C. THE LATCHING SHALL BE EXECUTED IN TWO PHASES:
  - 1. PHASE 1: MRL'S SHALL BE DRIVEN BETWEEN 5 AND 7 SECONDS TO TOPOLOGICAL CAPTURE WHILE THE SSRMS SHOULDER AND ELBOW JOINTS ARE IN POSITION HOLD AND THE WRIST JOINTS ARE LIMPED.
  - 2. PHASE 2: MRL'S ARE DRIVEN TO FULL SEAT WITH THE SSRMS JOINTS LIMPED OR BRAKED AND THE LEE CARRIAGE AT A ZERO PRELOAD POSITION.
- D. REMOVAL OF SSRMS LEE PRELOAD DURING PHASE 2 SHALL ONLY OCCUR AFTER CONFIRMATION OF THE FOLLOWING ITEMS:

ALL THREE MRL'S INDICATE READY FOR LATCH.

*Imposing constraints on the misalignments and latching sequence during OBSS reberth ensures that the loads generated in the system, as result of the latches pulling on the SSRMS, are within the flight planning limits. Operator-in-the-loop runs have shown that the operator can consistently maintain the roll misalignment (defined along the long axis of the OBSS) to within 2 deg provided adequate lighting conditions. Limping the wrist joints reduces the SSRMS resistance to the MRL's while allowing the shoulder and elbow joints to maintain the readys. Driving the latches in single-motor time reduces the loads rise time in the event of SSRMS safing during latching. Single-motor time is achieved with the following MRL circuit breakers open: MCA PWR AC2 3Φ MID 2, MCA PWR AC3 3Φ MID 2, and MCA PWR AC3 3Φ MID 4. Analysis shows that topological capture is achieved by driving the MRL's for 5-7 seconds in single-motor time. Since there is no telemetry on the MRL position while at an intermediate state, confirmation of topological capture is done by verifying the motor drive characteristics (motor currents and drive time) on the ground. Removing the LEE preload is achieved by derigidizing the SSRMS LEE. Analysis shows that reducing the LEE/GF interface stiffness through derigidization drastically reduces the loads built up in the SSRMS in the event of safing during latching. @[CR 7701 ]*

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## FLIGHT RULES

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12A\_C12-5

SSRMS/OBSS REBERTH CONSTRAINTS [HC] [C]  
(CONTINUED)

*Reference: Hazard Report ISS-MCH-0111-LF1, Inability to gain/maintain structural integrity using attachment mechanisms during ISS-based Orbiter Thermal Protection System (TPS) Inspection or Repair. ©[CR 7701 ]*

## FLIGHT RULES

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VIDEO SYSTEM MANAGEMENT

**12A\_C12-21**      **RESERVED** @[DN 109 ]

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## FLIGHT RULES

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SPACE VISION SYSTEM MANAGEMENT

12A\_C12-41      RESERVED @[DN 109 ]

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12A/STS-115  
12A-12A.1 STAGE

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 13 - AEROMEDICAL1

#### SHUTTLE ONLY RULES

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## **FLIGHT RULES**

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# FLIGHT RULES

## SECTION 13 - AEROMEDICAL

### SHUTTLE ONLY RULES

#### 12A\_A13-1 SHUTTLE COMPOUND SPECIFIC ANALYZER - COMBUSTION PRODUCTS (CSA-CP) MANAGEMENT

THE SHUTTLE CSA-CP PROVIDES BIASED READINGS AT PRESSURES OTHER THAN ITS CALIBRATION PRESSURE (14.7 PSIA). TABLE 12A\_A13-1-I LISTS THE INDICATED CSA-CP VALUES WHICH, WHEN PRESSURE-CORRECTED, EQUATE TO THE 24-HOUR SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATION (SMAC) LIMITS FROM RULE {A13-157G}, CABIN ATMOSPHERE CONTAMINATION FIRE/SMOKE. WHENEVER THE CSA-CP IS BEING USED, COMPARE THE INDICATED CSA-CP VALUES DIRECTLY WITH THE VALUES IN THE FOLLOWING TABLE INSTEAD OF THE 24-HOUR SMAC LIMITS SHOWN IN RULE {A13-157G}, CABIN ATMOSPHERE CONTAMINATION FIRE/SMOKE. THE VALUES LISTED IN THE TABLE BELOW ARE THE FIRE/SMOKE QUICK DON MASK (QDM) MASKING LEVELS FOR VARIOUS CABIN PRESSURES. NO CORRECTION FACTOR NEEDS TO BE APPLIED TO THE INDICATED CSA-CP VALUES WHEN USING THE VALUES IN THIS TABLE. @[CR 7480 ]

**TABLE 12A\_A13-1-I - CSA-CP READINGS EQUIVALENT TO 24-HOUR SMAC LIMITS (MASKING LEVELS)**

CABIN PRESSURE (PSIA)	HCN (PPM)	CO (PPM)	HCL (PPM)
16.00 - 14.00	4.0	20	2.0
13.99 - 12.00	2.9	20	*
11.99 - 10.0	2.2	19	*
9.99 - 8.00	1.8	18	*

\* PRESSURE-CORRECTED VALUES ARE NOT GIVEN FOR HCL BECAUSE THE CSA-CP IS NOT CHARACTERIZED FOR HCL AT REDUCED PRESSURES. THE HCL LIMIT SHOULD ONLY BE USED WHEN PRESSURE IS ABOVE 14.0 PSIA.

*The shuttle CSA-CP is used as one of the indicators to determine when the crew can doff QDM's as outlined in Rule {A13-157G}, CABIN ATMOSPHERE CONTAMINATION FIRE/SMOKE, following a fire or smoke event. CSA-CP unit testing indicated the hydrogen cyanide (HCN) and carbon monoxide (CO) sensors of the CSA-CP are biased low at lower pressures. Therefore, the actual constituent levels in the cabin could be higher than the CSA-CP unit readings. @[CR 7480 ]*

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## FLIGHT RULES

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12A\_A13-1

### SHUTTLE COMPOUND SPECIFIC ANALYZER - COMBUSTION PRODUCTS (CSA-CP) MANAGEMENT (CONTINUED)

The values in the table represent the indicated CSA-CP values at various cabin pressures. If appropriate pressure corrections are applied, the values listed in the table would equal the 24-hour SMAC for those compounds. Using the equivalent 24-hour SMAC limits provides a conservative approach to the biased readings that the CSA-CP provides. ©[CR 7480 ]

The true atmospheric contaminant concentrations at reduced pressure must be obtained by the flight control team by correcting the CSA-CP display value using the following equations:

$$C_t = D * CF$$

Where

$C_t$  = True atmospheric contaminant Concentration (ppm)

$D$  = CSA-CP Displayed value called down by the crew (ppm)

$CF$  = CSA-CP Correction Factor for that contaminant at that atmospheric pressure (unitless)

and the correction factors for carbon monoxide and hydrogen cyanide are given by:

Carbon Monoxide:  $CF = 1.4175127 + (-0.051128817P) + 0.0015392319P^2$

Hydrogen Cyanide:  $CF = -0.2117P + 4.111$

Where

$P$  = Absolute pressure at the time of the CSA-CP display call-down (psia)

A correction factor for HCl is not provided because HCl is too reactive a gas to be able to perform reduced pressure testing in the laboratory. However, the probability of a combustion event that does not produce CO is remote; hence, the progress of post-fire cabin cleanup can be monitored by measurement of CO and HCN, both of which are more difficult to remove than HCl.

The current shuttle CSA-CP design is certified as Criticality 3/3 GFE with an operational pressure range of 13.3 psia to 16.1 psia. However, limited ground testing has demonstrated that the STS-121 flight unit will perform nominally at lower pressures if the correction algorithms are applied.

Documentation: Orbit Flight Techniques Panel #220, May 9, 2005; SF2 05-41, STS-114 Compound-Specific Analyzer for Combustion Products (CSA-CP) Use at Reduced Pressures, June 2005; and judgment of the NASA Chief Toxicologist. ©[CR 7480 ]

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## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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12A\_C13-1

#### IODINATED WATER IN EVA DRINK BAGS

- A. DURING EVA, THE EVA CREWMEMBERS MAY CONSUME IODINATED WATER FROM THE EVA DRINK BAGS. ©[DN 26 ]
- B. DRINK BAG FILLS PRECEDING AN EVA BY MORE THAN 24 HOURS MUST CONTAIN IODINATED WATER. THE ORBITER GALLEY SHOULD BE PLACED IN THE "OVERNIGHT" CONFIGURATION FOR THE DURATION OF DRINK BAG FILLS TO ENSURE PROPER IODINE LEVELS.

*Consuming iodinated water from the EVA drink bags would result in consuming at most an additional 4 mg of iodine per EVA. According to consultants in this field, if the crewmember's thyroid stimulating hormone (TSH) is normal, the additional iodine consumed during the EVA would have no medical impact. Although Rule {A13-30}, IODINE REMOVAL REQUIREMENT [HC], limits daily iodine consumption to 1 mg per day, the Medical Operations Branch considers this increase an acceptable risk. Nominally, the EVA disposable in-suit drink bags (DIDB) will be used, and they will be filled with non-iodinated water. To ensure drink bag sterility if bags are filled 24 hours or greater before an EVA, the water must be properly iodinated. This will be the case when the orbiter galley is placed in the "overnight configuration". ©[DN 26 ]*

## FLIGHT RULES

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### 12A\_C13-2

### CABIN ATMOSPHERE CONTAMINATION - AMMONIA

- A. THE SHUTTLE CREW SHALL TAKE THE FOLLOWING ACTIONS FOLLOWING A CONFIRMED AMMONIA LEAK INTO THE ISS UNITED STATES ON-ORBIT SEGMENT (USOS) (TOX LEVEL 4 HAZARD, REFERENCE RULE {A13-155}, ORBITER HAZARDOUS SUBSTANCE SPILL RESPONSE [HC]): @[CR 7700 ]
1. PERFORM JOINT EMERGENCY EGRESS AND CLOSE HATCHES BETWEEN SHUTTLE AND ISS. DON PERSONAL PROTECTION EQUIPMENT (PPE) AS REQUIRED.
  2. ALL SHUTTLE CREWMEMBERS SHALL DON AND ACTIVATE SHUTTLE QUICK DON MASKS (QDM'S).
  3. SHUTTLE CLEANUP CREW SHALL TAKE THE FOLLOWING ACTIONS:
    - a. UNSTOW IVA AMMONIA DETECTION KIT AND OBTAIN READINGS PER CREW PROCEDURE
    - b. ENSURE AIRLOCK FAN OFF
    - c. CABIN TEMPERATURE CONTROLLER TO FULL COOL
    - d. INSTALL ATCO AND ONE FRESH LIOH CANISTER
    - e. TURN ON WCS
    - f. ACTIVATE SECOND WATER LOOP
    - g. CHANGE OUT CLOTHING AS PRACTICAL
  4. CREW SHALL PERFORM A CABIN DEPRESS TO 8 PSI AND A CONTINUOUS CABIN PURGE AT 8 PSI IF REQUIRED TO CONTROL PPO<sub>2</sub>. (REFERENCE RULE {A17-254}, CABIN O<sub>2</sub> CONCENTRATION).

*Ammonia is a colorless gas with a penetrating, pungent, and suffocating odor. Ammonia gas is also a severe irritant to the eyes, respiratory tract, and skin. Symptoms may include burning and tearing of the eyes, runny nose, coughing, chest pain, and death. The severity of injury depends upon the concentrations and duration of exposure. Short term exposure (5 minutes) to high concentrations (over 300 ppm or 200 mg/m<sup>3</sup>) is intolerable due to burning eyes, respiratory irritation that produces nasal congestion, and shortness of breath. Acute short-term exposure to 700 ppm can cause severe eye irritation. Acute short-term exposure of 1700 ppm will cause laryngospasm. Levels of 2500 ppm and greater can cause death. Reference Wong, 1994 (SMAC document). @[CR 7700 ]*

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## FLIGHT RULES

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12A\_C13-2

**CABIN ATMOSPHERE CONTAMINATION - AMMONIA**  
**(CONTINUED)**

*The ISS uses anhydrous ammonia in its early external thermal control system (EETCS). If a failure of an EETCS interface heat exchanger (IFHX) occurs, ammonia will mix with the water cooling loop and gaseous ammonia will inevitably be expelled into the cabin of the ISS. Each of the two cooling loops contains approximately 110 pounds (50 kg) of ammonia (NH<sub>3</sub>). Following the activation of the permanent external thermal control system (ETCS) after 12A.1 that number will increase to 300 pounds (136 kg). ©[CR 7700 ]*

*The table below shows the potential effects of ammonia exposure. Note that there will be a wide variety of human responses to specific concentrations because of differences in inherent susceptibility and differences in adaptation:*

**TABLE 12A\_C13-2-I - AMMONIA EFFECTS**

CONCENTRATION PARTS PER MILLION (PPM)	EXPOSURE DURATION	ESTIMATED EFFECT
10	LONG	NO EFFECTS
20	SHORT	SLIGHTLY IRRITATING TO MUCOUS MEMBRANES
50	LONG	MILD EYE, THROAT, AND MUCOSAL IRRITATION
100	SHORT	UPPER RESPIRATORY TRACT IRRITATION
300	SHORT	BURNING EYES, NASAL EYE IRRITATION, CONGESTION, ACUTE SHORTNESS OF BREATH
400	SHORT	IMMEDIATE THROAT IRRITATION
700	SHORT	SEVERE EYE IRRITATION
1700	SHORT	LARYNGOSPASM
2500	SHORT	DEATH

©[CR 7700 ]

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## FLIGHT RULES

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12A\_C13-2

### CABIN ATMOSPHERE CONTAMINATION - AMMONIA (CONTINUED)

*The table below lists the SMAC levels established by the JSC Toxicology group. ©[CR 7700 ]*

*The immediate priorities for a level 4 spill are to prevent crew exposure to the substance and to configure the ARS to scrub the environment. All crewmembers will don and activate QDM's to avoid any debilitating effects.*

*Hatches will be closed to prevent additional mixing of contaminated ISS atmosphere with the shuttle atmosphere.*

*The IVA Ammonia Detection Kit will allow the crew to determine the level of ammonia contamination in the orbiter. The crew procedures will utilize this kit to sample the cabin environment while configuring the orbiter to scrub the NH<sub>3</sub> from the atmosphere. A total of 30 Draeger tubes will be flown: 20 high-range (30-700 ppm) and 10 low-range (5-30 ppm).*

*The atmosphere sampling will be performed as follows: One Draeger pump will be used to perform high-range draeger tube sampling until the cabin concentration for two consecutive samples is less than 20 ppm. Sampling using low-range tubes will be used until the cabin concentration is less than 10 ppm. A final sample using the alternate Draeger pump and a low-range tube will be used to verify cabin concentration is less than 10 ppm prior to the crew doffing QDM's. Sampling will be performed every 30 minutes or on MCC call based on trend data.*

*Due to the solubility of ammonia, it can be condensed out of the atmosphere and sent in solution to the waste water system. Therefore, the crew will place the cabin temp controller to the "FULL COOL" position thus maximizing airflow across the ARS condensing heat exchanger.*

*The Ambient Temperature Catalytic Oxidizer (ATCO) is installed and aids in the removal of the NH<sub>3</sub> from the cabin air. A fresh LiOH canister is installed to ensure CO<sub>2</sub> levels are in an acceptable range once the cabin air is cleaned and the crew doffs QDM's. The WCS odor/bacteria filter is designed to remove ammonia (NH<sub>3</sub>) from the airflow through the WCS. Activation of the WCS commode will initiate the maximum airflow through the odor/bacteria filter and aid in scrubbing ammonia from the cabin atmosphere.*

*Activation of the second water coolant loop (WCL) will change the efficiency of the WCL HX and subsequently increase humidity in the orbiter cabin. Since NH<sub>3</sub> has a high affinity for water, the combination of increasing humidity and maximizing airflow across the ARS condensing heat exchanger to remove this humidity, will expedite NH<sub>3</sub> removal from the cabin. ©[CR 7700 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C13-2

### CABIN ATMOSPHERE CONTAMINATION - AMMONIA (CONTINUED)

*Changing out clothing is listed "as practical" because there is currently no requirement for crewmembers to select long pants, and long-sleeved shirts as part of their in-flight wardrobe. Donning long sleeves, long pants and gloves may minimize the amount of exposed skin and further protect the crewmembers from exposure to the toxic products. Contaminated clothes may be doffed, bagged, labeled, and stowed. ©[CR 7700 ]*

*A cabin depress to 8 psi and continuous purge at 8 psi will manage O<sub>2</sub> concentrations below maximum levels as well as decrease the concentration of the level 4 substance. This action could extend the time on orbit so as to avoid an ELS entry. Based on preliminary engineering estimates, 75 ppm to 10 ppm - 50 minutes, 150 ppm to 10 ppm - 66 minutes, and 350 ppm to 10 ppm - 86 minutes*

*Breathing 100 percent oxygen for extended periods of time can cause deleterious effects to the respiratory system. The FCR Surgeon and EECOM will determine the length of time the crew can continue to breathe 100 percent oxygen, reference Rules {A13-54}, 100 PERCENT OXYGEN USE CONSTRAINT and {A17-254}, CABIN O<sub>2</sub> CONCENTRATION.*

B. THE MCC WILL ASSIST IN EVALUATING THE CABIN CONCENTRATION OF AMMONIA. THE CREW WILL SEQUENTIALLY DOFF QDM'S BASED ON THE FOLLOWING OR ON MCC CALL. THE DOFFING SEQUENCE WILL BE DETERMINED BY THE CDR.:

1. AMMONIA DRAEGER TUBE READING <= 15(10) PPM
2. CREW SYMPTOMS

*Crew will remove QDM's based on coordinated communication with the Flight Director, Surgeon, and EECOM. Doffing QDM's sequentially will reduce the possibility that the entire crew will be simultaneously affected by unexpected high ammonia concentrations. QDM's will be donned if any symptoms are incurred. QDM's can stay doffed if crewmembers remain symptom-free for greater than 10 minutes. For crew comfort, crewmembers may don QDM if symptoms reoccur.*

*There are thirty Draeger tubes available for sampling the atmosphere. Taking samples once every 30 minutes will provide adequate insight into the rate of decontamination so as not to deplete the Draeger tube supply before a "clean" cabin is reached. Therefore, termination of cabin cleanup will be determined by trend data, crew symptoms, and MCC call. The indicated level of 10ppm is equivalent to the 7-day SMAC level. ©[CR 7700 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C13-2

**CABIN ATMOSPHERE CONTAMINATION - AMMONIA**  
**(CONTINUED)**

*At the direction of the NASA toxicologist, no operational pressure correction is required. Toxicologists report contaminant concentration and express SMAC values in terms of mg/m<sup>3</sup> (milligrams of contaminant per cubic meter of air). Draeger tube markings present the data in terms of ppm (parts per million) assuming the measurement is made at 14.7 psia. Medical effects depend on how many grams (or moles) of ammonia are in a volume of air inhaled. Because the Draeger pump supplies a uniform volume of air (regardless of pressure) - the Draeger tube readings directly measure how many grams (or moles) of ammonia are present in a volume of air regardless of atmospheric pressure. If the SMAC values and medical limits are a function of mg/m<sup>3</sup>, and expressed in terms of mg/m<sup>3</sup>, no pressure correction should be performed. ©[CR 7700 ]*

**TABLE 12A\_C13-2-II - SMAC LEVELS**

AMMONIA		
EXPOSURE TIME	PPM	MG/M3 (14.7 PSI)
1-HOUR	30	21
24-HOURS	20	14
7-DAYS	10	7

**TABLE 12A\_C13-2-III - REDUCED PRESSURE DRAEGER MEASUREMENTS (PPM AND MG/M3)**

14.7 PSIA			8.0 PSIA		
TUBE MARKIN G	PPM	MG/M3	TUBE MARKIN G	PPM	MG/M3
5	5	3.5	5	9.2	3.5
10	10	6.9	10	18.4	6.9
20	20	13.9	20	36.8	13.9
30	30	20.8	30	55.1	20.8
40	40	27.8	40	73.5	27.8
50	50	34.7	50	91.9	34.7
60	60	41.7	60	110.3	41.7
70	70	48.6	70	128.6	48.6

©[CR 7700 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C13-2

**CABIN ATMOSPHERE CONTAMINATION - AMMONIA**  
**(CONTINUED)**

C. MISSION DURATION IMPACTS WILL DEPEND ON TIME AND LEVEL OF EXPOSURE, CREW SYMPTOMS, AND CLINICAL JUDGMENT. ®[CR 7700 ]

*A real-time decision is to be made by the Flight Director, Surgeon, EECOM, and any other disciplines involved with the decision-making process to perform a landing after the crew has been exposed to ammonia. The actual mission duration or extension will be dependent upon such factors as time and level of ammonia exposure, continuing crew symptoms, and clinical medical judgment on the short-term risks of ammonia exposure for chronic delayed effects.*

**DOCUMENTATION:**

*Reference Rules {A13-155}, ORBITER HAZARDOUS SUBSTANCE SPILL RESPONSE [HC]; {A15-203}, CABIN ATMOSPHERE DECONTAMINATION FOLLOWING EVA; and {C17-10}, EMERGENCY PROCEDURES - ISS MANNED/MATED OPERATIONS [RC] [E].*

*“Ammonia” in JSC Toxicology Database.*

*“Ammonia Toxicity Flight Manual” by Robert S. Levy, Aerospace Medical clerk, October 2002.*

*Orbit Pocket Checklist “Hazardous Substance Spill Response -- Orbiter” cue card.*

*Wong, K. L., Ammonia (NH<sub>3</sub>) in Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol. 1, pp 39-60 (1994).*

*Draeger website ([www.draeger.com](http://www.draeger.com)) and catalog. ®[CR 7700 ]*

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## **FLIGHT RULES**

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### **SECTION 14 - SPACE ENVIRONMENT**

THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION

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## **FLIGHT RULES**

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# FLIGHT RULES

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## SECTION 15 - EXTRAVEHICULAR ACTIVITY (EVA)

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## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

#### GENERAL

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**FLIGHT RULES**

**SECTION 15 - EXTRAVEHICULAR ACTIVITY (EVA)**

**SHUTTLE ONLY RULES**

**12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION**

A. SIMPLIFIED AID FOR EVA RESCUE (SAFER) WILL NOT BE USED FOR LARGE AREA, THERMAL PROTECTION SYSTEM (TPS) MAPPING WITH A HAND HELD OR OTHER MANUALLY OPERATED CAMERA. @[CR 7642 ]

*Due to the mental workload during SAFER inspection flights, the crew must be able to focus on flight control while in motion. Any inspection activities should be reserved for periods of flight that have little relative motion with respect to the vehicle. This limits SAFER to point inspection only and precludes TPS mapping tasks.*

*Reference GFE Hazard Report US-SAFER-02, Impact/Collision with Structure During TPS Inspection.*

B. SUFFICIENT SAFER CONSUMABLES MUST BE RESERVED FOR THE DIFFERENT PHASES OF A TPS INSPECTION FLIGHT. THE FOLLOWING TABLE DEFINES THE CONSUMABLE REDLINES FOR POWERON TIME, GN<sub>2</sub>, AND POWER:

	MAX POWERON TIME PER EVA (MINUTES) [11]	GN <sub>2</sub> % [7]	PWR% [10]
GO FOR SINGLE/ SUBSEQUENT DAMAGE INSPECTION	23 (10)	45 (60)	38 (45)
TERMINATE INSPECTION	32	30	34
FLIGHT PLANNING	32 - N*9, (10)	30 + N*15, (60)	34 + N*4, (45)
SAFER UNUSABLE	45	0	28

N = NUMBER OF PLANNED INSPECTION SITES DURING FLIGHT

() = INDICATES UNIQUE REQUIREMENTS FOR DUROMETER MEASUREMENT FLIGHTS @[CR 7642 ]

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## FLIGHT RULES

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**12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)**

- C. A SINGLE SAFER UNIT CAN BE USED ON MULTIPLE INSPECTION FLIGHTS DURING THE SAME EVA. TOTAL ALLOWABLE HAND CONTROLLER MODULE (HCM) DEPLOYED TIME IS 1:15 (POWERED OR UNPOWERED). THEREFORE, THE HCM MUST BE POWERED OFF AND STOWED IN THE PROPULSION MODULE, WHILE NOT IN USE, TO PREVENT THERMAL DAMAGE. @[CR 7642 ]

*During TPS inspection EVA's, it may be desirable to relocate the arm closer to specific damage sites between SAFER flights. See GO/NO-GO matrix for details of power-on time limitations.*

- D. A SAFER CHECKOUT MUST BE PERFORMED WITHIN 24 HOURS OF THE INSPECTION EVA. IN ADDITION, A SAFER SELF-TEST MUST BE PERFORMED AT VACUUM IMMEDIATELY PRIOR TO INITIATION OF THE INSPECTION FLIGHT. THE FOLLOWING MATRIX AND NOTES DISCUSS THE CRITERIA THAT DETERMINE THE GO/NO-GO TO BEGIN A SAFER TPS INSPECTION FLIGHT. IF ANY OF THESE NO-GO CONDITIONS OCCUR DURING THE SAFER FLIGHT, THE CREW MUST TERMINATE THE INSPECTION AND RETURN TO STRUCTURE. @[CR 7642 ]

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## FLIGHT RULES

12A\_A15-1

GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)

FOR LOSS OF:	EVA STATUS
<b>THRUSTERS:</b>	
ANY NUMBER FAILED ON [1]	NO-GO
SINGLE FAILED OFF [2]	-
MULTIPLE FAILED OFF [3]	NO-GO
<b>AAH:</b>	
SINGLE AXIS [4]	NO-GO
RATE SENSOR DATA [5]	NO-GO
<b>PROPULSION:</b>	
PROPULSION SYSTEM PRESSURE INTEGRITY [6]	NO-GO
MINIMUM TANK GN2 PERCENT [7]	NO-GO
PYRO VALVE CONTROL (NSI) [8]	NO-GO
PYRO VALVE UNINTENTIONAL FIRE DURING IV CHECKOUT [8]	GO
<b>POWER:</b>	
MINIMUM BATTERY VOLTAGE DURING IV CHECKOUT [9]	NO-GO
MINIMUM PWR PERCENT [10]	NO-GO
ALLOWABLE POWER ON TIME [11]	NO-GO
PREVIOUS EVA BATTERY USAGE [12]	NO-GO
<b>CONTROLS:</b>	
ANY ROTATIONAL OR TRANSLATIONAL HAND CONTROLLER AXIS [13]	NO-GO
MODE SWITCH (TRANS MODE) [14]	NO-GO
MODE SWITCH (ROT MODE) [15]	NO-GO
STATUS SWITCH [16]	NO-GO
MANUAL ISOLATION VALVE OPEN [17]	NO-GO
MANUAL ISOLATION VALVE CLOSED [18]	NO-GO
<b>INSTRUMENTATION:</b>	
TANK PRESSURE XDUCER [19]	NO-GO
TANK TEMPERATURE XDUCER [19]	NO-GO
BATTERY CAPACITY GAUGE [20]	NO-GO
HCM DISPLAY [21]	NO-GO
THRUSTER LED [22]	GO
AAH LED [22]	GO
<b>OTHER:</b>	
1 YEAR ON-ORBIT LIFE [23]	NO-GO
DIGITAL EVA CAMERA [24]	NO-GO
BRT/MUT [25]	NO-GO
SAFER HARD MOUNT [25]	NO-GO
ORBIT DAY FOR DURATION OF PLANNED INSPECTION [26]	NO-GO
2ND DEDICATED EV CREW FOR GCA AND TETHER MANAGEMENT [27]	NO-GO
DIRECT SAFER TO IV COMMUNICATION [28]	GO

@[CR 7642 ]

GO = GO FOR TPS INSPECTION FLIGHT

NO-GO = NO-GO FOR TPS INSPECTION @[CR 7642 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES****12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)**

NOTES: @[CR 7642 ]

- [1] SAFER IS NO-GO FOR INSPECTION FOR ANY NUMBER OF FAILED-ON THRUSTERS. A FAILED-ON THRUSTER CAUSES UNCOMMANDED MOTION AND RAPIDLY DEPLETES SAFER GN<sub>2</sub>. FOR A SINGLE FAILED ON THRUSTER, A FULL GN<sub>2</sub> TANK WOULD BE DEPLETED IN ABOUT 240 SECONDS.
- [2] ALL SAFER TRANSLATION/ROTATION COMMANDS ARE STILL AVAILABLE WITH ONLY A SINGLE FAILED-OFF THRUSTER. A SAFER WITH THIS FAILURE IS NO-GO FOR DUROMETER INSPECTIONS DUE TO THE CLOSE PROXIMITY TO TPS AND THE PRECISION THAT THIS DEMANDS. THE SAFER IS GO IF THE INSPECTION ONLY INVOLVES PHOTOGRAPHY FROM A MINIMUM DISTANCE OF 5 FEET. AN ALTERNATE SAFER OR ROBOTIC BASED INSPECTION SHOULD BE USED IF AVAILABLE. SOME MINOR CROSS-COUPPLING WILL OCCUR IN THE COMMANDS THAT UTILIZE THE FAILED THRUSTER. SIMULATIONS HAVE SHOWN THAT THIS EFFECT DOES NOT SERIOUSLY HINDER SAFER MANEUVERABILITY, BUT MAY SLIGHTLY INCREASE PROPELLANT USAGE.
- [3] MULTIPLE FAILED-OFF THRUSTERS DEGRADE SAFER PERFORMANCE AND HINDER THE ABILITY FOR PRECISION FLYING, WHICH IS REQUIRED FOR TPS INSPECTION.
- [4] ALTHOUGH IT MAY BE POSSIBLE FOR AN EVA CREWMEMBER TO MANUALLY NULLIFY RATES IN THE LOST AXIS, SAFER IS NO-GO DUE TO THE ADDED FLIGHT COMPLEXITY, PROP INEFFICIENCY, AND DEGRADED PRECISION.
- [5] SAFER CONTAINS A RATE SENSOR TO SENSE ANGULAR RATES IN ROLL, PITCH, AND YAW ROTATION AXES. THESE RATES ARE NEEDED TO PROVIDE PROPER AUTOMATIC ATTITUDE HOLD (AAH). IF SENSOR OUTPUT IS LOST DUE TO A SENSOR FAILURE, THE SOFTWARE IS UNABLE TO DETERMINE WHEN RATES ARE NULLED. THIS RESULTS IN UNCONTROLLED ROTATIONAL ACCELERATIONS WHEN AAH IS ACTIVATED.
- [6] THE SAFER AVIONICS PROVIDE A LEAK DETECTION ALGORITHM (WHEN IN OPERATIONAL MODE) THAT RUNS CONTINUALLY IN THE BACKGROUND WHEN THRUSTERS ARE NOT BEING FIRED. IF THIS ALGORITHM DETERMINES THAT THERE HAS BEEN MORE THAN A 0.3 PERCENT DECREASE IN GN<sub>2</sub> MASS DURING THREE OF FOUR CONSECUTIVE 1-SECOND PERIODS, AN "EXCESSIVE LEAK" MESSAGE IS AUTOMATICALLY DISPLAYED ON THE HAND CONTROLLER MODULE (HCM) DISPLAY. THIS NET LEAK RATE IS EQUIVALENT TO THAT OF A SINGLE FAILED-ON THRUSTER. AT THIS RATE, A FULL GN<sub>2</sub> TANK WOULD BE DEPLETED IN ABOUT 240 SECONDS. BECAUSE GN<sub>2</sub> MASS IS CALCULATED BASED ON GN<sub>2</sub> PRESSURE AND TEMPERATURE, A SPORADIC TRANSDUCER MAY RESULT IN A FALSE LEAK INDICATION. LOSS OF TRANSDUCERS IS ALSO NO-GO AS ADDRESSED UNDER LOSS OF INSTRUMENTATION.
- [7] EXTENSIVE TESTING OF TPS SAFER INSPECTION FLIGHTS WAS PERFORMED USING VIRTUAL REALITY (VR) TO DETERMINE THE MINIMUM GN<sub>2</sub> REQUIREMENTS. IF MULTIPLE SAFERS ARE CONSIDERED GO, THE UNIT WITH THE MOST GN<sub>2</sub> SHOULD BE USED TO FURTHER INCREASE MARGIN. THE MINIMUM GN<sub>2</sub> REQUIRED TO INITIATE AN INSPECTION FLIGHT IS 45 PERCENT WHICH IS SUFFICIENT TO PHOTOGRAPH ONE DAMAGE SITE. FIFTEEN PERCENT SHOULD BE ADDED FOR EACH ADDITIONAL INSPECTION LOCATION PLANNED. IF REMAINING GN<sub>2</sub> EVER REACHES 30 PERCENT, THE INSPECTION SHALL BE IMMEDIATELY TERMINATED WITH RETURN FLIGHT TO STRUCTURE. IF MULTIPLE LOCATIONS ARE TO BE INSPECTED, THE SAFER IS GO TO PROCEED TO SUBSEQUENT DAMAGE SITES IF 45 PERCENT GN<sub>2</sub> REMAINS. THIS SHOULD BE SUFFICIENT TO COMPLETE THE INSPECTION PRIOR TO REACHING THE 30 PERCENT TERMINATE REDLINE. FORMAL STATISTICAL STUDIES HAVE NOT BEEN PERFORMED TO DETERMINE GN<sub>2</sub> CONSUMPTION DURING THE DUROMETER MEASUREMENT PHASE OF A POST REPAIR INSPECTION. VR EVALUATIONS USING CHARLOTTE TO SIMULATE REACTION FORCES DURING VEHICLE CONTACT INDICATE THAT 60 PERCENT GN<sub>2</sub> IS ADEQUATE TO INITIATE A FLIGHT THAT INCLUDES DUROMETER HARDNESS TESTS IN ADDITION TO PHOTOGRAPHY OF ONE LOCATION. @[CR 7642 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)

