

Joint Shuttle-ISS Operational Flight Rules Annex

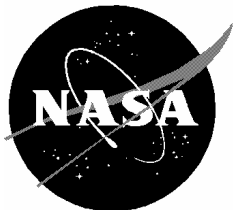
STS-120/10A

ISS Expeditions 15 & 16

Mission Operations Directorate

Final

September 25, 2007



National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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JOINT SHUTTLE-ISS OPERATIONAL FLIGHT RULES ANNEX

STS-120/10A

FINAL

SEPTEMBER 25, 2007

THIS DOCUMENT INCORPORATES CHANGES TO THE FOLLOWING RULES (SINCE THE BASIC, REV A DATED MAY 9, 2007) BY THE APPLICABLE 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>
10A_A1-3	CR 8875A		10A_A9-1	CR 8828A	
			10A_B9-6	CR 8818	
10A_A2-2	CR 8809		10A_C9-3	CR 8845	
10A_A2-3	CR 8835				
10A_A2-4	CR 8835		10A_A10-2	CR 8803	
10A_A2-5	CR 8835		10A_A10-3	CR 8804	
10A_A2-5	CR 8861		10A_A10-4	CR 8808	
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10A_A2-9	CR 8837		10A_A15-1	CR 8852	
10A_A2-10	CR 8886				
10A_A2-11	CR 8811A		10A_C17-1	CR 8859	[RC]
10A_C2-1	CR 8848				
10A_C2-46	CR 8891		10A_B19-3	CR 8815	
10A_C2-52	CR 8586	[RC]	10A_B19-4	CR 8815	
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10A_C2-75	CR 8876				
10A_C2-76	CR 8769				
10A_C2-87	CR 8812				
10A_C2-91	CR 8866	[RI]			
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10A_A4-3	CR 8710A				
10A_A5-1	CR 8706				
10A_A5-2	CR 8708A				
10A_A5-3	CR 8843				
10A-A8-2	CR 8858				
10A_A8-3	CR 8814				
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Verify that this is the correct version before use.

JOINT SHUTTLE-ISS OPERATIONAL FLIGHT RULES ANNEX

STS-120/10A, ISS EXPEDITIONS 15 & 16

FINAL

PREFACE


THIS DOCUMENT, DATED SEPTEMBER 25, 2007, CONTAINS THE FINAL VERSION OF THE STS-120/10A, ISS EXPEDITIONS 15 & 16 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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FLIGHT RULES

SECTION 1 - GENERAL, AUTHORITY, AND DEFINITIONS

SHUTTLE ONLY RULES

10A_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-120, Stage 10A.

10A_A1-2 STS-120 DEVELOPMENT TEST OBJECTIVE (DTO)/DETAILED SUPPLEMENTARY OBJECTIVE (DSO)/SHORT DURATION BIOASTRONAUTICS INVESTIGATIONS (SDBI) FCR RESPONSIBILITIES

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

- A. ASSEMBLY AND CHECKOUT OFFICER (ACO): NONE
- B. FLIGHT DYNAMICS OFFICER (FDO):
 DTO 805 CROSSWIND LANDING PERFORMANCE (DTO OF OPPORTUNITY)
- C. GUIDANCE, NAVIGATION, AND CONTROL (GNC): NONE
- D. INTEGRATED COMMUNICATIONS OFFICER (INCO): NONE
- E. MECHANICAL, MAINTENANCE, ARM AND CREW SYSTEMS (MMACS): NONE
- F. PUBLIC AFFAIRS OFFICER (PAO): NONE

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_A1-2 STS-120 DEVELOPMENT TEST OBJECTIVE (DTO)/DETAILED
SUPPLEMENTARY OBJECTIVE (DSO)/SHORT DURATION
BIOASTRONAUTICS INVESTIGATIONS (SDBI) FCR
RESPONSIBILITIES (CONTINUED)

G. SURGEON:

- SDBI 1503-S TEST OF MIDODRINE AS A COUNTERMEASURE AGAINST
POSTFLIGHT ORTHOSTATIC HYPOTENSION
(PRE/IN/POSTFLIGHT) @[DN 5]
- SDBI 1643 SLEEP-WAKE ACTIGRAPHY AND LIGHT EXPOSURE DURING
SPACEFLIGHT ('SLEEP-WAKE') (PRE/IN/POSTFLIGHT)
- SDBI 1490-B BIOAVAILABILITY AND PERFORMANCE EFFECTS OF
PROMETHAZINE DURING SPACEFLIGHT, PROTOCOL B
('PMZ') (PRE/IN/POSTFLIGHT)
- SDBI 1900 VALIDATION OF PROCEDURES FOR MONITORING IMMUNE
FUNCTION ('INTEGRATED IMMUNE')
(PRE/IN/POSTFLIGHT) @[DN 5]

FLIGHT RULES**10A_A1-3****STS-120 VEHICLE CONFIGURATION**

STS-120/OV-~~103~~ FLIGHT SPECIFIC VEHICLE CONFIGURATIONS AS RELATED TO THE GENERIC RULES ARE LISTED IN THE FOLLOWING TABLE: @ICR 8875A

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VEHICLE CONFIG DEPENDENT RULES	COMPONENT/SYSTEM	CONFIGURATION
{A10-361}, {A10-362}, {A10-363}, {A10-364}, {A10-365}	VIEWPORT	NO
{A15-201}, {A15-202}, {A15-204}, {A17-202}, {A17-302}, {A18-60}, {A18-61}, {A18-62}, {A18-301}, {A18-304}, {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}, {A17-204}, {A17-302}	N ₂ TANK SET	6
{A2-1001}, {A13-152}, {A13-155}, {A17-53}, {A17-151}, {A17-157}, {A17-158}, {A17-1001}, {C17-18}	CO ₂ CONTROL	LIQH UNDOCKED, CDRA WHILE DOCKED
{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

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FLIGHT RULES

10A_A1-3

STS-120 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 - TBD L - TBD R - TBD (PHASE II, BLOCK I, BLOCK II, OR BLOCK IIA)
{A6-2}, {A6-3}	OMS	L - 115 R - 106 (SERIAL NUMBER)
{A2-105}	SPARE HUD	NO
{A2-105}	PAYLOAD RECORDER	NO
{A2-323}	SPARE PDI	NO

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FLIGHT RULES

ISS ONLY RULES

10A_B1-1 ISS SUPPORT EQUIPMENT FCR RESPONSIBILITY

- A. OCA - OPS PLAN @[DN 146]
- B. ISS PLUG-IN PLAN - CIO

This rule supplements Rule {B1-24}, ISS SUPPORT EQUIPMENT FCR RESPONSIBILITY [RC]. @[DN 146]

10A_B1-2 STAGE DURATION DEFINITION

10A STAGE IS DEFINED AS THE TIME PERIOD FROM THE LAUNCH OF STS-120, ISS-10A UNTIL THE LAUNCH OF STS-122, ISS-1E.

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_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.

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FLIGHT RULES

10A_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	10A 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
MAUI & RAMBO	JSC DOD POCC	DOD REP	DEPARTMENT OF DEFENSE 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

10A_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
 - 3. ISIS DIGITAL CAMERA (IDC) - INCO
 - 4. LCS - INCO
 - 5. WLES (A.K.A. "EWBMTAU-WLE") - ACO
 - 6. DOUG - PDRS FOR ROBOTICS SUPPORT; EVA FOR EVA SUPPORT
 - 7. ET UMBILICAL CAMERA (KODAK DCS CAMERA MANAGER) - MMACS
 - 8. WVS - MMACS
 - 9. RSAD - PDRS
 - 10. FCMS - EGIL
 - 11. ALL OTHER SOFTWARE APPLICATIONS - FAO

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FLIGHT RULES

10A_C1-2 SHUTTLE SUPPORT EQUIPMENT FCR RESPONSIBILITY
(CONTINUED)

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.

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 SSV. @[DN 6]

- L. APCU/SPDU - EGIL
- M. AFD PCS - ODIN
- N. WLES HARDWARE (LAPTOP RECEIVER UNIT, CABLE RELAY UNITS, AND CABLES FOR A13 PANEL) - ACO
- O. ET UMBILICAL CAMERA HARDWARE (FIREWIRE CABLE AND CONVERTER) - MMACS
- P. LCS RJ45 CABLE (TO OPP) - INCO

FLIGHT RULES

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FLIGHT RULES

SECTION 2 - FLIGHT OPERATIONS

SHUTTLE ONLY RULES

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JOINT SHUTTLE/ISS RULES

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FLIGHT RULES

SECTION 2 - FLIGHT OPERATIONS

SHUTTLE ONLY RULES

10A_A2-1 STS-120 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. ©[DN 86]

This is a benign attitude and maintains all ISS components in the orbiter payload bay within the desired temperature limits. Thermal analysis was performed using the preferred attitude and includes OMS burns, planned water dumps, and IMU alignments.

Source: Rule {A2-131}, ATTITUDE RESTRICTIONS FOR ORBITAL DEBRIS, and Boeing Memo AG-92-J353-STN-RAH-2003-0003, Flight 10A/STS-120 Launch-To-Activation Summary, January 30, 2003.

- B. THE NOMINAL RNDZ PROFILE, FOR ALL BETA ANGLE CASES, WILL MAINTAIN ALL NODE 2 COMPONENTS ABOVE THEIR SURVIVAL LIMITS. THE FOLLOWING DEVIATIONS ARE ACCEPTABLE: ©[DN 19]

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 ISS elements in the orbiter payload bay.

Source: Boeing Memo AG-92-J353-STN-RAH-2003-0003, Flight 10A/STS-120 Launch-To-Activation Summary, January 30, 2003.

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FLIGHT RULES

10A_A2-1 STS-120 PREDOCK THERMAL ATTITUDES (CONTINUED)

- C. CONSIDERATION WILL NOT BE GIVEN TO UTILIZING A YVV ATTITUDE TO HELP MAINTAIN WLES BATTERY TEMPERATURES. @[DN 1]

Direction from MV/Steve Poulos on January 18, 2007: "The Orbiter [Project Office] will not be asking for any ATL [Attitude Timeline] changes to support the WLEIDS [a.k.a. WLES] ascent download requirement. The voltage regulator [modification] will be ready for [STS-118], so this concern [of losing access to ascent data] goes away very quickly." @[DN 1]

- D. 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 S3/4 components to return within the predicted temperature band.

Source: Boeing Memo AG-92-J353-STN-RAH-2003-0003, Flight 10A/STS-120 Launch-To-Activation Summary, January 30, 2003.

- E. 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 S3/4 components to exceed their upper temperature limits within 3 hours.

Source: Boeing Memo AG-92-J353-STN-RAH-2003-0003, Flight 10A/STS-120 Launch-To-Activation Summary, January 30, 2003.

- F. 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 Node 2 components to exceed their lower temperature limits within 5 hours. @[DN 19]

Source: Boeing Memo AG-92-J353-STN-RAH-2003-0003, Flight 10A/STS-120 Launch-To-Activation Summary, January 30, 2003.

FLIGHT RULES

10A_A2-2

STS-120 CONTAMINATION CONSTRAINTS MATRIX

TABLE 10A_A2-2-I - CONTAMINATION CONSTRAINTS MATRIX

ISS ELEMENT OR PAYLOAD	H ₂ 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
<u>P6</u>	<u>REQUIRED: INHIBIT SUPPLY AND WASTE WATER NOZZLE DUMPS WHILE P6 IS IN THE HANDOFF POSITION.</u> <u>NO CONSTRAINT TO FES DUMPS.</u>	<u>NONE</u>	<u>NONE</u>

@ICR 8809 1

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. While P6 is in the handoff position, starting FD6 through FD9 install, the P6 will be directly in front of the orbiter's dump nozzles. To preclude contamination of the P6, no nozzle dumps should be performed while the P6 is in this location. @ICR 8809 1

Additional water dump constraints that are applicable during proximity and mated operations with ISS are documented in Rules {10A_A2-85}, MATED FES DUMP CONSTRAINTS, and {10A_C17-1}, SHUTTLE VENT MANAGEMENT [RC].

Sources: Ram Burn Observation PIP (NSTS 21508), Basic + CHG-1, section 4.2.2.4, May 6, 2002, and Maui Analysis of Upper-Atmospheric Injections PIP (NSTS 21530), Basic + CHG-1, section 4.2.2.4, March 29, 2006. @DN 10 1

FLIGHT RULES

10A_A2-3

RESERVED @[DN 8] @[CR 8835]

10A_A2-4

EARLY MISSION TERMINATION PHILOSOPHY PRIOR TO COMPLETION OF ASCENT TPS INSPECTIONS @[DN 2] @[CR 8835]

A. THIS RULE PROVIDES GUIDANCE FOR ORBITER/SSME SYSTEMS FAILURES THAT REQUIRE EARLY MISSION TERMINATION PRIOR TO THE COMPLETION OF ASCENT TPS INSPECTIONS, WHICH INCLUDE:

1. THE COLLECTION AND DOWNLINK OF ALL FD2 NOSE CAP, PORT WING, STARBOARD WING, AND CREW CABIN SURVEYS AND FD3 RENDEZVOUS PITCH MANEUVER (RPM) IMAGERY BY THE CREW/FLIGHT CONTROL TEAM.
2. MMT REVIEW OF THE ORBITER PROJECT OFFICE IMAGERY/DAMAGE ASSESSMENT TEAM ANALYSIS.

There are a multitude of failure conditions that pose a serious risk to crew survivability including SSME failures or performance shifts during ascent and/or total orbiter systems failures during either the ascent or on-orbit timeframe. Malfunctions that significantly impact propulsive, electrical, active thermal control, or environmental consumables capability can place the orbiter at significant risk requiring an early mission termination because the vehicle cannot sustain the next worst failure or a loss of crew and vehicle will result. Depending on the severity of the failure(s), an emergency deorbit, next PLS, or MDF may be required. The purpose of this rule is to provide assistance with the crew risk balance associated with the immediate failure when compared to the benefit of proceeding with an on-orbit TPS inspection and follow-on data analysis.

The goal of the planned FD2 inspection procedures is to efficiently and expeditiously collect the required RCC data in order to review its configuration after exposure to the ascent environment. 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. The crew cabin survey is also performed on FD2 to inspect the TPS surrounding the windows and crew cabin. The FD3 RPM allows imagery of the nose landing gear and main landing gear doors, ET doors, and the remainder of the lower surface TPS.

Finally, the MMT will review the Orbiter Project Damage Assessment Team analysis in order to determine the TPS status for entry. References: NSTS 60517 Program Requirements Document for the Shuttle On-Orbit Thermal Protection System (TPS) Inspection System and NSTS 60520 Program Requirements Document for the Shuttle On-Orbit Thermal Protection System (TPS) Repair System. The MMT is involved in the TPS assessments because the analysis occurs outside of the Flight Control Team and can potentially involve operations outside of the shuttle operations base (Reference Rule {A1-4}, MISSION MANAGEMENT TEAM (MMT) AUTHORITY). @[CR 8835]

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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.

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FLIGHT RULES

10A A2-4 EARLY MISSION TERMINATION PHILOSOPHY PRIOR TO COMPLETION OF ASCENT TPS INSPECTIONS (CONTINUED)

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B. FOR THE ASCENT PHASE (LIFTOFF THROUGH GO FOR ORBIT OPS), IF AN ASCENT SYSTEM, SSME FAILURE, OR PERFORMANCE ANOMALY REQUIRES AN INTACT (RTLS, TAL, ATO, OR AOA) OR CONTINGENCY ABORT (ECAL/ELS), THE TPS WILL BE ASSUMED TO BE ACCEPTABLE FOR ENTRY. @[CR 8835]

For SSME failure(s), MPS performance anomalies, and/or orbiter systems problems that require an intact or contingency abort, the risk to the crew is significant with very few options to reduce the entry thermal environment. Additionally, the ability of the crew/MCC to detect and react to TPS anomalies during powered flight is limited since the powered flight time is approximately 8.5 minutes MET. The most benign abort mode from a thermal perspective is an RTLS abort, which must be declared prior to 4 minutes MET. It is unrealistic for a TPS impact to be detected, determined to be a significant concern, and acted upon by the crew and flight control team in the timeframe between liftoff and 4 minutes MET. Finally, in many cases, the abort mode selected is the only abort that is feasible from either an ascent performance or consumables perspective and no other option for crew survival exists.

The only option for the ascent powered flight timeframe is to accept an RTLS abort over a TAL abort when both are available (a 1 minute 20 second window) to reduce reentry heating. However, there is significantly greater risk to the crew with an RTLS abort due to the potential for ET recontact following ET separation due to the higher Q-bar for this abort mode. Thus, the TAL abort is preferred over the RTLS abort since the well documented and analyzed issues with ET recontact outweigh the unquantified risk of potential TPS damage.

The TIG for an AOA is approximately 37 minutes MET and does not allow for time to react to potential ascent debris impacts. Additionally, the AOA abort is only executed for performance problems (limited OMS/RCS post MECO capability) or significant systems problems including multiple OMS/RCS propellant or helium tank leaks, impending loss of all APU/hydraulic capability, sizeable cabin leak, impending loss of all cryo, loss of two Freon loops, or loss of two water loops. Similarly, an ATO Rev 3 deorbit has a TIG of approximately 4 hours MET, while all of the ascent imagery data has been shipped to JSC, KSC, and MSFC for analysis at approximately 2 hours MET. A rev 3 deorbit is only performed for serious systems failures where the risk of remaining in orbit for even 24 hours has been deemed to be too great.

Reference Rules {A2-52}, ASCENT MODE PRIORITIES FOR PERFORMANCE CASES: {A2-54}, RTLS, TAL, AND AOA ABORTS FOR SYSTEMS FAILURES [CIL]; {A2-57}, CONTINGENCY ASCENTS/ABORT; and {A2-301}, CONTINGENCY ACTION SUMMARY [HC]. @[CR 8835]

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FLIGHT RULES

10A A2-4 EARLY MISSION TERMINATION PHILOSOPHY PRIOR TO COMPLETION OF ASCENT TPS INSPECTIONS (CONTINUED)

C. FOR THE ORBIT PHASE (GO FOR ORBIT OPS THROUGH COMPLETION OF
THE DEORBIT BURN) THE TPS WILL BE ASSUMED TO BE ACCEPTABLE
FOR ENTRY IN THE EVENT OF AN EMERGENCY DEORBIT OR NEXT PLS.
@ICR 8835]

An emergency deorbit or next PLS reentry is required for only the most serious of conditions for which a landing must occur as soon as possible. An emergency deorbit is required for the loss of two Freon loops, loss of two water loops, multiple OMS/RCS propellant or helium tank leaks, impending loss of all APU/hydraulic capability, a cabin leak with a dp/dt that will not support a PLS, or impending loss of all cryo.

There are numerous failures documented in the Volume A Flight Rules that result in a next PLS deorbit. These are failures that result in conditions where the orbiter is zero fault tolerant to the next failure or where one additional failure causes a severe orbiter configuration management condition. In either the emergency deorbit or next PLS case, a delay in deorbit to perform TPS inspection is not warranted in the absence of indications of significant TPS damage. Flight history of TPS damage and substantial improvements in the ascent debris environment implemented starting with STS-114 provide confidence that the risk associated with executing a deorbit burn prior to inspection is less than the risk posed by the emergency deorbit/PLS/failure condition.

Reference: Rules {A2-102}, MISSION DURATION REQUIREMENTS; {A2-205}, EMERGENCY DEORBIT; {A2-301}, CONTINGENCY ACTION SUMMARY [HC]; and {A2-1001}, ORBITER SYSTEMS GO/NO-GO [HC]. @ICR 8835]

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FLIGHT RULES

10A A2-4 EARLY MISSION TERMINATION PHILOSOPHY PRIOR TO COMPLETION OF ASCENT TPS INSPECTIONS (CONTINUED)

D. FOR THE ORBIT PHASE ONLY, CONSIDERATION WILL BE GIVEN TO
CONTINUING WITH THE RENDEZVOUS/DOCKING AND THE TPS
INSPECTIONS/ANALYSIS DEPENDING ON THE SEVERITY OF THE
FAILURE(S) THAT REQUIRE A PLS AND THE RESULTS OF ASCENT
VISIBLE IMAGERY/WING LEADING EDGE (WLE) SENSOR ANALYSIS.
©[CR 8835]

Sound engineering judgment must be utilized if the orbiter sustains a failure requiring an early return and there are significant concerns on the TPS health based on multiple sensor indications including ground or on-board camera systems, wing leading edge sensor indicators, etc. If multiple sources indicate a severe anomalous event such as WLE response on multiple sensors (not explained by a known vehicle event that results in global sensor response), an observed large debris strike in ascent imagery, or missing tile in SRB or ET separation video, it would be prudent to proceed toward a FD2 inspection and/or FD3 RPM along with associated TPS thermal analysis (if required) while accepting the risk of exposure to the next failure in a next PLS situation.

If it is decided to proceed with inspections and rendezvous and the next worse failure occurs that affects components used for entry or landing (flight control systems, landing gear systems, payload bay door systems, etc.), a safe re-entry may not be possible regardless of the TPS inspection/assessment. Similarly, if the next worse failure occurs that affects an orbiter critical system (electrical, life support, data processing), a successful rendezvous may not be possible. Therefore, the decision to proceed with inspection and/or rendezvous must balance several potentially catastrophic scenarios in concert with the concern for TPS health. ©[CR 8835]

FLIGHT RULES

10A_A2-5

MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER
THE COMPLETION OF ASCENT TPS INSPECTIONS @[DN 20]
@[CR 8835]

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A. THIS RULE PROVIDES OVERALL GUIDANCE FOR TPS REPAIR AND EARLY
MISSION TERMINATION IN THE EVENT OF TPS DAMAGE DETECTED AS A
RESULT OF DATA COLLECTION/ANALYSIS OF THE ASCENT TPS
INSPECTIONS.

1. ASCENT TPS INSPECTIONS INCLUDE THE COLLECTION AND
DOWNLINK OF THE FD2 RCC/CREW CABIN INSPECTION, THE FD3
RENDEZVOUS PITCH MANEUVER (RPM) IMAGERY, OR ANY
SUBSEQUENT FOCUSED INSPECTION BY THE CREW/FLIGHT CONTROL
TEAM.
2. THE TPS ASSESSMENT PROCESS INCLUDES AN MMT REVIEW OF THE
ORBITER PROJECT OFFICE IMAGERY/DAMAGE ASSESSMENT TEAM
EVALUATION OF THE TPS USING ANY APPLICABLE ANALYSIS,
TESTING, AND RELEVANT FLIGHT HISTORY.

B. THE MMT TPS ASSESSMENT PROCESS WILL UTILIZE THE FOLLOWING
VEHICLE CLASSIFICATIONS TO GOVERN THE REMAINING MISSION
ACTIVITIES:

1. TPS NO-GO FOR DEORBIT: THE TPS IS NO GO FOR DEORBIT/ENTRY
IF TPS DAMAGE/FAILURE(S) CANNOT BE CLEARED FOR ENTRY
THROUGH ANALYSIS, TESTING, OR SIMILAR FLIGHT HISTORICAL
DAMAGE.

This TPS NO-GO for Deorbit category is designated only for the most severe of TPS damage that would preclude execution of a survivable entry.

2. TPS DAMAGED: THE TPS IS CONSIDERED DAMAGED WHEN THE
DAMAGE/FAILURE(S) ARE LIKELY TO CAUSE SIGNIFICANT
REDUCTION IN STRUCTURAL CAPABILITY DUE TO VARIOUS
ENVIRONMENTAL EFFECTS INCLUDING AEROTHERMAL, THERMAL, AND
STRUCTURAL LOADING.

TPS Damaged indicates that there is a high likelihood that underlying structure will exceed certification limits including a reduction in structural capability, but due to analysis, flight history, or test data, the damage is such that the risk to the crew is higher than a nominal entry but not to the level where loss of crew and vehicle is expected to occur. Examples include RCC/tile/blanket damage resulting in a significant decrease in structural margins in a region where failure modes are potentially catastrophic.
@[CR 8835]

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FLIGHT RULES**10A A2-5 MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER
THE COMPLETION OF ASCENT TPS INSPECTIONS
(CONTINUED)**

3. TPS DEGRADED: THE TPS IS CONSIDERED DEGRADED WHEN DAMAGE/FAILURE(S) RESULT IN LIMITED LOCALIZED STRUCTURAL/TEMPERATURE EXCEEDENCES THAT MAY RESULT IN LIMITED REDUCTION IN STRUCTURAL MARGINS FOR UNDERLYING COMPONENTS. @CR 8835]

TPS Degraded indicates a condition where the TPS has sustained some limited damage but the risk associated with a reentry is comparable with that of a nominal entry although some localized structural damage is possible. An example of this is a condition where analysis cannot show positive margins or acceptable temperatures, but test data/flight experience show a slight risk increase compared to a nominal entry and could result in a turnaround issue (i.e., some gap filler protrusions, blanket tears/protuberances, some instances of tile damage, or other similar TPS damage). The difference between TPS Degraded and TPS Acceptable for Entry is that even though both have been cleared for entry, the Degraded TPS may result in additional turnaround due to localized exceedences. @CR 8861]

4. TPS ACCEPTABLE FOR ENTRY: THE TPS IS DETERMINED TO BE ACCEPTABLE FOR ENTRY WHEN ALL IMAGERY HAS BEEN REVIEWED AND ALL TPS HAS BEEN CLEARED FOR ENTRY VIA ANALYSIS, TESTING, AND RELEVANT FLIGHT HISTORY.

Self-explanatoryC. FOLLOWING THE MMT DETERMINATION OF THE VEHICLE CLASSIFICATION, THE FOLLOWING ACTIONS WILL BE PERFORMED:

1. TPS NO-GO FOR DEORBIT:
- a. IF RENDEZVOUS AND DOCKING HAVE NOT BEEN COMPLETED, ALL POSSIBLE EFFORTS SHOULD BE MADE TO COMPLETE THE RENDEZVOUS AND DOCKING WITH ISS INCLUDING USE OF DEORBIT/ENTRY PROPELLANT IF REQUIRED.
- b. IF DOCKED TO ISS, CSCS/LON WILL BE READIED IN THE EVENT THAT THE TPS DAMAGE CANNOT BE REPAIRED.
- c. IF A REPAIR IS FEASIBLE, THIS WILL BECOME THE HIGHEST MISSION PRIORITY AND WILL BE PERFORMED AS SOON AS PRACTICAL.
- d. IN THE EVENT OF AN EMERGENCY DEORBIT OR NEXT PLS CONDITION PRIOR TO THE COMPLETION AND ANALYSIS OF A REPAIR, THE DEORBIT BURN WILL NOT BE EXECUTED AND CSCS/LON WOULD BE INVOKED. @CR 8835]

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FLIGHT RULES

10A A2-5 MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS (CONTINUED)

The TPS NO-GO for Deorbit category is designated only for the most severe of TPS damage that would preclude execution of a survivable entry. Prior to exposing the crew to the uncertainty of a CSCS/LON rescue, all efforts should be made to develop a comprehensive analysis of the damage, including a review of similar flight history and any relevant Arc Jet or other test data. @CR 8835]

Since the orbiter cannot return safely for this damage category, a repair strategy will be developed to attempt to avoid the CSCS/LON risks. Whether the repair would be executed would depend on the potential effectiveness of the repair and the risk to the crew to perform the repair. Upon completion of a repair (if a repair is attempted), thermal, aerothermal, and structural analysis would be required to determine the likelihood of survivability of the repair and an assessment would be performed to determine whether the damage could be reclassified from NO-GO to another less severe damage category. If the damage is not or cannot be repaired effectively, the crew will not perform a reentry, and CSCS/LON will be invoked.

2. TPS DAMAGED:

- a. IN THE EVENT AN EMERGENCY DEORBIT IS REQUIRED, CSCS WILL NOT BE INVOKED AND AN EMERGENCY DEORBIT WILL BE EXECUTED.
- b. FOR A NEXT PLS, CONSIDERATION WILL BE GIVEN TO PERFORMING A REPAIR PRIOR TO DEORBIT/ENTRY. A RISK ASSESSMENT OF THE REPAIR INCLUDING CREW RISKS AND LIKELIHOOD OF SUCCESS VERSUS THE ADDITIONAL TIME ON ORBIT AND EXPOSURE TO THE NEXT WORST FAILURE WILL BE PERFORMED.
- c. FOR A MINIMUM DURATION FLIGHT OR NOMINAL EOM, A REPAIR WILL BE PERFORMED AS SOON AS PRACTICAL AS LONG AS THE RISK OF THE REPAIR DOES NOT EXCEED THAT OF ENTRY WITH THE EXISTING DAMAGE.
- d. FOR CASES WHERE TPS DAMAGE CANNOT BE REPAIRED OR IF THERE IS SIGNIFICANT UNCERTAINTY IN THE SUCCESS OF THE REPAIR, LANDING SITE SELECTION WILL BE MANAGED PER THE COMPROMISED ORBITER PRIORITIES PER RULE {10A A2-9E}, LANDING SITE SELECTION [HC]. @CR 8835]

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FLIGHT RULES

**10A A2-5 MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER
THE COMPLETION OF ASCENT TPS INSPECTIONS
(CONTINUED)**

TPS Damaged indicates that there is a high likelihood that underlying structure will exceed certification limits including a reduction in structural capability, but due to analysis, flight history, or test data, the damage is such that the risk to the crew is higher than a nominal entry but not to the level where loss of crew and vehicle will occur. For these cases, it is prudent to deorbit the crew in an emergency situation rather than expose them to the risks of CSCS/LON. @ICR 8835]

In a Next PLS case, the risk of the next failure should be weighed against the risk of performing a repair and the risk of entry without repair vs risk of CSCS. This risk assessment should factor in the likelihood of a successful repair, the additional time on orbit while exposed to the next failure, and the crew risk associated with performing a repair. For an MDF or nominal EOM, the repair should be performed if the overall risk to the crew of the repair execution is not higher than returning in a non-repaired condition. If damage of this type is not repaired, there are enough uncertainties in the analysis to warrant an adjustment to the landing site priorities to protect the public. These priorities fall under Rule {10A A2-9}, LANDING SITE SELECTION [HC]. @ICR 8835]

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FLIGHT RULES

10A A2-5 MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS (CONTINUED)

3. TPS DEGRADED: @CR 8835]
- a. IN THE EVENT OF A NEXT PLS OR EMERGENCY DEORBIT, THE
TPS IS ACCEPTABLE FOR ENTRY.
 - b. FOR AN MDF OR NOMINAL EOM, CONSIDERATION WILL BE
GIVEN TO PERFORMING A REPAIR, IF APPLICABLE, WHILE
FACTORING IN MISSION OBJECTIVES, COMPLEXITY OF THE
REPAIR, LIKELIHOOD OF REPAIR SUCCESS, AND
EFFECTIVENESS OF THE REPAIR TECHNIQUE(S).
 - c. FOR CASES WHERE DEGRADED TPS IS NOT REPAIRED, THE
LANDING SITE SELECTION WILL BE MANAGED PER THE EOM
AND SYSTEM FAILURE PRIORITIES AS APPLICABLE.
REFERENCE RULE {10 A2-9C} AND D, LANDING SITE
SELECTION [HC].

TPS degraded indicates a condition where the TPS is not per pre-mission specifications, but the risk associated with a reentry is comparable with that of a nominal entry although some localized structural damage is possible. For these cases, it is acceptable to re-enter without performing a repair. If a repair is possible, it may be prudent to perform a repair to reduce turnaround impact and provide additional thermal/structural margin for entry. An assessment of the impact to the mission, risk to the crew, and benefit of the repair must be performed for these cases.

Additionally, landing site selection will be managed per the nominal EOM or System Failure priorities if failures exist since degraded TPS does not pose a significant increase in entry public risk.

4. TPS ACCEPTABLE FOR ENTRY: THERE ARE NO RESTRICTIONS
FOR ENTRY FOR AN EMERGENCY DEORBIT, PLS, MDF, OR EOM.

Once all the TPS imagery and thermal/structural analysis (when required) has been completed, there are no restrictions to the TPS use during entry whether it be for nominal EOM, next PLS, or emergency deorbit. @CR 8835]

FLIGHT RULES

10A_A2-6

A31P LAPTOP USAGE PRIORITIES

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. ISIS DIGITAL CAMERA (IDC) OPERATIONS @[DN 7]

IDC images are used for analysis of TPS integrity, for RCC in particular.

D. 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.

E. 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.

F. DOUG FOR TRAINED ROBOTIC OPERATIONS @[DN 7]

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.

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FLIGHT RULES

10A_A2-6 A31P LAPTOP USAGE PRIORITIES (CONTINUED)

G. DOWNLINK OF EXTERNAL TANK (ET) UMBILICAL WELL DIGITAL CAMERA IMAGERY @[DN7]

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.

Source: Flight Requirements Document, STS-115, NSTS 17462-115, Rev 028, section 3.1 m 6.

H. MANAGEMENT AND DOWNLINK OF WLES ON-ORBIT DATA @[DN7]

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

10A_A2-7

ORBITER ALONE SRMS/OBSS DAP CONSTRAINTS [HC]
[@\[CR 8798A\]](#)

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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:

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

THE DAP SHALL BE CONFIGURED PER TABLE 10A_A2-7-I.

TABLE 10A_A2-7-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 {10A_C12-4}, SRMS AND ORBITER BOOM SENSOR SYSTEM (OBSS) PARK.

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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 {10A_C12-4}, SRMS AND ORBITER BOOM SENSOR SYSTEM (OBSS) PARK.

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Reference CSDL Memorandum, STS-120 Mated Shuttle/ISS Operations DAP Modes and Constraints.
[@\[CR 8798A\]](#)

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FLIGHT RULES**10A A2-8 ENTRY THERMAL OPTIONS [HC]**

FOR ENTRY WHERE ADDITIONAL THERMAL MARGIN IS DESIRED OR REQUIRED, THE FOLLOWING OPTIONS WILL BE CONSIDERED TO IMPROVE THE VEHICLE ENTRY THERMAL PROFILE. FIRST LEVEL OPTIONS WILL BE CONSIDERED TO PROVIDE MARGIN FOR TPS CATEGORIZED AS EITHER "DAMAGED" OR "DEGRADED." SECOND LEVEL OPTIONS WILL BE CONSIDERED FOR TPS CATEGORIZED AS "DAMAGED." THIRD LEVEL OPTIONS WILL BE CONSIDERED WHEN TPS IS "NO-GO FOR DEORBIT" WHERE CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) IS NOT AN OPTION. @[CR 8839]

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A. FIRST LEVEL - CERTIFIED ENTRY OPTIONS:

1. REDUCE VEHICLE WEIGHT AS MUCH AS PRACTICAL WHILE MAINTAINING AT LEAST SINGLE FAULT TOLERANCE IN ENTRY-CRITICAL SYSTEMS AND PRESERVING FOUR DEORBIT OPPORTUNITIES ON 2 CONSECUTIVE DAYS.
2. UTILIZE CERTIFIED EQUILIBRIUM GLIDE BOUNDARY MARGIN (EGBM) DEORBIT TARGETING METHODOLOGY.
3. MOVE CG AFT WITHIN THE NOMINAL CG BOX (REF RULE {A4-153}, CG PLANNING).
4. MAXIMIZE LOWER SURFACE COLD SOAKING WHILE NOT VIOLATING OTHER ORBITER THERMAL LIMITS.
5. REDUCE ENTRY AND TOUCHDOWN STRUCTURAL LOADS (REF RULE {A2-260}, ENTRY LOAD MINIMIZATION).

B. SECOND LEVEL - OPTIONS THAT MAINTAIN THE ENTRY PROFILE WITHIN SODB VOLUME V GNC PERFORMANCE LIMITS BUT WITHOUT INTEGRATED VEHICLE CERTIFICATION:

1. REDUCE VEHICLE WEIGHT TO MAXIMUM EXTENT POSSIBLE WHILE MAINTAINING AT LEAST SINGLE FAULT TOLERANCE IN ENTRY-CRITICAL SYSTEMS AND PRESERVING AT LEAST ONE DEORBIT OPPORTUNITY TO TWO DIFFERENT LANDING SITES (NOT ON THE SAME REV) ON EOM ONLY.
2. INCREASE ANGLE-OF-ATTACK DURING ENTRY WITHIN SODB GNC LIMITS (REF RULE {A4-207}, ENTRY LIMITS) UTILIZING GMEM WRITE (PREFERRED) OR MANUAL CSS. @[CR 8839]

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FLIGHT RULES**10A A2-8 ENTRY THERMAL OPTIONS [HC] (CONTINUED)**

C. THIRD LEVEL - OPTIONS THAT ARE UNCERTIFIED, CSCS NOT AVAILABLE, AND DEORBIT/ENTRY IS REQUIRED: @[CR 8839]

1. REDUCE VEHICLE WEIGHT TO MAXIMUM EXTENT POSSIBLE.
2. INCREASE ANGLE-OF-ATTACK DURING ENTRY BEYOND SODB GNC ENVELOPE UTILIZING GMEM WRITE (PREFERRED) OR MANUAL CSS.
3. UTILIZE MINIMUM DRAG ENTRY TARGETING METHODOLOGY.
4. CONSIDERATION WILL BE GIVEN TO MAXIMIZE AFT RCS PROPELLANT DEPENDING ON THE DAMAGE SCENARIO.

The intent of this rule is to provide a list of options which are categorized according to their vehicle certification level that can be utilized in any combination to improve the vehicle thermal profile during entry. The levels were grouped in this manner to assist in determining the risk trades as a function of TPS damage. Detailed Boeing aerothermal, thermal, stress, and flight control analysis of the different combination of options will be conducted in real time to determine the appropriate options to select based on damage type, location, and severity.

As a result of the STS-107 accident, extensive analysis was conducted to determine options to reduce heating on the orbiter during entry. This was performed using the 6-DOF Spacecraft Trajectory Analysis and Mission Planning System (STAMPS) simulation for trajectory modeling and the Thermal/Structural Envelope Program (TSEP) to predict temperatures at representative locations. Three body points were analyzed: 5505 (panel 9 wing leading edge (WLE)), 1600 (belly centerline forward of main landing gear door), and 2360 (belly aft of main landing gear door). The results assume a no damage scenario (i.e., standard roughness, nominal aero) and apply to a typical ISS mission (51.6 deg inclination ascending approach into KSC) unless noted otherwise. Techniques identified in the course of the analysis that resulted in a reduction of vehicle heating were organized into the three categories shown in paragraphs A, B, and C.

First Level options - Using SSP-certified operational techniques, it was found that only slight reductions in WLE temperatures (approximately 5 percent or 150 deg) may be achieved. Better results were found for tile acreage, with approximately 20 percent reduction in heat load and 30-40 percent in heat rate for the body points examined. It was found that the modest WLE benefits were evenly split between aggressive weight reduction (43,440 lbs for this analysis) and EGBM targeting. Nearly all thermal benefits for tile acreage were achieved with weight reduction. Although procedures and tools used to model entry effects of vehicle weight reduction are certified, the actual methods necessary to offload this amount of weight would likely fall outside of normal shuttle/ISS operations. @[CR 8839]

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FLIGHT RULES**10A A2-8 ENTRY THERMAL OPTIONS [HC] (CONTINUED)**

Level One methods to reduce the orbiter weight include additional transfer of hardware during docked operations and consumables offloads. FCOH SOP 16.11 specifies items that may be offloaded to reduce orbiter mass. Orbiter consumables (prop, cryo, and water) will be managed to minimize landing weight while protecting two deorbit opportunities on both EOM and EOM+1 with minimal dispersion protection. ©[CR 8839]

Targeting an EGBM of +2 fps² is a certified deorbit burn targeting methodology that maintains adequate margins on entry drag and ranging. EGBM produces a heating profile off the thermal trade-off line (TTOL) and, by itself, results in increased heatload for some locations. Therefore, use of EGBM is dependent on the type and location of TPS damage incurred. It should be noted that OPS 3 ENTRY TRAJ display I-loads are generated for TTOL entry profiles; therefore, the shuttle bug will not track down the nominal line during an EGBM entry.

Aft cg movement provides modest thermal improvements for tile acreage. The analysis showed approximately 10 percent reduction in heat load and 10-20 percent in heat rate for body points 1600 and 2360 when the cg was moved aft by 20.9 inches. This, however, resulted in higher elevon surface temperatures and provided little thermal relief for the WLE. Therefore, use of this technique will be highly dependent on damage location.

STS-107 post-flight analysis showed that maximizing lower surface cold soak time had a small effect on delaying the onset of maximum temperatures. Similar minor thermal effects were observed when approach direction, crossrange, N-CYCLES, and apogee height were varied. Nevertheless, these techniques should be examined on a mission-specific basis as required in order to achieve the maximum effect.

Due to thermal stresses that may result from TPS damage and/or off-nominal entry thermal profiles, entry and landing loads should be minimized to the extent practical when these techniques are utilized. This may also include selection of straight-in HAC. Reference Rule {A2-260}, ENTRY LOAD MINIMIZATION. ©[CR 8839]

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FLIGHT RULES**10A A2-8 ENTRY THERMAL OPTIONS [HC] (CONTINUED)**

Second Level options - Additional techniques outside normal operating practices were identified that provide further thermal reductions. Flying a higher angle-of-attack prior to Mach 12 has been shown to reduce WLE temperatures. Simulation of the STS-107 entry with a 45-deg angle-of-attack indicates another 5 percent reduction (150-180 deg) is possible beyond that achieved with Level One techniques. A baseline Level Two alpha profile of 43 deg with no alpha modulation was selected for further analysis (as compared to a nominal entry profile of 40 ±3 deg). This provides 1 deg margin from the 44 deg GNC limit in NSTS 08934, Shuttle Operational Data Book, Vol V in order to protect against dispersions due to winds, IMU platform misalignment, and flight control. While technically within alpha cert limits, this profile falls outside the integrated vehicle certification envelope for thermal and flight control. It should also be noted that increasing the angle-of-attack moves the stagnation point lower on the WLE; therefore, location of damage along the WLE must be considered in the selection of an off-nominal alpha profile.

©ICR 8839]

Alpha modulation was disabled in order to fly the highest possible alpha profile, thus maximizing thermal benefit. This also yields a more predictable alpha and thermal profile. An undesirable effect of eliminating alpha modulation was a reduced ability to maintain actual drag on drag reference since alpha modulation provides a short-term drag control channel. This led to larger bank angle oscillations and decreased trajectory damping as guidance attempted to control drag. Another effect of higher alpha was decreased vehicle L/D, which led to a greater tendency towards roll limiting and approximately 100 nm less crossrange capability. Despite this, overall guidance performance was shown to be acceptable. A 500 cycle STAMPS Monte-Carlo study showed a 3-sigma range error at TAEM interface of only 2.2 nm (well within TAEM guidance capability). Since TSEP is not valid outside the nominal range of alpha, further analysis with Boeing aerothermal tools would be required in order to quantify the thermal benefit prior to implementing this technique.

Flying the off-nominal alpha profile would require either manual CSS or a GPS memory write (GMEM) update to overwrite angle-of-attack I-loads in the onboard GPC's. The GMEM option is preferred since it allows auto DAP during entry, resulting in a more predictable alpha and resultant heating profile, as opposed to manual CSS. The PASS I-loads may be modified via uplink to the G3 archive in OPS 2. The BFS can be configured directly by uplinking the GMEM in OPS 3. MCC tools would also require reconfiguration to properly target the deorbit burn and model entry performance.

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FLIGHT RULES**10A A2-8 ENTRY THERMAL OPTIONS [HC] (CONTINUED)**

Level Two includes more aggressive weight reduction efforts including offload of payload and orbiter hardware to the maximum extent possible (including jettison of hardware). Consumables management should strive to minimize vehicle weight as much as possible while maintaining consumables to support deorbit opportunities to two different sites on EOM with minimal dispersion protection. Turnaround issues associated with weight reduction or trajectory shaping will not be a consideration in the implementation of Level Two options. @ICR 8839]

Third Level options - Third Level options are used when there is severe TPS damage and no other alternative to deorbit/entry. These would be employed only as a last resort in order to attempt to safely return the crew and vehicle. Analysis indicates more significant reductions in vehicle heating can be achieved utilizing uncertified techniques, such as increasing alpha beyond the SODB GNC limit, and entering below the equilibrium glide boundary. A baseline Level Three trajectory with 50-deg angle-of-attack, no alpha modulation, and EGBM range between -3.5 to -5.0 fps^2 was assessed in multiple STAMPS Monte-Carlo studies. Preliminary Boeing thermal analysis showed WLE Panel 9 temperature reductions of approximately 17 percent (approximately 500 deg).

Detailed examination of STAMPS results for Level Three show guidance exhibiting similar, but more pronounced, results as those described for Level Two above. As expected, the combination of reduced L/D and very low energy resulted in extended periods of unconverged drag and roll saturation at zero deg for many cases. All sims made the runway, but the 3 sigma range error at TAEM interface was 4.6 nm, with the worst-case error being 20 nm (out of 500 cases). Additional Monte-Carlo runs determined that crossrange must be limited to 200 to 300 nm for EGBM -5.0 and -3.5, respectively, due to reduced L/D. Increased RCS usage, more than 2X the entry redline, was observed in many cases. This was primarily due to two factors: non-optimal guidance gains and occasional guidance roll limiting. The C16 gain used in computing roll command is designed for 40-deg alpha, and makes guidance overly sensitive to drag errors at higher alphas and lower drag levels. This gain may be adjusted via GMEM to remove this effect if desired. The second cause occurs when guidance limits roll commands to a non-zero value when the vehicle is banked towards the landing site. This may result in roll command oscillations between 0 deg (for ranging) and 20 or 15 deg (for delta-azimuth control). This "roll jitter" may be avoided by flying roll/yaw CSS during the region of concern. Consideration will be given to maximizing RCS propellant for Level Three options. @ICR 8839]

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FLIGHT RULES

10A A2-8 ENTRY THERMAL OPTIONS [HC] (CONTINUED)

Implementing Level Three options requires similar console and crew procedures as those listed in the second level. However, confidence in thermal, trajectory, and flight control predictions is significantly decreased due to use of techniques beyond the vehicle certification envelope. A reduced cg envelope may be required for flight control stability in these cases. Another important caveat to these results is that vehicle aerodynamics and heating assume there is no damage to the vehicle. Localized heating may be higher than predicted if the actual repair moldline is significantly different than the analyzed repair moldline and vehicle roughness. Additionally, the analysis did not factor in any aerodynamic changes such as early boundary layer transition as a result of the damage or damage repair. Extensive mission-specific analysis would be required to better quantify these risks in order to trade this option against CSCS if available. Vehicle reflight will not necessarily be protected for Level Three implementation.
@[CR 8839]

Reference A/EFTP's #205, September 17, 2004; #206, October 22, 2004; #208, December 10, 2004; and #209B January 25, 2005; and STSOC transmittal ADFD-05-012.

Reference Rule {10A A2-5}, MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS.

Reference Hazard Report ORBI 007, Debris Impact with the Orbiter. @[CR 8839]

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FLIGHT RULES

10A A2-9 LANDING SITE SELECTION [HC]

THE FOLLOWING EXCEPTIONS TO RULE {A2-207}, LANDING SITE SELECTION [HC], ARE APPLICABLE FOR STS-120/10A: @[CR 8837]

Due to 2007 Space Shuttle Program Probabilistic Risk Analysis (PRA) updates and an incorporation of the latest LANDSCAN 2005 population database, the overall shuttle entry public risk has improved by approximately 15 percent. This improvement warranted a change to the crossranges in Rule {A2-207C} and E, LANDING SITE SELECTION [HC], EOM Priorities, and Compromised Orbiter Priorities, for STS-120/10A. The updates documented in this annex rule were reviewed by Ascent/Entry Flight Techniques Panel #231 on May 18, 2007.

A. RTLS/TAL PRIORITIES: NO EXCEPTIONS

B. AOA PRIORITIES: NO EXCEPTIONS

C. EOM PRIORITIES:

1. KSC

2. EDWARDS 22/04

3. NORTHROP

NOTE: WHEN FEASIBLE AND WHILE SATISFYING OTHER LANDING SITE SELECTION PRIORITIES FOR WEATHER, CONSUMABLES, RUNWAY CONDITIONS, AND ENTRY CONSTRAINTS, THE FOLLOWING CROSSRANGES WILL BE AVOIDED IN ORDER TO ABATE RISK TO THE GENERAL PUBLIC:

	<u>ASCENDING LEFT</u>	<u>ASCENDING RIGHT</u>
<u>KSC</u>	<u>NONE</u>	<u>NONE</u>
<u>EDW 22</u>	<u>335-637 NM</u>	<u>NONE</u>
<u>EDW 04</u>	<u>0-22 NM</u> <u>356-680 NM</u>	<u>0-158 NM</u>
<u>NOR 17</u>	<u>NONE</u>	<u>720-731 NM</u>
<u>NOR 35</u>	<u>NONE</u>	<u>722-730 NM</u>

Due to the advantages in vehicle turnaround, the Space Shuttle Program has directed that nominal end of mission (EOM) landings utilize KSC as the first priority landing site. @[CR 8837]

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FLIGHT RULES**10A A2-9 LANDING SITE SELECTION [HC] (CONTINUED)**

After KSC, next in the EOM runway selection priority is Edwards AFB, because of the availability of the concrete runway and because of the significant vehicle post landing and turnaround operations capabilities. NOR is generally last priority; although it provides an excellent orbiter landing site (laser-leveled runways, crossing runways, significant runway lateral and longitudinal margin, all required landing aids, and NAVAIDS for day and night, etc.), the ability to support the orbiter systems post landing and for turnaround/ferry operations is much reduced as compared to KSC or Edwards, resulting in the potential for significant (several weeks) shuttle schedule/manifest impacts. @JCR 8837 _]

As a result of NASA Range Safety policy (reference NASA Procedural Requirements, NPR 8715.5, Range Safety Program), entry public risk is a consideration in space shuttle landing site selection. The Space Shuttle Program and the Agency have determined that the entry public risk associated with the highest risk ascending landing opportunity to KSC is acceptable for the remaining space shuttle missions. This is because of the established space shuttle design and operational constraints and, further, because any significant changes to shuttle entry operations could have a negative effect on the crew and mission. Additionally, the combination of STS hardware improvements, launch and orbit imagery capability, and post launch vehicle inspections established for Return to Flight (RTF) provides significant abatement for entry public risk. Finally, since all ascending approaches to KSC from the ISS orbit are of the same order of magnitude relative to entry public risk, there are no entry public risk restrictions for any EOM KSC ascending approach.