- [8] THE PYRO VALVE IS A SINGLE-USE COMPONENT WHICH AUTOMATICALLY FIRES WHEN SAFER IS POWERED UP UNLESS AN INHIBITOR IS INSTALLED. IF THE PYRO FIRES UNINTENTIONALLY DURING IV CHECKOUT, SAFER IS CONSIDERED GO FOR INSPECTION AS LONG AS IT HAS THE MINIMUM GN<sub>2</sub> PERCENT. @[CR 7642 ]
- DURING EVA, THE PYRO VALVE WILL FIRE WHEN SAFER IS POWERED ON. DURING THE SUBSEQUENT SELF TEST, AN "NSI CIRCUIT OPEN" AND "FAILED TEST" MESSAGE SHOULD BE DISPLAYED ON THE HCM. PRIOR TO OBSERVING SAFER THRUST, IT IS IMPOSSIBLE TO DETERMINE IF THESE MESSAGES ARE DUE TO THE NSI CONTROL SIGNAL NOT BEING RECEIVED, OR A NOMINAL PYRO FIRE. THEREFORE, THE SAFER EV SHALL FLY OUT OF THE SECOND EV'S GRASP RATHER THAN BEING PUSHED TOWARDS THE DAMAGE.
- [9] THE MINIMUM SAFER BATTERY VOLTAGE REQUIRED IS 35 VOLTS AS DETERMINED DURING CHECKOUT WITHIN 24 HOURS OF EVA. THIS IS ONLY APPLICABLE WHEN CHECKED AT IV AMBIENT TEMPERATURES, AS EXTREME COLD WILL LOWER THE VOLTAGE BELOW 35 VOLTS.
- [10] FORTY-FIVE MINUTES OF OPERATION IS POSSIBLE WITH 45 PERCENT POWER REMAINING AS SHOWN ON THE HCM DISPLAY. SAFER IS NOT FUNCTIONAL WHEN THE DISPLAY INDICATES 28 PERCENT POWER REMAINING. THE MINIMUM POWER REQUIRED TO INITIATE AN INSPECTION FLIGHT IS 38 PERCENT, WHICH IS SUFFICIENT TO PHOTOGRAPH ONE INSPECTION SITE. FOUR PERCENT SHOULD BE ADDED FOR EACH ADDITIONAL INSPECTION LOCATION PLANNED. POWER MUST BE RESERVED TO PROVIDE ENOUGH OPERATIONAL TIME FOR THE VARIOUS PHASES OF TPS INSPECTION FLIGHT. VR TESTING CONCLUDED WITH HIGH CONFIDENCE THAT 13 MINUTES IS SUFFICIENT TO RETURN TO STRUCTURE FROM ANY INSPECTION SITE. ACCORDINGLY, IF THE REMAINING POWER EVER REACHES 34 PERCENT, THE INSPECTION SHALL BE IMMEDIATELY TERMINATED WITH RETURN FLIGHT TO STRUCTURE. IF MULTIPLE LOCATIONS ARE TO BE INSPECTED DURING THE SAME FLIGHT, THE SAFER IS GO TO PROCEED TO SUBSEQUENT DAMAGE SITES IF 38 PERCENT POWER REMAINS. THIS WILL PROVIDE 9 ADDITIONAL MINUTES TO COMPLETE THE INSPECTION PRIOR TO REACHING THE 34 PERCENT TERMINATE REDLINE. THESE POWER LIMITS ARE CONSERVATIVE BECAUSE THEY ASSUME WORST CASE COLD, AND THAT ONE OF THREE PARALLEL BATTERY STRINGS HAS FAILED. BATTERY STRING FAILURE IS ONE OF THE MOST LIKELY ANOMALIES TO CAUSE LOSS OF FLIGHT CONTROL AND THERE IS NO EARLY CREW INDICATION OF THE PROBLEM. BATTERY DISCHARGE TESTS HAVE SHOWN THAT 100 MINUTES OF SAFER OPERATION CAN BE SUPPORTED IN WORST CASE COLD ENVIRONMENTS WITH 45 PERCENT INITIAL CAPACITY IF ALL THREE STRINGS ARE FUNCTIONING. IN THIS CASE, THE SAFER BECOMES UNUSABLE AT 5 PERCENT POWER. ALTHOUGH TWO STRINGS ALONE WILL NOT MEET THE CERTIFICATION REQUIREMENTS, THERMAL TESTS OF BATTERY CELL BUNDLES FROM THE SAME LOT AS THOSE LAUNCHED ON STS-114 ACHIEVED 43-46 MINUTES OF SAFER RUN TIME UNDER WORST-CASE TPS INSPECTION THERMAL CONDITIONS WITH ONLY TWO HEALTHY STRINGS.
- [11] THE MAXIMUM ALLOWABLE TIME THAT A SAFER CAN BE POWERED ON DURING A SINGLE EVA IS 45 MINUTES. THE INERTIAL RATE UNIT (IRU), WHICH IS CRITICAL FOR AAH FUNCTIONALITY, MAY REACH ITS MAXIMUM THERMAL LIMIT AFTER THIS TIME. TEMPERATURE INCREASE IS A FUNCTION OF INTERNAL HEAT GENERATION AND THE IRU LOCATION IS WELL INSULATED, WHICH PREVENTS SIGNIFICANT HEAT DISSIPATION. THEREFORE, NEGLIGIBLE TIME IS GAINED IN A COLD ENVIRONMENT. VR TESTING CONCLUDED WITH HIGH CONFIDENCE THAT 13 MINUTES IS SUFFICIENT TO RETURN TO STRUCTURE FROM ANY INSPECTION SITE. THEREFORE, IF THE POWER-ON TIME EVER REACHES 32 MINUTES, THE INSPECTION SHALL BE IMMEDIATELY TERMINATED WITH RETURN FLIGHT TO STRUCTURE. IF MULTIPLE LOCATIONS ARE TO BE INSPECTED DURING THE SAME FLIGHT, THE SAFER IS GO TO PROCEED TO SUBSEQUENT DAMAGE SITES IF POWER ON TIME IS LESS THAN 23 MINUTES. IF POWER ON TIME IS GREATER, THERE IS LESS CONFIDENCE THAT A SUCCESSFUL INSPECTION CAN BE COMPLETED PRIOR TO MEETING THE 32-MINUTE REDLINE AND; THEREFORE, THE SUBSEQUENT INSPECTION SHOULD NOT BE ATTEMPTED.
- [12] THE SAFER BATTERY IS ONLY CERTIFIED FOR ONE EVA USE. AFTER A BATTERY IS DISCHARGED IN A COLD ENVIRONMENT, ITS CAPACITY DECREASE CANNOT BE MEASURED ACCURATELY IN WARMER ENVIRONMENTS, SO THE PWR PERCENTAGE READING (AS DISPLAYED ON THE SAFER HCM) IS NOT VALID ON SUBSEQUENT EVA'S. THEREFORE, THE BATTERY IS NO-GO FOR INSPECTION CAPABILITY EVEN IF THE PWR PERCENTAGE READS GREATER THAN 45. THE SAFER CAN BE USED AGAIN IF A BATTERY CHANGEOUT IS PERFORMED.
- [13] SAFER TPS INSPECTION FLIGHT REQUIRES 6-DEGREE-OF-FREEDOM FLIGHT CONTROL. @[CR 7642 ]

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## FLIGHT RULES

**12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)**

- [14] FOR FUNCTIONAL LOSS OF THE TRANS POSITION OF THE MODE SWITCH, TRANSLATION CONTROL IS LOST IN THE Y AND Z AXES. SAFER TPS INSPECTION FLIGHT REQUIRES 6-DEGREE-OF-FREEDOM FLIGHT CONTROL. @[CR 7642 ]
- [15] FOR FUNCTIONAL LOSS OF THE ROT POSITION OF THE MODE SWITCH, ROTATION CONTROL IS LOST IN THE ROLL AND YAW AXES. SAFER TPS INSPECTION FLIGHT REQUIRES 6-DEGREE-OF-FREEDOM FLIGHT CONTROL.
- [16] THE SAFER IS NO-GO FOR TPS INSPECTION IF THE STATUS SWITCH IS FAILED IN BOTH DIRECTIONS BECAUSE THE SELF TEST AT VACUUM WILL NOT BE ABLE TO PROCEED BEYOND THE "NSI CIRCUIT OPEN" MESSAGE.
- [17] FOR A FAILED-CLOSED MANUAL ISOLATION VALVE, SAFER IS NO-GO FOR EVA BECAUSE IT CANNOT DELIVER GN<sub>2</sub> TO THE THRUSTER MANIFOLDS.
- [18] FOR A FAILED-OPEN MANUAL ISOLATION VALVE, SAFER IS NO-GO FOR EVA BECAUSE GN<sub>2</sub> TANK/THRUSTER ISOLATION IS LOST. GN<sub>2</sub> TANK/THRUSTER ISOLATION IS REQUIRED TO RECOVER FROM SAFER FAILURES THAT LEAD TO UNCOMMANDED MOTION (E.G., A THRUSTER MECHANICALLY FAILED-OPEN WHEN SAFER IS NOT IN USE).
- [19] FOR LOSS OF THE TANK PRESSURE OR TEMPERATURE TRANSDUCER, SAFER IS NO-GO FOR INSPECTION BECAUSE THESE READINGS ARE USED TOGETHER TO CALCULATE THE GN<sub>2</sub> MASS. THE CAPABILITY TO CONTINUOUSLY MONITOR GN<sub>2</sub> IS REQUIRED TO ENSURE AVAILABILITY FOR RETURN FLIGHT TO STRUCTURE.
- [20] FOR LOSS OF THE BATTERY CAPACITY GAUGE, SAFER IS NO-GO FOR INSPECTION. THE BATTERY CAPACITY GAUGE, LOCATED ON THE BATTERY PACK, IS REQUIRED TO ENSURE POWER AVAILABILITY FOR RETURN FLIGHT TO STRUCTURE. MONITORING CAPABILITY CAN BE RESTORED BY IV REPLACEMENT OF THE BATTERY PACK IF A SPARE BATTERY IS AVAILABLE.
- [21] MONITORING CAPABILITY OF GN<sub>2</sub> PERCENT, PWR PERCENT, AND "EXCESSIVE LEAK" MESSAGES MUST BE AVAILABLE SO THAT FLIGHT TERMINATION CAN BE PERFORMED IF REQUIRED.
- [22] THRUSTER AND AAH LED'S ARE NOT REQUIRED FOR TPS INSPECTION FLIGHTS BECAUSE THE PILOT WILL HAVE VERIFICATION OF PROPER AAH AND THRUSTER PERFORMANCE THROUGH FLIGHT CONTROL RESPONSE. IF THE LED FAILURE IS PRESENT DURING THE SELF TEST AT VACUUM, THE CREW WILL BE SENSITIVE TO RELY ON FLIGHT CONTROL RESPONSE RATHER THAN LED'S.
- [23] SAFER COMPONENTS ARE CERTIFIED FOR 1 YEAR ON-ORBIT LIFE. IF THIS DURATION IS EXCEEDED, SAFER IS CONSIDERED NO-GO FOR EVA.
- [24] THE DIGITAL EVA CAMERA IS REQUIRED FOR 2-D INSPECTION OF RCC AND 3-D INSPECTION OF TILE DAMAGE. RELIABLE VEHICLE RE-ENTRY ANALYSIS CANNOT BE PERFORMED BASED ON VOICE CALLS DURING A CREW VISUAL INSPECTION. THEREFORE, THE RISK OF SAFER FLIGHT IS NOT RECOMMENDED IN THIS CASE. A REAL-TIME RISK TRADE WOULD BE REQUIRED IF THE MECHANICAL CONTOUR GAUGE WERE TO BE USED IN THE ABSENCE OF A DIGITAL CAMERA. HOWEVER, IT IS EXPECTED THAT THIS WOULD ONLY PROVIDE THE DEPTH OF THE DEEPEST POINT WITH LARGE MARGINS OF ERROR. FOR POST REPAIR INSPECTIONS, THE BENEFIT OF HAVING ONLY A DUROMETER WILL NEED TO BE BALANCED AGAINST THE RISK OF USING SAFER.
- [25] DUE TO THE CLOSE PROXIMITY TO ORBITER TPS, THE EV CREW MUST BE ABLE TO MAKE FLIGHT ADJUSTMENTS AT ANY TIME. ONE-HANDED OPERATION OF THE HCM AND INSPECTION TOOLS IS REQUIRED. THE BODY RESTRAINT TETHER (BRT) OR MULTI-USE TETHER (MUT) IS REQUIRED FOR ONE-HANDED OPERATION OF THE DIGITAL CAMERA.
- [26] PLANNED SAFER FLIGHT IS NO-GO DURING ORBIT NIGHT BECAUSE THE HCM DISPLAY MAY NOT THERMALLY SURVIVE THE REQUIRED 45 MINUTES WITH MORE THAN 5 MINUTES OF NIGHT EXPOSURE. THE HCM SHALL NOT BE DEPLOYED MORE THAN 5 MINUTES PRIOR TO SUNRISE. ADDITIONALLY, SAFETY TETHER SLACK MANAGEMENT REQUIRES THE ABILITY TO SEE THE TETHER CABLE. PHOTOGRAMMETRIC 3-D ANALYSIS OF TILE DAMAGE IS ONLY POSSIBLE WITH IMAGES CAPTURED DURING ORBIT DAY (NIGHT IMAGES WITH FLASH ARE UNACCEPTABLE). @[CR 7642 ]

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## FLIGHT RULES

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**12A\_A15-1      GO/NO-GO FOR SAFER TPS INSPECTION (CONTINUED)**

- [27] A SECOND EV CREWMEMBER MUST BE AVAILABLE AND HAVE A DIRECT LINE OF SIGHT TO THE SAFER CREW THROUGHOUT THE ENTIRE INSPECTION. SIMULATIONS HAVE SHOWN THAT THE GCA PROVIDED BY THIS SECOND EV CREW GREATLY INCREASES FLIGHT EFFICIENCY, REDUCES PILOT ERRORS, AND ASSISTS IN RAPID MALFUNCTION DETECTION. THIS CREWMEMBER IS ALSO REQUIRED TO MANAGE SAFETY TETHER SLACK SO THAT CABLE TENSION DOES NOT IMPART LOADS INTO THE SAFER. IN THE EVENT OF A SAFER MALFUNCTION THAT CAUSES LOSS OF FLIGHT CONTROL, TETHER MANAGEMENT IS ESSENTIAL TO REDUCE THE POTENTIAL FOR CATASTROPHIC DAMAGE TO THE ORBITER OR EMU. @[CR 7642 ]
- [28] ONLY RELAY COMMUNICATION CAPABILITY IS REQUIRED FOR SAFER INSPECTION. THE SECOND EV CREWMEMBER, THEREFORE, MUST HAVE DIRECT COMMUNICATION WITH IV. @[CR 7642 ]

## FLIGHT RULES

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### 12A\_A15-2      KEEP-OUT ZONE FOR EVA OPERATIONS NEAR THE LDRI OR LCS [HC]

- A. WHEN THE LASER DYNAMIC RANGE IMAGER (LDRI) IS ENABLED (MODES 2-6), THE EVA KEEP-OUT ZONE (KOZ) IS 2.74 METERS (9.0 FEET) FROM THE RADIATING SOURCE AT THE FRONT OF THE LDRI. THERE IS NO KOZ FOR AN LDRI CONFIRMED TO BE IN MODE 1. ©[CR 7643 ]

*The LDRI has two KOZ's, one for the diffuse light generated by the LDRI diffuser window, and a second zone for beams escaping through voids or defects in the diffuser. This second KOZ is narrower and significantly longer than the zone for the nominal diffuse light. The KOZ for diffuse light hazards is a hemisphere resting on the surface of the diffuser window, with a radius of 0.61 meters (2 feet). The KOZ for escaping beams is a trapezoidal volume created by taking a 3 x 1.5 inch (7.6 x 3.8 cm) rectangle corresponding to the diffuser window area, and expanding it outwards at an angle of 10 deg from a line perpendicular to the window, to a distance of 2.74 meters (9 feet) from the window.*

*If the EV crew must enter the LDRI keep-out zone, the LDRI will be placed into Mode 1 (confirmed by using a camera view of the diffuser window to observe the laser turn off), and the command path removed for switching modes (VIDEO IN - not MIDDECK). In addition, the PTU/LDRI will be pointed away from the crewmember and subsequent PTU motion inhibited with ITVC ENA - OFF. The LDRI can survive thermally for the entire EVA in Mode 1, which provides it with heater power.*

*The LDRI uses a modulated laser to create range and video imagery during Reinforced Carbon-Carbon (RCC) and tile inspection for depth defect and surface area analysis. At a lesser distance than the specified keep-out zones, ocular exposure to this laser directly hitting the eyes could result in serious injury of the retina. This keep-out zone assumes no attenuation of the beam strength by the EMU visor. Additional details on the LDRI are provided in Rule {12A\_C2-33}, KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING LASER CAMERA SYSTEM (LCS) OPERATIONS [HC].*

- B. WHEN THE LCS IS SCANNING, THE EVA KEEP-OUT ZONE IS 19.1 METERS (62.7 FEET) FROM THE RADIATING SOURCE AT THE TOP OF THE LCS, WITH A NOMINAL FIELD OF VIEW (FOV).
- C. WHEN THE LASER CAMERA SYSTEM (LCS) IS IN HEATER-ONLY MODE (LCC DEACTIVATION COMPLETE), THE LASER IS INHIBITED. HOWEVER, IN ORDER TO MAINTAIN TWO-FAULT TOLERANCE, THE EV CREW MUST STAY OUTSIDE OF A KOZ THAT EXTENDS 14.4 METERS (42.2 FEET) FROM THE RADIATING SOURCE AT THE TOP OF THE LCS. ©[CR 7643 ]

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## FLIGHT RULES

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### 12A\_A15-2      KEEP-OUT ZONE FOR EVA OPERATIONS NEAR THE LDRI OR LCS [HC] (CONTINUED)

1. IF THE EV CREW HAS NOT BEEN WORKING ON OR NEAR THE LCS, THIS KOZ HAS A NOMINAL FOV. @[CR 7643 ]
2. IF THE EV CREW HAS BEEN WORKING ON/NEAR THE LCS OR IS STANDING IN A FOOT RESTRAINT ATTACHED TO THE ORBITER BOOM SENSOR SYSTEM (OBSS), THEN THE MAXIMUM FOV MUST BE USED.

D. THERE IS NO KOZ FOR AN UNPOWERED LCS.

*The length of the LCS KOZ depends on the initial state of the LCS and the subsequent failures that can occur. Two-failure tolerance is used in selecting the correct length. No attenuation of the beam strength by the EMU visor is assumed. The shape of the KOZ depends on whether the LCS galvanometers are physically held in place or could have been bumped outside of the nominal FOV by the crew.*

*While scanning, physical and electrical galvanometer constraints limit the beam to the nominal FOV. This is defined as a square pyramid with sides that angle outward at  $\pm 15$  deg from the central perpendicular ray. There are two two-failure cases that lead to differing KOZ lengths while scanning, so the most conservative one has been chosen, for a length of 19.1 meters (62.7 feet) from a point effectively 20 cm behind the aperture window (accounting for beam attenuation inside the LCS). The failures leading to this KOZ are a failure of the laser current amplifier U18B, leading to maximum laser power output, and a bitflip in the Complex Programmable Logic Device (CPLD), which causes the beam to remain stationary. Depending on the trajectory of the scan, the beam may actually be blocked from the crewmember by structure, but that must be determined by flight-specific analysis.*

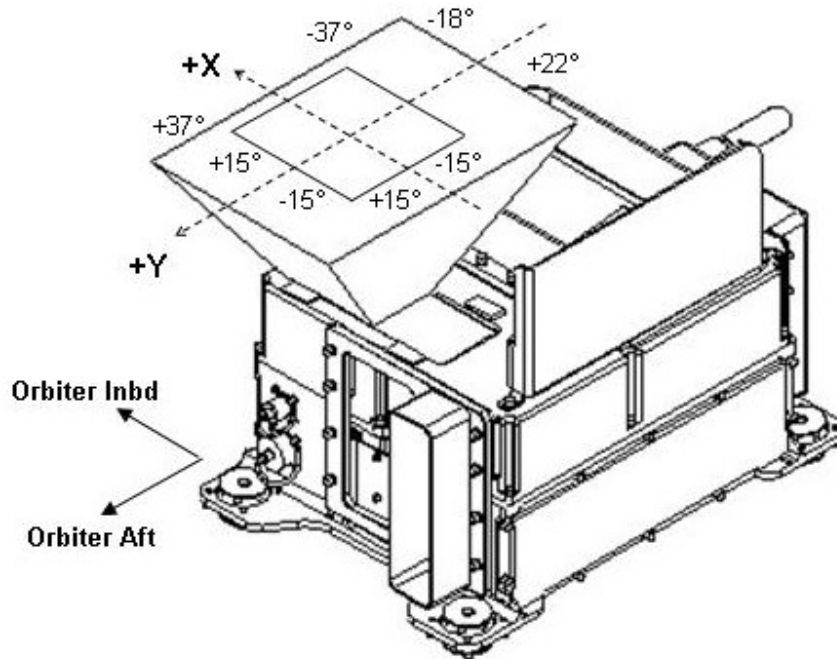
*When the LCS is not scanning, the galvanometers that direct the laser beam out the aperture window are not held in place, and could be bumped outside of the nominal FOV. Although unlikely, it is possible that the EV crew could bump the OBSS or LCS in just the right direction to do so. Therefore, when the EV crew has been working on or near the OBSS, it is assumed that this is the initial condition and the resulting EVA KOZ has a Maximum FOV. The Max FOV KOZ is an irregular rectangular pyramid. Along the LCS Y axis (which is parallel with the OBSS long axis), the sides of the pyramid are limited by the edge of the aperture window and angle outward from the central perpendicular ray at  $\pm 37$  degrees. Along the LCS +X axis (which points toward the LCS/orbiter inboard when OBSS is berthed in the MPM's), the side of the pyramid is also limited by the edge of the aperture window and angles outward at 18 deg from the central perpendicular ray. Along the LCS -X axis, the FOV is limited by the angle at which the beam misses the Y-galvanometer mirror that would direct it out of the window and is instead trapped inside the box. This side of the pyramid angles outward at 22 deg from the central perpendicular ray. Note that the aperture window (15.2 x 5.8 cm = 6.0 x 2.3 inches) is sized to allow light reflected from the scanned surface to enter the window and reach the sensors. The laser does not shine out through all parts of the window. @[CR 7643 ]*

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**FLIGHT RULES**

12A\_A15-2

**KEEP-OUT ZONE FOR EVA OPERATIONS NEAR THE LDRI OR LCS [HC] (CONTINUED)**



**FIGURE 12A\_A15-2-I - LCS NOMINAL AND MAX FOV ILLUSTRATION**  
 ©[CR 7643 ]

Once LCC DEACTIVATION has been completed and the LCS is in heater-only mode (e.g., following inspection activities), two failures must occur in order for the LCS to be actively lasing. Assembly Power Converter Unit (APCU) power must first be cycled off and on again in order to activate the Laser Camera Head (LCH), and then the CPLD bitflip described above would initiate lasing with a stationary beam at max power. A third event must occur - the crew entering the KOZ - in order for injury to occur. The EVA KOZ for an LCS in heater-only mode is a pyramid with total length of 14.4 meters (47.2 feet) from a point 20 cm behind the aperture window and shaped according to the appropriate FOV.

If the EV crew must enter the LCS Heater-Only KOZ, the LCS must be completely powered off, and a thermal clock must be started.

Reference Rule {12A\_A15-**TBD**}, LASER CAMERA SYSTEM (LCS) THERMAL CONSTRAINTS DURING DTO 849 (OBSS DTO). ©[CR 7643 ]

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## FLIGHT RULES

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**12A\_A15-2      KEEP-OUT ZONE FOR EVA OPERATIONS NEAR THE LDRI OR  
LCS [HC] (CONTINUED)**

*The LCS uses a continuous laser to create range data during RCC and tile inspections. Ocular exposure to this laser directly hitting the eyes could result in serious injury to the cornea. Additional details on the LCS are provided in Rule {12A\_C2-33}, KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING LASER CAMERA SYSTEM (LCS) OPERATIONS [HC].* ©[CR 7643 ]

*DOCUMENTATION: EV Memo, Normal Hazard Zone for Laser Dynamic Range Imager, March 11, 2005; NDG007332, Laser Safety Analysis for the OBSS LCS, Rev 3, March 2006; and Hazard Reports LDRI-5, Pathological/Physiological/Psychological; and OBSS LCS 001, Crew Eye or Skin Injury as a Result of Exposure to Laser Radiation.* ©[CR 7643 ]

## FLIGHT RULES

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### 12A\_A15-3

### EMU GO/NO-GO CRITERIA WITH ENHANCED CWS

THE EMU CAPABILITIES LISTED IN THE EMU GO/NO-GO MATRIX ARE CONSIDERED LOST IF ONE OF THE FOLLOWING CONDITIONS ARE MET:

@[CR 7644 ]

- A. SUIT PRESSURE INTEGRITY - EMU PRESSURE DECAY > 0.3 PSI/MIN DURING INTEGRITY CHECK

*A leak > 0.3 psi/min can no longer be considered a worst case for EMU specification leakage (i.e., seal leaks and metabolic use). At greater than 0.3 psi/min, there is some other leak that could possibly propagate.*

*The automated leak check will report failure when the pressure drop is  $\geq 0.3$  psi over 1 minute for a manned suit or 2 minutes for an unmanned suit. A manual leak check can be performed where failure is determined by a pressure drop of  $\geq 0.3$  psi over 1 minute for a manned suit or 2 minutes for an unmanned suit.*

*For loss of suit pressure integrity, if the failure occurs prior to EVA, the EMU is considered to be non-fail-safe and is therefore NO-GO for EVA. If the failure occurs during EVA, the SCU may provide a safe configuration if the leak (minor leak) does not allow the suit pressure to drop below the caution and warning SUIT P LOW limit (4.05 psid). If this is the case, then a TERMINATE EVA (i.e., enter airlock, connect SCU) is required for the affected crewmember. If the suit leak allows the suit pressure to drop below the CWS limit (major leak), an ABORT EVA (i.e., both crewmembers enter airlock and perform emergency repress) is required.*

- B. PRIMARY O<sub>2</sub> TANK PRESSURE INTEGRITY - PRIMARY O<sub>2</sub> PRESSURE DECAYS AT A RATE > 110 PSI/24 HRS FROM A FULLY CHARGED STATE, AND LEAK RATE IS SUCH THAT IT WILL PRECLUDE SAFE COMPLETION OF THE INTENDED EVA TASK.

*The primary O<sub>2</sub> tanks are considered fully charged when they are pressurized > 850 psi. Leak rates > 110 psi/24 hrs are indicative of a significant primary tank leak. An excessive external leak of the primary O<sub>2</sub> tanks will cause the primary O<sub>2</sub> supply to be depleted at a higher than normal rate. However, in the case where an excessive external leak is detected, real-time analysis may indicate that the leak will not preclude an EVA for the intended tasks. Further testing may determine that the leak is internal to the suit volume, which may not impact the O<sub>2</sub> use rate during EVA. @[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

### EMU GO/NO-GO CRITERIA WITH ENHANCED CWS (CONTINUED)

*The EMU is considered NO-GO for EVA for a major leak. A major leak is a leak rate that is too high to support on the SCU (i.e., requires more O<sub>2</sub> than can be provided by the orbiter, case specific). If a major leak happens during EVA, then an ABORT EVA is required, since the EMU is no longer capable of remaining at vacuum. A minor leak is a leak rate that can be supported on the SCU. The EMU is considered GO for EVA if the leak is minor and if periodic recharges do not interfere with completing the EVA tasks. The EMU is considered GO to remain on the SCU if the leak is a minor leak and if frequent recharges interfere with completing the EVA tasks. If this happens during EVA, then a TERMINATE EVA is required for the affected crewmember. Leak propagation is not a concern with primary O<sub>2</sub> tank leaks because the seals in this system are hard/static seals. ©[CR 7644 ]*

- C. PRESSURE REGULATION - SUIT PRESSURE CANNOT BE MAINTAINED IN A RANGE ABOVE THE SOP REGULATION PRESSURE AND BELOW THE POSITIVE PRESSURE RELIEF VALVE (PPRV) CRACKING PRESSURE.

*If the primary suit regulator cannot maintain suit pressure above SOP regulation pressure, the SOP will flow during the EVA and the emergency oxygen supply will be consumed, eventually making the SOP incapable of supporting 30 minutes of DCM purge flow. If the primary suit regulator cannot regulate below the positive pressure relief valve (PPRV) cracking pressure, the PPRV will open during the EVA and primary oxygen will be depleted more rapidly than normal.*

*The operational specification for the primary regulator with the O<sub>2</sub> actuator in PRESS or EVA is 4.2 to 4.4 psid. Checkout values outside of this range warrant further investigation to ensure that the requirements of this rule will be met. If the primary regulator is determined to be stable between 4.05 - 4.55 psid, then SOP flow and PPRV cracking should not be a concern since the specifications of the SOP regulator and PPRV will not overlap this range. If the primary regulation pressure is outside of the 4.05 to 4.55 psid range, real-time analysis considering the preflight performance of the specific EMU will be required.*

*The specification for SOP regulation is 3.33 to 3.9 psid (dependent on flow rate). The specification for the minimum cracking pressure for the PPRV is 4.7 psid. A "SUIT P LOW" message occurs when sensed suit pressure is less than 4.05 psid. A "SUIT P EMERG" message occurs when sensed suit pressure is less than 3.10. A "SUIT P HIGH" message will occur when sensed suit pressure is 4.55 psid or greater.*

*For scheduled or unscheduled EVA's, the EMU is considered to be non-fail-safe and is therefore NO-GO. For contingency EVA's, the EMU is considered GO for SCU ops to be available for rescue/assist scenarios. For either types of EVA's, if a pressure regulation failure happens during EVA, a TERMINATE EVA is required for the affected crewmember. ©[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS  
(CONTINUED)**

D. OPERATIONAL SECONDARY OXYGEN PACK (SOP) : @[CR 7644 ]

1. SOP BOTTLE PRESSURE (AT IV AMBIENT TEMPERATURES) < 5410 PSI.

*The SOP must be capable of supporting (with DCM purge valve open) a minimum of 30 minutes. The design specification for the EMU SOP bottle pressure is  $\geq 5410$  psig (at ambient IV temperatures) which guarantees a minimum of 30 minutes secondary O<sub>2</sub>.*

*For scheduled or unscheduled EVA's, the EMU is considered to be non-fail-safe and is therefore NO-GO. For contingency EVA's, the EMU is considered GO for SCU ops to be available for rescue/assist scenarios.*

*Reference: EMU On-Orbit Operation, Maintenance, Testing, Storage, and Tracking Requirements and Constraints - FEMU-R-003, JSC #60417, Rev. B, Change 1. Requirement 7.1.3.4 - #3.*

2. SOP REGULATOR IS NOT CAPABLE OF MAINTAINING SUIT PRESSURE ABOVE 3.33 PSI AND BELOW PRIMARY O<sub>2</sub> REGULATION PRESSURE FOR 30 MINUTES DURING EMERGENCY DCM PURGE.

*The operational specification for the SOP regulator is 3.33 to 3.9 (dependent on flow rate). SOP checkout values outside of this range warrant further investigation to ensure that the requirements of this rule will be met. Emergency DCM purge is representative of the worst case oxygen demand that could occur during an EVA. The SOP must be capable of maintaining suit pressure at a safe level (> 3.33 psi) during an emergency purge configuration (DCM purge valve open). An SOP that is regulating above the specification limit of 3.9 is satisfactory as long as it is regulating below the regulation pressure of the primary regulator. If the SOP regulates above the primary regulator pressure, the SOP oxygen will be consumed instead of primary oxygen. If this occurs during EVA, a TERMINATE EVA is required for the affected crewmember.*

*For scheduled or unscheduled EVA's, the EMU is considered to be non-fail-safe and is therefore NO-GO. For contingency EVA's, the EMU is considered GO for SCU ops to be available for rescue/assist scenarios. @[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS**  
**(CONTINUED)**

3. SOP FIRST STAGE REGULATION PRESSURE CANNOT BE MAINTAINED BELOW 600 PSIG AS MEASURED BY THE INTERSTAGE GAUGE DURING SOP CHECKOUT. @[CR 7644 ]

*The primary intent of the interstage gauge (located between the first- and second-stage pressure regulators) is to detect excessive leakage or failed open conditions related to the SOP first-stage regulator. Preflight processing also uses this gauge as a reference point for first-stage regulation. The 600 psig value is based on nominal first-stage regulation of 200 psig added to the +400 psig gauge tolerance. Due to the inaccuracy of the gauge at the low end (+400/-200 psig), detection of regulator shifts is difficult. However, gauge readings are worthwhile for comparison with pre-flight data. If the SOP interstage gauge fails on orbit, it is impossible to verify that the first-stage regulator was unaffected by the damaging event. A failed SOP first-stage regulator followed by a failed SOP second-stage regulator will result in rapid suit overpressurization and rupture.*

*For scheduled or unscheduled EVA's, the EMU is considered to be non-fail-safe and is therefore NO-GO. For contingency EVA's, the EMU is considered GO for SCU ops to be available for rescue/assist scenarios.*

- E. MINIMUM RF COMMUNICATIONS (REF. RULE {A15-7}, MINIMUM RF COMMUNICATIONS DEFINITION)

*For crew safety, two-way voice (including relay) communication must be available. Crewmembers must preserve the availability to vocally communicate in case assistance or aid is necessary in areas where the crewmember might not be able to maintain visual contact.*

*For scheduled or unscheduled EVA's, the EMU is considered to be non-fail-safe and is therefore NO-GO. For contingency EVA's, the EMU is considered GO for SCU ops to be available for rescue scenarios. For either types of EVA's, if the failure happens during EVA, a TERMINATE EVA is required for the affected crewmember.*

- F. POSITIVE PRESSURE RELIEF VALVE - FAILS CLOSED DURING DEPRESS

*This failure is only detected during depressurization. The EMU is considered NO-GO for EVA if the valve cannot be opened, because the EMU is not fail-safe for overpressurization. @[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS  
(CONTINUED)**

- G. VENTILATION FLOW - INSUFFICIENT FLOW (< 4.0 ACFM) TO PROVIDE CO<sub>2</sub> REMOVAL FROM THE HELMET OR DEFOGGING CAPABILITY. @[CR 7644 ]

*The vent flow sensor detects low flow at less than 4.0 acfm, and the CWS message (NO VENT FLOW) is triggered when vent flow drops below this level. This is the minimum flow required to adequately remove CO<sub>2</sub> from the helmet. CO<sub>2</sub> buildup in the helmet will lead to hypercapnia (excess CO<sub>2</sub> in the blood stream) which increases heart and respiration rate and can impair a crewmember's judgment and ability to perform the EVA task. Hypercapnia will eventually lead to an unconscious crewmember. Normal ventilation flow is 6 to 8 acfm. Helmet purge valve may be used to provide alternate vent flow if EMU consumables can be managed to support this.*

*Insufficient ventilation flow will also increase the fogging of the visor. This will hinder the crewmember's vision and will impair their ability to perform the EVA task. Under this condition while EVA, the crewmember is in a safe configuration while attached to the SCU. The EMU is somewhat degraded, but operational, for a possible crewmember assist/rescue scenario.*

- H. CO<sub>2</sub> CONTROL - PRESSURE COMPENSATED PPCO<sub>2</sub> LEVEL CANNOT BE MAINTAINED BELOW 12.4 MMHG (8.0 MMHG UNCOMPENSATED).

*With a PPCO<sub>2</sub> indication of 12.4 mmHg (8.0 mmHg uncompensated) by the ECWS, the actual CO<sub>2</sub> level in the EMU could be as high as 15 mmHg with sensor and calculation error. This PPCO<sub>2</sub> level can cause physiological changes (hypercapnia) that can impair the crewmember's judgment and ability to perform the EVA task. Reference Rule {A13-107}, PPCO<sub>2</sub> CONSTRAINT (ONE GAS) [HC].*

*Under this condition, the crewmember is in a safe condition while attached to the SCU with the helmet purge valve open. The EMU is somewhat degraded, but operational, for a possible crewmember assist/rescue scenario.*

- I. BATTERY POWER - EMU BATTERY IS NOT CAPABLE OF PROVIDING POWER.

*The EMU battery provides power for all EMU systems once off of the SCU. At cabin pressure, the battery may be replaced by a spare and the EMU is GO-For-EVA. If a spare is unavailable, the EMU will be able to remain on the SCU for a possible crewmember assist/rescue scenario. @[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS**  
**(CONTINUED)**

- J. THERMAL CONTROL - THERMAL CONTROL CANNOT BE MAINTAINED IN A TOLERABLE RANGE THROUGHOUT ALL SUITED OPERATIONS WHILE STILL PROVIDING AN ADEQUATE LEVEL OF WATER VAPOR REMOVAL. @[CR 7644 ]

*Thermal control must be maintained throughout all EMU suited operations. If water vapor produced by the crewmember and as a byproduct of the chemical reaction of CO<sub>2</sub> with LiOH is not removed, excessive water vapor levels in the EMU will cause fogging of the visor, degrading crewmember visibility. If cooling control is lost, it may be possible, if the crewmember is too cold, for the crewmember to manage cooling by periodically opening and closing the feedwater shutoff valve. Another option, if the crewmember is too hot, involves opening one of the two available purge valves on the suit. The feasibility of utilizing these options is case dependent.*

*If thermal control is lost via the SCU, the EMU is considered GO for EVA, since cooling will be restored once at vacuum when the sublimator is activated. If this is the case, when not on the sublimator, cooling must be provided through the DCM purge valve, assuming that the SCU can support the purge flow for the required time or by swapping SCU's if possible. If the failure happens during EVA, the EMU is considered GO to continue EVA. If thermal control is lost via the EMU (i.e., failure in either sublimator or LCVG), the EMU is considered GO to remain on the SCU, since cooling will be provided via the SCU (for sublimator failure) or will be provided with the DCM purge valve (for LCVG failure), assuming the SCU can support the purge flow for the required time. If the failure happens during EVA, a TERMINATE EVA is required for the affected crewmember.*

- K. CRITICAL INSTRUMENTATION:

1. LOSS OF EVA CREW'S CAPABILITY TO MONITOR BOTH SUIT PRESSURE SENSOR AND DISPLAY AND CONTROL MODULE (DCM) SUIT PRESSURE GAUGE

*The capability must exist to monitor suit pressure via either the pneumatic gauge or the pressure transducer at all times during the EVA*

*With the loss of both suit pressure transducer and gauge, there is no indication to the crewmember of suit pressure. For a scheduled or unscheduled EVA, the EMU is considered NO-GO. Since a third failure has to occur before the crewmember's life is in danger, the EMU is considered GO for SCU ops for a contingency EVA so that the crewmember is available for rescue ops.*

2. LOSS OF OPERATIONAL CWS:

*Reference Rule {A15-8}, OPERATIONAL CAUTION AND WARNING SYSTEM (CWS) DEFINITION.  
@[CR 7644 ]*

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## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS**  
**(CONTINUED)**

- a. BITE LIGHT ILLUMINATED @[CR 7644 ]

*The built-in test equipment (BITE) light is illuminated when the BITE circuitry has detected either a hardware or software problem within the CWS. The EMU should be considered No-Go in this condition, unless the status list can be verified to be functioning accurately.*

- b. CREWMEMBER OR MCC DETERMINES INSUFFICIENT RELIABLE DATA AVAILABLE.