When EDW and NOR must be utilized, the level of risk defined by the highest risk KSC opportunity serves as benchmark to define higher risk crossranges that should be given special consideration. For EDW-04, ascending left crossranges from 0-22 nm and 356-680 nm along with ascending right crossranges from 0 to 158 nm exceed the highest risk KSC opportunity. For EDW-22, only ascending left crossranges from 335-637 nm exceed this limit. For Northrup 17 landings, ascending right crossranges from 720-731 nm exceed that of the highest risk KSC opportunity. For Northrup 35 landings, ascending right crossranges from 722-730 nm exceed that of the highest risk KSC opportunity. When Edwards or Northrup is required, the deorbit/entry approach should be selected to avoid these crossranges to the extent feasible and when not precluded by other high priority requirements that provide for a safe entry and landing such as weather, consumables, runway conditions, entry constraints, crew health, etc.

For PLS planning, the special EDW and NOR crossrange placards will not be utilized to select the daily and/or no comm PLS to maximize operational flexibility and number of landing opportunities available. Once a PLS is declared, this rule will be utilized to determine the correct landing site and deorbit opportunity. @JCR 8837 _]

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FLIGHT RULES**10A A2-9 LANDING SITE SELECTION [HC] (CONTINUED)**

Additionally, EOM descending opportunities are not used operationally on ISS missions because of significant impacts to the crew timeline and sleep shifting, noctilucent clouds concerns during the summer months (June through August), and an additional 15 fps propellant cost for the deorbit burn, which is not budgeted for pre-mission. However, if a descending opportunity were planned for nominal EOM, there are no restrictions for Edwards approaches. KSC-15 opportunities for descending right 749-758 nm will be avoided to the extent feasible. KSC-33 opportunities from descending left 741-777 nm along with descending right 737-771 nm will also be avoided to the extent feasible. Finally, Northrup descending left opportunities from 767-784 nm will be avoided to the extent feasible. @ICR 8837]

Finally, EDW-04 opportunities with ascending left crossranges from 8 nm to 35 nm need to be carefully evaluated using established Flight Dynamics Officer and Entry Support procedures to ensure that initial bank direction is in the expected direction (to the left). Based on this analysis, the EDW-04 crossrange placards for these opportunities may need to be expanded.

Reference: Program Requirements Control Board, December 2, 2004; AEFTP #209A, January 21, 2005; and AEFTP #231, May 18, 2007.

Reference Rule {A4-109}, DEORBIT PRIORITY FOR EOM WEATHER.

Reference Rule {A2-202}, EXTENSION DAY GUIDELINES, for cases where the PLS is NO-GO.

D. SYSTEMS FAILURE PRIORITIES: NO EXCEPTIONS

E. COMPROMISED ORBITER PRIORITIES:

1. FOR THE PURPOSES OF ENTRY PUBLIC RISK ONLY, A COMPROMISED ORBITER IS A CONDITION THAT SUBSTANTIALLY REDUCES THE LIKELIHOOD OF A NOMINAL ENTRY INCLUDING:

- a. LOSS OF ALL FAULT TOLERANCE IN AN ENTRY CRITICAL SYSTEM DUE TO A COMMON CAUSE FAILURE MODE
- b. APU, OMS, RCS FUEL LEAK WITH RISK OF FUEL COMBUSTION DURING ENTRY
- c. STUCK OR MECHANICAL DEGRADATION OF ANY AEROSURFACE ACTUATOR (ELEVON, BODYFLAP, SPEEDBRAKE, OR RUDDER)
- d. THERMAL PROTECTION SYSTEM (TPS) CATEGORIZED AS "TPS DAMAGED" WHICH CANNOT BE REPAIRED OR HAS SIGNIFICANT UNCERTAINTY IN THE SUCCESS OF THE REPAIR. @ICR 8837]

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FLIGHT RULES

10A A2-9 LANDING SITE SELECTION [HC] (CONTINUED)

- e. ENTRY CRITICAL STRUCTURAL OR MECHANISM DAMAGE
@ICR 8837]
- f. ANY CONDITION(S) THAT CAUSE THE ORBITER TO FLY
OUTSIDE CERTIFIED ENTRY CAPABILITY

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2. IN THE CASE OF A COMPROMISED ORBITER, WHEN LANDING IS
REQUIRED AND/OR CONTINGENCY SHUTTLE CREW SUPPORT NOT
AVAILABLE, THE EOM PRIORITIES ARE MODIFIED TO FURTHER
ABATE RISK TO THE GENERAL PUBLIC BY SELECTING SPECIFIC
LOWER PUBLIC RISK APPROACHES. FOR NORTHRUP AND EDWARDS,
THE SPECIFIC CROSSRANGES IN THE TABLE WILL BE TARGETED:

- a. NORTHRUP
- b. EDW 22/04
- c. KSC

<u>CROSSRANGE</u>	<u>ASCENDING LEFT</u>	<u>ASCENDING RIGHT</u>
<u>NOR 17</u>	<u>0-430 NM</u>	<u>0-178 NM</u> <u>230-630 NM</u> <u>780-830 NM</u>
<u>NOR 35</u>	<u>0-462 NM</u>	<u>0-140 NM</u> <u>167-227 NM</u> <u>269-649 NM</u> <u>772-828 NM</u>
<u>EDW 22</u>	<u>NONE</u>	<u>459-617 NM</u> <u>670-702 NM</u>
<u>EDW 04</u>	<u>NONE</u>	<u>410-600 NM</u>
<u>KSC</u>	<u>NONE</u>	<u>NONE</u>

A compromised orbiter is defined as any condition or failure that substantially reduces the likelihood of a nominal entry and landing. A compromised orbiter results from a loss of all fault tolerance in an entry critical system due to a common cause failure mode or known damage in vehicle structures, mechanisms, or thermal protection system (TPS), or any scenario that is predicted to result in conditions that cause the orbiter to fly outside the certified entry capability. In order to meet the compromised orbiter definition, there must be a known pre-deorbit burn condition where there is a significant increased risk of loss of control during entry such as those listed in Paragraph E1. Since it is impossible to list all possible compromised orbiter scenarios, other failures with a significantly increased risk of loss of control during entry may be evaluated in real time. @ICR 8837]

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FLIGHT RULES

10A A2-9 LANDING SITE SELECTION [HC] (CONTINUED)

Loss of Entry Critical Fault Tolerance: Loss of all fault tolerance (i.e., zero fault tolerant configuration) in an entry critical system does not constitute a compromised orbiter scenario unless that loss of fault tolerance is due to a common cause failure mechanism (i.e., generic failure mode). For a loss of all fault tolerance in an entry critical system unrelated to common cause, the EOM priorities shall be followed and are as listed in Paragraphs C and D of this rule. ©[CR 8837]

APU, OMS, RCS Fuel Leaks: OMS, RCS, or APU fuel leaks pose a significant risk of combustion and collateral damage in the associated pod or aft part of the vehicle during the subsonic portion of entry.

Stuck or Mechanically Degraded Aerosurface: These are Crit 1/1 failure modes that the vehicle Flight Control System (FCS) was not designed to accommodate. Other FCS Channel problems are governed by Paragraph TBD.

TPS: The TPS "Damaged" category indicates that there is a high likelihood that underlying structure will exceed certification limits including a reduction in structural capability, but due to analysis, flight history, or test data, the damage is such that the risk to the crew is higher than a nominal entry but not to the level where loss of crew and vehicle will occur. This category results in a significant risk to the crew/orbiter/general public as compared with a nominal entry. As a result, risk to the general public will be abated by reprioritizing landing sites and restricting orbiter crossranges. Upon completion of a repair, an orbiter assessment would be performed and the MMT would determine whether the damage could be reclassified from "Damaged" to another less severe category, thus, precluding the need to restrict landing site/crossrange to abate public risk.

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A compromised orbiter entry will be performed to Northrup, Edwards, and KSC, in that order of priority and within the landing site crossrange restrictions listed, in order to abate the public risk to the extent feasible while maintaining a CONUS PLS landing capability. The crossranges identified in Paragraph E reduce risk to the general public by approximately one order of magnitude when compared to the highest risk KSC opportunity.

Although descending opportunities are not planned to be used pre-mission, if they are utilized in a compromised orbiter scenario, the following crossranges should be utilized provided mission specific crossrange limits are met. ©[CR 8837]

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FLIGHT RULES

10A A2-9 LANDING SITE SELECTION [HC] (CONTINUED)

<u>CROSSRANGE</u>	<u>DESCENDING LEFT</u>	<u>DESCENDING RIGHT</u>
<u>NOR 17</u>	<u>476-512 NM</u> <u>128-474 NM</u>	<u>29-189 NM</u> <u>204-410 NM</u> <u>497-600 NM</u>
<u>NOR 35</u>	<u>131-527 NM</u>	<u>34-198 NM</u> <u>201-416 NM</u> <u>497-604 NM</u>
<u>EDW 22</u>	<u>≥ 764 NM</u> <u>694-709 NM</u>	<u>≥ 831 NM</u> <u>769-784 NM</u>
<u>EDW 04</u>	<u>> 665 NM</u>	<u>773-786</u>
<u>KSC</u>	<u>NONE</u>	<u>NONE</u>

@ICR 8837 1

Contingency Shuttle Crew Support (CSCS): Situations where CSCS will be considered are not defined by this rule, which provides guidance on the landing site priorities in scenarios with entry critical TPS damage and other significant orbiter failures. Rule {10A C2-105}, ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON), provides guidance on the scenarios where CSCS/LON should be considered. These include orbiter systems failures that result in the inability of the orbiter to perform a successful entry and landing or result in a low probability of a successful entry and landing. In fail critical scenarios, CSCS can also be used to provide time to properly assess and evaluate the systems failures and the risks of entry and landing.

There are cases where CSCS may not be available due to ISS or orbiter failures such as the inability to dock (ATO abort, propellant system failure, etc.). There are also other specific ISS failures where the risk of CSCS may be greater than the risk of entering with TPS damage or some other significant orbiter failure. These must be considered on a case by case basis since each and every scenario is unique. In those cases where entry is the option that is deemed necessary, this rule provides the CONUS landing site options that minimize risk to the public per NASA Range Safety policy (reference NASA Procedural Requirements, NPR 8715.5, Range Safety Program).

F. PREDEORBIT LANDING SITE EVALUATION: NO EXCEPTIONS

Entry Critical Structural Damage: Any damage to structure or mechanisms that provides insufficient thermal or structural margin for entry and landing will be placed in the compromised orbiter category (i.e., a vent door or star tracker doors failed open).

Conditions Outside Certified Entry Capability: When an entry is planned such that the vehicle is flying outside the certified analyzed entry capability, the compromised orbiter landing site considerations apply. One known exception to this category is a landing weight exceedance that is subsequently cleared through thermal and/or structural analysis.

Reference Rule {10A A2-5}, MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS. @ICR 8837 1

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FLIGHT RULES

10A A2-10 RENDEZVOUS MANEUVER EXECUTION

A. ALL MANEUVERS COMPONENTS WILL BE TRIMMED TO VGO < 0.2 FPS IN ALL AXES. @CR 8886]

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Based on flight experience, the required trim, < 0.2 fps, is the best trim accuracy achievable by the crew on a consistent basis. This accuracy is required during rendezvous to keep deviations from pre-mission and real-time planned profiles to a minimum.

B. MIDCOURSE MANEUVERS, MC1, MC2, AND MC3, AS WELL AS THE OUT-OF-PLANE NULL WILL ALWAYS BE EXECUTED.

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Midcourse maneuvers are designed to correct the orbiter intercept trajectory based on the most current relative state information. Even with no additional relative state sensor data, these maneuvers correct for trim errors from previous burns and attitude maneuver effects that are sensed via the accelerometers. Additionally, executing MC1 reduces the probability of experiencing targeting alarms and/or significant TIG slips at MC2 as a result of these dispersion effects. Executing MC2 with its elevation angle constraint reduces dispersions at the manual phase take-over point. The radar fail correction burn "rule of thumb" used in the radar fail procedures at MC3 + 2 min is most valid when the MC3 burn is executed, resulting in a more benign manual phase and slightly lower prop usage (ref. Orbit Flight Techniques Panel #166, June 26, 1998). The out-of-plane null is performed when the orbiter is at the out-of-plane node which is the optimum point to null out-of-plane motion.

This rule is a result of the implementation of the ORBT Rendezvous Profile baselined during Orbit FTP #161, February 14, 1997.

C. MC4 WILL NOT BE PERFORMED IN RADAR FAILED CASES.

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The radar fail procedures have the CDR begin manual piloting immediately after MC3, so MC4 should not be performed in this case. The onboard navigation state is not accurate enough to support a targeted intercept of the Rbar when the radar is failed.

IN THE EVENT THAT RADAR DATA BECOMES AVAILABLE POST-MC2, THE DATA MAY BE INCORPORATED INTO THE NAV FILTER BUT WILL NOT BE USED FOR ORBITER POINTING OR TARGETING. RADAR FAILED PROCEDURES WILL CONTINUE TO BE PERFORMED UNLESS MCC DEEMS THAT THE ONBOARD RELATIVE STATE IS SUFFICIENTLY CONVERGED AND THAT THE TRAJECTORY WOULD BENEFIT FROM A TARGETED MC4 BURN. @CR 8886]

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FLIGHT RULES

10A A2-10 RENDEZVOUS MANEUVER EXECUTION (CONTINUED)

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In the event that a previously failed (or unavailable) radar system becomes available after MC2, then radar failed procedures will continue to be executed including the MC3 + 2 minute radar failed correction burn based on target position in the -Z COAS. Since the radar failed correction burn is dependent on orbiter pointing (i.e., position of target in -Z COAS), the radar data may be incorporated into the FLTR vector only if the PROP vector has been selected as the UPP source on RelNav (SPEC 33) so as not to impact the target track attitude. At this point, the radar failed procedures are at least as good as executing MC3 and MC4 off an onboard relative state that may not be completely converged. The ground has the authority to return the crew to nominal MC3 and MC4 targeting making use of the new radar sensor data if it can be shown in real time that the onboard relative state is sufficiently converged and the trajectory would benefit from targeted burns. In general, targeted burns will benefit trajectories that are short of the targeted MC4 point while radar failed procedures are better suited for long trajectories. ©[CR 8886]

This rule is a result of the implementation of the ORBT Rendezvous Profile baselined during Orbit FTP #161, February 14, 1997. ©[CR 8886]

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FLIGHT RULES**10A A2-11 OMS/RCS MANEUVER CRITICALITY**

A. DELTA V MANEUVERS CRITICAL FOR CREW SAFETY WILL BE TARGETED SUBJECT TO THE FOLLOWING GUIDELINES: @CR8811A]

1. OMS-1, OMS-2, AND DEORBIT BURNS WILL BE PERFORMED USING TWO OMS ENGINES UTILIZING DUAL OR SINGLE-DOWNMODE CAPABILITY (AS AVAILABLE) IF REQUIRED TO MEET DELTA V REQUIREMENTS.
2. SPACECRAFT SEPARATION BURNS WILL BE PLANNED SUCH THAT A SINGLE-DOWNMODE CAPABILITY (OMS OR RCS) EXISTS TO MEET MINIMUM DELTA V REQUIREMENTS.

B. FLIGHT SUCCESS DELTA V MANEUVERS ARE DEFINED AS THOSE MANEUVERS ESSENTIAL TO FLIGHT SUCCESS WHICH CANNOT BE POSTPONED BEYOND THE SPECIFIED TIG SLIP. A SINGLE DOWNMODE ACTION WILL BE ACCOMPLISHED IF REQUIRED TO COMPLETE A FLIGHT SUCCESS DELTA V MANEUVER IF THE FOLLOWING APPLY:

1. A PROPELLANT SYSTEM FAILURE DOES NOT EXIST

AND

2. PROPELLANT IS AVAILABLE TO COVER A MEAN RENDEZVOUS AND THE GREATER OF RCS SHALLOW DEORBIT DELTA V REQUIREMENTS WITH NODE 2 OR RCS STEEP DEORBIT DELTA V REQUIREMENTS WITHOUT NODE 2.

C. NONCRITICAL DELTA V MANEUVERS ARE DEFINED AS ALL THOSE MANEUVERS WHICH DO NOT FALL IN THE CATEGORIES DEFINED IN PARAGRAPHS A AND B. DOWNMODING TO COMPLETE A NONCRITICAL BURN IS NOT ALLOWED.

For all maneuvers critical for crew safety, engine downmode capability is required to maintain fail-safe engine redundancy during the burn. Single OMS engine burns with downmode capability to the RCS +X jets are preferable to dual OMS engine burns, minimizing OMS engine starts, and increasing OMS engine lifetime. Sufficiently large delta V maneuvers such as OMS-1, OMS-2, and the deorbit burn will be performed using two OMS engines in order to avoid any OMS valve reconfiguration during a nominal burn (i.e., crossfeeding halfway through the burn so that OMS propellant remains balanced) and to reduce the amount of OMS propellant required for the burn if the downmode option is utilized.
@CR8811A]

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FLIGHT RULES**10A A2-11 OMS/RCS MANEUVER CRITICALITY (CONTINUED)**

For spacecraft separation burns, downmoding will be performed only to satisfy the minimum delta V requirement necessary to avoid any orbiter damage from the spacecraft PKM firing. Following an OMS engine failure, propellant redlines must be redefined to protect RCS steep deorbit capability and propellant may not be available to complete the separation maneuver to the nominal delta V requirement. ©[CR 8811A]

Downmoding will be performed on flight success delta V maneuvers only for OMS engine failures providing preburn analysis shows that sufficient propellant is available to protect the greater of RCS shallow deorbit delta V and prebank requirements with Node 2 onboard or RCS steep deorbit delta V requirements after Node 2 has been successfully transferred to the ISS. If sufficient OMS propellant is not available to fully support RCS deorbit delta V requirements, protecting RCS propellant for Aft and/or Forward perigee adjusts is acceptable. For a propellant system failure or an engine failure and insufficient propellant remaining to protect a mean rendezvous and the greater of RCS shallow deorbit capability with Node 2 or RCS steep deorbit capability without Node 2, the burn must be terminated and deorbit will be attempted at the next PLS opportunity.

Protecting propellant for an RCS shallow deorbit with the payload provided that RCS steep deorbit is regained after the payload is deployed was accepted for STS-117/13A with the S3/S4 truss at A/EFTP #227 on February 16, 2007. This propellant protection philosophy was subsequently accepted by DA8 for future flights with a single deployable payload whose mass affects the capability to protect RCS steep deorbit. Although specific updates will not be made, additional rules may be affected by this protection philosophy, including:

{A2-108}, CONSUMABLES MANAGEMENT.

{A2-201}, DEORBIT GUIDELINES.

{A2-1001}, ORBITER SYSTEMS GO/NO GO [HC].

{A4-103}, OFF-NOMINAL ORBITAL ALTITUDE RECOVERY PRIORITIES.

{A6-51}, OMS FAILURE MANAGEMENT [CIL] [HC].

{A6-107}, OMS ENGINE FAILURE MANAGEMENT.

{A6-303}, OMS REDLINES [CIL].

{A6-1001}, OMS/RCS GO/NO GO CRITERIA [CIL].

Downmoding will not be performed on noncritical burns so that propellant redlines can be redefined prior to committing propellant to a delta V maneuver unnecessarily. ©[CR 8811A]

FLIGHT RULES

ISS ONLY RULES

10A_B2-1 CONTINGENCY EVA'S

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

- A. COMPLETE 10A ASSEMBLY TASKS: @[DN 36]
 - 1. INSTALL NODE 2 ON-ORBIT INSTALLABLE HANDRAILS.
 - 2. NODE 2 GAP SPANNER INSTALLATION
 - 3. INSTALL NODE 2 WIFS.
 - 4. NODE 2 PDGF AND TERMINATOR/COVER INSTALL
 - 5. RELEASE NODE 2 ZENITH ACBM PETAL RESTRAINTS AND REMOVE UP TO 4 NODE 2 RADIAL HATCH LATCH PINS.
 - 6. BSP RETRIEVE
 - 7. RPCM S0-4BC REMOVE AND REPLACE
 - 8. SFU CONFIG FOR S1 RADIATOR DEPLOY (AND POST-DEPLOY CONFIG)
- B. REPLACE AN EXTERNALLY LOCATED MDM (LOCATED ON PMA 1, S0, S1, P1, S3/S4, OR P3/P4).
- C. REPLACE SEQUENTIAL SHUNT UNIT (SSU).
- D. REMOVE/STOW BATTERY CHARGE/DISCHARGE UNIT (BCDU).
- E. NH₃ LEAK REPAIR (FLUID LINE ANCHOR PATCH (FLAP) AND LAUNCH-ON-NEED OF FLUID LEAK DETECTOR)
- F. REPLACE PHOTOVOLTAIC CONTROL UNIT (PVCU) MULTIPLEXER-DEMULPLEXER (MDM).
- G. REPLACE EXTERNAL THERMAL CONTROL SYSTEM (ETCS) PUMP MODULE ASSEMBLY. @[DN 36]

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FLIGHT RULES

10A_B2-1 CONTINGENCY EVA'S (CONTINUED)

- H. REPLACE MAIN BUS SWITCHING UNIT (MBSU). @[DN 36]
- I. REPLACE EXTERNAL (EXT) MDM.
- J. REPLACE DC SWITCHING UNIT (DCSU).
- K. REPLACE INTERFACE HEAT EXCHANGER.
- L. REPLACE FLEX HOSE ROTARY COUPLER (FHRC).
- M. REPLACE DC-DC CONVERTER UNIT (DDCU-E).
- N. REPLACE PUMP FLOW CONTROL SUBASSEMBLY (PFCS) ON PVTCS.
- O. MANUAL POSITIONING OF SOLAR ARRAYS
- P. CBM CONTINGENCIES
 - 1. REMOVE AND REPLACE CBM CONTROLLER PANEL ASSEMBLY (CPA).
 - 2. REMOVE AND REPLACE CENTER DISK COVER.
 - 3. MANUALLY OPEN/CLOSE CBM PETAL.
 - 4. CLEAR/RESTRAIN CBM CAPTURE LATCH.
 - 5. REMOVE AND REPLACE CBM CAPTURE LATCH.
 - 6. REMOVE AND REPLACE CBM PETAL.
 - 7. REMOVAL OF RTL

The tasks listed in this rule are compiled from the requirements in the Increment Definition and Requirements Document (IDRD). @[DN 36]

FLIGHT RULES

10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC]

- A. THE FLIGHT ATTITUDES AND THEIR ASSOCIATED ATTITUDE ENVELOPES DEFINED IN TABLE 10A_B2-2-I PROVIDE THE LIMITING ATTITUDE ENVELOPE VALUES IN THE EVENT THAT THE EATCS ATTITUDE ENVELOPE CONSTRAINTS IN TABLE 10A_B2-2-II ARE EXCEEDED. @[DN 156]

TABLE 10A_B2-2-I - ATTITUDE ENVELOPE LIMITS IF EATCS ATTITUDE CONSTRAINTS ARE EXCEEDED

REFERENCE FRAME	BETA	ATTITUDE NAME	APPROVED ATTITUDE RANGES		
			YAW	PITCH	ROLL
ISS LVLH	$\beta < -52^\circ$	+ZLV +XVV	-5° TO +15°	-20° TO +15°	0° TO +15°
	$-52^\circ < \beta < +52^\circ$		-15° TO +15°	-20° TO +15°	-15° TO +15°
	$\beta > +52^\circ$		-15° TO +5°	-20° TO +15°	-15° TO +5°
	$\beta < -52$	+ZLV -XVV	+165° TO +185°	-20° TO +15°	-15° TO +5°
	$-52 \leq \beta \leq +52$		+165° TO +195°	-20° TO +15°	-15° TO +15°
	$\beta > +52$		+175° TO +195°	-20° TO +15°	0° TO +15°

The nominal flight attitudes and their associated attitude envelopes and constraints are identified in Table 10A_B2-2-I above and do not take into account ETCS analysis. Table 10A_B2-2-II was developed to capture these attitude envelope modifications.

The TRRJ Autotrack algorithm requires attitude specific PPL's to operate per design, per Rule {10A_B18-**TBD**}, TRRJ AUTOTRACK BIAS MANAGEMENT. In the event that Autotrack is not used, the TRRJ will be parked per analyzed parking Tables in Rule {10A_B18-2}, MANUAL TRRJ POSITIONING.

These PPL's and parking tables were constructed around the predicted tea's (± 5 deg per axis) at the time of the active thermal control system (ATCS) analysis. These same TEA's were used to construct the attitude envelopes in Table 10A_B2-2-II.

It is understood that based upon a number of variables, the TEA's analyzed by ATCS could differ from the ones that the GN&C attitude controllers (which are certified to meet the +ZLV \pm XVV attitude envelope requirements) will try to maintain when they are implemented on-orbit. In the event that the actual, on-orbit TEA's fall outside of the range of the attitude envelopes shown in Table 10A_B2-2-II, but remain within the bounds of Table 10A_B2-2-I, guidance is provided in the Table Notes on the positioning of the TRRJ's. @[DN 156]

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FLIGHT RULES

10A_B2-2

PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE
DEVIATIONS [HC] [RC] (CONTINUED)

1. TRANSITORY EXCURSIONS OUTSIDE APPROVED RANGES MAY BE UP TO AND INCLUDING 5 DEGREES PER AXIS. @[DN 156]

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).

2. MANEUVERS BETWEEN APPROVED ATTITUDE ENVELOPES SHALL BE PERFORMED WITH THE FOLLOWING CONSTRAINTS:
 - a. THE MAXIMUM MANEUVER TIME SHALL BE ONE ORBITAL PERIOD.
 - b. THE SOLAR POINTING VECTOR IN THE ISS BODY AXIS SHALL NOT BE STATIC DURING THE MANEUVER.

Under extremely 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.

Source: SSCN 3383B (January 2001) TO D684-10198-06 DCN002, ISS Flight Attitudes (December 1, 1999). @[DN 156]

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FLIGHT RULES

10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] (CONTINUED)

B. THE PLANNED STAGE ATTITUDE ENVELOPES ARE DEFINED IN TABLE 10A_B2-2-II. @[DN 156]

TABLE 10A_B2-2-II - PLANNED ATTITUDE ENVELOPES

REFERENCE FRAME	BETA [2]	ATTITUDE NAME	PLANNED ATTITUDE ENVELOPES [2] [3]		
			YAW	PITCH	ROLL
ISS LVLH	$\beta < -52^\circ$ [1]	+ZLV +XVV	-15° TO -5° [5]	-11° TO -1°	-2° TO +3° [4]
	$-52^\circ \leq \beta \leq +52^\circ$		-15° TO -5°	-11° TO -1°	-7° TO +3°
	$\beta > +52^\circ$ [1]		-15° TO -5°	-11° TO -1°	-7° TO +3°
	$\beta < -52^\circ$ [1]	+ZLV -XVV	+165° TO 172°	-10° TO 0°	-7° TO +3°
	$-52^\circ \leq \beta \leq +52^\circ$		+165° TO 172°	-10° TO 0°	-7° TO +3°
	$\beta > +52^\circ$ [1]		+165° TO 172° [5]	-10° TO 0°	-2° TO +3° [4]

NOTES:

- [1] THE YAW AND ROLL RANGES FOR THE +ZLV ± XVV ATTITUDES WHEN |BETA| > 52 ARE CONSTRAINED BY NODE 1 MDM AND ESP1 PFCS 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 [HC] [RC] [E] [J]. THIS INCLUDES TRANSITIONS BETWEEN LVLH REFERENCE FRAME ATTITUDES.
- [3] IN THE EVENT THAT THE AVERAGE VEHICLE YAW, PITCH, OR ROLL VALUES OVER THE COURSE OF A FULL ORBIT FALL OUTSIDE OF THE RANGE DEFINED IN TABLE 10A_B2-2-II, THE TRRJ WILL BE MANAGED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {10A_B18-TBD}, TRRJ AUTOTRACK BIAS MANAGEMENT.
- [4] GN&C ANALYSIS HAS SHOWN THAT THE ROLL ATTITUDE ENVELOPE LIMIT OF 0 DEG MAY BE VIOLATED BY UP TO 2 DEG UNDER STEADY STATE CONDITIONS. THE ROLL ATTITUDE MAY SETTLE OUT AT ROLL = -2 DEG. PTCS, MSER AND ATCS HAVE APPROVED THIS POTENTIAL CONSTRAINT VIOLATION AND HAVE NO ISSUES. PTCS ACCEPTANCE OF THIS CONSTRAINT EXCEEDANCE APPLIES TO 10A STAGE ONLY.
- [5] PRELIMINARY ESTIMATES OF THE YAW TEA'S SHOW THAT THEIR VALUES WILL BE OUTSIDE OF THE APPROVED +ZLV ±XVV ATTITUDE ENVELOPES IF MATED OPERATIONS AT |B| > 52 DEG ARE USED. ISSUE RESOLUTION IS CURRENTLY ON-GOING AND MAY BE RESOLVED IN A FUTURE CR TO EXPAND THE YAW ATTITUDE ENVELOPES.

Between Flight 5A and Assembly Complete, the MDM radiator's coating degrades the heat rejection capability, and IR heating from adjacent structure increases the base plate temperatures (to temperatures greater than component limits). This constraint restricts the ISS flight attitudes in an effort to prevent the MDM from overheating until the enhanced radiator is installed (ref. SSCM 1128). @[DN 156]

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FLIGHT RULES

10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] (CONTINUED)

C. RUSSIAN VEHICLE DOCKING ATTITUDES USING +ZLV ±XVV ©[DN 156]

RUSSIAN VEHICLE DOCKINGS WILL BE PERFORMED IN THE FLIGHT ATTITUDE ENVELOPES DEFINED BY TABLE 10A_B2-2-III

TABLE 10A_B2-2-III - PERMISSIBLE ATTITUDE ENVELOPES FOR +ZLV ±XVV

ATTITUDE	BETA RANGE	ATTITUDE ENVELOPE				
		YAW	PITCH	ROLL	TIME IN ATTITUDE	RECOVERY TIME
+ZLV +XVV	$\beta < -52^\circ$	[3]			[1]	N/A
	$-52^\circ \leq \beta \leq +52^\circ$					
	$\beta > +52^\circ$					
+ZLV -XVV	$\beta < -52^\circ$	[3]			[2]	
	$-52^\circ \leq \beta \leq +52^\circ$					
	$\beta > +52^\circ$					

NOTES

- [1] 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] [J]. THOUGH A CERTIFIED ATTITUDE, TIME IN THE DOCKING ATTITUDE CONFIGURATION IS NOT UNLIMITED.
- [2] 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] [J]. THOUGH SIMILAR TO THE +ZLV +XVV CERTIFIED ATTITUDE, TIME IN THE DOCKING ATTITUDE CONFIGURATION IS NOT UNLIMITED.
- [3] THE ATTITUDE ENVELOPES FOR +ZLV ±XVV TO BE USED FOR RUSSIAN VEHICLE DOCKINGS ARE DEFINED IN TABLE 10A_B2-2-I.

D. IF MANUAL RUSSIAN VEHICLE FINAL APPROACH AND DOCKING ARE REQUIRED, ISS WILL SWITCH TO THE CURRENT INERTIAL ATTITUDE ("ТП" OR "ИСК-Т"). THIS ATTITUDE WILL BE HELD FOR THE LENGTH OF THE FINAL APPROACH, WHICH IS APPROXIMATELY 10 MINUTES. USE OF THIS SWITCH WHETHER PLANNED OR AS A CONTINGENCY, MUST FIRST BE APPROVED VIA THE CHIT PROCESS.

MCC-M requires this switch in order to provide for better manual control. ©[DN 156]

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FLIGHT RULES

10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] (CONTINUED)

E. RUSSIAN VEHICLE (RV) UNDOCKING ATTITUDES @[DN 156]

THIS RULE SUPERSEDES THE ATTITUDES SPECIFIED IN THE FIRST SENTENCE EACH OF PARAGRAPHS A AND B OF RULE {D2-303}, ISS ATTITUDE FOR SOYUZ/PROGRESS UNDOCKING [HC] [RC]. THE FLIGHT ATTITUDE ENVELOPES IN TABLE 10A_B2-2-IV WILL BE USED FOR RUSSIAN VEHICLE UNDOCKING. USE OF THE -XLV ±ZVV ATTITUDES MUST FIRST BE APPROVED VIA THE CHIT PROCESS.

TABLE 10A_B2-2-IV - RUSSIAN VEHICLE UNDOCKING ATTITUDE ENVELOPES

RUSSIAN VEHICLE	ATTITUDE	REFERENCE FRAME	BETA RANGE	ATTITUDE ENVELOPE				
				YAW	PITCH	ROLL	TIME IN ATTITUDE	RECOVERY TIME
SOYUZ /PROGRES S FROM SM AFT PORT	+ZLV +XVV	ISS LVLH	[1]	[1]			[3]	NA
	+ZLV -XVV		[2]	[2]			[4]	NA
SOYUZ /PROGRES S FROM ANY NADIR PORT	-XLV +ZVV	ISS LVLH	$-75^\circ \leq \beta \leq +75^\circ$	-5° TO +5°	+85° TO +95°	-5° TO +5°	30 MINUTES	1.5 HOURS
	-XLV -ZVV		$-75^\circ \leq \beta \leq +75^\circ$	+175° TO +185°	+85° TO +95°	-5° TO +5°	30 MINUTES	1.5 HOURS

NOTES

- [1] THE PERMISSIBLE BETA RANGES AND ATTITUDE ENVELOPES FOR +ZLV +XVV ARE FOUND IN TABLE 10A_B2-2-I.
- [2] THE PERMISSIBLE BETA RANGES AND ATTITUDE ENVELOPES FOR +ZLV -XVV ARE FOUND IN TABLE 10A_B2-2-I.
- [3] 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] [J]. THOUGH A CERTIFIED ATTITUDE, TIME IN THE UNDOCKING ATTITUDE CONFIGURATION IS NOT UNLIMITED.
- [4] 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] [J]. THOUGH SIMILAR TO THE +ZLV +XVV CERTIFIED ATTITUDE, TIME IN THE UNDOCKING ATTITUDE CONFIGURATION IS NOT UNLIMITED.

Per Hazard Report RSCE-0021, a minimum 40 deg negative pitch angle LVLH (0, -40, 0) is required for safe short term and long term clearance (i.e., no collision) between ISS and an uncrewed Progress departing a nadir port for the case that the Progress MCS fails after undocking and no separation burns are performed. In this scenario, sufficient time is not available for the ISS crew to set up the TORU equipment and perform the burns manually. @[DN 156]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_B2-2

PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] (CONTINUED)

While the Hazard Report specifically identifies this negative pitch attitude, in concept, any attitude that points the nadir ports the given number of degrees away from nadir toward the -Vbar will satisfy the intent of the report. (For example, if the duty attitude is +YVV +ZLV, then a +40 deg roll will point the nadir ports 40 deg away from nadir toward the -Vbar, thus satisfying the intent for Soyuz/Progress departure.) In addition, a full 90 deg pitch in either direction, pointing the nadir ports along either the +Vbar or -Vbar, will result in a safe posigrade or retrograde separation in the event of such failures. As documented in Hazard Report RSTV-0026, a similar attitude is not required for Soyuz due to the backup capability of the Soyuz crew to manually perform the burns. ©[DN 156]

Nonetheless, the 90 deg pitch attitudes also provide a larger separation rate from ISS for both Soyuz and Progress, thus providing additional clearance relative to ISS during the Soyuz/Progress deorbit burn (nominally 1.5 - 2 revs after undocking).

References: Hazard Report RSCE-0021-9A.1, Collision of a Spacecraft with the Station After Separating - Cause 2. Hazard Report RSTV-0026-A, The Soyuz TMA Vehicle and the Station Collide During Separation - Causes 1 and 3. Hazard Report TCS-1204, Loss of ISS Element or Critical and Non-Critical Hardware Due to Thermal Extreme - Cause 2, Control 5

F. SOYUZ RELOCATION ATTITUDES

1. FOR SOYUZ UNDOCKING AND FLYAROUND, ISS WILL HOLD THE ATTITUDE LVLH (0, -20, 0) (YAW-PITCH-ROLL).
2. PRIOR TO THE START OF FINAL APPROACH, ISS WILL SWITCH TO THE CURRENT INERTIAL ATTITUDE ("ТИ" OR "ИСК-Т"). NOMINALLY, THIS SWITCH WILL OCCUR 2 MINUTES PRIOR TO ORBITAL SUNSET. THIS ATTITUDE WILL BE HELD FOR THE LENGTH OF THE FINAL APPROACH, WHICH IS APPROXIMATELY 10 MINUTES.
3. NOMINALLY, FINAL APPROACH WILL BEGIN AT ORBITAL SUNSET AND COMPLETE DURING ECLIPSE.
4. USE OF THE +ZLV +XVV ATTITUDE RELOCATION ATTITUDE (INCLUDING SWITCH TO INERTIAL ATTITUDE) MUST FIRST BE APPROVED VIA THE CHIT PROCESS.

MCC-M requires the switch to inertial in order to provide for better manual control. By starting in the 20 deg pitch down attitude, a good portion of the inertial "rotation" relative to the LVLH reference frame will occur within the permissible envelope in Paragraph A. This plan, in combination with the inertial hold occurring during orbital eclipse, should minimize the thermal implications of the inertial hold. The entire attitude timeline must first be approved via the CHIT process. ©[DN 156]

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FLIGHT RULES**10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE
DEVIATIONS [HC] [RC] (CONTINUED)**

G. THE ALLOWABLE ATTITUDE ENVELOPE FOR THE DEBRIS AVOIDANCE MANEUVER (DAM) USING A DC-1 NADIR PROGRESS IS DEFINED IN TABLE 10A_B2-2-I. @[DN 156]

H. FREE DRIFT OR LOAC PERIODS

1. FREE DRIFT OR LOAC DURING A THRUSTER INHIBIT PERIOD

IF THE ISS IS IN FREE DRIFT OR EXPERIENCES A LOSS OF ATTITUDE CONTROL (LOAC) EVENT WHEN PERFORMING A PLANNED ACTIVITY THAT REQUIRES ALL THRUSTER FIRINGS TO BE INHIBITED, THE ACTIVITY MAY BE CONTINUED WHILE IN FREE DRIFT UNTIL IT CAN BE PROPERLY SAFED. SAFING OF THE ACTIVITY MAY ENTAIL ITS COMPLETION IF OTHER OPERATIONAL CONSIDERATIONS, WHEN TAKEN INTO ACCOUNT, INDICATE THAT COMPLETION OF THE ACTIVITY IS NECESSITATED.

a. TEMPERATURES OF ALL INSTRUMENTED EXTERNAL COMPONENTS WILL BE MONITORED DURING THE ATTITUDE EXCURSION.

(1) IF TEMPERATURE TRENDS INDICATE THAT OPERATIONAL LIMITS WILL BE VIOLATED, THE ISS MUST RETURN TO THE NOMINAL +ZLV ±XVV ATTITUDE DEFINED IN PARAGRAPH A OR B PRIOR TO THE HARDWARE LIMIT VIOLATION.

(2) FOLLOWING AN ATTITUDE ENVELOPE DEVIATION, THE ISS ATTITUDE MUST REMAIN INSIDE THE ENVELOPE FOR 10 HOURS BEFORE ADDITIONAL DEVIATIONS OCCUR.

b. POWER GENERATION MUST BE SUFFICIENT TO SUSTAIN THE NECESSARY ISS SYSTEMS. ANY DEFICIENCIES WILL BE MANAGED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].

c. FOR GUIDANCE ON EATCS OPERATIONS REFER TO RULE {10A_B18-2}, MANUAL TRRJ POSITIONING. @[DN 156]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-2 PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC] (CONTINUED)

Boeing PTCS performs thermal analysis that results in temperatures that are used as initial conditions to be applied to the ISS structures. These temperature gradients and profiles give rise to thermal loads between the structural interfaces and to the internal primary members of the structure. These loads, added to the mechanical transient loads on the ISS, are assessed to determine if they remain within the allowable load ICD limits that yielded positive margins of safety at the time the ISS structures were certified for flight. ©[DN 156]

In the process of performing thermal structural analysis for multiple new flight attitudes, there were attitude instances where the transient temperatures of certain elements of the ISS structure yielded loads that were 50 percent to 60 percent higher than the allowable load ICD limits within 1 and 1/2 hours. Owing to this fact, the use of a "X" number of hours in any attitude rule, that assumes that the thermal loads of the ISS structures will remain within the allowable load ICD limits, as long as the ISS ORU's temperatures limits are not exceeded, is no longer valid.

In the event that a LOAC occurs and the mated stack goes into free drift, the period of time that the mated stack is in free drift should be minimized as much as operationally possible to minimize the potential that a structural load limit will be exceeded.

2. FREE DRIFT OR LOAC EVENT WHILE THRUSTER FIRINGS ARE ALLOWED

IF THE ISS EXPERIENCES AN UNPLANNED LOAC EVENT AND IS FORCED INTO FREE DRIFT, PROPULSIVE ATTITUDE CONTROL SHOULD BE USED AS SOON AS IT IS OPERATIONALLY FEASIBLE TO RETURN THE ISS TO THE +ZLV ±XVV ATTITUDE ENVELOPES DEFINED IN PARAGRAPH A OR B. ©[DN 156]

10A_B2-3 RESERVED

10A_B2-4 P6 SOLAR ARRAY DEPLOYMENT ATTITUDE, SARJ, AND BGA CONFIGURATION

TBD

FLIGHT RULES

10A_B2-5

**ISS SYSTEM MANAGEMENT FOR DEBRIS AVOIDANCE
MANEUVERS USING PROGRESS ON DC-1 NADIR**

- A. THE ATTITUDE ENVELOPE FOR DEBRIS AVOIDANCE MANEUVER (DAM) USING A DC-1 NADIR PROGRESS IS DEFINED IN TABLE 10A_B2-5-I. IN THE EVENT THAT THIS ATTITUDE IS REQUIRED FOR USE, IT MUST FIRST BE APPROVED VIA THE CHIT PROCESS. ©[DN 85]

TABLE 10A_B2-5-I - DEBRIS AVOIDANCE MANEUVER ATTITUDE ENVELOPE

BETA ANGLES	ATTITUDE REFERENCE FRAME [1]	ISS ATTITUDE NAME	PERMISSIBLE ATTITUDE ENVELOPE		
			YAW	PITCH	ROLL
-75° < β < +75°	ISS LVLH	-XVV PITCH BIAS	+175° TO +185°	+61° TO +71°	-5° TO +5°

The constraints documented in this rule remain in effect for execution of the DAM. The chit will provide additional constraints and guidance based on the final analysis results.

- ISS MAY REMAIN IN THE DAM ATTITUDE FOR 3 HOURS.

The attitude is only allowed for cases where a DAM is needed to be performed by the Progress on the DC-1 Nadir port. The analysis allows for 3 hours in the DAM attitude. The maneuver to and from the DAM attitude is covered by Rule {10A_B2-2}, PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC], for stage approved attitudes. To minimize risk of exceeding hardware temperature limits and the total time out of the attitude envelope, the vehicle should be maneuvered back to the approved attitude (Rule {10A_B2-2}, PERMISSIBLE ISS STAGE ATTITUDES AND ATTITUDE DEVIATIONS [HC] [RC]) envelope as soon as possible after completion of the DAM.

Preliminary analysis for the +XVV pitch bias DAM attitude has shown that it is undesirable. S1/P1 radiator manifold constraints will be violated in the +XVV pitch bias DAM attitude for most Beta regimes regardless of whether the TRRJ is parked or in autotrack.

A 1.0 m/s DAM during the 10A stage performed by the DC-1 Nadir docked Progress using R&D thrusters is estimated to take approximately 22 minutes. Typically, the maneuver from the TEA to the DAM attitude is executed 1 hour and 15 minutes prior to the TIG. This time may be shortened to help reduce the thermal risk; however, that is dependent upon the commands the RS software must execute and the telemetry that must be monitored and verified prior to the critical operation. In addition, there are situations that may be required for the DAM such as direct commanding to the Progress performed via Russian Ground Sites (RGS's) and the need for telemetry which can only be received through the RGS. ©[DN 85]

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FLIGHT RULES

10A_B2-5

**ISS SYSTEM MANAGEMENT FOR DEBRIS AVOIDANCE
MANEUVERS USING PROGRESS ON DC-1 NADIR
(CONTINUED)**

Engineering thermal verification has identified concerns with this attitude for 3 hours. Of specific concern are S1 NH₃ lines due to loss of heater redundancy and P1 NTA due to heater failure, and possible over-temperature of P6 PFCS Baseplate, P6 LS PFCS Baseplate, and P6 PVCU MDM. In the future, it is understood that the DAM attitude will be assessed on a stage-specific basis via CHIT. At that time, thermal team will assess the specific case to determine if concerns still exist. It is also understood that in the event a DAM using Progress on DC-1 Nadir is necessary, the priorities associated with avoiding debris outweigh any thermal-induced hardware risk resulting from the attitude.
 ©[DN 85]

Reference: ESC Group Memo ESCG-4019-05-5401-011, Reboost Performance Analysis - Revision U Mass Properties, August 10, 2005, provides the estimated amount of time to perform the DAM maneuver.

2. TEN HOURS OF RECOVERY IN A PERMISSIBLE ±XVV ATTITUDE SHALL BE FLOWN UPON COMPLETION OF THIS ATTITUDE.

Allows sufficient time to recover temperatures that may have deviated during the time spent in the DAM attitude

B. THERMAL CONSTRAINTS

1. NO POWER-DOWN OF EXTERNAL TRUSS HARDWARE
2. IF SHELL HEATER POWER-DOWN IS REQUIRED
 - a. A RESERVE OF 400 W IS NECESSARY TO WARM THE COLDEST SHELL ZONE(S) FOR THE FULL PERIOD SPENT OUT OF ATTITUDE.
 - b. IN THE EVENT THE PROJECTED POWER GENERATION IS INSUFFICIENT TO COVER THE REQUESTED RESERVE POWER, A PRE-HEAT WILL BE PERFORMED FOR THE NODE 1, PMA 1-2, AND THE AIRLOCK AT A RATE OF 1 HOUR FOR EACH HOUR OF POWER-DOWN. HEATER POWER IS TO BE REMOVED FROM A ZONE IF THE TEMPERATURE OF ANY ONE OF THE ASSOCIATED ZONE SENSOR ACHIEVES 42 DEG C (APPROX 109 DEG F).
3. RECOVERY REQUIRES ENABLING HEATERS FOR 10 HOURS AND RETURNING TO A NOMINAL ATTITUDE FOR 10 HOURS. ©[DN 85]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-5

**ISS SYSTEM MANAGEMENT FOR DEBRIS AVOIDANCE
MANEUVERS USING PROGRESS ON DC-1 NADIR
(CONTINUED)**

The DAM attitude assessment does not account for loss of power to external truss hardware. If a load shed/power-down is initiated, there is additional and more widespread risk to components depending on the nature of powerdown and time required to regain loads. Based on flight experience, 400 W is needed if a shell power down is required. Since this attitude is across the entire beta range, the 400 W requirement is to be reserved on both power channels. ©[DN 85]

4. THE TRRJ WILL BE POSITIONED PER RULE {10A_B18-2}, MANUAL TRRJ POSITIONING, USING THE RESPECTIVE TABLE FOR THE SELECTED DAM ATTITUDE.

ATCS analysis has identified potential EATCS manifold freezing issues for the DAM attitude using nominal Autotrack articulation software; therefore, it is necessary to position the TRRJ to a fixed gamma angle. There are no locking requirements associated with the DAM attitude. Rule {10A_B18-2}, MANUAL TRRJ POSITIONING, provides TRRJ positions for both stagnant and flowing loop conditions for a variety of beta angles. The appropriate value must be chosen to allow the full 3 hours in the DAM attitude.

ATCS analysis performed under WPRR 104 and WPRR 8623 have shown that the -XVV pitch bias DAM attitude is acceptable with the operational constraint documented above.

Reference: A92-J353-STN-TEM-2005-0008, WPRR 104 Task 4 Active Thermal Analysis Final Report, January 18, 2005, T. Michel/Boeing, and Memo ISS-HOU-ATCS-TEM-06XXX, WPRR 8623 ATCS Thermal Assessment -XVV Z-Nadir High Positive Pitch Bias Orbiter Reboost Attitude for Stage 13A to 15A, July 22, 2006, T. Michel/Boeing.