*For the loss of operational CWS, the crewmember is in a safe condition while attached to the SCU. The EMU is somewhat degraded, but operational, for a possible crewmember assist/rescue scenario.*

3. DCM DISPLAY - CREWMEMBER IS UNABLE TO READ DCM DISPLAY AND MCC CANNOT MONITOR EMU DATA VIA REAL-TIME DATA DOWNLINK.

*EMU is considered GO (fail-ops) if MCC is capable of monitoring EMU status via the EMU Real-Time Data System (RTDS). EMU is considered GO to remain on the SCU if MCC monitoring capability is not available. If the failure happens during EVA, EMU is considered GO to continue EVA, unless MCC monitoring capability of EMU data is lost. If MCC monitoring capability is lost, then a TERMINATE EVA is required by the affected crewmember.*

- L. SINGLE COMPONENT INSTRUMENTATION - LOSS OF ONE OF THE FOLLOWING SENSORS:

SUIT PRESSURE XDUCER	SUBLIMATOR PRESSURE XDUCER
	SOP PRESSURE XDUCER
VENT FLOW SENSOR	H <sub>2</sub> O GAS PRESSURE XDUCER
CO <sub>2</sub> XDUCER	H <sub>2</sub> O WATER PRESSURE XDUCER
BATTERY VDC XDUCER	H <sub>2</sub> O TEMPERATURE XDUCER
BATTERY AMP XDUCER	
O <sub>2</sub> PRESSURE XDUCER	

@[CR 7644 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A15-3

### EMU GO/NO-GO CRITERIA WITH ENHANCED CWS (CONTINUED)

*EMU is considered GO (fail-ops). For the loss of any one sensor or transducer, the integrity of the system monitored by the failed sensor can be monitored via other sensors. A failure in that system will be manifested by a warning message from another sensor or by some other noticeable indication. For CO<sub>2</sub> transducer loss, the ability to detect a high CO<sub>2</sub> level relies entirely on the crewmember's ability to detect physiological symptoms and take appropriate action as required, such as purge valve activation (Rule {A13-52B}, PPCO<sub>2</sub> CONSTRAINT (TWO GAS) [HC], rationale indicates symptoms of CO<sub>2</sub> exposure). For SOP interstage gauge loss, there is no other instrumentation device available in flight to verify SOP first-stage regulation. For any single sensor loss, consider using EMU 3 (if available) to regain full operational capability, depending on the extent of resizing necessary to accommodate the affected crewmember. If the first-stage regulator function cannot be verified, the EMU could be one failure away (second-stage regulator failing open) from a catastrophic hazard, with a time of effect of seconds. ©[CR 7644 ]*

M. SCU POWER - NO POWER PROVIDED TO EMU THROUGH SERVICE AND COOLING UMBILICAL

*The EMU is considered fully operational on battery power. Battery may need to be changed out prior to depressurization to preserve full EVA time capability. EMU is considered GO-for-EVA under this condition.*

N. ECG TELEMETRY - NO ECG TELEMETRY IS PROVIDED TO MCC.

*The EMU is considered fully operational. Reference Rule {A15-20}, ECG TELEMETRY CHECKOUT.*

O. LOSS OF OPERATIONAL EMU HEATED GLOVE(S) IS NOT A CONSTRAINT TO PERFORMING AN EVA.

1. FOR A FAILURE OF HEATED GLOVES PRE-EVA AND THERMAL ANALYSIS INDICATING SKIN TEMPERATURE VIOLATIONS WITHOUT USE OF HEATED GLOVES BY THE CREW, ACTION WILL BE TAKEN TO RESTORE HEATED GLOVE POTENTIAL OR ESTABLISH CREW LIMITS WITHIN MISSION CAPABILITIES.

*The actions for a failure are: EVA flights fly backup heated gloves for EV crewmembers which should be used for a heater element failure; replacement of batteries; identify to the crew potential keep-out areas or limit handling of items for durations as specified in the EMU Glove Palm Certification Curves if capability is not restored (i.e., scheduled use of items listed in paragraph 2 of rule); swapping to backup EMU components (i.e., PLSS/HUT or arm segments) for a harness failure. The last action may place an EV crewmember in a non-optimum sized EMU and is the least preferred action and will be decided real time. ©[CR 7644 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS**  
**(CONTINUED)**

*The EMU is considered GO for a failure of EMU heated glove(s) before the EVA. Reasonable effort will be made to restore the capability so that heated gloves will be available to the EV crewmember if preflight thermal analysis deems likely the use of heated gloves. Need for heated gloves depends on mission attitude, timelines, locations of EVA tasks, and initial hand temperatures. The heated glove system for the EMU is a simple wire harness connecting a battery to the heater elements in the glove fingertips through connectors and toggle switches routed along the outside of the PLSS and arms. For the 3-volt system, a single failure will result in the loss of only one heated glove because each has a separate wire harness and battery. ©[CR 7644 ]*

*Reference Documentation: JSC-39116 (CTSD-SS-1621) EMU Phase VI Glove Thermal Vacuum Test and Analysis Final Report, "Glove Palm Certification Limits" graphs, August 20, 1998.*

2. FOR LOSS OF OPERATIONAL HEATED GLOVE DURING THE EVA, THE FOLLOWING OPTIONS, LISTED IN PRIORITY, ARE AVAILABLE TO THE EV CREW:
  - a. NOTIFICATION TO CREW OF POTENTIAL COLD AREAS TO AVOID, IF POSSIBLE, BASED ON THERMAL ANALYSIS.
  - b. FOR SINGLE GLOVE FAILURE, USE OF NON-AFFECTED HAND FOR GRASPING AND HANDLING COLD OBJECTS.
  - c. USE OF BRT (OR OTHER RESTRAINT DEVICE) TO ALLOW HANDS-FREE OPERATION.
  - d. USE OF ADJUSTABLE THERMAL MITTENS.
  - e. USE OF OTHER EV CREWMEMBER FOR OPERATIONS THAT ARE DEEMED TOO COLD BY THE AFFECTED EV CREW OR LIMIT HAND CONTACT DURATION.
  - f. USE OF EMU LCVG BYPASS.
  - g. CREW WOULD NOT WORK DURING NIGHT PASSES.
  - h. EV CREW MAY MOVE TO SUN SIDE TO WARM HANDS AFTER TASK.

*For a failure of the EMU heated gloves during the EVA, the EMU is GO to continue. The loss may require the affected EV crewmember to modify his/her operations as deemed necessary by that crewmember. For the 3-volt system, a single failure will result in the loss of only one heated glove because each has a separate wire harness and battery. ©[CR 7644 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_A15-3

**EMU GO/NO-GO CRITERIA WITH ENHANCED CWS**  
**(CONTINUED)**

*Restraint devices can be used to hold ORU's or restrain crewmembers to handrails. Thermal mittens may be used as an added layer to the EMU gloves but will reduce dexterity of the hands. The other EV crewmember may be used for cold tasks. Least preferred options include; EMU LCVG bypass may be used in an attempt to warm the crewmember's core temperature in an effort to warm the arms and hands, not working during night passes, or having the affected crewmember warm hands on the sun side as required. ©[CR 7644 ]*

*The crewmember shall be reminded to preclude affected hand(s) from becoming too cold in the first place. Once the hands are cold, it will invalidate the crewmember's sense of temperature and lower their "threshold" of comfort. The affect is that the crewmember's hand does not need to warm as much to give the sensation of being comfortable; therefore, the hand will start at a colder initial temperature the next time it is exposed. Iterations of this process over the EVA duration could lead to tissue damage without the crewmember being aware.*

*Reference Documentation: JSC-39116 (CTSD-SS-1621), EMU Phase VI Glove Thermal Vacuum Test and Analysis Final Report, "Glove Palm Certification Limits" graphs, August 20, 1998. ©[CR 7644 ]*

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**FLIGHT RULES**

12A\_A15-3

EMU GO/NO-GO CRITERIA WITH ENHANCED CWS  
(CONTINUED)

	PRE EVA			EVA			COMMENTS (FOR EVA CASE)
	NO GO	GO FOR SCU	GO FOR EVA	ABORT	TERMINATE	CONTINUE	
LOSS OF:							
A	SUIT PRESSURE INTEGRITY MAJOR LEAK MINOR LEAK	X X			X	X	SUIT P LOW & O <sub>2</sub> USE HIGH MSGS DISPLAYED ONLY O <sub>2</sub> USE HIGH MSG DISPLAYED
B	PRIMARY O <sub>2</sub> TANK P INTEGRITY MAJOR LEAK MINOR LEAK PERIODIC RECHARGE ACCEPTABLE PERIODIC RECHARGE <u>NOT</u> ACCEPTABLE	X		X		X	LEAK RATE TOO HIGH TO SUPPORT ON SCU  RECHARGE ON SCU AS REQUIRED REMAIN ON SCU IF RECHARGE FREQUENCY TOO HIGH TO SUPPORT EVA TASKS
C	PRESSURE REGULATION HIGH LOW	X X	C C		X X		ASSUMES SCU CAN SUPPORT PPRV FLOW ASSUMES SOP OPERATIONAL
D	OPERATIONAL SOP	X	C		X		
E	MINIMUM RF COMMUNICATIONS	X	C		X		
F	POS PRESS RELIEF VALVE FAILS CLOSED	X					ONLY DETERMINED DURING DEPRESS
G	VENTILATION FLOW		X		X		ASSUMES SCU CAN SUPPORT PURGE FLOW
H	CO <sub>2</sub> CONTROL		X		X		ASSUMES SCU CAN SUPPORT PURGE FLOW
I	BATTERY POWER		X		X		EMU WILL NOT HAVE POWER WHEN OFF SCU
J	THERMAL CONTROL SCU EMU			X		X	ASSUMES SCU CAN SUPPORT PURGE FLOW ASSUMES SCU CAN SUPPORT PURGE FLOW
K	CRITICAL INSTRUMENTATION: SUIT P XDUCER & GAUGE CWS DCM DISPLAY WITH MCC MONITOR WITHOUT MCC MONITOR	X	C				TERMINATE EVA IF MCC MONITORING LOST
L	SINGLE COMPONENT INSTRUMENTATION: SUIT P XDUCER GAUGE VENT FLOW SENSOR CO <sub>2</sub> XDUCER BATTERY VDC XDUCER BATTERY AMPS XDUCER O <sub>2</sub> P XDUCER SUBLIMATOR XDUCER SOP P XDUCER SOP INTERSTAGE GAUGE H <sub>2</sub> O GAS P XDUCER H <sub>2</sub> O WATER P XDUCER H <sub>2</sub> O TEMP XDUCER			X X X X X X X X X X X X X X X X X X X			
M	SCU POWER		X			X	MAY REQUIRE BATTERY CHANGEOUT
N	ECG TELEMETRY		X			X	
O	HEATED GLOVE(S)		X			X	WORKAROUNDS NOTED IN FLIGHT RULE

@[CR 7644 ]

NOTE: C = CONTINGENCY EVA ONLY @[CR 7644 ]

## FLIGHT RULES

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### ISS ONLY RULES

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#### 12A\_B15-1 MISSE PEC 5 RF INHIBITS AND KEEPOUT ZONE DURING EVA [HC]

- A. MATERIALS ISS EXPERIMENT (MISSE) PAYLOAD EXPERIMENT CARRIER (PEC) 5 RADIO FREQUENCY (RF) TRANSMISSIONS WILL BE INHIBITED VIA THE XMIT OFF COMMAND DURING THE THREE DOCKED MISSION EVA'S AS LONG AS THE EVA CREWMEMBERS REMAIN OUTSIDE OF THE 1.35M KEEP-OUT ZONE (KOZ). @[DN 31 ] @[CR 7645 ]
- B. FOR A CONTINGENCY, WHERE AN EVA CREWMEMBER NEEDS TO VIOLATE THE 1.35M KOZ, THE RESET COMMAND WILL BE ISSUED PRIOR TO THE CREWMEMBER ENTERING THE KOZ.

*The MISSE PEC 5 system has RF controlled inhibits to prevent the transmitter from operation during EVA. The inhibits are radio transmitter commanded and remove the power from the transmitter to prevent inadvertent transmission. For EVA operations outside of the 1.35m KOZ, there is no risk to catastrophic hazards and therefore three verifiable inhibits or four unverifiable inhibits (per the unpowered bus exception) are not required. By using the XMIT OFF command, the MISSE 5 can continue data collection and battery charging while providing two inhibits for preventing interference of the EVA comm. All of the 12A EVA's will be conducted outside of the 1.35m KOZ. @[DN 31 ]*

*Twenty-four hours prior to any ISS EVA, the POD will notify the DOD payload representative to perform a XMIT OFF of the MISSE PEC 5 RF system. DOD Payload representatives will provide the time the shutdown command was sent and verbal verification of its success. In the event that the EV crew must violate the KOZ, the IV crewmember will be required to send the RESET command prior to the EV crew entering the KOZ. This assumes that there was not sufficient time for coordination with the POD and DOD to have the RESET command issued from the ground. @[DN 31 ]*

*Reference: MISSE Inc 10 IURC report, Document EV7-04-3034, Near Field Computations for MISSE 5 Payload with Dual Antenna Configurations; MISSE PEC 5 Payload Flight Safety Data Package - Phase III; Hazard Report MISSE-8, Radio Frequency Radiation Interfering with ISS Circuitry, SSRMS, Orbiter Circuitry, SRMS, Extravehicular Mobility Unit and/or other Payloads; SSP 57260 MISSE PEC 5 HW ICD; and Boeing report D 683-35499-20, Section 4.3 of the OZ Payload Guideline and Constraint Report. @[DN 31 ] @[CR 7645 ]*

## FLIGHT RULES

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12A\_B15-2

EMU CONSUMABLES WITH REAL-TIME EMU DATA DOWNLINK

EVA CREWMEMBERS MUST BE COMPLETE WITH AIRLOCK INGRESS AND CONNECTED TO THE SERVICE AND COOLING UMBILICAL (SCU) WHEN 30 MINUTES REMAIN OF ANY EMU CONSUMABLE AS DETERMINED BY MCC.

©[CR 7647 ]

*Thirty minutes is considered the redline for primary consumables (O<sub>2</sub>, power, CCC and water). This 30-minute reserve is necessary to prevent bringing the non-replenishable redundant oxygen system (secondary oxygen pack (SOP)) on-line. If real-time data capability with MCC is available, the flight control team can use this information to determine which consumable will reach the 30-minute limit first. MCC consumables calculations can be more realistic due to the use of flight specific initial loading data rather than the standard minimum required values used by the EMU Caution and Warning System (CWS). S/G voice must be available for MCC to alert crew when they are approaching the 30-minute limit. If S/G voice capability is available, but is interrupted by periods of LOS, MCC can confirm consumables status with the crew prior to LOS. The affected crewmember(s) must be complete with airlock ingress and pre-repress when 30 minutes remain of any consumable. If consumables allow, the other crewmember will continue with remaining EVA tasks and will complete sortie cleanup. Timeline management will ensure that the EVA sortie cleanup, airlock ingress, and pre-repress is completed prior to the last crewmember reaching the 30-minute redline. Translation time back to the airlock will be determined by either Neutral Buoyancy Laboratory (NBL) or Virtual Reality (VR) Laboratory crew training. EVA tasks will be modified or deleted real time to ensure that the EV crewmember is connected to the SCU within the timeframe necessary to maintain the 30-minute reserve. Connection to the SCU is considered a safe configuration because the SCU can support the loss of any EMU consumable. Battery and CCC have a finite capacity; however, opening the helmet purge valve while on the SCU compensates for the loss of CCC, and configuring the EMU to accept airlock power compensates for the loss of battery. In the event that airlock power is not available, opening the helmet purge valve while on the SCU can compensate for the loss of the battery. Oxygen is rechargeable at vacuum. If the 30 minute consumable is oxygen, the crewmembers can connect to the SCU, recharge the consumable, and return to EVA tasks. Water recharge at vacuum is not an option on ISS due to hardware limitations. This rule is considered an operational constraint.*

*DOCUMENTATION: Hamilton Sundstrand Engineering Memorandum EMUM1-0404, Consumable Tracking During EVA, March 15, 2000, and Engineering judgment. ©[CR 7647 ]*



## FLIGHT RULES

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12A\_B15-3

EMU CONSUMABLES WITHOUT REAL-TIME EMU DATA  
DOWNLINK

- A. IF NO S/G VOICE CAPABILITY, AN EVA CREWMEMBER WILL TERMINATE THE EVA WHEN THE CAUTION AND WARNING SYSTEM (CWS) ISSUES A 30-MINUTE ALERT FOR ANY EMU CONSUMABLE. ©[CR 7648 ]

*If S/G voice and real-time EMU data capability with MCC are not available, the EMU CWS will be used to determine which consumable will reach the 30-minute limit first. If the EV crewmember has no ability to communicate with MCC, the only insight into the EMU consumables is via the CWS. The EV crewmember will rely on the CWS to display a message when 30 minutes remain of any EMU consumable. Oxygen is rechargeable at vacuum. If the 30-minute consumable is oxygen, the crewmembers can connect to the SCU, recharge the consumable, and return to EVA tasks. Water recharge at vacuum is not an option on ISS due to hardware limitations. This Rule is considered an operational constraint.*

- B. IF S/G VOICE CAPABILITY, AN EVA CREWMEMBER WILL TERMINATE THE EVA WHEN THE CAUTION AND WARNING SYSTEM (CWS) ISSUES A 30-MINUTE ALERT FOR OXYGEN, CCC, OR WATER CONSUMABLES. THE EVA CREWMEMBER MUST BE COMPLETE WITH AIRLOCK INGRESS AND CONNECTED TO THE SERVICE AND COOLING UMBILICAL (SCU) WHEN 30 MINUTES OF POWER REMAIN AS DETERMINED BY MCC THROUGH PERIODIC REPORTS OF EMU STATUS.

*If S/G voice is available but real-time EMU data is not available, the EMU CWS will be used to determine which consumable (oxygen, CCC, or water) will reach the 30-minute limit first. However, battery power can be tracked on the ground with a periodic status, because the power usage is relatively constant during the EVA as compared with other consumables. The EV crew will give an hourly EMU status for the first 6.5 hours followed by an increase in status calls to every 10 minutes so that MCC can track more closely the battery performance towards the lower end of its capacity. Oxygen, CCC and water calculations depend on crewmember metabolic rate requiring more frequent status checks to get an accurate estimate of use rate. The CWS messages for these consumables are more conservative than real-time consumables data. The battery 30-minute limit will be calculated by the ground using the periodic status checks. Oxygen is rechargeable at vacuum. If the 30-minute consumable is oxygen, the crewmembers can connect to the SCU, recharge the consumable, and return to EVA tasks. Water recharge at vacuum is not an option on ISS due to hardware limitations. This rule is considered an operational constraint.*

*DOCUMENTATION: Hamilton Sundstrand Engineering Memorandum EMUM1-0404, Consumable Tracking During EVA, March 15, 2000, and Engineering judgment. ©[CR 7648 ]*

## FLIGHT RULES

**12A\_B15-4      ORLAN EVA KEEP-OUT ZONES [HC] [RC] [E]**

AN EVA CREWMEMBER IN AN ORLAN SUIT MUST MAINTAIN A SAFE DISTANCE OUTSIDE THE FOLLOWING KEEP-OUT ZONES UNDER THE SPECIFIED CONDITIONS (ANTENNA KEEP-OUT ZONES ARE BASED ON PHYSIOLOGICAL CONSTRAINTS ONLY) : ©[CR 7649 ]

*Reference Physiology Radio Frequency (RF) Exposure Keep-Out Distances from SSO, ISS USOS, and Russian Antennas, JSC-62610, Rev-A, June 2005.*

ISS SYSTEM	KEEP-OUT ZONE	CONDITION
U.S. ANTENNAS:		
KU-BAND	NONE	POWERED NOM MODE
S-BAND HIGH GAIN (S1 AND P6/P1)	0.9 M	POWERED
S-BAND LOW GAIN (S1 AND P6/P1)	0.3 M	POWERED
UHF (U.S. LAB AND P1)	0.3 M	HIGH/LOW POWER MODE
WETA (NODE 1 AND P1)	NONE	POWERED
EWIS	NONE	POWERED
RS ANTENNAS:		
(FGB)		
RADIOTELEMETRY [БР-9ЦУ-8]	0.1 M	POWERED
KOMPARUS [КИС]	0.1 M	POWERED
TRACKING 38G6	0.2 M	POWERED
KURS A [КУРС А] - AC-BKA	0.2 M	POWERED
KURS A [КУРС А] - AKP-BKA	NONE	POWERED
KURS P [КУРС P] - 4AO-BKA	0.3 M	POWERED
KURS P [КУРС P] - AP-BKA	0.2 M	POWERED
KURS P [КУРС P] - 2AP-BKA	0.2 M	POWERED
KURS P [КУРС P] - AKP (OMNI)	NONE	POWERED
TV [КЛ-108А]	0.2 M	POWERED
SIRIUS	0.3 M	POWERED
TORU [ТОРУ] - SLOT	0.2 M	POWERED
TORU [ТОРУ] - TV	0.2 M	POWERED
(SERVICE MODULE)		
VHF-1 [CTTC]		
VHF-2 [CTTC]	0.1 M	POWERED
ONBOARD TELEMETRY	NONE	POWERED, EVA MODE
MEASUREMENT		
(BITS) [БИТС2-12]	0.2 M	POWERED
TV [ТВС]	0.3 M	POWERED
REGUL (HIGH GAIN - AFT END)	0.7 M	POWERED
[РЕГУЛ]	0.1 M	POWERED
REGUL (LOW GAIN) [РЕГУЛ]	0.2 M	POWERED
ORBIT RADIO TRACKING [РКО]	NONE	NO ELECTRONICS UNIT
LIRA [ЛИРА]	0.2 M	NO ELECTRONICS UNIT
GLOBAL TIMING SYSTEM (GTS 1)	NONE	POWERED
GLOBAL TIMING SYSTEM (GTS 2)	0.3 M	POWERED
KURS P [КУРС P] - 4AO-BKA	0.2 M	POWERED
KURS P [КУРС P] - AP/2AP-BKA	NONE	POWERED
KURS P [КУРС P] - AKP-BKA		
(ORLAN)	NONE	POWERED
ORLAN 1	NONE	POWERED
ORLAN 2		

©[CR 7649 ]

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**FLIGHT RULES**

12A\_B15-4

ORLAN EVA KEEP-OUT ZONES [HC] [RC] [E]  
(CONTINUED)

ISS SYSTEM	KEEP-OUT ZONE	CONDITION
(PROGRESS) TELEOPERATOR TELEMETRY TV TRACKING COMMAND (OMNI) KURS-A	0.3 M 0.3 M 0.3 M 0.2 M 0.1 M 0.2 M	POWERED POWERED POWERED POWERED POWERED POWERED
(SOYUZ) TELEOPERATOR TELEMETRY TV TRACKING COMMAND (OMNI) KURS-A [KYPC A] - AKR-VKA KURS-A [KYPC A] - 2AO-VKA KURS-A [KYPC A] - 2ASF1-M-VKA N1 & N2	0.2 M 0.3 M 0.3 M 0.2 M 0.2 M NONE NONE 0.2 M	POWERED POWERED POWERED POWERED POWERED POWERED POWERED POWERED
THRUSTERS: (FGB) FGB REBOOST (417 KGF) FGB ATTITUDE CONTROL (1.3 KG) FGB ATTITUDE CONTROL (40 KG) (SERVICE MODULE) SM REBOOST (313 KGF) SM ATTITUDE CONTROL (13.3 KGF) (PROGRESS) PROGRESS M/M1 ATTITUDE CONTROL (13.3 KGF)	NO CONTACT NO CONTACT NO CONTACT  NO CONTACT LARGE DIAMETER OF SM  <b>TBD</b>	          DRIVER POWER OFF NOT INHIBITED
OTHER EQUIPMENT: SARJ S1 (P1) RADIATOR BEAM MOBILE TRANSPORTER	OUTBOARD OF SARJ 2.0 FT/0.6 M 5.0 FT	ACTIVATED BEAM FREE TO ROTATE MT TRANSLATING

©[CR 7649 ]

## FLIGHT RULES

### 12A\_B15-5      EMU CONSUMABLES REDLINES

THE FOLLOWING TABLE IDENTIFIES EMU CONSUMABLES REDLINES. THE REDLINES WILL: @[CR 7651 ]

- A. PROTECT THE REQUIRED 30-MINUTE RESERVE (REF RULE {12A\_B15-2}, EMU CONSUMABLES WITH REAL-TIME EMU DATA DOWNLINK, OR {12A\_B15-3}, EMU CONSUMABLES WITHOUT REAL-TIME EMU DATA DOWNLINK).
- B. WITH MCC EMU DATA - REQUIRE THE EV CREW TO BE CONNECTED TO THE SERVICE AND COOLING UMBILICAL (SCU) BY THE TIME THESE LIMITS ARE REACHED.
- C. WITHOUT MCC EMU DATA - REQUIRE THE EV CREW TO TERMINATE THE EVA WHEN THESE LIMITS ARE REACHED.

	PRIMARY O <sub>2</sub>	WATER	POWER	LIOH	METAL OXIDE
LIMIT WITH EMU DATA TO MCC	150 PSIA	CWS MESSAGE RESERVE WATER ON / TIME LF = 0:30 [4]	MCC FLIGHT SPECIFIC AMP-HR CALCULATION [1] OR CWS MESSAGE PWR TIME LEFT= 0:30 [4] OR 16.5 VOLTS (BATT VDC LOW CWS MESSAGE)	CO2 = 2.75 MMHG AND INCREASING [2] OR MCC FLIGHT SPECIFIC BTU CALCULATION [2]	CO2 = 3.2 MMHG AND INCREASING [3] OR MCC 7400 BTU CALCULATION [3]
LIMIT WITHOUT EMU DATA TO MCC	CWS MESSAGE O2 TIME LEFT = 0:30 [4]	CWS MESSAGE RESERVE WATER ON / TIME LF = 0:30 [4]	MCC FLIGHT SPECIFIC AMP-HR CALCULATION[1] OR CWS MESSAGE PWR TIME LEFT= 0:30 [4] OR 16.5 VOLTS (BATT VDC LOW CWS MESSAGE)	CWS MESSAGE MONITOR CO2 = 8.0 MMHG (PRESSURE COMPENSATED) OR 3.0 MMHG (UNCOMPENSATED)	CWS MESSAGE MONITOR CO2 = 8.0 MMHG (PRESSURE COMPENSATED) OR 3.0 MMHG (UNCOMPENSATED)

@[CR 7651 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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### 12A\_B15-5      EMU CONSUMABLES REDLINES (CONTINUED)

NOTES: @[CR 7651 ]

- [1] FIRST OF EITHER LIMIT REACHED (VOLTS OR AMP-HR LEFT CALCULATION). MCC WILL HAVE THE PRE-EVA AMP-HR CHARGE CAPACITY OF THE EMU BATTERY. GROUND CALCULATION OF THE AMP-HRS USED DURING THE EVA WILL BE SUBTRACTED FROM THE PRE-EVA CAPACITY TO DETERMINE AMP-HR LEFT IN BATTERY. IF USING THE AMP-HR CALCULATION ON THE GROUND, THE CREW WILL BE ON THE SCU PRIOR TO REACHING THE 30 MINUTES LEFT INDICATION. OTHERWISE, THE CWS MESSAGES (PERCENT PWR LEFT AND BATT VDC LOW) WILL ALERT THE CREW TO TERMINATE WHEN 30 MINUTES OF BATTERY POWER REMAIN.
- [2] FIRST OF EITHER LIMIT REACHED (MMHG OR BTU LEFT CALCULATION). MCC WILL HAVE PRE-EVA LIOH CANISTER BTU CAPACITY. PER AGREED 30-MINUTE RESERVE OF 1500 BTU, GROUND CALCULATION OF THE BTU'S USED DURING THE EVA WILL BE SUBTRACTED FROM THE BTU CAPACITY TO DETERMINE BTU'S LEFT IN THE CANISTER. FOR LIOH, THE CO<sub>2</sub> VALUE OF 2.75 MMHG IS WHEN THE EV CREW WILL TERMINATE THE EVA. MONITORING OF CO<sub>2</sub> TRENDING SHOULD BEGIN AT 2.4 MMHG. THESE VALUES ASSUME PRESSURE COMPENSATION OF THE CO<sub>2</sub> SENSOR READINGS. IF PRESSURE COMPENSATION IS LOST, THE EVA WILL BE TERMINATED AT A CO<sub>2</sub> VALUE OF 1.7 MMHG.
- [3] FIRST OF EITHER LIMIT REACHED (MMHG OR BTU LEFT CALCULATION). METOX CANISTERS WILL HAVE A MAXIMUM 8000-BTU CAPACITY. PER AGREED 30-MINUTE RESERVE OF 600 BTU, A TOTAL OF 7400 BTU'S IS AVAILABLE FOR EVA TIME. GROUND CALCULATION OF THE BTU'S USED DURING THE EVA WILL BE SUBTRACTED FROM THE BTU CAPACITY TO DETERMINE BTU'S LEFT IN THE CANISTER. DUE TO THE DIFFERENCE IN COMPOSITION AND OPERATION OF METOX AS COMPARED TO LIOH, THE CO<sub>2</sub> VALUE OF 3.2 MMHG IS WHEN THE EV CREW WILL TERMINATE THE EVA. MONITORING OF CO<sub>2</sub> TRENDING SHOULD BEGIN AT 2.9 MMHG. THESE VALUES ASSUME PRESSURE COMPENSATION OF THE CO<sub>2</sub> SENSOR READINGS. IF PRESSURE COMPENSATION IS LOST, THE EVA WILL BE TERMINATED AT A CO<sub>2</sub> VALUE OF 2.0 MMHG.
- [4] THE EMU C&W SYSTEM PROVIDES 30-MINUTE LIMITING CONSUMABLE MESSAGES FOR:

a. OXYGEN: WHEN O<sub>2</sub> TIME LEFT = 
$$\frac{O_2 \text{ P} - 75}{O_2 \text{ USE RATE}} = 30 \text{ MINUTES.}$$

b. WATER: WHEN H<sub>2</sub>O GAS PRESS - H<sub>2</sub>O WATER PRESS > 2.1 PSID.

c. POWER: WHEN PWR TIME LEFT = 
$$\frac{\text{INITIAL CAPACITY} - \text{AMP HR USED}}{\text{PWR USE RATE}} = 30 \text{ MINUTES.}$$

THE PERCENTAGE OF O<sub>2</sub> AND POWER REMAINING IS DISPLAYED TO THE CREWMEMBER. THE LIMITING CONSUMABLE AND THE TIME LEFT IN THE EVA IS ALSO DISPLAYED. THE CALCULATION IN PARAGRAPH C IS BASED ON THE CREWMEMBER INPUT INITIAL CAPACITY OF THE BATTERY PER MCC-H DIRECTION. THE CWS ASSUMES A DEFAULT OF 32 AMP-HRS IF THE CREWMEMBER MAKES NO INITIAL SELECTION.

*DOCUMENTATION: Hamilton Sundstrand Engineering Memorandums EMUM1-0404, Consumable Tracking During EVA, March 15, 2000; EMUM1-0598; and EVAM-0215, IRCO2 Sensor Pressure Compensation with ECWS, February 22, 2006; and Engineering judgment. @[CR 7651 ]*

## FLIGHT RULES

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12A\_B15-6

RESERVED

## FLIGHT RULES

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### 12A\_B15-7 GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]

THIS RULE SUPERSEDES RULES {B15-55}, JOINT AIRLOCK GO/NO-GO CRITERIA [RC] [C], AND {B17-251}, AIRLOCK MINIMUM REQUIREMENTS FOR 530 MMHG/10.2 PSIA OPERATIONS. @[CR 7655 ]

GO/NO-GO DECISIONS FOR ALL PHASES OF ISS EMU EVA PREBREATHE OPERATIONS WITH AN ADDITIONAL CREWMEMBER ON ISS WILL BE BASED ON THE FOLLOWING REQUIREMENTS:

#### A. MASK PREBREATHE

1. CONFIRMATION OF SUFFICIENT OXYGEN FLOW AT THE PREBREATHE HOSE ASSEMBLY (PHA) QDM BY ONE OF THE FOLLOWING MEANS:
  - a. THE UIA O<sub>2</sub> SUPPLY PRESSURE AND O<sub>2</sub> HI P SUPPLY PRESSURE REMAIN GREATER THAN 1431 KPA (207.5 PSIA)
  - b. QUALITATIVE REPORT BY CREWMEMBERS THAT O<sub>2</sub> SUPPLY TO THE QDM IN EMERGENCY (POSITIVE PRESSURE) MODE IS ACCEPTABLE

*Mask prebreathe is performed during the exercise prebreathe and overnight campout protocols. If mask prebreathe operations are not possible, EVA preparation using the in-suit prebreathe protocol may be an option if the O<sub>2</sub> high-pressure supply system is still available. O<sub>2</sub> supply pressure greater than 1431 kPa is based on the maximum outlet pressure of the PHA regulator (150 ±5 psia) plus pressure sensor accuracy (range 0-3500 psia ±1.5 percent). Confirmation on multiple independent pressure sensors reduces the risk of prebreathe termination due to sensor bias.*

*The determination of acceptable oxygen flow from the QDM is subjective. Flow is affected by factors such as inlet pressure, total flow rate, respiratory rate, inspiration volume, and rate of inspiration (peak flow). The QDM regulator may 'flutter' in low demand conditions or with insufficient inlet pressure and flow rate.*

2. ACTIVE INTRAMODULE VENTILATION IN THE MODULE WHERE EV CREW IS LOCATED

*The mask prebreathe protocol is conducted by two EV crewmembers wearing PHA's in the 'emergency' (positive pressure) mode. The oxygen released by the masks must be mixed with cabin air in order to minimize any increased fire risk due to localized regions of elevated oxygen concentration. Sufficient intramodule ventilation may be provided by a cabin fan/CCAA, a Portable Fan Assembly (PFA), or IMV air exchange with another module. @[CR 7655 ]*

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## FLIGHT RULES

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12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

3. TWO PHA KITS WITH A MINIMUM HOSE LENGTH TO MAINTAIN OXYGEN FLOW RATES AS DETERMINED BY PARAGRAPH A.1, A RELIEF VALVE ASSEMBLY IN SERIES WITH SUPPLY PORT, AND AN OPERATIONAL QDM EMERGENCY MODE. @[CR 7655 ]

*During exercise, oxygen flow demands vary between members of the astronaut office. While some crewmembers may obtain sufficient flow with shorter lengths, 120 feet of PHA hose should be used, if available, to provide sufficient accumulation and mobility. Even with this configuration, crewmembers who are heavy breathers may find this insufficient while using ROOBA. In this situation, the high-pressure supply should be reconfigured as described in the rationale of paragraph B.1.*

B. EXERCISE PREBREATHE

1. OPERATIONAL OXYGEN HIGH PRESSURE SUPPLY SYSTEM.

*The O<sub>2</sub> high-pressure supply system provides oxygen to the PHA ports in the Equipment Lock. The oxygen system must be configured properly in order to route oxygen for EVA operations. If ROOBA does not provide sufficient flow to support exercise, the exercise portions of the prebreathe protocol will be conducted using PHA hose connected to the joint airlock PHA ports with supply from an ISS oxygen tank, or PHA hose connected to the orbiter LEH ports on the middeck.*

2. THE CYCLE ERGOMETER WITH VIBRATION ISOLATION SYSTEM (CEVIS)

IN THE EVENT CEVIS IS UNAVAILABLE, THE SHUTTLE ERGOMETER CAN BE USED

3. ONE HEART RATE MONITOR (HRM)
4. BLUE OR BLACK THERABAND EXERCISE TUBING
5. CYCLING SHOES

*The exercise portion of the exercise prebreathe protocol is conducted by two EV crewmembers wearing PHA's. Therefore, criteria for both mask prebreathe and exercise prebreathe must be satisfied during this phase of EVA preparations. If exercise prebreathe operations are not possible, EVA preparation using either the overnight campout or in-suit prebreathe protocol may be an option.*

*Reference Rule {B13-107}, EVA PREBREATHE PROTOCOL [RC] [E], for definitions of functionality and workarounds for the exercise hardware. @[CR 7655 ]*

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## FLIGHT RULES

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12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

C. ISOLATED AIRLOCK WITH CREW AWAKE @[CR 7655 ]

1. IF ALL ISS CREWMEMBERS ARE ISOLATED, TWO FUNCTIONAL PORTABLE COMPUTER SYSTEMS (PCS'S) MUST BE LOCATED IN THE JOINT AIRLOCK.
  - a. ONE PCS MUST BE CONNECTED TO THE C&C MDM TO PROVIDE THE ISOLATED CREWMEMBERS WITH VEHICLE CAUTION & WARNING MESSAGES AND MANUAL EMERGENCY ANNUNCIATION CAPABILITY.
  - b. IN THE EVENT OF A SINGLE PCS FAILURE, EVA PREPARATIONS CAN CONTINUE.

*The ISS crew is isolated in the Joint Airlock during the exercise prebreathe and overnight campout protocols. If isolated airlock operations cannot be supported during the crew awake period, EVA preparation using the in-suit prebreathe protocol may be an option.*

*The PCS provides the crew with caution & warning messages, as well as a manual means of annunciating a Class I emergency event. The second PCS provides the crew with a backup in the case of a PCS failure. Both outlets on the Equipment Lock Utility Outlet Panel (UOP) provide power and 1553 data on the CB CT4 bus.*

*If a PCS failure were to occur while the entire crew was isolated and awake, the crew can swap to the spare PCS and continue EVA preparations. If all PCS capability is lost, the isolated operations should be terminated. In addition to the caution & warning impacts, the crew will be unable to command the Node 1 stbd IMV valves as a potential Joint Airlock repress method.*

2. IF THERE ARE NON-ISOLATED CREWMEMBERS ON ISS, ONLY ONE PCS IS REQUIRED IN THE AIRLOCK PRIOR TO HATCH CLOSE. IF THE PCS FAILS, EVA PREPARATIONS MAY CONTINUE.

*Non-isolated crewmembers will have access to other PCS terminals, as well as manual access to the Node 1 stbd IMV valves.*

*Reference Rule {B7-110}, CAUTION AND WARNING OPERATIONS [RC] [E].*

3. ONE FUNCTIONAL ATU IS REQUIRED IN THE AIRLOCK. IN THE EVENT THE ATU FAILS, EVA PREPARATIONS MAY CONTINUE.

*The ATU's provide ISS caution & warning tones in addition to a voice communication path. There are three ATU's located in the Equipment Lock. @[CR 7655 ]*

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## FLIGHT RULES

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GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

*If ATU communication is lost while the entire crew is isolated and awake, the crew can activate the UHF subsystem and communicate via the EMU's. The crew will maintain voice communication with MCC-H; however, ISS Caution & Warning tones would be lost. In this case, the crew can monitor the PCS for new messages or communicate with a non-isolated crewmember, if available. There would be an approximately 20-minute period from helmet donning through airlock repress where IV would not have direct communications with MCC-H and the EV crew. Coordination of Joint Airlock repressurization would have to be accomplished through the helmet and with hand signals, or by communication with non-isolated crewmembers. ©[CR 7655 ]*

4. EMERGENCY EQUIPMENT LOCATED IN THE JOINT AIRLOCK
  - a. ONE PORTABLE FIRE EXTINGUISHER (PFE)
  - b. ONE QDM AND PORTABLE BREATHING APPARATUS (PBA) OXYGEN BOTTLE FOR EACH ISOLATED CREWMEMBER

*PBA oxygen bottles provide portable oxygen sources to be used with the PHA QDM's. In the event of an emergency, the EV crewmembers connect their PHA QDM's to PBA bottles as their emergency oxygen source. IV crewmembers may use the spare PHA QDM with a third PBA bottle, or a complete PBA kit borrowed from elsewhere on ISS.*

5. OPERATIONAL AIRLOCK PCA
  - a. TOTAL PRESSURE MONITORING
  - b. AUTOMATIC RAPID DEPRESSURIZATION DETECTION AND RESPONSE
  - c. O<sub>2</sub> INTRODUCTION CAPABILITY

*Airlock PCA, Crewlock Cabin Pressure Sensor, as well as the I-138 Feedwater Pressure Sensor on each EMU can serve as cabin total pressure sensors. However, the Airlock PCA provides rapid depress detection and automatic software response. Oxygen introduction can also be accomplished with the PHA's. N<sub>2</sub> introduction may be needed to decrease the O<sub>2</sub> percent if the flammability limit is exceeded, but this is not considered a requirement since there are alternate methods of responding to out of limit O<sub>2</sub> concentrations. For example, isolated operations can be aborted or a small depress/repress can be performed to utilize stack air.*

6. OPERATIONAL LAB PCA OR RUSSIAN ДДИ

*Rapid depressurization detection and response capability is required in the remainder of the ISS common volume. ©[CR 7655 ]*

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## FLIGHT RULES

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12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

7. SMOKE DETECTION IN EACH MODULE EXCEPT AIRLOCK IF ALL CREWMEMBERS ARE ISOLATED @[CR 7655 ]

IF THERE ARE NON-ISOLATED CREWMEMBERS AWAKE ON ISS, THEY CAN PERFORM SMOKE DETECTION DUTIES FOR ISS.

*During isolated operations of the entire crew, no one will be present to smell smoke in the ISS common volume. If MCC-H loses insight into smoke detection in the Lab, Node 1, or the Russian Segment, the prebreathe will be terminated until smoke detection capability is recovered. Active IMV air exchange between adjacent modules does not provide sufficient smoke detection capability. If the Joint Airlock cabin smoke detector is lost while the crew is awake, EVA preparations can continue.*

*Reference Rule {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E].*

8. OPERATIONAL AIRLOCK COMMON CABIN AIR ASSEMBLY (CCAA)

IF THE CCAA FAILS, EVA PREPARATION MAY CONTINUE, PROVIDED THE CREW DOES NOT EXPERIENCE SYMPTOMS OF CO<sub>2</sub> EXPOSURE AND THE CABIN TEMPERATURE IS ACCEPTABLE FOR CREW COMFORT.

*The CCAA provides air cooling for the isolated airlock. There is no alternative for cabin cooling if this CCAA were to fail. The CCAA is also required for CO<sub>2</sub> Removal Box functionality. If the Airlock CCAA fails prior to isolation, a portable fan assembly (PFA) and LiOH may be used for CO<sub>2</sub> removal for 1 hour. If this is determined to be sufficient CO<sub>2</sub> removal for the duration of the isolated operations, the protocol may continue. Reference Rule {B13-53}, PPCO<sub>2</sub> CONSTRAINT [RC] [E].*

9. ONE OPERATIONAL NODE 1 STARBOARD IMV VALVE

*Either Node 1 stbd forward or aft IMV valve is required for contingency airlock depress.*

10. OPERATIONAL NODE 1 STARBOARD HATCH AND MPEV. WHILE AT 10.2 PSIA, THE HATCH INDICATOR MUST BE IN THE EQUALIZE POSITION TO PROVIDE POSITIVE PRESSURE RELIEF.

11. OPERATIONAL MEANS OF AIRLOCK DEPRESSURIZATION USING ONE OF THE FOLLOWING METHODS:

- a. DEPRESS PUMP ASSEMBLY
- b. PCA VRIV

*If the depress pump is not used, 24 pounds of air will be lost during depress to 10.2 psia. @[CR 7655 ]*

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**FLIGHT RULES**

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**GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]**  
**(CONTINUED)**

12. COMPOUND SPECIFIC ANALYZER FOR OXYGEN (CSA-O<sub>2</sub>) SENSORS MUST BE COMPARED TO A WORKING PPO<sub>2</sub> SENSOR (MCA, SOYUZ GAS ANALYZER, SHUTTLE O<sub>2</sub> SENSORS) WITHIN 24 HOURS OF ISOLATION. MCC-H WILL THEN DETERMINE THE ACCURACY OF THE CSA-O<sub>2</sub>'S. MONITORING OF JOINT AIRLOCK OXYGEN LEVELS MUST BE ACCOMPLISHED BY ONE OF THE FOLLOWING MEANS: ©[CR 7655 ]
- a. OPERATIONAL MAJOR CONSTITUENTS ANALYZER (MCA) AND ONE COMPOUND SPECIFIC ANALYZER FOR OXYGEN (CSA-O<sub>2</sub>)
  - b. SIMULTANEOUS COMPARISON OF TWO COMPOUND SPECIFIC ANALYZER FOR OXYGEN (CSA-O<sub>2</sub>) SENSORS

*CSA-O<sub>2</sub>'s have exhibited a downward drift over time during ground testing. MCC-H will perform a root sum square analysis against an unlike sensor such as the MCA, Soyuz Gas Analyzer, or the shuttle ppO<sub>2</sub> sensors to determine the CSA-O<sub>2</sub>'s are within allowable error bands as defined in Rule {B17-15}, USE OF OXYGEN PARTIAL PRESSURE SENSORS [RC] [E]. If the CSA-O<sub>2</sub> accuracy is still within range, there is good confidence that the sensor will not drift out of range in the next 24 hours, and the CSA-O<sub>2</sub> can be used for isolated operations.*

*Two oxygen monitors are required at all times during isolated airlock operations so that a potential drift in one sensor can be detected and possible prebreathe violations are recognized.*

13. OPERATIONAL CO<sub>2</sub> REMOVAL RECEPTACLE LOADED WITH CONTAMINATION CONTROL CARTRIDGES (CCC), EITHER METOX OR LIOH IS REQUIRED.

IF CCC'S ARE UNAVAILABLE OR IF THE CO<sub>2</sub> REMOVAL RECEPTACLE IS FAILED, ISOLATED OPERATIONS MAY BE PERFORMED PROVIDED THE CO<sub>2</sub> LEVEL REMAINS WITHIN ALLOWABLE LIMITS PER RULE {B13-53}, PPCO<sub>2</sub> CONSTRAINT [RC] [E].

*Each regenerable Metox canister is capable of removing 1.6 lbm of CO<sub>2</sub> from the atmosphere. When used in the CO<sub>2</sub> removal receptacle, each canister is limited to a total of 16 man-hours at 10.2 psia. Although Metox is the preferred method for CO<sub>2</sub> removal in the isolated airlock, EMU LiOH may also be used in the removal receptacle with the same capacity limitations. Reference FEMU-R-003, EMU On-Orbit Operation, Maintenance, Testing, Storage, and Tracking Requirements and Constraints. In practice, one pair of Metox canisters is used for two exercise prebreathe protocols before regeneration is necessary. For overnight campout, one pair of Metox canisters is used only once and then scheduled for regeneration. In the event of a CO<sub>2</sub> Removal Box failure that does not affect the CCAA, a Portable Fan Assembly (PFA) may be used with LiOH for up to one hour. ©[CR 7655 ]*

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## FLIGHT RULES

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12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

14. A FUNCTIONAL LIGHTING SOURCE MUST BE AVAILABLE IN THE AIRLOCK DURING EVA OPERATIONS. @[CR 7655 ]

*Lighting is required to perform EVA operations in the Joint Airlock. There are two Equipment Lock and two Crewlock GLA's available for crew usage. In addition, each EMU is nominally equipped with two helmet lights (left and right are functionally independent). The crew may also utilize portable flashlights.*

D. ISOLATED AIRLOCK WITH CREW ASLEEP

1. ALL CRITERIA FOR ISOLATED AIRLOCK WITH CREW AWAKE ARE ALSO APPLICABLE WHILE CREW IS ASLEEP, UNLESS OTHERWISE STATED.

*The overnight campout protocol requires the two EV crewmembers to sleep in the Joint Airlock at 10.2 psia. If the Joint Airlock cannot support overnight campout, EVA preparation using the exercise or in-suit prebreathe protocols may be an option.*

2. ONE FUNCTIONAL ATU IS REQUIRED IN THE AIRLOCK. IN THE EVENT THE ATU FAILS, EVA PREPARATIONS MAY CONTINUE.

*Non-isolated crewmembers have access to other ATU's, as well as the UHF subsystem. During the campout prebreathe protocol, only the two EV crewmembers are isolated leaving an additional crewmember outside the airlock. If there are only two crewmembers on ISS, reference Rule {B15-206}, GO/NO-GO CRITERIA FOR ISS EMU EVA WITH ISS UNMANNED [RC].*

3. OPERATIONAL AIRLOCK COMMON CABIN AIR ASSEMBLY (CCAA)

IF THE CCAA FAILS DURING CREW SLEEP, THE CREW MUST REMAIN AWAKE UNTIL CCAA RESTART. IF THE DURATION OF SLEEP INTERRUPTION IS ACCEPTABLE, EVA PREPARATIONS CAN CONTINUE.

*If the CCAA fails prior to initiation of campout, the PFA cannot be used as an alternative because it is limited to 1 hour of continuous operation due to noise level constraints. If the CCAA fails during crew sleep, a caution alarm will wake the crew. The crew must remain awake until CCAA restart due to lack of circulation and in order to provide smoke detection capability. Lack of circulation can result in elevated CO<sub>2</sub> pockets, condensation, and incomplete oxygen mixing. Acceptability of sleep interruption will be determined by the crew and Surgeon console. @[CR 7655 ]*

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## FLIGHT RULES

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**GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]**  
**(CONTINUED)**

4. PRIOR TO ISOLATED CREWMEMBER SLEEP, PARTIAL PRESSURE OF OXYGEN MUST BE VERIFIED BETWEEN 25.9 PERCENT AND 28.2 PERCENT USING SENSORS DESCRIBED IN PARAGRAPH C.12. TOTAL PRESSURE MUST BE VERIFIED BETWEEN 10.24 AND 10.84 PSI.  
@[CR 7655 ]
5. MCA IS HIGHLY DESIRED.

*During crew sleep portions of the campout protocol, the CSA-O<sub>2</sub> is not usable because it requires manual readings. The MCA is used to monitor partial pressures of CO<sub>2</sub> and O<sub>2</sub>: high CO<sub>2</sub> can cause hypercapnia, low O<sub>2</sub> concentrations (as an indication of the ppN<sub>2</sub> for a given total pressure) can cause decompression sickness during the EVA, and high O<sub>2</sub> concentrations present flammability risks.*

*In the event of an MCA failure, these risks are mitigated by the following controls:*

*The partial pressure of CO<sub>2</sub> is controlled by the CCAA and the CO<sub>2</sub> removal box. Without the MCA there is no insight into CCC effectiveness or failure; therefore, CO<sub>2</sub> removal capability must be assumed lost. With no CO<sub>2</sub> removal, according to Hazard Report UNQ-TeSS-017, the crew will wake up if exposed to high ppCO<sub>2</sub> levels. In addition, assuming a CO<sub>2</sub> production rate of 0.18 lbm/hr for two crewmembers, the ppCO<sub>2</sub> in the airlock will not rise more than 10.8 mmHg during the nine hour isolation. Maximum CO<sub>2</sub> concentrations will not reach hazardous levels during the isolated period. If levels are elevated and symptoms are present at crew wake, nominal procedures call for PHA donning and airlock equalization, which will aid in alleviating symptoms. After mask donning, the crew and Surgeon will evaluate crews' readiness for EVA.*

*The initial O<sub>2</sub> concentration and total pressure are established such that they will not drop below 24.2 percent and 10.01 psi even if the PCA fails to introduce O<sub>2</sub>/N<sub>2</sub> during the subsequent 9-hour isolation. This analysis assumes a metabolic O<sub>2</sub> consumption rate of 1.84 lbm O<sub>2</sub>/day/person for two crewmembers for nine hours. Once awake, the crew must verify the O<sub>2</sub> concentration is within allowable limits with two CSA-O<sub>2</sub>'s prior to any gas introduction in order to continue the campout protocol.*

*The airlock PCA will be used to identify a leak into the isolated airlock. The high pressure caution is set to alert the crew when prebreathe pressure limits are reached. Worst case, an O<sub>2</sub> leak would result in an O<sub>2</sub> concentration < 34 percent. In this situation, the elevated concentration has been accepted via an NCR. @[CR 7655 ]*

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## FLIGHT RULES

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12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]  
(CONTINUED)

E.    IN-SUIT PREBREATHE    @[CR 7655 ]

*In-suit prebreathe is required for all EVA prebreathe protocols. If in-suit prebreathe cannot be supported, EVA preparations must be terminated.*

1.    SUITED EV CREWMEMBERS MUST BE ABLE TO COMMUNICATE WITH EACH OTHER AND IV USING EITHER HARDLINE OR RF (SSCS) .

*If hardline communication is unavailable, the EMU SSER may be activated and used with the Airlock internal antennas and SSSR. If the Airlock internal antennas are not functional, the SSER may be able to communicate with the SSSR via the Internal Antenna Assembly (IAA) in Node 1. This requires powering the IAA, and the Node 1 stbd hatch must be open.*

2.    ONE SERVICE AND COOLING UMBILICAL (SCU) MUST PROVIDE COOLING FOR THE EMU .
3.    ONE SERVICE AND COOLING UMBILICAL (SCU) TO MAINTAIN THE EMU PRIMARY O<sub>2</sub> TANK PRESSURE ABOVE 575 PSIA (600 PSIA INDICATED) FOR THE DURATION OF EMU PURGE .
4.    A FUNCTIONAL LIGHTING SOURCE MUST BE AVAILABLE IN THE AIRLOCK DURING EVA OPERATIONS .

*While the EMU is connected to the SCU, the O<sub>2</sub> high pressure supply system provides the EMU with a continuous supply of oxygen for primary tank recharge and nominal suit operations. If only one SCU is available during operations in the cabin, the EV crewmembers can alternate using the functional SCU, as required to recharge their primary oxygen tanks and complete purge. If SCU oxygen is unable to maintain EMU O<sub>2</sub> pressure above 575 psi, real-time analysis must determine if sufficient purge can be accomplished by extending the duration. Calibration data for the EMU's sensors are provided in the EMU Flight Data Book, and may be used to confirm the actual EMU O<sub>2</sub> tank pressures. The maximum specification error for the O<sub>2</sub> tank pressure sensors is 27.5 psi. As many conservative analysis assumptions produced the resultant pressure limits, this was rounded to 25 psi to aid operational simplicity.*

*The EMU is dependent on the vehicle for cooling while not at vacuum. The Airlock SPCE Heat Exchanger is the thermal interface between the LTL and the EMU cooling loop (via the UIA and SCU). The EV crewmembers should not don the EMU without SCU cooling available. If only one SCU is available during operations in the cabin, the EV crewmembers can alternate using the functional SCU, as required.    @[CR 7655 ]*

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## FLIGHT RULES

**12A\_B15-7      GO/NO-GO CRITERIA FOR EVA PREBREATHE [RI]**  
**(CONTINUED)**

*This rule addresses hardware requirements for EVA prebreathe. Physiological requirements and workarounds for EVA prebreathe are defined in Rule {B13-107}, EVA PREBREATHE PROTOCOL [RC] [E].* ©[CR 7655 ]

**TABLE 12A\_B15-7-I - ISS SYSTEMS NEEDED FOR A GO**

SYSTEM	MASK PREBREATHE	EXERCISE PREBREATHE	ISOLATED AIRLOCK - AWAKE	ISOLATED AIRLOCK - ASLEEP	IN-SUIT PREBREATHE
<b><u>ECLSS</u></b>					
• HI PRESSURE O2 SUPPLY	-	B.1	-	-	E.3
• SUFFICIENT PHA FLOW	A.1	A.1	-	-	-
• INTRAMODULE VENTILATION	A.2	A.2	-	-	-
• PFE	-	-	C.4.a	C.4.a	-
• QDM + PBA BOTTLE	-	-	C.4.b	C.4.b	-
• AIRLOCK PCA	-	-	C.5	C.5	-
• LAB PCA OR ДДИ	-	-	C.6	C.6	-
• SMOKE DETECTION	-	-	C.7	C.7	-
• AIRLOCK CCAA	-	-	C.8	D.3	-
• NODE 1 STBD IMV VALVES	-	-	C.9	C.9	-
• NODE 1 STBD HATCH/MPEV	-	-	C.10	C.10	-
• O2 MONITORING	-	-	C.12	C.12, D.4	-
• MCA	-	-	C.12	D.4, D.5	-
• A/L DEPRESS METHOD	-	-	C.11	-	-
<b><u>EVA</u></b>					
• 2 PHA's	A.3	A.3	-	-	-
• CO2 REMOVAL RECEPTACLE	-	-	C.13	C.13	-
• LIGHT SOURCE	-	-	C.14	C.14	E.4
• SCU COOLING	-	-	-	-	E.2
• SCU O2	-	-	-	-	E.3
<b><u>SURGEON</u></b>					
• CEVIS	-	B.2	-	-	-
• HEART RATE MONITOR	-	B.3	-	-	-
• EXERCISE TUBING	-	B.4	-	-	-
• CYCLING SHOES	-	B.5	-	-	-
<b><u>C&amp;DH</u></b>					
• PCS	-	-	C.1, C.2	C.2	-
<b><u>C&amp;T</u></b>					
• VOICE COMMUNICATIONS	-	-	C.3	C.3, D.2	E.1
• ATU's	-	-	C.3	C.3, D.2	-

©[CR 7655 ]



## FLIGHT RULES

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### 12A\_B15-8 GO/NO-GO CRITERIA FOR EVA [RI]

THIS RULE SUPERSEDES RULE {B15-55}, JOINT AIRLOCK GO/NO-GO CRITERIA [RC] [C]. @[CR 7656A ]

GO/NO-GO DECISIONS FOR CREWLOCK DEPRESS/EVA WITH AN ADDITIONAL CREWMEMBER ON ISS ARE BASED ON THE FOLLOWING REQUIREMENTS:

- A. EV CREWMEMBERS MUST MEET MINIMUM COMMUNICATION REQUIREMENTS PER RULE {B15-6}, MINIMUM RF COMMUNICATIONS DEFINITION.
- B. OPERATIONAL MEANS OF CREWLOCK DEPRESSURIZATION MUST EXIST USING ONE OF THE FOLLOWING METHODS:
  1. DEPRESS PUMP ASSEMBLY IN COMBINATION WITH PCA VRIV AND/OR EV HATCH MPEV
  2. PCA VRIV AND EMERGENCY MANUAL PRESSURE EQUALIZATION VALVE (EMPEV)

*The Depress Pump Assembly requires the INT and A/L MDM's to function. When RPCM AL1A4A A RPC 1 is commanded closed via the INT MDM, the INT also commands the A/L MDM to light the ENABLE LED on the UIA. When the Depress Pump power switch is actuated, the A/L MDM receives a command to start/stop the depress pump and passes this command to the Depress Pump electronics unit. Telemetry and fault status is passed from the electronics unit back to the A/L MDM. The Depress Pump Assembly also requires the MTL for cooling. Failure to use the Depress Pump Assembly results in a loss of 12-14 lbm of cabin air. Since the Depress Pump alone cannot evacuate the Crewlock to vacuum, one of the other depress mechanisms (PCA VRIV or EV Hatch MPEV) must be used in conjunction with the pump.*

*The Emergency Manual Pressure Equalization Valve (EMPEV) in the bulkhead between the Crewlock and Equipment Lock is connected to a Vacuum Access Jumper (VAJ) which provides an overboard flow path via the Vent and Relief Isolation Valve (VRIV).*

*Crewlock depress will nominally be performed by the EV crewmembers using the Depress Pump and by MCC-H ground command to the VRIV. The EV Hatch MPEV may also be used, in accordance with Rule {B15-14}, AIRLOCK HATCH COVER THERMAL CONSTRAINTS.*

- C. TWO OPERATIONAL MEANS TO MAINTAIN CREWLOCK REPRESS CAPABILITY USING THE FOLLOWING METHODS:
  1. IV HATCH PRESSURE EQUALIZATION VALVE (IV PEV) @[CR 7656A ]

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## FLIGHT RULES

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**12A\_B15-8      GO/NO-GO CRITERIA FOR EVA [RI]      (CONTINUED)**

2. EMERGENCY MPEV @[CR 7656A ]

*Crewlock repress will nominally be performed by the EV crewmembers using the IV hatch PEV. If that manual valve were to fail in the closed state, IV crewmembers would disconnect the Vacuum Access Jumper from the Emergency MPEV and repress the crewlock through that valve.*

- D. OPERATIONAL NODE 1 STARBOARD HATCH
- E. OPERATIONAL NODE 1 STARBOARD HATCH MPEV
- F. OPERATIONAL IV HATCH
- G. CLOSEABLE NODE 1 STARBOARD/AFT, STARBOARD/FORWARD IMV VALVES

*Capability must exist for contingency Equipment Lock isolation and depressurization in the event the EV hatch fails to seal. Node 1 stbd fwd and stbd aft IMV valves must either be commandable, or manually closed prior to Crewlock depress.*

*For Equipment Lock repressurization, the Node 1 stbd MPEV will be the primary repress method. Alternatively, the Node 1 stbd IMV valves provide a redundant repress path.*

- H. ONE SCU MUST PROVIDE OXYGEN PRIOR TO CREWLOCK DEPRESS INITIATION.

IF SCU OXYGEN SUPPLY IS LOST AFTER DEPRESS INITIATION, THE EVA CAN CONTINUE WITH THE FOLLOWING CONSTRAINTS:

- 1. THE EMU O<sub>2</sub> ACTUATOR MUST REMAIN IN THE EVA POSITION ANYTIME THE CREWLOCK PRESSURE IS LESS THAN 5 PSI.
- 2. ANY TERMINATE EVA CONDITIONS THAT REQUIRE PURGE OPERATIONS MUST BE TREATED AS ABORT CASES.

*The O<sub>2</sub> high-pressure supply system provides oxygen to the SCU's. Loss of the oxygen supply eliminates the primary means of safing an EV crewmember on the umbilical in a terminate EVA situation. Crewlock depress will not be initiated with a known loss of oxygen supply. @[CR 7656A ]*

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

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**12A\_B15-8      GO/NO-GO CRITERIA FOR EVA [RI] (CONTINUED)**

*If SCU oxygen is lost, the EMU is still fail-safe with at least 30 minutes of emergency oxygen in the primary and secondary oxygen tanks. The O<sub>2</sub> actuator must remain in the EVA position when Crewlock pressure is below 5 psi to ensure secondary oxygen availability to sustain suit pressure. Low primary O<sub>2</sub> tank pressures may not support the higher flow demand during repress. To avoid secondary oxygen package (SOP) usage and any associated logistical impacts, consideration will be given to reserving 225 psi in the primary system prior to repressing, which should be done at a slower than normal rate. EMU malfunctions that would typically result in a terminated EVA with purge operations on the umbilical must be treated as an abort due to the lack of sustainable oxygen. In this case consideration should be given to turning EMU water OFF and connecting the SCU prior to crewlock repress at nominal rates. This will prevent damage to EMU sublimators, provide crewmember cooling, and prevent eardrum damage during repress. @[CR 7656A ]*

I. ONE SCU MUST PROVIDE COOLING PRIOR TO CREWLOCK DEPRESS INITIATION.

IF SCU COOLING IS LOST DURING EVA, THE EVA CAN CONTINUE

*Without SCU cooling, the EMU is still fail-safe. In the event of a subsequent loss of EMU cooling, the EV crewmembers can use their helmet or DCM purge valve to aid in cooling while terminating the EVA.*

J. A FUNCTIONAL LIGHTING SOURCE MUST BE AVAILABLE IN THE CREWLOCK.

*Either of the two GLA's in the Crewlock or the EMU helmet lights will satisfy this requirement. However, if two GLA's are not available in the Crewlock, ability to use the Gold Salt hydrazine detector is severely limited. The color comparison chart was developed in a lighting simulator that modeled the Crewlock with two GLA's. The color emitted by EMU helmet lights changes with battery voltage. This can alter the crew interpretation of the sampler reading. @[CR 7656A ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_B15-8      GO/NO-GO CRITERIA FOR EVA [RI] (CONTINUED)**

*The GO for EVA will occur prior to initiation of crewlock depress. This rule addresses vehicle hardware requirements. EMU requirements are defined in Rule {B15-52}, EMU GO/NO-GO CRITERIA. @[CR 7656A ]*

**TABLE 12A\_B15-8-I - ISS SYSTEMS NEEDED FOR A GO**

SYSTEM	CREWLOCK DEPRESS
ECLSS	
NODE 1 STBD IMV VALVES	G
NODE 1 STBD HATCH	D
NODE 1 STBD HATCH MPEV	E
IV HATCH	F
C-LK DEPRESS METHOD	B
2 C-LK REPRESS METHODS	C
EVA	
LIGHT SOURCE	J
SCU COOLING	I
SCU O2	H
C&T	
VOICE COMMUNICATIONS	A

@[CR 7656A ]

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### GENERAL

#### 12A\_C15-1      EVA GUIDELINES [RI] [C]

A. EVA WILL BE PLANNED FOR A MAXIMUM DURATION OF 6.5 HOURS WITH A 10.2 PSI OR EXERCISE PREBREATHE PROTOCOL AND 4 HOURS WITH A 14.7 PSI PREBREATHE PROTOCOL. REAL TIME, THE EVA MAY BE EXTENDED BASED UPON THE FOLLOWING FACTORS: @[DN 29 ]

1. REMAINING SUIT CONSUMABLES
2. CREW PHYSIOLOGY
3. MISSION PRIORITIES
4. IMPACT OF NOT COMPLETING THE EVA
5. LENGTH OF REMAINING TASKS COMPARED TO SCHEDULED EVA TIME REMAINING
6. REMAINING CREW DAY

B. FOR STS-115, AFTER CONSIDERATION OF THE CRITERIA IN PARAGRAPH A, THE EVA WILL BE EXTENDED AS FOLLOWS:

FOR EVA 2, UP TO 7 HOURS PHASE ELAPSED TIME (PET) TO ACCOMPLISH ALL EVA TASKS REQUIRED PRIOR TO SARJ CHECKOUT AND SAW DEPLOYMENT.

*All EVA Solar Array Wing (SAW) preparation tasks must be completed prior to the IV commanded deployment of the SAW's. SAW deployment cannot occur until SARJ checkout and 180-degree rotation of the SARJ in order to avoid interference with the P6 port SAW. All EVA SARJ tasks must be completed prior to SARJ checkout and rotation. SARJ checkout and SAW deployment will need to be deferred until after EVA 3 if these EVA tasks are not completed by the end of EVA 2.*

## FLIGHT RULES

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### 12A\_C15-2 UNSCHEDULED/CONTINGENCY EVA

- A. IN THE EVENT ALL PLANNED ASSEMBLY TASKS CANNOT BE COMPLETED WITHIN THE SCHEDULED EVA PERIODS, AN UNSCHEDULED EVA WILL BE USED TO COMPLETE MANDATORY EVA ACTIVITIES AS DEFINED IN THE ISS ASSEMBLY PRIORITIES IN SECTION 2 (RULE {12A\_C2-11}, MISSION EXTENSION).

*The SSP and ISSP have agreed to provide consumables to support the three scheduled EVA's and one unscheduled EVA during the shuttle present timeframe. An unscheduled EVA will be used if contingencies preclude completion of all mandatory tasks on the first three EVA's. Up to two stage EVA's after orbiter departure are available to complete the less critical tasks associated with 12A.*

- B. THE FOLLOWING UNSCHEDULED AND CONTINGENCY EVA'S MAY BE PERFORMED BY THE SHUTTLE CREW:
1. OPEN/CLOSE PRLA.
  2. DEPLOY MANIPULATOR POSITIONING MECHANISM (MPM)
  3. RELEASE SRMS SHOULDER BRACE
  4. SRMS/SSRMS FRGF RELEASE
  5. SSAS CAPTURE LATCH ACTUATION
  6. P3 TRUSS CAPTURE USING PAYLOAD RETENTION DEVICES
  7. SSAS MBA BOLT ACTUATION
  8. SSAS CONTINGENCY BOLT INSTALLATION

*ISS does not have full structural integrity between the time the SSAS capture latch achieves topological capture (the P3 capture bar is "trapped" by the P1 capture latch) and sufficient bolts have been tightened to support shuttle undocking loads (per Rule {12A\_C2-54}, DOCKED LOADS CONSTRAINTS).*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C15-2      UNSCHEDULED/CONTINGENCY EVA (CONTINUED)**

9. SSAS CAPTURE LATCH FAILS IN A SOFT CAPTURE CONFIGURATION DURING SEGMENT P3/P4 INSTALLATION.

*The EVA crewmember can use the capture latch MDA to manually open the capture latch. If the MDA has failed, it is possible that the capture latch can be opened by releasing the capture latch release pins. The EVA crewmember may be able to gain access to the capture latch release pins from within the P3 inboard bay. However, if a preload exists between the capture latch and the P3 capture bar, the EVA crewmember may not be able to release the capture latch.*

10. VERIFICATION AND TORQUING OF THE UTILITY TRANSPORT ASSEMBLY (UTA) CENTER BOLT
11. MANUAL DEPLOY AND RETRACT OF THE SOLAR ARRAY WINGS
12. MANUAL UNLATCH/LATCH/RE-SPOOL OF THE P4 SOLAR ARRAY BLANKET BOXES
13. MANUAL DEPLOY AND RETRACT OF THE P4 RADIATOR
14. PV RADIATOR RE-CINCH
15. MANUALLY OVERRIDE THE BETA GIMBAL ANTI-ROTATION LATCH.
16. MANUALLY RELEASE SOLAR ARRAY BLANKET BOX BRS PINS.
17. INSTALL SOLAR ARRAY WING LOCKING STRUT AIDS.
18. MANUAL ASSIST OF THE 4-BAR LINKAGE DEPLOYMENT
19. EVA ASSISTED DEPLOYMENT OF P4 SAW
20. RETURN DLA TO LAUNCH POSITION
21. BGA MANUAL ROTATION
22. REMOVE AND REPLACE RJMC. ®[DN 57 ]
23. REMOVE/STOW BATTERY CHARGE/DISCHARGE UNIT (BCDU) . ®[DN 57 ]

*Required to allow remaining BCDU's to charge batteries at full charge rate*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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**12A\_C15-2      UNSCHEDULED/CONTINGENCY EVA (CONTINUED)**

24. MANUALLY RELEASE AND JETTISON SOLAR ARRAY WING. @[DN 57 ]
  25. MANUALLY RELEASE AND JETTISON PV RADIATOR.
  26. REMOVE AND REPLACE ECU.
  27. REMOVE AND REPLACE SSU.
  28. REMOVE AND REPLACE PFCS.
  29. REMOVE AND REPLACE DCSU.
  30. REMOVE AND REPLACE PVCU.
  31. REMOVE AND REPLACE PV DDCU.
  32. REMOVE AND REPLACE MSS ACU, MCU, OR CRPCM.
  33. INSTALLATION OF FLUID QUICK DISCONNECT (FQD) DETENT  
BUTTON @[DN 57 ]
- C. THE FOLLOWING CONDITIONS WILL REQUIRE A CONTINGENCY EVA TO  
SUPPORT UNDOCKING AND LANDING:
1. ODS CAPTURE LATCH FAILS TO RELEASE (FOR DOCKING)
  2. APAS FAILS TO RELEASE (96-BOLT CONTINGENCY) (FOR DOCKING)
  3. STOW RADIATORS.
  4. KU-BAND GIMBAL ALIGNMENT
  5. PERFORM SRMS JOINT ALIGNMENT, TIEDOWN, OBSS OR MPM MANUAL  
STOW.
  6. PLB DOOR CLOSURE
  7. TPS REPAIR



## FLIGHT RULES

12A\_C15-3

EVA HAZARD MANAGEMENT

THE FOLLOWING TABLE DOCUMENTS FLIGHT-SPECIFIC HAZARDS TO THE EVA CREW. THE HAZARD CONTROLS MUST BE IN PLACE PRIOR TO AND THROUGHOUT THE EVA'S:

PAYLOAD/ELEMENT	HAZARD TYPE	DETAILS/CONTROLS
TCS	SHARP EDGE LASER	BACKSHELLS OF TCS CONNECTORS HAVE EXPOSED THREADS (INCIDENTAL CONTACT ONLY).  DISABLE TCS LASER BY COMMANDING TCS SOFTWARE TO SHUTDOWN MODE AND POWERING TCS PGSC OFF. OTHERWISE, EV CREW MUST MAINTAIN CLEAR OF LASER (POINTS IN -Z DIRECTION). NOTE: TCS LASER CONSIDERED EYE SAFE DURING NORMAL OPERATION AND WOULD ONLY BE CONSIDERED A HAZARD IF A HARDWARE FAILURE CAUSED THE LASER BEAM TO STAY IN ONE POSITION WITH A SMALL (< 5 CM) SPOT SIZE. THE EMU VISOR WOULD ALSO PROVIDE ADDITIONAL PROTECTION.
P1 ELECTRICAL CONNECTORS	ELECTRICAL ARCING/MOLTEN METAL	REFERENCE RULE {12A_C9-1}, POWER CONNECTION INHIBITS. INHIBITS MUST BE IN PLACE WHILE THE EVA CREW IS HANDLING THE CONNECTORS.
P3/P4 TRUSS ELEMENTS	SHARP EDGES	REFERENCE 12A EVA CHECKLIST FS.
SOLAR ARRAY BLANKET BOXES	INADVERTENT COLLISION	REFERENCE RULE {12A_C15-4}, EVA KEEPOUT ZONES [HC].
P3 SOLAR ALPHA ROTARY JOINT	INADVERTENT COLLISION	REFERENCE RULE {B15-15}, EVA KEEPOUT ZONES [HC] [RC].
S1 (P1) RADIATOR BEAM	INADVERTENT COLLISION/KICK LOADS	REFERENCE RULES {12A_C15-4}, EVA KEEPOUT ZONES [HC], AND {B18-351}, TRRJ DLA CONFIGURATION MANAGEMENT [HC].