5. IF A TRRJ CANNOT BE POSITIONED PER RULE {10A_B18-2}, MANUAL TRRJ POSITIONING, THE ISS MAY ONLY REMAIN IN THE DAM ATTITUDE FOR 1 HOUR. HOWEVER, IF ISS DOES NOT RETURN TO A NOMINAL ATTITUDE OR THE TRRJ IS NOT IN AN ACCEPTABLE CONFIGURATION (PER RULE {10A_B18-2}, MANUAL TRRJ POSITIONING) AT THE END OF 1 HOUR, THE RADIATOR(S) ON THE AFFECTED ETCS LOOP MUST BE VENTED, WHICH COULD OCCUR WHILE IN THE DAM ATTITUDE WAITING FOR THE DAM TIG. ©[DN 85]

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FLIGHT RULES

10A_B2-5

ISS SYSTEM MANAGEMENT FOR DEBRIS AVOIDANCE
MANEUVERS USING PROGRESS ON DC-1 NADIR
(CONTINUED)

Rule {10A_B18-2}, MANUAL TRRJ POSITIONING, provides acceptable TRRJ positions for either flowing or stagnant ETCS conditions for the full range of Beta angles. If for any reason the TRRJ cannot be positioned appropriately (for example, the ETCS is stagnant and there are no acceptable TRRJ positions, or the TRRJ is failed and cannot be moved to a safe position), there is significant risk of causing NH₃ to freeze if the ISS remains misconfigured in the DAM attitude for more than 1 hour. A subsequent thaw of NH₃ poses a rupture risk at the affected radiator manifold(s). Therefore, if the TRRJ cannot be configured in a safe position, use of the DAM attitude must be limited to 1 hour and the ETCS must be vented within 1 hour of the misconfiguration to prevent hardware failure. Vent of NH₃ from the radiators in an ETCS loop generally means loss of functionality for that loop until sufficient NH₃ can be manifested to refill the radiators. ©[DN 85]

Reference Hazard Report TCS-1204, Loss of ISS Element or Critical and Non-Critical Hardware Due to Thermal Extreme, Cause 2, Control 5.

C. FOR SOLAR ARRAY CONSTRAINTS, REFER TO RULE {10A_B2-45},
 USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC] [RC].

D. CONTAMINATION CONFIGURATION

1. MSS CAMERAS MUST BE MAINTAINED PER RULE {B12-106}, MSS
 CAMERA CONTAMINATION KEEP-OUT ZONES [C].

The effect of thruster particles is to remove the AR coating from the optical glass and leave small craters or pits in the window surface. This damage reduces transmissivity by a small amount and increases glare. Increasing glare eventually reduces resolution in poor lighting conditions. Need to limit the total lens coating damage to the lens to 30 percent over 10 years and the guideline is 3 percent per year. Reference: SSRMS-SYS-TN-094.

The MSS is expected to have no thermal issues as long as it is in dual-string keep-alive, or operational. However it should be noted that the MCAS IMCA is prone to under temperature conditions in certain attitudes. In a DAM situation, an integrated scenario-specific thermal analysis would be required to predict MCAS thermal conditions. There should not be any erosion or contamination concerns from the R&D thrusters as they point well away from the U.S. segment and the MSS workspace.

2. THE LAB WINDOW SHUTTER MUST BE CLOSED PER RULE {B2-19},
 U.S. LAB WINDOW OPERATIONAL CONSTRAINTS.

Lab window shutter to remain closed to preclude the possibility of contamination of lab window during thruster operations per Rule {B2-19}, U.S. LAB WINDOW OPERATIONAL CONSTRAINTS. In addition, the lab window must be closed for condensation concerns due to the shell heater power down. ©[DN 85]

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FLIGHT RULES

10A_B2-6

THERMAL RADIATOR ROTARY JOINT (TRRJ) CONSTRAINTS FOR SSRMS OPERATIONS

DURING THE FOLLOWING SSRMS OPERATIONS, THE P1 AND S1 THERMAL RADIATOR ROTARY JOINTS (TRRJ) SHALL BE CONFIGURED PER TABLE 10A_B2-6-I AS ALLOWED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {B18-352}, MANUAL TRRJ POSITIONING [HC].

TABLE 10A_B2-6-I

OPERATION	FLIGHT DAY	P1 TRRJ CONFIGURATION	S1 TRRJ CONFIGURATION	RATIONALE
SASA STOW RELOCATION TO PLB	FD4	NO CONSTRAINTS	PARKED AT ZERO	ALLOW S1 CAMERA TO BE USED FOR CLEARANCE MONITORING
NODE 2 INSTALLATION ON NODE 1 PORT	FD4	LOCKED AT ZERO	NO CONSTRAINTS	MAXIMIZE CLEARANCE WITH SSRMS/NODE 2 AND ALLOW P1 CAMERA TO BE USED FOR CLEARANCE MONITORING
P6 DEMATE FROM Z1	FD6	PARKED AT ZERO	NO CONSTRAINTS	ALLOW P1 CAMERA TO BE USED TO MONITOR P6/Z1 INTERFACE
PMA2 RELOCATION TO NODE2	STAGE EVA 1	LOCKED AT ZERO	NO CONSTRAINTS	MAXIMIZE CLEARANCE WITH SSRMS/PMA2 AND ALLOW P1 CAMERA TO BE USED FOR CLEARANCE MONITORING
NODE2/PMA2 RELOCATION TO LAB FWD	IV STACK RELOCATION	LOCKED AT ZERO	NO CONSTRAINTS	MAXIMIZE CLEARANCE WITH SSRMS/NODE 2/PMA2 AND ALLOW P1 CAMERA TO BE USED FOR CLEARANCE MONITORING

During Node 2 install to Node 1, PMA 2 relocation to Node 2, and Node 2/PMA 2 stack relocation to Lab forward, clearance concerns between the SSRMS and P1 TRRJ can result depending on the position of the TRRJ. Locking P1 TRRJ at the specified positions maximizes the clearances and simplifies the robotics operations. The P1 and S1 lower outboard cameras provide the SSRMS operators with critical clearance monitoring cues when operating at the ISS airlock of the port side on Node 1. The P1 and S1 TRRJ's are parked at zero during critical operations to simplify the clearance monitoring and increase the overall efficiency of the robotics operations. Parking a TRRJ means that it will be put into Directed Position mode at the desired angle. Locking a TRRJ means that the TRRJ will be in Checkout Mode with the cross-strapped DLA locked.

Typically stopping a TRRJ at 0 deg is allowed. However, if an angle required in Table 10A_B2-6-I is not allowed per the TRRJ parking constraints Rules {10A_B18-2}, MANUAL TRRJ POSITIONING and {B18-352}, MANUAL TRRJ POSITIONING [HC], then new angle will have to be coordinated that satisfy both clearance concerns and radiator freezing concerns.

FLIGHT RULES

10A_B2-7

NODE 1, NODE 2, AND U.S. LAB STOWAGE CONSTRAINTS
AND RESTRICTIONS [RC]

- A. MAINTAIN A 2-FOOT CLEARANCE AROUND DIFFUSERS, REGISTERS, BOOSTER FANS, SMOKE DETECTORS, OR OTHER AIR FLOW SENSORS IN NODE 1 AND THE LAB.
- B. STOWAGE SHALL NOT BLOCK ACCESS TO THE RACK POWER SWITCHES (RPS'S) OF THE NODE 2 AVIONICS RACK.
- C. STOWAGE SHALL NOT IMPEDE INTERIOR AIRFLOW WITHIN THE NODE 2 MODULE.

Reference: GGR&C Part 1: Strategic and Tactical Planning, Rev A, DCN 009 (SSP 50261-01) and OSCAR: Pressurized Volume, Rev C, January 2004 (SSP 50621), and Rev E, November 2006, section 4.5, part 4.5.2, Node2 Stowage Constraints.

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E]

IN THE EVENT OF A PLANNED DECREWING (NON-EMERGENCY) OF THE ISS, THE FOLLOWING TWO TABLES REPRESENT A STARTING CHECKLIST OF ACTIVITIES THAT SHOULD BE SCHEDULED OR CONSIDERED PRIOR TO CREW DEPARTURE. THIS LIST IS TIME DEPENDENT AND SUBJECT TO MODIFICATION BASED ON THE PARTICULAR CONDITION WHICH IS DRIVING THE PLANNED DECREWING. MCC-H AND MCC-M WILL CLOSELY COORDINATE ANY REQUIRED ADDITIONS/DELETIONS AND STATUS COMPLETED ACTIVITIES TO KEEP THE ENTIRE TEAM IN SYNC AS THEY MOVE TOWARDS THE PLANNED CREW DEPARTURE.

This rule will require periodic updates as ISS assembly occurs or the vehicle configuration changes. Current list is expected to be viable through the ISS-10A (Node-2) mission but should be reviewed and updated if the vehicle configuration changes due to significant hardware failure or reconfig. In the event that the time available prior to the targeted departure does not allow all items in the configuration tables to be completed, the items identified with an asterisk in the U.S. table will be given priority over other U.S. items. In the event of an emergency return, existing emergency procedures will be used and this rule does not apply. For details on the planned demanning decision making process, reference ISS De-crewing and Re-crewing Plan SSP 50715.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)**TABLE 10A_B2-8-I - UNITED STATES ON-ORBIT SEGMENT PLANNED
UNMANNED CONFIGURATION**

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
C&DH	- ALL PCS POWERED DOWN	- 30 MINUTES * FOR 1 CREW	- CREW (RIGHT BEFORE DEPARTURE)
	- COMPUTERS IN NOMINAL CONFIG	- NONE	- INT 2 MDM PRIMARY DESIRED FOR LTL REDUNDANCY
MCS	- NO DELTAS	- NONE	
EPS	- VERIFY ALL RACK POWER SWITCHES ARE IN THE ON POSITION	- 10 MINUTES FOR 1 CREW	- CREW - GROUND INHIBIT RPS MONITORING
	- VERIFY ALL FUNCTIONING GLA LIGHTING SWITCHES SET TO "ON" FULL BRIGHT AND VERIFY SRCA ON	- 5 MINUTES FOR 1 CREW	- CREW
	- SOLAR ARRAY OPS TO REDUCE DRAG BUT PROVIDE ADEQUATE POWER	- NONE	- GROUND
	- UPDATE LOAD SHED AND PROXIMITY OPS TABLES FOR UNMANNED CONFIG	- NONE	- GROUND
TCS	- ITCS LOOPS WILL BE CONFIGURED PER UNMANNED CONFIG PROCEDURE (1/2 U.S. LAB AVIONICS JUMPERED TO LTL)	- 30 MINUTES * FOR 1 CREW	- CREW USING SODF ECLSS 2.815 - GROUND WILL TAKE CARE OF THE REST OF THE ITCS RECONFIGURATION (LTL SETPOINTS, VALVES, ETC)
	- PERFORM ITCS FILTER AND/OR GAS TRAP R&R'S IF REQUIRED	- 1 HR FOR 1 CREW IF BOTH MT AND LT ARE REQUIRED	- DE-CREWING TIMEFRAME DEPENDENT, LTL FILTER CHANGEOUT DEPENDS ON PPA STATUS
	- CONSIDER IF ITCS ACCUMULATORS REQUIRE TOP-OFF USING THE FSS	- 8 HOUR FOR 2 CREW	- DE-CREWING TIMEFRAME DEPENDENT
	- IF AVAILABLE, CONSIDER INSTALLATION OF SPARE PPA AND MONITOR FOR 24 HOURS TIME. IF FAILING, RESTORE ORIGINAL PPA	- 1 HOUR 30 MIN FOR 2 CREW	- DE-CREWING TIMEFRAME DEPENDENT BASED ON CURRENT PPA PERFORMANCE, WHICH ONE HAS THE MOST RUN TIME, AND HOW CLOSE TO THE END OF EXPECTED LIFE CYCLE.
	- NON ESSENTIAL RACKS POWERED DOWN AND RFCA'S OPEN TO 100 LB/HR	- NONE	- GROUND

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FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)

TABLE 10A_B2-8-I - UNITED STATES ON-ORBIT SEGMENT PLANNED UNMANNED CONFIGURATION (CONTINUED)

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
TCS (CONTINUED)	- CHANGE LT/MT SETPOINTS TO 13.9 °C (57 °F) AND BEGIN OPERATING IN DUAL MODE AS SOON AS POSSIBLE	- NONE	- GROUND, RECOMMENDED TRADE-OFF VALUE FOR OPTIMIZING LOOP LIFE AND DEW POINT, AND VERIFY STABLE PLANNED CONFIGURATION BEFORE CREW DEPARTURE
	- TRRJ'S IN DIRECTED POSITION (ONLY REQUIRED IF ETCS IS ACTIVE)	- NONE	- GROUND
ECLSS	- DETAILED HATCH SEAL INSPECTION	- 10 MIN PER HATCH FOR USOS * FOR 1 CREW	- CREW, GROUND WILL ASSESS TIME SINCE LAST INSPECTION.
	- ALL HATCHES CLOSED BETWEEN MODULES	- 30 MIN FOR USOS * FOR 2 CREW	- CREW (COVERED IN SODF ECLSS 2.815). A/L EL TO CL HATCH WILL REMAIN OPEN.
	- ALL MPEV'S CONFIGURED PER SODF ECLSS 2.815	- PART OF HATCH CLOSURE TIMES * FOR 2 CREW	- CREW (COVERED IN SODF ECLSS 2.815)
	- VERIFY LAB WINDOW SHUTTER CLOSED	- 5 MINUTES * FOR 1 CREW	- CREW (ASSESS IF INTERIOR COVER DESIRED)
	- DRAIN U.S. LAB CONDENSATE TANK INTO A CWC DOWN TO THE NEUTRAL POINT	- 1 HOUR * FOR 1 CREW	- FILL CWC EARLY ENOUGH TO USE IN SRV-K BEFORE DEPARTURE
	- PROCESS THE CWC THRU THE SRV-K	- 10 MINUTES * FOR 1 CREW	
	- VENT THE U.S. LAB CONDENSATE TANK TO VACUUM	- NONE *	- GROUND; PERFORM 3 DAYS BEFORE CREW DEPARTURE (IN CASE OF ICING)
	- CDRA POWERED DOWN	- 15 MINUTES IF REQUIRED FOR 1 CREW (REMOVE JUMPER) *	- CREW/GROUND (IF REQUIRED)
	- CONFIGURE A/L PCA WITH VRCV, VERIFY A/L EMPEV IS CLOSED	- 30 MINUTES FOR 2 CREW	- CREW (IFM 4.2.317), TO PROVIDE REDUNDANT POSITIVE PRESSURE RELIEF OPTION. VAJ REMAINS INSTALLED.
- IMV VALVES OPEN, IMV FANS OFF	- NONE	- CONTROLLED VIA GROUND/FDIR AS REQUIRED. PREVENTS PRESSURE DIFFERENTIAL DEVELOPMENT	
- ALL CCAA'S OFF, NODE 1 CABIN FAN OFF, SMOKE DETECTORS OFF	- NONE - NOTE: LOSS OF GROUND INSIGHT	- CONTROLLED VIA GROUND IF REQUIRED (MINIMIZE POTENTIAL FIRE SOURCES)	

THIS RULE CONTINUED ON NEXT PAGE

Verify that this is the correct version before use.

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)**TABLE 10A_B2-8-I - UNITED STATES ON-ORBIT SEGMENT PLANNED
UNMANNED CONFIGURATION (CONTINUED)**

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
ECLSS (CONTINUED)	- PMA-2 CONNECT VAJ BETWEEN NODE 2 FWD HATCH MPEV AND PCA VENT PORT	- 30 MIN FOR 1 CREW	- PROVIDES GROUND CONTROLLED REPRESS AND DEPRESS OF PMA-2
	- MCA OFF	- NONE	
	- N2 AND O2 SUPPLY VALVES - CLOSED	- NONE	- GROUND. ISO VALVES WILL REMAIN OPEN.
	- TCCS OFF	- NONE	- CAN BE POWERED OFF POST CREW DEPARTURE AS REQUIRED TO MAINTAIN SOME INSIGHT WHILE CREW PRESENT
	- VACUUM VENT SYSTEM: DISCONNECT ALL PAYLOADS FROM VES AND VRS AT UIP, CAPABILITY/VERIFY ALL VES AND VRS QD'S ARE CAPPED, DEACTIVATE SYSTEM	- 10 MINUTES TO DISCONNECT PAYLOADS FOR 1 CREW	- CREW - GROUND, SODF ECLSS 1.602
COMM	- TWO GOOD TAPES LOADED IN VTR'S. VTR'S RECENTLY CLEANED AND SWITCHED TO REMOTE OPS	- 10 MINUTES * FOR 1 CREW	- CREW
	- CREW TO CONFIGURE CAMCORDERS FOR VIEW OF LAB AND NODE INTERIORS AND LEAVE POWERED (NO TAPES IN CAMCORDERS).	- 20 MINUTES FOR 1 CREW	- CREW/GROUND. VIDEO SYSTEM POWERED OFF WHEN NOT REQUIRED
	- BACKUP S-BAND STRING POWERED UP AND READY AS HOT BACKUP	- NONE	- GROUND
	- AUDIO SYSTEM POWERED OFF AFTER CREW DEPARTURE	- NONE	- GROUND

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)**TABLE 10A_B2-8-I - UNITED STATES ON-ORBIT SEGMENT PLANNED
UNMANNED CONFIGURATION (CONTINUED)**

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
EVA	- DISPOSE EMU BATTERIES IN PROGRESS OR DOUBLE BAG - CONSIDER VENTING EMU SOP O2 TANKS - CONSIDER VENTING EMU PLSS O2 TANKS - VERIFY ALL BAGS/LOOSE ITEMS STOWED, PANEL SWITCHES OFF	- ~ 2.5 HOURS FOR 2 CREW (AS REQUIRED)	- CREW (TIME IS VARIABLE/DEPENDENT ON CONFIG) - PROVIDES PROTECTION AGAINST O2 TANK LEAKAGE, RENDERS EMUS NO-GO FOR FUTURE EVA USE. O2 VENTING MAY NOT BE NECESSARY IF ANALYSIS INDICATES AIRLOCK WILL REMAIN <120 DEG F FOR THE SPECIFIC CASE.
	- CONSIDER REMOVAL OF CREWLOCK EQUIPMENT BLOCKING EXTERNAL HATCH AND ANY ITEMS THAT WOULD CAUSE DAMAGE TO ISS IF EXPOSED TO VACUUM IF INGRESS OF ISS PERFORMED VIA A/L (CONTINGENCY)	-30 MIN FOR 1 CREW	- TRADEOFF ASSESSMENT REQUIRED: CREW TIME FOR REMOVING CREWLOCK H/W AS PREP FOR EMERGENCY ALTERNATE INGRESS PATH FOR SHUTTLE MISSION. (EQUIP LOCK WOULD GO TO VACUUM WITH REMAINING H/W - TRADEOFF: CREW TIME VS VERY LOW LIKELIHOOD VS RISK)
OPS LAN	- ALL OPS LAN COMPONENTS POWERED DOWN - LAN CABLES BETWEEN MODULES UNPLUGGED	- 1 HOUR * FOR 1 CREW	- CREW. SODF POC 2.217
	- PRINTER CARTRIDGES REMOVED	- 10 MIN FOR 1 CREW	- CREW.
CREW HEALTH/ MEDICAL OPERATIONS	- MEDICAL EQUIPMENT CONFIG FOR UNMANNED OPS: INCLUDES H/W PWRDN (EXERCISE, DEFIB) AND RECONFIG (VOA, TEPC, IV-CPDS), TVIS ACO, AND SAMPLES & DOSIMETERS COLLECTION	- ~ 2.5 HOURS FOR 1 CREW	- UNMANNED CONFIG/PLAN FOR SUPPORTABLE RE-CREWING - SOYUZ MANIFEST/RS COORD
	- CONSIDER TRANSFER OF EQUIPMENT TO SOYUZ	- ~ 30 MIN * FOR 1 CREW	- IF REQUIRED. LIST IS CASE AND RS COORD SPECIFIC. ITEMS TO CONSIDER: AMP, ALSP, CSA-CP, CCPK, AND DEFIB FOR CREW SAFETY
	- ENVIRONMENTAL SAMPLING	- ~ UP TO 4 HOURS FOR 1 CREW	- DEMANNING CASE SPECIFIC - SOYUZ MANIFEST/RS COORD
HOUSEKEEPING, MAINTENANCE AND STOWAGE	- NORMAL WEEKLY CLEANING (CLOSE TO DEPARTURE)	- 3 HOURS FOR 2 CREW *	- TIMING/DEPARTURE DEPENDENT
	- UNPOWER/DISCONNECT U.S. FOOD WARMER	- 10 MINUTES * FOR 1 CREW	

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FLIGHT RULES

10A_B2-8 CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)

TABLE 10A_B2-8-I - UNITED STATES ON-ORBIT SEGMENT PLANNED UNMANNED CONFIGURATION (CONTINUED)

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
HOUSEKEEPING, MAINTENANCE AND STOWAGE (CONTINUED)	- REMOVE BATTERIES FROM PORTABLE EQUIPMENT AS APPROPRIATE	- ~ 2 HOURS FOR 1 CREW	- MER TO PROVIDE THE LATEST LIST OF HARDWARE FOR SPECIFIC DEMANNING CASE
	- ASSESS REQUIRED OPS FOR PERISHABLE ITEMS (FOOD/TRASH, ETC.)	- ~ 4 HOURS FOR 2 CREW - NOTE: ADDITIONAL STOWAGE TIME IS ALSO ALLOCATED IN ROS PROGRESS OPS TASKS	- UPDATING IMS FOR LOCATIONS OF ITEMS AND DOWNLINK AN ISS INTERIOR VIDEO SURVEY IF FEASIBLE
	- CONSIDER DOUBLE-BAGGING ANY SIGNIFICANT CWC WATER TO PROTECT AGAINST POTENTIAL LEAKAGE.	- ~ 30 MINUTES FOR 1 CREW	- USE RS RUBBER-LINED TRASH BAGS (RS COORD REQ'D)
PAYLOADS	- ASSESS SCIENCE IMPACTS AND DEPARTURE CONFIG. - EXPRESS RACK 1 AND 4 ACTIVE, FILTERS CLEANED - HRF GASMAP DONE IF NOT DONE IN LAST 30 DAYS - CONFIGURE OTHER RACK FACILITIES AND DEPLOYED PAYLOADS FOR UNMANNED OPS.	- UP TO 2 HOURS IF GASMAP REQUIRED, ELSE 30 MINUTES FOR 1 CREW	- ALL PL LAPTOPS OFF - ASSESS OTHER POTENTIAL PAYLOAD ACTIONS - ER 1 & 4 HAVE SAMS & MAMS – REQUIRES AAA FAN, SD, AND HCOR – ON IF LEFT ON.

NOTES:

THIS ADDS UP TO APPROXIMATELY 12* - 60 HOURS OF DESIRABLE USOS OPS TO BE CONSIDERED DEPENDING ON THE SPECIFIC DEMANNING CASE AS WELL AS THE TIME AVAILABLE. OF THE TOTAL HOURS, 4* - 22 HOURS REQUIRE 2 CREW SIMULTANEOUSLY. THE TASKS IN THIS TABLE EQUAL ABOUT 1*4.5 DAYS OF USOS PREP OPS.

MORE IMPORTANT/DESIRABLE ACTIVITIES FOR CONSIDERATION ARE NOTED WITH AN * IN THE EVENT SUFFICIENT TIME IS NOT AVAILABLE FOR ALL ACTIVITIES.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)**TABLE 10A_B2-8-II - RUSSIAN ORBITAL SEGMENT PLANNED UNMANNED CONFIGURATION**

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
PROGRESS	PROGRESS WASTE STOWAGE OPS. DOCKING MECHANISM INSTALL ONTO HATCH [VC-21] MATCHING UNIT REMOVAL ЛКТ AND ROM REMOVAL PROGRESS ACTIVATION DOCKING CLAMP REMOVAL HATCH CLOSURE KURS A SYSTEM UNITS REMOVAL	- 3 HOURS FOR 2 CREW - 1 HOUR FOR 2 CREWMEMBERS - 1 HOUR FOR 1 CREWMEMBER - 1 HOUR FOR 1 CREWMEMBERS - 20 MIN FOR 1 CREWMEMBER - 20 MIN FOR 2 CREWMEMBERS - 20 MIN FOR 2 CREWMEMBERS - 3 HOURS FOR 2 CREWMEMBERS	LIKELY PROGRESS CONFIGURATION AND TIMEFRAME DEPENDENT. SOME AMOUNT OF WORK IS ASSUMED IF TIME IS AVAILABLE REFERENCE THE RODF PROGRESS CARGO VEHICLE TRANSFER OPERATIONS BOOK
СОГС	ELEKTRON DEACTIVATION	- 30 MINUTES	RADIOGRAM WILL BE CASE SPECIFIC
КИК	ГА-СУ(РМА1) HATCH CLOSURE	- 10 MINUTES FOR 2 CREWMEMBERS	IRS 2.3.2
[СОТР]	ВД1, ВД2 AIR DUCTS REMOVAL	- 25 MINUTES FOR 1 CREWMEMBER	IRS 2.3.1
КИК	ПГО-ГА HATCH RING REMOVAL	- 15 MINUTES FOR 1 CREWMEMBER	IRS 2.3.3
СОГС	VOZDUKH DEACT	- 30 MINUTES FOR 1 CREWMEMBER	IRS 2.5.4
СОГС	БМП CARTRIDGE REGEN AND SYSTEM DEACTIVATION	- 20 MINUTES FOR 1 CREWMEMBER (CREW TIME IS SPREAD OVER SEVERAL DAYS DURING REGEN PROCESS)	СОГС 5.5 OR RADIOGRAM WILL BE CASE SPECIFIC
[СТТС]	FGB AUDIO SUBSYSTEM [СТС] DEACTIVATION	- 10 MINUTES	IRS 2.3.4
СУБА	FGB CAUTION AND WARNING PANEL (ПСС) DEACTIVATION	- 5 MINUTES	IRS 2.3.5
СОЖ	FOOD SUPPLY SYSTEM (СОП) DEACTIVATION	- 15 MINUTES	IRS 2.5.1
[СОТР]	THERMAL CONTROL SYSTEM [СОТР] DEACTIVATION	- 10 MINUTES	IRS 2.5.2
СОЖ	WATER SUPPLY SYSTEM [СВО] DEACTIVATION	- 20 MINUTES	IRS 2.5.3 INCLUDES RODNIK AND [СРБК-2М]
СОЖ	TOILET SYSTEM [АСУ] DEACTIVATION	- 20 MINUTES	IRS 2.5.5
[СОТР]	VENTILATION SYSTEM [СВ] DEACTIVATION	- 20 MINUTES	IRS 2.5.6
[СОТР]	AIR DUCT DISASSEMBLY	- 20 MINUTES	IRS 2.5.7
ССВП	РО-ПРК HATCH RING REMOVAL	- 15 MINUTES	IRS 2.5.8

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-8

CREW CONTINGENCY RETURN [RC] [E] (CONTINUED)

**TABLE 10A_B2-8-II - RUSSIAN ORBITAL SEGMENT PLANNED UNMANNED
CONFIGURATION (CONTINUED)**

SYSTEM	UNMANNED CONFIGURATION	CREW TIME REQUIRED	COMMENTS
[CTTC]	SM AUDIO SUBSYSTEM [CTTC] STATE CHECK	- 20 MINUTES	IRS 2.5.9
СОЖ	PRESSURE ALARM SYSTEM (ДСД) DEACTIVATION	- 5 MINUTES	IRS 2.5.11
СУБА	CAUTION AND WARNING PANEL (ПСС) DEACTIVATION	- 5 MINUTES	IRS 2.5.12
СУБА	DIGITAL CLOCK DEACTIVATION	- 5 MINUTES	IRS 2.5.13
	CONSIDER IF INTERNAL PRESSURE COVERS REQUIRED ON ANY RSOS WINDOWS		CREW/GROUND COORDINATE BASED ON LATEST WINDOW CONDITION ASSESSMENTS
	DC1 DEACTIVATION	- 15 MINUTES	IRS 2.4. INCLUDES HATCH CLOSURES
	FGB DE-CREW	- 20 MINUTES FOR 1 CREWMEMBER	IRS 2.6.1 INCLUDES HATCH CLOSURES
	SM DE-CREW	- 20 MINUTES FOR 1 CREWMEMBER	IRS 2.6.3 INCLUDES HATCH CLOSURES
	DC1 DE-CREW	- 25 MINUTES FOR 1 CREWMEMBER	IRS 2.6.2 INCLUDES HATCH CLOSURES

NOTES:

THIS ADDS UP TO APPROXIMATELY 17 CREW HOURS OF RSOS OPS DEPENDING ON TIME AVAILABLE, OF WHICH ABOUT 9 HOURS ARE PARALLEL 2 MAN TIME (EQUALS ABOUT 2 DAYS OF RSOS PREP OPS).

FLIGHT RULES

10A_B2-9 ISS DRAG-THROUGH CABLES [RI]

DRAG-THROUGH CABLES WITHIN THE ISS WILL BE USED AS FOLLOWS:
@[DN 117]

- 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 1 TO FGB) - CONNECTED FOR UP TO 5 CONSECUTIVE DAYS FOR VIDEO ROUTING DURING PROGRESS/SOYUZ DOCKING AND UNDOCKING
- E. O₂ PREBREATHE LINE (A/L TO LAB) - CONNECTED DURING ANY EVA PREPARATIONS
- F. VIDEO CABLE (NODE 1 TO CAMCORDER IN THE SM) - CONNECTED FOR PERIODIC TVIS P/TV OPS, NOT CONNECTED OVERNIGHT
- G. AIRLOCK FLEX DUCT (EQUIPMENT LOCK TO CREW LOCK) - CONNECTED AT ALL TIMES
- H. TBD AIR DUCT (NODE 1 TO NODE 2) - CONNECTED AS REQUIRED TO SUPPORT NODE 2 INGRESS PRIOR TO FULL NODE 2 ACTIVATION.
- I. TWO 1553 DATA CABLES (LAB TO NODE 1 TO NODE 2 AFT BULKHEAD) - CONNECTED AT ALL TIMES PRIOR TO VESTIBULE PREPARATION FOR PMA 2/NODE 2 STACK RELOCATE.
- J. CBCS VIDEO CABLE (NODE 1 ICP TO NODE 2) - CONNECTED FOR PREPARATION OF PMA 2 RELOCATE TO NODE 2 FORWARD.
- K. CBCS POWER CABLE (NODE 1 UOP TO NODE 2) - CONNECTED FOR PREPARATION OF PMA 2 RELOCATE TO NODE 2 FORWARD. @[DN 117]

FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C]

A1. LOADS CONSTRAINTS DURING PMA 2 RELOCATION ARE DEFINED IN TABLE 10A_B2-10-I, PMA 2 RELOCATION LOADS CONSTRAINTS.
 ©[DN 114]

TABLE 10A_B2-10-I - PMA 2 RELOCATION LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1]		ISS ATTITUDE CONTROL			OPERATIONS							
		CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (SM. PROG)	UNDOCKING (RS)	DOCKING (RS)	PORT TRR// SAR// P4 BGA ROTATION	STBD TRR// SAR// S4 BGA ROTATION	MT TRANS/ SSRMS OPS
PMA 2	MOM MGMT NO DESATS	USTO										
SSRMS OPS	UNLOADED SSRMS (ANY CONFIGURATION)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
CBM OPS	LOOSENING CBM BOLTS	OK	OK	OK		NOT OK		NOT OK				
	1ST SET OF BOLTS REMOVED	OK	OK	OK		NOT OK		NOT OK				
	2ND SET OF BOLTS REMOVED	OK	OK	OK		NOT OK		NOT OK				
	3RD SET OF BOLTS REMOVED	OK	NOT OK	NOT OK	NOT OK	NOT OK		NOT OK				
	FINAL SET OF BOLTS REMOVED	OK	NOT OK	NOT OK	NOT OK	NOT OK		NOT OK				
	DEPLOYING CAPTURE LATCHES	OK	NOT OK	NOT OK	NOT OK	NOT OK		NOT OK				
SSRMS OPS [4][5]	MNVR TO DEMATE POSN (CLEARANCE < 2' FROM STRUCTURE)	OK	NOT OK	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	N/A
	MNVR TO DEMATE POSN (CLEARANCE > 2' FROM STRUCTURE)	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT DEMATE POSN	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
	MNVR TO INTERMEDIATE POSN	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT INTERMEDIATE POSN	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
	MNVR TO PRE-INSTALL SETUP POSN	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT PRE-INSTALL SETUP POSN	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
	MNVR TO PRE-INSTALL POSN	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT PRE-INSTALL POSN	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
	MNVR TO INSTALL (CLEARANCE >)	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
MNVR TO INSTALL (CLEARANCE <)	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	N/A	

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

TABLE 10A_B2-10-I - PMA 2 RELOCATION LOADS CONSTRAINTS (CONTINUED)

ATTITUDE CONTROL & OPS [1]		ISS ATTITUDE CONTROL			OPERATIONS							
		CMG - TA		THRUSTERS Only	CREW EXERCISE (ISOLATED OR UNISOLATED)	EVA OPS	REBOOST (SM, PROG)	UNDOCKING (RS)	DOCKING (RS)	PORT TRR// SAR// P4 BGA ROTATION	STBD TRR// SAR// S4 BGA ROTATION	MT TRANS/ SSR MS OPS
MOM MGMT NO DESATS	USTO	OK	NOT OK									
PMA 2	READY TO LATCH	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	OK	N/A
CBM OPS	AT PMA2 INSTALL FROM CBM INITIATION OF 1ST STAGE CAPTURE TO ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [2]	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	OK	
	CBM AT ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [2]	OK	OK	OK	OK	OK	OK	OK	NOT OK	OK	OK	
	CBM FROM ≥ 12 BOLTS WITH A-BOLTS COMPLETE TO ≥ 12 BOLTS WITH F-BOLTS COMPLETE [2]	OK	OK	OK	OK	OK	OK	OK	NOT OK [3]	OK	OK	

@[DN 114]

NOTES:

[1] KEY: - ACS OR OPS ALLOWED. - ACS OR OPS NOT ALLOWED - NOT ANALYZED.

[2] REFERENCE RULE {TBD}, CBM STRUCTURAL LOADS CONSTRAINTS.

[3] RISK OF PERMANENT DAMAGE TO CBM SEALS FOR THIS CASE

[4] THE FOLLOWING REBOOST OPTIONS WERE ANALYZED:

- PROGRESS AT SM AFT 8R&D
- PROGRESS AT SM AFT 4 R&D WITH PROGRESS AT DC-1 ROLL ASSIST
- PROGRESS AT SM AFT 4 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
- PROGRESS AT DC-1 AFT 2 MID-RING WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
- PROGRESS AT DC-1 AFT 2 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
- 2 SM MAIN JETS
- SR-1 SM MAIN JET
- SR-2 SM MAIN JET
- ATV 2 OCS JETS
- ATV 4 ACS JETS @[DN 114]

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

- [5] THE FOLLOWING PROGRESS/SM/ATV ACS OPTIONS WERE ANALYZED: @[DN 114]
- PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, SM JETS ROLL
 - PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 - PROGRESS AT SM AFT R&D JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 - SM PITCH-YAW-ROLL (NO PROGRESS OR ATV AT SM AFT)
 - SM PITCH-YAW-ROLL, PROGRESS AT DC-1 ROLL
 - ATV AT SM AFT PITCH-YAW, PROGRESS AT DC-1 ROLL
 - ATV AT SM AFT PITCH-YAW-ROLL

- [6] SSRMS BRAKES ON ONLY @[DN 114]

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

A2. LOADS CONSTRAINTS DURING NODE 2/PMA 2 RELOCATION ARE DEFINED IN TABLE 10A_B2-10-II, NODE 2/PMA 2 RELOCATION LOADS CONSTRAINTS. @[DN 114]

TABLE 10A_B2-10-II - NODE 2/PMA 2 RELOCATION LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1] NODE 2/ PMA 2		ISS ATTITUDE CONTROL			OPERATIONS							
		CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (SM, PROG)	UNDOCKING (RS)	DOCKING (RS)	PORT TRR// SAR// P4 BGA ROTATION	STBD TRR// SAR// S4 BGA ROTATION	MT TRANS/ SSRMS OPS
		MOM MGMT NO DESATS	USTO [3]									
SSRMS OPS	UNLOADED (ANY CONFIGURATION)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	N/A
CBM OPS	LOOSENING CBM BOLTS	OK	OK	OK		NOT OK			NOT OK	OK	OK	
	1ST SET OF BOLTS REMOVED	OK	OK	OK		NOT OK			NOT OK	OK	OK	
	2ND SET OF BOLTS REMOVED	OK	OK	OK		NOT OK			NOT OK	OK	OK	
	3RD SET OF BOLTS REMOVED	OK	NOT OK	NOT OK	NOT OK	NOT OK			NOT OK	OK	OK	
	FINAL SET OF BOLTS REMOVED	OK	NOT OK	NOT OK	NOT OK	NOT OK			NOT OK	OK	OK	
	DEPLOYING CAPTURE LATCHES	OK	NOT OK	NOT OK	NOT OK	NOT OK			NOT OK	OK	OK	
SSRMS OPS [6][7]	MNVR TO DEMATE POSN (CLEARANCE < 2)	OK	NOT OK	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	N/A
	MNVR TO DEMATE POSN (CLEARANCE > 2)	OK	OK	NOT OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT DEMATE POSN	OK	OK	OK	OK	OK	OK [5]	OK	OK	OK	OK	N/A
	MNVR TO CLEARANCE POSN	OK	OK	NOT OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT CLEARANCE POSN	OK	OK	OK	OK	OK	OK [5]	OK	OK	OK	OK	N/A
	MNVR TO PASSIVE CBM INSPECTION POSN	OK	OK	NOT OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT PASSIVE CBM INSPECTION POSN	OK	OK	OK	OK	OK	OK [5]	OK	OK	OK	OK	N/A
	MNVR TO PRE-INSTALL POSN	OK	OK	NOT OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
	AT PRE-INSTALL POSN	OK	OK	OK	OK	OK	OK [5]	OK	OK	OK	OK	N/A
	MNVR TO INSTALL (CLEARANCE > 2)	OK	OK	NOT OK	OK	OK	NOT OK	OK	OK	OK	OK	N/A
MNVR TO INSTALL (CLEARANCE < 2)	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	N/A	

@[DN 114]

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

TABLE 10A_B2-10-II - NODE 2/PMA 2 RELOCATION LOADS CONSTRAINTS (CONTINUED)

ATTITUDE CONTROL & OPS [1] NODE 2/ PMA 2	ISS ATTITUDE CONTROL			OPERATIONS							
	CMG - TA	THRUSTERS ONLY		CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST (SM, PROG)	UNDOCK -ING (RS)	DOCKING (RS)	PORT TRRJ/ SARJ/ P4 BGA ROTATION	STBD TRRJ/ SARJ/ S4 BGA ROTATION	MT TRANS/ SSRMS OPS
CBM OPS											
READY TO LATCH											
AT PMA2 INSTALL FROM CBM INITIATION OF 1ST STAGE CAPTURE TO ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [4]	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	OK	
CBM AT ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [4]	OK	OK	OK	OK	OK	OK	OK	NOT OK	OK	OK	
CBM FROM ≥ 12 BOLTS WITH A-BOLTS COMPLETE TO ≥ 12 BOLTS WITH F-BOLTS COMPLETE [4]	OK	OK	OK	OK	OK	OK	OK	NOT OK [4]	OK	OK	

@[DN 114]

NOTES:

- [1] KEY: - ACS OR OPS ALLOWED. **NOT OK** - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] REFERENCE RULE {TBD}, CBM STRUCTURAL LOADS CONSTRAINTS.
- [3] REFERENCE RULE {10A_C8-TBD}, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [4] RISK OF PERMANENT DAMAGE TO CBM SEALS FOR THIS CASE.
- [5] SM MAIN ENGINE REBOOST NOT ALLOWED
- [6] THE FOLLOWING REBOOST OPTIONS WERE ANALYZED:
 PROGRESS AT SM AFT 8R&D
 PROGRESS AT SM AFT 4 R&D WITH PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT SM AFT 4 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT DC-1 AFT 2 MID-RING WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT DC-1 AFT 2 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 2 SM MAIN JETS
 SR-1 SM MAIN JET
 SR-2 SM MAIN JET
 ATV 2 OCS JETS
 ATV 4 ACS JETS
- [7] THE FOLLOWING PROGRESS/SM/ATV ACS OPTIONS WERE ANALYZED
 PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, SM JETS ROLL
 PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 PROGRESS AT SM AFT R&D JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 SM PITCH-YAW-ROLL (NO PROGRESS OR ATV AT SM AFT)
 SM PITCH-YAW-ROLL, PROGRESS AT DC-1 ROLL
 ATV AT SM AFT PITCH-YAW, PROGRESS AT DC-1 ROLL
 ATV AT SM AFT PITCH-YAW-ROLL @[DN 114]

THIS RULE CONTINUED ON NEXT PAGE

Verify that this is the correct version before use.

FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

B. LOADS CONSTRAINTS FOR THE MOBILE TRANSPORTER ARE DEFINED THE FOLLOWING TABLE: @[DN 114]

TABLE 10A_B2-10-III - MOBILE TRANSPORTER LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1] MT CONFIGURATION [3]	ISS ATTITUDE CONTROL [4]			OPERATIONS							
	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST [5]	UN-DOCKING [6]	DOCK-ING [6]	PORT TRR// SAR// P4 BGA ROTATION	STBD SAR// S4 BGA ROTATION	SRMS OPS/ SSRMS OPS
	MOM MGMT NO DESATS	USTO [15]									
LATCHED AT WORKSITE (MIN 3 OF 4 LTU'S)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
LATCH TRANSITION	OK			OK [9]	OK [7][10]				TBD [12]	TBD [12]	
UNLATCHED (BRAKES ON)	OK	OK [8]	OK	OK [9]	OK [7][10]	OK [11]	OK	NOT OK	TBD [12]	TBD [12]	
UMA TRANSLATING	OK	NOT OK [13]		OK [9]	OK [7][10]				TBD [12]	TBD [12]	
TRANSLATING (NO SSRMS)	OK	OK [2]		OK [9]	OK [7][10]			NOT OK	TBD [12]	TBD [12]	
TRANSLATING WITH SSRMS	OK	OK [2]		OK [9]	OK [7][10]			NOT OK	TBD [12]	TBD [12]	

NOTES:

[1] KEY: - ALLOWED - NOT ALLOWED - NOT ANALYZED.

[2] THRUSTER FIRINGS ARE NOT ALLOWED WHEN THE MT IS TRANSLATING ACROSS S0/S1, S0/P1, S1/S3 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

[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 @[DN 114]

THIS RULE CONTINUED ON NEXT PAGE

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

- [5] UNLOADED SSRMS ONLY @[DN 114]
- [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] THE FOLLOWING USTO HOLD JET SELECTS ARE ALLOWED: [PRG RPY],[PRG R, SM PY], [SM R, PRG PY], [SM RPY].
- THE FOLLOWING USTO MANEUVER JET SELECTS ARE ALLOWED: [SM R, PRG PY], [SM RPY].
- THE FOLLOWING RS HOLD (INCLUDING AUTO-HANDOVER) JET SELECTS ARE ALLOWED: [SM R, PRG PY].
- RS MANEUVERS (INCLUDING RECOVERY FROM FREE-DRIFT/LOAC) ARE NOT ALLOWED, EXCEPT DURING TRANSLATIONS #4 OR #5 WHEN THE SSRMS IS ON THE LAB. DURING THOSE TWO TRANSLATIONS, THE JET SELECTS ALLOWED ARE: [PRG RPY], [PRG R, SM PY], [SM R, PRG PY], [SM RPY].
- [9] EXERCISE: THE FOLLOWING ARE ALLOWED IN CONJUNCTION OR SEPARATELY:
- TVIS/IREDC/CEVIS
- TVIS/IREDC/SM ERGOMETER
- CREWMEMBER SQUATS AND HEEL RAISES USING THE UNISOLATED INTERIM RESISTIVE EXERCISE DEVICE (IREDC) ARE LIMITED TO A MINIMUM TIME OF 3 SECONDS BETWEEN REPETITIONS.
- SM ERGOMETER RATE LIMITED TO 60 RPM'S TO AVOID STRUCTURAL TUNING
- 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] RESERVED
- [12] BGA ROTATION ALLOWED
- [13] RESERVED
- [14] REFERENCE HAZARD REPORT GNC-701-02-02 (OCAD 3744). @[DN 114]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

C. LOADS CONSTRAINTS FOR EVA ARTICULATING PORTABLE FOOT RESTRAINT (APFR) AND EVA TEMP STOW OPERATIONS ARE DEFINED IN TABLE 10A_C2-10-IV. IN GENERAL, PRCS, IRED AND RS MANEUVERS 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. @[DN 114]

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 10A_B2-10-IV - APFR AND EVA TEMP STOW LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1] APFR LOCATION	ISS ATTITUDE CONTROL			OPERATIONS				
	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED) [2]	EVA OPS	REBOOST	UNDOCK-ING	DOCKING
	MOM MGMT NO DESAT	USTO [3]						
ISS BASED APFR	OK	OK [4]	OK [4]	OK [2]	OK			
SSRMS BASED APFR	OK	OK [4]	OK [4]	OK [2]	OK			

NOTES:

- [1] KEY: - ACS OR OPS ALLOWED. - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] IRED NOT ALLOWED DURING STRUCTURE-MOUNTED APFR OPS
- [3] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [4] ATTITUDE HOLD OK, NO MANEUVERS ALLOWED @[DN 114]

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FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

D. P1 RADIATOR LOADS CONSTRAINTS ARE DEFINED IN TABLE 10A_C2-10-V, P1 RADIATOR LOADS CONSTRAINTS. ©[DN 114]

TABLE 10A_B2-10-V -P1 RADIATOR LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1]		STS ATTITUDE CONTROL [14]		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 TRRJ/SAR // P4 BGA ROTATION	STBD TRRJ/SAR // S4 BGA ROTATION	MT TRANS/SSRMS OPS/ SRMS OPS [4]
				MOM MGMT NO DESAT	USTO [6]									
P1 RADIATOR CONFIGURATION	FULLY CINCHED (6 CINCHES INSTALLED)	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOR OR EVA DRIVEN DEPLOY/RETRACT			OK				OK [3]			OK [5]	OK [5]	OK [3]	
	UNCINCHED/PARTIALLY DEPLOYED [2]	A12		OK	OK	OK	OK	OK	OK	OK [7]	OK [7]	OK [5]	OK [5]	OK [5]
	FULLY DEPLOYED	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

NOTES:

- [1] KEY: OK - ACS OR OPS ALLOWED. NOT OK - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] UNCINCHED/PARTIALLY DEPLOYED IS DEFINED AS A RADIATOR THAT HAS NO CINCHES INSTALLED AND IS LESS THAN 100 PERCENT DEPLOYED. THIS CASE INCLUDES THE FULLY RETRACTED RADIATOR THAT IS READY TO BE CINCHED. DURING NOMINAL OPERATIONS, AN UNCINCHED RADIATOR WILL BE TREATED WITH THE SAME CONSTRAINTS AS "DURING MOTOR OR EVA DRIVEN DEPLOY/RETRACT" WITH TWO EXCEPTIONS: USTO AND RS MCS ATTITUDE HOLD ARE ALLOWED AND CREW EXERCISE SHALL BE PERMITTED.
- [3] NO MAX EVA LOADS DURING RADIATOR DEPLOYMENT. MAX EVA LOADS INCLUDE VIGOROUS BODY MOTION, QUICK GRAB, KICKOFF TETHER RESTRAINTS, AND PFR INGRESS.
- [4] RMS/MT OPS ARE DEFINED AS RMS OR MT MOTION.
- [5] TRRJ ROTATION OF A PARTIALLY DEPLOYED RADIATOR WILL BE ANALYZED DURING THE FLIGHT, IF NECESSARY, DEPENDING ON REASON FOR PARTIAL DEPLOY AND NEED TO ROTATE.
- [6] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [7] FEATHERING CONSTRAINTS FOR ORBITER AND RUSSIAN VEHICLE DOCKINGS TO A PARTIALLY DEPLOYED HRS RADIATOR ARE **TBD**. ©[DN 114]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_B2-10 STAGE LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

The constraints on a partially cinched radiator will vary depending on the number and location of cinches remaining. If, real time, a cinch release failure results in a partially cinched configuration, allowable loads will be provided by the MER real-time based on the actual configuration. The uncinched configuration was analyzed outside the design configuration using contingency methodology and non-test verified linear models. This analysis included all of the loading events in the table up through the next orbiter docking. Therefore, the uncinched analysis results should be considered valid for contingency cases, not nominal operations. The state of the radiator after the cinches are released during the nominal deploy sequence should be considered the same as "During Motor or EVA Driven Deploy/Retract." Analysis indicates that propulsive attitude hold and crew exercise generate relatively low deflections and are therefore allowed to provide timeline flexibility. During crew exercise, an uncinched/undeployed radiator should be visually monitored for large displacements via available camera views in order to provide additional confidence in the linear analysis. ©[DN 114]

Analysis for rotating a partially deployed HRS radiator has not been conducted. However, all BGA's and both SARJ's may freely suntrack. The other TRRJ may operate, provided it does not have a partially deployed HRS radiator. SARJ start-up and shut-down operations should be avoided during radiator deployment operations but are acceptable in a contingency.

Source: Boeing Technical Memo A92-J332-STN-M-TSW-170, Mechanical Assessment of Free Drift vs CMG Momentum Manager Environment, December 11, 2001, AG-J332-STN-M-ER-2002-061- Dynamic Loads Assessment for the Partially Deployed HRS Radiator Study, 3-47300H/2002DIR-5000 - Partially Deployed Assessment of the HRS Radiators Using Boeing Supplied Element Loads Envelope, 3-47300H/2002DIR-5002 - UnCinched and UnDeployed Assessment of the HRS Radiators Using Boeing Supplied Element Loads Envelope. ©[DN 114]

FLIGHT RULES

10A_B2-11

10A STAGE LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS

- A. PMA 2 RELOCATION FROM U.S. LAB TO NODE 2 TIME CONSTRAINT IS 4 HOURS FOR SOLAR BETA ANGLES < -60 DEG IN +XVV AND > 60 DEG IN -XVV, OTHERWISE THERE IS NO CONSTRAINT. THE CLOCK STARTS AT PMA 2 REMOVAL FROM THE U.S. LAB AND ENDS AT PMA 2 CONNECTION TO NODE 2. THE LAB FORWARD EV HATCH COVER MUST BE INSTALLED FOR THESE TIME CONSTRAINTS TO BE VALID. ©[DN 116]

The thermal analysis was performed assuming a nominal mission and attitude timeline. Minor attitude deviations are not considered to be an impact to the overall time constraints of this rule. However, significant changes in the timing of any of these activities will result in impacts to the time constraints, which must be assessed as part of the real-time operations. Passive thermal analysis shows maximum temperature limits are exceeded for the PMA 2 PCBM after 4 hours at solar beta angles less than -60 deg for +XVV.

During the 10A docked mission, Node 2 is mated to Node 1 Port. After departure of the orbiter, PMA 2 is relocated from Lab Forward to Node 2 Forward. The Node 2/PMA 2 assembly is then relocated from Node 1 Port to the Lab Forward. The Lab Forward docking port is exposed from the time that PMA 2 is removed until the Node 2/PMA 2 assembly is attached. During this timeframe, which may be several days, the Lab Forward Berthing plate may be exposed to environments conducive to the formation of condensation. Analysis defining PMA 2 relocation beta angle constraints assumed that the hatch cover was in place. Analysis also assumed active CPA, 22.2 deg C (72 deg F) cabin temperature, and 8.9 deg C (48 deg F) dewpoint.

Source: PMA 2 Relocation Analysis, Boeing Huntsville ECLSS/Thermal Analysis (B. Evans); PTCS Forum, February 26, 2007. ©[DN 116]

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FLIGHT RULES

**10A_B2-11 10A STAGE LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS
(CONTINUED)**

B. NODE 2/PMA 2 RELOCATION FROM NODE 1 TO U.S. LAB TIME CONSTRAINTS ARE LISTED IN TABLE 10A-B2-11-I. TIMES LISTED ARE DEPENDENT UPON SOLAR BETA, AND FLIGHT ATTITUDE. THE CLOCK STARTS AT NODE 2 SHELL HEATER DEACTIVATION WHILE ON NODE 1 AND ENDS AT NODE 2 SHELL HEATER ACTIVATION WHILE ON U.S. LAB. ©[DN 116]

TABLE 10A_B2-11-I - NODE 2 RELOCATION TIME CONSTRAINTS

ATTITUDE	BETA (DEG)	TIME LIMIT
+ XVV [1]	+75	58 HRS
	+60	55 HRS
	+45	48 HRS
	+30	45 HRS
	0	38 HRS
	-30	31 HRS
	-45	29 HRS
	-60	25 HRS
	-75	20 HRS

NOTES:

[1] FOR -XVV ATTITUDE, THE ROW WITH THE OPPOSITE SIGN OF BETA ANGLE MAY BE USED.

The thermal clocks in this rule are event-based. Thermal analysis shows that components on Node 2 or PMA 2 will reach their lower limit by the times listed above in Table 10A_B2-11-I. Times listed in this table are for the most limiting component for each Beta range. The thermal analysis was performed assuming a nominal mission and attitude timeline. Minor attitude deviations are not considered to be an impact to the overall time constraints of this rule. However, significant changes in the timing of any of these activities will result in impacts to the time constraints, which must be assessed as part of the real-time operations.

This analysis also assumes that if Node 2 was ingressed while on Node 1, then Moisture Removal Kits (MRK's) were deployed prior to Node 2 closeout for relocation.

Source: Boeing Technical Memo #TS-TM-04-014, ISS Flight 10A (STS-120) Launch-To-Activation And ISS-Only Stage Thermal Analysis Documentation, June 14, 2004. ©[DN 116]

FLIGHT RULES

SOLAR ARRAY CONSTRAINTS

10A_B2-41 USOS SOLAR ARRAY CONSTRAINTS DEFINITIONS [HC] [RC]

- A. THE FOLLOWING DEFINITIONS APPLY TO THE STRUCTURAL LOAD MATRICES OF APPENDIX C.
1. BGA STRUCTURAL
 - a. RED ZONE - BGA POSITION EXCEEDS THE LOAD/LIMIT LOAD RATIO. THIS POSITION WILL EXPOSE THE STRUCTURE TO LOAD THAT CAN CAUSE A CATASTROPHIC FAILURE OF THE ARRAY STRUCTURE.
 - b. YELLOW ZONE - BGA POSITION INDUCES HIGH LOADS IN THE STRUCTURE. THIS POSITION WILL REDUCE THE FATIGUE LIFE OF THE ISS STRUCTURE AND SHOULD BE AVOIDED. THIS POSITION HAS THE POTENTIAL FOR A BGA CONTROLLER FDIR TRIP IF THE BGA IS UNLOCKED.
 - c. GREEN ZONE - BGA POSITION IS ALLOWED.
 2. SARJ STRUCTURAL
 - a. RED ZONE - SARJ POSITION EXCEEDS THE LOAD/LIMIT LOAD RATIO OF A LOCKED SARJ. THIS POSITION WILL EXPOSE THE STRUCTURE TO LOAD THAT CAN CAUSE A CRITICAL FAILURE OF THE SARJ INTERFACE.
 - b. YELLOW ZONE - SARJ POSITION EXCEEDS THE LOAD/LIMIT LOAD RATIO OF AN UNLOCKED SARJ. THIS POSITION WILL EXPOSE THE STRUCTURE TO LOAD THAT CAN CAUSE A CRITICAL FAILURE OF THE DLA MECHANISM. THEREFORE, THE SARJ MUST BE LOCKED.
 - c. GREEN ZONE - SARJ POSITION IS ALLOWED FOR A LOCKED AND UNLOCKED SARJ
- B. THE FOLLOWING DEFINITIONS APPLY TO THE ENVIRONMENTS MATRICES OF APPENDIX C.
1. SAW EROSION/CONTAMINATION
 - a. RED ZONE - UNACCEPTABLE LIFETIME EROSION/CONTAMINATION IMPACT

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-41 USOS SOLAR ARRAY CONSTRAINTS DEFINITIONS [HC] [RC]
(CONTINUED)

- b. YELLOW ZONE - ACCEPTABLE LIFETIME EROSION/CONTAMINATION IMPACT (TRANSITION ZONE)
 - c. GREEN ZONE - NEGLIGIBLE EROSION/CONTAMINATION IMPACT
2. SOME PORTIONS OF THE MATRICES INCLUDE AREAS WHICH CONTAIN NO DATA (PURPLE), INDICATING THAT THEY ARE UNANALYZED CASES. THESE AREAS ARE TO BE TREATED AS RED ZONES UNTIL ANALYSIS SHOWS OTHERWISE.
 3. SINGLE LONGERON SHADOWING - OCCURS WHEN ONE OF THE PANELS OF THE SOLAR ARRAY CASTS A SHADOW ALONG THE COMPLETE LENGTH OF ONE OF THE FOUR LONGERONS OF THE ARRAY'S MAST. DUE TO THE TEMPERATURE DIFFERENTIAL BETWEEN THE SHADOWED LONGERON AND THE UNSHADOWED LONGERONS, BUCKLING AND STRUCTURAL FAILURE OF THE MAST MAY OCCUR IN AS LITTLE AS 30 MINUTES.

USOS solar arrays in XVV LVLH with a parked SARJ and a fixed BGA will experience significant durations of single longeron shadowing if shadowing is occurring in one of four shadow zones as the sun passes through the solar array relative YZ plane (plane perpendicular to the mast length). Long durations of shadowing occur due to the orientation of the arrays as the sun passes over the length of the panel, it will present a nearly constant sun-bias relative to the normal of the array. Such shadowing induces significant loads into the longerons of the mast - always enough to be a fatigue concern, usually enough to exceed the buckling limit of the mast if combined with mechanical loading, and, at high magnitude betas, enough to exceed the buckling limit without any combined loads.

Excluding truss shadowing which can induce about an additional 10 minutes of shadow along most of the length of a longeron, shadow durations will range from 25 to 45 minutes in low beta magnitudes, depending primarily on the BGA position, roll of the vehicle, and the solar beta, and secondarily on the yaw of the vehicle and the SARJ position relative to eclipse. Shadow durations will range from 45 to 80 minutes at high magnitude betas.

Twenty-five minutes of shadowing induces a delta T between the shadowed longeron and those in the sun of about 100 degrees F which will be cycled each orbit (fatigue concern). As the shadow duration increases from 25 to 45 minutes, a delta T of 137 degrees F will be exceeded. This is the value that induces loads that, when combined with other nominal loading of the array and vehicle, may exceed the buckling limit of the mast. Forty-five minutes of shadowing generates delta T's approaching 160 degrees F, inducing loads at the buckling limit from shadowing alone. Eighty minutes of shadowing will cause delta T's at or above 180 degrees F, inducing loads well beyond the limit for buckling.

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ISS EXPEDITIONS 15 & 16				

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FLIGHT RULES

10A_B2-41 USOS SOLAR ARRAY CONSTRAINTS DEFINITIONS [HC] [RC]
(CONTINUED)

It should also be noted that the maximum delta T for a given shadowing event is not attained in the first insolation pass if the solar beta magnitude is less than 65 degrees. It will reach maximum value in the second or third insolation pass as the longeron in shadow attains its coldest value. As a crude rule of thumb, the first orbit delta T is approximately 20 degrees F less than the maximum it will attain and repeat in subsequent orbits.

It should also be noted that the delta T is reduced significantly during eclipse as the hot longerons cool down. Another crude rule of thumb is a drop in delta T of 4 degrees F per minute of eclipse, affording the opportunity to execute loading events when the thermally induced load has been reduced. Note that this cycling of the thermal load affects fatigue life.

Also note that sun-tracking the SARJ with a BGA fixed in a shadow zone likely sustains shadowing throughout the orbit, inducing delta T's that likely exceed 160 degrees F and often exceed it significantly, possibly attaining 220 degrees F.

Buckling of the mast is defined as a catastrophic hazard due to the possibility that it will cause structural failure of the mast which may result in high energy contact with pressure shells and other safety critical components. It is likely that such a failure would occur about 2/3 of the way along the mast toward the tip-shell.

Reference: Hazard Reports ISS-STR-115-12A.1 and NCR ISS-STR-188-12A.1

4. SINGLE LONGERON SHADOWING ZONES - THE RANGE OF ANGLES BETWEEN THE NORMAL TO THE ACTIVE FACE OF AN ARRAY AND THE COMPONENT OF THE SUN VECTOR LYING IN THE PLANE PERPENDICULAR TO THE ROTATION AXIS OF THE ARRAY. THERE ARE MULTIPLE SHADOW ZONES PER ARRAY AND THESE ZONES VARY DEPENDING ON SOLAR BETA AND ATTITUDE.

STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-71
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_B2-42

USOS SOLAR ARRAY CONSTRAINT ZONE MANAGEMENT AND CHART INTERPRETATION [HC] [RC]

THE FOLLOWING RULES SHALL BE USED WHEN INTERPRETING THE MATRICES IN APPENDIX C DURING IDENTIFICATION OF CONSTRAINTS FOR COMBINATIONS OF BGA AND SARJ ANGLE: ©[DN 96]

- A. BEFORE ENTERING THE MATRICES, AN INITIAL CHOICE MUST BE MADE REGARDING SELECTION OF A BGA ANGLE AND A SARJ ANGLE. FOR A GIVEN THRUSTER CONFIGURATION OR EVENT, LOCATE THE APPROPRIATE CHARTS FOR THE BGA AND SARJ. CELLS ARE IDENTIFIED BY LOCATING BGA ANGLE ACROSS THE ROW AND SARJ ANGLE DOWN THE COLUMN.
- B. FOR EACH BGA, FIRST REFER TO THE RESPECTIVE BGA STRUCTURAL CHARTS IN APPENDIX C.
 1. A BGA SHALL NOT BE PARKED IN A RED ZONE.
 2. A BGA MAY BE PARKED IN A YELLOW ZONE IF THERE ARE NO SOLUTIONS PER RULE {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC], WHICH YIELD A GREEN ZONE.
 3. IF THERE ARE ANY RED ZONES WITHIN THE SAME ROW, THE BGA SHALL BE PARKED AND LATCHED. IF THERE ARE ANY RED ZONES WITHIN THE SAME COLUMN, THE SARJ SHALL NOT BE ALLOWED TO TRACK.

Controller analysis shows that the BGA motor can hold position under plume loads for BGA angles located within a nominal green zone. However, the BGA must be parked to prevent a single BGA failure from resulting in rotation into a red zone. The BGA must also be latched to maintain two-fault tolerance associated with hazard requirements. This ensures that the BGA cannot rotate into an adjacent red zone.

Controller analysis also shows that the BGA motor may not be able to hold position under plume loads for BGA angles located within yellow zones. Approximately 50 percent of analyzed events indicated plume loads would result in a divergence trip causing the BGA motor to turn off. In this situation, the array is free to rotate. Latching is required to avoid rotation into a red zone.

SARJ tracking is not allowed if it would cause the BGA to pass through red zones. ©[DN 96]

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FLIGHT RULES

10A_B2-42

USOS SOLAR ARRAY CONSTRAINT ZONE MANAGEMENT AND CHART INTERPRETATION [HC] [RC] (CONTINUED)

4. IF THE ROW DOES NOT CONTAIN ANY RED ZONES BUT CONTAINS YELLOW ZONES, THE BGA SHOULD BE PARKED TO AVOID TRACKING THROUGH THE YELLOW ZONES. IF THE COLUMN DOES NOT CONTAIN ANY RED ZONES BUT CONTAINS YELLOW ZONES, THE SARJ SHOULD NOT BE ALLOWED TO TRACK TO AVOID BGA PASSING THROUGH YELLOW ZONES. HOWEVER, TRACKING THROUGH YELLOW ZONES MAY BE ALLOWED TO MEET HIGHER LEVEL PRIORITIES DEFINED IN RULE {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]. ©[DN 96]

There is a risk that if the row contains any yellow zones, the BGA motor may trip off due to plume impingement while tracking through a yellow zone. Therefore, the BGA should be parked to avoid passing through these zones. Tracking may be allowed to meet higher level priorities.

SARJ tracking should be avoided if it would cause the BGA to pass through yellow zones.

5. IF THE ROW IS ALL GREEN, BGA TRACKING IS ALLOWED.
- C. FOR EACH BGA SOLUTION, NEXT REFER TO THE SARJ STRUCTURAL CHART IN APPENDIX C.
1. IF THE ENTIRE SAJR CHART IS GREEN, SARJ TRACKING IS ALLOWED UNLESS ANY RELATED BGA CHART DETERMINED SARJ TRACKING IS PROHIBITED, IN WHICH CASE, PARK THE SARJ. THE BGA'S DO NOT NEED TO BE LATCHED UNLESS LATCHING WAS REQUIRED PER THE SPECIFIC BGA CHART.
2. IF THE COLUMN IS ALL GREEN, THE SARJ MAY AUTOTRACK AS LONG AS ALL OUTBOARD BGA'S ARE LATCHED. HOWEVER, IF ANY RELATED BGA CHART DETERMINED SARJ TRACKING IS PROHIBITED, THE REQUIREMENTS BELOW FOR PARKING THE SARJ APPLY.

If the column is all green, a rotating SARJ would not pass through any red or yellow zones at the given BGA angle. However, failure of an unlatched BGA which results in a free-wheeling array can result in damage to SARJ components if the BGA rotates to an angle that puts the SARJ in a red or yellow zone. To protect for this, the BGA must be latched to prevent rotation.

3. IF THE COLUMN IS NOT ALL GREEN OR IF ANY RELATED BGA CHART DETERMINED SARJ TRACKING WAS NOT ALLOWED, THE SARJ MUST BE PARKED. ©[DN 96]

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FLIGHT RULES

10A_B2-42

**USOS SOLAR ARRAY CONSTRAINT ZONE MANAGEMENT AND
CHART INTERPRETATION [HC] [RC] (CONTINUED)**

4. IF THE SARJ IS PARKED: ©[DN 96]
- a. THE SARJ SHALL NOT BE PARKED IN A RED ZONE.
 - b. THE SARJ MAY BE PARKED IN A YELLOW ZONE AS LONG AS IT IS LOCKED.

The SARJ must be locked in a yellow zone to avoid damage to the hardware.

- c. IF THERE ARE ANY RED ZONES WITHIN THE SAME ROW, ALL OUTBOARD BGA'S MUST BE LATCHED.

Failure of an unlatched BGA which results in a free-wheeling array can result in damage to SARJ components if the BGA rotates to an angle that puts the SARJ in a red zone.

- d. IF THE ROW DOES NOT CONTAIN ANY RED ZONES BUT CONTAINS YELLOW ZONES, EITHER THE SARJ MUST BE LOCKED OR ALL OUTBOARD BGA'S MUST BE LATCHED.

Failure of an unlatched BGA which results in a free-wheeling array can result in damage to SARJ components if the BGA rotates to an angle that puts the SARJ in a yellow zone and it is not locked. To protect for this, either the SARJ must be locked or the BGA must be latched to prevent rotation.

- e. IF THE ROW IS ALL GREEN, SARJ LOCKING IS NOT REQUIRED.

D. IF SARJ TRACKING IS ALLOWED, REFER AGAIN TO EACH BGA STRUCTURAL CHART:

- 1. IF THE BGA CHART CONTAINS ANY RED ZONES, THAT BGA SHALL BE LATCHED.

If the SARJ is allowed to track, the failure of the BGA to hold position may cause that BGA to enter a red zone. Therefore, the BGA must be latched. ©[DN 96]

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FLIGHT RULES

10A_B2-42

**USOS SOLAR ARRAY CONSTRAINT ZONE MANAGEMENT AND
CHART INTERPRETATION [HC] [RC] (CONTINUED)**

2. IF THE BGA CHART DOES NOT CONTAIN ANY RED ZONES BUT CONTAINS YELLOW ZONES, THE BGA SHOULD BE PARKED TO AVOID TRACKING THROUGH THE YELLOW ZONES. HOWEVER, TRACKING THROUGH YELLOW ZONES MAY BE ALLOWED TO MEET HIGHER LEVEL PRIORITIES DEFINED IN RULE{10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]. @[DN 96]
3. MCC-H GROUND TOOLS WILL BE USED TO DETERMINE THE LONGERON SHADOWING ZONE (RED OR GREEN) OF AN ARRAY DURING THE SELECTION OF A COMBINATION OF SARJ AND BGA ANGLES. THESE ZONE DEFINITIONS ARE EQUIVALENT TO THOSE FOR THE BGA STRUCTURAL CHART.

The matrices of Appendix C do not account for longeron shadowing. MCC-H has ground tools which are used to evaluate if a longeron shadowing hazard exists at a specified combination of attitude, beta angle, SARJ angle, and BGA angles. This tool will be used to determine the zone of an array. There are only two zones, Red (in the zone) and Green (not in the zone).

4. MCC-H GROUND TOOLS WILL BE USED TO DETERMINE THE IMPACTS TO POWER AVAILABILITY DURING THE SELECTION OF A COMBINATION OF SARJ AND BGA ANGLES WHILE TRYING TO MEET THE OTHER CONSTRAINTS OF THIS RULE. POWER GENERATION WILL BE MAXIMIZED ACCORDING TO THE CONSTRAINTS AND TAKING INTO CONSIDERATION THE PRIORITIES OUTLINED IN RULE {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC].

The matrices of Appendix C do not account for power generation. MCC-H has ground tools, which are used to evaluate the impacts to power generation at a specified combination of attitude, beta angle, SARJ angle, and BGA angles. @[DN 96]

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FLIGHT RULES

10A_B2-42

USOS SOLAR ARRAY CONSTRAINT ZONE MANAGEMENT AND
CHART INTERPRETATION [HC] [RC] (CONTINUED)

- E. FOR EACH RESULTING BGA AND SARJ ANGLE COMBINATION, NEXT REFER TO THE BGA ENVIRONMENTS CHARTS IN APPENDIX C. @[DN 96]
1. THE BGA SHOULD NOT BE PARKED IN OR ALLOWED TO TRACK THROUGH A RED ZONE. THE YELLOW ZONE SHOULD BE AVOIDED IF POSSIBLE.

Attempts should be made to avoid placing the arrays in red or yellow erosion/contamination zones; however, other higher priority constraints may override.

- a. FOR A GIVEN SARJ ANGLE, BGA TRACKING IS PERMITTED IF THE ROW CONTAINS NO RED ZONES.
 - b. FOR A GIVEN BGA ANGLE, SARJ TRACKING IS PERMITTED IF THE COLUMN CONTAINS NO RED ZONES.
2. THE PROCESS TO SELECT A SARJ AND BGA ANGLE COMBINATION SHOULD BE ITERATED TO OPTIMIZE ALL CONSTRAINTS. THIS MAY REQUIRE ADJUSTING THE BGA AND/OR SARJ ANGLES OR USING A DIFFERENT THRUSTER CONFIGURATION IF AVAILABLE. @[DN 96]

FLIGHT RULES

10A_B2-43 SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]

SOLAR ARRAY POSITIONING OPERATIONS WILL INCORPORATE THE FOLLOWING PRIORITIZED CONSTRAINTS, IN ORDER OF DECREASING IMPORTANCE:

Where conflicts arise in solar array positioning constraints, this rule takes precedence. This means angular positions may be adjusted to meet these priorities.

- A. THE U.S. SOLAR ARRAYS WILL BE POSITIONED SUCH THAT POWER TO A SINGLE STRING OF EQUIPMENT NECESSARY FOR CREW AND/OR STATION SURVIVAL IS MAINTAINED.
- B. THE U.S. SOLAR ARRAYS WILL NOT BE POSITIONED AT ANY LOCATION (COMBINATION OF SARJ AND BGA ANGLES) THAT MAY EXPOSE THE SAW MAST TO A POTENTIAL STRUCTURAL FAILURE.

Structural failure of the SAW mast may occur due to loading caused by:

- a. *Thruster pluming*
- b. *The thermal environment with or without coupled docked loads (e.g., longeron shadowing). For nominal mission and stage planning where an array(s) needs to be parked for a specific activity, the ground will have a planning tool available to verify that the selected array angle avoids the longeron shadowing zones. Where conflicts arise, there will be sufficient time during the planning cycle to consult engineering. A loss of BGA function while outside a shadow zone would not cause LS until either the solar beta changed sufficiently, at least 2 degrees (a minimum of 9 hours), or the vehicle attitude is changed. This allows sufficient time for the ground to predict whether LS is a concern for upcoming changes in beta and attitude and decide on a course of action.*
- C. THE U.S. SOLAR ARRAYS WILL BE POSITIONED SUCH THAT POWER TO CORE SYSTEM REDUNDANCY IS MAINTAINED.
- D. THE U.S. SOLAR ARRAYS WILL BE POSITIONED ACCORDING TO RULE {10A_B9-4}, PLASMA HAZARD MITIGATION DURING EVA [HC] [RC], DURING AN EVA TO CONTROL PLASMA HAZARDS.
- E. THE U.S. SOLAR ARRAYS WILL BE POSITIONED SUCH THAT POWER TO EQUIPMENT REQUIRED FOR MISSION SUCCESS IS MAINTAINED.

These loads are specified on an activity by activity basis. For example, docking is a mission success goal.

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FLIGHT RULES

10A_B2-43 SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]
(CONTINUED)

F. THE U.S. SOLAR ARRAYS WILL NOT BE PUT AT ANY LOCATION THAT WILL CAUSE STRUCTURAL FATIGUE OF THE SAW MAST.

Fatigue of the SAW mast may occur due to repeated loading caused by:

- a. *Thruster pluming*
- b. *The thermal environment with or without coupled docked loads (e.g., Longeron Shadowing).*

G. THE U.S. SOLAR ARRAYS WILL BE POSITIONED SO THAT THEY DO NOT INTERFERE WITH ANY DOCKING VEHICLE COMMUNICATION SYSTEMS (KURS COMMUNICATION FOR SOYUZ/PROGRESS/ATV DOCKING, GPS COMMUNICATION FOR ATV).

Communication paths from the ISS and the approaching vehicle will be kept clear to ensure the accuracy of the docking vehicle's guidance algorithm.

H. EARLY FEATHERING OF THE U.S. SOLAR ARRAYS TO REMOVE THE POTENTIAL OF PASSING THROUGH A LONGERON SHADOWING ZONE WILL BE PERFORMED FOR MANEUVERS TO INERTIAL ATTITUDES AT ANY BETA AND LVLH ATTITUDES FOR |BETA| ABOVE 50.

During attitude maneuvers to inertial attitudes and high beta LVLH attitudes, there exists a risk that the BGA motor will stop rotating at a position that will cause longeron shadowing when the new attitude is entered. Feathering the array at an acceptable angle prior to the maneuver removes the potential for a BGA failure to result in a longeron shadowing hazard.

In these cases, information regarding potential longeron shadowing will be provided from the ISS MER in a best effort case a minimum of 2 weeks prior to the Monday of the week of execution before the event for planning and analysis to minimize impacts to payloads and operations. Without this information, it must be assumed that solar array will pass through the longeron shadow zones.

All other BGA repositioning activities will not preclude passing through longeron shadowing zones based on given time and available tools for analysis.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B2-43 **SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]**
(CONTINUED)

I. THE U.S. SOLAR ARRAYS WILL NOT BE POSITIONED WHERE THEY WILL BE CONTAMINATED OR ERODED.

Contamination and Erosion are caused by:

- a. *Thruster Pluming. ISS and approaching vehicles have thrusters that may point at the solar arrays.*
- b. *Water dumps. Ice particle formation as a result of venting water overboard may impact the solar arrays.*

J. THE U.S. SOLAR ARRAYS WILL BE POSITIONED TO POWER PAYLOADS.

All excess power, beyond that required for critical system redundancy and mission success, will be supplied to payloads.

Reference Hazard Reports ISS-COL-1006, Hazards to Solar Array Wings; EPS-0503, Loss of Degradation of ISS Electrical Power Results in Loss of Critical Function; and ISS-STR-0115, Structural Failure of the Solar Array Wing (SAW) Mast Longerons due to Extended Shadowing. ©[DN 52]

10A_B2-44 **SOLAR ARRAY BIAS RESTRICTIONS [RC]** ©[DN 42]

BIASING THE SARJ'S AND BGA'S FOR DRAG REDUCTION WILL NOT BE PERFORMED DURING FLIGHT AND STAGE 10A OPERATIONS.

Biasing or off-pointing the solar arrays for drag reduction can complicate longeron shadowing in certain failure scenarios. If solar panels are pointed directly toward the solar vector at the time of a failure which fixes the SAW in a particular position means that a number of days are required before the failed SAW is in a longeron shadow zone (5-7 days assuming standard 4.5 deg/day change in solar beta angle). For 10A stage, until tools/training to mitigate the hazard are complete, ISSPO has accepted the fact MOD will not protect against longeron shadowing. therefore, solar panels shall not be biased for drag reduction purposes.

FLIGHT RULES

10A_B2-45 **USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC]**
[RC]

FOR NOMINAL PLANNING, THE USOS SOLAR ARRAYS WILL BE MANAGED AS FOLLOWS: ©[DN 91]

- A. A CHIT WILL BE WRITTEN DOCUMENTING SOLAR ARRAY AND SARJ ANGLE CONSTRAINTS FOR SPECIFIC AND GENERIC ACTIVITIES. THE CHIT WILL INCLUDE THE CONSTRAINTS AS AN ATTACHMENT WORKED THROUGH THE INTEGRATED SOLAR ARRAY OPERATIONS WORKING GROUP (AKA THE "CHEAT SHEET"). THIS DOCUMENT CONSTITUTES THE OFFICIAL CONSTRAINTS ON SOLAR ARRAY OPERATION FOR PLANNED EVENTS AND CERTAIN CONTINGENCY RESPONSES.
- B. FOR THE LISTED ACTIVITIES, ARTICULATING JOINTS WILL BE CONFIGURED AS DOCUMENTED IN THE CHIT. THE ANGLES AND RANGES WITHIN THIS CHIT OPTIMIZE APPLICABLE STRUCTURAL LOADS AND ENVIRONMENTAL EROSION CONSTRAINTS.

An angle 180 degrees opposite of those listed in the chit may also be used. Except for power generation, this presents a similar orientation relative to other constraints.

- C. AN ANGLE WITHIN THE GIVEN RANGE WILL BE CHOSEN TO OPTIMIZE POWER GENERATION AND AVOID PARKING IN A LONGERON SHADOWING ZONE. THIS PROCESS MAY REQUIRE ITERATION.

Longeron shadowing and power generation are dependent on both vehicle attitude and beta angle. These constraints are not directly accounted for in the table. During the planning phase, ground tools are used to determine the impacts of these constraints.

- D. AN ACTIVITY MAY PROCEED WITHOUT DELAY AS LONG AS PARAGRAPHS B AND C ARE MET.
- E. WHERE CONFLICTS ARISE AMONG CONSTRAINTS, REFER TO RULE {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]. ©[DN 91]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

**10A_B2-45 USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC]
[RC] (CONTINUED)**

- F. IF ANY SARJ OR SOLAR ARRAY CANNOT BE CONFIGURED PER THE ESTABLISHED CONSTRAINTS IN THE CHIT, PHALCON MAY USE THE INTEGRATED CONSTRAINTS MANAGEMENT TOOL TO SELECT AN APPROPRIATE APPENDAGE CONFIGURATION, PER RULE {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]. IN THE EVENT THAT NO ACCEPTABLE SOLUTION CAN BE FOUND, THE EVENT WILL BE DELAYED OR ABORTED UNTIL FURTHER ENGINEERING ANALYSIS CAN BE PERFORMED. FUNCTIONAL BGA'S WILL BE RETURNED TO AUTOTRACK TO AVOID POTENTIAL LONGERON SHADOWING. ©[DN 91]
- G. THE INTEGRATED SOLAR ARRAY CONSTRAINTS CHIT MAY BE UPDATED AS NEEDED. THE OFFICIAL VERSION WILL BE ARCHIVED AND CONFIGURATION CONTROLLED ON THE MCC HOUSTON WEBSITE (**TBD**).

Source documents: **TBD**

The Integrated Solar Array Constraints Working Group (ISAOWG) is a multi-discipline team (PHALCON, VIPER, GN&C, Environments, Loads and Dynamics, ADCO, et al) responsible for developing a workable set of constraints for planned events and select contingencies. The document produced is commonly referred to as The Cheat Sheet, which explicitly lists the constraints on SARJ and BGA positioning/locking for ISS events. Due to the fact that the constraints within are often solar beta angle dependent, power balance and longeron shadowing analysis often needs to be redone to accommodate launch slips and event delays. This analysis is often performed after the rule is required to be submitted. To avoid the overhead associated with changing angles within the rule, a chit based system will be used to formally document the constraints. The constraints will be updated via chit, if necessary, if planned operations change, or power balance/longeron shadowing analysis deems the original constraints unmanageable. Since PHALCON is an integral member of the ISAOWG team, changes to the constraints (Cheat Sheet) will already be known and expected. The chit will make it official. The constraints established in the chit have the same official merit as a rule.

*The official version of the solar array constraints will be stored on the MCC Houston website, location **TBD**. ©[DN 91]*

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

PRELAUNCH

10A_C2-1 SHUTTLE LAUNCH WINDOW

A. LAUNCH WINDOW OPEN AND CLOSE TIMES FOR TARGET LAUNCH DATES CHOSEN BY THE SPACE SHUTTLE PROGRAM WILL BE BASED ON THE LATEST ISS REFERENCE TRAJECTORY AND STANDARD PLANAR CONSTRAINTS. THE ASCENT FLIGHT DIRECTOR IS THE OFFICIAL SOURCE FOR DISSEMINATING THE LAUNCH TIME AND LAUNCH WINDOW DETAILS FOR ANY SPECIFIC LAUNCH DATE. @CR 8848]

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 23 MINUTES EACH DAY, REPEATING APPROXIMATELY EVERY 60 DAYS.

Because the launch window and launch date can change frequently, the Ascent Flight Director is the official source for disseminating this information based on data provided by the Flight Dynamics Officers (FDO's). For early mission planning, Flight Design generates the official launch window products. Once the launch is 4-6 weeks away, the FDO's become another resource to generate the launch data since they can readily respond to ISS trajectory, launch date, and other changes. @CR 8848]

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FLIGHT RULES

10A_C2-1

SHUTTLE LAUNCH WINDOW (CONTINUED)

B. 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-120: @ICR 8848 _]

1. THE MAXIMUM PHASE ANGLE AT OMS-2 FOR A FD3 RENDEZVOUS IS APPROXIMATELY 315 DEGREES WHILE THE MINIMUM PHASE ANGLE IS APPROXIMATELY 36 DEGREES.

Since the ISS altitude is expected to be approximately 185 nm at launch, everyday 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 315 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 B4), and a FD3 posigrade day of rendezvous NC maneuver of at least 6 fps. On launch days where the phase angle is slightly larger than 315 degrees, retrograde maneuvers (reference paragraph B4) and launch time adjustments (reference paragraph C) can be used to change an apparent FD4 rendezvous into a FD3 rendezvous.

2. 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. IN CASES WHERE A THIRD BURN IS NOT REQUIRED, OMS-2 TARGETS WILL BE SELECTED TO ALLOW FD2 RENDEZVOUS. THE MAXIMUM PHASE ANGLE AT OMS-2 THAT CAN SUPPORT FD2 RENDEZVOUS IS APPROXIMATELY 150 DEGREES.

If an MDF is declared early on FD1, a FD2 rendezvous offers the possibility of additional mated operations. On the other hand, a FD2 rendezvous timeline imposes FD1 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 phasing be arrested to achieve a FD3 rendezvous without propellant penalty. Due to very tight timeline constraints and required FD2 inspection activities on STS-120, FD2 phasing will not be protected if doing so requires a third burn on FD1 to switch to a FD3 rendezvous. @ICR 8848 _]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-1

SHUTTLE LAUNCH WINDOW (CONTINUED)

3. TO PROVIDE MAXIMUM PHASING CAPABILITY, POST OMS-2 PERIGEE HEIGHT CAN BE AS LOW AS 85 NM AND RETROGRADE PHASING BURNS MAY BE PLANNED. @ICR 8848]

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 in order to increase phase rate above that for a nominal, propellant-efficient rendezvous restricted to posigrade burns. 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.

With active trajectory control of the ISS, it is possible that FD3 rendezvous can be preserved for almost all available launch dates in October/November. However, since the expected altitude of the ISS at shuttle launch is close to 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 cannot be optimized correctly for FD3 rendezvous because of other Program requirements.

- C. THE PREFERRED LAUNCH TIME WILL BE DETERMINED AS DOCUMENTED IN RULE {A2-8}, LAUNCH TIME SELECTION FOR GROUND-UP RENDEZVOUS. FOR STS-120, 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 B2), 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 B2) and can be used in addition to or instead of retrograde maneuvers (reference paragraph B4). 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. @ICR 8848]

FLIGHT RULES**10A_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 4 WITH BOTH CETA CARTS STARBOARD OF THE MT AND THE SSRMS ON LAB PDGF. @[DN 112] @[DN 113]
 2. SINGLE FAULT TOLERANT AIRLOCK SYSTEM FUNCTIONALITY TO PERFORM CAT 1 MISSION OBJECTIVES (DETERMINATION MAY BE BASED ON PREVIOUS USAGE)
 3. SINGLE FAULT TOLERANT PORT NODE 1 CBM SYSTEMS, (INCLUDING COMMAND AND CONTROL CAPABILITY). REFERENCE RULE {B10-51}, CBM FAILURE IMPACT MATRIX [HC].
 4. A SINGLE STRING OF THE CENTERLINE BERTHING CAMERA SYSTEM (CBCS) HAS BEEN INSTALLED AND CHECKED OUT WITH VIDEO OF THE CHECKOUT DOWNLINKED TO THE GROUND.

CBCS is the primary berthing cue for this flight. If CBCS has not been checked out prior to launch, there is no guarantee that the hardware is functional. CBCS relies on having two functioning strings to comply with certification requirements. If a CBCS ORU is failed, a spare can be used, but this leaves the primary berthing cue system zero fault tolerant. CBCS is disassembled following each use and returned to on-orbit storage. Equipment damage can result from the repeated assembly and disassembly of the components. Should the prelaunch checkout fail, enough time must be available to get a flight spare on the manifest to avoid being zero fault tolerant on the primary berthing cue system; thus, the pre-launch checkout should be scheduled far enough in advance of launch to allow for manifesting a spare ORU if required. Downlinking the CBCS video to the ground is required in order to verify all components of the ISS Video Distribution System (VDS) required for use with CBCS are functioning. When installed, CBCS is out of the normal translation path of the crew and is not at high risk for being damaged after it is installed. All CBCS components are designed to withstand on-orbit loads, including kick loads. @[DN 113]

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FLIGHT RULES

10A_C2-2 ISS DRIVEN SHUTTLE LAUNCH COMMIT CRITERIA [RI]
(CONTINUED)

5. C&DH/SOFTWARE CONFIGURATION AS FOLLOWS: @[DN 113]

a. THERE MUST BE TWO OF EACH OF THE C&C, NCS, EXT, INT, GNC, AND PMCU MDM'S ABLE TO SUPPORT THE SCHEDULED 10A OPERATIONS. @[DN 155]

b. ALL POWERED/OPERATIONAL MDM'S IN SYNC

B. NON-ISS SHUTTLE CARGO ELEMENT LCC: NONE @[DN 79] @[DN 113]

10A_C2-3 RESERVED @[DN 150]

FLIGHT RULES

PRIORITIES AND MISSION DURATION

10A_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: @[DN 11]
1. INSTALL NODE 2 TO NODE 1 PORT CBM AND ACTIVATE NODE 2 SHELL HEATERS. (CAT 1)
 2. ROTATE ONE EXP 15/16 CREW WITH EXP 16 CREW, TRANSFER CRITICAL CREW ROTATION CARGO PER ISS-10A TRANSFER PRIORITY LIST, AND PERFORM MANDATORY CREW ROTATION TASKS (SAFETY BRIEF, IELK INSTALL, SOKOL SUIT CHECKOUT). (CAT 1)
 3. TRANSFER MANDATORY WATER QUANTITIES PER 10A TRANSFER PRIORITY LIST. (CAT 1)
 4. TRANSFER CRITICAL ITEMS PER ISS-10A TRANSFER PRIORITY LIST. (CAT 1)
 5. P6 RELOCATION TASKS: (CAT 1)
 - a. INSTALL P6 AFT RADIATOR SHROUD.
 - b. DISCONNECT Z1/P6 UTILITY TRAY POWER, DATA, AND FLUID UMBILICALS.
 - c. INSTALL SSU COVERS PRIOR TO BEGINNING P6 RELOCATION.
 - d. REMOVE P6 FROM Z1 AND INSTALL P6 TO P5.
 - e. CONNECT P5/P6 UTILITY TRAY POWER AND DATA UMBILICALS.
 - f. CONFIGURE MBSU JUMPERS TO SUPPORT P6 STARTUP ON P5.
 6. TRANSFER NODE 2 PDGF TO ISS. (CAT 2)
 7. RETRIEVE SASA FROM Z1 FOR RETURN IN SHUTTLE PLB. (CAT 2)
@[DN 11]

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FLIGHT RULES**10A_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)**

8. INSTALL MAIN BUS SWITCHING UNIT (MBSU) TO ESP2. (CAT 2)
@DN11]
9. PERFORM MINIMUM HANDOVER TIME OF 12 HOURS FOR ROTATING CREWMEMBER. (CAT 2)
10. TRANSFER ALL REMAINING CARGO PER ISS-10A TRANSFER PRIORITY LIST. (CAT 2)
11. TRANSFER REQUIRED O₂ FROM SHUTTLE TO ISS HPGT'S AS ORBITER CONSUMABLE MARGINS PERMIT (AT LEAST 25 LBS DESIRED).
12. TRANSFER REQUIRED N₂ FROM SHUTTLE TO ISS HPGT'S AS ORBITER CONSUMABLE MARGINS PERMIT (AT LEAST 50 LBS DESIRED)
13. INSTALL NODE 2 PDGF AND NODE 2 PDGF TERMINATOR AND COVER (NODE 2 RELOCATION/ISS-1E PREPARATORY TASK). (CAT 2)
14. INSTALL FOUR NODE 2 TRUNNION AND ONE KEEL PIN COVER. (CAT 2)
15. PERFORM P6 RE-ACTIVATION: (CAT 2)
 - a. RELEASE P6 FORWARD RADIATOR CINCHES, DEPLOY PHOTOVOLTAIC RADIATOR, AND ACTIVATE PHOTOVOLTAIC THERMAL CONTROL SYSTEM.
 - b. REMOVE SSU COVERS.
 - c. CONFIGURE P6 ELEMENTS FOR POWER GENERATION AND DEPLOY P6 (CHANNEL 2B AND 4B) SOLAR ARRAY WINGS.
 - d. ACTIVATE P6.
16. DEPLOY S1 RADIATOR OUTER PANELS: (CAT 3)
 - a. CONNECT SQUIB FIRING UNITS (SFU'S) POWER HARNESS AND RELEASE CINCHES. @DN11]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)

- b. DEPLOY S1 RADIATOR OUTER PANELS (TWO). @[DN 11]
 - c. DISCONNECT THE SFU'S POWER HARNESS AND RECONFIGURE TO POWER RADIATOR BEAM LINE HEATERS, AND ACTIVATE S1 FLUID LINE SECONDARY HEATERS.
17. REMOVE/REPLACE S0 4BC REMOTE POWER CONTROL MECHANISM (RPCM).
18. PERFORM USOS/RS DAILY ISS PAYLOAD STATUS CHECKS AS REQUIRED.
19. INSTALL NODE 2 HANDRAILS (UP TO 11) AND GAP SPANNERS (TWO)
20. RETRIEVE/RETURN Z1 BSP.
21. THE FOLLOWING TASKS ARE DEEMED TO FIT WITHIN THE EXISTING EVA TIMELINES; HOWEVER, THEY MAY BE DEFERRED IF THE EVA IS BEHIND SCHEDULE. THE EVA WILL NOT BE EXTENDED TO COMPLETE THESE TASKS:
- a. INSTALL NODE 2 EXTERNAL OUTFITTING HARDWARE INCLUDING WIF'S (UP TO THREE).
 - b. RELEASE NODE 2 ZENITH ACBM PETAL RESTRAINTS AND REMOVE UP TO FOUR NODE 2 RADIAL HATCH LATCH PINS.
22. PERFORM THE FOLLOWING UTILIZATION ACTIVITIES:
- a. SDBI 1503-S MIDODRINE
 - b. SDBI 1409B/1634 PROMETHAZINE (PMZ)/SLEEP SHORT
 - c. SDBI 1900 INTEGRATED IMMUNE
 - d. PERCEPTUAL MOTOR DEFICITS IN SPACE ON ISS (PMDIS)
 - e. OPERATOR FOR ISS INTEGRATED IMMUNE LONG DURATION CREW SUBJECT (CAN BE EITHER SSP OR ISS CREW) @[DN 11]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)

23. INGRESS NODE 2 AND PERFORM OUTFITTING TASKS AS TIME PERMITS. @DN11]
24. PERFORM USOS/RUSSIAN ISS PAYLOAD RESEARCH OPERATIONS TASKS.
25. REBOOST THE ISS WITH THE ORBITER AS MISSION RESOURCES ALLOW, CONSISTENT WITH ISS TRAJECTORY ANALYSIS AND PLANNING.
26. PREPARE U.S. LAB FORWARD VESTIBULE FOR HATCH CLOSURE AND PMA-2 INSTALLATION:
 - a. INSTALL U.S. LAB FORWARD ACBM CONTROLLER PANEL ASSEMBLIES (FOUR).
 - b. INSTALL U.S. LAB FORWARD OUTER HATCH WINDOW HYZOD COVER.
 - c. INSTALL PMA-2 CBCS TARGET.
 - d. DISCONNECT O₂/N₂ LINES BETWEEN LAB AND PMA-2.
27. SHUTTLE FLYAROUND USING AVAILABLE PROPELLANT (CAT 4)
28. PERFORM MINIMUM HANDOVER TIME OF 16 HOURS FOR ROTATING CREWMEMBER.
29. PERFORM RAM BURN OBSERVATIONS (RAMBO) AND MAUI ANALYSIS OF UPPER-ATMOSPHERIC INJECTIONS (MAUI) PAYLOADS OF OPPORTUNITY.
30. PERFORM SDTO 13005-U, FORCING FUNCTION DEFINITION AND MICROGRAVITY ALLOCATION DURING NODE 2 INSTALLATION (IWIS). @DN11]

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FLIGHT RULES

10A_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)

B. EVA PRIORITY MATRIX - THIS MATRIX IDENTIFIES WHAT EVA TASKS WOULD BE PERFORMED ON FLIGHT 10A BASED ON THE MISSION PRIORITIES IF ALL THREE SCHEDULED EVA'S CANNOT BE EXECUTED.
@[DN71]

IF ONLY ONE EVA CAN BE PERFORMED, THE MAJOR EVA OBJECTIVES ARE TO RETRIEVE SASA, PREP NODE 2 FOR UNBERTH (INCLUDING TRANSFER OF PDGF TO ISS), AND TRANSFER THE MBSU TO ISS.

Node 2 unberth would occur the day following EVA 1.

IF ONLY TWO EVA'S CAN BE PERFORMED, THE MAJOR EVA OBJECTIVES ARE TO PERFORM P6 DETACH, PERFORM P6 ATTACH, AND PREP NODE 2 FOR UNBERTH (INCLUDING TRANSFER OF PDGF TO ISS). @[DN71]

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FLIGHT RULES

10A_C2-11 ON-ORBIT PRIORITIES [RI] (CONTINUED)

TABLE 10A_C2-11-I - EVA PRIORITIES MATRIX

EVA TASK	NOMINAL EVA PERF	RATIONALE	EVA DURING WHICH TASK PERF IF 1 EVA	EVA DURING WHICH TASK PERF IF 2 EVA
SASA RETURN SASA RETRIEVE FROM Z1 SASA STOW ON PLB SIDEWALL CARRIER	EVA 1 EVA 1	RETURN REQUIRED FOR REFURB AS A SPARE	1 1	1 1
NODE 2 PREP FOR UNBERTH HORSESHOE CONNECTOR RELEASE PDGF TEMP STOW ON NODE 2 PCBM COVER REMOVAL LTA CABLE DISCONNECT	EVA 1 EVA 1 EVA 1 EVA 1	REQUIRED FOR NODE 2 INSTALL ON NODE 1 AND PDGF TRANSFER TO ISS BETTER EVA ACCESS WITH NODE IN PLB EASIEST TRANSFER OF PDGF TO ISS (STRAPPED TO NODE 2) REQUIRED FOR NODE 2 BERTH TO NODE 1 REQUIRED FOR NODE 2 UNBERTH FROM PLB	1 1 1 1	1 1 1 1
MBSU TRANSFER MBSU REMOVAL FROM PLB MBSU INSTALL ONTO ESP-2	EVA 3 EVA 3	REQUIRED AS ISS SPARE	1 1	2 2
DISCONNECT Z1 TO P6 FLUID QDS (4)	EVA 1	REQUIRED FOR P6 RELOCATION		
AFT RADIATOR SHROUD INSTALLATION	EVA 1	REQUIRED FOR FINAL THERMAL CONFIG		
SSU SHROUD INSTALLATION	EVA 1	REQUIRED FOR P6 RELOCATION (THERMAL)		
DISCONNECT Z1 TO P6 UMBILICALS (9)	EVA 2	REQUIRED FOR P6 RELOCATION		
DETACH P6 FROM Z1 RELEASE RTAS BOLTS (4) & GRND STRAPS (4) OPEN CAPTURE LATCH	EVA 2 EVA 2	REQUIRED FOR P6 RELOCATION		
SFU CONFIGURATION CONFIGURE SFU FOR S1 RAD DEPLOY CONFIGURE SFU POST DEPLOY	EVA 2 EVA 3	REQUIRED FOR S1 RADIATOR DEPLOY REQUIRED FOR S1 RADIATOR HTR CONFIG		1 2
MBSU JUMPER RECONFIGURATION	EVA 2	REQUIRED FOR P6 ACTIVATION		
RPCM S04B-C R&R	EVA 2	REQ'D FOR NODE 2 PDGF USE AS BASE (1E)		1
NODE 2 PDGF INSTALLATION	EVA 2	REQUIRED FOR NODE 2 MOVE TO LAB FWD		
ATTACH P6 TO P5 BACK OUT BOLT 1 CLOSE CAPTURE LATCH ENGAGE RTAS BOLTS (4) & GRND STRAPS (4) CONNECT P5 TO P6 UMBILICALS	EVA 3 EVA 3 EVA 3	REQUIRED FOR P6 INSTALLATION ON P5		
RELEASE P6 OUTBOARD RADIATOR CINCHES	EVA 3	REQUIRED FOR P6 ACTIVATION		
REMOVE SSU SHROUDS	EVA 3	REQUIRED FOR P6 ACTIVATION		
RETRIEVE BSP	EVA 3	RETURN REQ'D FOR UPGRADE AS A SPARE		1
NODE 2 OUTFITTING TRUNNION COVERS (4) KEEL PIN COVER (1)	EVA 2 EVA 2	REQUIRED FOR NODE 2 THERMAL CONFIG REQUIRED FOR NODE 2 THERMAL CONFIG		2 2
PROGRAM-APPROVED GET AHEADS: ZENITH ACBM PETAL RESTRAINTS (8) RADIAL HATCH LATCH PIP PINS (4) HANDRAILS (11) GAP SPANNERS (2) WIFS (3)	EVA 2 EVA 2 EVA 2 EVA 2 EVA 2	REQUIRED FOR PETAL OPENING REQUIRED FOR HATCH OPENING REQUIRED FOR EVA TRANSLATION & CABLES REQUIRED FOR EVA TRANSLATION REQUIRED FOR EVA WORKSITE ACCESS		2 2 2 2 2

@[DN 71]

Verify that this is the correct version before use.