@[DN 50 ] @[DN 79 ]

## FLIGHT RULES

**12A\_C15-4      EVA KEEPOUT ZONES [HC]**

THE FOLLOWING ARE FLIGHT-UNIQUE EVA KEEPOUT ZONES, WHICH ARE TO BE OBSERVED IN ADDITION TO THE KEEPOUT ZONES DEFINED IN RULE {B15-15}, EVA KEEPOUT ZONES [HC] [RC]:

ISS SYSTEM	KEEPOUT ZONE	CONDITION
SOLAR ARRAY BLANKET BOXES	AREA OF THE 4-BAR MECHANISM BETWEEN THE BETA GIMBAL PLATFORM AND THE IEA BULKHEAD [1]	BGA DEPLOYMENT
	PIVOT FITTING AND SWING ARM [2]	SABB ROTATION
	SABB LATCH MECHANISM [3]	SABB UNLATCHING OR LATCHING
	UNDERSIDE OF SABB [4]	AFTER BGA DEPLOYMENT
S1 (P1) RADIATOR BEAM	2.0 FT/0.6 M IN ALL DIRECTIONS FROM THE RADIATOR BEAM ROTATION ENVELOPE	DLA NOT LOCKED AND BEAM NOT TETHERED
	2.0 FT/0.6 M	DLA LOCKED, FREE FLOATING EV AND EVA CREWMEMBER > 130 IN FROM CENTER OF TRRJ
MOBILE TRANSPORTER	5 FEET [5]	DURING MT TRANSLATION WITH EV CREW ON FACE 1
UHF (P1 SEGMENT)	B* 1.0FT/0.3M [6] [7]	HIGH/LOW POWER MODE

\* THE MOST RESTRICTIVE KEEPOUT ZONE IS BASED ON EXPOSURE LIMITS FOR [P]HYSIOLOGY, [E]MU, OR [B]OTH (I.E., ZONES INDISCERNIBLE). THE ZONE OF THE LESS RESTRICTIVE LIMIT IS LISTED IN PARENTHESES FOR REFERENCE. PHYSIOLOGICAL DISTANCES ARE BASED ON A CONTROLLED ENVIRONMENT AS DEFINED BY IEEE STANDARD FOR SAFETY LEVELS WITH RESPECT TO HUMAN EXPOSURE TO RADIO FREQUENCY ELECTROMAGNETIC FIELDS, 3 KHZ TO 300 GHZ, IEEE STD C95.1, 1999.

NOTES:

- [1] THE AREA OF THE 4-BAR MECHANISM BETWEEN THE BETA GIMBAL PLATFORM AND INTEGRATED EQUIPMENT ASSEMBLY (IEA) BULKHEAD IS A DESIGNATED KEEPOUT ZONE UNTIL THE BGA LOCKS INTO PLACE UPON FULL DEPLOYMENT. IN THE EVENT OF AN INCOMPLETE NOMINAL DEPLOYMENT OF THE BGA, THE PAYLOAD RETENTION DEVICE (PRD) MAY BE INSTALLED AFTER THE BGA HAS PARTIALLY DEPLOYED. THIS CAN BE ACCOMPLISHED WITHOUT VIOLATING THE KEEPOUT ZONE. DOCUMENTATION: HAZARD REPORT ISS-EVA-302-12A, EVA CREWMEMBER EXPOSURE TO SHARP EDGES/CORNERS, PINCH POINTS AND ENTANGLEMENT/ENTRAPMENT, JANUARY 3, 2002.
- [2] DURING THE EVA TASK TO UNSTOW THE SOLAR ARRAY BLANKET BOX (SABB) AND ROTATE IT INTO POSITION, THE EVA CREWMEMBER WILL STAY CLEAR OF THE PIVOT FITTING AND THE SWING ARM DURING THE SABB ROTATION. THIS AREA IS DESIGNATED A KEEPOUT ZONE DUE TO THE PRESENCE OF PINCH POINTS. DOCUMENTATION: HAZARD REPORT ISS-EVA-302-12A, EVA CREWMEMBER EXPOSURE TO SHARP EDGES/CORNERS, PINCH POINTS AND ENTANGLEMENT/ENTRAPMENT, JANUARY 3, 2002.

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## FLIGHT RULES

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### 12A\_C15-4      EVA KEEPOUT ZONES [HC] (CONTINUED)

- [3] THE LATCHES ON THE SABB ARE NOMINALLY IV ACTIVATED. HOWEVER, THERE IS AN EVA MANUAL OVERRIDE BACKUP CAPABILITY. IT TAKES APPROXIMATELY 20 SECONDS TO COMPLETE THE LATCH OR UNLATCH CYCLE. DURING THE OPERATION TO UNLATCH OR LATCH THE SABB, THE EVA CREWMEMBER WILL KEEP THEIR HANDS CLEAR OF THE LATCH MECHANISM, WHETHER THE OPERATION IS BEING PERFORMED BY IVA OR EVA METHODS. DOCUMENTATION: HAZARD REPORT ISS-EVA-302-12A, EVA CREWMEMBER EXPOSURE TO SHARP EDGES/CORNERS, PINCH POINTS AND ENTANGLEMENT/ENTRAPMENT, JANUARY 3, 2002.
- [4] ALTHOUGH THERE NO PLANNED EVA TASKS WHICH WOULD REQUIRE THE EVA CREWMEMBER TO COME IN CONTACT WITH THE UNDERSIDE OF THE OUTBOARD EDGE OF THE SABB, THERE ARE UNSCHEDULED EVA TASKS WHICH MAY REQUIRE THE EVA CREWMEMBER TO BE NEAR THIS AREA. THIS AREA CONTAINS EXPOSED REELS, GUIDE WIRES MECHANISMS, AND BLANKET BOX TENSION MECHANISM AND SHOULD BE CONSIDERED A KEEPOUT ZONE. IF THE EVA CREWMEMBER IS REQUIRED TO APPROACH THIS AREA, THEY WILL EXERCISE CAUTION. DOCUMENTATION: HAZARD REPORT ISS-EVA-302-12A, EVA CREWMEMBER EXPOSURE TO SHARP EDGES/CORNERS, PINCH POINTS AND ENTANGLEMENT/ENTRAPMENT, JANUARY 3, 2002.
- [5] BECAUSE THE POTENTIAL EXISTS FOR LOSS OF MT TRANSLATION CONTROL, WHICH COULD RESULT IN MT COLLISION WITH THE EV CREW, THE CREWMEMBER MUST MAINTAIN A 5-FOOT KEEPOUT ZONE FROM THE MT IN ORDER TO HAVE ENOUGH REACTION TIME TO MOVE OUT OF THE MT PATH. THE MAXIMUM MT VELOCITY IS 1.18 INCHES PER SECOND AND AN EV CREWMEMBER CAN EASILY TRANSLATE AT 12 INCHES PER SECOND. THIS RULE IS INCONSISTENT WITH THE OPS CONTROL (REF ISS HAZARD REPORT ISS-MT-0019-AC, REV B, CAUSE 3, CONTROL 4), WHICH STATES THAT THE MT STOP MUST BE DEPLOYED BETWEEN THE EV CREWMEMBER AND THE MT.
- [6] THE EMU/SSER CERTIFICATION LIMIT FOR THE UHF SYSTEM (414.2 MHZ) IS 60 V/M RMS. FOR NOMINAL EVA COMMUNICATION CONFIGURATION, THE UHF SYSTEM OPERATES IN THE LOW POWER MODE. BASED ON RF ANALYSIS, THE KEEPOUT ZONE IN LOW POWER IS 0.3 FT/0.1 M. HOWEVER, BECAUSE THE SYSTEM IS ZERO-FAULT TOLERANT TO AN INADVERTENT SWITCH TO HIGH POWER, THE LARGER KEEPOUT ZONE ASSOCIATED WITH HIGH POWER WILL BE MAINTAINED WHENEVER POSSIBLE. THE P1 UHF ANTENNA HAS A SLIGHTLY SMALLER (0.2M IN HIGH POWER) KEEPOUT ZONE DUE TO LINE LOSS; HOWEVER, FOR SIMPLICITY, THE LARGER KEEPOUT ZONE OF THE LAB ANTENNA IS APPLIED TO BOTH UHF ANTENNAS. THE PHYSIOLOGICAL LIMIT AT UHF IS 72 V/M RMS.  
DOCUMENTATION: FOR SSOR, REFERENCE EVA RULE {A15-26}, KEEPOUT ZONE FOR EVA OPERATIONS NEAR THE ORBITER UHF PAYLOAD BAY ANTENNA; ISS USOS AND SSO ANTENNA RF EXPOSURE KEEPOUT ZONE DATA BOOK, JSC 29045 - VOLUME I, EV4-01-906, DECEMBER 2000. PHYSIOLOGY RF EXPOSURE KEEPOUT DISTANCE FROM ISS USOS, SSO, AND RUSSIAN ANTENNAS, EV4-01-937, AUGUST 2001.
- [7] THE SUIT CERTIFICATION LIMITS FOR RF EXPOSURE ARE TYPICALLY STRICTER THAN THE ANSI PHYSIOLOGICAL LIMITS; THEREFORE, THE KEEPOUT ZONES GIVEN ABOVE ENCOMPASS ALL LIMITS.  
ALL USOS ANTENNAS HAVE CYLINDRICAL RADIATION PATTERNS WHICH REQUIRE A CYLINDRICAL KEEPOUT ZONE. FOR EASE OF OPERATIONS, A SPHERICAL PATTERN (RADIUS GIVEN ABOVE AS KEEPOUT ZONE) IS UTILIZED FOR ALL ANTENNAS EXCEPT KU-BAND. THE CYLINDRICAL RADIATION PATTERNS FOR USOS CAN BE FOUND IN THE REPORTS REFERENCED IN NOTES 1, 2, AND 3.

*When the DLA is not locked and the radiator beam is not tethered, the beam may rotate. A 2-ft keepout zone prevents inadvertent collision between an EVA crewmember and the beam.*

*If the beam is locked, a 2.0 ft keepout zone is required if crewmembers will be working at locations in the vicinity of (but not on) the beam at distances greater than 130 in from the center of the TRRJ. This ensures that inadvertent kick loads imparted to the beam do not cause inadvertent motion and/or damage TRRJ mechanisms. Note that work within 2 ft, or on the beam itself, at distances greater than 130 in from the center of the TRRJ is allowed as long as the beam is properly configured. Reference Rule {B18-351}, TRRJ DLA CONFIGURATION MANAGEMENT [HC], for specific TRRJ DLA configurations during EVA operations on/near the beam. ®[DN 51 ]*

*Documentation: Hazard Reports ISS-EVA-0301-9A, EVA Crewmember Collision, June 1, 2001 and ISS-EVA-0301-11A, EVA Crewmember Collision, June 1, 2001; and Mission Action Request (CHIT) ISS0122 (Mission 9A).*

## FLIGHT RULES

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### 12A\_C15-5      EQUIPMENT INSTALLED ON SSRMS

THE APFR/SAFETY TETHER MUST BE REMOVED FROM THE SSRMS FOLLOWING AN EVA UNLESS THERE IS A SUBSEQUENT EVA PRIOR TO THE NEXT PLANNED USE OF THE SSRMS LEE.

*With an APFR/safety tether installed in the SSRMS WIF, the SSRMS allowable grapple envelope is exceeded. Because there are no contingencies that require an SSRMS walk-off without EVA support, it is acceptable to leave the APFR installed on the SSRMS until the next EVA.*

### 12A\_C15-6      CETA CART SAFING

- A. THE CETA CART MUST BE COUPLED TO THE MT WITH THE PARKING BRAKE DISENGAGED FOLLOWING AN EVA.
- B. THE CETA CART MUST HAVE ALL FOUR WHEEL BOGIES ENGAGED ON THE RAIL IN ORDER TO SUPPORT NOMINAL CETA CART OPERATIONS.

FOR THREE OF FOUR WHEEL BOGIES ENGAGED ON THE RAIL, THE CETA CART WILL BE TRANSLATED BY HAND WITHOUT TFR INGRESS AND COUPLED TO THE MT. THE PARKING AND DYNAMIC BRAKES CANNOT BE USED, BUT THE CETA CART CAN REMAIN COUPLED TO THE MT DURING MT TRANSLATIONS.

*Leaving the CETA cart on the truss with the parking brake engaged precludes MT translation past the CETA cart. Coupling the CETA cart to the MT at the end of a series of EVA's ensures that the MT can translate the length of the truss.*

*If the CETA cart does not have all four wheel bogies engaged to the MT rails, loads induced by nominal CETA cart operations could damage the rails. With only three of four wheel bogies, the TFR cannot be ingressed, brakes cannot be engaged, and the CETA cart cannot be used as a work platform without the risk of damaging the rails. Because of this, the CETA cart must be translated by hand to the MT for coupling. With three of four wheel bogies, the CETA cart can be coupled to the MT during MT translations.*

## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATIONS

THE FOLLOWING REQUIREMENTS APPLY WHENEVER THE ISS OXYGEN RECHARGE LINE IS USED TO SUPPORT ISS EVA OPERATIONS. @[CR 7657 ]

#### A. VEHICLE OXYGEN SYSTEMS CONFIGURATION

1. THE ISS OXYGEN SYSTEM WILL BE CONFIGURED AS FOLLOWS:
  - a. THE O<sub>2</sub> LO P (VL009) AND O<sub>2</sub> HI P (VL010) VALVES WILL BE CLOSED.
  - b. THE O<sub>2</sub> XOVER VALVE (VL011) WILL BE OPENED.
  - c. THE ROOBA (TO: QD11 OR SPARE) QD WILL BE MATED WITH QD011.
  - d. THE O<sub>2</sub> RECHARGE LINE QD WILL BE MATED WITH THE ROOBA (TO: O<sub>2</sub> RECHARGE LINE) QD.
  - e. THE O<sub>2</sub> LO P (L003) AND O<sub>2</sub> HI P (L002) SUPPLY VALVES WILL BE COMMANDED OPEN.
2. THE ORBITER OXYGEN SYSTEM WILL BE CONFIGURED AS FOLLOWS:
  - a. THE GO<sub>2</sub> XFER PANEL FLOW VALVE WILL BE OPENED.
  - b. THE EMU O<sub>2</sub> ISOLATION VALVE WILL BE OPENED.
  - c. ORBITER CRYO O<sub>2</sub> WILL BE CONFIGURED TO SUPPORT EVA OPERATIONS PER RULE {A9-263}, CRYO O<sub>2</sub> MANAGEMENT FOR EVA SUPPORT. @[CR 7657 ]

**THIS RULE CONTINUED ON NEXT PAGE**

**FLIGHT RULES**

12A\_C15-7

**ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)**

3. IN ADDITION TO THE REQUIREMENTS OF RULE {B15-55}, JOINT AIRLOCK GO/NO-GO CRITERIA [RC] [C], THE FOLLOWING OXYGEN SYSTEM MINIMUM HARDWARE REQUIREMENTS APPLY FOR EXERCISE PREBREATHE, EMU PURGE, AND EVA VACUUM OPERATIONS: @[CR 7657 ]

a. MINIMUM HARDWARE REQUIREMENTS:

(X/Y = X OF Y, "-" = NO REQUIREMENT) (Z)= REF. NOTE Z)

SYSTEM	EXERCISE P/B & EMU PURGE	EVA	RULE REFERENCE
ORBITER			
• O2 SUPPLY/DIST SYSTEM	NO LEAKS OR OTHER HIGH DEMANDS	NO LEAKS	-
• CRYO O2 ECS SUPPLY	2/2	2/2	-
• O2 CROSSOVER SYSTEM	2/2	2/2	-
• CRYO TANK HEATERS	1/2	1/2	-

b. IF MINIMUM HARDWARE REQUIREMENTS CANNOT BE MET, THE ISS OXYGEN SYSTEM MUST BE RECONFIGURED TO UTILIZE THE ISS OXYGEN TANKS FOR THE DURATION OF EVA OPERATIONS.

*The configuration needed to supply orbiter cryogenic oxygen to EMU's in the ISS airlock requires on the order of 20 restrictors, regulators, QD's, and valves to be functional and properly configured. Most orbiter system hardware is properly configured for EVA support due to other nominal on-orbit operational requirements and per the MCC-H morning cryo configuration call to the crew. The EMU O<sub>2</sub> isolation valve and GO<sub>2</sub> xfer panel flow valve are configured per O<sub>2</sub> transfer procedures upon docking.*

*Rule {A9-263}, CRYO O2 MANAGEMENT FOR EVA SUPPORT, helps to maintain higher transfer system pressures, as does configuring to supply from both orbiter systems 1 and 2 cryo O<sub>2</sub> ECS supply and crossovers. This would normally provide immediate supply redundancy. However, no previous flight data nor O<sub>2</sub> system analyses have identified the resultant O<sub>2</sub> transfer pressures should only one system be supplying the entire EVA flow demand. Therefore, it is assumed that both are required to maintain similar flow rates to those experienced over the EVA history of the Shuttle Program. @[CR 7657 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

*During EMU purge operations (denitrogenation or contingency vacuum purges), O<sub>2</sub> supply pressures must be maintained high enough to hold the EMU suit pressures above required levels. Leaks in the O<sub>2</sub> supply system or high demands created by other concurrent operations (e.g., cabin represses) could cause insufficient EMU suit pressures, requiring denitrogenation purge time extensions or activation of the EMU's Secondary Oxygen Pack (SOP). During EVA, a planned, intermittent high demand is considered acceptable as the likelihood of concurrent EMU contingency ops is low and the SOP is capable of making up the flow required to stabilize the suit pressure. It is also assumed that such planned occurrences could be terminated if a contingency arose. This allows some flexibility to avoid timelines requiring consuming reconfigurations from ISS O<sub>2</sub> supply to orbiter supply between a series of EVA's.*

@[CR 7657 ]

*If an orbiter O<sub>2</sub> system leak were to develop, subsequent troubleshooting steps require closing various O<sub>2</sub> system valves. Therefore, it is desirable to decouple the leak troubleshooting steps from EVA requirements by configuring the EVA supply to the ISS O<sub>2</sub> tank. This is also done to conserve orbiter resources if such a contingency develops.*

#### B. MASK PREBREATHE

1. THE PHA PORT STANDALONE CONFIGURATION WILL BE CONSIDERED OPERATIONAL TO SUPPORT EXERCISE DURING EVA MASK PREBREATHE IF BOTH THE FOLLOWING CONDITIONS ARE MET:
  - a. THE MCC-H COMPUTED VALUE FOR AT LEAST TWO OF THE FOLLOWING SENSORS REMAINS GREATER THAN 1068.7 KPA (155 PSIA) ACTUAL.
    1. UIA O<sub>2</sub> SUPPLY PRESSURE (> 81 PSIA INDICATED)
    2. O<sub>2</sub> LO P SUPPLY PRESSURE (> 107 PSIA INDICATED)
    3. O<sub>2</sub> HI P SUPPLY PRESSURE (> 112 PSIA INDICATED)
  - b. QUALITATIVE REPORT BY EXERCISING CREWMEMBERS THAT O<sub>2</sub> SUPPLY TO THE QUICK-DON MASK (QDM) IN EMERGENCY (POSITIVE PRESSURE) MODE WAS ACCEPTABLE. @[CR 7657 ]

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

2. IF PER PARAGRAPH 1 THE ISS OXYGEN RECHARGE LINE DOES NOT PROVIDE SUFFICIENT FLOW FOR MASK PREBREATHE ON EVA DAY, THE ISS OXYGEN SYSTEM MUST BE RECONFIGURED TO UTILIZE THE ISS OXYGEN TANKS FOR THE DURATION OF EVA OPERATIONS ON THAT DAY. ©[CR 7657 ]

IF PHA AND O<sub>2</sub> SYSTEM RECONFIGURATION FOR SHUTTLE O<sub>2</sub> IS POSSIBLE, SUBSEQUENT EVA MASK PREBREATHE MAY BE PERFORMED USING SHUTTLE LEH O<sub>2</sub>.

*O<sub>2</sub> supply pressure greater than 1068.7 kPa is based on the maximum outlet pressure of the PHA regulator (150 ±5 psia). MCC-H should then consider any identified pressure sensor bias as each of the three sensors are biased low. Confirmation on multiple independent pressure sensors reduces the risk of test failure due to unidentified sensor bias. SPN# 20626, PVCS ID 2065, has established that, for each of the three ISS oxygen system sensors, a built-in bias exists in the data processing software which is not planned to be incorporated into the calibration curve until 15A. Additionally, an engineering white paper provides additional bias estimates. Currently, MCC-H ECLSS displays compensate for 97 psi of an estimated 140 psi low bias on the O<sub>2</sub> Hi P supply pressure.*

*On-orbit testing of the exercise prebreathe protocol during STS-104/ISS 7A [2001/198/≈ 07:45] demonstrated that the oxygen recharge line flow restrictor (oxygen recharge orifice) prevented sufficient flow of oxygen to an exercising crewmember. During this test, the UIA O<sub>2</sub> supply pressure sensor [ALEA31SR0001P] detected a rapid drop in line pressure to approximately 3000 mmHg = 58 psia = 400 kPa indicated and the crewmember experienced a lack of sufficient flow to the QDMA.*

*When the ISS oxygen system is configured to accept oxygen from the orbiter, both the O<sub>2</sub> low pressure supply pressure sensor [ALEA33SR0001P] and O<sub>2</sub> high pressure supply pressure sensor [ALEA32SR0001P] monitor the line pressure upstream of the O<sub>2</sub> high pressure regulator and UIA O<sub>2</sub> supply pressure sensor. During the STS-104 exercise prebreathe protocol test, the O<sub>2</sub> low pressure supply pressure sensor detected a drop in line pressure to approximately 6000 mmHg = 116 psia = 800 kPa indicated at the same time the drop was detected by the UIA O<sub>2</sub> supply pressure sensor. Given the current identified bias for these two sensors, the actual pressure was likely approximately 150 psia, supporting the idea that O<sub>2</sub> starvation of the PHA regulator was occurring below approximately 155 psia, since this was concurrent with the crew report of insufficient O<sub>2</sub> flow. ©[CR 7657 ]*

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## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

*During the exercise prebreathe protocol test during STS-104, two significant pressure transients were observed. These are thought to be the result of the opening of the O<sub>2</sub> Hi P supply valve (transient decrease to 29,000 mmHg or 561 psia or 3867 kPa) and the connection of the PHA masks to the PHA ports (transient decrease to 8,500 mmHg or 164 psia or 1133 kPa). Pressure transients prior to the initiation of mask prebreathe should be noted, but not evaluated as part of the test period. While exercise is occurring, system pressure swings can be expected. Therefore, a failure of the system to stay above 155 psia should be considered over a time period equivalent to several breaths, not via a single data point. Flow demand will also increase when the crewmember momentarily pulls the mask away from the face to verify positive O<sub>2</sub> flow; this is required at several points in the procedure. Low pressures at these times would not be considered a failure so long as the system pressure recovers. @[CR 7657 ]*

*The determination of acceptable oxygen flow from the QDM is subjective. Flow is affected by factors such as inlet pressure, hose accumulation effect, total flow rate, respiratory rate, inspiration volume, and rate of inspiration (peak flow). The QDM regulator may 'flutter' in low demand conditions or with insufficient inlet pressure and flow rate. These factors will vary from one day to the next and from crewmember to crewmember; therefore, confidence must be gained beyond 12A.*

*Reference Rule {B13-107}, EVA PREBREATHE PROTOCOL [RC] [E], for any impacts to the prebreathe protocol.*

*If ROOBA does not provide sufficient flow to support exercise, the exercise portions of the prebreathe protocol will be conducted using either of the two previously flight-proven methods: PHA hose connected to the orbiter LEH ports on the middeck, or PHA hose connected to the joint airlock PHA ports with supply from an ISS oxygen tank.*

*On EVA day, reconfiguration to the ISS oxygen tanks (instead of using orbiter oxygen from the LEH ports) is preferable in order to minimize the time lost on EVA day for PHA reconfiguration. The mask prebreathe test prior to 12A EVA1 allows time to perform the PHA reconfiguration, thereby supplementing the PHA ports with orbiter LEH O<sub>2</sub> via the 90-ft PHA bag. This configuration would allow utilization of orbiter O<sub>2</sub> for subsequent EMU purge operations, thereby still achieving the ISS Program's desire to reduce use of the ORCA. @[CR 7657 ]*

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## FLIGHT RULES

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12A\_C15-7      ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

- C. EMU DENITROGENATION PURGE @ [CR 7657 ]
1. THE ISS OXYGEN RECHARGE LINE WILL BE CONSIDERED OPERATIONAL TO SUPPORT EMU PURGE OPERATIONS IF ALL OF THE FOLLOWING CONDITIONS ARE MET:
    - a. BOTH EMU PRIMARY OXYGEN TANK PRESSURES REMAIN GREATER THAN 575 PSIA (600 PSIA INDICATED).
    - b. MCC-H REAL-TIME ANALYSIS CONFIRMS THE TOTAL EMU PURGE FLOW RATE INTO THE CABIN IS CONSISTENT WITH A RATE GREATER THAN OR EQUAL TO 9 LBM/HR AFTER EMU O<sub>2</sub> TANK PRESSURE STABILIZATION.
  2. IF THE ISS OXYGEN RECHARGE LINE DOES NOT PROVIDE SUFFICIENT FLOW TO SUPPORT EMU DENITROGENATION PURGE OPERATIONS, THE ISS OXYGEN SYSTEM MUST BE RECONFIGURED TO UTILIZE THE ISS OXYGEN TANKS FOR THE DURATION OF EVA OPERATIONS ON THAT DAY.
  3. IF BOTH EMU PRIMARY OXYGEN TANK PRESSURES DO NOT REMAIN AT OR ABOVE 700 PSIA (725 PSIA INDICATED), THE EMU DENITROGENATION PURGE TIME WILL NEED TO BE EXTENDED TO A TOTAL PURGE TIME OF 11 MINUTES.

*Simultaneous purge of two EMU's at nominal cabin pressure is the greatest demand on the ISS oxygen system. This is approximately 9.75 to 11 lbm/hr for two EMU's purging into the cabin atmosphere with a Service and Cooling Umbilical (SCU) inlet pressure of 850 psia.*

*If the EMU tank pressure drops below 575 psia actual during purge, the suit pressure will soon drop to unacceptable levels. In denitrogenation purge cases, flow rates from the EMU's would be excessively slow and the low suit pressures could cause stagnant gases within localized areas of the EMU soft goods, causing poor nitrogen washout; this would be more likely if purging continued during the airlock repress. Under normal circumstances, pressures this low are not expected and likely indicate a system misconfiguration or component failure. As very little troubleshooting time is available on an EVA day, reconfiguration to a simpler, higher pressure system would likely allow the EVA preparations to continue without delay. Therefore, below this pressure, reconfiguration to the flight-proven method (ISS O<sub>2</sub> tanks) is required. @ [CR 7657 ]*

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## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

*In the Shuttle EVA Program, the EMU denitrogenation purge consists of opening the DCM purge valve for 8 minutes in a 10.2 psi cabin or 12 minutes in a 14.7 cabin. This requires a purge flow rate of 4.3 lbm/hr per EMU. This rate is based on an EMU primary oxygen flow restrictor (item 113B) inlet pressure of 700 psia and the hardware minimum flow specification. The ISS 10.2 prebreathe protocols conduct the denitrogenation purge prior to and after the transition from 10.2 psia to 14.7 psia cabin pressure (5 minutes of purge at 10.2 psia before initiation of cabin repressurization, 3 minutes after); the 700 psia specification ensures the purge is as conservative as the historical shuttle protocol. ©[CR 7657 ]*

*If an EMU's O<sub>2</sub> tank pressure drops below 700 psia, but stays above 575 psia, the purge will be completed by extending the purge to a total purge time of 11 minutes (5 minutes at 10.2 psia, 6 minutes at 14.7 psia). This will result in a conservative purge as the analysis assumes that the EMU O<sub>2</sub> tanks have been at 575 psia during the entirety of the subsequent 11 minutes of total purge time.*

*Calibration data for the EMU's sensors are provided in the EMU Flight Data Book, and may be used to confirm the actual EMU tank pressures. The maximum specification error for the O<sub>2</sub> tank pressure sensors is 27.5 psi. As many conservative analysis assumptions produced the resultant pressure limits, this was rounded to 25 psi to aid operational simplicity.*

*There is no direct means of measuring the EMU purge flow rate. A methodology has been developed to determine the approximate total EMU purge flow rate into the cabin based on the change in cabin pressure (dP/dT) measured by the airlock Pressure Control Assembly (PCA) during the first 5 minutes of EMU purge (isolated airlock at 10.2 psi). However, this methodology has a measurement and computational error band of ±3.6 lbm/hr. While the purge rate cannot be determined with a high degree of accuracy, the ground computation provides a verification of the preflight engineering analysis of expected flow rates. A review of joint airlock-based EVA flight data from STS-104/7A EVA 3, STS-110/8A, STS-111/UF-2, STS-112/9A, STS-113/11A, and the Increment 6 stage EVA's was conducted using this methodology. The analysis revealed stable purge flow rates of approximately 10.8 to 12.5 lbm/hr when using the ISS oxygen tanks. This same data revealed that the UIA O<sub>2</sub> supply pressure (upstream supply to the EMU) remained greater than 800 psi during these denitrogenation purges.*

*A minimum flow rate of 9 lbm/hr is based on two factors. First is the minimum rate necessary to support the denitrogenation purge of two EMU's (discussed above; 4.3 lbm/hr x 2 suits = 8.6 lbm/hr) without an extension of purge time. The second factor is the current engineering requirement of 9.04 lbm/hr total flow to support an EMU contingency requiring two open helmet purge valves while at vacuum. This conservative value is based on a decontamination bake-out scenario while maintaining EMU suit pressures at the maximum nominal pressure of 4.4 psia. As long as suit pressure is maintained above the SOP regulation band (3.3 to 3.9 psia), the EMU is in a safe configuration and SOP flow will not be required.*

*Reference EMUM 1388, Appendix C, Nitrogen Purge Analysis, and EVAM-0114. ©[CR 7657 ]*

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## FLIGHT RULES

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12A\_C15-7

### ISS OXYGEN RECHARGE LINE REQUIREMENTS FOR EVA OPERATION (CONTINUED)

- D. IN THE EVENT THAT CONTINGENCY EMU PURGE OPERATIONS ARE REQUIRED AT VACUUM WHILE CONNECTED TO THE SCU, THE ISS OXYGEN SYSTEM WILL BE RECONFIGURED TO UTILIZE THE ISS OXYGEN TANKS FOR EMU SUPPORT UNDER THE FOLLOWING CIRCUMSTANCES: @[CR 7657 ]
1. SIMULTANEOUS DCM PURGE OF TWO EMU'S
  2. EVIDENCE OF INSUFFICIENT UMBILICAL OXYGEN FLOW TO AN EMU CONDUCTING HELMET OR DCM PURGE

*The reconfiguration is performed to protect the EMU SOP consumable. The high flow demands of EMU denitrogenation purge are not expected to be duplicated during EVA. In most EMU failure scenarios, only one EMU would require a sustained demand (< approx 5 lb/hr) from the umbilical, with the other EMU requiring only a short, high demand for an O<sub>2</sub> tank refill.*

*During EMU decontamination operations at vacuum, both EMU's may be required to purge simultaneously. If EMU tank pressures fall much lower than 630 psia during vacuum contingency purging, SOP oxygen would be required to supplement the umbilical flow and stabilize the suit pressures. This would be preceded by a SUIT P LOW message being issued by the EMU's Caution and Warning System. Configuring to supply from the ISS O<sub>2</sub> tanks will conserve the SOP consumable, which cannot be refilled on-orbit and would therefore require logistical replanning. This can be avoided as such high demand events are normally known far enough prior to umbilical connection that reconfiguration to the ISS O<sub>2</sub> system can be planned.*

*The methodology used to determine the approximate total EMU purge flow rate into the cabin during the first 5 minutes of EMU purge has a measurement and computational error band of ±3.6 lbm/hr. A determination of 9 lbm/hr could represent an actual flow rate of as low as 5.4 lbm/hr. This flow rate would be sufficient to maintain a habitable pressure within the EMU with either one DCM purge valve open at vacuum (4.74 to 4.986 lbm/hr at an EMU pressure of 3.45 psi) or two helmet purge valves open at vacuum (2.5 ±0.4 lbm/hr at an EMU pressure of 3.35 psi).*

*It should be noted, however, that a successful completion of pre-EVA denitrogenation purge does not guarantee similar purge success during the subsequent EVA. Various systems can draw O<sub>2</sub> from the orbiter's cryo system at varying rates during a mission, causing supply pressure fluctuations. Cryo Tank stratification events are also possible. The ISS high pressure O<sub>2</sub> system however is dedicated entirely to EMU support during EVA, helping to guarantee that the SOP will not be activated.*

*If ground telemetry indicates that the oxygen flow through the ISS SCU is insufficient to support any EMU purge configuration at vacuum, the IV crew will be instructed to reconfigure the ISS oxygen system to utilize the ISS oxygen tanks. In the event of a loss of communication with the crew during this time period, the EVA cuff checklist Terminate EVA procedure instructs the crew to perform an emergency repressurization of the crew lock (Abort EVA) if their suit is unable to maintain a pressure greater than 3.3 psi. @[CR 7657 ]*

# FLIGHT RULES

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## SECTION 16 - POSTLANDING

THERE ARE NO FLIGHT SPECIFIC STS-115/12A RULES FOR THIS SECTION

# FLIGHT RULES

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## FLIGHT RULES

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### SECTION 17 - LIFE SUPPORT

#### SHUTTLE ONLY RULES

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12A_A17-2	LOSS OF AVIONICS BAY FAN.....	17-2

#### ISS ONLY RULES

THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION.....	17-4
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#### JOINT SHUTTLE/ISS RULES

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## **FLIGHT RULES**

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## FLIGHT RULES

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### SECTION 17 - LIFE SUPPORT

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#### SHUTTLE ONLY RULES

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#### 12A\_A17-1 USE OF EXPIRED LIOH CANS

EXPIRED LIOH CANS MAY BE USED FOR CO<sub>2</sub> REMOVAL IN THE SHUTTLE.