FLIGHT RULES

10A_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.	TPS INSPECTION	INCLUDES PROPELLANT REQUIRED FOR ANY DEDICATED MANEUVERS AND ATTITUDE HOLDS FOR TPS INSPECTION.
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 SINCE THAT 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.	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.
10.	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 COST.
11.	PROVIDE ADDITIONAL DEORBIT ATTEMPTS UP TO 2-2-2, INCLUDING ANY REQUIRED ORBIT ADJUST BURNS	TO PROVIDE 2-2-2 (TWO ATTEMPTS ON THREE CONSECUTIVE DAYS) WILL REQUIRE AN ADDITIONAL TWO REVS OF WAVEOFF ABOVE 2-1-1 CAPABILITY.

@[DN 27]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-12

ON-ORBIT PROPELLANT PRIORITIES [RI] (CONTINUED)

PRIORITY	FLIGHT ACTIVITY	NOTES
12.	SHUTTLE CONTROL OF MATED STACK FOR ATTITUDE MANEUVERS	CONSERVES ISS PROPELLANT.
13.	SHUTTLE CONTROL OF MATED STACK FOR ATTITUDE HOLD	AVAILABLE SHUTTLE MARGIN WILL BE USED FOR MATED ATTITUDE HOLD IN ORDER TO CONSERVE ISS PROPELLANT. NOTE THAT IT IS OPERATIONALLY PREFERABLE FOR THE ISS TO BE IN CONTROL DURING EVA AND RMS OPERATIONS.
14.	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.
15.	OMS ENGINE FAIL	REF RULES {A6-303}, OMS REDLINES (CIL); {A6-304}, FORWARD RCS REDLINES; AND {A6-305}, AFT RCS REDLINES [HC].
16.	ISS REBOOST	AVAILABLE SHUTTLE MARGIN WILL BE USED TO REBOOST THE ISS. REBOOST IS CONSTRAINED TO A TOTAL OF 3 HOURS OF CONFIG 3 AND CONFIG 4 (PER RULE {C2-12}, MATED REBOOST CONFIGURATION AND CONSTRAINTS [RC]).
17.	ISS FLYAROUND	
18.	SECONDARY PAYLOAD OPERATIONS	FLIGHT SPECIFIC (I.E., MAUI, RAMBO, ETC.)
19.	KU OPTIMIZATION FOR OBSS INSPECTION	KU OPTIMIZATION REDUCES THE AMOUNT OF PLAYBACK TIME REQUIRED FOR OBSS INSPECTION DATA.
20.	ADJUST ORBIT FOR ADDITIONAL LANDING OPPORTUNITIES	ADDITIONAL OR DIFFERENT LANDING OPPORTUNITIES MAY BE DESIRED BEYOND WHAT IS PROVIDED BY 2-2-2.

@[DN 27]

- 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.

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ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_C2-13 MISSION EXTENSION

- A. THE NOMINAL 10A 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. IF FOCUSED INSPECTION REQUIRED, ADD EXTRA DAY WHILE DOCKED, IF REQUIRED.
- D. THE 10A 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.

The Cat 1 objectives should be accomplished if at all possible. ©[DN 87]

FLIGHT RULES

10A_C2-14 CONTINGENCY EVA'S [RI]

- A. PRIOR TO NODE 2 UNBERTH FROM THE PAYLOAD BAY, EVA 1 AND NODE 2 INSTALLATION WILL BE DELAYED AND A CONTINGENCY EVA CONSIDERED IF REQUIRED TO RECOVER FUNCTIONS SUPPORTING MATING OF NODE 2 TO NODE 1. ©[DN 77]

Other than Shuttle docking, Node 2 installation is the highest priority mission objective. The LTA cable in the PLB (during EVA 1) should not be disconnected and Node 2 subsequently unberthed unless SSRMS and CBM functionality (and in some cases, system redundancy) will support Node 1 berthing.

Reference Rule {10A_C15-2}, UNSCHEDULED/CONTINGENCY EVA.

- B. CONTINGENCY EVA'S AFTER NODE 2 BERTH TO NODE 1
SEE SECTION 15 CONTINGENCY/UNSCHEDULED EVA.

Reference Rule {10A_C15-2}, UNSCHEDULED/CONTINGENCY EVA. ©[DN 77]

FLIGHT RULES

10A_C2-15 SHUTTLE NON-PROPULSIVE CONSUMABLES MANAGEMENT

THE PRIORITIES FOR O₂, H₂, AND N₂ 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 NODE 2 @ [DN 49]

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 O₂ is being budgeted for this EVA. A total of 3.62 lbm of N₂ is being budgeted for the EVA.

- 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 O₂ is being budgeted for the two scheduled EVA's. A total of 7.24 lbm of N₂ is being budgeted for each of the two scheduled EVA's.

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

This includes orbiter thermal requirements.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-15 SHUTTLE NON-PROPULSIVE CONSUMABLES MANAGEMENT
(CONTINUED)

F. ONE UNSCHEDULED ISS-BASED EVA @[DN 49]

Currently, 4 lbs of O₂ is being budgeted for the unscheduled EVA. A total of 3.62 lbm of N₂ is being budgeted for the unscheduled EVA.

G. N₂ TO SUPPORT ORBITER 10.2 EVA BACKUP CAPABILITY

44 lbm of N₂ 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).

H. O₂/N₂ FOR TRANSFER TO THE ISS

Line transfer of a minimum of 25 lbm O₂ will be budgeted. If shuttle consumable margins allow, additional O₂/N₂ for line transfer will be supplied on an as-needed basis. DOCUMENTATION: SIA (NSTS 21458).

I. 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.

J. ADDITIONAL SHUTTLE DEORBIT OPPORTUNITIES ABOVE 2-2-2 @[DN 49]

FLIGHT RULES

10A_C2-16 MINIMUM DURATION FLIGHT [RI]

- A. AN MDF WILL BE CONSTRUCTED PER THE PRIORITIES SHOWN IN RULE {10A_C2-11}, ON-ORBIT PRIORITIES [RI]. THIS LEADS TO THE FOLLOWING SEQUENCE OF EVENTS:
1. FD3 - RENDEZVOUS AND DOCK WITH ISS, MANDATORY CREW ROTATION TASKS, SSRMS WALKOFF TO MBS PDGF 3 @[DN 12]
 2. FD4 - COMPLETE MANDATORY CREW ROTATION TASKS, EVA1 - AFT P6 RADIATOR SHROUD INSTALL, P6 FLUID/UMBILICAL DEMATE, P6 DETACH, MBSU JUMPER RECONFIG, START OF NODE 2 PREP FOR UNBERTH, SFU CONFIG FOR S1 RADIATOR DEPLOY
 3. FD5 - TRANSFER MANDATORY AND CRITICAL ITEMS PER 10A TRANSFER LIST, DEPLOY OUTBOARD S1 RADIATORS.
 4. FD6 - EVA 2 - P6 ATTACH AND UMBILICAL INSTALLATION, PV RADIATOR DEPLOY, SFU CONFIG POST-DEPLOY, FINAL NODE 2 PREP FOR UNBERTH
 5. FD7 - SSRMS WALKOFF TO LAB PDGF, OBSS UNBERTH AND HANDOFF TO SRMS, UNBERTH NODE 2 AND INSTALL ON NODE 1 PORT CBM, CONNECT NODE 2 VESTIBULE UTILITIES AND ACTIVATE NODE 2 SHELL HEATERS, TRANSFER PDGF FROM SHUTTLE PLB TO ISS.
 6. FD8 - UNDOCK, LATE INSPECTION
 7. FD 9 - CABIN STOW, FCS CHECKOUT, AND RCS HOT FIRE
 8. FD10 - 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.

If Focused Inspection is required, an additional day would be required either on FD4 or FD8, due to OBSS/Robotics choreography. @[DN 12]

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FLIGHT RULES

10A_C2-16 MINIMUM DURATION FLIGHT [RI] (CONTINUED)

This plan recognizes the desire to terminate the mission early due to orbiter failures, install Node 2, relocate P6, perform an ISS crew exchange, 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. ©[DN 12]

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, consideration will be given to completing additional objectives as time permits.

C. NODE 2 WILL ONLY BE UNBERTHERED AND INSTALLED ON ISS IF THERE IS 1 FULL DOCKED DAY TO PERFORM EVA1.

Since Node 2 unberthing requires EVA operations to disconnect heater power cables, Node 2 cannot be removed from the PLB and installed on Node 1 unless EVA 1 can be performed. The combination of EVA and Robotics activities necessary to accomplish Node 2 installation require an entire crew day to complete. ©[DN 12]

Reference Rule {10A_C2-11}, ON-ORBIT PRIORITIES [RI].

FLIGHT RULES

SAFETY DEFINITION AND MANAGEMENT

10A_C2-31 **ISS CARGO ELEMENT RETURN**

ONCE THE NODE 2 TRUNNIONS ARE ABOVE THE V-GUIDES, NODE 2 WILL REMAIN ON THE ISS. @[DN 13]

There are no credible failures which would cause us to re-berth Node 2 in the shuttle. In case of a shuttle emergency, Node 2 would remain on the SSRMS in a safe-for-undock position, to be installed on Node 1 after shuttle departure. CBM problems severe enough to preclude Node 2 berthing are not deemed credible. Inability to pressurize the vestibule would not justify return and re-launch of the Node 2 element. @[DN 13]

FLIGHT RULES

RENDEZVOUS/PROXIMITY AND DEPLOY/SEPARATION OPERATIONS

10A_C2-41 **RESERVED** ©[DN 14]

10A_C2-42 **ISS ATTITUDE CONSTRAINTS FOR RENDEZVOUS AND DOCKING**

THIS RULE SUPERSEDES RULE {C2-103}, ISS ATTITUDE CONSTRAINTS FOR APPROACH AND DOCKING [HC] [RC].

- A. IN ORDER TO SUPPORT RENDEZVOUS NAVIGATION USING THE TRACKING LIGHT, THE STATION SHOULD BE IN AN ATTITUDE THAT WILL ALLOW THE TRACKING LIGHT TO BE VISIBLE TO THE ORBITER IN THE POST-TI NIGHT PASS. THE LIGHT SHOULD BE TURNED ON AT THE SUNSET AFTER TI AND STAY ON UNTIL SUNRISE.

The Station tracking light provides a way for the shuttle star trackers to be used as a navigation sensor post Ti in the event of a Ku radar failure. Because the angular size of the Station in the shuttle star tracker field of view is too large to permit accurate tracking during the daytime, the Station must maneuver to an acceptable attitude to make the tracking light visible for a night star tracker pass. The ISS attitude of YPR 0, 0, 0 deg is a good attitude for this, but the ISS TEA attitude may also suffice. Refer to the Rendezvous and Proximity Operations Design Reference (RPODR), section 4.1.2.2 for details on the tracking light field of view specifications. If the Station is unable to attain an acceptable configuration, both the -Y and -Z star tracker may not be available as a backup rendezvous sensor. Post-Ti sunset normally occurs at Ti+28 minutes. For low-beta approaches (Beta < 15 deg), the post-Ti sunset may occur at Ti+38 minutes.

- B. THE STATION MUST BE IN THE DOCKING ATTITUDE FOR APPROACH WITHIN 183 M (600 FEET).

600 feet protects U.S. solar array load limits for arrays deployed outboard of S3 or P3.

- C. IF THE RBAR PITCH MANEUVER FOR TPS INSPECTION IS TO BE PERFORMED, THE STATION MUST BE IN LVLH 0,0,0 DOCKING ATTITUDE WITHIN 189 M (620 FT).

The RPM can begin at a maximum range of 189 m (620 ft). The docking attitude allows the Station crew to take digital still photographs of the orbiter through the service module windows. Relatively small excursions from the docking attitude may result in obscuration of these views by vehicles docked on the docking compartment.

THIS RULE CONTINUED ON NEXT PAGE

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ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_C2-42 ISS ATTITUDE REQUIREMENTS FOR RENDEZVOUS AND DOCKING (CONTINUED)

- D. THE STATION ATTITUDE CONTROL SYSTEM MUST MEET THE FOLLOWING CRITERIA BEFORE BEING "GO" FOR ORBITER FINAL APPROACH AND DOCKING:
1. ATTITUDE MUST BE WITHIN ± 1.0 DEGREE PER AXIS OF THE COMMANDED DOCKING ATTITUDE.
 2. LVLH ANGULAR RATE MUST BE STABLE AND WITHIN ± 0.04 DEGREES PER SECOND PER AXIS.

DOCUMENTATION: JSC-27240, Rendezvous and Proximity Operations Design Reference (RPODR), section 3.1.1.2.

- E. IF STATION LOSES ATTITUDE CONTROL AFTER THE SHUTTLE IS INSIDE OF APPROXIMATELY 183 METERS (600 FEET), THEN THE SHUTTLE WILL NULL CLOSING RATES AND PERFORM A BACKOUT PER RULE {10A C4-TBD}, SHUTTLE CORRIDOR BACKOUT/FAILED MECHANICAL CAPTURE.

Loss of attitude control means that the Station is no longer under active control and will eventually drift out of attitude due either to residual rates or plume impingement from the approaching shuttle. A backout must be performed prior to the Station drifting out of attitude to ensure that the shuttle does not fly outside the analyzed relative envelope. The true angular limit for the allowable attitude error is 8 degrees. This error was developed with a quick-look assessment at the protection already in the loads analysis. A 2-degree margin should be subtracted from the 8-degree limit for operational margin so that action can be taken before the actual limit is reached. However, since the maximum nominal rate that could be imparted on the Station is 0.04 deg/s, the 6 (or 8) degree limit could be broken in as little as 3 minutes. Therefore, it was decided at the JOP #36 (December 17, 1996) to begin the backout immediately since waiting for the 6 (or 8) degree excursion did not buy any significant time.

- F. WHEN THE ISS USES RS THRUSTER CONTROL DURING ORBITER DOCKING, THE RS TVM RATE SOURCES SHALL BE IN THE FOLLOWING ORDER FROM HIGHEST PRIORITY TO LOWEST: 1) GIVUS; 2) ORT; 3) RGA.

FOR DOCKING, IF ORT BECOMES THE HIGHEST PRIORITY RATE SOURCE IN THE RS TVM AND THE ORBITER IS OUTSIDE OF 75 FEET, MCC-M SHALL RECONFIGURE TO USE THE RGA DATA AS HIGHEST PRIORITY AND PLACE THE ORT AS A HOT BACKUP.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-42

ISS ATTITUDE REQUIREMENTS FOR RENDEZVOUS AND DOCKING (CONTINUED)

The use of RGA data is preferred over ORT data. When the ISS is under RS Thruster control, the TVM determines the rate source to which it controls attitude. The priority scheme of GIVUS, ORT, and RGA is the nominal configuration for shuttle dock. A change to this nominal configuration would require a change to nominal operations, possible RS software/cyclogram changes, and possible additional reconfiguration resulting in a loss of rate redundancy. This was discussed at the March 17, 2005, MCS Telecon.

The GIVUS hardware is single fault tolerant. Due to system failures or reconfiguration, the ORT may become the highest priority rate source. If the ORT is used as the selected rate source, the ORT has a drift rate that can affect the propagation of the ISS attitude, which may result in an angular misalignment requiring orbiter flyout. The orbiter crew is sometimes capable of beginning to read the docking target for alignment at around the 50-foot range. The actual alignment will occur at 30 ± 5 feet. Therefore, 75 feet was chosen to allow sufficient time for MCC-M to send the command through RGS or S-band for the rate source reconfiguration to be complete before the orbiter crew begins alignment activities, and to prevent a possible flyout due to ORT drift. If the ORT is selected for use inside of 75 feet, the effect on the propagated attitude is minimal and docking may continue without system reconfiguration.

FLIGHT RULES

10A_C2-43 RESERVED

10A_C2-44 ISS TRANSLATION MANEUVERS BY SHUTTLE [RC]

- A. ALL REBOOST MANEUVERS SHALL BE PLANNED TO SATISFY THE CONSTRAINTS FOR ALL LAUNCH, RENDEZVOUS, DOCKING, UNDOCKING, DEORBIT, AND LANDING OF ALL VISITING VEHICLES AFTER LAUNCH OF STS-120/ISS 10A. ©[DN 29]

Shuttle FDO and ISS TOPO will coordinate with Russian Ballistics to ensure launch and landing requirements for the Soyuz and Progress vehicles and the rendezvous altitude for STS-122/1E are not violated by any planned reboost maneuvers during STS-120/10A. ©[DN 29]

- B. THE ORBITER WILL PERFORM ANY REQUIRED COLLISION AVOIDANCE MANEUVERS TO AVOID CLOSE CONJUNCTIONS WHILE DOCKED TO ISS. THE AUTOMATED REBOOST TECHNIQUE WILL BE UTILIZED TO PERFORM COLLISION AVOIDANCE MANEUVERS. CONSIDERATION WILL BE GIVEN TO SATISFYING THE REQUIREMENTS OF PARAGRAPH A, BUT SAFETY OF THE CREW TAKES PRECEDENCE AND THE REQUIRED AVOIDANCE MANEUVER MAY RESULT IN VIOLATING SOME OF THESE CONSTRAINTS.

Automated reboost procedures will be utilized to execute a burn, if required. All four techniques require the orbiter/ISS stack to perform an attitude maneuver in order to achieve posigrade delta V. This is normally preferred so as to accomplish orbit reboost during the collision avoidance maneuver. If possible, the collision avoidance maneuver will be targeted to satisfy the trajectory requirements of paragraph A. However, in order to provide a safe distance from the conjuncting object, the avoidance burn may violate some of these requirements. For example, it may be necessary to violate the requirements in order to avoid performing a retrograde collision avoidance maneuver.

FLIGHT RULES

10A_C2-45

SHUTTLE CORRIDOR BACKOUT/FAILED MECHANICAL CAPTURE
[HC] @[DN 68]

THIS RULE IS TO BE USED IN PLACE OF RULE {C4-452}, SHUTTLE BACKOUT/FAILED MECHANICAL CAPTURE [RC].

A. CORRIDOR BACKOUT PRIOR TO CONTACT:

ONCE THE SHUTTLE IS ON THE ISS VBAR, IF BACKOUT IS NECESSARY PRIOR TO CONTACT, THE SHUTTLE CREW WILL INITIATE AND MAINTAIN AT LEAST 0.03 M/SEC (0.1 FT/SEC) OPENING RATE. IF THE BACKOUT IS INITIATED WITHIN 75 FT, NORM Z PULSES WILL BE USED AND NORM Z PULSE SIZE MAY NOT EXCEED 0.01 FPS. IF THE BACKOUT IS INITIATED OUTSIDE 75 FT, LOW Z PULSES WILL BE USED. THE BACKOUT WILL FOLLOW THE CORRIDOR DEFINED IN RULE {C2-102}, RENDEZVOUS (RNDZ)/PROXIMITY OPERATIONS (PROX OPS) DEFINITIONS [HC] [RC], WITH THE EXCEPTION THAT IF STATION MODES TO FREE DRIFT, THEN A POINT CLOSE TO THE STATION CENTER OF MASS WILL BE USED AS THE CORRIDOR REFERENCE POINT.

Analysis indicates this procedure will minimize plume impingement during a delay backout. Low Z/Norm Z management and pulse size requirements are similar to those used on approach.

B. FAILED CAPTURE (FAILED CAPTURE IS DEFINED AS BOUNCE-OFF. A BOUNCE-OFF WILL BE VISUALLY RECOGNIZED BY THE CREW AS AN INCREASING RING-TO-RING SEPARATION.)

1. THE SHUTTLE WILL MAINTAIN AT LEAST A 0.03 M/SEC (0.1 FT/SEC) OPENING RATE FOLLOWING THE CORRIDOR DEFINED IN RULE {C2-102}, RENDEZVOUS (RNDZ)/PROXIMITY OPERATIONS (PROX OPS) DEFINITIONS [HC] [RC].
2. IF STATION MODES TO FREE DRIFT, THEN A POINT CLOSE TO THE STATION CENTER OF MASS WILL BE USED AS THE CORRIDOR REFERENCE POINT, AND STATION WILL RETURN TO ACTIVE ATTITUDE CONTROL AS SOON AS POSSIBLE AFTER THE SHUTTLE SEPARATION.
3. ONCE CONTACT HAS OCCURRED, IF CAPTURE IS NOT SUCCESSFUL, 6 MINUTES MUST PASS BEFORE CONTACT ON THE NEXT CAPTURE ATTEMPT.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-45

SHUTTLE CORRIDOR BACKOUT/FAILED MECHANICAL CAPTURE [HC] (CONTINUED)

Dynamics from a failed capture due to a "bounce-off" result in a separation rate of approximately 0.03 to 0.06 m/sec (0.1 to 0.2 ft/sec). In general, the Station is not expected to mode to free drift during a failed capture scenario. If the Station modes to free drift, failed capture dynamics may induce a rotation rate. The Station should return to attitude hold as soon as possible to avoid collision of the shuttle with Station appendages. If there is a crew onboard, the crew would mode the vehicle immediately. If there is not a crew onboard, the Station would be moded as soon as a link from the ground can be established.

A point near the Station center of mass is used as the reference point because the docking port may rotate.

Backout can always be halted and approach reinitiated when Station is correctly configured for docking as long as there are at least 6 minutes between attempts. The 6-minute pause is required to allow the Station structure time to damp out any energy from the failed docking attempt.

- C. THE STATION WILL MAINTAIN DOCKING CONFIGURATION UNTIL THE SHUTTLE CREW REPORTS THE SHUTTLE IS 183 METERS (600 FEET) FROM THE STATION.

In order to minimize plume impingement loads on ISS structure, ISS attitude and appendage orientation must remain as required for docking until the range is greater than 600 ft and shuttle is in Low Z.

- D. THE SHUTTLE WILL STATIONKEEP NO CLOSER THAN 10 METERS (30 FEET). BACKOUT CAN ALWAYS BE HALTED AND APPROACH REINITIATED WHEN STATION IS IN THE CORRECT CONFIGURATION. IF THE STATION CANNOT MAINTAIN THE DOCKING ATTITUDE OR CANNOT KEEP THE ARRAYS FEATHERED, THEN THE ORBITER MUST PROCEED OUTSIDE 600 FT.

For all flights, stationkeeping can occur at any range if the Station is in docking attitude, has the arrays feathered, and the orbiter is in Low Z (when the range is between 1000 ft and 75 ft). In general, the Station is not expected to mode to free drift in a failed capture scenario. Generally, the orbiter will back out and stationkeep at 600 ft, because that will minimize plume loads if the ISS is not configured for docking. However, it is not required to back out to this range as long as the Station is in active attitude control in the docking attitude and has the arrays feathered appropriately.

Reference Hazard Report ISS-COL-1003, "Hazards During Proximity Operations", Cause 1, Control 1B.
©[DN 68]

FLIGHT RULES

10A_C2-46

UNDOCKING SEPARATION BURNS WITH SRMS/OBSS IN THE HANDOFF POSITION

NOMINAL SEPARATION BURNS DURING UNDOCKING OPERATIONS ARE ALLOWED WITH THE SRMS/OBSS IN THE HANDOFF POSITION FOR THE FOLLOWING BURN SIZES:

- A. A CONTINUOUS BURN UP TO AND INCLUDING 1.5 FEET PER SECOND IN THE ORBITER +X DIRECTION FOR SEP 1
- B. A CONTINUOUS BURN UP TO AND INCLUDING 1.0 FEET PER SECOND IN THE ORBITER -X DIRECTION FOR SEP 2

With the SRMS/OBSS in the handoff position during undocking, limitations on separation burn sizes are required to ensure SRMS/OBSS loads and motion are within the constraints analyzed and certified. The SEP 1 burn occurs on the Vbar followed approximately 28 minutes later by the SEP 2 burn which provides the final opening rate. Certification limits of the SRMS/OBSS in the handoff position during separation burns are documented in memo ESCG06-18 and in MDA report number SC-0617 and SC-0515. A flyaround with the SRMS/OBSS in the handoff position has been analyzed and is allowed as documented in memo ESCG-07-09. ©[CR 8891]

Deleted: unstowed

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FLIGHT RULES

10A_C2-47 RESERVED

10A_C2-48 ISS ATTITUDE HOLD CONSTRAINTS FOR ORBITER
SEPARATION

THIS RULE SUPERSEDES PARAGRAPH F IN RULE {C2-153}, ATTITUDE CONSTRAINTS FOR ORBITER SEPARATION GO/NO-GO CRITERIA [HC] [RC].

AFTER UNDOCKING IS COMPLETE AND THE ISS HAS RETURNED TO ACTIVE ATTITUDE CONTROL, THE ISS MUST REMAIN IN ATTITUDE HOLD AT THE CURRENT LVLH ATTITUDE AND MAY NOT MANEUVER TO ANY OTHER ATTITUDE UNTIL THE SHUTTLE HAS REACHED 183 METERS (600 FEET) CG-TO-CG SEPARATION.

The ISS MCS is restored to control in a slow, deliberate fashion to prevent recontact with the shuttle. There are competing desires to return to control as soon as possible to prevent plume load effects versus staying in drift as long as possible to prevent a control overshoot from causing a re-contact at the ODS. Once 600 ft cg-cg separation is achieved, plume concerns are reduced and so the ISS may maneuver to any attitude.

FLIGHT RULES

10A_C2-49 A31P LAPTOP CONFIGURATION FOR RETURN

THE ORBITER WILL UNDOCK WITH A MINIMUM OF THREE FULLY FUNCTIONAL A31P LAPTOPS.

Three A31p's on the shuttle allow nominal laptop operations (KFX, DOUG, WLES, etc.) as well as protecting for any late inspection scanning that may be required

10A_C2-50 ISS SYSTEM MANAGEMENT FOR SHUTTLE APPROACH AND DOCKING [HC] [RC]

IN ADDITION TO THE CONSTRAINTS LISTED IN RULE {C2-104}, ISS SYSTEM MANAGEMENT FOR SHUTTLE APPROACH AND DOCKING [HC] [RC], THE FOLLOWING CONSTRAINTS SHALL APPLY DURING MISSION 10A:

A. ISS APPENDAGE CONFIGURATION:

1. USOS SOLAR ARRAYS (REQUIRED BEFORE SHUTTLE R = 600 FT), PER RULE {10A_C2-TBD}, SOLAR ARRAY FEATHERING REQUIREMENTS AND CONSTRAINTS.

Reference Rules {10A_C2-52}, ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC], and {10A_C2-TBD}, SOLAR ARRAY FEATHERING REQUIREMENTS AND CONSTRAINTS, for USOS array constraints in off-nominal scenarios.

2. TRRJ APPENDAGE CONFIGURATION

TRRJ (LOOP A & LOOP B) MUST BE LOCKED.

Locking of the joint is required to prevent loads exceedances of TRRJ drive mechanism. For specific TRRJ angle constraint reference Rule {10A_B18-TBD}.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-50

ISS SYSTEM MANAGEMENT FOR SHUTTLE APPROACH AND DOCKING [HC] [RC] (CONTINUED)

- B. SARJ AND BGA SUN TRACKING CAN BE RESUMED WHEN CAPTURE IS CONFIRMED AND ISS IS IN FREE DRIFT IF ARRAY FEATHERING FOR POST DOCKING MANEUVER TO FLIGHT ATTITUDE IS NOT REQUIRED PER RULE {10A_C2-~~TBD~~}, SOLAR ARRAY FEATHERING REQUIREMENTS AND CONSTRAINTS.

After capture, and ISS modes to free drift, the mated stack is in a safe configuration and a subsequent separation is unlikely. Therefore, SARJ and BGA sun tracking will be initiated as soon as possible to allow ISS to recover from the rendezvous powerdown, provided the arrays are not required to be feathered for the subsequent maneuver from docking attitude to flight attitude. Note that if array feathering is required, but not locking, the BGA locking pin can be disengaged at this time. If energy margin is sufficient to allow the arrays to remain fixed for an additional length of time, it is desirable to do so to avoid imparting additional torques on the vehicle that could interfere with docking ring retraction and hook closure.

FLIGHT RULES

10A_C2-51 ISS SYSTEM MANAGEMENT FOR UNDOCKING [HC] [RC]

- A. FOR SOLAR ARRAY CONSTRAINTS, REFER TO RULE {10A_B2-45}, USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC] [RC]. @[DN 45]
- B. TRRJ APPENDAGE CONFIGURATION

NO CONSTRAINTS FOR UNDOCKING (**TBD**)
- C. SSRMS SHALL BE IN A PRE-ANALYZED UNDOCKING CONFIGURATION.

Reference Hazard Report ISS-COLL-1003, Cause 7, Control 5.

- D. BGA AND SARJ SUN TRACKING MAY BE RESUMED ONCE THE ORBITER IS GREATER THAN 600 FEET AWAY FROM THE STATION.

After the orbiter is clear of the rotation path of the arrays and plume loads are no longer a factor, the BGA's and SARJ can resume autotrack. Sun tracking will be initiated as soon as possible to allow ISS to recover from the undocking powerdown.

- E. REFER TO RULE {B2-19}, U.S. LAB WINDOW OPERATIONAL CONSTRAINTS, FOR MANAGEMENT OF THE LAB SHUTTER DURING SHUTTLE UNDOCKING.
- F. ACS MODING CONFIGURATION @[DN 45]
 - 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-51

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

2. 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, Cause 1, Control 1B2. @[DN 45]

- G. USE OF U.S. THRUSTER ONLY (USTO) CONTROLLERS IS NOT ALLOWED AFTER UNDOCK WHILE THE ORBITER IS WITHIN 600 FT. @[DN 45]

The combined loads from the pluming effect of the orbiter and the pulse pattern of the USTO controllers are not analyzed.

FLIGHT RULES

10A_C2-52

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

SYSTEM	FAILURE	TI	PROX OPS	RPM [36]	R < 600 FT	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]
	U.S. ARRAYS NOT IN REQUIRED POSITION FOR DOCKING	GO	GO	GO	DLY[2]	GO[2]		GO [2]	GO [2]
	LOOP A OR LOOP B TRRJ NOT LOCKED	TBD	TBD	TBD	TBD	TBD		TBD	TBD
	ISS IS NOT IN DOCKING ATTITUDE	GO	GO [3]	NO-GO [26]	ABT [1]	ABT [1]		ABT [1]	ABT [1]
	ISS TRACKING LIGHT	GO [3]	GO	GO	GO	GO		GO	GO
	ISS ATTITUDE CONTROL MODING COMMAND AND VERIFICATION	TI DLY [18]	GO [43]	GO [43]	GO [43]	GO [43]		GO [43]	NO-GO [43]
	ISS TRANSLATIONAL JETS NOT INHIBITED	TI DLY	ABT [19]	NO-GO [19]	ABT [19]	ABT [19]		ABT [19]	ABT [19]
	ISS SYSTEM FAILURE [7]	TI DLY	ABT	NO-GO	ABT	ABT		ABT	ABT
	PRIMARY C&C MDM	TI DLY [23]	GO	GO	DLY [23]	DLY [23]		DLY [23]	DLY [23]
	PRIMARY GNC MDM (WHILE UNDER RS THRUSTER CONTROL)	GO	GO	GO	GO	GO		GO	GO
	PRIMARY INT MDM	GO	GO	GO	GO [21]	GO [21]		GO [21]	GO [21]
	LA1 AND LA2 MDM'S	GO	GO	GO	GO [21]	GO [21]		GO [21]	GO [21]
	LOSS OF ATTITUDE CONTROL	TI DLY (22)	GO	NO-GO [27]	ABT [24]	ABT [24]		ABT [24]	ABT [24]
DIGITAL STILL CAMERA (ALL ISS 400/800 MM↓)	GO	GO	NO-GO	GO	GO		GO	GO	
PROPRCS	VRCS	GO	GO	GO	GO	GO	GO	GO	GO
	LAST AFT FIRING JET (+X)	TI DLY [8]	ABT [32]	NO-GO [28]	ABT [32]	ABT [32]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD FIRING JET (-X)	TI DLY [8]	ABT [32]	NO-GO [28]	ABT [32]	ABT [32]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD OR AFT LEFT FIRING JET (+Y)	TI DLY [8]	GO [37]	NO-GO [28]	GO [37]	GO [37]	ABT [4]	ABT [4]	ABT [4]
	LAST FORWARD OR AFT RIGHT FIRING JET (-Y)	TI DLY [8]	GO [37]	NO-GO [28]	GO [37]	GO [37]	ABT [4]	ABT [4]	ABT [4]
	LAST UP FIRING JET IN FORWARD OR EITHER AFT (+NZ)	TI DLY [8]	GO	GO	GO	GO	ABT [4]	ABT [4]	ABT [4]
	2 FORWARD FIRING JETS (DEGRADED -X, +LZ)	GO [5]	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 [5]	GO [5]	NO-GO [39]	GO [5]	GO [5]	GO [5]	GO [5]	GO [5]
	LAST DOWN FIRING JET ON EITHER SIDE OF FORWARD (+LZ PITCH AND PCT)	TI DLY [8]	ABT [38]	[33]	ABT [38]	ABT [38]	ABT [4, 6]	ABT [4, 6]	ABT [4, 6]
	LAST DOWN FIRING JET IN EITHER AFT POD (+LZ ROLL AND PCT)	TI DLY [8]	GO [29]	NO-GO[34]	GO [29]	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	NO-GO [38]	GO	GO	GO	GO	GO	
GNC	IMU'S	2 ↓	TI-DLY [8]	GO [35]	NO-GO [30]	GO [35]	GO [35]	ABT	ABT
	CAMERAS	BOTH CENTERLINE/KEEL CAMERAS FAIL	GO	GO	GO [40]	GO	GO	ABT	ABT
	TCS/HHL	ALL UNITS FAILED	GO	GO	NO-GO [31]	GO	GO	GO	ABT [20]
	CAMERA A & D	BOTH UNITS FAILED	GO	GO	GO	GO	GO	GO	ABT [20]
	STAR TRACKER	2 ↓	GO	GO	GO	GO	GO	GO	GO
	RNDZ RADAR	1 ↓	GO	GO (IF VIS)	GO	GO	GO	GO	GO
	COAS	1 ↓	GO	GO	GO	GO	GO	GO	GO
	ANGULAR ALIGN	ANGULAR ALIGNMENT CANNOT BE VERIFIED	GO	GO	GO	GO	GO	GO	ABT
AFT THC	3 ± X ↓ OR 3 ± Y ↓ OR 3 ± Z ↓	TI-DLY [8]	ABT	NO-GO	ABT	ABT	ABT	ABT	
CONTACTS	2 ± Z ↓	TI-DLY [8]	GO	GO	GO	GO	ABT[12,42]	ABT[12,42]	
DPS	1 OF 3 GNC GPC'S	1 ↓	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]	GO [9]
	1 OF 2 GNC GPC'S	1 ↓	TI-DLY	GO	NO-GO [30]	GO	GO	ABT [10]	ABT [10]
	ANY GPC'S	2 ↓	ABT [14]	ABT [14]	NO-GO [14]	ABT [14]	ABT [14]	ABT [14]	ABT [14]
	MDM (FF, FA, PL)	1 ↓	GO	GO	GO [41]	GO	GO	GO	GO
	SM GPC	1 ↓	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]	GO [16]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-52 ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC]
(CONTINUED)

NOTES:

- [1] THE CORRIDOR APPROACH IS DESIGNED TO ENSURE PROXIMITY OPERATIONS ARE WITHIN THE LOADS DATABASE AND THAT TCS TARGETS ARE AVAILABLE. TO PROTECT THE U.S. SOLAR ARRAYS, THE ORBITER CANNOT PROCEED CLOSER THAN 600 FT WITHOUT THE ISS BEING IN DOCKING ATTITUDE. PERFORM THE CONTINGENCY TORVA OR BACKOUT TO 600 FT ON THE VBAR TO STATIONKEEP AND AWAIT THE ATTITUDE MANEUVER.
- [2] WITH LOW Z: FOR U.S. SOLAR ARRAYS, DELAY APPROACH WITHIN 600 FT UP TO AN ORBIT IF POSSIBLE TO POSITION SOLAR ARRAYS. OTHERWISE, PROCEED CLOSER WITHOUT ARRAYS BEING FEATHERED ONLY IF ARRAY POSITIONS ARE CONFIRMED OUTSIDE OF A KEEP-OUT ZONE PER RULE {10A_C2-TBD}, SOLAR ARRAY FEATHERING REQUIREMENTS AND CONSTRAINTS [HC] [RC].
 WITHOUT LOW Z:
 PROCEED WITHOUT RS SOLAR ARRAYS BEING FEATHERED.
 FOR U.S. SOLAR ARRAYS DELAY APPROACH WITHIN 600 FT UP TO AN ORBIT IF POSSIBLE TO POSITION SOLAR ARRAYS. OTHERWISE, PROCEED CLOSER WITHOUT USOS ARRAYS FEATHERED ONLY IF ARRAY POSITIONS ARE CONFIRMED OUTSIDE A KEEP-OUT ZONE PER RULE {10A_C2-TBD}, SOLAR ARRAY FEATHERING REQUIREMENTS AND CONSTRAINTS [HC] [RC].
 REF RULES {10A_C2-50}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], AND {C2-109}, RNDZ/PROX OPS LOW Z/NORM Z MANAGEMENT [HC] [RC].
- [3] 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 DELAYED. 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-701-9A.
- [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.

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FLIGHT RULES

10A_C2-52

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

- [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] ~~+Z TRANSLATION MUST BE SINGLE FAULT TOLERANT. GO IF THE FORWARD THC IS AVAILABLE FOR BRAKING INPUTS. LOSS OF ONE OR MORE +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. @CR 8586~~
- [13] RESERVED
- [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.
- [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 CAMERA 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 {10A_C2-50}, 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 600 FT ON +VBAR TO MITIGATE SHUTTLE PLUME AND COLLISION CONCERNS IF ISS DRIFTS OUT OF ATTITUDE. THE ORBITER MAY CONTINUE IN FROM 600 FT ONCE ISS HAS ASSUMED ATTITUDE CONTROL AND IS BACK IN THE DOCKING ATTITUDE. REFERENCE: HAZARD REPORT ISS-GNC-701-9A.
- [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.

Deleted: 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

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FLIGHT RULES

10A_C2-52

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

- [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 600 FT ON VBAR TO AWAIT TROUBLESHOOTING.
- [28] POSITIVE CONTROL IS REQUIRED IN EACH AXIS IN ORDER TO SET UP THE INITIAL CONDITIONS FOR THE RPM.
- [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-COUPLING 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].

Reference Hazard Report ISS-COL-1003-11A, Hazards during Proximity Operations. ©[DN 54]

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FLIGHT RULES

10A C2-53 SHUTTLE NOSE IN-PLANE BREAKOUT [RI]

A. THE SHUTTLE NOSE IN-PLANE BREAKOUT MAY BE EXECUTED WHEN THE SHUTTLE STATE SATISFIES THE FOLLOWING CONDITIONS: @[CR 8887]

SHUTTLE IS WITHIN 700 FT (CG TO CG) OF THE TARGET VEHICLE.

SHUTTLE X AND Z BODY AXES ARE IN THE ORBITAL PLANE OF THE TARGET VEHICLE.

THE TARGET VEHICLE IS IN A STABLE POSITION ON THE SHUTTLE -Z AXIS.

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DURING APPROACH, USE ONLY AFTER TORVA HAS BEEN INITIATED (+X BURNS ARE COMPLETE)

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B. THE IN-PLANE BREAKOUT MANEUVER SEQUENCE WILL BE AS FOLLOWS:

1. IF WITHIN 150 FT INTERFACE TO INTERFACE, THE SHUTTLE CREW WILL NULL THE CLOSING RATE, THEN BACK OUT BY INITIATING AND MAINTAINING AT LEAST 0.1 FT/SEC OPENING RATE WHILE MAINTAINING THE TARGET VEHICLE POSITIONED NEAR THE SHUTTLE -Z BODY AXIS.

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For ranges inside 150 ft, a backout must be initiated to provide adequate clearance and minimize plume loads for the remainder of the breakout sequence. For ISS flights, this would involve performing a Corridor Backout.

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2. WHEN RANGE IS GREATER THAN 150 FT INTERFACE TO INTERFACE, PERFORM AT LEAST A 1.5 FPS BURN IN THE "CLOCKWISE" DIRECTION (+X ORBITER BODY BURN IF OMICRON IS 0, -X ORBITER BODY BURN IF OMICRON IS 180 DEGREES). FOLLOWING THE BURN, MODE TO INERTIAL HOLD.

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This X burn results in the orbiter opening from the target vehicle. Moding the DAP to INRTL results in an orbiter attitude profile that, when coupled with the relative motion, maintains the target vehicle near the orbiter -Z body axis. This relative orientation minimizes plume loads on the target when the DAP is in Low Z mode. The 1.5 fps burn was sized to ensure that the orbiter is at least 1000 ft from the target after 22 min at which time Low Z is deselected and the maneuver to attitude for the next burn commences. Since this breakout exposes the target vehicle to possible direct PRCS firings just outside of 1000 ft, it is not adequate for target vehicles that require Low Z protection outside 1000 ft. @[CR 8887]

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FLIGHT RULES

10A C2-53 SHUTTLE NOSE IN-PLANE BREAKOUT [RI] (CONTINUED)

3. AT 30 MINUTES AFTER THE ±X BURN, PERFORM A 3.6 FPS OUT-OF-PLANE AND 4.3 FPS POSIGRADE/RETROGRADE BURN USING THE +X RCS JETS. AT 22 MINUTES AFTER THE ±X BURN, DESELECT LOW Z AND INITIATE THE MANEUVER TO BURN ATTITUDE. @[CR 8887]

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This final burn needs to be performed 30 minutes after the ±X burn to provide a safe trajectory. The size of this burn (5.6 ft/sec RSS) was designed to provide a safe trajectory for all initial conditions that satisfy the conditions of applicability for this breakout. The breakout also allows for the selection of either a posigrade or retrograde component to provide flexibility for subsequent mission objectives. The burn combines the out-of-plane and posigrade/retrograde components and is performed as a +X burn with a maneuver to attitude in order to save propellant. Time is allotted to allow a worst case 180 deg maneuver to attitude at 0.5 deg/sec. @[CR 8887]

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FLIGHT RULES

ISS DOCKED OPERATIONS

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]

A. THE FLIGHT ATTITUDES AND THEIR ASSOCIATED ATTITUDE ENVELOPES DEFINED IN TABLE 10A_C2-71-I PROVIDE THE LIMITING ATTITUDE ENVELOPE VALUES IN THE EVENT THAT THE EATCS ATTITUDE ENVELOPE CONSTRAINTS DEFINED IN PARAGRAPH B OF THIS RULE ARE EXCEEDED.
 ©[DN 157]

TABLE 10A_C2-71-I - APPLICABLE ATTITUDE ENVELOPE LIMITS WITHOUT LTA AND EATCS ATTITUDE CONSTRAINTS

BETA ANGLES	ATTITUDE REFERENCE FRAME	ISS ATTITUDE NAME	APPROVED ATTITUDE ENVELOPES		
			YAW	PITCH	ROLL
$-75^\circ \leq \beta < -60^\circ$	ISS LVLH	+ZLV +XVV	-5° TO $+15^\circ$ TBR	0° TO $+25^\circ$	0° TO $+15^\circ$ TBR
$-60^\circ \leq \beta \leq +60^\circ$		+ZLV +XVV	-15° TO $+15^\circ$	0° TO $+25^\circ$	-15° TO $+15^\circ$
$+60^\circ < \beta \leq +75^\circ$		+ZLV +XVV	-15° TO $+5^\circ$	0° TO $+25^\circ$	-15° TO $+5^\circ$
$-75^\circ \leq \beta < -60^\circ$		+ZLV -XVV	$+165^\circ$ TO $+185^\circ$	0° TO $+25^\circ$	-15° TO $+5^\circ$
$-60^\circ \leq \beta \leq +60^\circ$		+ZLV -XVV	$+165^\circ$ TO $+195^\circ$	0° TO $+25^\circ$	-15° TO $+15^\circ$
$+60^\circ < \beta \leq +75^\circ$		+ZLV -XVV	$+175^\circ$ TO $+195^\circ$ TBR	0° TO $+25^\circ$	0° TO $+15^\circ$ TBR

The nominal flight attitudes and their associated attitude envelopes and constraints are identified in Table 10A_C2-71-I above and do not take into account launch to activation (LTA), P6 Relocation, or ETCs attitude constraints. Tables in paragraph B of this rule were developed to capture these attitude envelope modifications. The table is based on an RS vehicle located on the ISS aft. GN&C analysis has shown that the pitch attitude envelope limit of 25 deg may be violated by up to 6 deg under steady state conditions for various Russian vehicle docked configurations. The pitch attitude may settle out at pitch values up to +31 deg. SSCN **TBD** will be drafted to approve this expansion to the 10A pitch attitude envelope. Also, preliminary estimates of the yaw and roll TEA's show that their values will be outside of the approved +ZLV, ±XVV attitude envelopes if mated operations at $|\beta| > 60$ deg are used (issue resolution is currently on-going for these changes in ypr).

The TRRJ Autotrack algorithm requires attitude specific PPL's to operate per design, per Rule {10A_B18-**TBD**}, TRRJ AUTOTRACK BIAS MANAGEMENT. In the event that Autotrack is not used, the TRRJ will be parked per analyzed parking tables in Rule {10A_B18-2}, MANUAL TRRJ POSITIONING.
 ©[DN 157]

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FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC] (CONTINUED)

These PPL's and parking tables were constructed around the predicted tea's (± 5 deg/axis) at the time of the active thermal control system (ATCS) analysis. These same TEA's were used to construct the attitude envelopes in Table 10A_C2-71-II. ©[DN 157]

It is understood that based upon a number of variables, the TEA's analyzed by ATCS could differ from the ones that the GN&C attitude controllers will try to maintain when they are implemented on-orbit. In the event that the actual, on-orbit TEA's fall outside of the range of the attitude envelopes shown in Table 10A_C2-71-II but remain within the bounds of Table 10A_C2-71-I, guidance is provided in the Table Notes on the positioning of the TRRJ's.

ISS hardware is designed to operate within an approximate envelope of ± 15 deg. Certain hardware further constrains this envelope at high solar beta angles, above absolute value of 52 deg. This hardware includes, but not limited to the PI NTA, N1 MDM's, and ESP-1 PFCS.

1. 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).

2. MANEUVERS BETWEEN APPROVED ATTITUDE ENVELOPES SHALL BE PERFORMED WITH THE FOLLOWING CONSTRAINTS:
 - a. THE MAXIMUM MANEUVER TIME SHALL BE ONE ORBITAL PERIOD.
 - b. THE SOLAR POINTING VECTOR IN THE ISS BODY AXIS SHALL NOT BE STATIC DURING THE MANEUVER. ©[DN 157]

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FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC] (CONTINUED)

B. TABLES 10A_C2_71-II THROUGH 10A_C2-71-V DEFINE THE PLANNED FLIGHT ATTITUDE ENVELOPES THAT ACCOUNT FOR N₂ LTA, P6 RELOCATION, AND EATCS CONSTRAINTS DISCUSSED IN PARAGRAPH A RATIONALE ABOVE. IN THE EVENT THAT THESE ATTITUDE ENVELOPES ARE EXCEEDED, GUIDANCE IS GIVEN ON WHAT ACTIONS TO PERFORM IN THE NOTES SECTION FOR EACH TABLE. @[DN 157]

1. FROM DOCKING UNTIL JUST PRIOR TO MOVING P6 TO THE OVERNIGHT PARK POSITION (ONP) (NODE 2 INSTALLATION AND P6 DEMATING INCLUDED), THE PLANNED MATED STACK ATTITUDE ENVELOPES ARE DEFINED IN TABLE 10A_C2-71-II.

TABLE 10A_C2-71-II - PLANNED ATTITUDE ENVELOPES FROM DOCKING UNTIL PRIOR TO P6 DEMATING

BETA ANGLES	ATTITUDE REFERENCE FRAME	ISS ATTITUDE NAME	PLANNED ATTITUDE ENVELOPE [1] [2] [3]		
			YAW	PITCH	ROLL
$\beta > +60^\circ$	ISS LVLH	+ZLV +XVV	<u>-6° TO +4°</u>	<u>+11° TO +21°</u>	<u>-8° TO +2°</u>
$-60^\circ \leq \beta \leq +60^\circ$			<u>-6° TO +4°</u>	<u>+11° TO +21°</u>	<u>-8° TO +2°</u>
$\beta < -60^\circ$ [4]			<u>-5° TO +4°</u>	<u>+11° TO +21°</u>	<u>0° TO +2° (TBR)</u>
$\beta > +60^\circ$ [4]	ISS LVLH	+ZLV -XVV	<u>+175° TO +184°</u>	<u>+12° TO +22°</u>	<u>0° TO +2° (TBR)</u>
$-60^\circ \leq \beta \leq +60^\circ$			<u>+174° TO +184°</u>	<u>+12° TO +22°</u>	<u>-8° TO +2°</u>
$\beta < -60^\circ$			<u>+174° TO +184°</u>	<u>+12° TO +22°</u>	<u>-8° TO +2°</u>

NOTES:

- [1] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].
- [2] IN THE EVENT THAT THE AVERAGE VEHICLE YAW, PITCH, OR ROLL VALUES OVER THE COURSE OF A FULL ORBIT FALL OUTSIDE OF THE RANGE DEFINED IN TABLE 10A_C2-71-II, THE TRRJ WILL BE MANAGED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {10A_B18-TBD}, TRRJ AUTOTRACK BIAS MANAGEMENT.
- [3] THE ORBITER MAY REQUEST +ZLV ±XVV AS AN ALTERNATE CONDITIONING ATTITUDE TO PROTECT THE FOLLOWING THERMAL CONSTRAINTS: ORBITER MAIN LANDING GEAR TIRE LOW TEMPERATURE LIMIT MAY BE EXCEEDED IF $|\beta| > 50$ DEG BASED ON A TIRE TEMPERATURE LIMIT OF -43 DEG F. ORBITER NOSE LANDING GEAR HYDRAULIC LINE MAY FALL BELOW ITS -65 DEG F LOW LIMIT. PRIMARY RCS OPERATIONAL TEMPERATURE LIMIT MAY BE EXCEEDED IF $|\beta| > 63$ DEG.
- [4] PRELIMINARY ESTIMATES OF THE YAW AND ROLL TEA'S SHOW THAT THEIR VALUES WILL BE OUTSIDE OF THE APPROVED +ZLV ±XVV ATTITUDE ENVELOPES IF MATED OPERATIONS AT $|\beta| > 60$ DEG ARE USED. ISSUE RESOLUTION IS CURRENTLY ON-GOING AND MAY BE RESOLVED IN A FUTURE CR TO EXPAND THE YAW AND ROLL ATTITUDE ENVELOPES. @[DN 157]

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FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC] (CONTINUED)

2. FROM THE P6 ONP POSITION UNTIL JUST PRIOR TO RELOCATING P6 TO THE PRE-INSTALL POSITION ON P5, THE PLANNED MATED STACK ATTITUDE ENVELOPES ARE DEFINED IN TABLE 10A_C2-71-III. @[DN 157]

TABLE 10A_C2-71-III - PLANNED ATTITUDE ENVELOPES FOR P6 ONP POSITION

BETA ANGLES [1]	ATTITUDE REFERENCE FRAME	ISS ATTITUDE NAME	PLANNED ATTITUDE ENVELOPES [2] [3] [4]		
			YAW	PITCH	ROLL
$\beta > +60^\circ$ [5]	ISS LVLH	+ZLV +XVV	-1° TO +5° (TBR)	+11° TO +21°	-7° TO +3°
$+60^\circ \geq \beta \geq -20^\circ$			-1° TO +9°	+11° TO +21°	-7° TO +3°
$-20^\circ > \beta \geq -60^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$\beta < -60^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$\beta > +60^\circ$	ISS LVLH	+ZLV -XVV	ALLOWED FOR DURATION PER LTA RULE [5]		
$+60^\circ \geq \beta > +20^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$+20^\circ \geq \beta \geq -60^\circ$			+179° TO +189°	+11° TO +21°	-7° TO +3°
$\beta < -60^\circ$ [5]			+179° TO +185° (TBR)	+11° TO +21°	-7° TO +3°

NOTES:

- [1] P6 RELOCATION CONSIDERATIONS REQUIRE THE MATED STACK TO FLY THIS ATTITUDE FOR THE GIVEN SOLAR BETA ANGLE RANGE.
- [2] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].
- [3] IN THE EVENT THAT THE AVERAGE VEHICLE YAW, PITCH, OR ROLL VALUES OVER THE COURSE OF A FULL ORBIT FALL OUTSIDE OF THE RANGE DEFINED IN TABLE 10A_C2-71-III, THE TRRJ WILL BE MANAGED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {10A_B18-TBD}, TRRJ AUTOTRACK BIAS MANAGEMENT.
- [4] THE ORBITER MAY REQUEST +ZLV ±XVV AS AN ALTERNATE CONDITIONING ATTITUDE TO PROTECT THE FOLLOWING THERMAL CONSTRAINTS: ORBITER MAIN LANDING GEAR TIRE LOW TEMPERATURE LIMIT MAY BE EXCEEDED IF $|\beta| > 50$ DEG BASED ON A TIRE TEMPERATURE LIMIT OF -43 DEG F. ORBITER NOSE LANDING GEAR HYDRAULIC LINE MAY FALL BELOW ITS -65 DEG F LOW LIMIT. PRIMARY RCS OPERATIONAL TEMPERATURE LIMIT MAY BE EXCEEDED IF $|\beta| > 63$ DEG.
- [5] PRELIMINARY ESTIMATES OF THE YAW AND ROLL TEA'S SHOW THAT THEIR VALUES WILL BE OUTSIDE OF THE APPROVED +ZLV ±XVV ATTITUDE ENVELOPES IF MATED OPERATIONS AT $|\beta| > 60$ DEG ARE USED. ISSUE RESOLUTION IS CURRENTLY ON-GOING AND MAY BE RESOLVED IN A FUTURE CR TO EXPAND THE YAW AND ROLL ATTITUDE ENVELOPES.
- [6] THE LTA RULE, {10A_C2-73}, 10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS, GOVERNS THE TIME CONSTRAINTS IN THE -XVV AND +XVV ATTITUDE FOR THESE BETA RANGES. AN ATTITUDE CHANGE IS REQUIRED WHEN FLYING -XVV FOR BETA ANGLES $> +20$ DEG TO PROTECT ORU LOWER TEMPERATURE LIMITS. THE YPR CONSTRAINTS FOR THE ASSOCIATED ±XVV LISTED IN THE TABLE APPLY. THE PREFERENCE IS TO FLY -XVV TO MITIGATE ORBITER MMOD RISK. @[DN 157.]

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FLIGHT RULES

**10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]
(CONTINUED)**

Flying -XVV reduces the orbiter's risk of Micrometeoroids and Orbital Debris (MMOD) impact as compared to flying the nominal +XVV attitude. +XVV attitudes are required to protect lower temperature limits while P6 is unpowered for certain beta ranges. P6 components which are predominately at risk include the IEA batteries and the PVCU MDM. The analyzed nominal timeline using switching between -XVV to +XVV for the indicated beta ranges shows acceptable margins for all components during P6 relocation. ©[DN 157]

3. FROM P6 PRE-INSTALL POSITION THROUGH P6 REACTIVATION, THE PLANNED MATED STACK ATTITUDE ENVELOPES ARE DEFINED IN TABLE 10A_C2-71-IV.

TABLE 10A_C2-71-IV - PLANNED MATED ATTITUDE ENVELOPES FOR P6 PRE-INSTALL THROUGH P6 RE-ACTIVATION

BETA ANGLES [1]	ATTITUDE REFERENCE FRAME	ISS ATTITUDE NAME	PLANNED ATTITUDE ENVELOPES [2] [3]		
			YAW	PITCH	ROLL
$\beta > +60^\circ$ [4]	ISS LVLH	+ZLV +XVV	$+7^\circ$ TO $+15^\circ$ (TBR)	$+10^\circ$ TO $+20^\circ$	-14° TO -4°
$+60^\circ \geq \beta \geq -20^\circ$			$+7^\circ$ TO $+15^\circ$	$+10^\circ$ TO $+20^\circ$	-14° TO -4°
$-20^\circ > \beta \geq -60^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$\beta < -60^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$\beta > +60^\circ$	ISS LVLH	+ZLV -XVV	ALLOWED FOR DURATION PER LTA RULE [5]		
$+60^\circ \geq \beta > +20^\circ$			ALLOWED FOR DURATION PER LTA RULE [5]		
$+20^\circ \geq \beta \geq -60^\circ$			$+186^\circ$ TO $+195^\circ$	$+10^\circ$ TO $+20^\circ$	-14° TO -4°
$\beta < -60^\circ$ [4]			$+186^\circ$ TO $+195^\circ$ (TBR)	$+11^\circ$ TO $+21^\circ$	-7° TO $+3^\circ$

©[DN 157]

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Verify that this is the correct version before use.

FLIGHT RULES

**10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]
(CONTINUED)**

NOTES: @[DN 157]

- [1] LAUNCH-TO-ACTIVATION (LTA) CONSIDERATIONS REQUIRE THE MATED STACK TO FLY THIS ATTITUDE FOR THE GIVEN SOLAR BETA ANGLE RANGE.
- [2] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].
- [3] IN THE EVENT THAT THE AVERAGE VEHICLE YAW, PITCH, OR ROLL VALUES OVER THE COURSE OF A FULL ORBIT FALL OUTSIDE OF THE RANGE DEFINED IN TABLE 10A_C2-71-IV, THE TRRJ WILL BE MANAGED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {10A_B18-TBD}, TRRJ AUTOTRACK BIAS MANAGEMENT.
- [4] PRELIMINARY ESTIMATES OF THE YAW AND ROLL TEA'S SHOW THAT THEIR VALUES WILL BE OUTSIDE OF THE APPROVED +ZLV ±XVV ATTITUDE ENVELOPES IF MATED OPERATIONS AT $|B| > 60$ DEG ARE USED. ISSUE RESOLUTION IS CURRENTLY ON-GOING AND MAY BE RESOLVED IN A FUTURE CR TO EXPAND THE YAW AND ROLL ATTITUDE ENVELOPES.
- [5] THE LTA RULE {10A_C2-73}, 10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS, GOVERNS THE TIME CONSTRAINTS IN THE -XVV AND +XVV ATTITUDE FOR THESE BETA RANGES. AN ATTITUDE CHANGE IS REQUIRED WHEN FLYING -XVV FOR BETA ANGLES $> +20$ DEG TO PROTECT ORU LOWER TEMPERATURE LIMITS. THE YPR CONSTRAINTS FOR THE ASSOCIATED ±XVV LISTED IN THE TABLE APPLY. THE PREFERENCE IS TO FLY -XVV TO MITIGATE ORBITER MMOD RISK.

Flying -XVV reduces the Orbiter's risk of Micrometeoroids and Orbital Debris (MMOD) impact as compared to flying the nominal +XVV attitude. +XVV attitudes are required to protect lower temperature limits while P6 is unpowered for certain beta ranges. P6 components which are predominately at risk include the IEA batteries and the PVCU MDM. The analyzed nominal timeline using switching between -XVV to +XVV for the indicated beta ranges shows acceptable margins for all components during P6 relocation.

- 4. FOR POST P6 RE-ACTIVATION, THE PLANNED MATED STACK ATTITUDE ENVELOPES ARE DEFINED IN TABLE 10A_C2-71-V.

TABLE 10A_C2-71-V - PLANNED MATED ATTITUDE ENVELOPES FOR POST P6 RE-ACTIVATION

BETA ANGLES	ATTITUDE REFERENCE FRAME	ISS ATTITUDE NAME	PLANNED ATTITUDE ENVELOPES [2] [3] [4]		
			YAW	PITCH [6]	ROLL
$\beta > +60^\circ$ [1] [7]	ISS LVLH	+ZLV +XVV [5]	+7° TO +15° (TBR)	+10° TO +20°	-14° TO -4°
$-60^\circ \leq \beta \leq +60^\circ$			+7° TO +15°	+10° TO +20°	-14° TO -4°
$\beta < -60^\circ$ [1][7]			+7° TO +15°	+10° TO +20°	-14° TO -4° (TBR)
$\beta > +60^\circ$ [1] [7]		+ZLV -XVV [5]	+186° TO +195°	+10° TO +20°	-14° TO -4° (TBR)
$-60^\circ \leq \beta \leq +60^\circ$			+186° TO +195°	+10° TO +20°	-14° TO -4°
$\beta < -60^\circ$ [1] [7]			+186° TO +195° (TBR)	+10° TO +20°	-14° TO -4°

@[DN 157]

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FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC] (CONTINUED)

NOTES: @[DN 157]

- [1] THE YAW AND ROLL RANGES FOR THE +ZLV ±XVV ATTITUDES WHEN |BETA| > 60 ARE CONSTRAINED BY NODE 1 MDM, P1 NTA, AND ESP1 PFCS THERMAL LIMITS.
USE OF THE MATED ±XVV FLIGHT ATTITUDES ABOVE SOLAR BETA MAGNITUDES OF 60 DEGREES IS APPROVED FOR OPERATIONS AND NOT JUST RESERVED FOR CSCS SCENARIOS, PENDING PROGRAM APPROVAL.
- [2] IN THE EVENT THAT THE AVERAGE VEHICLE YAW, PITCH, OR ROLL VALUES OVER THE COURSE OF A FULL ORBIT FALL OUTSIDE OF THE RANGE DEFINED IN TABLE 10A_C2-71-V THE TRRJ WILL BE MANAGED PER RULES {10A_B18-2}, MANUAL TRRJ POSITIONING AND {10A_B18-TBD}, TRRJ AUTOTRACK BIAS MANAGEMENT.
- [3] ENERGY MANAGEMENT WILL BE PERFORMED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].
- [4] THE ORBITER MAY REQUEST +ZLV ±XVV AS AN ALTERNATE CONDITIONING ATTITUDE TO PROTECT THE FOLLOWING THERMAL CONSTRAINTS: ORBITER MAIN LANDING GEAR TIRE LOW TEMPERATURE LIMIT MAY BE EXCEEDED IF |β| > 50 DEG BASED ON A TIRE TEMPERATURE LIMIT OF -43 DEG F. ORBITER NOSE LANDING GEAR HYDRAULIC LINE MAY FALL BELOW ITS -65 DEG F LOW LIMIT. PRIMARY RCS OPERATIONAL TEMPERATURE LIMIT MAY BE EXCEEDED IF |β| > 63 DEG.
- [5] THERMAL ANALYSIS SHOWS THAT KU-BAND ANTENNA HARDWARE MAY EXCEED BOTH ITS UPPER AND LOWER THERMAL LIMITS WHILE IN THIS FLIGHT ATTITUDE. BECAUSE OF THIS, KU-BAND COVERAGE MAY BE IMPACTED. THERMAL MANAGEMENT OF THIS HARDWARE MUST BE PERFORMED UNDER RULE {B11-27}, ISS KU-BAND EXTERNAL ORU THERMAL MANAGEMENT.
- [6] GN&C ANALYSIS HAS SHOWN THAT THE PITCH ATTITUDE ENVELOPE LIMIT OF 25 DEG MAY BE VIOLATED BY UP TO 6 DEG UNDER STEADY STATE CONDITIONS FOR VARIOUS RUSSIAN VEHICLE DOCKED CONFIGURATIONS. THE PITCH ATTITUDE MAY SETTLE OUT AT PITCH VALUES UP TO +31 DEG. SSCN TBD WILL BE DRAFTED TO APPROVE THIS EXPANSION TO THE 10A PITCH ATTITUDE ENVELOPE.
- [7] PRELIMINARY ESTIMATES OF THE YAW AND ROLL TEA'S SHOW THAT THEIR VALUES WILL BE OUTSIDE OF THE APPROVED +ZLV ±XVV ATTITUDE ENVELOPES IF MATED OPERATIONS AT |β| > 60 DEG ARE USED. ISSUE RESOLUTION IS CURRENTLY ON-GOING AND MAY BE RESOLVED IN A FUTURE CR TO EXPAND THE YAW AND ROLL ATTITUDE ENVELOPES. @[DN 157]

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FLIGHT RULES

**10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]
(CONTINUED)**

C. IN THE EVENT THAT AN ORBITER REBOOST IS REQUIRED, THE ALLOWABLE MATED STACK ATTITUDE ENVELOPE IS DEFINED IN TABLE 10A_C2-71-VI. @[DN 157]

TABLE 10A_C2-71-VI - MATED REBOOST ATTITUDE ENVELOPE

	REFERENCE	ISS ATTITUDE	PLANNED ATTITUDE ENVELOPES [3] [4]			TIME LIMIT [1]	RECOVERY TIME
	FRAME	NAME	YAW	PITCH	ROLL		
REBOOST	ISS LVLH	+ZLV -XVV [2]	+175° TO +185°	+1° TO +11°	-5° TO +5°	5 HRS TBR	1:1 TBR

NOTES:

- [1] THE TIME LIMIT COLUMN REFERS TO THE SPECIFIC PERIOD OF TIME SPENT IN THE ORBITER REBOOST ATTITUDE, PLUS THE TIME PERIOD BETWEEN THE INITIAL ATTITUDE ENVELOPE VIOLATION AND WHEN THE VEHICLE REACHES THE SPECIAL OPERATIONS ATTITUDE.
- [2] ORBITER CONFIGURATION 3, REFERENCE FLIGHT SPECIFIC "MATED REBOOST CONFIGURATION AND CONSTRAINTS" RULE.
- [3] 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] [J].
- [4] FEATHERING GUIDELINES FOR SARJ AND BGA'S ARE FOUND IN RULE {10A_B2-45}, USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC] [RC].

This attitude is equivalent to an Orbiter Config. 3 reboost. Upon completion of the reboost, a recovery in the nominal attitude is required to thermally condition hardware prior to another reboost attitude. The reboost attitude duration is limited to mitigate EATCS freeze concerns. @[DN 157]

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FLIGHT RULES

**10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]
(CONTINUED)**

D. CSCS ORBITER SEPARATION ATTITUDE @[DN 157]

IN THE EVENT THAT A CSCS SCENARIO IS DECLARED, THE ALLOWABLE MATED STACK ATTITUDE ENVELOPE TO PERFORM THE CSCS CONTINGENCY SEPARATION IS DEFINED IN TABLE 10A_C2-71-VII. THIS FLIGHT ATTITUDE HAS NOT BEEN APPROVED PREFLIGHT AND WILL REQUIRE THAT A CHIT BE WRITTEN FOR APPROVAL OF ITS USE SHOULD CSCS BE DECLARED.

TABLE 10A_C2-71-VII - MATED ATTITUDE ENVELOPE FOR CSCS CONTINGENCY SEPARATION

BETA ANGLES	REF FRAME	ISS ATTITUDE NAME	ORM EVENT [1] [2]	PLANNED ATTITUDE ENVELOPE		
				YAW	PITCH	ROLL
$-75^\circ \leq \beta \leq +75^\circ$	LVLH	-XLV +ZVV	CSCS CONTINGENCY SEPARATION	-5° TO +5°	+90°	-5° TO +5°

NOTES:

- [1] ALLOWABLE TIME IN ATTITUDE IS 2.5 HOURS.
- [2] PTCS THERMAL ANALYSIS OF THE CSCS CONTINGENCY SEPARATION ATTITUDE HAS SHOWN THAT SOME ORU'S MAY POTENTIALLY EXCEED THEIR THERMAL LIMITS UNDER STEADY STATE CONDITIONS. THESE ATTITUDES ARE USED FOR ONLY SHORT PERIODS OF TIME (< 2.5 HOURS), WHICH MAY PRECLUDE POTENTIAL VIOLATIONS FROM OCCURRING.

Rationale for use 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.

Passive thermal analysis shows ORU's exceed maximum temperature limits in this attitude. These ORU's include, but not limited to, the S-band (System 1 and 2), the S1 and P1 HRS HCA, the P6 PVCU MDM, P6 PFCS, and the P6-LS PFCS and EEATCS accumulators. These hot concerns occurred above a solar beta of 60 deg (absolute). The analysis assumed P6 on Z1 (prior to move outboard). Flight specific analysis will be performed to further determine attitude constraints if CSCS is declared and solar betas exceed 60 deg (absolute).

The analysis assumed P6 on Z1 (prior to move outboard). For P6 outboard, the attitude is acceptable up to beta 60 deg based similarity in the thermal environment of P4 and P6, along with use of engineering judgment for Z1. @[DN 157]

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FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC] (CONTINUED)

- E. DURING PRE EVA, EVA, AND POST EVA ACTIVITIES, THE EXTERNAL AIRLOCK (A/L) SUPPLY LINES WILL NOT HAVE THE SUN IN THEIR FIELD-OF-VIEW (FOV) FOR MORE THAN 30 MINUTES. ©[DN 157]

|Beta| < 60 degrees: The FOV of the A/L lines is defined as a half-cone angle of 65 degrees from a bore site direction in the X-Z plane, 65 degrees from the orbiter -X body axis, and 25 degrees from the orbiter -Z body axis.

Violations of the FOV for longer than 30 minutes are allowed provided adequate recovery time outside the FOV is planned prior to EVA. Before launch, the attitude timeline will be analyzed for acceptability. After launch, changes to the attitude timeline are approved in real time by orbiter TCS.

This FOV protects the external A/L supply lines from payload bay liner thermal reflections. For sun in the X-Z plane, sun pitch 5 degrees above the orbiter tail and up to 60 degrees above the orbiter nose are both acceptable. The oxygen supply line will reach its upper operational limit of 90 deg F within 30 minutes if the attitude violation occurs during a sun pass.

The orbiter airlock service line attitude constraints described above protect the 90 deg F operational limit for the external airlock O₂ supply line and 100 deg F limit for the water lines. The non-operational limit of 160 deg F at the zone 1 to zone 2 interface QD's is also protected. The criteria to connect the EMU to the SCU is defined in Rule {A15-202}, EXTERNAL AIRLOCK LCG PRESSURE AND TEMPERATURE MANAGEMENT USING THE EMU. The allowable IH sun angle relaxation for the non-operational limit has not been defined and does not significantly expand the allowable envelope defined for EVA operations. The limiting beta angles for the LVLH attitudes would increase slightly for the non-operational limit. Orbiter TCS provides preflight and real-time mission support of all ATL considered. Therefore, the non-operational constraints are not provided. The LVLH beta constraints above cover beta angles to 75 deg; the IH orbiter airlock service lines FOV envelope covers up to Beta=60 deg, but the envelope would be similar for 60 < |Beta| < 75 deg, although larger. TCS provides high beta mission analysis when directed by the JMICB.

- F. IF THE ORBITER AIRLOCK SERVICE LINES CONSTRAINT IS VIOLATED, AS DEFINED IN PARAGRAPH G ABOVE, EXTRA VEHICULAR ACTIVITY MAY BE PERFORMED FROM THE ISS AIRLOCK, PROVIDED THAT THE O₂/N₂ CONSUMABLES ARE SUPPLIED BY THE ISS.

O₂ and N₂ consumables from the orbiter can be transferred to the ISS when the orbiter airlock service lines are not in violation of the constraints defined in paragraph B3.

Reference Integrated Hazard Report ITHM-01, Exposure to Thermal Environment Exceeds Capability of SSV. ©[DN 157]

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STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-129
ISS EXPEDITIONS 15 & 16

Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-71 MATED ATTITUDES AND ATTITUDE CONSTRAINTS [HC] [RC]
(CONTINUED)

G. FREE DRIFT OR LOAC PERIODS @[DN 157]

1. FREE DRIFT OR LOAC DURING A THRUSTER INHIBIT PERIOD

IF THE MATED STACK IS IN FREE DRIFT OR EXPERIENCES A LOSS OF ATTITUDE CONTROL (LOAC) EVENT WHEN PERFORMING A PLANNED ACTIVITY THAT REQUIRES ALL THRUSTER FIRINGS TO BE INHIBITED, THE ACTIVITY MAY BE CONTINUED WHILE IN FREE DRIFT UNTIL IT CAN BE PROPERLY SAFED. SAFING OF THE ACTIVITY MAY ENTAIL ITS COMPLETION IF OTHER OPERATIONAL CONSIDERATIONS, WHEN TAKEN INTO ACCOUNT, INDICATE THAT COMPLETION OF THE ACTIVITY IS NECESSITATED.

a. TEMPERATURES OF ALL INSTRUMENTED EXTERNAL COMPONENTS WILL BE MONITORED DURING THE ATTITUDE EXCURSION.

(1) IF TEMPERATURE TRENDS INDICATE THAT OPERATIONAL LIMITS WILL BE VIOLATED, THE MATED STACK MUST RETURN TO ONE OF THE ATTITUDES DEFINED IN PARAGRAPHS A OR B (DEPENDING UPON WHAT POINT IN THE MISSION HAS BEEN REACHED) PRIOR TO THE HARDWARE LIMIT VIOLATION.

(2) FOLLOWING AN ATTITUDE ENVELOPE DEVIATION, THE MATED STACK ATTITUDE MUST REMAIN INSIDE THE ENVELOPE FOR 10 HOURS BEFORE ADDITIONAL DEVIATIONS OCCUR.

b. POWER GENERATION MUST BE SUFFICIENT TO SUSTAIN THE NECESSARY ISS SYSTEMS. ANY DEFICIENCIES WILL BE MANAGED PER RULE {B9-453}, ENERGY MANAGEMENT [HC] [RC] [E] [J].

c. FOR GUIDANCE ON EATCS OPERATIONS REFER TO RULE {10A_B18-2}, MANUAL TRRJ POSITIONING. @[DN 157]

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FLIGHT RULES

10A_C2-71

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

Boeing PTCS performs thermal analysis that results in temperatures that are used as initial conditions to be applied to the ISS structures. These temperature gradients and profiles give rise to thermal loads between the structural interfaces and to the internal primary members of the structure. These loads, added to the mechanical transient loads on the ISS, are assessed to determine if they remain within the allowable load ICD limits that yielded positive margins of safety at the time the ISS structures were certified for flight. @DN 157]

In the process of performing thermal structural analysis for multiple new flight attitudes, there were attitude instances where the transient temperatures of certain elements of the ISS structure yielded loads that were 50 percent to 60 percent higher than the allowable load ICD limits within 1 and 1/2 hours. Owing to this fact, the use of a "X" number of hours in any attitude rule, that assumes that the thermal loads of the ISS structures will remain within the allowable load ICD limits, as long as the ISS ORU's temperatures limits are not exceeded, is no longer valid.

In the event that a LOAC occurs and the mated stack goes into free drift, the period of time that the mated stack is in free drift should be minimized as much as operationally possible to minimize the potential that a structural load limit will be exceeded.

2. FREE DRIFT OR LOAC EVENT WHILE THRUSTER FIRINGS ARE ALLOWED

IF THE MATED STACK EXPERIENCES AN UNPLANNED LOAC EVENT AND IS FORCED INTO FREE DRIFT, PROPULSIVE ATTITUDE CONTROL SHOULD BE USED AS SOON AS IT IS OPERATIONALLY FEASIBLE TO RETURN THE MATED STACK TO ONE OF THE APPROVED FLIGHT ATTITUDE ENVELOPES DEFINED IN PARAGRAPHS A, OR B (DEPENDING UPON WHAT POINT IN THE MISSION HAS BEEN REACHED) . @DN 157]

FLIGHT RULES

10A_C2-72 COMMUNICATIONS COVERAGE REQUIREMENTS [C]

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 {10A_C10-4}, COMMUNICATION REQUIREMENTS FOR SSAS OPERATIONS, FOR SPECIFIC COMMUNICATION REQUIREMENTS DURING SEGMENT-TO-SEGMENT ATTACHMENT SYSTEM (SSAS) OPERATIONS.

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

- B. PHOTOVOLTAIC RADIATOR (PVR) DEPLOY
1. PRIOR TO THE START OF A DEPLOY SEQUENCE, IF DOWNLINK TELEMETRY IS LOST, THE DEPLOY WILL BE DELAYED UNTIL A COMM LINK IS REGAINED.
 2. IF THE PHYSICAL DEPLOY HAS BEEN INITIATED AND DOWNLINK TELEMETRY IS LOST, THE DEPLOY WILL BE ALLOWED TO CONTINUE UNTIL COMPLETION.

To ensure a nominal deploy, it is considered prudent to halt operations until the ground can monitor the deploy. Once the deploy has been initiated, it is better to allow the deploy to proceed, rather than halt and restart. Note, only downlink telemetry is required for the deploys.

- C. 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.

FLIGHT RULES

10A_C2-73 10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS

- A. NODE 2 LTA TIME CONSTRAINTS ARE LISTED IN TABLE 10A-C2-73-I. LTA TIMES LISTED ARE DEPENDENT UPON SOLAR BETA, AND FLIGHT ATTITUDE. THE LTA CLOCK STARTS AT REMOVAL OF THE ORBITER POWER TO NODE 2 HEATERS AND ENDS AT NODE 2 SHELL HEATER ACTIVATION WHILE ON NODE 1. ©[DN 116]

TABLE 10A_C2-73-I - NODE 2 LTA TIME CONSTRAINTS

ATTITUDE	BETA	TIME LIMIT [1]	CONSTRAINT
+ XVV	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
-XVV	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>

NOTES:

[1] TBD

The thermal clocks in this rule are event-based. Thermal analysis shows that components on Node 2 will reach their lower limit by the times listed above in Table 10A_C2-73-I. Times listed in this table are for the most limiting component for each Beta range. The thermal analysis was performed assuming a nominal mission and attitude timeline. 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.

Source: TBD

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FLIGHT RULES

10A_C2-73 10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS
(CONTINUED)

B. P6 RELOCATION TIME CONSTRAINTS ARE LISTED IN TABLE 10A-C2-73-II. THE TIMES LISTED ASSUME THAT P6 WAS UNPOWERED AT THE Z1 LOCATION FOR NO MORE THAN 7 HOURS. TIMES LISTED ARE DEPENDENT UPON SOLAR BETA, AND FLIGHT ATTITUDE. @[DN 116]

TABLE 10A_C2-73-II - P6 RELOCATION TIME CONSTRAINTS

ATTITUDE	BETA	OVERNIGHT PARK LIMIT [1]	INSTALL LIMIT [2]	CONSTRAINT
+ XVV [3]	+60	78	21	IEA BATTERY/PVCU
	+40	78	54	N/A
	+20	78	54	N/A
	0	48	54	IEA BATTERY
	-20	42 [4]	54	IEA BATTERY
	-40	37 [4]	44	IEA BATTERY
	-60	31 [4]	38	IEA BATTERY
-XVV	+60	31 [5]	38	IEA BATTERY
	+40	37 [5]	44	IEA BATTERY
	+20	42 [5]	54	IEA BATTERY
	0	48	54	IEA BATTERY
	-20	78	54	N/A
	-40	78	54	N/A
	-60	78	21	IEA BATTERY/PVCU

NOTES:

- [1] THE OVERNIGHT PARK TIME LIMIT IS DEFINED AS THE TIME ALLOWED THAT P6 CAN REMAIN (UNPOWERED) AT THE OVERNIGHT PARK POSITION. THE ANALYSIS ASSUMED THAT P6 REMAINED UNPOWERED AT THE Z1 LOCATION FOR 7 HOURS. IF THE TIME SPENT UNPOWERED AT Z1 IS MORE OR LESS THAN 7 HOURS, THEN THIS TIME MAY BE ABLE TO BE ADJUSTED. THIS CLOCK STARTS WHEN P6 REACHES THE OVERNIGHT PARK POSITION AND ENDS WHEN P6 REACHES THE INSTALL POSITION.
- [2] THE INSTALL POSITION IS DEFINED AS WITHIN 5 FEET OF P5 OR CONNECTED TO P5. THE INSTALL LIMIT IS DEFINED AS THE TIME ALLOWED FOR P6 TO REMAIN AT THE INSTALL POSITION WHILE UNPOWERED. THIS CLOCK STARTS WHEN P6 REACHES THE INSTALL POSITION AND STOPS WHEN P6 HAS BEEN ACTIVATED TO THE POINT THAT ALL P6 ORU'S HAVE TEMPERATURE CONTROL.
- [3] THE TIME IN +XVV WILL BE MINIMIZED DUE TO ADDITIONAL MMOD RISK TO THE ORBITER.
- [4] DUE TO LESS THAN 40 HOURS BEING AVAILABLE FOR THE OVERNIGHT PARK LIMIT, +XVV SHOULD NOT BE FLOWN FOR BETA ANGLES OF -20 DEG OR LESS.
- [5] SINCE THE OVERNIGHT PARK LIMIT DOES NOT MEET THE 40 HOUR DESIRED CAPABILITY, THE ISS ATTITUDE IS REQUIRED TO BE CHANGED TO +XVV FOR THE LAST PORTION OF THE RELOCATION OPERATION AT THE OVERNIGHT PARK POSITION, THUS ALLOWING THE USE OF THE +XVV LIMIT. THE TIME IN +XVV WILL BE MINIMIZED DUE TO ADDITIONAL MMOD RISK TO THE ORBITER. @[DN 116]

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FLIGHT RULES

10A_C2-73

10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS (CONTINUED)

The thermal clocks in this rule are event-based. Thermal analysis shows that components on the P6 truss will reach their lower limit by the times listed above in Table 10A_C2-73-II. Times listed in this table are for the most limiting component for each Beta range. The thermal analysis was performed assuming a nominal mission and attitude timeline. The analyzed ISS attitude (Y,P,R) was (2,16,-2) for +XVV and (182,16,-2) for -XVV. Minor attitude deviations (up to 5 deg in each axis) are not considered to be an impact to the overall time constraints of this rule. However, significant changes in the timing 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 116]

The analyzed overnight park position was +1678, -1279, +3/-29.4, +83.0, -130.7 (xyz/PYR, FOR - P6 Demate). The analyzed BGA 2B and 4B park positions for the P6 BGA's were 225 ±15 Deg. The analysis also assumes that the P6 SSU shrouds are installed. An IEA Battery lower temperature limit of -25 degrees C (-13 degrees F) was assumed in the analysis.

Flying -XVV reduces the orbiter's risk of micrometeoroids and orbital debris (MMOD) impact as compared to flying the nominal +XVV attitude. +XVV attitudes are required to protect lower temperature limits while P6 is unpowered for certain beta ranges. P6 components which are predominately at risk include the IEA batteries and the PVCU MDM. The analyzed nominal timeline using switching between -XVV to +XVV for the indicated beta ranges show acceptable margins for all components during P6 relocation.

Source: A. Ketola, Flight 10A ~ P6 Relocation Analysis, Boeing memo # ISS-HOU-PTCS-ASK-070004, March 30, 2007. ©[DN 116]

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FLIGHT RULES**10A_C2-73 10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS**
(CONTINUED)

C. THERMAL TIME CONSTRAINTS FOR ITEMS BEING TRANSFERRED DURING FLIGHT 10A ARE LISTED IN TABLE 10A-C2-73-III. ©[DN 116]

TABLE 10A_C2-73-III - THERMAL CONSTRAINTS FOR ORU TRANSFERS

COMPONENT	MLI CONFIG	TIME LIMIT (HRS)	START	STOP
Z1 SPARE SASA	MLI COVER INSTALLED	2 HR	REMOVAL OF HEATER POWER AT Z1	APPLICATION OF HEATER POWER IN THE PLB
Z1 BSP	NONE	2 HR	REMOVAL OF HEATER POWER	TRANSFER TO AIRLOCK
NEW RPCM S04B-C	EVA MLI BAG	6 HR TRANSFER CLOCK PROVIDES A 2 HR ACTIVATION CLOCK	TRANSFER CLOCK – REMOVAL FROM THE A/L ACTIVATION CLOCK – REMOVAL FROM MLI BAG	TRANSFER CLOCK – REMOVAL FROM MLI BAG ACTIVATION CLOCK – RPCM PHYSICALLY INSTALLED
	NO MLI BAG	2.5 HR TRANSFER/ACTIVATION	REMOVAL FROM THE A/L	RPCM PHYSICALLY INSTALLED
FAILED RPCM S04B-C	EVA MLI BAG	1.5 HR REMOVAL CLOCK PROVIDES AN 8 HR TRANSFER CLOCK	REMOVAL CLOCK – RPCM PHYSICALLY REMOVED TRANSFER CLOCK – RPCM PLACED IN MLI BAG	REMOVAL CLOCK – RPCM PLACED IN MLI BAG TRANSFER CLOCK – RPCM PLACED IN A/L
	NO MLI BAG	2 HR REMOVAL/TRANSFER	RPCM PHYSICALLY REMOVED	RPCM PLACED IN A/L
SPARE MBSU	EXISTING MLI ON SPARE MBSU	6 HR	REMOVAL OF HEATER POWER IN THE PLB	HEATER ACTIVATION ON ESP-2
NODE 2 PDGF	NONE	NONE	N/A	N/A

The ORU transfers must be accomplished within the time limits specified above to prevent the components from violating their minimum temperature limits

Source: ISS Chit 3367 (RPCM), TBD (MBSU), TBD (S-band hardware), engineering judgment (MISSE and PDGF). ©[DN 116]

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FLIGHT RULES

10A_C2-73

10A LAUNCH-TO-ACTIVATION (LTA) CONSTRAINTS
(CONTINUED)

- D. THE P6 SSU THERMAL SHROUDS MAY BE REMOVED UP TO 1 HOUR PRIOR TO SSU ACTIVATION. FOLLOWING SSU ACTIVATION AND PRIOR TO SSU SHROUD REMOVAL, THE SSU WILL BE DEACTIVATED IF REQUIRED TO PROTECT OVERTEMP LIMITS. @[DN 116]

The P6 SSU shrouds are installed for P6 relocation to protect against SSU undertemps. If the shrouds are removed too much before SSU activation, then an undertemp could occur. After the SSU has been activated, the SSU temperatures can be monitored to ensure that an overtemp condition does not occur prior to SSU shroud removal. If necessary, the SSU can be deactivated to allow for a cool-down period.
@[DN 116]

FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]

A1. LOADS CONSTRAINTS DURING NODE 2 INSTALLATION ARE DEFINED IN THE FOLLOWING TABLE:

TABLE 10A_C2-74-I - NODE 2 INSTALLATION LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL			OPERATIONS							
		VRCS	PRCS	CMG - TA		THRUS - TERS 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/ TRRJ ROTATION	STBD SARJ/ S4 BGA/ TRRJ ROTATION	MT TRANS/ SSRMS OPS/ SRMS OPS
				MOM MGMT NO DESATS	USTO [3]									
N2 BERTHED IN PAYLOAD BAY		OK	OK	OK	OK	OK	OK	OK		OK	OK	OK	OK	OK
SSRMS OPS [6] [7]	MNVR TO LOW HOVER POSN	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT LOW HOVER POSN	OK	OK	OK	OK	OK [8]	OK	OK	OK [9][10][11]	OK	OK [2]	OK	OK	
	MNVR TO PORT HOVER POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT PORT HOVER POSN	OK	OK	OK	OK	OK [8]	OK	OK	OK [9][10][11]	OK	OK [2]	OK	OK	
	MNVR TO INTERMEDIATE POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT INTERMEDIATE POSN	OK	OK	OK	OK	OK	OK	OK	OK [10]	OK	OK	OK	OK	
	MNVR TO PRE-INSTALL POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT PRE-INSTALL POSN	OK	OK	OK	OK	OK	OK	OK	OK [10]	OK	OK	OK	OK	
MNVR TO INSTALL	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK		

@[DN 154]

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

**TABLE 10A_C2-74-I - NODE 2 INSTALLATION LOADS CONSTRAINTS
 (CONTINUED)**

S34 CONFIG	ATTITUDE CONTROL ROL & OPS	STS ATTITUDE CONTROL (16)		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/ TRRJ ROTATION	STBD SARJ/ S4 BGA/ TRRJ ROTATION	MT TRANS/ SSRMS OPS/ SRMS OPS
				MOM MGMT NO DESATS	USTO									
CBM OPS	READY TO LATCH	OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK				
	AT N2 INSTALL FROM CBM INITIATION OF 1ST STAGE CAPTURE TO ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [4]	OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK				
	CBM AT ≥ 8 BOLTS (EVERY OTHER BOLT) WITH A-BOLTS COMPLETE [4]	OK	NOT OK [14]	OK	OK	OK	OK	OK	OK	OK	NOT OK			
	CBM FROM ≥ 12 BOLTS WITH A-BOLTS COMPLETE TO ≥ 12 BOLTS WITH F-BOLTS COMPLETE [4]	OK	OK	OK	OK	OK	OK	OK	OK	OK	NOT OK [5]			

@[DN 154]

NOTES:

- [1] KEY: - ALLOWED - NOT ALLOWED - NOT ANALYZED.
- [2] MINIMUM DISTANCE CONSTRAINT IS 2 FT FOR VRCS AND SM THRUSTERS, 5 FT FOR PRCS.
- [3] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [4] REFERENCE RULE {B10-106}, CBM STRUCTURAL LOADS CONSTRAINTS [HC].
- [5] RISK OF PERMANENT DAMAGE TO CBM SEALS FOR THIS CASE
- [6] THE FOLLOWING REBOOST OPTIONS WERE ANALYZED:
 PROGRESS AT SM AFT 8 R&D
 PROGRESS AT SM AFT 4 R&D WITH PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT SM AFT 4 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT DC-1 AFT 2 MID-RING WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 PROGRESS AT DC-1 AFT 2 R&D WITH SM PITCH-YAW ASSIST AND PROGRESS AT DC-1 ROLL ASSIST
 2 SM MAIN JETS
 SR-1 SM MAIN JET
 SR-2 SM MAIN JET
 ATV 2 OCS JETS
 ATV 4 ACS JETS @[DN 154]

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

- [7] THE FOLLOWING PROGRESS/SM/ATV ACS OPTIONS WERE ANALYZED: @[DN 154]
 PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, SM JETS ROLL
 PROGRESS AT SM AFT MID-RING JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 PROGRESS AT SM AFT R&D JETS PITCH-YAW, PROGRESS AT DC-1 ROLL
 SM PITCH-YAW-ROLL (NO PROGRESS OR ATV AT SM AFT)
 SM PITCH-YAW-ROLL, PROGRESS AT DC-1 ROLL
 ATV AT SM AFT PITCH-YAW, PROGRESS AT DC-1 ROLL
 ATV AT SM AFT PITCH-YAW-ROLL
- [8] ONLY PROGRESS AT SM AFT R&D JETS PITCH-YAW, PROGRESS AT DC-1 ROLL ACS IS ALLOWED.
- [9] PROGRESS AT SM AFT 8 R&D REBOOST NOT ALLOWED
- [10] SM REBOOST NOT ALLOWED
- [11] PROGRESS AT SM AFT 4 R&D WITH PROGRESS AT DC-1 ROLL ASSIST NOT ALLOWED
- [12] SSRMS BRAKES ON ONLY

A2. LOADS CONSTRAINTS DURING P6 INSTALLATION ARE DEFINED IN THE FOLLOWING TABLE:

TABLE 10A_C2-74-II - P6 INSTALLATION LOADS CONSTRAINTS

P6 CONFIG	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 (STS, SM, PROG)	UN-DOCK-ING (STS/RS)	DOCK-ING (STS/RS)	PORT SARJ/ P4 BGA/ TRRJ ROTATION	STBD SARJ/ S4 BGA/ TRRJ ROTATION	MT TRANS/ SSRMS/ OPS/ SRMS OPS
				MOM MGMT NO DESATS	USTO [3]									
SSRMS OPS	MNVR TO P6 DEMATE POSN (WS4) CLEARANCE < 2'	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	MNVR TO P6 DEMATE POSN (WS4) CLEARANCE > 2'	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT DEMATE POSN (WS4)	OK		OK	OK	NOT OK	OK	OK		OK		OK	OK	
	MNVR TO INTERMEDIATE POSN (WS4)	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT DEMATE INTERMEDIATE POSN (WS4)	OK		OK	OK	NOT OK	OK	OK		OK		OK	OK	
	MNVR TO HANDOFF POSN (WS4)	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	OK	OK	
	AT HANDOFF POSN WITH SRMS UNGRAPPLED	OK		OK	OK	NOT OK	OK	OK		OK		OK	OK	

@[DN 154]

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FLIGHT RULES

10A_C2-74

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

**TABLE 10A_C2-74-II - P6 INSTALLATION LOADS CONSTRAINTS
(CONTINUED)**

ATTITUDE CONTROL & OPS [1]		STS ATTITUDE CONTROL [16]		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 SAR/J P4 BGA/ TRR/ ROTATION	STBD SAR/J S4 BGA/ TRR/ ROTATION	MT TRANS/ SSRMS OPS/ SRMS OPS
				MOM MGMT NO DESATS	USTO									
S34 CONFIG														
SIMO	AT HANDOFF (WS4) WITH BOTH SRMS & SSRMS GRAPPLED	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK		NOT OK			OK	OK	
SRMS OPS	AT HANDOFF WITH SSRMS UNGRAPPLED			OK	OK				TBD	TBD		OK	OK	
SIMO	AT HANDOFF (WS8) WITH BOTH SRMS & SSRMS GRAPPLED	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK		NOT OK			OK	OK	
SSRMS OPS	AT HANDOFF (WS8) WITH SRMS UNGRAPPLED	OK		OK	OK	NOT OK	OK	OK				OK	OK	
	MNVR TO P6 PRE-INSTALL INTERMEDIATE 1 (WS8) POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK [4]	OK	
	AT P6 PRE-INSTALL INTERMEDIATE 1 (WS8) POSN	OK		OK	OK	NOT OK	OK	OK				NOT OK	OK	
	MNVR TO P6 PRE-INSTALL INTERMEDIATE 2 (WS8) POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	
	AT P6 PRE-INSTALL INTERMEDIATE 2 (WS8) POSN	OK		OK	OK	NOT OK	OK	OK				NOT OK	OK	
	MNVR TO P6 PRE-INSTALL (WS8) POSN	NOT OK	NOT OK	OK	OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	
	AT P6 PRE-INSTALL (WS8) POSN	OK		OK	OK	NOT OK	OK	OK				NOT OK	OK	
	MNVR TO P6 RTAS CAPTURE	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	
RTAS OPS	RTAS CAPTURE CLAW DRIVEN TO CAPTURE BAR CONTACT	OK	NOT OK		NOT OK	NOT OK	NOT OK					NOT OK	OK	

@[DN 154]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

**TABLE 10A_C2-74-II - P6 INSTALLATION LOADS CONSTRAINTS
(CONTINUED)**

	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 (STS, SM, PROG)	UN-DOCKING (STS/RS)	DOCKING (STS/RS)	PORT SAR/J P4 BGA/ TRRJ ROTATION	STBD SAR/J S4 BGA/ TRRJ ROTATION	MT TRANS/ SSRMS OPS/ SRMS OPS
				MOM MGMT NO DESATS	USTO [3]									
P6 CONFIG														
RTAS	CAPTURE CLAW DRIVEN TO FULLY CLOSED	OK	NOT OK	OK	OK [5]	OK [5]	NOT OK	OK				NOT OK		
	RTAS BOLTS INITIAL TORQUE	OK	NOT OK	OK	OK [5]	OK [5]	NOT OK	OK				NOT OK		
	BOLTS 1 AND 3 TO FINAL TORQUE	OK	NOT OK	OK	OK [5]	OK [5]	NOT OK	OK				NOT OK		
	BOLTS 2 AND 4 TO FINAL TORQUE	OK	NOT OK	OK	OK [5]	OK [5]	NOT OK	OK				NOT OK		
	RELEASE P5 CAPTURE LATCH	OK	NOT OK	OK	OK [5]	OK [5]		OK						

@[DN 154]

NOTES:

- [1] KEY: - ALLOWED - NOT ALLOWED - NOT ANALYZED.
- [2] MINIMUM DISTANCE CONSTRAINT IS 2 FT FOR VRCS AND SM THRUSTERS, 5 FT FOR PRCS.
- [3] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [4] ROTATION NOT OK DUE TO PHYSICAL CLEARANCES
- [5] ATTITUDE HOLD ONLY (NO MANEUVERS) @[DN 154]

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FLIGHT RULES

**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)**

B. LOADS CONSTRAINTS FOR THE MOBILE TRANSPORTER ARE DEFINED THE FOLLOWING TABLE:

TABLE 10A_C2-74-III - MOBILE TRANSPORTER LOADS CONSTRAINTS

MT CONFIGURATION [3]	STS ATTITUDE CONTROL [14]		ISS ATTITUDE CONTROL [4]			OPERATIONS							
	VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST [5]	UNDOCKING [6]	DOCKING [6]	PORT SARJ/ P4 BGA/ TRRJ ROTATION	STBD SARJ/ S4 BGA/ TRRJ ROTATION	SRMS OPS/ SSRMS OPS
			MOM MGMT NO DESATS	USTO [15]									
LATCHED AT WORKSITE (MIN 3 OF 4 LTU'S)	OK	OK [5]	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
LATCH TRANSITION	Diagonal	Diagonal	OK	Diagonal	Diagonal	OK [9]	OK [7] [10]	Diagonal	Diagonal	Diagonal	TBD [12]	TBD [12]	Diagonal
UNLATCHED (BRAKES ON)	OK	OK	OK	OK	OK	OK [9]	OK [7] [10]	OK [11]	OK	NOT OK	TBD [12]	TBD [12]	Diagonal
UMA TRANSLATING	Diagonal	Diagonal	OK	NOT OK [13]	Diagonal	OK [9]	OK [7] [10]	Diagonal	Diagonal	Diagonal	TBD [12]	TBD [12]	Diagonal
TRANSLATING (NO SSRMS)	OK [2] [5]	NOT OK	OK	OK [2]	Diagonal	OK [9]	OK [7] [10]	Diagonal	Diagonal	NOT OK	TBD [12]	TBD [12]	Diagonal
TRANSLATING WITH SSRMS	OK [2] [5]	NOT OK	OK	OK [2]		OK [9]	OK [7] [10]			NOT OK	TBD [12]	TBD [12]	

@[DN 154]

NOTES:

- [1] KEY: - ALLOWED - NOT ALLOWED - NOT ANALYZED.
- [2] THRUSTER FIRINGS ARE NOT ALLOWED WHEN THE MT IS TRANSLATING ACROSS S0/S1, S0/P1, S1/S3 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

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FLIGHT RULES**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [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] THE FOLLOWING USTO HOLD JET SELECTS ARE ALLOWED: [PRG RPY],[PRG R, SM PY], [SM R, PRG PY], [SM RPY]. ©[DN 154]
THE FOLLOWING USTO MANEUVER JET SELECTS ARE ALLOWED: [SM R, PRG PY], [SM RPY].
THE FOLLOWING RS HOLD (INCLUDING AUTO-HANDOVER) JET SELECTS ARE ALLOWED: [SM R, PRG PY].
RS MANEUVERS (INCLUDING RECOVERY FROM FREE-DRIFT/LOAC) ARE NOT ALLOWED, EXCEPT DURING TRANSLATIONS #4 OR #5 WHEN THE SSRMS IS ON THE LAB. DURING THOSE TWO TRANSLATIONS, THE JET SELECTS ALLOWED ARE: [PRG RPY], [PRG R, SM PY], [SM R, PRG PY], [SM RPY].
- [9] EXERCISE: THE FOLLOWING ARE ALLOWED IN CONJUNCTION OR SEPARATELY:
TVIS/IRED/CEVIS
TVIS/IRED/SM ERGOMETER
CREWMEMBER 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] SHUTTLE VRCS REBOOST ALLOWED, SHUTTLE PRCS REBOOST NOT ALLOWED. PROGRESS REBOOST OFF-PULSING ALLOWED
- [12] BGA ROTATION ALLOWED
- [13] USTO ALLOWED DURING UMA REACQUISITION
- [14] REFERENCE HAZARD REPORT GNC-701-02-02 (OCAD 3744).
- [15] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
©[DN 154]

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FLIGHT RULES

**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)**

C. LOADS CONSTRAINTS FOR THE P6 SOLAR ARRAY AND RADIATOR DEPLOY ARE DEFINED IN THE FOLLOWING TABLE: @[DN 154]

TABLE 10A_C2-74-IV - P6 SOLAR ARRAY AND RADIATOR DEPLOY LOADS CONSTRAINTS

P6 CONFIG	ATTITUDE CONTROL & OPS [1]	STS ATTITUDE CONTROL [14]		ISS ATTITUDE CONTROL			OPERATIONS							
		VRC S	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 TRR/J SARJ/P4 BGA ROTATION	STBD TRR/J SARJ/S4 BGA ROTATION	MT TRANS/SSRMS OPS/SRMS OPS
				MOM MGMT NO DESAT	USTO [15]									
P6 SOLAR WING (*)	FULLY LATCHED	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOREVA DRIVEN DEPLOY/RETRACT/LATCH OPS			OK				OK [7]					OK	
	READY TO DEPLOY OR RELATCH (UNLATCHED)	OK	NOT OK	OK	OK	OK [11]	OK	OK [7]	OK [9]	OK	OK	OK	OK	OK
	PARTIALLY DEPLOYED: < 1 MAST BAY EXTENDED (MOTOR STOPPED)	OK	NOT OK	OK	OK	OK [11]	OK	OK [7]	OK [9]	OK [10]	NOT OK	OK [2]	OK [2]	OK [8]
	PARTIALLY DEPLOYED: > = 1 MAST BAY EXTENDED (MOTOR STOPPED)	OK	NOT OK	OK	OK	OK [11]	OK	OK	OK [9]	OK [10]	OK [10] [12]	OK [2]	OK [2]	OK
	FULLY DEPLOYED	OK	OK	OK	OK	OK	OK	OK	OK [13]	OK [10]	OK [10]	OK	OK	OK
P6 RADIA TOR	FULLY CINCHED (6 CINCHES INSTALLED)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOREVA DRIVEN DEPLOY/RETRACT	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	OK	NOT OK
	READY TO DEPLOY OR WINCH	OK	NOT OK	OK	OK	OK	OK	OK	OK	OK	NOT OK	OK	OK	OK
	PARTIALLY DEPLOYED	OK	NOT OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	FULLY DEPLOYED	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

@[DN 154]

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FLIGHT RULES

**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)**

NOTES:

- [1] KEY: – ALLOWED – NOT ALLOWED – NOT ANALYZED.
- [2] 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 AND TRRJ ROTATION IS ACCEPTABLE.
- [3] RESERVED @[DN 154]
- [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.
- [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. EVA OPERATION FOR MANUAL SAW DEPLOY REQUIRES PFR INGRESS
- [8] MT TRANSLATIONS ARE ALLOWED. SSRMS EVA CREWMEMBER TRANSLATIONS ARE ACCEPTABLE. CONFIGURATIONS WILL BE ANALYZED DURING THE FLIGHT, IF NECESSARY.
- [9] STS VRCS, SM REBOOST, AND PROGRESS REBOOST ALLOWED. STS PRCS REBOOST NOT ALLOWED
- [10] ARRAYS MUST BE FEATHERED FOR ORBITER DOCKING AND 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. A FEATHERED STATION IS DEFINED IN RULES {C2-104}, ISS SYSTEM MANAGEMENT FOR APPROACH AND DOCKING [HC] [RC], AND {10A_C2-52}, ISS GO/NO-GO MATRIX FOR RENDEZVOUS [HC] [RC].
- [11] THRUSTERS ONLY ATTITUDE CONTROL IS ALLOWED WITH THE PROGRESS ON DC1 USED FOR ROLL CONTROL. ROLL CONTROL USING THE SM JETS WAS NOT ANALYZED.
- [12] NO RUSSIAN VEHICLE DOCKING TO FGB NADIR WHEN SOLAR ARRAY IS IN A PARTIALLY DEPLOYED STATE
- [13] SEE RULE {10A_C2-TBD}, ROTATING MECHANISMS LOADS CONSTRAINTS, FOR SARJ/BGA RESTRICTIONS DURING REBOOST.
- [14] REFERENCE HAZARD REPORTS ISS-MCH-0109-10-03.A2 (OCAD 44375) AND ISS-MCH-0109-11-03.B (OCAD 44376).
- [15] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS. @[DN 154]

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

** - 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.*

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. AG-92-J383-STN-EAR-03-067 - Dynamic Analysis of Unwinched PV Radiators Outboard of SARJ, June 2, 2003 ; AG-92-J383-STN-EAR-04-006 - Dynamic Loads Assessment of Russian Vehicle Docking for a Partially Deployed P4/S4 PV Radiator, January 28, 2004.