©[CR 7603 ]

*When LiOH canisters are produced, they are triple bagged and hermetically sealed with air free of CO<sub>2</sub>. Two of the three wrappers are removed when a LiOH canister is loaded into a vehicle prior to flight. An expired LiOH canister is defined as a canister that has had only a single wrapper for longer than 127 weeks.*

*Testing results showed that the CO<sub>2</sub> removal capabilities of expired versus new LiOH cans were statistically the same in the shuttle setting. Assumptions for the shuttle setting used in the analysis include 26 cfm through each canister, 50-degree dew point, and each canister in airflow stream for 12 to 24 hours.*

*DOCUMENTATION: CTSD-SH-151, 5LiOH Shelf Life Rev D, May 20, 2004. ©[CR 7603 ]*

**FLIGHT RULES**

**12A\_A17-2      LOSS OF AVIONICS BAY FAN**

AV BAY COOLING @ [CR 7705 ]

AVIONICS BAY FAN SHALL BE CONSIDERED LOST IF THE FAN DELTA PRESSURE IS GREATER THAN THE UPPER LIMITS OR LESS THAN THE LOWER LIMITS AS DEFINED IN THE FOLLOWING TABLE:

VEHICLE		CABIN P = 14.5 - 14.9 PSI		CABIN P = 10.0 - 10.6 PSI	
		UPPER LIMIT (IN. H <sub>2</sub> O)	UPPER LIMIT (IN. H <sub>2</sub> O)	LOWER LIMIT (IN. H <sub>2</sub> O)	UPPER LIMIT (IN. H <sub>2</sub> O)
OV104	AV BAY 1	2.50	4.50	1.91	3.51
	AV BAY 2	2.50	4.50	1.91	3.51
	AV BAY 3 (STD FAN)	2.90	5.10	2.21	3.98

*The minimum value corresponds to the estimated fan delta pressure of two-phase fan operation. This delta pressure should also provide adequate cooling flow in the case of duct leakage or degraded fan performance.*

*The maximum delta pressure/minimum airflow is based on a temperature violation of the GPC's. A delta pressure > the specified upper limit for the respective vehicle and av bay will not meet the required minimum flowrate for adequate cooling. A delta pressure exceeding this value would be indicative of possible duct blockage or filter blockage.*

*The minimum and maximum delta pressure values are in general agreement with current LCC and OMRSD limits which are based on analytical predictions of flowrates as described in reference documentation.*

*Fan delta pressure is a coarse representation of avionics bay cooling performance. Other indicators to determine the effectiveness of the cooling are avionics bay air outlet, active water coolant loop heat exchanger inlet and outlet temperatures, and H<sub>2</sub>O flowrate. Therefore, measurement error for delta pressure will not be used to determine the loss of an avionics bay fan.*

*Fan delta pressure limits at a cabin pressure range of 14.5 to 14.9 psi were determined by analysis using the Thermal Hydraulic Analyzer Program (THAP). @ [CR 7705 ]*

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## FLIGHT RULES

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### 12A\_A17-2      LOSS OF AVIONICS BAY FAN (CONTINUED)

*Fan delta pressure limits at a cabin pressure range of 10.0 to 10.6 psi were provided by Boeing in the Boeing Technical Memorandum No. TS-TM-06-005 dated March 28, 2006. The avionics bay fan delta pressure limits at a cabin pressure range of 10.0 to 10.6 psi were determined by fitting a curve to actual flight data from STS-114, 109, 104, 100, and 102. This equation is as follows and is valid for cabin pressures ranging from 9.55 to 15.12 psia: ©[CR 7705 ]*

$$\Delta p_{new} = \Delta p_{14.7} \{P_{new} \div 14.7\}^{0.73} \{T_{14.7} \div T_{new}\}$$

*DOCUMENTATION: Boeing Technical Memorandum No. TS-TM-06-005 Avionics Fan Performance as a Function of Cabin Pressure, March 28, 2006. RI-D IL-287-203-91-003, IL-287-203-90-86, Update to Avionics Bay Changes for Installation of new GPC's and TACAN's; BNA Memo No. SJ00-SJCOD-2004-029, Avionics Bay Cooling Limits; BNA Memo No. 287-200-098-019, Bay 3A Enhanced Avionics Fan Delta Pressure Limit, and Engineering judgment. ©[CR 7705 ]*

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## FLIGHT RULES

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ISS ONLY RULES

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THERE ARE NO STS-115/12A ISS ONLY RULES FOR THIS SECTION

## FLIGHT RULES

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### JOINT SHUTTLE/ISS RULES

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#### 12A\_C17-1 SHUTTLE VENT MANAGEMENT [RC]

A. WHILE THE SHUTTLE IS IN THE VICINITY OR DOCKED WITH ISS, THERE ARE NO CONSTRAINTS ON:

1. PURGING THE FUEL CELLS
2. FLASH EVAPORATOR SYSTEM (FES) OPERATIONS
3. VACUUM VENTING

*Periodic fuel cell purges will be required to maintain acceptable performance from the fuel cells. The FES is required to provide thermal control of the vehicle or dispose of excess fuel cell H<sub>2</sub>O as required. It may be enabled at all times during the docked phase. The vacuum venting is required to provide venting of WCS, wet trash, RCRS, and fuel cell generated H<sub>2</sub>. @[DN 108 ]*

B. SUPPLY WATER MANAGEMENT WHILE SHUTTLE IS IN THE VICINITY OR DOCKED WITH ISS:

1. DURING RENDEZVOUS, SUPPLY WATER NOZZLE DUMPS SHALL BE INHIBITED.
2. WHILE DOCKED
  - a. SUPPLY WATER DUMPS WILL BE MANAGED IN ACCORDANCE WITH RULE {A18-55}, SUPPLY WATER DUMP.
  - b. SUPPLY WATER NOZZLE DUMPS WILL ONLY BE PERFORMED SIMO WITH WASTE WATER DUMPS WHEN PRACTICAL. IF REQUIRED, SUPPLY WATER-ONLY NOZZLE DUMPS MAY BE PERFORMED.
  - c. PRIOR TO DUMPING WATER, IT IS MANDATORY TO FEATHER USOS SOLAR ARRAYS PER RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS. @[DN 108 ]

*To minimize the number of nozzle dump occurrences and the associated attitude changes, supply water nozzle dumps should be performed simultaneously with waste water dumps when possible. Supply water-only nozzle dumps may be performed, when required, if supply water production and usage prohibit scheduling supply water nozzle dumps simultaneous to waste water dumps.*

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## FLIGHT RULES

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### 12A\_C17-1 SHUTTLE VENT MANAGEMENT [RC] (CONTINUED)

- d. IT IS HIGHLY DESIRED TO INHIBIT ANY SHUTTLE NOZZLE-BASED H<sub>2</sub>O DUMPS FOLLOWING 4A SAW DEPLOY. SUCH DUMPS WILL ONLY BE CONSIDERED IF A GIVEN SITUATION REQUIRES, ON A CASE-BY-CASE BASIS. @[DN 108 ]

*The planned SARJ alpha angle is zero. Because of this, the 4A solar array is in direct line with the orbiter dump nozzle.*

#### C. WASTE WATER MANAGEMENT WHILE SHUTTLE IS IN THE VICINITY OR DOCKED WITH ISS:

1. A WASTE WATER DUMP WILL BE SCHEDULED AS LATE AS POSSIBLE, BUT PRIOR TO THE FIRST RENDEZVOUS BURN ON THE DAY OF RENDEZVOUS/DOCKING.

*In an effort to minimize the amount of waste water dumped while docked, a waste water dump should be scheduled as late as possible prior to docking. Also, waste water dumps performed on the morning of rendezvous just before the first burn of the day appear to have little to no detectable impact on the trajectory, according to analysis presented by Flight Design to the Generic Trench Tagup on March 14, 2000. In fact, dumps performed on the morning of rendezvous are preferable from a trajectory standpoint to dumps performed the night before because the trajectory dispersions have less time to propagate into downtrack errors at the first burn on the morning of rendezvous.*

2. DURING RENDEZVOUS, WASTE WATER NOZZLE DUMPS SHALL BE INHIBITED.
3. WHILE DOCKED
  - a. WASTE WATER DUMPS WILL BE MANAGED IN ACCORDANCE WITH RULE {A17-503}, WASTE WATER MANAGEMENT [HC].
  - b. IF A WASTE WATER DUMP IS REQUIRED, THE DUMP QUANTITY WILL BE MINIMIZED TO AVOID ISS CONTAMINATION.

*Minimizing the quantity of waste water dumped reduces the potential for ISS contamination. For 12A, there are additional concerns for such contamination on a newly deployed array. Sufficient waste quantity will be dumped to provide enough ullage in the waste tank to accommodate waste water generation until a dump opportunity is available post undocking.*

- c. PRIOR TO DUMPING WASTE WATER, IT IS MANDATORY TO FEATHER USOS SOLAR ARRAYS PER RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS. @[DN 108 ]

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## FLIGHT RULES

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12A\_C17-1      SHUTTLE VENT MANAGEMENT [RC] (CONTINUED)

- d. IT IS HIGHLY DESIRED TO INHIBIT ANY SHUTTLE NOZZLE-BASED H<sub>2</sub>O DUMPS FOLLOWING 4A SAW DEPLOY. SUCH DUMPS WILL ONLY BE CONSIDERED IF A GIVEN SITUATION REQUIRES, ON A CASE-BY-CASE BASIS. @[DN 108 ]

*The planned SARJ alpha angle is zero. Because of this, the 4A solar array is in direct line with the orbiter dump nozzle.*

- e. SRMS VIDEO OF A WASTE DUMP PRIOR TO DOCKING, OR THE FIRST DOCKED DUMP, IS HIGHLY DESIRED IF MODIFICATION OR MAINTENANCE THAT COULD PERTURB THE WASTE DUMP PLUME PATTERN HAS OCCURRED SINCE THE LAST IN-FLIGHT VERIFICATION OF A NOMINAL (PERPENDICULAR TO THE ORBITER FUSELAGE) WASTE DUMP PLUME PATTERN.

*To ensure that the waste dump plume will not impinge on the USOS solar arrays, it is highly desired to get SRMS wrist camera video of the plume. This can be accomplished during shuttle free flight (more desirable) or during the first waste dump while docked. In addition to video verification of a perpendicular plume pattern, waste dump nozzle temperature and flowrate data will also be used to verify that there is no ice forming on the nozzle that could deflect the plume. Inability to confirm nominal waste dump characteristics could result in the prohibition of docked waste dumps and in the use of CWC's for all condensate and urine collection during docked operations.*

- f. FOR FLIGHT ATTITUDE REQUIREMENTS WHILE DOCKED TO THE ISS SEE RULE {12A\_C2-51}, MATED ATTITUDES AND ATTITUDE CONSTRAINTS [RC].

- D. IF A CWC DUMP IS NECESSARY PRIOR TO UNDOCKING, IT WILL BE PERFORMED AFTER A SCHEDULED SUPPLY OR WASTE WATER DUMP WHEN PRACTICAL. IF REQUIRED, A CWC-ONLY DUMP MAY BE PERFORMED.

PRIOR TO DUMPING WATER, IT IS MANDATORY TO FEATHER USOS SOLAR ARRAYS PER RULE {12A\_C9-2}, USOS ARRAY FEATHERING DURING WATER DUMPS. @[DN 108 ]

- E. URINE WILL BE STORED IN THE ORBITER WASTE TANK ONLY, UNLESS A WASTE SYSTEM FAILURE REQUIRES URINE TO BE STORED IN CWC'S.

*Due to cabin contamination concerns, the stowage of waste water in CWC's will not be considered as a method of minimizing the amount of waste water dumped while docked. Engineering judgment.*

## FLIGHT RULES

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### 12A\_C17-2

### SHUTTLE AIRLOCK FAN MANAGEMENT

THE SHUTTLE AIRLOCK FAN CONFIGURATION WILL BE MANAGED IN THE FOLLOWING MANNER:

- A. THE SHUTTLE AIRLOCK FAN WILL NOMINALLY BE BYPASSED AND DEACTIVATED. THIS BYPASS CONFIGURATION WILL BE USED DURING THE DOCKED AND UNDOCKED TIMEFRAMES.
- B. WHILE DOCKED, THE PMA2 GRILL COVER WILL BE FULLY OPENED WITH THE LAB IMV FORWARD STARBOARD VALVE OPEN AND THE LAB IMV STARBOARD FORWARD IMV FAN OPERATIONAL.

*In this configuration, conditioned air will be pushed by the orbiter cabin fan (approx 206 to 221 lb/hr spec) to the middeck floor fitting and through the bypass ducting. This air will be pushed through the airlock tee and out through the airlock halo. This configuration will support crew operations in the orbiter airlock.*

*Analysis indicates that approx 171 lb/hr (40 cfm) will be provided in this configuration for airflow through the airlock halo. The halo is bypassed during the ISS ingress procedures following docking. In this configuration, the majority of the 40 cfm of conditioned air will be pushed from the orbiter cabin fan and pulled by the Lab Stbd IMV Fan to the ISS for CO<sub>2</sub> removal.*

- C. THE SHUTTLE AIRLOCK FAN WILL BE ACTIVATED TO SUPPORT DOCKING OPERATIONS.

*The airlock fan is required for docking to provide smoke detection and conditioning of the docking window to prevent fogging.*

- D. DURING DOCKED OPERATIONS, THE AIRLOCK FAN MAY BE ACTIVATED TO SUPPORT CO<sub>2</sub> REMOVAL DURING CREW SLEEP PERIODS. THE PMA2 GRILL COVER WILL BE CLOSED WHILE IN THIS CONFIG. ©[DN 58 ]

*The PPCO<sub>2</sub> levels in the orbiter during the crew sleep timeframe may require additional CO<sub>2</sub> removal capabilities to supplement the ISS CO<sub>2</sub> removal capability. Orbiter CO<sub>2</sub> levels will be monitored and compared to pre-flight predictions to determine if additional CO<sub>2</sub> removal is required for an upcoming crew sleep period. Scrubbing capabilities will be selected based on several factors including consumables margins and crew time. Specific capabilities include fresh LiOH cans, expired LiOH cans, and airlock fan activation. To ensure proper airflow rates to the station, the PMA2 grill cover will be closed while the shuttle airlock fan is operating. ©[DN 58 ]*

**THIS RULE CONTINUED ON NEXT PAGE**



## FLIGHT RULES

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**12A\_C17-2      SHUTTLE AIRLOCK FAN MANAGEMENT (CONTINUED)**

E. THE AIRLOCK FAN MAY BE ACTIVATED TO SUPPORT EMU CHECKOUT OPERATIONS IN THE AIRLOCK.

*While the crew is performing EMU checkout in the airlock, a potential for CO<sub>2</sub> pockets in the airlock exists. Turning the airlock fan on will assist with CO<sub>2</sub> removal in the airlock.*

*DOCUMENTATION: Engineering judgment and TS-TM-02-247 Impact of No Booster Fan on Docked Operations, Boeing, October 2002.*

*Reference Rule {B13-56}, TIME ALLOWED IN MODULE WITHOUT INTER- OR INTRA-MODULE VENTILATION [HC] [RC] [E].*

## FLIGHT RULES

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12A\_C17-3

### SPHERES CO2 CONSTRAINTS FOR SATELLITE OPERATIONS

AT LEAST ONE OF THE TWO FOLLOWING CONDITIONS MUST BE MET TO INITIATE SYNCHRONIZED POSITION HOLD, ENGAGE, REORIENT, EXPERIMENTAL SATELLITE (SPHERES) SATELLITE OPERATIONS:

- A. CDRA MUST BE OPERATING IN DUAL-BED MODE.
- B. P<sub>PCO<sub>2</sub></sub> LEVELS ARE VERIFIED THROUGH TELEMETRY TO BE LESS THAN 4.0 MM HG. SPHERES SATELLITE OPERATIONS SHALL BE IMMEDIATELY TERMINATED IF CO<sub>2</sub> LEVELS INCREASE TO 6.0 MM HG.

*Analysis has shown that CDRA in dual-bed mode will prevent CO<sub>2</sub> levels from reaching SMAC values. Further analysis by the Toxicology Office has shown that release of 18 SPHERES CO<sub>2</sub> tanks will still result in a CO<sub>2</sub> level in the Lab of less than SMAC value.*

*Reference Toxicology Group Memo 587, February 6, 2001; ISS ECLSS Group Memo EC-02-174, November 19, 2002; and Hazard Report, SPHERES-8, Control 1.2.*

# FLIGHT RULES

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## SECTION 18 - THERMAL

### SHUTTLE ONLY RULES

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### JOINT SHUTTLE/ISS RULES

THERE ARE NO STS-115/12A JOINT SHUTTLE/ISS RULES FOR THIS SECTION.....18-3

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## **FLIGHT RULES**

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**FLIGHT RULES**

**SECTION 18 - THERMAL**

**SHUTTLE ONLY RULES**

**12A\_A18-1      BONDLINE ENTRY INTERFACE (EI) TEMPERATURES**

MAXIMUM ALLOWABLE BONDLINE ENTRY INTERFACE (EI) TEMPERATURES ARE BASED ON STRUCTURAL CONSTRAINTS AND FLIGHT-SPECIFIC PARAMETERS FOR VEHICLE LOADING. THE LIMITS LISTED BELOW ARE THE OPPORTUNITY-INDEPENDENT LIMITS FOR STS-115:

DESCRIPTION	TEMPERATURE MEASUREMENT NO'S	STS-115 MAX LIMIT, DEG F
PLBD	V37T1000	74.0
	V37T1006	74.0
	V37T1002	77.0
	V37T1004	77.0
PORT (STBD)	V09T1012(14)	94.3
	V09T1724(20)	116.7
	V09T1030(28)	66.8
	V34T1106(08)	119.6
	V34T1102(04)	67.6
TOP	V09T1524	42.0
	V09T1004	94.3
	V09T1024	94.3
BOTTOM	V09T1624	149.9
	V09T1702	109.0
	V09T1000	118.6
	V09T1002	118.6
	V09T1016	166.4
	V09T1022	159.4
	V34T1110	123.4
	V34T1112	124.4

©[CR 7474 ]

*These are the STS-115 flight-specific limits, as referenced in Rule {A18-401B}, THERMAL PROTECTION SYSTEM (TPS) BONDLINE TEMPERATURES. The term "Opportunity-Independent" refers to the representative set of deorbit opportunity cases from which these limits are derived. The limits listed represent the most restrictive for each MSID from all of the cases including a weight change of up to 3000 lb and a cg shift of up to 3 inches.*

*DOCUMENTATION: STS-115 Flight Design Product DSCT-29, May 3, 2006. ©[CR 7474 ]*

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## FLIGHT RULES

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ISS ONLY RULES

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RESERVED ©[DN 93 ]

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### JOINT SHUTTLE/ISS RULES

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THERE ARE NO STS-115/12A JOINT SHUTTLE/ISS RULES FOR THIS SECTION.

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## **FLIGHT RULES**

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# FLIGHT RULES

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## SECTION 19 - PAYLOADS

### SHUTTLE ONLY RULES

THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION.....19-1

### ISS ONLY RULES

12A_B19-1	MELFI LTL FLOW RATE AND TWMV OUT TEMPERATURE REQUIREMENTS.....	19-2
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### JOINT SHUTTLE/ISS RULES

THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION.....19-8

# FLIGHT RULES

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## FLIGHT RULES

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### SECTION 19 - PAYLOADS

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#### SHUTTLE ONLY RULES

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THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION

## FLIGHT RULES

### ISS ONLY RULES

**12A\_B19-1**      **MELFI LTL FLOW RATE AND TWMV OUT TEMPERATURE REQUIREMENTS**

- A. MELFI REQUIRES LTL SUPPLY TEMPERATURES TO BE BETWEEN 3.3 AND 7.2 DEG C FOR NOMINAL OPERATIONS. MELFI CAN BE OPERATED WITH LTL SUPPLY TEMPERATURES BETWEEN 1.1 AND 11 DEG C WITH ADDITIONAL POWER AND FLOW REQUIREMENTS OUTLINED IN THE TABLE BELOW. @[CR 7638 ]
- B. THE LTL TWMV SETPOINT TEMPERATURE SHALL BE SET 1.0 DEG C BELOW THE DESIRED LTL SUPPLY TEMPERATURE TO MELFI.

MELFI FLOW RATE REQUIREMENTS ARE PER THE TABLE BELOW:

LTL TEMPERATURE	MINIMUM LTL FLOW RATE	ADDITIONAL MELFI POWER	TOTAL MELFI POWER
3.3°C TO 7.2°C	81.4 KG/HR (179 LBM/HR)	0W	900W
7.2°C TO 8.3°C	81.4 KG/HR (179 LBM/HR)	50W	950W
8.3°C TO 10.0°C	81.4 KG/HR (179 LBM/HR)	100W	1000W
10.0°C TO 11.0°C	136 KG/HR (300 LBM/HR)	150W	1050W

*MELFI rejects all heat through the LTL and is more efficient at the higher range of flow and lower inlet temperatures. MELFI operations are most efficient when LTL TWMV out temperatures are between 3.3 and 7.2 deg C. LTL temperatures below 3.3 deg C are not practical, given external loop setpoints and IFHX efficiencies, but operations above 7.2 deg C are probable. Rack specific telemetry analysis by the payloads team (after on-orbit activation) may result in a change to the maximum allowable LTL supply temperature requirement.*

*The LTL TWMV controls to an operational range of  $\pm 0.6$  C of the commanded setpoint and the associated temperature sensor accuracy is approximately  $\pm 0.4$  C, resulting in a total control accuracy of  $\pm 1.0$  C. This results in the need to set the LTL TWMV setpoint 1.0 deg C below the desired maximum LTL supply temperature. Since the maximum allowed supply temperature to MELFI is 11.0 deg C, the maximum LTL TWMV setpoint for MELFI operations is 10.0 deg C. @[CR 7638 ]*

**THIS RULE CONTINUED ON NEXT PAGE**

## FLIGHT RULES

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12A\_B19-1

MELFI LTL FLOW RATE AND TWMV OUT TEMPERATURE  
REQUIREMENTS (CONTINUED)

*Setpoint constraints for the EETCS are documented in Rule {B18-168}, EETCS SETPOINT CONSTRAINTS, which notes that the nominal operational PPL setpoint is 5.8 deg C. This is to ensure that NH<sub>3</sub> freeze protection FDIR's do not trigger during system transients. With the 5.8 deg C EETCS setpoint, flight experience has shown that the lowest achievable LTL TWMV out temperature is approximately 7.5 deg C. If a lower EETCS setpoint is required, operational precautions are documented in Rule {B18-168}, EETCS SETPOINT CONSTRAINTS. ©[CR 7638 ]*

*Additional impacts for MELFI operations would have to be coordinated with Phalcons for the extra power draw when LTL out temperatures are greater than 7.2 deg C and ECLSS for the additional condensate collected with the lower LTL temperatures.*

*DOCUMENTATION: MELFI FLIGHT MODEL USER MANUAL, Issue 4, September 1, 2004. ©[CR 7638 ]*

## FLIGHT RULES

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### 12A\_B19-2      MELFI LAB104 FLOW START/STOP REQUIREMENTS

POWER SHOULD BE ESTABLISHED FOR MELFI WITHIN 30 MINUTES OF APPLICATION OF FLOW THROUGH THE LAB104 RFCA. LIKEWISE, ALL FLOW THROUGH THE LAB104 RFCA FOR MELFI WILL BE TERMINATED WITHIN 30 MINUTES AFTER MELFI DEACTIVATION. @[CR 7638 ]

*Overheating may occur if MELFI is operated without LTL cooling established. Prolonged LTL flow while MELFI is off could create condensation around the internal components of the rack.*

*DOCUMENTATION: MELFI FLIGHT MODEL USER MANUAL, Issue 4, September 1, 2004. @[CR 7638 ]*

### 12A\_B19-3      MELFI ORU MAINTENANCE DECISION REQUIREMENTS

DUE TO THE TIME CONSTRAINT FOR BRAYTON MACHINE POWEROFF, THE DECISION FOR MELFI MAINTENANCE MUST BE MADE WITHIN THE FOLLOWING TIME PERIODS: @[CR 7638 ]

- A. FOR A BRAYTON MACHINE CHANGEOUT, THE DECISION MUST BE MADE WITHIN 2 HOURS.
- B. FOR AN ELECTRONICS UNIT CHANGEOUT, THE DECISION MUST BE MADE WITHIN 4 HOURS.

*MELFI ORU changeouts take several hours; therefore, in order to meet the 8-hour Brayton Machine poweroff constraint, the actual decision to change the ORU must be made within the above constraints.*

*DOCUMENTATION: MELFI Flight Model User Manual, Issue 4, September 1, 2004. @[CR 7638 ]*

## FLIGHT RULES

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**12A\_B19-4****MELFI MAIN POWER RPC MANAGEMENT**

MELFI MAIN POWER (RPCM LA2A3B-B RPC 01) WILL REMAIN OPEN COMMAND INHIBITED UNTIL ALL DEWARs HAVE COOLED DOWN TO THEIR TEMPERATURE SETPOINTS. @[CR 7638 ]

*The MELFI rack has four dewars which provide cold stowage services for payloads. Dewar temperatures can be maintained at separate setpoints with at least one dewar at the lowest setpoint of minus 95 degrees C. MELFI is designed to maintain dewar temperatures within scientifically acceptable limits of preserving payloads up to 8 hours (with sufficient thermal mass) after being powered off once the dewars have cooled down to their respective setpoints. Due to its large thermal mass, MELFI requires several weeks for all dewars to complete their initial cool down during which MELFI is most susceptible to being powered off. A power off during the cool down phase will further extend the time by which the dewars reach their setpoints resulting in the delay of providing cold stowage services. It is therefore critical to protect this high priority facility serving multiple payload users from being powered off until the dewars have reached their setpoints. Consequently, at the Load Shed Working Group on February 24, 2006, MOD and POIC agreed to inhibit the MELFI main RPC from opening to prevent the MELFI rack from powering off during its cool down phase. POIC will be responsible for monitoring the MELFI main power RPC Open Command status and informing PHALCON when the RPC Open Command Inhibit should be put in place and removed. @[CR 7638 ]*

## FLIGHT RULES

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### 12A\_B19-5

### HRF ACOUSTIC CONSTRAINTS

THE HRF RACKS 1 AND 2 CANNOT OPERATE SIMULTANEOUSLY. HRF ACOUSTIC LIMITS: THE FOLLOWING TABLE LISTS THE OPERATIONAL SCENARIOS AND TIME LIMITATIONS FOR THE HRF EXPERIMENT HARDWARE THAT ARE NECESSARY TO MEET ACOUSTIC LIMITS: ©[CR 7714 ]

SCENARIO	POWERED TIME CONSTRAINT
HRF RACK 1, PC	UNLIMITED
HRF RACK 1, PC, SLAMMD	8 HOURS PER DAY
HRF RACK 1, PC, WORKSTATION 2	8 HOURS PER DAY
HRF RACK 1, PC, WORKSTATION 2, SLAMMD	8 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND	4.5 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND, COOLING STOWAGE DRAWER	4 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND, WORKSTATION 2	4 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND, WORKSTATION 2, SLAMMD	4 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND, WORKSTATION 2, COOLING STOWAGE DRAWERS 1 AND 2	3 HOURS PER DAY
HRF RACK 1, PC, ULTRASOUND, WORKSTATION 2, COOLING STOWAGE DRAWERS 1 AND 2, SLAMMD	3 HOURS PER DAY
HRF RACK 2, PC	UNLIMITED
HRF RACK 2, PC, GASMAP	UNLIMITED
HRF RACK 2, PC, PFM/PAM	UNLIMITED
HRF RACK 2, PC, PFM/PAM, GASMAP	UNLIMITED
HRF RACK 2, PC, WORKSTATION 2	8 HOURS PER DAY
HRF RACK 2, PC, PFM/PAM, WORKSTATION 2, GASMAP	6 HOURS PER DAY
HRF RACK 2, PC, REFRIGERATED CENTRIFUGE	3.5 HOURS PER DAY
HRF RACK 2, PC, WORKSTATION 2, REFRIGERATED CENTRIFUGE	3 HOURS PER DAY
HRF RACK 2, PC, PFM/PAM, REFRIGERATED CENTRIFUGE, GASMAP	3 HOURS PER DAY

*Acoustic limits prohibit both racks from being powered at the same time. The HRF is an intermittent noise source whose impact to the overall ISS noise environment must be limited.*

*DOCUMENTATION: D683-35499-23, Stage ULF1.1 Payload Guidelines and Constraints Reports, Revision A, Jan. 2006. ©[CR 7714 ]*



## FLIGHT RULES

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### 12A\_B19-6

### ON-ORBIT MAINTENANCE [HC]

CORRECTIVE MAINTENANCE IS ONLY ALLOWED ON PAYLOADS WITH PRIOR APPROVAL OF THEIR MAINTENANCE HAZARD ASSESSMENT (MHA) BY THE PAYLOAD SAFETY REVIEW PANEL (PSRP) AND SUBMITTAL/APPROVAL OF THEIR MAINTENANCE PROCEDURES TO PAYLOAD OPERATIONS INTEGRATION CENTER (POIC). THE INCREMENT SPECIFIC PAYLOAD REGULATIONS DOCUMENT IDENTIFIES PAYLOADS THAT HAVE SUBMITTED MHA'S ON THEIR MAINTENANCE OPERATIONS AND SUBMITTED THE RESPECTIVE PROCEDURES. ©[CR 7713B ]

*The purpose of this rule is to maintain safe access to all components of the payload's hardware. The Maintenance Hazard Assessment is to control hazards that could result from access to nominally inaccessible components. This required assessment addresses:*

- a. *Safe Access: All potential access paths for contact hazards (such as sharp edges, touch temperature, stored energy, and electrical shock, etc.) that may be present during maintenance activities.*
- b. *Modification of Existing Safety Features: Hazards that maintenance activities could create (contamination); this includes establishing why the maintenance tasks are safe and why it is acceptable to defeat any hazard controls during the maintenance activity.*
- c. *Reverification of Safety Critical Features: The approach to verify or re-verify any safety critical features that may be modified during maintenance and that will be required during subsequent operations.*

*Reference: Interpretation Letter MA2-00-038, PSRP, NSTS/ISS 18798-B Rev B, "Interpretations of NSTS/ISS Payload Safety Requirements."* ©[CR 7713B ]

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## FLIGHT RULES

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JOINT SHUTTLE/ISS RULES

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THERE ARE NO FLIGHT-SPECIFIC STS-115/12A RULES FOR THIS SECTION

# FLIGHT RULES

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## ACRONYMS AND ABBREVIATIONS

A/G	AIR-TO-GROUND
A/L	AUTOLAND
	AIRLOCK
A/R	ASCENDING RIGHT
A&L	APPROACH AND LAND
AAH	AUTOMATIC ATTITUDE HOLD
ABCD	ADIABATIC BUBBLE COMPRESSION DETONATION
ABE	ARMED BASED ELECTRONICS
ABIT	ACTIVE BUILT IN TEST ERROR
ABT	ABORT
AC	ALTERNATING CURRENT
ACBSP	BASEBAND SIGNAL PROCESSOR
ACC	ACCELEROMETER
ACCEL	ACCELERATION
ACIP	AERODYNAMIC COEFFICIENT INSTRUMENTATION PACKAGE
ACK	ACKNOWLEDGE
ACLS	AUGMENTED CONTINGENCY LANDING SITE
ACO	ASSEMBLY AND CHECKOUT OFFICER
ACQ	ACQUISITION
ACS	ATTITUDE CONTROL SYSTEM
ACT	ACTIVATION
ACT/DEACT	ACTIVATION/DEACTIVATION
ACTIV	ACTIVITY
ACU	ARM COMPUTER UNIT
AD	AIR DATA
ADACS	ATTITUDE DETERMINATION AND CONTROL SYSTEM
AEM	ANIMAL ENCLOSURE MODULE
AERO	AERODYNAMICS
AFD	AFT FLIGHT DECK
AFGL	AIR FORCE GEOPHYSICS LABORATORY
AJIS	ALPHA JOINT INTERFACE STRUCTURE
AKA	ACTIVE KEEL ASSEMBLY
AL	ASCENDING LEFT
ALT	ALTERNATE, ALTITUDE
ALT DAP	ALTERNATE DIGITAL AUTO PILOT
AMCS	ATTITUDE MEASUREMENT AND CONTROL SYSTEM
AMP (S)	AMPERE (S)
AOA	ABORT ONCE AROUND
AOI	AREA OF INTEREST
AOPROC	ATOMIC OXYGEN PROCESSING EXPERIMENT
AOS	ACQUISITION OF SIGNAL
APC	ADVANCE PROCESS CONTROLLER
APCU	ASSEMBLY POWER CONVERTER UNIT

**FLIGHT RULES**


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APE-B	AURORAL PHOTOGRAPHY EXPERIMENT-B
APM	ATTITUDE PROCESSOR MODULE
	ASCENT PERFORMANCE MARGIN
APU	AUXILIARY POWER UNIT
ARCS	AFT RCS
ARCU	AMERICAN TO RUSSIAN CONVERTER UNIT
ARD	ABORT REGION DETERMINATION
ARISS	AMATEUR RADIO ON INTERNATIONAL SPACE STATION
ARS	ATMOSPHERIC REVITALIZATION SYSTEM
ARS	ATTITUDE REFERENCE SYSTEM
ARTIC	ADVANCED THERMOELECTRIC REFRIGERATOR/FREEZER
ASAP	AS SOON AS POSSIBLE
ASAP	AS SOON AS PRACTICAL
ASE	AIRBORNE SUPPORT EQUIPMENT
ASF	ADACS SCAN BOX FILTER
ATA	AMMONIA TANK ASSEMBLY
ATCS	ACTIVE THERMAL CONTROL SYSTEM
ATL	ATTITUDE TIMELINE
ATR	AMBIENT TEMPERATURE RECORDER
ATT	ATTITUDE
AUG	AUGMENTED
AUTO	AUTOMATIC
AUX	AUXILIARY
AV	AVIONICS
AVG	AVERAGE
AVU	ARTIFICIAL VISION UNIT
BATTS	BATTERIES
BB	BLANKET BOX
BBC	BOLT BUS CONTROLLER
BBS	BOLT BACK SWITCH
BD	BAND
BCDU	BATTERY CHARGE/DISCHARGE UNIT
BFS	BACKUP FLIGHT SYSTEM
BGA	BETA GIMBAL ASSEMBLY
BGTS	BETA GIMBAL TRANSITION STRUCTURE
BIA	BUS INTERFACE ADAPTER
BITE	BUILT-IN TEST EQUIPMENT
BPSMU	BATTERY POWERED SPEAKER MICROPHONE UNIT
BMRRM	BEARING, MOTOR, ROLL RING MODULE
BRIC	BIOLOGICAL RESEARCH IN CANISTERS
BRK	BREAK
BRKOUT	BREAKOUT
BRS	BLANKET RESTRAINT SYSTEM
BRT	BODY RESTRAINT TETHER
BTS	BOLT TIGHT SWITCH

**FLIGHT RULES**


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BTU	BUS TERMINAL UNIT
C	CELSIUS
C&C	COMMAND AND CONTROL
C&W	CAUTION AND WARNING
C/M I	CONTROL/MONITOR INSTRUMENTATION
C/O	CHECKOUT
CAB	CABIN
CAEM	COMMERCIAL ANIMAL ENCLOSURE MODULE
CAL	CALIBRATION
CAPCOM	CAPSULE COMMUNICATOR
CAPL	CAPILLARY PUMP LOOP EXPERIMENT
CAR	CARRIER
CAS	CALIBRATED ANCILLARY SYSTEM
CAT	CATEGORY
CBE	CHEMICAL BEAM EPITAXY
CBM	COMMON BERTHING MECHANISM
CCDS	CENTER FOR THE COMMERCIAL DEVELOPMENT OF SPACE
CCM	CELL CULTURAL MODULE
CCS	COMMAND AND CONTROL SYSTEM, CONTAMINATION CONTROL SYSTEM, COMMAND AND CONTROL SOFTWARE
CCTV	CLOSED CIRCUIT TELEVISION
CCW	COUNTERCLOCKWISE
CDMS	COMMAND AND DATA MANAGEMENT SYSTEM
CDR	COMMANDER
CDS	COMMAND DATA SYSTEM
CDSS	CONSOLIDATED DATA SELECT SWITCH
CDV	CABIN DEPRESS VALVE
CERL	U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH
CETA	CREW AND EQUIPMENT TRANSFER ASSEMBLY
CG	CENTER OF GRAVITY
CGBA	COMMERCIAL GENERIC BIOPROCESSING APPARATUS
CHAWS	CHARGE ANALYSIS AND WAKE STUDIES
CHT	SEE ARCU
CIC	CREW INTERFACE COORDINATOR
CID	COMPUTER INTERFACE DEVICE CIRCUIT ISOLATION DEVICE CIRCUIT INTERRUPT DEVICE
CIL	CRITICAL ITEMS LIST
CIO	CUSTOMER INTEGRATION OFFICE
CIP	CUSTOMER INTERFACE PANEL
CIR	CARGO INTEGRATION REVIEW
CIRC	CIRCULARIZATION
CITE	CARGO INTEGRATION TEST EQUIPMENT
CK	CHECK