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STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-147
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

D. LOADS CONSTRAINTS FOR EVA ARTICULATING PORTABLE FOOT RESTRAINT (APFR) AND EVA TEMP STOW OPERATIONS ARE DEFINED IN TABLE 10A_C2-74-V - APFR LOADS AND EVA TEMP STOW CONSTRAINTS. IN GENERAL, PRCS, IRED, AND RS MANEUVERS ARE PRECLUDED DURING ANY APFR OPERATIONS FROM A STRUCTURE-MOUNTED WORKSITE INTERFACE (WIF). @[DN 154]

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 10A_C2-74-V - APFR AND EVA TEMP STOW LOADS CONSTRAINTS

APFR LOCATION	STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL			OPERATIONS				
	VRCS	PRCS	CMG - TA		THRUSTERS ONLY	CREW EXERCISE (ISOLATED OR UN-ISOLATED)	EVA OPS	REBOOST	UNDOCKING	DOCKING
			MOM MGMT NO DESAT	USTO [3]						
ISS BASED APFR	OK	NOT OK	OK	OK [4]	OK [4]	OK [2]	OK			
SSRMS BASED APFR	OK	NOT OK	OK	OK [4]	OK [4]	OK [2]	OK			
SRMS BASED APFR	OK	NOT OK	OK	OK [4]	OK [4]	OK [2]	OK			

NOTES:

- [1] KEY: - ACS OR OPS ALLOWED. - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] IRED NOT ALLOWED DURING STRUCTURE-MOUNTED APFR OPS
- [3] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [4] ATTITUDE HOLD OK, NO MANEUVERS ALLOWED @[DN 154]

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FLIGHT RULES

**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)**

E. LOADS CONSTRAINTS FOR ORBITER BOOM SENSING SYSTEM (OBSS) OPERATIONS ARE DEFINED IN TABLE 10A_C2-74-VI, OBSS OPERATIONS LOADS CONSTRAINTS. @[DN 154]

TABLE 10A_C2-74-VI - OBSS OPERATIONS LOADS CONSTRAINTS

OBSS CONFIG [2]		ATTITUDE CONTROL & OPS [1][3][4]		STS ATTITUDE CONTROL		ISS ATTITUDE CONTROL [6][9]			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 [17]								
OBSS SSRMS UNBERTH/ BERTH	UNLOADED STATIC	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	
	UNLOADED MANEUVERING	OK	OK	OK	OK	OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	
	MNVR CLEARANCE < 2 FT)	NOT OK	NOT OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	
	MNVR TO LOW HOVER (CLEARANCE > 2 FT)	OK	OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	
	LOW HOVER POSITION	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	NOT OK	
	OBSS MNVR TO HANDOFF POSITION	OK	OK	OK	OK	OK	OK	OK	NOT OK [12]	NOT OK [12]	NOT OK [12]	NOT OK [12]	
	OBSS AT HANDOFF POSITION	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	
	OBSS GRAPPLED TO SRMS AND SSRMS	///	///	OK	///	///	///	///	///	///	///	///	
	MNVR TO OBSS BERTHED POSITION (CLEARANCE > 2 FT)	OK	OK2	OK	OK	OK	OK	OK	NOT 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	NOT OK	

@[DN 154]

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)

TABLE 12A_C2-74-VI - OBSS OPERATIONS LOADS CONSTRAINTS
(CONTINUED) @[DN 154]

OBSS CONFIG [2]		ATTITUDE CONTROL & OPS [1][3][4]		STS ATTITUDE CONTROL [16]		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 [17]									
OBSS SRMS OPS	OBSS AT HANDOFF POSITION	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	NOT OK		
	MANEUVER TO OBSS DOCKED SURVEY POSITIONS (WITHOUT EVA CREWMEMBER)	OK	OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	/				
	IN DOCKED SURVEY POSITIONS (WITHOUT EVA CREWMEMBER)	OK	OK	OK	OK	OK	OK	OK	OK					
	OBSS MNVR TO HANDOFF POSITION	OK	OK	OK	NOT OK	NOT OK	OK	OK	NOT OK	NOT OK	NOT OK			
AFTER OBSS LATCHING		A12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		

@[DN 154]

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
- [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.
- [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.

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FLIGHT RULES

**10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C]
(CONTINUED)**

- [15] UNDOCKING FOR CMG VIEWING POSITION CANNOT BE PERFORMED UNLESS OBSS IS MOVED TO A MODIFIED CMG VIEWING POSITION (WRIST ROLL ROTATED NEGATIVE 90 DEG FROM CMG R&R VIEWING POSITION). UNDOCKING IN THIS NEW POSITION WILL BE PERFORMED ONLY IF AN EXPEDITED UNDOCKING IS REQUIRED; OTHERWISE, THE SRMS WILL BE MOVED TO THE OBSS HANDOFF POSITION.
 - [16] REFERENCE HAZARD REPORT GNC-701-02-02 (OCAD 3744).
 - [17] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS. @[DN 154]
- F. S1 RADIATOR LOADS CONSTRAINTS ARE DEFINED IN TABLE 10A_C2-74-VII, S1 RADIATOR LOADS CONSTRAINTS.

TABLE 10A_C2-74-VII - S1 RADIATOR LOADS CONSTRAINTS

ATTITUDE CONTROL & OPS [1]		STS ATTITUDE CONTROL [14]		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 TRRJ/SARJ/P4 BGA ROTATION	STBD TRRJ/SARJ/S4 BGA ROTATION	MT TRANS/ SRMS OPS/ SRMS OPS [4]
				MOM MGMT NO DESAT	USTO [6]									
S1(P1) RADIATOR CONFIGURATION														
HRS RADIATOR (INNER, OUTER)	FULLY CINCHED (6 CINCHES INSTALLED)	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	DURING MOTOR OR EVA DRIVEN DEPLOY/RETRACT			OK										
	UNCINCHED/PARTIALLY DEPLOYED [2]	A12		OK	OK	OK	OK	OK	OK	OK [7]	OK [7]	OK [5]	OK [5]	OK [5]
	FULLY DEPLOYED	A12	B12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

NOTES:

- [1] KEY: - ACS OR OPS ALLOWED. - ACS OR OPS NOT ALLOWED - NOT ANALYZED.
- [2] UNCINCHED/PARTIALLY DEPLOYED IS DEFINED AS A RADIATOR THAT HAS NO CINCHES INSTALLED AND IS LESS THAN 100 PERCENT DEPLOYED. THIS CASE INCLUDES THE FULLY RETRACTED RADIATOR THAT IS READY TO BE CINCHED. DURING NOMINAL OPERATIONS, AN UNCINCHED RADIATOR WILL BE TREATED WITH THE SAME CONSTRAINTS AS "DURING MOTOR OR EVA DRIVEN DEPLOY/RETRACT" WITH TWO EXCEPTIONS: USTO AND RS MCS ATTITUDE HOLD ARE ALLOWED AND CREW EXERCISE SHALL BE PERMITTED.
- [3] NO MAX EVA LOADS DURING RADIATOR DEPLOYMENT. MAX EVA LOADS INCLUDE VIGOROUS BODY MOTION, QUICK GRAB, KICKOFF TETHER RESTRAINTS, AND PFR INGRESS.
- [4] RMS/MT OPS ARE DEFINED AS RMS OR MT MOTION.
- [5] TRRJ ROTATION OF A PARTIALLY DEPLOYED RADIATOR WILL BE ANALYZED DURING THE FLIGHT, IF NECESSARY, DEPENDING ON REASON FOR PARTIAL DEPLOY AND NEED TO ROTATE.
- [6] REFERENCE RULE {10A_C8-2}, MATED USTO CONSTRAINTS, FOR ADDITIONAL USTO USAGE CONSTRAINTS.
- [7] FEATHERING CONSTRAINTS FOR ORBITER AND RUSSIAN VEHICLE DOCKINGS TO A PARTIALLY DEPLOYED HRS RADIATOR ARE TBD. @[DN 154]

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FLIGHT RULES

10A_C2-74 DOCKED LOADS CONSTRAINTS [HC] [RI] [C] (CONTINUED)

The constraints on a partially cinched radiator will vary depending on the number and location of cinches remaining. If, real time, a cinch release failure results in a partially cinched configuration, allowable loads will be provided by the MER real-time based on the actual configuration. The uncinched configuration was analyzed outside the design configuration using contingency methodology and non-test verified linear models. This analysis included all of the loading events in the table up through the next orbiter docking. Therefore, the uncinched analysis results should be considered valid for contingency cases, not nominal operations. The state of the radiator after the cinches are released during the nominal deploy sequence should be considered the same as "During Motor or EVA Driven Deploy/Retract." Analysis indicates that propulsive attitude hold and crew exercise generate relatively low deflections and are therefore allowed to provide timeline flexibility. During crew exercise, an uncinched/undeployed radiator should be visually monitored for large displacements via available camera views in order to provide additional confidence in the linear analysis. ©[DN 154]

Analysis for rotating a partially deployed HRS radiator has not been conducted. However, all BGA's and both SARJ's may freely suntrack. The other TRRJ may operate provided it does not have a partially deployed HRS radiator. SARJ startup and shutdown operations should be avoided during radiator deployment operations but are acceptable in a contingency.

Source: Boeing Technical Memo A92-J332-STN-M-TSW-170, Mechanical Assessment of Free Drift vs CMG Momentum Manager Environment, December 11, 2001, AG-J332-STN-M-ER-2002-061- Dynamic Loads Assessment for the Partially Deployed HRS Radiator Study, 3-47300H/2002DIR-5000 - Partially Deployed Assessment of the HRS Radiators Using Boeing Supplied Element Loads Envelope, 3-47300H/2002DIR-5002 - UnCinched and UnDeployed Assessment of the HRS Radiators Using Boeing Supplied Element Loads Envelope. ©[DN 154]

10A_C2-75 RESERVED ©[CR 8876]

Deleted: S3/S4 INSTALLATION
CONSTRAINTS AND MINIMUM
CRITERIA

STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-152
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_C2-76 DDCU S14B POWERDOWN CONSTRAINTS, @[DN 104] @[CR 8769]

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ORU HEATERS POWERED BY DDCU S14B MAY BE POWERED DOWN FOR UP TO 10 HOURS.

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R&R of RPCM S04B-C requires powerdown of DDCU S14B for electrical safing. The following ORU's have non-redundant heaters that are downstream of DDCU S14B: TUS-1 gearbox heater, BBC heaters, MDM heaters, and MBSU/DDCU coldplate heaters. Passive thermal analysis and engineering judgment show that these ORU's can survive without heater power for up to 10 hours. The ETCS Loop A line heaters are also downstream of DDCU S14B, but are not required for ETCS Loop A operations.

Sources: Increment 6/Stage 11A EVA #2 Thermal Assessment, L. Joshi, et al, PTCS Forum, March 19, 2003; 10A FOR Action DDCU S14B Powerdown, M. Navarro, et al, PTCS Forum, April 30, 2007; and Chit 005052. @[CR 8769]

10A_C2-77 RESERVED @[DN 35]

FLIGHT RULES

10A_C2-78 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 SIT-UPS USING THE UNISOLATED INTERIM RESISTIVE EXERCISE DEVICE (IRED) ARE LIMITED TO A MINIMUM TIME OF 2 SECONDS BETWEEN REPETITIONS.
 3. CREWMEMBER TORSO BENDING AND ROWING EXERCISES USING THE RUSSIAN FORCE LOADER HC-1 ARE LIMITED TO A MINIMUM TIME OF 3 SECONDS BETWEEN REPETITIONS.
 4. 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, minimum delay times are imposed. ©[DN 147]

5. CREWMEMBER EXERCISE ON ANY SHUTTLE UNISOLATED TREADMILL (IF MANIFESTED) IS PROHIBITED.
6. IF THERE IS AN EVA WHILE THE ORBITER IS CONTROLLING ATTITUDE WITH PRCS JETS USING 2-JET OR 3-JET LZC MODE, ONLY TVIS EXERCISE IS ALLOWED DURING THE EVA.

Reference: ISS-HOU-MSER-DGY-0600157, VAC-13A.1 Integrated On-Orbit Loads and Dynamics Structural Loads Report, September 8, 2006.

7. USE OF THE THERABAND OR ANY OTHER EXERCISE BAND WHILE EXERCISING ON THE SHUTTLE ERGOMETER IS PROHIBITED, EXCEPT DURING EVA EXERCISE PREBREATHE. REFER TO RULE {10A B15-TBD}B, GO/NO-GO CRITERIA FOR EVA PREBREATHE, FOR EXERCISE PREBREATHE SCENARIOS. ©[DN 147]

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FLIGHT RULES

10A_C2-78 EXERCISE CONSTRAINTS WHILE DOCKED [RC]
(CONTINUED)

8. USE OF EXERCISE BANDS WHILE EXERCISING ON THE CEVIS IS PROHIBITED. REFER TO RULE {10A_B15-**TBD**}B, GO/NO-GO CRITERIA FOR EVA PREBREATHE, FOR EXERCISE PREBREATHE SCENARIOS. @[DN 147]
- B. CONSTRAINTS ON ORBITER CREW EXERCISE DURING ATTITUDE CONTROL, REBOOST, AND PAYLOAD BERTHING OPERATIONS ARE AS LISTED AS FOLLOWS:
1. DURING 2-JET AND 3-JET ALT PRCS CONTROL, SHUTTLE BICYCLE ERGOMETER USE IS PROHIBITED.
 2. DURING ORBITER REBOOST CONFIG 1 AND CONFIG 2, SHUTTLE BICYCLE ERGOMETER USE IS PROHIBITED.
 3. DURING ISS-COMMANDED ATTITUDE MANEUVERS, SHUTTLE BICYCLE ERGOMETER USE IS PROHIBITED.
 4. DURING ISS CMG DESATURATIONS, SHUTTLE BICYCLE ERGOMETER USE IS LIMITED TO 65 RPM.
 5. DURING NODE-2 BERTHING OPERATIONS, SHUTTLE BICYCLE ERGOMETER USE IS PROHIBITED.
 6. DURING P6 BERTHING OPERATIONS, SHUTTLE BICYCLE ERGOMETER USE IS PROHIBITED.

NOTE: ONLY CONTROL MODES FOR WHICH ORBITER CREW EXERCISE CONSTRAINTS ARE REQUIRED ARE LISTED.

Attitude control loads for some shuttle and ISS control modes, combined with other shuttle/ISS mated load, can result in unacceptable load levels on shuttle and ISS components. Loads due to crew exercise are a major contributor. Limiting the shuttle crew exercise use as listed is required to alleviate the loads issues. @[DN 147]

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FLIGHT RULES

10A_C2-78 EXERCISE CONSTRAINTS WHILE DOCKED [RC]
(CONTINUED)

- C. CONSTRAINTS ON ISS HARDMOUNTED EXERCISE DURING ORBITER ATTITUDE CONTROL AND REBOOST ARE AS FOLLOWS: @[DN 147]
1. DURING 3-JET ALT PRCS ATTITUDE CONTROL, USE OF ISS HARDMOUNTED EXERCISE EQUIPMENT IS PROHIBITED.
 2. DURING REBOOST CONFIGS 1 AND 2, USE OF ISS HARDMOUNTED EXERCISE EQUIPMENT IS PROHIBITED.

Attitude control loads for some shuttle and ISS control modes, combined with other shuttle/ISS mated load, can result in unacceptable load levels on shuttle and ISS components. Limiting the crew exercise on ISS hardmounted equipment is required to alleviate the loads issues. Exercise with TVIS and CEVIS is allowed.

- D. IF ONLY SIX HOOKS ARE LATCHED AT THE SHUTTLE ANDROGYNOUS PERIPHERAL ATTACHMENT SYSTEM (APAS) INTERFACE, ALL ORBITER AND ISS EXERCISE IS PROHIBITED.

When only six hooks are latched at the shuttle, APAS interface crew exercise loads result in unacceptable load levels on the shuttle APAS interface. (Reference Boeing VIPER document D684-10337-23, VAC-13A.1 VE23 Document, V12A1.24.1-53, Orbiter/ISS On-Orbit Loads and Dynamics Analysis Abstract.)

- E. REFER TO RULE {10A_C2-74}, DOCKED LOADS CONSTRAINTS [HC] [RI] [C], FOR EXERCISE CONSTRAINTS DURING SPECIFIC MISSION OPERATIONS.

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. @[DN 147]

10A_C2-79 RESERVED @[DN 105]

10A_C2-80 RESERVED

10A_C2-81 RESERVED @[DN 21]

FLIGHT RULES

10A_C2-82 DRAG-THROUGH CABLES [RI]

- A. DRAG-THROUGH CABLES FROM THE SHUTTLE WILL BE USED AS FOLLOWS DURING ASSEMBLY MISSION 10A:
1. PMA/ODS INTERFACE AIR DUCT (SHUTTLE ODS TO PMA2) - CONNECTED ENTIRE DOCKED MISSION
 2. DRAG THROUGH QUICK DISCONNECT (QD) (AT PMA2/LAB HATCH):
 - a. TWO BATTERY POWERED SPEAKER MIKE UNIT (BPSMU) (SHUTTLE ODS TO LAB) - CONNECTED ENTIRE DOCKED PERIOD @[DN 118]
 - b. TWO RWS V10 CABLES (SHUTTLE FLIGHT DECK TO LAB) - CONNECTED ENTIRE DOCKED PERIOD

The drag through QD is capable of connecting and disconnecting two video cables and two BPSMU cables. For mission 10A, the crew will bring two BPSMU cables across to ISS.

3. O₂ SUPPLY LINE (SHUTTLE ODS TO PMA2) - CONNECTED ENTIRE DOCKED MISSION
4. TWO PHA HOSES (ISS AIRLOCK TO SHUTTLE MIDDECK) - AS REQUIRED DURING EVA CREW HYGIENE BREAKS ON MORNINGS OF EVA DAYS.
5. N₂ SUPPLY LINE (SHUTTLE ODS TO PMA2) - CONNECTED FOR DURATION OF N₂ TRANSFER OPS @[DN 118]

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FLIGHT RULES

10A_C2-82 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):

	FD03	FD04 EVA 1	FD05	FD06 EVA 2	FD07	FD08 EVA 3	FD09	FD10
AIR DUCT	X	X	X	X	X	X	X	X
DRAG THRU QD(2 BPSMU, 2 V10) [2]	X	X	X	X	X	X	X	X
O2 SUPPLY	X	X	X	X	X	X	X	X
PHA HOSES (TWO)		[1]		[1]		[1]		
N2 SUPPLY			X	X	X			

©[DN 118]

- [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] THE DRAG THROUGH QD IS CAPABLE OF CONNECTING AND DISCONNECTING TWO VIDEO CABLES AND TWO BPSMU CABLES. FOR MISSION 10A, THE CREW WILL BRING TWO BPSMU AND TWO V10 CABLES ACROSS TO ISS VIA THE DRAG THROUGH QD. ©[DN 118]

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 10A.

FLIGHT RULES

10A_C2-83

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.
- 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 74 DEG X 40 DEG PERPENDICULAR TO THE LCH OPTIC WINDOW. ©[DN 41]

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	> 14.4 Meters (> 47.2 Feet)	14.4 to 10.7 Meters (47.2 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 (48 to 27 Feet)	< 8.2 Meters (< 27 Feet)

©[DN 41]

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 Flight Director 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.

THIS RULE CONTINUED ON NEXT PAGE

Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-83

**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 flight rule are based on Adidas Model 124 sunglasses that are manifest for each STS crewmember.

Hazard Report OBSS LCS 001, Rev F 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 at maximum power; this would produce a potential laser beam radiation hazard critical to a crewmember's eye if continually radiated for greater than 10 seconds. These two failures must occur simultaneously in the order to generate this KOZ. A single failure which results in a stationary beam is the next worst case failure with an associated KOZ of 14.4 meters. The crew would be notified of the failure, allowing them to take action prior to the second failure. Using the 14.4 meter distance as the KOZ maintains the two failure tolerance in that a crewmember would need to enter the KOZ before injury would occur. ©[DN 41]

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. The nominal operational field of view (FOV) of the LCS is a 30 deg x 30 deg square projected out from the LCS optic window. Due to a separate failure condition that would allow the laser to go outside this nominal FOV, the maximum FOV of the LCS is used for this rule. PDRS will model this maximum FOV as an irregular rectangular pyramid projected out from the LCH optic window. 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 ±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. Figure 10A_C2-83-I illustrates the FOV of the LCS. ©[DN 41]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-83

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

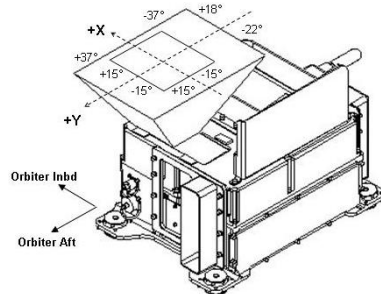


FIGURE 10A_C2-83-I - LCS NOMINAL AND MAX FOV ILLUSTRATION ©[DN 41]

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 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-83 KEEP-OUT ZONE (KOZ) FOR IVA CREWMEMBERS DURING
LASER CAMERA SYSTEM (LCS) OPERATIONS [HC]
(CONTINUED)

DOCUMENTATION:

Hazard Report OBSS LCS 001, Rev F; Crew Eye or Skin Injury As a Result Of Exposure to Laser Radiation, Cause A, Inadvertent Activation or Commanding of the Laser Source, June 16, 2006.

Hazard Report LDRI-5, Pathological/Physiological/Psychological Cause C: Improper Design of Laser Containment Exposing EVA/IVA Crew to Class IV Laser.

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.

FLIGHT RULES

10A_C2-84

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.
- 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. LDRI RCC Motion Surveys 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.

THIS RULE CONTINUED ON NEXT PAGE

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FLIGHT RULES

10A_C2-84 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.
- D. THERE ARE NO KOZ'S FOR LDRI WHILE THE OBSS IS BERTHED.

DOCUMENTATION:

Hazard Report OBSS LCS 001, Rev E, Crew Eye or Skin Injury As a Result Of Exposure to Laser Radiation, Cause A, Inadvertent Activation or Commanding of the Laser Source.

Hazard Report LDRI-5, Pathological/Physiological/Psychological, Cause C, Improper Design of Laser Containment Exposing EVA/IVA Crew to Class IV Laser.

NASA Memorandum SD-06-03, 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.

FLIGHT RULES

10A_C2-85 **MATED FES DUMP CONSTRAINTS**

- A. TO PREVENT ATTITUDE CONTROL DISTURBANCES DURING MATED OPERATIONS, SUPPLY WATER DUMPS USING THE SHUTTLE FLASH EVAPORATOR SYSTEM (FES) SHOULD NOT BE INITIATED OR TERMINATED DURING THE FOLLOWING PERIODS:
1. ANYTIME THERE IS A REQUIREMENT THAT THRUSTERS ARE TO BE INHIBITED FOR A PLANNED ACTIVITY. THESE PLANNED ACTIVITIES INCLUDE:
 - a. OBSS UNBERTHS, BERTHS, AND HANDOFFS @[DN 26]
 - b. MT TRANSLATION AND P6 TRUSS HANDOFFS
 - c. P6 4B/2B SOLAR ARRAY WING (SAW) DEPLOY

If the U.S. GNC CMG's could not maintain attitude control in momentum management, moding to free drift would be required per Rule {10A_C2-74}, DOCKED LOADS CONSTRAINTS [HC] [RI] [C]. 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. @[DN 26]

2. FLIGHT DAY 4, WHILE ON MOMENTUM MANAGEMENT CONTROL STARTING WITH SSRMS OPERATIONS FOR NODE 2 PREGRAPPLE THROUGH THE NODE 2 INSTALL BOLTS COMPLETION.
3. WITHIN TWO ORBITS AFTER MOMENTUM MANAGEMENT STARTUP

In order to avoid significant increases in momentum when momentum management is the only allowable control mode, as specified in Rule {10A_C2-74}, DOCKED LOADS CONSTRAINTS [HC] [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.

4. STARTING FLIGHT DAY 6, FROM 2 HOURS PRIOR TO MOMENTUM MANAGEMENT STARTUP AFTER ORBITER DUMP, THROUGH FLIGHT DAY 8 P6 INSTALL BOLTS COMPLETION, WHILE ON MOMENTUM MANAGEMENT.
- B. FOR COMPLETE ORBITER WATER DUMP CONSTRAINTS, THIS RULE SHOULD BE USED IN CONJUNCTION WITH RULES {10A_A2-2}, CONTAMINATION STS-120 CONSTRAINTS MATRIX, AND {10A_C17-1} SHUTTLE VENT MANAGEMENT [RC].

FLIGHT RULES

10A_C2-86

P6 RELOCATION CONSTRAINTS

- A. DURING P6 GRAPPLE AND DEMATE FROM Z1, THE KU ANTENNA SHALL BE PARKED AT ELEVATION +10 DEG AND CROSS ELEVATION +45 DEG.

Available camera views during P6 grapple and demate do not provide the SSRMS operator with the cues required to monitor clearances between the SSRMS and the Ku antenna during P6 grapple and demate on Z1. Parking the Ku antenna at the specified angles maximizes the clearances and allows the SSRMS operators to grapple and demate P6 with available camera views and without needing EVA crew assistance for clearance monitoring.

- B. THE TIME SPENT WITH P6 ON THE SRMS SHALL BE MINIMIZED.

The nominal plan for P6 relocation requires the SRMS to hold P6 while the MT is relocated from WS4 to WS8. Minimizing the time P6 spends on the SRMS protects P6 in the unlikely event of an early orbiter departure.

- C. THE PORT SARJ AND P4 BGA'S SHALL BE CONFIGURED AS FOLLOWS PRIOR TO THE P6 MANEUVER TO THE PRE-INSTALL SETUP POSITION:

1. PORT SARJ LOCKED AT +90 DEG.
2. 4A BGA LOCKED AT +90 DEG.
3. 2A BGA LOCKED AT +90 DEG.

Locking the port SARJ at 90 deg is required to place the active side of the RTAS (on P5) at the proper orientation for P6 install. The SARJ must be locked prior to maneuvering to the pre-install setup position to ensure the SSRMS/P6 maintain the required clearances with the 4A and 2A array wings. Locking the 4A BGA at 90 deg allows the SSRMS operators to utilize the orbiter cameras during the install operation. Both BGA's must be locked to provide the EVA crew members with the workspace required to attach P6 to P5. There are no robotics driven constraints on the placement of the 2A array.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-86 P6 RELOCATION CONSTRAINTS (CONTINUED)

D. DURING P6 MATING TO P5, THE FOLLOWING CONSTRAINTS SHALL BE APPLIED TO THE GCA OPERATIONS:

1. EVA SHALL GCA P6 AS DEEP AS POSSIBLE INTO THE P5 CLAW CAPTURE ENVELOPE, PAST THE MINIMUM READY-TO-LATCH POINT, UNTIL CONTACT BETWEEN P6 CONES AND P5 ALIGNMENT CUPS IS OBSERVED OR SUSPECTED.

The nominal ready-to-latch (RTL) point is defined as the point where all four alignment pins on P6 break the plane of their corresponding cups on P5. Driving P6 as deep as possible into the capture envelope, past the RTL point, reduces the amount of time the capture claw spends pulling on the SSRMS thereby reducing the exposure to a failure that results in the SSRMS brakes to be applied.

2. ONCE CONTACT IS OBSERVED/SUSPECTED, EVA SHALL VERIFY THAT ALL FOUR P6 ALIGNMENT PINS ARE PENETRATING THEIR CORRESPONDING P5 CUPS PRIOR TO DRIVING THE CAPTURE CLAW.
3. IF ANY OF THE PINS IS OBSERVED TO BE OUTSIDE ITS CUP, P6 SHALL BE MOVED BACK TO A SEPARATION OF 15 CM, EVA SHALL PROVIDE GCA CALLS TO CORRECT ANY REMAINING MISALIGNMENTS, AND P6 SHALL BE DRIVEN BACK UNTIL CONTACT WITH P5 IS OBSERVED/SUSPECTED.

All alignment operations must be completed prior to the P6 pins breaking the plane of the cups on P5. If realignment is required, the P6 must be moved back to ensure that the alignment maneuvers do not induce unexpected contact and load build up.

4. ONCE CONTACT IS OBSERVED/SUSPECTED AND ALL P6 PINS ARE PENETRATING THEIR CORRESPONDING CUPS, THE P5 CAPTURE CLAW SHALL BE OPERATED IN TWO PHASES

PHASE 1: WITH SSRMS IN POSITION HOLD, THE CLAW IS DRIVEN AT **TBD** RPM UNTIL IT CONTACTS THE CAPTURE BAR. AT THAT POINT, THE SSRMS JOINTS ARE LIMPED.

PHASE 2: WITH ALL THE SSRMS IN LIMP MODE, THE CLAW IS DRIVEN AT **TBD** RPM UNTIL FULLY SEATED.

*In phase 1, the capture claw is not used to pull on the SSRMS joint while in position hold to avoid load build up. In phase 2, the claw is driven at **TBD** speed with the SSRMS joint limped to bring the two halves of the interface until fully seated.*

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C2-86

P6 RELOCATION CONSTRAINTS (CONTINUED)

E. VIEWS FROM THE SRMS ELBOW AND END-EFFECTOR CAMERAS ARE HIGHLY DESIRABLE DURING P6 INSTALL OPERATIONS.

There are limited camera views available to the SSRMS operators during P6 install to P5. The nominal plan is to position the SRMS at an install viewing position to provide the SSRMS operators with additional situational awareness views. The views from the SRMS cameras are highly desirable but not mandatory. P6 install operations can be safely performed without them.

FLIGHT RULES

10A_C2-87 CBM THERMAL EQUALIZATION REQUIREMENTS

- A. DURING BERTHING OF NODE 2 TO NODE 1 PORT CBM, **TBD** THERMAL EQUALIZATION PERIOD IS REQUIRED.

Boeing thermal analysis has determined that the Node 2/Node 1 CBM interface should be within the thermal limitations documented in Rule {B10-105}, CBM THERMAL HOLD REQUIREMENT [J].

- B. DURING BERTHING OF PMA-2 TO THE NODE 2 FORWARD CBM, NO THERMAL EQUALIZATION PERIOD IS REQUIRED. @[CR 8812]

The analysis thus far (ISS Flight 10A (STS-120) Launch-To-Activation and ISS-Only Stage Thermal Analysis Documentation, TS-TM-04-014) was for the nominal timeline with thermal cover removal 214 hrs (approx 9 days) before PMA2 install. There were no thermal clocks needed to meet the thermal limitations documented in Rule {B10-105}, CBM THERMAL HOLD REQUIREMENT [J], for this nominal timeline. This analysis was done in the 2004 timeframe and may need to be looked at again to ensure the timeline assumptions are still valid.

Deleted: THE FOLLOWING STEPS WILL BE TAKEN TO PREVENT CONDENSATION AT LAB FORWARD UNTIL NODE 2/PMA-2 STACK IS MAT

- C. DURING BERTHING OF THE NODE 2/PMA-2 STACK TO THE LAB FORWARD CBM, A **TBD** THERMAL EQUALIZATION PERIOD IS REQUIRED. @[CR 8812]

*Boeing thermal analysis has determined that the Lab/Node 2 CBM interface should require approximately **TBD** hours of thermal equalization to reach the thermal limitations documented in Rule {B10-105}, CBM THERMAL HOLD REQUIREMENT [J].*

Deleted: LABF is driven by exposure of the hatch area and trying to preclude condensation. The time to condensation with only the LAB hatch thermal cover in place is 2 hrs for worst case conditions. Based on discussions at the VCB on April 28, 2003, the consensus was to reduce Lab dewpoint, constrain Beta of operation between ±52o, install CPA MLI covers, and power CPA's to standby. Also, it was proposed to investigate assembly sequence modification that allows PMA2 umbilicals to be disconnected during 10A Flight and to investigate yaw/roll bias controller to provide additional margin.¶

FLIGHT RULES

10A_C2-88

CBM NODE 1 PORT PETAL COVER CONSTRAINTS

- A. ALL FOUR NODE 1 PORT CBM PETALS CAN REMAIN OPEN FOR 24 HOURS IF THE FOLLOWING CONSTRAINTS ARE MET:
1. ALL FOUR CPA'S ARE POWERED,
 2. THERMAL SHROUD (CLOSEOUT AROUND CENTER DISK FLAP OPENING) IS INSTALLED,
 3. BETA ANGLES $< +25$ DEGREES IN THE XVV ATTITUDE AND > -25 DEGREES IN THE -XVV ATTITUDE, AND
 4. THE STATION IS WITHIN ± 5 DEG OF STAGE TEA (YPR = -2 DEG, -9 DEG, -1 DEG FOR XVV; YPR = 178 DEG, -9 DEG, -1 DEG FOR -XVV) .
- B. OTHERWISE, ALL FOUR NODE 1 PORT CBM PETALS CAN REMAIN OPEN FOR 2.8 HOURS IF THE FOLLOWING CONSTRAINTS ARE MET:
1. BETA ANGLES $> +25$ DEGREES AND $< +50$ DEGREES IN THE XVV ATTITUDE AND > -50 DEGREES AND < -25 DEGREES IN THE -XVV ATTITUDE, AND
 2. THE STATION IS WITHIN ± 5 DEG OF ANALYZED STAGE TEA (YPR = -2 DEG, -9 DEG, -1 DEG FOR XVV; YPR = 178 DEG, -9 DEG, -1 DEG FOR -XVV) .
- C. PETAL OPEN OPERATIONS SHOULD ONLY BE PERFORMED IN THE NOMINAL DESIGN ATTITUDE ENVELOPE FOR +XVV AND -XVV ATTITUDES FOR BETA ANGLES BETWEEN -50 AND $+50$ DEGREES .

Attitude and exposure duration constraints for petal open operations are required to avoid exceeding hatch mechanism and CPA/CBM hardware temperature limits. Constraints assume center disk cover flap is open.

The ISS should be within the nominal $\pm XVV$ attitude envelope 24 hrs prior to petal open operations.

Additional thermal assessment of petal open capability required for YPR outside of ± 5 deg of stage TEA (YPR = -2 deg, -9 deg, -1 deg for XVV; YPR = 178 deg, -9 deg, -1 deg for -XVV).

Preliminary analysis indicates additional petal open capability may be obtained at some attitudes by unpowering the CPA's. Additional thermal assessment is required to determine open petal capability for the specific attitude with CPAs unpowered.

Reference: "Open Petal Constraints for Node 1 and Node 2 Radial Ports," Andy Burt, Presentation to PTCS forum, November 29, 2006.

STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-170
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_C2-89 ENABLING AUTO HANDOVER FROM CMG CONTROL TO RS THRUSTER CONTROL DURING MATED CREW SLEEP [RC]

- A. DURING MATED OPERATIONS, UNLESS ASSEMBLY TASKS DICTATE OTHERWISE, THE AUTO HANDOVER FROM U.S. TO RS CONTROL SHALL BE ENABLED DURING CREW SLEEP PERIODS, AND AUDIBLE ANNUNCIATION OF THE LOSS OF CMG ATTITUDE CONTROL C&W SHALL BE SUPPRESSED.

During ISS/shuttle mated flights, the crew's timeline is extremely busy. It is important to have undisturbed sleep periods during mated flights, especially the nights prior to events such as EVA's. If the Auto Handover to RS was inhibited and there was a loss of CMG attitude control, then the C&W message would annunciate on board and direction would be given to the shuttle crew to regain attitude control. This scenario is low probability given the redundancy of a fully operational GNC system. A possible off-nominal scenario could be a large, unexpected external torque causing the CMG's to saturate. If this off-nominal situation occurred and the Auto Handover to RS was enabled, then attitude control would be automatically handed over to Russian Thrusters. The risk of a shuttle/ISS force fight is prevented because the shuttle crew is asleep and they are required to start shuttle control, and procedures are in place requiring communications with the ground prior to any attitude control actions. The longest length of time the Russian Thrusters would be in control would be approximately 8 hours during crew sleep, after which attitude control would be handed over to the shuttle. However, for a CMG saturation event, the CMG system should be ready to resume control in approximately 1 hour, and if it takes significantly longer than 1 hour, then there are very significant ISS failures.

10A_C2-90 P6 AFT RADIATOR SHROUD CONSTRAINT

THE THERMAL SHROUD ON THE P6 AFT RADIATOR MUST BE INSTALLED PRIOR TO P6 REMOVAL FROM Z1. @[DN 39]

Both P6 EETCS radiators (starboard and aft) require thermal shrouds to be able to survive as spare ORU's with P6 connected to P5. The starboard radiator shroud was installed during the 12A.1 Stage EVA's.

Source: **TBD** @[DN 39]

10A_C2-91 STS/ISS PRINTER SWAP [RI]

BOTH VEHICLES WILL HAVE FUNCTIONING PRINTERS PRIOR TO UNDOCK. THE ORBITER WILL HAVE ONE FUNCTIONING PRINTER WHILE ISS WILL HAVE AT LEAST ONE (LAB, SM, OR BOTH). @[CR 8866]

The STS and ISS lab printer are scheduled to be swapped during the docked mission. If the ISS lab printer is failed prior to the printer swap activity, the swap will be aborted (the SM printer will not be swapped for the Shuttle printer). After the swap, if either the STS or ISS lab printer do not function correctly (after limited troubleshooting), they will be swapped back to the original configuration. It is mandatory the shuttle undocks with a functioning printer to be able to print out entry messages. @[CR 8866]

STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-171
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

CONTINGENCY SCENARIOS

10A_C2-101 STS-120/10A RAPID SAFING [HC]

RAPID SAFING DURING THE DOCKED PHASE WILL BE MANAGED BY THE FOLLOWING TABLE:

RAPID SAFING PHASE [1]	PHASE DESCRIPTION [2]
PHASE 1: NOMINAL CONFIG FOR UNDOCK 00:10 SAFING DURATION (HH:MM)	ALL CASES WHERE THE ISS AND ORBITER ARE IN A NORMAL CONFIGURATION FOR UNDOCK. (I.E. NO SRMS, SSRMS, EVA, OR ISS INGRESS OPS). STOW SRMS IF REQUIRED, UNDOCK ODS FROM PMA2.
PHASE 2 A, B: MIDDECK PL TRANSFER 00:05 SAFING DURATION	A STILL BOLTED (COMPLETELY/PARTIALLY) TO ORBITER; STOW PROPERLY FOR ENTRY (00:05) NOTE: MAY BE PERFORMED SIMO WITH OTHER PHASES
	B UNBOLTED: COMPLETE HANDOFF TO STATION CREW (00:05) NOTE: MAY BE PERFORMED SIMO WITH OTHER PHASES
PHASE 3: MT IS TRANSLATING 00:30 MIN SAFING DURATION	CASE: MT TRANSLATION WILL COMPLETE.
PHASE 4: INGRESS ONLY 00:25 SAFING DURATION	ISS INGRESS IN PROGRESS: STOP/SAFE INGRESS OPS, STS CREW EGRESS ISS, STOW SRMS IN PARALLEL IF REQUIRED, MANEUVER SSRMS CLEAR AS REQUIRED, AND UNDOCK ODS FROM PMA2.
PHASE 5 A, B, C, D, E, F, G: S3/4 INSTALL TBD MAX SAFING DURATION	A IF S3/4 HAS NOT BEEN GRAPPELED BY SRMS: MANEUVER SSRMS CLEAR AS REQUIRED, STS CREW EGRESS ISS, AND UNDOCK ODS FROM PMA2 (00:55)
	B IF S3/4 IS ON THE SRMS AND BELOW TOP OF V-GUIDES: RETURN TO PLB, LATCH PRLA'S, UNGRAPPLE P3/4, MANEUVER SSRMS CLEAR AS REQUIRED, STS CREW EGRESS ISS, AND UNDOCK ODS FROM PMA2 (00:50).
	C IF S3/4 IS ON THE SRMS AND ABOVE TOP OF V-GUIDES: MANEUVER S3/4 TO HANDOFF POSITION, HANDOFF S3/4 TO SSRMS, SRMS MANEUVER TO SAFE POSITION, STS CREW EGRESS ISS, AND UNDOCK ODS FROM PMA2 (TBD).
	D IF S3/4 IS ON THE SRMS AND AT OR NEAR THE HANDOFF POSITION: HANDOFF TO SSRMS, SRMS MANEUVER TO SAFE POSITION, STS CREW EGRESS ISS, AND UNDOCK ODS FROM PMA2 (TBD).
	E IF S3/4 GRAPPELED BY SSRMS, BUT SSAS CAPTURE LATCH NOT YET ENGAGED: MANEUVER S3/4 CLEAR OF STRUCTURE, STS CREW EGRESS ISS, AND UNDOCK ODS FROM PMA2 (00:55).
	F IF S3/4 GRAPPELED BY SSRMS, SSAS CAPTURE LATCH ENGAGED, BUT BOLTING OPS NOT YET IN PROGRESS: OPEN SSAS CAPTURE LATCH, MANEUVER S3/4 CLEAR OF STRUCTURE, STS CREW EGRESS ISS, AND UNDOCK ODS FOR PMA2 (TBD).
	G IF S3/4 TO S1 SSAS BOLTING OPS IN PROGRESS: PRESS WITH BOLTING WHILE STS CREW EGRESSES ISS. WHEN THREE OF FOUR SSAS BOLTS SECURE, MANEUVER SSRMS TO SAFE POSITION, UNDOCK ODS FROM PMA2 (TBD).
PHASE 6: ISS EVA IN PROGRESS TBD SAFING DURATION	SAFE EVA HARDWARE, STS CREW EGRESS ISS, DEPRESS STS AIRLOCK FOR EVA CREW INGRESS. MANEUVER SRMS & SSRMS CLEAR AS REQUIRED, AND UNDOCK ODS FROM PMA2.
PHASE 7: ISS EVA PREP IN PROGRESS TBD SAFING DURATION	ISS EVA PREP IN PROGRESS (PRIOR TO HATCH OPEN): MANEUVER SRMS & SSRMS CLEAR AS REQUIRED, EVA CREW DOFF EMU, IV CREW STOP/SAFE INGRESS, STS CREW EGRESS ISS, CLOSE PMA2/ODS HATCHES, AND UNDOCK ODS FROM PMA2.

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-101 STS-120/10A RAPID SAFING [HC] (CONTINUED)

NOTES:

- [1] TIMES SHOWN IN THIS COLUMN REFLECT THE MAXIMUM TIME REQUIRED TO SAFE THE ORBITER IN PREPARATION FOR DEPARTURE AND DO NOT INCLUDE TIME FOR SEPARATION BURNS.
- [2] TIMES SHOWN IN THIS COLUMN ARE SIMPLY A MORE GRANULAR BREAKOUT OF THE TIMES DISCUSSED IN NOTE [1] ABOVE.
- [3] IN THE EVENT THAT S3/P4 INSTALL IS DELAYED FROM ITS SCHEDULED FD4 TIME, THE CONSTRAINT IDENTIFIED IN RULE {12A_C2-31}, ISS CARGO ELEMENT RETURN, MAY APPLY AND JETTISON OF S3/S4 COULD BE REQUIRED.

Rapid Safing was designed to protect both the shuttle and station crews in the event of an orbiter emergency that requires a rapid return to Earth. In some cases, leaving hardware on the SSRMS was selected as the fastest way to safe the orbiter payload bay for undocking. If the severity of the emergency is such that it allows for significantly more time to safe the payload bay, then the option of securing hardware either to shuttle or station will be considered.

Documentation: Hazard Report ISS-STR-907-12A, Cause 1.