**FLIGHT RULES**


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CLA	CAMERA AND LIGHT ASSEMBLY
CLPA	CAMERA, LIGHT, AND PAN/TILT ASSEMBLY
CM	COMBUSTION MODULE
CMC	CAROUSEL MOTOR CONTROLLER
CMD	COMMAND
CMG	CONTROL MANAGEMENT GYROSCOPE
CMIX	COMMERCIAL MDA ITA EXPERIMENT
CMT	CARGO MANAGEMENT TEAM
CNTCS	CONTACTS
CNTL	CONTROL
CO	CARBON MONOXIDE
CO <sub>2</sub>	CARBON DIOXIDE
COAS	CREW OPTICAL ALIGNMENT SITE
COF	PATRICK AIR FORCE BASE (TACAN)
COMM	COMMUNICATION
COMP	COMPENSATION
CONCAP	CONSORTIUM FOR MATERIALS IN SPACE COMPLEX AUTONOMOUS PAYLOAD
CONCOP	CONTAINER LESS COATING PROCESS
CONFIG	CONFIGURATION
CONT	CONTINUED
CONTING	CONTINGENCY
CONUS	CONTINENTAL UNITED STATES
CPCG-H	COMMERCIAL PROTEIN CRYSTAL GROWTH - HIGH DENSITY
CPL	CAPILLARY PUMP LOOP
CPLD	COMPLEX PROGRAMMABLE LOGIC DEVICE
CPU	CENTRAL PROCESSING UNIT
CR	CHANGE REQUEST
CR/IM	COMMERCIAL REFRIGERATOR/INCUBATOR MODULE
CRIM	COMMERCIAL REFRIGERATOR INCUBATOR MODULE
CRIT	CRITICALITY
CRPCM	CANADIAN REMOTE POWER CONTROL MODULE
CRT	CATHODE RAY TUBE
CRYO	CRYOGENICS
CSA-CP	COMPOUND SPECIFIC ANALYZER - COMBUSTION PRODUCTS
CSCS	CONTINGENCY SHUTTLE CREW SUPPORT
CSM	CARGO SYSTEMS MANUAL
CSR	CUSTOMER SUPPORT ROOM
CW	CLOCKWISE
CWC	CONTINGENCY WATER CONTAINER
CWEA	CAUTION AND WARNING ELECTRONICS ASSEMBLY
CWS	CAUTION AND WARNING SYSTEM
D	DAY
D&C	DISPLAY AND COMMAND

## FLIGHT RULES

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D/C	DISPLAY AND CONTROL
D/L	DESCENDING LEFT
D/R	DESCENDING RIGHT
DAM	DEBRIS AVOIDANCE MANEUVER
DAP	DATA ACQUISITION PLAN; DIGITAL AUTOPILOT
DAPCS	DATA ACQUISITION AND PROCESS CONTROL SYSTEM
DAT	DAMAGE ASSESSMENT TEAM
DB	DATA BASE
DC	DIRECT CURRENT
DCSU	DIRECT CURRENT SWITCHING UNIT
DCU	DIRECT COMMAND UNIT
DDCU	DC-DC CONVERTER UNIT
DDS	DIGITAL DATA SYSTEM
DDU	DATA DISPLAY UNIT
DEACT	DEACTIVATION
DECAT	DYNAMIC ENVIRONMENT COMMUNICATIONS ANALYSIS TESTBED
DECOM(S)	DECOMMUTATOR(S)
DEG	DEGREE
DEG/S	DEGREES PER SECOND
DEG/SEC	DEGREE PER SECOND
DELTA V	CHANGE IN VELOCITY
DEU	DISPLAY ELECTRONICS UNIT
DFL	DOWNLINK FORMAT LOAD
DFVT	DATA FLOW VERIFICATION TEST
DHS	DATA HANDLING SYSTEM
DIDB	DISPOSABLE IN-SUIT DRINK BAGS
DIST	DISTRIBUTION
DJOPS	DEGRADED JOINT OPERATIONS
DLA	DRIVE LOCK ASSEMBLY
DLISA	DOUBLE LID INTERLOCK SWITCH ASSEMBLY
DLMA	DILEMMA
DLY	DELAY
DMA	DIMENSIONAL MICROGRAVITY ACCELEROMETER
DMU	DATA MANAGEMENT UNIT
DN	DISCREPANCY NOTICE
DOD	DEPARTMENT OF DEFENSE
DOH	DISCRETE OUTPUT HIGH
DOL	DISCRETE OUTPUT LOW
DOLILU	DAY-OF-LAUNCH I-LOAD UPDATE
DOUG	DYNAMIC ONBOARD UBIQUITOUS GRAPHICS
DP/DT	RATE OF CHANGE OF PRESSURE WITH RESPECT TO TIME
DPLY	DEPLOY
DPS	DATA PROCESSING SYSTEM
DPU	DATA PROCESSING UNIT
DQA	DATA QUALITY ANALYZER

**FLIGHT RULES**


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DS	DUAL STRING
DSC	DISCRETE
DSM	DIGITAL SELECT MATRIX
	DATA SELECT MODE
DSO	DETAILED SUPPLEMENTARY OBJECTIVE
DT	DOWNTRACK
DTMF	DUAL TONE MULTI FREQUENCY
DTO	DEVELOPMENT TEST OBJECTIVE
DTV	DIGITAL TELEVISION
DU	DISPLAY UNIT
DVIS	DIGITAL VOICE INTERCOMMUNICATION SYSTEM
EAM	EARTH ACQUISITION MODE
EAS	EARLY AMMONIA SERVICER
EATCS	EXTERNAL ACTIVE THERMAL CONTROL SYSTEM
EB	EFFECTIVE BETA
EBIT	END-TO-END BERTHING INTEGRATION TEAM
ECAL	EAST COAST ABORT LANDING
ECG	ECHOCARDIOGRAPHY
ECLIPSE	EQUIPMENT FOR CONTROLLED LIQUID PHASE SINTERING EXPERIMENT
ECLSS	ENVIRONMENTAL CONTROL AND LIFE SUPPORT
ECS	ENVIRONMENTAL CONTROL SYSTEM
ECU	ELECTRONICS CONTROL UNIT
	ENVIRONMENTAL CONTROL UNIT
EDFT	EVA DEVELOPMENT TEST
EDO	EXTENDED DURATION ORBITER
EDW	EDWARDS AIR FORCE BASE, CALIFORNIA
EE	END EFFECTOR
EECOM	EMERGENCY, ENVIRONMENTAL, AND CONSUMABLES MANAGEMENT SYSTEMS
EETCS	EARLY EXTERNAL THERMAL CONTROL SYSTEM
EFE	ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM
EFGF	ELECTRICAL FLIGHT GRAPPLE FIXTURE
EGIL	ELECTRICAL, GENERATION, AND INTEGRATED LOADING
EGSE	ELECTRICAL GROUND SUPPORT EQUIPMENT
EI	ENTRY INTERFACE
ELEC	ELECTRICAL
	ELECTROCARDIOGRAPH
ELS	EMERGENCY LANDING SITE
ELSM	EJECTION LIMIT SWITCH MODULE
EMC	ELECTROMAGNETIC COMPATIBILITY
EMER	EMERGENCY
EMPEV	EMERGENCY MANUAL PRESSURE EQUALIZATION VALVE
EMU	EXTRAVEHICULAR MANEUVERING/MOBILITY UNIT



**FLIGHT RULES**


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ENA	ENABLE
ENBL	ENABLE
EOE	EXPERIMENT OPS ENGINEER
EOM	END OF MISSION
EPICS	ELECTROLYSIS PERFORMANCE IMPROVEMENT CONCEPT STUDY
EPS	ELECTRICAL POWER SYSTEM (SUBSYSTEM)
ERADS	EARTH REFERENCE ATTITUDE DETERMINATION
ERPCL	EXTENDED RANGE PAYLOAD COMMUNICATION LINK
ESS	ESSENTIAL
ESTL	ELECTRONIC SYSTEMS TEST LABORATORY
ET	EXTERNAL TANK
ETCS	EXTERNAL THERMAL CONTROL SYSTEM
ETIP	EXTERNAL TANK IMPACT POINT
ETOV	EARTH-TO-ORBIT VEHICLE
ETRO	ESTIMATED TIME OF RETURN TO OPERATION
ETRS	EVA TEMP RAIL STOP
ETVCG	EXTERNAL TELEVISION CAMERA GROUPS
EUV	EXTREME ULTRAVIOLET
EVA	EXTRAVEHICULAR ACTIVITY
EVAL	EVALUATE, EVALUATION
EVN	EVENTS
EWBMTAU-WLE	WING LEADING EDGE SENSORS APPLICATION SOFTWARE
EXCP	EXPERIMENT CONNECTOR PANEL
EXP	EXPERIMENT
	EXPEDITION
EXT	EXTEND
F	FAHRENHEIT
F/C	FLIGHT CONTROL
FA	FLIGHT AGREEMENT
FAO	FLIGHT ACTIVITIES OFFICER
FC	FUEL CELL
FCA	FUEL CONTROL ASSEMBLY
FCOH	FLIGHT CONTROL OPERATIONS HANDBOOK
FCP	FUEL CELL PURGE
FCR	FLIGHT CONTROL ROOM
FCS	FLIGHT CONTROL SYSTEM
FCT	FLIGHT CONTROL TEAM
FCV	FLOW CONTROL VALVE
FD	FLIGHT DAY, FLIGHT DIRECTOR
FDO	FLIGHT DYNAMICS OFFICER
FDA	FAULT DETECTION AND ANNUNCIATION
FDF	FLIGHT DATA FILE
FDIR	FAULT DETECTION, ISOLATION, AND RECOVERY
FE	FLIGHT EXPERIMENT

## FLIGHT RULES

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FEB	FLOWMETER ELECTRONIC BOX
FEP	FRONT END PROCESSOR
FES	FLASH EVAPORATOR SYSTEM
FET	FIELD EFFECT TRANSISTOR
FF	FLIGHT FORWARD
FF	FREE FLYER
FGB	FUNCTIONAL CARGO BLOCK
FIM	FLIGHT INTEGRATION MANAGER
FIV	FUEL ISOLATION VALVE
FLT	FLIGHT
FM	FREQUENCY MODULATION
FN	FLIGHT NIGHT
FOIG	FLIGHT OPERATIONS INTEGRATION GROUP
FOP	FLIGHT OPERATIONS PLAN
FOR	FLIGHT OPERATIONS REVIEW
FOSA	FLIGHT OPERATIONS SUPPORT ANNEX
FOV	FIELD OF VIEW
FPIP	FUEL PUMP INLET PRESSURE
FPMU	FLOATING POTENTIAL MANAGEMENT UNIT
FPP	FLOATING POTENTIAL PROBE
FPR	FLIGHT PERFORMANCE RESERVE
FPS	FEET PER SECOND
FPV	FLOW PROPORTIONING VALVES
FR	FLIGHT RULES
FRCB	FLIGHT RULES CONTROL BOARD
FRCS	FORWARD REACTION CONTROL SYSTEM
FRD	FLIGHT REQUIREMENTS DOCUMENT
FRGF	FLIGHT RELEASABLE GRAPPLE FIXTURE
FRR	FLIGHT READINESS REVIEW
FSCU	FIRE SUPPRESSION CONTROL UNIT
FSS	FIRE SUPPRESSION SYSTEM
FT	FEET
FTMU	FLYER TEMPERATURE MEASUREMENT UNIT
FTP	FLIGHT TECHNIQUES PANEL
FWD	FORWARD
GA	GALLIUM
GAP	GROUP ACTIVATOR PACK
GAS	GET AWAY SPECIAL
GBA	GAS BRIDGE ASSEMBLY
GCA	GROUND CONTROLLED APPROACH
GEVS	GENERAL ENVIRONMENTAL VERIFICATION SPECIFICATIONS
GF	GRAPPLE FIXTURE
GG	GRAVITY GRADIENT
GLO	SHUTTLE GLOW EXPERIMENT

**FLIGHT RULES**


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GMT	GREENWICH MEAN TIME
GN <sub>2</sub>	GASEOUS NITROGEN
GNC	GUIDANCE, NAVIGATION, AND CONTROL
GOM	GROUND OPERATIONS MANAGER
GOR	GROUND OPERATIONS REVIEW
GPC	GENERAL PURPOSE COMPUTER
GPM	GENERALIZED PAYLOAD MODEL
GPO	GUIDANCE & PROCEDURES OFFICER
GPS	GLOBAL POSITIONING SYSTEM
GRAF	GRAPHICS RESEARCH ANALYSIS FACILITY
GSE	GROUND SUPPORT EQUIPMENT
GSFC	GODDARD SPACE FLIGHT CENTER
GVL	GENERAL VIBRATION LAB
GYRO	GYROSCOPE
H <sub>2</sub> O	WATER
HA	HEIGHT ADJUST
HAC	HEADING ALIGNMENT CONE
HBR	HYDROGEN BROMIDE
HCM	HAND CONTROLLER MODULE
HCN	HYDROGEN CYANIDE
HDR	HIGH DATA RATE
HE	HELIUM
HEDS	HUMAN EXPLORATION AND DEVELOPMENT OF SPACE
HF	HYDROGEN FLUORIDE
HFA	HUMAN FACTORS ASSESSMENT
HGA	HIGH GAIN ANTENNA
HH	HITCHHIKER
HH-JR	HITCHHIKER JR
HHL	HAND-HELD LIDAR
HKU	HOUSEKEEPING UNIT
HOSC	HUNTSVILLE OPERATIONS SUPPORT CENTER
HP	HEIGHT OF PERIGEE
HPDU	HEATER POWER DISTRIBUTION UNIT
HPFP	HIGH PRESSURE FUEL PUMP
HPFT	HIGH PRESSURE FUEL TURBOPUMP
HPGT	HIGH PRESSURE GAS TANK
HR	HAZARD REPORT
HRF	HUMAN RESEARCH FACILITY
HRS	HOURS
HS	HANDSHAKING
HSG	HOUSTON SUPPORT GROUP
HSR	HOUSTON SUPPORT ROOM
HSTD	HIGH SPEED TRACKING DATA
HTD	HEDS TECHNOLOGY DEMONSTRATION

## FLIGHT RULES

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HUD	HEADS UP DISPLAY
H/W	HARDWARE
HX	HEAT EXCHANGER
HYD	HYDRAULICS
HZ	HERTZ
I	INHIBIT
I/F	INTERFACE
I/O	INPUT/OUTPUT
ICD	INTERFACE CONTROL DOCUMENT
ICH	INTERCHANGER
ICU	INTERIM CONTROL UNIT
IDC	ISIS DIGITAL CAMERA
IEA	INTEGRATED EQUIPMENT ASSEMBLY
IEH	INTEGRATED ELECTROLYSIS UNIT
IEH-1	INTERNATIONAL EXTREME ULTRAVIOLET HITCHHIKER
IFC	INTERNATIONAL FUEL CELL
IFM	IN-FLIGHT MAINTENANCE
IMAPS	INTERSTELLAR MEDIUM ABSORPTION PROFILE SPECTROGRAPH
IMC	ISS MANAGEMENT CENTER
IMCA	INTEGRATED MOTOR/CONTROLLER ASSEMBLY INTEGRATED MOTOR CONTROLLER ACTUATOR
IMU	INERTIAL MEASUREMENT UNIT
IN	INCHES
INCO	INTEGRATED COMMUNICATIONS OFFICER
INFLT	IN-FLIGHT
INIT	INITIAL
INST	INSTRUMENTATION
INSTR	INSTRUMENTATION
IP	INTEGRATION PLAN
IPDS	INDEPENDENT PAYLOAD DATA STREAM
IREC	INTERIM RESISTIVE EXERCISE DEVICE
ISIS	INTEGRATED SENSOR INSPECTION SYSTEM
ISO	ISOLATION
ISOL	ISOLATION
ISS	INTERNATIONAL SPACE STATION
ITCS	INTERNAL THERMAL CONTROL SYSTEM
ITEPC	INTER MARS TEPIC
ITS	INTEGRATED TRUSS SEGMENT
IVA	INTRAVEHICULAR ACTIVITY
ITVC	INTENSIFIED TELEVISION CAMERA
IVT	INTERFACE VERIFICATION TEST

**FLIGHT RULES**


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JET	JETTISON
JEUS	JOINT EXPEDITED UNDOCKING AND SEPARATION
JIS	JOINT INTEGRATED SIMULATION
JOIP	JOINT OPERATIONS INTERFACE PROCEDURE
JSC	LYNDON B. JOHNSON SPACE CENTER
JURe	JOINT UNDERSPEED RECOVERY
KBPS	KILOBITS PER SECOND
KCA	KU-BAND COMMUNICATIONS ADAPTER
KEAS	KNOTS EQUIVALENT AIR SPEED
KGS	KILOGRAMS
KM	KILOMETERS
KOZ	KEEP-OUT ZONE
KSC	JOHN F. KENNEDY SPACE CENTER
KT	KNOT
KU-BAND	15.250 TO 17.250 GHZ
KU-REC	KU BAND FORWARD LINK RECEIVER
KuSP	Ku SIGNAL PROCESSOR
KW	KILOWATTS
L&L	LAUNCH AND LANDING
LAB	LABORATORY
	LOCAL AREA BUS
LAN	LOCAL AREA NETWORK
LB(S)	POUND(S)
LB/HR	POUNDS PER HOUR
LBM	POUND MASS
LBM/HR	POUND MASS PER HOUR
LCC	LAUNCH COMMIT CRITERIA
LCH	LASER CAMERA HEAD
LCS	LASER CAMERA SYSTEM
LCVG	LIQUID COOLING AND VENTILATION GARMENT
LDRI	LASER DYNAMIC RANGE IMAGER
LED	LIGHT EMITTING DIODE
LEH	LAUNCH AND ENTRY HELMET
LGA	LOW GAIN ANTENNA
LHCP	LEFT HAND CIRCULARLY POLARIZED
LIGHTSORB	LIGHT ADSORPTION
LIOH	LITHIUM HYDROXIDE
LLCO	LOW-LEVEL CUTOFF
LO	LOW
LON	LAUNCH ON NEED
LOS	LOSS OF SIGNAL
LPFP	LOW PRESSURE FUEL PUMP
LPFT	LOW PRESSURE FUEL TURBOPUMP

**FLIGHT RULES**


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LRR	LAUNCH READINESS REVIEW
LSP, lsp	LOW SPECIFIC IMPULSE
LSSM	LAUNCH SITE SUPPORT MANAGER
LSSP	LAUNCH SITE SUPPORT PLAN
LTA	LAUNCH TO ACTIVATION
LTL	LOW TEMP LOOP
LTS	LIGHTS
LTU	LOAD TRANSFER UNIT
LVLH	LOCAL VERTICAL/LOCAL HORIZONTAL
MA	MILLIAMPS
MADS	MODULAR AUXILIARY DATA SYSTEM
MAGR	MINIATURE AIRBORNE GPS RECEIVER
MAL	MALFUNCTION
MAN	MANUAL
MAR	MIDDECK ACCOMMODATIONS RACK
MAX	MAXIMUM
MBA	MOTORIZED BOLT ASSEMBLY
MBDS	MAIN BUS DISABLE STATION
MBE	MOLECULAR BEAM EPITAXY
MBM	MANUAL BERTHING MECHANISM
MBPS	MEGABITS PER SECOND
MBS	MOBILE REMOTE SERVICER BASE SYSTEM
MBSU	MAIN BUS SWITCHING UNIT
MC	MID COURSE
MCA	MOTOR CONTROL ASSEMBLY
MCC	MISSION CONTROL CENTER
MCC-H	MISSION CONTROL CENTER (HOUSTON)
MCDS	MULTIFUNCTION CRT DISPLAY SYSTEM
MCE	MOTOR CONTROL ELECTRONICS
MCIU	MANIPULATOR CONTROLLER INTERFACE UNIT
MCU	MOBILE BASE COMPUTER SYSTEM UNIT
MD	MIDDECK
MDA	MATERIAL DISPERSION APPARATUS
MDF	MINIMUM DURATION FLIGHT
MDK	MIDDECK
MDM	MODULATOR/DEMULATOR
	MULTIPLEXER/DEMULTIPLEXER
MDSSC	MCDONNELL DOUGLAS SPACE SYSTEMS CORPORATION
MECH	MECHANICAL
MECO	MAIN ENGINE CUTOFF
MEL	MINIMUM EQUIPMENT LIST
MEPSI	MICRO-ELECTROMECHANICAL SYSTEM-BASED PICO SATELLITE INSPECTOR
MER	MISSION EVALUATION ROOM

## FLIGHT RULES

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MES	MODIFIED GAS EJECTION SYSTEM
MET	MISSION ELAPSED TIME
MGMT	MANAGEMENT
MHA	MAINTENANCE HAZARD ASSESSMENT
MHZ	MEGAHERTZ
MICRON	ONE MILLIONTH OF A METER
MID	MIDDLE
MIN	MINIMUM
MISSE	MATERIALS ISS EXPERIMENT
MLI	MULTILAYER INSULATION
MLP	MOBILE LAUNCHER PLATFORM
MMACS	MECHANICAL, MAINTENANCE, ARM, AND CREW SYSTEMS
MMC	MID MOTOR CONTROL
MMD	MICROGRAVITY MEASUREMENT DEVICE
MMHG	MILLIMETERS OF MERCURY
MMOD	MICROMETEORIDS AND ORBITAL DEBRIS
MMT	MISSION MANAGEMENT TEAM
MMU	MASS MEMORY UNIT
MNA	MAIN A
MNB	MAIN B
MNC	MAIN C
MNVR	MANEUVER
MOC	MISSION OPERATIONS COMPUTER
MPC	MAIN POWER CONVERTER
MPCC	MULTI-PROGRAM CONTROL CENTER
MPEV	MANUAL PRESSURE EQUALIZATION VALVE
MPM	MANIPULATOR POSITIONING MECHANISM
MPS	MAIN PROPULSION SYSTEM
MPSR	MULTIPAYLOAD SUPPORT ROOM
MRL	MANIPULATOR RETENTION LATCH
MRTAS	MODIFIED ROCKETDYNE TRUSS ATTACHMENT SYSTEM
MS	MISSION SPECIALIST
MSB	MOST SIGNIFICANT BIT
MSBLS	MICROWAVE SCANNING BEAM LANDING SYSTEM
MSFC	MARSHALL SPACE FLIGHT CENTER
MSG	MESSAGE
MSS	MOBILE SERVICING STATION
MSX	MID-COURSE SPACE EXPERIMENT
MT	MOBILE TRANSPORTER
MTL	MODERATE TEMPERATURE LOOP
MTM	MOC TELEMETRY MESSAGE
MTR	MOTOR
MTSAS	MODULE TRUSS ATTACHMENT SYSTEM
MTU	MASTER TIMING UNIT

## FLIGHT RULES

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N/A	NOT APPLICABLE
N <sub>2</sub>	NITROGEN
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NBL	NEUTRAL BUOYANCY LABORATORY
NC	NOMINAL CORRECTION, PHASE ANGLE ADJUSTMENT MANEUVER
NCC	CORRECTIVE COMBINATION MANEUVER
NCR	NONCOMPLIANCE REPORT
NEG	NEGATIVE
NEOM	NOMINAL END OF MISSION
NGT	NASA GROUND TERMINAL
NGTD	NOSE GEAR TOUCHDOWN
NH <sub>3</sub>	AMMONIA
NIH	NATIONAL INSTITUTE OF HEALTH
NIH-R	NATIONAL INSTITUTE OF HEALTH - RODENTS
NLT	NOT LATER THAN
NM	NAUTICAL MILES
NMI	NAUTICAL MILES
NMS	NEUTRAL MASS SPECTROMETER
NOM	NOMINAL
NORM	NORMAL
NPC	PLANE CHANGE MANEUVER
NPSP	NET POSITIVE SUCTION PRESSURE
NPV	NON-PROPULSIVE VENT
NSTS	NATIONAL SPACE TRANSPORTATION SYSTEM
NTA	NITROGEN TANK ASSEMBLY
NVR	NONVOLATILE RESIDUE
O&C	OPERATIONS AND CHECKOUT
O <sub>2</sub>	OXYGEN
OBSS	ORBITER BOOM SENSOR SYSTEM
OCA	OPERATIONAL COMMUNICATIONS ADAPTER
OCAD	OPERATIONAL CONTROL AGREEMENT DOCUMENT
OCAS	OPERATOR-COMMANDED AUTO SEQUENCE
OCCB	ORBITER CONFIGURATION CONTROL BOARD
OCP	OFFICE COMMERCIAL PROGRAMS
OD	OPERATIONS DIRECTOR, OPERATIONS DOWNLINK
ODIN	OUTSOURCING DESKTOP INITIATIVE FOR NASA
ODS	ORBITER DOCKING SYSTEM
ODS-ISS	ORBITER DOCKING SYSTEM - INTERNATIONAL SPACE STATION
OFTP	ORBIT FLIGHT TECHNIQUES PANEL
OIU	ORBITER INTERFACE UNIT
OME	ORBITAL MANEUVERING ENGINE
OMS	ORBITAL MANEUVERING SYSTEM



## FLIGHT RULES

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ONP	ORBITER OVERNIGHT PARK
OOP	OUT OF PLANE
OOR	OUT OF RANGE
OORB	OUT OF RANGE BIT
OOV	ORBITER VEHICLE
OP	OVERNIGHT PARK
OPF	ORBITER PROCESSING FACILITY
OPR	OPERATIONAL
OPS	OPERATIONS
OPT	OPERATIONAL PRESSURE TRANSDUCER
OPTN	OPTIONAL
ORB	ORBITER
ORCA	OXYGEN RECHARGE COMPRESSOR ASSEMBLY
ORFEUS	ORBITING RETRIEVABLE FAR AND EXTREME ULTRAVIOLET SPECTROMETER
ORM	ORBITER REPAIR MANEUVER
ORSEP	ORGANIC SEPARATION
ORU	ORBITAL REPLACEMENT UNIT
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OSO	OPERATIONS SUPPORT OFFICER
OST	OPERATIONS SUPPORT TEAM
OSVS	ORBITER SPACE VISION SYSTEM
OSVU	ORBITER SPACE VISION UNIT
P	PITCH
P/L	PAYLOAD
P/TV	PHOTO/TELEVISION
PADM	PORTABLE AUDIO DATA MODEM
PAO	PUBLIC AFFAIRS OFFICER
PARE	PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT
PASS	PRIMARY AVIONICS SOFTWARE SYSTEM
PATH	POSTFLIGHT ALTITUDE TRAJECTORY HISTORY
PBD	PAYLOAD BAY DOOR
PBIT	PASSIVE BUILT IN TEST ERROR
PCA	PRESSURE CONTROL ASSEMBLY
PCD	POCC CAPABILITIES DOCUMENT
PCG-STES	PROTEIN CRYSTAL GROWTH - SINGLE LOCKER
PCM	PULSE CODE MODULATION
PCMMU	PULSE CODE MODULATION MASTER UNIT
PCR	PAYLOAD CHECKOUT ROOM
PCS	PORTABLE COMPUTER SYSTEM
PCT	POST CONTACT THRUSTER
PCU	POWER CONTROL UNIT
PDGF	POWER/DATA GRAPPLE FIXTURE
PDI	PAYLOAD DATA INTERLEAVER
PDIP	PAYLOAD DATA INTERFACE PANEL

**FLIGHT RULES**


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PDRS	PAYLOAD DEPLOYMENT AND RETRIEVAL SYSTEM
PDU	POWER DISTRIBUTION UNIT
PEC	PAYLOAD EXPERIMENT CARRIER
PET	PHASE ELAPSED TIME
PF	PAYLOAD FORWARD
PFCS	PUMP FLOW CONTROL SUBASSEMBLY
	PUMP AND FLOW CONTROL SYSTEM
PFDF	PAYLOAD FLIGHT DATA FILE
PFR	PAYLOAD FOOT RESTRAINT; PORTABLE FOOT RESTRAINT
PGHM	PAYLOAD GROUND HANDLING MECHANISM
PGSC	PAYLOAD GENERAL SUPPORT COMPUTER
PGT	PISTOL GRIP TOOL
PH	HYDROGEN ION CONCENTRATION
PHA	PREBREATHE HOSE ASSEMBLY
PHE	POCC HAZARDOUS ENHANCEMENT
PHRR	PAYLOAD HIGH RATE RECORDER
PI	PAYLOAD INTEGRATOR
PICOSAT	<b><u>TBD</u></b>
PILOT	PORTABLE INFLIGHT LANDING OPERATIONS TRAINER
PIM	PLASMA INTERACTION MODEL
PIP	PAYLOAD INTEGRATION PLAN
PL	PAYLOAD
PL OPS	PAYLOAD OPERATIONS
PL SYS	PAYLOAD SYSTEMS
PLB	PAYLOAD BAY
PLBD	PAYLOAD BAY DOOR
PLBFL	PAYLOAD BAY FLOODLIGHT
PLHX	PAYLOAD HEAT EXCHANGER
PLO	PAYLOAD OFFICER
PLS	PRIMARY LANDING SITE, PULSE
PLT	PILOT
PM	PHASE MODULATION
PMA	PRESSURIZED MATING ADAPTER
PMBT	PROPELLANT MEAN BULK TEMPERATURE
PMCR	PAYLOAD MANAGEMENT COUNTDOWN REVIEW
PMCU	POWER MANAGEMENT AND CONTROL UNIT
POA	PAYLOAD ORU ACCOMMODATION
POCC	PAYLOAD OPERATIONS CONTROL CENTER
POD	PAYLOAD OPERATIONS DIRECTOR
POIC	PAYLOAD OPERATIONS INTEGRATION CENTER
POM	PROXIMITY OPERATIONS MODE
POO	PLUMES OF OPPORTUNITY
POR	POWER ON/RESET
POS	POSITION
	POSITION HOLD
POSN	POSITION

**FLIGHT RULES**


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POWG	PAYLOAD OPERATIONS WORKING GROUP
PPCO	PARTIAL PRESSURE OF CARBON MONOXIDE
PPCO <sub>2</sub>	PARTIAL PRESSURE OF CARBON DIOXIDE
PPF	PAYLOAD PARAMETER FRAME, PAYLOAD PROCESSING FACILITY
PPM	PARTS PER MILLION
PPO <sub>2</sub>	PARTIAL PRESSURE OF OXYGEN
PPRV	POSITIVE PRESSURE RELIEF VALVE
PPS	PAYLOAD PRELAUNCH SIMULATION
PPU	POWERFUL PROCESSING UNIT
PRCB	PROGRAM REQUIREMENTS CONTROL BOARD
PRCS	PRIMARY REACTION CONTROL SYSTEM
PRD	PAYLOAD RETENTION DEVICE
PREP	PREPARATION
PRESS	PRESSURE
PRI	PRIMARY
PRLA	PAYLOAD RETENTION LATCH ASSEMBLY/ACTUATOR
PROP	PROPELLANT
PROX	PROXIMITY
PROX OPS	PROXIMITY OPERATIONS
PRP	AID TO MOSCOW FLIGHT DIRECTOR
PRR	PAYLOAD READINESS REVIEW
PS	PLATFORM SYSTEM
PSA	PROVISIONS STOWAGE ASSEMBLY
PSDP	PAYLOAD STATION DISTRIBUTION PANEL
PSE	PHYSIOLOGICAL SYSTEMS EXPERIMENT
PSI	POUNDS PER SQUARE INCH
PSIA	POUNDS PER SQUARE INCH ABSOLUTE
PSIG	POUNDS PER SQUARE INCH GAUGE
	PROPULSION SYSTEMS INTEGRATION GROUP
PSP	PAYLOAD SIGNAL PROCESSOR
PSR	PAYLOAD SAFETY REVIEW
PSRP	PAYLOAD SAFETY REVIEW PANEL
PTB	PAYLOAD TIMING BUFFER
PTI	PROGRAMMED TEST INPUT
PTU	PRECISION TIMING UNIT
PV	PHOTOVOLTAIC
PVCA	PHOTOVOLTAIC CONTROL ASSEMBLY
PVCU	PHOTOVOLTAIC CONTROLLER UNIT
PVCE	PHOTOVOLTAIC CONTROLLER ELEMENT
PVM	PHOTOVOLTAIC MODULE
PVR	PHOTOVOLTAIC RADIATOR
PVTCS	PHOTOVOLTAIC THERMAL CONTROL SYSTEM
PWR	POWER, PAYLOAD WATER RESERVOIR

## FLIGHT RULES

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QA	QUALITY ASSURANCE
QD	QUICK DISCONNECT
QDM	QUICK DON MASK
QTY	QUANTITY
R	RATE
R-T-L	READY-TO-LATCH
RACU	RUSSIAN-TO-AMERICAN POWER CONVERTER UNIT
RAD	RADIATION ABSORBED DOSE
RAM	RANDOM ACCESS MEMORY
RAMBO	RAM BURN OBSERVATION
RBAR	RADIUS VECTOR
RBI	REMOTE BUS ISOLATOR
RBVM	RADIATOR BEAM VALVE MODULE
RCA	REACTION CONTROL ASSEMBLY
RCC	REINFORCED CARBON-CARBON
RCRS	REGENERABLE CARBON DIOXIDE REMOVAL SYSTEM
RCS	REACTION CONTROL SYSTEM
RCV	REACTION CONTROL VALVE
RCVR	RECEIVER
RDOT	RATE OF CHANGE OF RATE
REDUND	REDUNDANCY
REF	REFERENCE
REGRAP	REGRAPPLE
REL	RELATIVE
RELNAV	RELATIVE NAVIGATION
REM	RELEASE/ENGAGE MECHANISM
REP	REPRESENTATIVE
REQ	REQUIRED
REQD	REQUIRED
REQMTS	REQUIREMENTS
REV	REVOLUTION
RF	RADIO FREQUENCY
RFG	RADIO FREQUENCY GROUP
RFI	RADIO FREQUENCY INTERFERENCE
RGS	RUSSIAN GROUND SITE
RHC	ROTATIONAL HAND CONTROLLER
RHEED	REFLECTION HIGH ENERGY ELECTRON DIFFRACTION
RIO	RUSSIAN INTERFACE OFFICER
RJMC	ROTARY JOINT MOTOR CONTROLLER
RLY	RELAY
RMA	REMOTE MANIPULATOR ASSISTED
RME	RISK MITIGATION EXPERIMENT
RMS	REMOTE MANIPULATOR SYSTEM
RNDZ	RENDEZVOUS

**FLIGHT RULES**


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RNG	RANGE
ROBO	ROBOTICS; ROBOTICS OFFICER
ROOBA	RECHARGE OXYGEN ORIFICE BYPASS ASSEMBLY
ROT	ROTATION, ROTATIONAL
RP	MCC-M SHIFT FLIGHT DIRECTOR
RPC	REMOTE POWER CONTROLLER
RPCM	REMOTE POWER CONTROL MODULE
RPM	REVOLUTIONS PER MINUTE
	RBAR PITCHOVER MANEUVER
RPOCC	REMOTE POCC
RPOP	RENDEZVOUS PROXIMITY OPERATORS PROGRAM
RS	REDUNDANT SET
RSAD	RMS SITUATIONAL AWARENESS DISPLAY
RSC	RMS SIDEVIEW CAMERA
RSOS	RUSSIAN ON-ORBIT SEGMENT, RUSSIAN OPERATIONAL SEGMENT
RSR	RUSSIAN SUPPORT ROOM
RSS	ROOT SUM SQUARE, RAM SIDE SENSOR
RSSI	RECEIVED STRENGTH SIGNAL INDICATOR
RT	RATE; REMOTE TERMINAL
RTD	RESISTIVE TEMPERATURE DETECTOR
RTDS	REAL-TIME DATA SYSTEM
RTL	READY TO LATCH
RTLS	RETURN TO LAUNCH SITE
RTN	RETURN
RTS	REMOTE TRACKING STATION
RBVM	RADIATOR BEAM VALVE MODULE
RX	RECEIVER
S	STARBOARD
S/G	SPACE-TO-GROUND
S/W	SOFTWARE
SA	SITUATIONAL AWARENESS
SAA	SOUTH ATLANTIC ANOMALY
SAAMD	STANDALONE ACCELERATION MEASUREMENT DEVICE
SABB	SOLAR ARRAY BLANKET BOX
SAFER	SIMPLIFIED AID FOR EVA RESCUE
SAGI	SPACEHAB AUDIO GROUND ISOLATOR
SAL	SPACECRAFT ACOUSTIC LAB
SAMS	SPACE ACCELERATION MANAGEMENT SYSTEM
SAREX	SHUTTLE AMATEUR RADIO EXPERIMENT
SARJ	SOLAR ALPHA ROTARY JOINT
SASA	S-BAND ANTENNA STRUCTURAL ASSEMBLY
SASS	SEGMENT TO SEGMENT ATTACH SYSTEM
SAW	SOLAR ARRAY WING

**FLIGHT RULES**


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SC	SPACECRAFT COMPUTER
SCA	SHUTTLE CARRIER AIRCRAFT
SCG	SOLUTION CRYSTAL GROWTH
SCIU	SIGNAL CONTROL INTERFACE UNIT
SCP	STANDARD CONSOLE PROCEDURE
SCU	SERVICE AND COOLING UMBILICAL
SDA	STANDARD DOOR ASSEMBLY
SDBI	SHORT DURATION BIOASTRONAUTICS INVESTIGATION
SEBS	SPACELAB EMERGENCY BREATHING SYSTEM
SEC	SECOND
SEEL	SPACE ENVIRONMENT EFFECTS LAB
SEH	SOLAR EXTREME ULTRAVIOLET HITCHHIKER
SEM	SAFE EMERGENCY MODE, SPACE EXPERIMENT MODULE
SEP	SEPARATION
SES	SHUTTLE ENGINEERING SIMULATOR
SGPS	SKYGPS
SIA	STATION INTERFACE AGREEMENT
SIF	SPACELAB INTEGRATION FACILITY
SIMO	SIMULTANEOUS
SIP	STANDARD INTERFACE PANEL
SJ	SINGLE JOINT
SLF	SHUTTLE LANDING FACILITY
SLS	SECONDARY LANDING SITE
SM	SYSTEMS MANAGEMENT (GPC FUNCTION); SERVICE MODULE
SMAC	SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATION
SMCH	STANDARD MIXED CARGO HARNESS
SMS	SHUTTLE MISSION SIMULATOR
SN	SPACE NETWORK
SNSR	SENSOR
SOC	STATE OF CHARGE
SODB	SHUTTLE OPERATIONS DATA BOOK
SOM	SPACEHAB OPERATIONS MANAGER
SOP	SECONDARY OXYGEN PACK
SOV	SHUTOFF VALVE
SP	SIGNAL PROCESSOR
SPAS	SHUTTLE PALLET SATELLITE
SPASP	SMALL PAYLOAD ACCOMODATIONS SWITCH PANEL
SPC	STORED PROGRAMMED COMMAND
SPCH	SEAMLESS POWER CHANNEL HANDOVER
SPD	SPOOL POSITIONING DEVICE
SPDA	SECONDARY POWER DISTRIBUTION ASSEMBLY
SPEC	SPECTROMETER
SPEE	SPECIAL PURPOSE END EFFECTOR
SPHERES	SYNCHRONIZED POSITION HOLD, ENGAGE, REORIENT, EXPERIMENTAL SATELLITE
SPIF	SHUTTLE POCB INTERFACE FACILITY

## FLIGHT RULES

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SPN	STATION PROGRAM NOTE
SPOC	SPAS PAYLOAD OPERATIONS CONTROL CENTER
SPRD	SINGLE PALLET ROTATION DEVICE
SR	SUPPORT REQUIREMENT
SRB	SOLID ROCKET BOOSTER
SRMS	SHUTTLE REMOTE MANIPULATOR SYSTEM
SS	SINGLE-STRING
SSAS	SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM
SSER	SPACE TO SPACE EMU RADIO
SSME	SPACE SHUTTLE MAIN ENGINE
SSP	SPACE SHUTTLE PROGRAM
SSPA	SOLID STATE POWER AMPLIFIER
SSRMS	SPACE STATION REMOTE MANIPULATOR SYSTEM
SSU	SEQUENTIAL SHUNT UNIT
SSV	SPACE SHUTTLE VEHICLE; SEQUENTIAL STILL VIDEO
STA	SHUTTLE TRAINING AIRCRAFT
STA-KEEP	STATIONKEEP
STAMPS	SPACECRAFT TRAJECTORY ANALYSIS AND MISSION PLANNING SYSTEM
STBD	STARBOARD
STBY	STANDBY
STD	SOFTWARE TEST DESCRIPTION
STDN	SPACEFLIGHT TRACKING AND DATA NETWORK
STK	STACK
STL	SPACE TISSUE LOSS
STL-NIH-C	SPACE TISSUE LOSS-NATIONAL INSTITUTE OF HEALTH- CELLS
STRNG	STRING
STS	SPACE TRANSPORTATION SYSTEM
SUMM	SUMMARY
SVEC	SPACE VACUUM EPITAXY CENTER
SVO	SPECIAL VEHICLE OPERATIONS
SVS	SPACE VISION SYSTEM
SW	SWITCH
SYNC	SYNCHRONIZE
SYS	SYSTEM
T	TAKEOFF
TA	THRUSTER ASSIST
TAA	TUNNEL ADAPTER ASSEMBLY
TACAN	TACTICAL AIR COMMAND AND NAVIGATION SYSTEM
TAEM	TERMINAL AREA ENERGY MANAGEMENT
TAGS	TEXT AND GRAPHICS SUBSYSTEM
TAL	TRANSATLANTIC LANDING
	TRANSOCEANIC ABORT LANDING

## FLIGHT RULES

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TBC	TO BE CONSIDERED
TBD	TO BE DETERMINED
TBR	TO BE RESOLVED
TBS	TO BE SUPPLIED
TC	TEST CONNECTOR
	TOPOLOGICAL CAPTURE
TCA	TIME OF CLOSEST APPROACH
TCDT	TERMINAL COUNTDOWN DEMONSTRATION TEST
TCS	TRAJECTORY CONTROL SENSOR; THERMAL CONTROL SYSTEM
TCU	TEMPERATURE CONTROL UNIT; THERMAL CONTROL UNIT
TDDP	TRAJECTORY DESIGN DATA PACKAGE
TDRS	TRACKING AND DATA RELAY SATELLITE
TDRSS	TDRS SYSTEM
TDT	TURBINE DISCHARGE TEMPERATURE
TEA	TORQUE EQUILIBRIUM ATTITUDE
TEG	TRIETHYLGALLIUM
TEL	TELEMETRY
TEMP	TEMPERATURE
TES-2	THERMAL ENERGY STORAGE-2
TFL	TELEMETRY FORMAT LOAD
TGHR	TIME-CRITICAL GROUND HANDLING EQUIPMENT
THAP	THERMAL HYDRAULIC ANALYZER PROGRAM
THC	TRANSLATIONAL HAND CONTROLLER
TI	PHASE INITIATION; TIME OF IGNITION; TRANSITION INITIATION
TIC	TPS IMAGERY COORDINATOR
TIG	TIME OF IGNITION
TK	TANK
TLE	TIMELINE ENGINEER
TLM	TELEMETRY
TM	TELEMETRY
TMU	TEMPERATURE MEASUREMENT UNIT
TOP	TECHNICAL OPERATING PROCEDURES
TOPO	TRAJECTORY OPERATIONS OFFICER
TPG	TOTAL PRESSURE GAGE
TPL	TRANSFER PRIORITY LIST
TPS	THERMAL PROTECTION SYSTEM
TRAD	TOOLS FOR RENDEZVOUS AND DOCKING
TRAN(S)	TRANSLATION(S)
TRRJ	THERMAL RADIATOR ROTARY JOINT
TSA	TOOL STOWAGE ASSEMBLY
TSH	THYROID STIMULATING HORMONE
TT&C	TELEMETRY, TRACKING, AND CONTROL
TT-0	TAKE-OFF POWER
TV	TELEVISION
TWT	TRAVELING WAVE TUBE



## FLIGHT RULES

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TX	TRANSMITTER
UCCAS	UNPRESSURIZED CARGO CARRIER ATTACH SYSTEM
UHUP	UNIVERSITY OF HOUSTON-UNIVERSITY PARK
UNCERT	UNCERTAINTY
UNLTCH	UNLATCH
UOP	UTILITY OUTLET PANEL
USOS	U.S. ON-ORBIT SEGMENT, U.S. OPERATIONAL SEGMENT
USSTRATCOM	U.S. STRATEGIC COMMAND
USTO	U.S. THRUSTERS ONLY
UTA	UTILITY TRANSPORT ASSEMBLY
UVSTAR	ULTRAVIOLET SPECTROGRAPH TELESCOPE FOR ASTRONOMICAL RESEARCH
V	VOLTS; VELOCITY
V/M	VOLTS PER METER
VAA	VIEWPORT ADAPTER ASSEMBLY
VAC	VACUUM
VAJ	VACUUM ACCESS JUMPER
VATF	VIBRATION AND ACOUSTIC TEST FACILITY
VBAR	ALONG THE VELOCITY VECTOR
VCB	VEHICLE CONTROL BOARD
VCP	VIDEO CAMERA PORT
VDU	VIDEO DISTRIBUTION UNIT
VERN	VERNIER
VGO	VELOCITY GO
VGOX	VELOCITY GO IN X DIRECTION
VIP	VACUUM ION PUMP
VIS	VISIBLE
VLV	VALVE
VP	VIEWPORT
VPF	VERTICAL PROCESSING FACILITY
VPU	VIDEO PROCESSING UNIT
VR	VIRTUAL REALITY
VRCS	VERNIER REACTION CONTROL SYSTEM
VRIV	VENT AND RELIEF ISOLATION VALVE
VSSA	VIDEO SYSTEM SUPPORT ASSEMBLY
W/I	WITHIN
WBSAAMD	WIDEBAND STAND ALONE ACCELERATION MEASUREMENT DEVICE
WCCS	WIRELESS CREW COMMUNICATION SYSTEM
WCCU	WIRELESS COMM UNIT

## FLIGHT RULES

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WCS	WASTE COLLECTION SYSTEM
WDC	WATCH DOG CIRCUIT
WETA	WIRELESS VIDEO SYSTEM EXTERNAL TRANSCIEVER ASSEMBLY
WETF	WEIGHTLESS ENVIRONMENT TRAINING FACILITY
WFCEU	WATER FLOW CONTROL ELECTRONICS UNIT
WFCR	WHITE FLIGHT CONTROL ROOM
WFCV	WATER FLOW CONTROL VALVE
WH	WATT HOURS
WLE	WING LEADING EDGE
WLES	WING LEADING EDGE SENSOR
WLP	WIDE LANGMUIR PROBE
WS	WORKSITE
WSF	WAKESHIELD FACILITY
WSGT	WHITE SANDS GROUND TERMINAL
WSSH	WHITE SANDS SPACE HARBOR
WVS	WIRELESS VIDEO SYSTEM
XFER	TRANSFER
XLV	X LOCAL VERTICAL
XMISSION	TRANSMISSION
XMTR	TRANSMITTER
XPNDR	TRANSPONDER
Y	YAW
ZCG	ZEOLITE CRYSTAL GROWTH
ZLV	Z-AXIS LOCAL VERTICAL
ZOE	ZONE OF EXCLUSION
ZSI	Z-AXIS SOLAR INERTIAL

# FLIGHT RULES

## APPENDIX B - CHANGE CONTROL

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## **FLIGHT RULES**

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## FLIGHT RULES

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### APPENDIX B

#### CHANGE CONTROL

#### 1.0 INTRODUCTION

#### 1.1 PURPOSE

The purpose of this appendix is to delineate change control procedures for Volumes A, B, C, D, and flight-specific/increment-specific Flight Rules Annexes. This will ensure the proper coordination of changes and provide a record of the proposed changes including the rule rationale and the reason for making the change. The web-based database, Workflow, is now being used to generate CR's for Volumes A, B, C, D, and Flight Rules Annexes and is the preferred method for initiating CR's. Refer to paragraph 2.1.1 for Workflow enrollment instructions. The change request (CR) form on page B-10 is designed to assist this change control process only when it is not possible to use Workflow. Workflow is available at URL: <http://mod.jsc.nasa.gov/da8>. Under the **Workflow Link** title, click on the **Flight Rule CR System** link.

#### 1.2 GENERAL

All Flights critical items list (CIL)-related rules and generic rules with a recurring potential for mission-specific options or exceptions will be flagged so that they are readily identifiable in the All Flights generic documents. Hazard control (HC)-related rules are monitored by NA/Safety Division, and impact to an HC rule requiring PRCB/JPRCB/SSPCB is reported to the FRCB/JFRCB. When a change to a CIL-related specific flight rule, or an HC-related rule, is approved and CIL retention rationale is affected by the change, the change will not be incorporated until a corresponding change to the retention rationale is approved by the Shuttle or Station Programs. The same general philosophy applies to the changes that modify existing payload or orbiter hazard controls. These flight rule changes will not be incorporated until the appropriate safety organization approves a corresponding change to the related hazard control documentation. A [CIL] tag, in brackets, will be added to the title for CIL-related rules. Some Volume A rules not identified as CIL are identified as hazard control and an [HC] tag, in brackets, will be added to the title of those rules. Volume B rules primarily have been identified for hazard control and will be tagged [HC] in the title. Examples of All Flights rules that have the recurring potential for flight-specific options or exceptions are some of the remote manipulator system rules. For those type flight rules, the options or exceptions can be exercised as part of the flight-specific Flight Rules Annex development process. Flight-specific exceptions to any other All Flights generic rules must be approved by the appropriate Flight Rules Control Board (FRCB) or Joint Flight Rules Control Board (JFRCB).

It is suggested that those organizations with flight rules which affect CIL retention rationale or hazard controls implement an independent internal CR handling procedure that identifies CIL or HC flight rules and protects against inappropriate changes to these types of rules.

The FRCB/JFRCB is responsible for review and approval of CR's written against the Volume A, B, C, and D generic rules documents. The FRCB/JFRCB is chaired by the Director, Mission Operations or his designee.

## FLIGHT RULES

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### 1.3 EFFECTIVITY

June 29, 2004

### 1.4 DOCUMENT REVIEW

This document is reviewed for process evaluation not less than every other year. Representatives of the MOD Flight Rules Control Board who are delegated by their management to represent specific volume sections for flight rules oversee this review.

### 2.0 CHANGE PROCEDURES

#### 2.1 SUBMISSION OF CHANGES

The flight rules change control process starts when someone in the technical community identifies a valid need to delete or modify an existing flight rule or to add a new rule. The web-based database, Workflow, is now being used to generate CR's for Volumes A, B, C, D, and Flight Rules Annexes. Refer to the paragraphs below for Workflow user and enrollment instructions. That individual fills out the Workflow CR form. (If access to the Workflow form is not available to the user, a paper form is provided on page B-10.) In developing the Workflow change file, the CR author should cut and paste appropriate pages from the Flight Rules document and SAVE AS a user file in the user's directory. Changes may be made to the appropriate rules of the author's file. When working this file, please accept any revisions on the copied page then turn the REVISION MODE **ON** so the change inputs are highlighted. Extracted rule pages or blank pages free of the graphics frame are encouraged.

All of the current Flight Rules documents are available on the internet. The URL is: **<http://mod.jsc.nasa.gov/da8>**. No ID or password will be required to access any of the rules provided the user is accessing from a trusted site (all NASA centers, contractors, and International Partners). If unable to access, users need to send an e-mail note to DA8/M. L. Griffith ([mary.l.griffith1@jsc.nasa.gov](mailto:mary.l.griffith1@jsc.nasa.gov)) with their full name, company, IP address, and a justification statement for access.

The completed CR is then submitted to a division FRCB/JFRCB representative for approval. That representative should ensure that all CR's are coordinated within the originating division before submitting them to the DA8/Flight Director Office, Lyndon B. Johnson Space Center, Houston, Texas 77058. Each division should establish its own process to handle this internal coordination. DF/System Division is an exception to this protocol. CR's from DF are not processed through the DF FRCB representative, but submitted to the Flight Director Office by DF Branch Offices. When internal coordination has been completed, the division FRCB/JFRCB representative signs the form and forwards it to the Flight Director Office. For Workflow CR's, facsimile signature is recognized by the DA8/Flight Director Office when the CR is routed electronically from the appropriate Group Lead, Branch Manager, or the Division FRCB/JFRCB representative within MOD to DA8/J. M. Bryant (to the appropriate DA8/Book Manager for Annexes) for generic rule CR's and cc to DA8/W. P. Dill for Space Shuttle Operational Flight Rules, Volume A; DA8/J. M. Bryant for ISS Generic Operational Flight Rules, Volume B; and DA8/W. P. Dill for Joint Shuttle/ISS Generic Operational Flight Rules, Volume C, or Soyuz/Progress/ISS Joint Flight Rules, Volume D. **Examples of the electronic addresses are: SMPT: [william.p.dill1@jsc.nasa.gov](mailto:william.p.dill1@jsc.nasa.gov) or [smp:wdill@ems.jsc.nasa.gov](mailto:smp:wdill@ems.jsc.nasa.gov).**

## FLIGHT RULES

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Organizations outside MOD may submit CR's through the appropriate MOD division to facilitate presubmittal review and coordination or may submit completed CR's directly to the Flight Director Office. Workflow CR's submitted from outside MOD require a tailored setup for the author as the CR will not be processed without one additional review/approval inside the author's Branch, Group, etc. When practicable, coordination should include the Flight Director. Workflow CR's are encouraged from outside MOD.

### 2.1.1 Enrollment

"Workflow" is a web-based database which uses e-mail to route and announce CR's for review or approval. The approval process is discussed in paragraph 2.2. Workflow requires the user to be enrolled in the database.

Anyone with a need who resides in the JSC Domain or certain trusted domains may be enrolled in Workflow by providing their full name, 4-digit mail code, domain user ID, telephone number, and e-mail address. The request and information should be provided to Division database editors, trusted domain database editors, or to the Book Manager listed on the Preface page of the flight rules documents.

Enrollment for users outside the JSC Domain/trusted domains is available if the user has a need to change or review flight rules. At URL: <http://mod.jsc.nasa.gov/da8>), under the title **Workflow Link**, click the **Process for obtaining access to Workflow** link. Fill out the form and follow the submitting instructions. The DA8/Flight Director Office will sponsor each request. The requester will be informed when the application is approved and enrollment completed.

The Workflow URL is: <https://jsc-mod-wrflow.jsc.nasa.gov>. Refer to the Help and Frequently Asked Questions and the Complete Users Guide links for further information. There is also a Workflow Trainer CBT which is at URL: <http://mod.jsc.nasa.gov/da8>.

### 2.1.2 Format

Individuals desiring to submit a flight rule change will complete the Workflow CR form. For new flight rule submittals, the rule and its associated rationale should be phrased as it is intended to appear in the flight rules document. Supporting data for the rationale may be attached. For changes to existing rules, the proposed changes must be made obvious when making the Workflow file attachment by accepting any revisions on the Flight Rule page to be modified, then turn the revision mode **ON** so that changes may be clearly identified.

### 2.1.3 CR Input Nonconformance

If an error is discovered while reviewing an incorporated Flight Rule CR, please notify the Book Manager of the nonconformance using the EZ CR form provided on the next page of this appendix. (Be aware that this is not the Flight Rule CR form and should only be used to report nonconformances.) Verification of the nonconformance initiates a metric input, correction, possible corrective action, nonconformance disposition/approval, and closure. Closure of "Control of Nonconforming Product" nonconformance EZ CR's are approved by the Flight Director Office USA supervisor or his designee. Closure of "Corrective and Preventive Action" nonconformance EZ CR's are approved by the Chief of the Flight Director Office or his designee.

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**FLIGHT RULES**

**FLIGHT RULES EZ CR**

DATE	INITIATED BY: ORG/NAME/PHONE	RULE NUMBER	CONTROL NUMBER
CR FLIGHT EFFECTIVITY	OTHER AFFECTED FLIGHT RULES	DOCUMENT w/Date   REV Date	ALL FLTS VOL ANNEX
Rule Element		Rule Section	
SHORT DESCRIPTIVE TITLE OF CHANGE			RULE RATIONALE
<u>Nonconformance Description - Attached (If required)</u> Special instructions (if required):			
		Approval	Date
<b>NONCONFORMANCE</b> TECHNICAL ERROR <input type="checkbox"/> EDITORIAL ERROR <input type="checkbox"/>			
	RECEIVED: INCORPORATED: EZ CR STATUS: OPEN	(DA8 Use Only)	
SUBMIT CR TO: Annex Book Manager or DA8/W. P. DILL, NASA/JSC, PHONE 281-483-5418 SMPT: william.p.dill1@jsc.nasa.gov			



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## FLIGHT RULES

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### INSTRUCTIONS

1. DATE - Enter FLIGHT RULES EZ CR initiation date.
2. INITIATED BY: ORG/NAME/PHONE - Enter the originator's organization, name, and phone number (including area code if other than JSC).
3. RULE NUMBER - Enter the nonconformance rule number.
4. CONTROL NUMBER - Leave blank; will be assigned and entered by the document manager.
5. FLIGHT EFFECTIVITY - Enter whether Generic or Flight Specific Number.
6. OTHER AFFECTED RULES - Enter other rules affected.
7. DOCUMENT DATE w/Date/ REV Date - Enter the "affective document" document date and the PCN/Rev (if applicable ) that contains the rule to be modified.
8. Enter All Flights Volume A, B, or C, or check the appropriate box for the annex
9. RULE ELEMENT - Enter the rule element number.
10. RULE SECTION - Enter the rule section number
11. SHORT DESCRIPTIVE TITLE OF CHANGE - Enter a short descriptive title of the change.
12.  RULE,  RATIONALE - Check appropriate box for whether the nonconformance is in rule and/or rationale.
13. NONCONFORMANCE DESCRIPTION - Enter a description of the nonconformance.
14. SPECIAL INSTRUCTIONS (IF REQUIRED) - Enter any special instruction here.
15. NONCONFORMANCE - Leave blank; will be assigned and entered by the document manager.

## FLIGHT RULES

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### 2.2 CR APPROVAL

#### 2.2.1 Coordination

Pre-coordination between the author and affected disciplines is assumed. In Workflow, when the Flight Director Office receives a generic flight rule CR for disposition, it will automatically be assigned a control number, and it will be assigned to a coordinating flight director. The coordinating flight director works with the initiator on any desired changes to the wording for the rule or rationale. The coordinating flight director conducts the Flight Director Office review and assists in the identification of any additional data or coordination that may be required. When this initial coordination has been completed and external coordination is required, a mandatory review sheet is readied by the coordinating flight director and distributed for formal review and comment with an appropriate suspense date provided. When required, all FRCB/JFRCB members plus others identified by the coordinating flight director will receive review copies via Workflow. To allow adequate review time, the suspense date is established to support the next scheduled FRCB/JFRCB (or specific launch date). CR's are required to be delivered to the Flight Director Office for review no later than 3 weeks prior to the FRCB/JFRCB. CR's submitted after the 3-week deadline may be scheduled on the FRCB/JFRCB agendas at the discretion of the Board Chair.

This review includes an assessment of impact to retention rationale for CIL-related rules and a review of related orbiter or payload hazard reports. For all proposed changes to CIL/HC-related flight rules, the rationale must be approved by the respective Program before the CR may be placed on the Board agenda.

## FLIGHT RULES

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### **2.2.2 Approved/Disapproved/Deferred CR's**

#### **2.2.2.1 Generic CR's**

For minor changes to generic rules/rationale, format only changes to flight rules, and when no mandatory review assignments have been made by the reviewing Flight Director, the FRCB/JFRCB Chairman may approve the CR without formal presentation to the board, provided no changes were recommended by the board members. These are the CR's identified on the FRCB/JFRCB agenda with an asterisk. Occasionally, the FRCB/JFRCB Chairman will approve and sign a CR out of board to expedite a CR through the process, and usually that CR will be presented at the next FRCB/JFRCB. All other CR's will be considered by the FRCB/JFRCB with a formal presentation. The FRCB/JFRCB considers each CR based on the impact on operations, the impact on documented hazard controls or CIL retention rationale, and the technical justification. Each CR will then be approved, disapproved, or deferred. Approved changes will be incorporated into the next page change notice (PCN) or revision to the generic document. Disapproved CR changes will be returned to the initiator along with the reason for disapproval. Disapprovals may be appealed to the Level II Program Office, if desired. The last possible FRCB/JFRCB action is deferral. CR's will be deferred for only two reasons: all mandatory concurrences have not been received, or additional data or analysis is needed. CR deferrals will be rescheduled for a subsequent FRCB/JFRCB meeting.

FRCB/JFRCB minutes document the status of each CR dispositioned (approved, deferred, approved with modification, actions given, and status of past actions). Workflow databased CR's may be processed by the Book Manager acting for the FRCB/JFRCB Chair in accordance with the FRCB/JFRCB CR status documented in the minutes.

#### **2.2.2.2 Annex CR's**

The Lead Flight Director has approval authority of CR's for Flight Specific Increment Annexes or for Flight Specific Annexes.

## **3.0 DOCUMENT REVISIONS/DEVELOPMENT**

### **3.1 DEVELOPMENT**

The Flight Director Office will compile for the generic documents the effective changes and corrections of minor typographical errors into complete Revisions or PCN's to the basic document.

The Flight Director Office prepares annexes on a per flight basis according to schedule template at approximately launch minus 7 months in most cases.

Editorial changes may be used to correct typographical errors if there are no other changes on the page concerned.

## FLIGHT RULES

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### 3.2 DOCUMENT APPROVAL

#### 3.2.1 Generic Rules Documents

Revisions/PCN's to the Volume A document will be approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Shuttle Program. Pen and Ink (P&I) changes will be approved by the Chief, Flight Director Office under DA8 memorandum with concurrence by the Director, Mission Operations. Real-time CR's are approved by the Flight Director and the Mission Operations Director and are stasured to the Mission Management Team.

Revisions/PCN's to the Volume B and D documents will be approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Station Program. P&I changes will be approved by the Chief, Flight Director Office under DA8 memorandum with concurrence by the Director, Mission Operations. Real-time CR's are approved by the Flight Director and the Mission Operations Director and are stasured to the Mission Management Team.

Revisions/PCN's to the Volume C document will be approved by the Chief, Flight Director Office; Director, Mission Operations; Manager, Space Shuttle Program; and Manager, Space Station Program. P&I changes will be approved by the Chief, Flight Director Office under DA8 memorandum with concurrence by the Director, Mission Operations. Real-time CR's are approved by the Flight Director and the Mission Operations Director and are stasured to the Mission Management Team.

Documents are updated with approved CR's and stasured at program review boards. If all signatures are not obtained in time to meet publication schedules, signatures pages will be posted by eratta when they are received.

#### 3.2.2 Annex Documents

A "Headsup" review copy of the "Final" document is provided for program review 5 working days prior to "Final" presentation to the affected Program Requirements Control Board (PRCB) or SSCB or Joint Board. After the 5-day review, the Flight Director is scheduled on the appropriate board agenda via a Control Board CR to brief any flight specific issues potentially affecting Program policies. Also, any additional significant changes received during the 5-day review period will be briefed.

Pre-Final documents are approved by the Lead Flight Director or his designee.

The Annex Final and Revisions/PCN's to the Final document will be approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Shuttle Program. Pen and Ink (P&I) changes will be approved by the Lead Flight Director under DA8 memorandum with concurrence by the Chief, Flight Director Office and Director, Mission Operations. Real-time CR's are approved by the Flight Director and the Mission Operations Director and are stasured to the Mission Management Team.

The Increment Annex Final and Revisions/PCN's to the Final will be approved by the Chief, Flight Director Office; Director, Mission Operations; Manager, Space Shuttle Program; and Manager, Space Station Program. Pen and Ink changes will be approved by the Lead Flight Director under DA8 memorandum with concurrence from the Chief, Flight Director Office and the Director, Mission Operations. Real-time CR's are approved by the Flight Director and the Mission Operations Director and are stasured to the Mission Management Team.

## FLIGHT RULES

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### 3.3 PUBLICATION

#### 3.3.1 Schedule

##### 3.3.1.1 Generic Rules

All Flights documents (Volumes A, B, C, and D) originating as initial documents would approximately follow the schedule described for annexes except the FRCB/JFRCB would exercise individual rules approval prior to obtaining respective PRCB/JPRCB/SSPCB approvals. After initial release of Volumes A, B, C, etc., in "Final" form, subsequent revisions will be in the form of PCN's or Pen and Inks (P&I's), depending on CR traffic and mission requirements.

##### 3.3.1.2 Annex/Increment Rules

Initial publication of annexes will be in "Basic" form and provided for the Flight Operations Review (FOR) data pack distribution at approximately launch minus 4 months for Space Shuttle only missions and L-5 months for Joint Shuttle/ISS missions (schedule provided by Payload FOR memorandum.) Post-FOR, the flight rules will be published in "Basic, Revision" form and distributed in time to support the flight simulation schedule. The "Final" approval process takes place at approximately liftoff minus 1 month. The logistics required for the formal approval process precludes initiating a PCN within 2 weeks of launch. Within 2 weeks of the launch, the Pen and Ink (P&I) process is invoked with P&I changes processed "on console" at launch minus 1 day, and produced on an "as required" basis. After liftoff, changes will be processed real time per JSC-26843, Flight Control Operations Handbook (FCOH) Shuttle Operations, SOP 1.2.1, Real-Time Flight Rules Changes, or JSC-29279, FCOH Station Operations, SOP 2.6, Real-Time Flight Rules Changes.

#### 3.3.2 Distribution

Hard copy publications will be printed and distributed through normal administrative channels. Use of electronic copies off the website is encouraged. All of the current Flight Rules documents are available on the internet at URL: <http://mod.jsc.nasa.gov/da8>.

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**FLIGHT RULES**

**CHANGE REQUEST**

(TO BE USED ONLY WHEN WORKFLOW DATABASE IS UNAVAILABLE.)

DATE	INITIATED BY: ORG/NAME/PHONE	CONTROL NUMBER	RULE NUMBER
CR FLIGHT EFFECTIVITY & Term	OTHER AFFECTED FLIGHT RULES	DOCUMENT w/Date   REV Date	ALL FLTS VOL
Terminate after:		Rev:	ANNEX
Rule Element	Rule Section		
SHORT DESCRIPTIVE TITLE OF CHANGE			RULE
			RATIONALE
<b>Rule Change - Attached</b>			
Special instructions (if required):			
REASON FOR CHANGE (required input - each paragraph is limited to 255 characters)			
Para 1:			
Para 2:			
<b>Pre-Coord: (org/name)</b>			
<b>APPROVED:</b> Signed By:	CIL HAZARD CONSTRAINTS TO OPERATIONS? YES <input type="checkbox"/> NO <input type="checkbox"/>	<b>APPROVED:</b> Signed By:	
SUBMITTING ORGANIZATION FRCB/JFRCB MEMBER	DOES THIS CHANGE MODIFY EXISTING CIL RETENTION RATIONALE? YES <input type="checkbox"/> NO <input type="checkbox"/>	FRCB/JFRCB CHAIRMAN	
DATE:		DATE:	
<b>CHANGE IS A RESULT OF:</b>	DOES THIS CHANGE AFFECT CREW PROCEDURES? YES <input type="checkbox"/> NO <input type="checkbox"/>	<b>APPROVED: (ANNEX ONLY)</b> Signed By:	
NEW CAPABILITY <input type="checkbox"/> H/W <input type="checkbox"/>	DOES THIS CHANGE MODIFY FOR A CONTROLLED HAZARD? YES <input type="checkbox"/> NO <input type="checkbox"/>	LEAD FLIGHT DIRECTOR	
PROCEDURE CHG <input type="checkbox"/> S/W <input type="checkbox"/>		DATE:	
EDITORIAL <input type="checkbox"/> OTHER <input type="checkbox"/>			
<b>EVALUATION SUMMARY:</b> SUBMIT FINAL COMMENTS BY:			
(DA8 USE ONLY)		IN SUPPORT OF JOP ON:	
		IN SUPPORT OF FRCB/JFRCB ON:	
MAND (X)	Evaluator	DATE	A A/M D Comments
<b>SUBMIT CR TO: Annex Book Manager or</b> DA8/W. P. DILL. NASA/JSC. PHONE 281-483-5418 E-MAIL: william.p.dill1@jsc.nasa.gov	RECEIVED: INCORPORATED: CR STATUS:	(DA8 Use Only)	

JSCDA8 Ver 11.0 (Rev July 2001) Electronic Media CR Form for Use with Word Ver 6.0 and later releases

Verify that this is the correct version before use.

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# FLIGHT RULES

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### INSTRUCTIONS

1. DATE - Enter CR initiation date.
2. INITIATED BY: ORG/NAME/PHONE - Enter the originator's organization, name, and phone number (including area code if other than JSC).
3. CONTROL NUMBER - Leave blank; will be assigned and entered by the document manager.
4. RULE NUMBER - Enter the existing rule number to be modified. If this is a new rule, enter the section number and the document manager will assign a rule number.
5. FLIGHT EFFECTIVITY & Term and Terminate after: - Enter the first flight for which the rule is required. If generic, enter "ALL". For Annex or Increment Annex STS-XX or INC X/STS-XX, if there is a mission that requires termination thereafter, make that entry here using similar annotation STS-XX, etc.
6. OTHER AFFECTED RULES - Enter other rules which either reference this rule or which this rule references.
7. DOCUMENT DATE w/Date/ REV Date - Enter the "affective document" document date and the PCN/Rev (if applicable ) that contains the rule to be modified.
8.  ALL FLIGHTS VOL,  ANNEX - Enter All Flights Volume A, B, or C, or check the appropriate box for the annex document for which the CR is intended.
9. RULE ELEMENT - Enter the rule element number.
10. RULE SECTION - Enter the rule section number.
11. SHORT DESCRIPTIVE TITLE OF CHANGE - Enter a short descriptive title of the change.
12.  RULE,  RATIONALE - Check appropriate box for rule and/or rationale.
13. RULE CHANGE- ATTACHED - Enter the rule and rationale exactly as it will appear in the document to be changed. It is preferred that the page(s) being changed be copied and pasted below the page break of the CR form ("Instructions" page to be deleted). The rule/rationale should be modified with revision mode ON. For a new rule, enter rule below the page break using format shown below:
14. TITLE - In capital letters and underlined.  
RULE - In capital letters exactly as it will appear in the document.  
RATIONALE - Enter the word "Rationale" followed by the rule rationale in lower case letters.
15. SPECIAL INSTRUCTIONS (IF REQUIRED) - Enter any special instruction here.
16. REASON FOR CHANGE - Enter the technical or philosophical reason for changing the existing rule or why a new rule is required.
17. PRE-COORD: (ORG/NAME) - Enter any pre-coordination information obtained here.
18. APPROVED: SUBMITTING ORGANIZATION FRCB/JFRCB MEMBER/DATE - This block is to be signed/dated by the Flight Rules Control Board (FRCB) or Joint FRCB member of the organization submitting the rule. Concurrences, if required, may be initialed in this block. Changes originating from organizations which have no FRCB/JFRCB membership may submit their proposed changes directly to the Flight Director Office, DA8, Lyndon B. Johnson Space Center, Houston, Texas 77058.
19. CIL HAZARD CONSTRAINTS TO OPERATIONS: YES  NO  - Optional, the originator may attempt to answer this question; however, the responsibility lies with DF to determine if the CR affects JSC 23227, "CIL/Hazard Constraints to Operations." This is the MOD ops retention rationale document.
20. DOES THIS CHANGE MODIFY EXISTING CIL RETENTION RATIONALE: YES  NO  - Optional, the originator may attempt to answer this question; however, the responsibility lies with DF to make this assertion.
21. DOES THIS CHANGE AFFECT CREW PROCEDURES? YES  NO  - The originator should attempt to answer this question and make reference to changes in the crew procedures document in item 11.
22. DOES THIS CHANGE MODIFY RATIONALE FOR A CONTROLLED HAZARD? YES  NO  - Optional, the originator may attempt to answer this question; however, the responsibility lies with the Systems or Operations Divisions to make this assessment.
23. APPROVED: FRCB/JFRCB CHAIRMAN - This block is to be signed by the FRCB/JFRCB Chairman, Operations Director, or his alternate signifying approval by the FRCB/JFRCB.
24. APPROVED: LEAD FLIGHT DIRECTOR - This block is to be used only for Lead Flight Director concurrence for changes to the flight-specific annexes.
25. CHANGE IS RESULT OF - Check appropriate box.
26. EVALUATION SUMMARY - Leave blank; used by DA8 to identify/request mandatory CR review.
27. RECEIVED/INCORPORATED/CR STATUS: - Leave blank; this block is used for internal document control by the document manager.

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## **FLIGHT RULES**

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