STS-120/10A 09/25/07 FINAL FLIGHT OPERATIONS 2-173
ISS EXPEDITIONS 15 & 16

Verify that this is the correct version before use.

FLIGHT RULES

10A_C2-102 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 ONBOARD 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.

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 over 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 two-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, O₂, etc. to be transferred over 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 {10A_C2-103}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) DECLARATION ACTIONS [RI], and NSTS 21519 LON Crew Rescue Mission MIP.

FLIGHT RULES

10A_C2-103 **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.

IN SUPPORT OF THE CSCS, THE FOLLOWING ACTIONS WILL BE INVOKED:

- A. ORBITER CSCS GROUP C+ POWERDOWN
- B. THE STS-3XX 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 STS-3XX Rescue mission is put in motion and processing is initiated.

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FLIGHT RULES

10A_C2-103 **CONTINGENCY SHUTTLE CREW SUPPORT (CSCS)**
DECLARATION ACTIONS [RI] (CONTINUED)

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, and STS-3XX, Launch on Need (LON) Crew Rescue.

Although 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.

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 {10A_C2-102}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI], and NSTS-21519, Launch on Need Crew Rescue Flight MIP.

FLIGHT RULES

10A_C2-104 POWERDOWNS FOR SAFE HAVEN RISK

A. A MODIFIED GROUP C POWERDOWN WILL BE MAINTAINED TO THE EXTENT PRACTICAL IF THE TPS IS CATEGORIZED AS "NO-GO FOR DEORBIT." CONSIDERATION WILL BE GIVEN TO IMPLEMENTING THIS POWERDOWN FOR TPS CATEGORIZED AS "DAMAGED." @[CR 8840]

The orbiter is typically in a Group B powerdown while docked to ISS. A modified Group C powerdown will conserve more cryogenes 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. With SSPTS, additional mission duration capability is provided and therefore based on the type of damage and/or repair options this capability may suffice in providing the additional margin required to effect those repairs. @[CR 8840]

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+ powerdown 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, #6 for Group C+, unmanned undocking, LON.

Reference Rule {10A_A2-5}, MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS. @[CR 8840]

Deleted: ENTRY CRITICAL TPS DAMAGE IS SUSPECTED AND BEFORE IT HAS BEEN CLEARED FOR DEORBIT.

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FLIGHT RULES

10A_C2-105 ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)

- A. CSCS/LON WILL BE CONSIDERED IN SUPPORT OF THE FOLLOWING ORBITER FAILURE SCENARIOS:
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. TPS CATEGORIZED AS "NO-GO FOR DEORBIT" @CR 8838]
- 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.
 2. DOCKED:

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.

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FLIGHT RULES

10A_C2-105 ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)
(CONTINUED)

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, 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 re-entry 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).

For the cases where the orbiter failure(s) result 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.

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FLIGHT RULES

**10A_C2-105 ORBITER SYSTEM FAILURES AND CONTINGENCY SHUTTLE
CREW SUPPORT (CSCS)/LAUNCH ON NEED (LON)
(CONTINUED)**

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.

TPS damage categorized as NO-GO for Deorbit is when the TPS cannot safely support a deorbit and entry of the orbiter. CSCS/LON option will be considered until the TPS damage is repaired and cleared for entry. Since the orbiter cannot return safely for this damage category, a repair strategy will be developed to attempt to avoid the CSCS/LON risks and will be worked in parallel with the CSCS/LON preparation. Whether the repair would be executed would depend on the potential effectiveness of the repair and the risk to the crew to perform the repair. Upon completion of a repair (if a repair is attempted), thermal, aerothermal, and structural analysis would be required to determine the likelihood of survivability of the repair and an assessment would be performed to determine whether the damage could be reclassified from NO-GO to another less severe damage category. If the damage is not or cannot be repaired effectively, the crew will not perform a reentry, and CSCS/LON will be invoked. @CR 8838

Deleted: 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.

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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 re-entry 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.

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FLIGHT RULES

**10A_C2-105 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).

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; {10A_C2-102}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) [RI]; {10A_C2-103}, CONTINGENCY SHUTTLE CREW SUPPORT (CSCS) DECLARATION ACTIONS [RI]; and {10A_A2-5}, MISSION TERMINATION/TPS REPAIR PHILOSOPHY AFTER THE COMPLETION OF ASCENT TPS INSPECTIONS. @ICR 8838 1

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FLIGHT RULES

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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. @[DN 8]

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.

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10A_A2-3

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.
- 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.

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10A_A2-3

NEXT PRIMARY LANDING SITE (PLS)
REQUIREMENTS (CONTINUED)

TABLE 10A_A2-3-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	FD1 OR NEXT PLS	TILE: FD1 OR NEXT PLS [1]

FAILING		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]

[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.

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10A_A2-3

NEXT PRIMARY LANDING SITE (PLS) REQUIREMENTS (CONTINUED)

2. IF THE ORBITER TPS IS 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, 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 10A_A2-3-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.

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10A_A2-3

**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:
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.

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. ©[DN 8]

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10A_A2-3

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

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. ©[DN 8]

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 (FDI). On FDI, 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 FDI, 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 FDI 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 FDI. Additionally, the FDI 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 FDI 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 FDI abort scenarios is an accepted risk as part of the flight rationale for RTF.

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10A_A2-3

**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].

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.

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10A_A2-3

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

Prior to Docking, Orbiter TPS is Suspect

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.

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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.

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.

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

OMS/RCS Delta-V Loss

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.

FLIGHT RULES

SECTION 3 - GROUND INSTRUMENTATION

THERE ARE NO FLIGHT-SPECIFIC STS-120/10A RULES FOR THIS SECTION

FLIGHT RULES

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FLIGHT RULES

SECTION 4 - TRAJECTORY AND GUIDANCE

SHUTTLE ONLY RULES

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DEFINITION

ISS ONLY RULES

THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION.....4-9

JOINT SHUTTLE/ISS RULES

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FLIGHT RULES

SECTION 4 - TRAJECTORY AND GUIDANCE

SHUTTLE ONLY RULES

10A_A4-1 SHUTTLE TRAJECTORY AND GUIDANCE PARAMETERS

STS-120 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%
{A4-55}	DELTA V ABOVE AFT PRESS QTY	87.8 FT/SEC
{A4-1A}	2 SIGMA + MEAN INFLT FPR	1796 LBS
{A4-1B}	3 SIGMA + MEAN INFLT FPR	2651 LBS
{A2-52}, {A4-55}	MINIMUM HP	85 NM
{A4-55}	DESIGN MECO UNDERSPEED	160 FT/SEC
{A4-55}	CRITICAL MECO UNDERSPEED 1 ENGINE OUT CRITICAL MECO UNDERSPEED 2 ENGINES OUT	586.7 FT/SEC 567.2 FT/SEC
{A4-57A}	NOMINAL	40 FT/SEC
{A2-205B}	UNDISPERSED CROSSRANGE ASCENDING LEFT ASCENDING RIGHT DESCENDING LEFT DESCENDING RIGHT	846 NM 900 NM 858 NM 875 NM
{A4-107E}	DISPERSED CROSSRANGE ASCENDING LEFT ASCENDING RIGHT DESCENDING LEFT DESCENDING RIGHT	786 NM 836 NM 791 NM 825 NM
{A4-159}	CONT PAYLOAD RETURN AFTER ORBIT 3	N/A

~~@[CR 8806]~~

~~NOTE: THE DISPERSED CROSSRANGE LIMITS LISTED ABOVE ARE VALID FOR EARLY MISSION RETURN FOR LANDING WEIGHTS UP TO 237,000 LBS. @[CR 8806]~~

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FLIGHT RULES

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SHUTTLE TRAJECTORY AND GUIDANCE PARAMETERS (CONTINUED)

Mission-specific USA entry thermal analysis was performed for STS-120 early mission return. This was conducted using steep thermal trade line deorbit targeting. For a FD3 PLS that protects for the rendezvous breakout case, the worst case landing weight is 235,264 lbs. In order to provide some margin for real-time consumable usage variations, the entry thermal analysis was performed for a landing weight of 237,000 lbs. Furthermore, the analysis was performed with crossranges of 50 nm, 450 nm, and the dispersed crossrange limit for each approach direction. All observed TSEP Thermal Math Model violations were below the ATO limits. Therefore, there are no issues raised by the assessment and no trajectories were forwarded to Boeing. Note that this analysis does not guarantee thermal coverage for all crossranges up to the dispersed crossrange limit, although the analysis indicates actual thermal violations are not expected within the envelope of these cases. Since a guarantee cannot be provided for crossrange values other than those listed here, real-time assessment will likely be required for an early payload return case. The pre-flight analysis is documented in USA Flight Design STF# ADFD-07-023, titled "STS-120 No Dock PLS Downweight Thermal Analysis." @[CR 8806]

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FLIGHT RULES

10A A4-3 MANUAL THROTTLE SELECTION [HC]

MANUAL THROTTLE WILL BE INITIATED FOR THE FOLLOWING CONDITIONS:
@CR 8710A]

A. FAILURE TO INITIATE/TERMINATE THRUST BUCKET COMMANDS FOR
FIRST STAGE α CONTROL.

During first stage flight, the boost throttling task provides an open-loop throttle command to limit maximum dynamic pressure and gain desired performance. When the relative velocity exceeds an I-load value of OPOLYJ, the throttle command is set to an I-load value of THROTJ if SRB performance is nominal, and the segment index J is incremented by 1. For off-nominal SRB performance, adaptive guidance throttling adjusts either THROT2 or THROT3 depending on whether performance is high or low. If SRB performance is high, the THROT2 level (throttle command between about Mach 0.4 and 0.7) is reduced (approximately 21 percent for 3 sigma hot SRB's). If SRB performance is low, the THROT3 level (throttle command between about Mach 0.7 and Mach 1.3) is increased (approximately 6 percent for 3 sigma cold SRB's). Since there is no crew insight onboard into SRB performance, manual throttles should not be invoked at OPOLY2 or OPOLY3 simply to match the nominal throttle bucket based on the THROTJ I-loads.

Manual throttles shall only be invoked if guidance fails to throttle back at OPOLY3 or fails to throttle up to maximum power level at OPOLY4. If manual throttles are invoked during the throttle bucket, throttles shall remain under manual control until second stage guidance has been evaluated and declared GO.

B. FAILURE TO ACHIEVE FUEL DISSIPATION THROTTLE COMMAND ON
INITIATION OF RTLS.

The current throttle command for the fuel dissipation phase of powered RTLS is established by the SSME-out safing task or the RTLS initialization task depending on the number of active SSME's. If a SSME failure has previously occurred, the throttle command should have been set to an I-load value KMAX by the SSME-out safing task. If no engine failure has occurred, the RTLS initialization task sets the throttle command to a level equal to two thirds of KMAX. Thus, if the current throttle command in the RTLS fuel dissipation phase is not equal to KMAX (two SSME's active) or two thirds KMAX (three SSME's active), then the SSME-out safing task or RTLS initialization task was not properly executed.

C. INITIATION OF A TWO-SSME RTLS WITH ONE SSME THROTTLE STUCK IN
THE THRUST BUCKET. RETURN TO AUTO THROTTLE WILL BE INITIATED
DURING FLYBACK PHASE ON GROUND CALL AFTER CONFIRMATION OF
GUIDANCE CONVERGENCE. @CR 8710A]

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FLIGHT RULES

10A A4-3 MANUAL THROTTLE SELECTION [HC] (CONTINUED)

During the fuel dissipation phase of an RTLS, the PEG flyback predictions assume a vehicle thrust acceleration equivalent to a desired throttle command. With two engines active with one throttle stuck at the thrust bucket level, the actual vehicle acceleration is less than assumed. After the powered pitcharound (i.e., flyback initiation), the PEG guidance senses the lower acceleration and becomes unconverged as it attempts to adjust the steering solution. During this interval, it is possible (although unlikely) for PEG to issue an erroneous MECO command. As a precaution to protect against an inadvertent shutdown, manual throttle must be selected prior to flyback initiation. Since there is no direct indication of when flyback initiation will occur, manual throttle should be selected at initiation of RTLS. To avoid a manual MECO, a ground call for return to AUTO throttle will be made after guidance has reconverged with a stable solution. ©[CR 8710A]

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D. INCORRECT THROTTLE COMMAND FOR TAL OMS DUMP CONTROL.

Beginning with OI-8D, flight software provides for an automatic throttledown following TAL abort selection in order to maximize capability to complete the pre-MECO OMS dump. This throttling action is cued by two site-specific I-loads that define the threshold throttledown velocities for either two- or three-engine operation. If the appropriate throttledown command is not issued, the software is not performing correctly, and manual throttle will be exercised to perform the same function. Alternately, when an SSME failure is not recognized by guidance, the throttle-down may be erroneously commanded based on the three-engine throttle down velocity. Manual throttles may be used to prevent or correct this erroneous throttle-down. This philosophy is consistent with paragraphs A and B above.

E. THROTTLE COMMAND NOT DECREASED TO MAINTAIN 3-G ACCELERATION.

The 3-g acceleration-limiting logic is provided to assure that vehicle loads do not exceed design constraints. Therefore, manual throttle will be invoked to protect this limit if the flight software fails to do so. Reference the rationale for Rule {A4-58C}, AUTO GUIDANCE NO-GO, for further background.

F. ANY TIME CSS IS SELECTED.

As a conservative guideline, any time the AUTO guidance is unacceptable for vehicle attitude control, it should not be allowed to control the main engines. If the vehicle attitude is not maintained to satisfy the guidance solution, the guidance may go unconverged and potentially could issue an undesired MECO command. Thus, to avoid an inadvertent shutdown, manual throttle should be selected whenever CSS takeover is initiated. ©[CR 8710A]

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FLIGHT RULES**10A A4-3 MANUAL THROTTLE SELECTION [HC] (CONTINUED)**

G. IF THE MECO UNDERSPEED IS PREDICTED TO EXCEED 500 FPS FOR TWO OR THREE ENGINES OPERATING, THROTTLES WILL BE MANUALLY COMMANDED TO THE MINIMUM POWER LEVEL AT 2 PERCENT PROPELLANT REMAINING. @[CR 8710A]

FOR TWO ENGINES OPERATING, AUTO THROTTLES WILL BE SELECTED AFTER THROTTLING TO THE MINIMUM POWER LEVEL.

Flight software MECO preparation throttling is triggered by K-loaded timing values. When the guidance-computed TGO becomes less than TGO FCD K-load, the MPS guidance cutoff task begins cyclic execution. This task determines when to command the SSME's to the cutoff power level, and assumes that they will remain at that setting for K-load DT MIN K seconds. However, the software also assumes a guided MECO will result and has no way of compensating for an impending early (low-level) cutoff. Therefore, for predicted MECO underspeeds greater than a threshold value for two or three engines operating, a low-level shutdown may be commanded before the engines reach the desired cutoff throttle setting. In such instances, the throttles will be manually commanded to the minimum power level shortly before MECO to provide the required safe shutdown configuration.

Under most circumstances, the onboard propellant remaining computation is sufficiently accurate to use as a throttledown cue. Ascent/Entry Flight Techniques Panel #62 determined in January 1990 that 2 percent propellant remaining provided a generic value that covered both the pre-MECO dump and no-dump cases. However, the flight software computation is inaccurate when off-nominal mixture ratios are involved, due to the buildup of unusable LOX or LH₂; the software senses the extra mass but does not recognize it as unusable. Likewise, the onboard mass estimation algorithm in first stage assumes all engines are operating at the commanded power level; therefore, an engine locked before the bucket will consume more propellant than the mass tracking function accounts for. This leads to the second stage software believing it has more propellant than is actually available.

Although the resultant mass dispersions are a function of the size and direction of the mixture ratio dispersion or the depth and length of the bucket, the 2 percent propellant remaining cue still provides sufficient time to throttle down. (Reference Rule {A5-112}, MANUAL THROTTLEDOWN FOR LO2 NPSP PROTECTION AT SHUTDOWN [HC].)

Beginning with OI-32, the single engine completion task is automated in PASS OPS 1. In this case, the PASS flight software will automatically throttle the last remaining engine back to 67 percent as part of the single engine MECO prep task once the total calculated mass gets below the arming mass. No manual throttling is required for a single engine completion in OPS 6. For an ECAL or contingency abort, MECO is imminent after declaring the abort and propellant depletion is not a concern. For an RTLS, the software automatically protects for a single engine completion after 2 OUT RED. Reference A/EFTP #230, April 20, 2007. @[CR 8710A]

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FLIGHT RULES

10A A4-3 MANUAL THROTTLE SELECTION [HC] (CONTINUED)

After manual throttledown, the crew will return throttles to AUTO for two engines operating or be prepared to perform a manual MECO at the desired MECO velocity should it be reached prior to the low-level cutoff for three engines operating. With three engines operating, a late engine failure would cause the remaining engines to throttle back up to 104.5 percent if throttle control were returned to AUTO. Two engines at 104.5 percent is an unsafe power level for LLCO, and the crew may not have enough time to manually throttle the engines back before the LLCO occurs, which could result in an uncontained shutdown. For the two engine case, AUTO can be selected after manual throttling since another engine failure would allow for the automatic single engine throttle back for NPSP protection. Reference A/EFTP #230, April 20, 2007. ©[CR 8710A]

H. TO PROTECT LH₂ NPSP REQUIREMENTS.

Rule {A5-155}, LIMIT SHUTDOWN CONTROL, MANUAL THROTTLING, AND MANUAL SHUTDOWN FOR LOW LH₂ NPSP [CIL] [HC], addresses scenarios requiring manual throttles. Manual throttles will be maintained and a manual MECO required for the flow control valve anomaly case. Uphill capability will be evaluated at each throttle setting. Two-engine and single-engine performance boundaries will be made based on minimum power level as time permits. Since this dynamic throttle profile is difficult to model, two-engine and single-engine capability may not be evaluated accurately until the failure actually occurs.

Manual throttles will be selected prior to aborting TAL for an LH₂ leak. OI-8D software (STS-38 and subs) 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 LH₂ tank 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 cause engine failures but this is an accepted risk to avoid vehicle structural damage. Operating the SSME's at 104 percent results in a higher inertial velocity at MECO than if the SSME's had been throttled down to 67 percent.

I. A TAL UNDERSPEED IS PREDICTED AND CAN BE REDUCED BY FLYING AT A LOWER THROTTLE SETTING. THROTTLES WILL BE RETARDED TO MINIMUM POWER LEVEL WHEN THE PERFORMANCE GAIN IS MAXIMIZED.

The slope of the TAL range-velocity target line results in a point in the powered flight trajectory where MPS propellant margins may be increased by flying at a reduced throttle setting. As the throttle is retarded, the powered flight time is extended which in turn results in a MECO position which is farther downrange than would have occurred at a higher power level. The farther downrange position equates to less distance to the TAL site at MECO, and hence, a lower MECO target velocity. This in turn translates to increased MPS margin since less delta V is required to reach the smaller target velocity. Early in powered flight, gravity losses at the lower throttle are large and offset any R-V target benefit; however, eventually sufficient velocity is achieved such that the inverse is true; i.e., the smaller target velocity offsets the gravity losses, which diminish with time and the square of the current velocity. ©[CR 8710A]

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FLIGHT RULES**10A A4-3 MANUAL THROTTLE SELECTION [HC] (CONTINUED)**

In real time, the MCC ARD can determine when this boundary condition is reached, and subsequently when the performance gain is maximized. The FDO will then call for throttledown to minimize the R-V underspeed. Improving proximity to the R-V line in this manner reduces the likelihood of requiring low-energy guidance during entry, and is especially critical for out-of-plane sites where high crossrange severely limits underspeed tolerance. ©[CR 8710A]

Note that this procedure will not be utilized unless an underspeed is predicted at the current power level.

J. THREE ENGINES RUNNING AND TWO STUCK THROTTLES PRIOR TO TAL OR RTLS ABORT.

- 1. TAL: SELECT MANUAL THROTTLES, ABORT TAL, SELECT AUTO THROTTLES.**
- 2. RTLS: SELECT MANUAL THROTTLES, MINIMUM THROTTLES, AUTO THROTTLES, WAIT 10 SECONDS, ABORT RTLS. IF BOTH ENGINES WITH STUCK THROTTLES ARE AT NOMINAL POWER LEVEL (104.5 PERCENT), THESE RTLS STEPS ARE NOT NECESSARY.**

For TAL, it is undesirable to throttle down the good engine due to the guidance transients which may occur and the fact that little time would be gained to perform the abort dump. Therefore, manual throttles will be selected to prevent an automatic throttledown when TAL is declared. This action is not required if TAL is declared early enough that automatic throttling will not occur at abort selection. However, since there is no disadvantage to selecting manual throttles for this short period of time, manual throttles will always be selected for consistency. AUTO throttles will be reselected after TAL is declared.

For three-engine RTLS cases with two stuck throttles, minimum throttles will be selected prior to abort selection for any engine stuck at a power level below the nominal 104.5 percent. Doing so will allow guidance to converge on the correct average thrust level and will reduce the probability of an early PPA. For guidance to have enough time to converge, minimum throttle levels must be achieved at least 10 seconds prior to RTLS selection. If not, an early PPA may occur, resulting in MECO conditions that are not optimized, since additional propellant above the 2 percent target may remain in the ET at MECO. AUTO throttles should be reselected immediately after the minimum throttles is selected. Doing so ensures that RTLS guidance fine mass control is maintained. If manual throttles is active at PPA or enabled anytime after PPA, then guidance fine mass control is disabled. ©[CR 8710A]

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FLIGHT RULES**10A A4-3 MANUAL THROTTLE SELECTION [HC] (CONTINUED)**

If both stuck engines are at the nominal power level (104.5 percent), these steps are unnecessary since the chances of an early PPA are eliminated. In this case, a late PPA is possible since the guidance turnaround velocity limit (VLATE) is being approached and the man/min/auto throttle steps could cause the crew to exceed this velocity limit prior to aborting RTLS. Reference Ascent/Entry Flight Techniques Panel #215, October 28, 2005. ©[CR 8710A]

Reference Rules {A5-109}, MANUAL SHUTDOWN FOR TWO STUCK THROTTLES (NOT DUAL APU FAILURES) [HC]; and {A8-61}, SSME SHUTDOWN DUE TO HYDRAULIC SYSTEM FAILURES [HC].

K. TO MAINTAIN THROTTLES AT 109 PERCENT POWER LEVEL DURING THE FLYBACK PHASE OF AN RTLS ABORT.

When maximum throttles are enabled (SPEC 51 Item 4), guidance replaces the maximum power level (KMAX) of 104 percent with 109 percent. However, during the flyback phase, the commanded power level (KCMD) is not simply set to KMAX but is adjusted to achieve the desired mass conditions at MECO (assuming CSS or manual throttles did not occur anytime during flyback). For two engines running, the typical throttle command during flyback is about 100 percent and is unaffected by KMAX. Therefore, if 109 percent power level is desired during the flyback phase of an RTLS abort, manual throttles are required.

Reference Rule {A4-53E.1}, USE OF MAXIMUM THROTTLES; and Rule {A5-151D}.3, PRE-MECO MPS HELIUM SYSTEM LEAK ISOLATION [CIL].

L. IF A LOWER SSME POWER LEVEL IS REQUIRED SUBSEQUENT TO ENABLING MAXIMUM THROTTLES.

When maximum throttles are enabled (SPEC 51 Item 4), guidance replaces the maximum power level (KMAX) of 104 percent with 109 percent. If throttle selection is auto and 3-g throttling is not active, the commanded power level (KCMD) is set to the new maximum power level of 109 percent (except during RTLS flyback phase, see paragraph K. above). If a lower power level is required subsequent to enabling maximum throttles, manual throttles must be selected and the lower power level commanded manually. (Note, if throttle selection is auto, the fine count throttle setting will be commanded regardless if maximum throttles have been enabled). A second SPEC 51 Item 4 will not reset the maximum or commanded power level to 104 percent. Therefore, the lower power level must be commanded manually. Once the desired power level is reached, throttles can be returned to auto. However, a subsequent engine failure with auto throttles selected will result in the commanded power level being reset to 109 percent.

Reference Hazard Reports IMPS-08, Underpressurization of the Integrated MPS O2 System, and IVLD-01, Exposure to Induced Environment Exceed Structural Capability of SSV. ©[CR 8710A]

FLIGHT RULES

ISS ONLY RULES

THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_C4-1

RESERVED

FLIGHT RULES

SECTION 5 - BOOSTER

SHUTTLE ONLY RULES

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FLIGHT RULES

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FLIGHT RULES

SECTION 5 - BOOSTER

SHUTTLE ONLY RULES

10A A5-1 MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES [HC]

MANUAL SHUTDOWN OF AN AFFECTED ENGINE WILL BE PERFORMED PRIOR TO MECO FOR THE FOLLOWING COMMAND AND/OR DATA PATH FAILURE CASES: @[CR 8706]

A. COMMAND PATH FAILURE.

1. NOMINAL/ATO:

a. THREE ENGINES ON - SHUT DOWN AT VI = 23K FPS USING THE AC POWER SWITCHES AND SHUTDOWN PB.

b. TWO ENGINES ON - SHUT DOWN AT VI = 24.5K FPS USING THE AC POWER SWITCHES AND SHUTDOWN PB.

MCC CONFIRMS COMMAND PATH FAILURE BY NO THROTTLING OF AFFECTED ENGINE WHEN THE ENGINES ARE COMMANDED TO THROTTLE.

2. RTLS:

TWO OR THREE ENGINES ON - SHUT DOWN DURING POWERED PITCHDOWN AT ALPHA = -1 USING THE AC POWER SWITCHES AND SHUTDOWN PB.

3. TAL:

TWO OR THREE ENGINES ON - SHUT DOWN AT VI = 22.5K FPS USING AC POWER SWITCHES AND SHUTDOWN PB. @[CR 8706]

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FLIGHT RULES**10A A5-1 MANUAL SHUTDOWN FOR COMMAND/DATA PATH
FAILURES [HC] (CONTINUED)**

In the case of a command path failure, the only way to shut down an engine is with the engine ac power switches. Shutting down with the ac power switches also creates a data path failure. Therefore, the shutdown pushbutton is pushed to tell guidance that an engine is out. The engine is shut down approximately 30 seconds before MECO to prevent depleting LO₂ and LH₂ through an SSME, causing uncontained engine damage. A velocity which equates to MECO minus 30 seconds also gives guidance time to compensate for late engine out and converge to the proper MECO targets. The only exception is an RTLS where the engine is shut down during powered pitch down at alpha = -1 degree. Prior to OI-32, the crew cue for shutting down an engine with BFS engaged was based on a time of MECO-30 seconds, since there were no flight instruments available. With the implementation of OI-32, the crew will have all flight instruments available, and the shut-down cue is now the same for PASS and BFS. Reference A/EFTP #230, April 20, 2007. On a three- or two-engine abort RTLS, if an engine is shut down at TGO ≤ 60 seconds, guidance will not mode to the target set corresponding to the remaining number of engines. ©[CR 8706]

The cue of alpha = -1 degree (approx MECO-5 sec) was chosen to allow SSME shutdown to begin prior to predicted MECO while the LO₂ is still under g's from the other engine(s). This alleviates LO₂ net positive suction pressure concerns for the high pressure oxidizer turbopump (HPOTP). Alpha = -1 degree also protects for 1-sigma aerodynamic dispersions. Although sizable transients can be expected subsequent to engine shutdown, flight control has been demonstrated to null these transients prior to ET separation (in some cases ET separation inhibits of approximately 1 second will occur, reference A/EFTP #87, February 21, 1992, and A/EFTP #122, March 10, 1995 minutes).

B. DATA PATH FAILURE**1. MCC DECISION (PRIME)****NOMINAL/ATO/TAL/RTLS :****a. NO ACTION REQUIRED****b. MCC CONFIRMS COMMAND PATH OPERATIONAL BY GH₂
OUTLET PRESSURE COMPARISON TO POWER LEVEL
COMMAND. ©[CR 8706]****Formatted:** Line spacing: Exactly 13 pt**Formatted:** Lowered by 3 pt**THIS RULE CONTINUED ON NEXT PAGE**

FLIGHT RULES**10A A5-1 MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES [HC] (CONTINUED)****2. ONBOARD DECISION (NO COMMUNICATION) @[CR 8706]****NOMINAL/ATO/TAL/RTLS :****CREW ACTION SAME AS FOR COMMAND PATH FAILURE**

For a data path failure, the engine will accept throttling and MECO commands so no action is required. The crew cannot tell the difference between a data path failure and a command/data path failure. The two failures that caused the data path failure may also have caused a command path failure (i.e., two controller interface adapters (CIA's), or a CIA and a multiplexer interface adapter (MIA) in the EIU). Unless the command capability is verified by the MCC, the crew will assume a command and data path failure and will take the same action as a command path failure. The MCC can verify the command path status by observing that the GH₂ outlet pressure changes with the throttle command. If an engine throttles down when commanded, its command path is operational.

C. COMMAND AND DATA PATH FAILURE.**1. MCC DECISION (PRIME)****NOMINAL/ATO/TAL/RTLS :****a. ACTION SAME AS COMMAND PATH FAIL****b. MCC CONFIRMS CASE BY NO CHANGE IN GH₂ OUTLET PRESSURE ON THE AFFECTED ENGINE WHEN ENGINE COMMANDED TO THROTTLE.****Formatted:** Line spacing: Exactly 13 pt**Formatted:** Lowered by 3 pt**2. ONBOARD DECISION (NO COMMUNICATION)****NOMINAL/ATO/TAL/RTLS :****CREW ACTION SAME AS FOR COMMAND PATH FAILURE**

The loss of an EIU or the loss of an MIA and a CIA or the loss of two CIA's will cause a data path failure and a command path failure on the same engine. @[CR 8706]

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FLIGHT RULES

10A A5-1 MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES [HC] (CONTINUED)

This is a very serious failure mode because this failure will close the prevalues on an operating engine at MECO if preventative action is not taken. A water-hammer effect will occur which will rupture the LO₂ feedline and result in uncontained engine damage and loss of crew and vehicle. At MECO, the GPC logic assumes an engine with a data path failure does not have a command path loss (i.e., the GPC assumes the engine accepted and complied with the shutdown command); therefore, the prevalues are commanded closed. To prevent this catastrophic shutdown of the engine at MECO, the engine ac power switches must be used to shut down the engine before MECO is commanded. The ac power switches will shut down the engine; the pushbutton is then pressed to mode guidance. @[CR 8706]

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Reference Hazard Report IMPS-17, Inadvertent SSME Shutdown. @[CR 8706]

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FLIGHT RULES**10A A5-2 MANUAL THROTTLEDOWN FOR LO2 NPSP PROTECTION
AT SHUTDOWN [HC]**

- A. FOR TWO OR THREE ENGINES OPERATING, MANUAL THROTTLING TO THE MINIMUM SSME POWER LEVEL WILL BE PERFORMED TO PROTECT MECO LO₂ NPSP REQUIREMENTS WHEN LO₂ LOW-LEVEL CUTOFF IS PREDICTED TO OCCUR BEFORE FINE COUNT. UNDER THESE CIRCUMSTANCES, MANUAL THROTTLING TO THE MINIMUM POWER LEVEL WILL BE PERFORMED WHEN THE ONBOARD PROPELLANT REMAINING COMPUTATION REACHES 2 PERCENT AND THE MCC FLIGHT DYNAMICS OFFICER (FDO) IS PREDICTING AN UNDERSPEED GREATER THAN 500 FT/SEC. @[CR 8708A]
- B. FOR THREE ENGINES OPERATING, 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 REQUIRED.
- C. FOR TWO ENGINES OPERATING, AUTO THROTTLES WILL BE SELECTED AFTER THROTTLING TO MINIMUM POWER LEVEL.

If FDO is predicting a low-level cutoff prior to the guidance software issuing the fine count command for two or three engines operating (ref. rationale of Rule {A4-59G}, MANUAL THROTTLE SELECTION [HC]), the engine(s) will shut down at an unsafe power level due to a low LO₂ NPSP condition. The LO₂ NPSP violation during shutdown may cause uncontained engine damage.

For the two- or three-engine operating 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 (based on 2 sigma MPS propellant protection) is no greater than 500 ft/sec. The two/three-engine operating case assumes a vehicle mass of 379,000 lbs at MECO minus 10 seconds. Both cases assume that the thrust provided by a single engine at 104 percent is 488,800 lbf. The 500 ft/sec cue is derived from using the $F = M \cdot A$ 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 for two or three engines operating is greater than 500 ft/sec, manual throttling will be performed to the minimum power level, thereby reducing the NPSP requirements prior to reaching a low-level cutoff condition. @[CR 8708A]

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FLIGHT RULES**10A A5-2 MANUAL THROTTLEDOWN FOR LO2 NPSP PROTECTION
AT SHUTDOWN [HC] (CONTINUED)**

The throttledown cue of 2 percent propellant remaining was selected to allow sufficient time to perform the manual throttling while minimizing any performance impact. ©ICR 8708A]

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 (Isp). Worst-on-worst analysis with two engines out simultaneously at the press-to-MECO boundary and the third engine operating with an Isp 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.

Beginning with OI-32, manual throttledown for a single remaining engine is not required because the single engine completion task is automated in PASS OPS 1. In this case, the PASS flight software will automatically throttle the last remaining engine back to 67 percent as part of the single engine MECO prep task once the total calculated mass gets below the arming mass. No manual throttling is required for a single engine completion in OPS 6. For an ECAL or contingency abort, MECO is imminent after declaring the abort and propellant depletion is not a concern. For an RTLS, the software automatically protects for a single engine completion after 2 OUT RED. Reference A/EFTP #230, April 20, 2007.

After manually throttling back to 67 percent for two engines operating and a predicted underspeed greater than 500 fps, the crew will return throttles to AUTO or be prepared to perform a manual MECO at the desired MECO velocity should it be reached prior to the low-level cutoff. For the two engine case, AUTO can be selected after manual throttling since another engine failure would allow for the automatic single engine throttle back for NPSP protection. Reference A/EFTP #230, April 20, 2007.

With three engines operating and a predicted underspeed greater than 500 fps, manual throttles will be maintained until MECO after throttling back to 67 percent. This is to ensure that the engines remain at a safe power level. If throttle control were returned to AUTO after throttling down, a late engine failure would cause the remaining engines to throttle back up to 104.5 percent, which is an unsafe power level for LLCO. The crew may not have enough time to take manual throttles again, and throttle the engines down before the LLCO occurs, and this could result in an uncontained shutdown. Reference A/EFTP #230, April 20, 2007.

Reference Hazard Report IMPS-08, Underpressurization of the Integrated MPS O2 System. ©ICR 8708A]

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FLIGHT RULES**10A A5-3 USE OF MPS ENGINE CUTOFF SENSOR VOLTAGE
MONITORING SYSTEM FOR STS-120/10A**

FOR STS-120/10A, THE MPS ENGINE CUTOFF (ECO) SENSOR VOLTAGE MONITORING SYSTEM WILL NOT BE USED TO DETERMINE ECO SENSOR FUNCTIONALITY DURING POWERED FLIGHT. @[CR 8843]

STS-120/10A is the second flight of the MPS ECO Voltage Monitoring System installed on both the LO₂ and LH₂ ECO sensors (MCR 23448/TAD 30070). This system is Crit 3 instrumentation, which was initially conceived to assist with the troubleshooting of prelaunch ECO sensors failures with the goal of isolating a failure to either the External Tank wiring and/or sensor or the orbiter wiring/point sensor box. The additional use of this data for LCC and real-time monitoring of the ECO sensor system health was also discussed when the instrumentation was designed.

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The first flight of the MPS ECO Voltage Monitoring System was STS-118, and all voltage sensors indicated within the expected range of operation for healthy ECO sensors. More data is desired from the system before certifying for use in powered flight, so the voltage monitoring system shall only be used for prelaunch determination of ECO sensor status on STS-120/10A.

The use of ECO sensor voltage monitoring for LCC purposes was reviewed at the Program Requirements Control Board on April 5, 2007. Based on this review, the PRCB determined that the ECO instrumentation could be used to determine a failed wet sensor when the instrumentation is reading 14.0 volts dc (currently a preliminary functional value of 13.184 volts dc), which indicates an open circuit. The results of this discussion are documented in PRCBD S063611 in which the Space Shuttle Program directed the Operations and Engineering communities "to formulate, through the LCC working group, an LCC on LH₂ ECO voltage measurements, which will not be implemented in the GLS (i.e., a manual call), to protect for the 14 vdc open circuit condition, time ending at T-5 minutes." After T-5 minutes and counting through MECO, the Space Shuttle Program has accepted the risk of undetected failed wet ECO sensor. @[CR 8843]

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FLIGHT RULES

ISS ONLY RULES

THERE ARE NO STS-120/10A ISS-ONLY RULES FOR THIS SECTION

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

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SECTION 6 - PROPULSION

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SECTION 7 - DATA SYSTEMS

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FLIGHT RULES

SECTION 8 - GNC

SHUTTLE ONLY RULES

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FLIGHT RULES

SECTION 8 - GNC

SHUTTLE ONLY RULES

10A_A8-1 RESERVED @[DN 145]

10A A8-2 MISSION DURATION IMPACTS FOR TACAN/SINGLE-STRING GPS FAILURES

FOR STS-120/10A, THE FOLLOWING MISSION DURATION GUIDELINES APPLY
FOR TACAN/GPS FAILURES: @[CR 8858]

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A. FOR A SINGLE TACAN FAILED, A SINGLE TACAN AND GPS FAILED, OR
TWO TACANS FAILED SUCH THAT THE REMAINING TACAN AND GPS HAVE
INDEPENDENT POWER SOURCES AND DATA PATHS, CONTINUE TO NOMINAL
END OF MISSION (EOM) .

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For any of the above failure scenarios, the navigation system could sustain two additional failures and still maintain a mechanism via MCC entry delta-state command uplinks to maintain acceptable navigation during entry/landing. For the subsequent failure, the entry would occur nominally using the last remaining TACAN or GPS and a delta-state uplink as a backup.

Reference Rule {A2-102}, MISSION DURATION REQUIREMENTS, for details of mission duration philosophy for entry critical system failures.

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B. FOR TWO TACANS FAILED SUCH THAT THE REMAINING TACAN AND GPS
DO NOT HAVE INDEPENDENT POWER SOURCES AND DATA PATHS, OR FOR
THREE FAILED LRU'S (TACANS AND/OR GPS), PERFORM A MINIMUM
DURATION FLIGHT (MDF) THAT ALLOWS FOR DEORBIT ON AN
OPPORTUNITY(S) THAT MAXIMIZES THE ON-ORBIT C-BAND/TDRS AND
ENTRY HIGH SPEED TRACKING ASSETS.

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For the above failure scenarios, the onboard navigation system is single-fault tolerant with MCC delta-state command capability remaining should the last LRU fail; therefore, an MDF will be implemented. Because the remaining redundancy is sufficient to maintain entry navigation capability such that a safe landing will be accomplished, high priority flight objectives can be performed prior to ending the mission early. The STS-120 Entry Team has trained to perform delta-state updates during entry to maintain the onboard navigation state should the last LRU fail. Additionally, a complete review of all the MCC and network components required to execute a delta-state will be performed prior to deorbit to ensure that redundancy exists in the entry command delta-state capability. Finally, the deorbit opportunities will be planned to maximize all available tracking assets including pre-deorbit burn low speed TDRS and C-band tracking, and post deorbit burn high speed C-band tracking. @[CR 8858]

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FLIGHT RULES

10A A8-2 MISSION DURATION IMPACTS FOR TACAN/SINGLE-STRING GPS FAILURES (CONTINUED)

Reference Rule [10A C2-16], MINIMUM DURATION FLIGHT [RI], for MDF mission length philosophy. @[CR 8858]

C. FOR ALL TACANS AND GPS FAILED:

1. PROVIDED THAT COMPLETE REDUNDANCY EXISTS IN END-TO-END DELTA-STATE COMMAND CAPABILITY, PERFORM AN MDF THAT ALLOWS FOR DEORBIT ON AN OPPORTUNITY(S) THAT MAXIMIZES THE ON-ORBIT C-BAND/TDRS AND ENTRY HIGH SPEED TRACKING ASSETS.

With all three TACAN's and GPS failed, an MDF will be performed as long as complete redundancy exists in the end-to-end delta-state command system including multiple high-speed ground tracking radars from the landing area, dual source ROCC computers and associated assets, two high-speed tracking data transmission circuits, two MCC FEP's, redundant MCC trajectory/telemetry/command server processing, MCC Kalman filter and delta-state processing, and redundant S-band command paths from the MCC to the orbiter. The onboard navigation will degrade to undesired levels prior to MLS processing if TACAN and GPS updates are not available or MCC delta-state vector updates are not incorporated during entry. Complete redundancy in the end-to-end delta-state command system is required to ensure ground navigation update capability exists during entry.

If docking has not been completed prior to the failure of the last LRU, it is prudent to continue with the rendezvous and docking to allow time to verify that all required delta-state equipment is functioning and to plan the deorbit opportunities to maximize all available tracking including pre-deorbit low speed TDRS and C-band assets, and post burn high speed C-band tracking.

2. IF REDUNDANCY IN THE END-TO-END DELTA-STATE COMMAND CAPABILITY DOES NOT EXIST AND CANNOT BE RECOVERED, DEORBIT AT THE NEXT PLS OPPORTUNITY(S) THAT MAXIMIZES THE ON-ORBIT C-BAND/TDRS AND ENTRY HIGH SPEED TRACKING ASSETS.

Since an MCC ground delta-state uplink is required during entry, if redundancy cannot be restored in the command delta-state process, a landing at the next PLS opportunity that ensures accurate ground navigation capability should be performed. This minimizes the exposure to a subsequent failure in the end-to-end delta-state update process that would eliminate the MCC's ability to update the nav state during entry. @[CR 8858]

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FLIGHT RULES

10A A8-2 MISSION DURATION IMPACTS FOR TACAN/SINGLE-STRING GPS FAILURES (CONTINUED)

D. IF IN A SCENARIO DESCRIBED IN PARAGRAPH B OR C, THESE ADDITIONAL ACTIONS WILL BE PERFORMED TO MAXIMIZE THE ACCURACY OF THE ONBOARD NAVIGATION STATE: @[CR 8858]

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1. PERFORM MORE FREQUENT STATE VECTOR UPLINKS TO MAINTAIN NAV ACCURACY FOR EMERGENCY DEORBIT. THIS SUPERSEDES RULE {A4-101}, ONBOARD NAVIGATION MAINTENANCE.

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The on-orbit navigation state is typically maintained such that the maximum downtrack error is 20 nm predicted to the next deorbit TIG. A 20 nm downtrack error is the maximum safe energy error that can be steered out after 130,000 feet altitude (reference Rule {A4-151}, IMU ALIGNMENT [HC]) using either TACAN or GPS. In the case where TACAN and GPS are not available, more frequent state vector uplinks will be performed to reduce the amount of onboard navigation error in the event of an emergency deorbit or total loss of communication.

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2. IMU INERTIAL PLATFORM MISALIGNMENT WILL BE MINIMIZED, TO THE EXTENT POSSIBLE, PRIOR TO DEORBIT. THIS MAY REQUIRE ADDITIONAL STAR ALIGNMENTS AND/OR A DELAYED DEORBIT ALIGN, DEPENDENT ON IN-FLIGHT IMU PERFORMANCE AND STAR AVAILABILITY.

Rule {A4-151}, IMU ALIGNMENT [HC], governs the normal maximum allowed IMU errors. Deorbit will not be attempted if the IMU attitude error at Entry Interface is predicted to be greater than 0.5 degrees because of downtrack navigation errors during entry caused by the misalignment and due to flight control system performance caused by angle of attack errors. Per Rule {A4-151}, IMU ALIGNMENT [HC], deorbit will be delayed in order to perform an IMU alignment to correct the errors to less than 0.25 degrees. Only in a contingency situation are errors between 0.25 and 0.5 degrees acceptable. The 0.25 degree RSS limit is intended to protect system performance margins during entry. A maximum misalignment at EI of 0.25 degrees under worst case conditions protects the limiting parameter, a dynamic pressure of 300 psf that conforms to compartment venting constraints in the transonic region. The 0.25 degree misalignment also corresponds to a downrange error of approximately 6 nm at an altitude of 130,000 feet, which is within TACAN/GPS capability to correct and does not violate the delta state update criteria. @[CR 8858]

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FLIGHT RULES

10A A8-2 MISSION DURATION IMPACTS FOR TACAN/SINGLE-STRING GPS FAILURES (CONTINUED)

IMU alignment errors are typically managed on orbit to less than 0.25 degrees, and to less than 0.10 degrees for nominal deorbit. On orbit management (alignment and drift) is typically limited by the availability of star pairs with sufficient angular separation to minimize measurement errors. Additionally, HAINS gyro drift terms are typically compensated to less than one sigma (0.006 deg/hr) per axis, allowing deorbit to be performed with misalignment less than 0.10 degrees RSS. In the case of no functioning TACAN's or GPS, additional on orbit alignments or maneuvers may be required if typical star data is not available. Also, if HAINS gyro drift characteristics are not normal and cannot be adequately compensated, a delayed deorbit alignment may be required to minimize entry misalignment. It should be noted that the IMU and star tracker systems share common data paths and power sources with the TACAN's and GPS; therefore, failures of these common items may also complicate the ability to minimize IMU misalignment. ©[CR 8858]

Since MCC command delta-state capability is required to update the navigation state during entry with no functioning TACAN or GPS, IMU misalignment and associated platform drift will be managed to the extent possible to maximize the state vector accuracy produced by the onboard navigation system. This provides the best possible navigation state for the nominal entry and for an emergency deorbit/loss of comm situation.

Reference Rules {A4-151}, IMU ALIGNMENT [HC], and {A8-110}, IMU SYSTEM MANAGEMENT.
©[CR 8858]

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FLIGHT RULES

10A A8-3 GPS TIMING SYSTEM MANAGEMENT

WHEN GPS IS REQUIRED, IN THE EVENT OF TIMING SYSTEM FAILURES THAT CAUSE THE GPS AGE OF AIDING TO VIOLATE CERTIFICATION LIMITS (-5 MS TO 400 MS), THE AUTOMATED GPS TIME CORRECTION FUNCTION WILL BE ENABLED PRIOR TO EXCEEDING THE CERTIFICATION LIMITS. @[CR 8814]

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For STS-120, with TACAN data available, GPS is not required. Actions may be taken as soon as practical to maintain GPS aiding and accuracy. GPS is desirable for landing so an effort should be made to keep it aided.

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A timing system failure may cause GPS data to become degraded or unusable if the GPS age of aiding (AoA) exceeds the nominal operating range of -5 ms to 400 ms. How GPS degrades depends upon the GPC drift direction. A GPC clock that is speeding up will cause the age of aiding (AoA) to decrease from its nominal value of 240 ms. In the region from -5 ms to -960 ms, the GPS receiver will reject IMU aiding data, but the GPS state vector will still be available to NAV. At values less than -960 ms, the GPS state vector will be unaided and no longer available to NAV. A GPC clock that is slowing down will cause AoA to increase from its nominal value of 240 ms. In the region from 400 ms to 1900 ms, GPS will still accept IMU aiding data; however the GPS state will be degraded due to aiding latency. Aiding latency can cause a phenomenon called Nearly Repeated Time Tag (NRTT). NRTT's will occur at a 1HZ rate when AoA exceeds 400 ms and will result in velocity spikes up to 30 percent of vehicle acceleration causing intermittent OA3 failures. If AoA exceeds 1900 ms, the GPS state vector will not be available for use in NAV.

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GPS uses aiding data from the IMU's to propagate the GPS state vector in between GPS state updates. This data allows GPS to track satellites with increased accuracy by narrowing the satellite search window with accurate code position and rates. Without aiding data, GPS may become "lost" during dynamic flight in the plasma region on entry. GPS typically tracks three or fewer satellites during plasma, which is not sufficient to determine an accurate state vector. Without aiding data, GPS utilizes a ballistic propagation of the last known GPS state vector which does not accurately represent the orbiter's trajectory. This will result in degraded satellite acquisition, and GPS may not recover prior to landing.

If GPC clock drift causes GPS to go into unaided mode (PVA), then a GPS delta time uplink is required before the auto compensation logic will correct the timing problem.

A minimum 50-minute time limit for GPS auto time correction activation has been derived from the spec drift rates of the GPC internal timing clocks (approximately 5 ms/min), with the GPC clock speeding up. This is an estimated worst case scenario and will cause AoA to decrease from its nominal 240 ms value to -5 ms within 50 minutes, at which time GPS will reject the IMU aiding data and risk becoming "lost" during plasma. After a timing system failure has occurred, and the actual GPC drift rate is established, the time at which GPS will become degraded and/or unaided will be determined with greater accuracy. @[CR 8814]

FLIGHT RULES

ISS ONLY RULES

STAGE OPERATIONS

10A_B8-1 STAGE USTO CONSTRAINTS @[DN 37]

STAGE USTO CONTROL CONSTRAINTS ARE DEFINED IN TABLE 10A_B8-1-I. FOR USE IN A PARTICULAR OPERATION AT LEAST ONE "ALLOWED" FOR BOTH CONTROL AUTHORITY AND LOADS MUST BE TRUE.

TABLE 10A_B8-1-I - 10A STAGE USTO CONTROL CONSTRAINTS @[DN 37]

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]							
UNMATED OPERATIONS USING USTO[3]	CONTROL AUTHORITY	LOADS					
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D-YPR)	
MANEUVERS AT MANEUVER RATE IN THE PPL: 0.01 DEG/SEC							
MANEUVERS FROM +XVV TO -XVV	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVERS FROM - XVV TO +XVV	TBD	TBD	TBD	TBD	TBD	TBD	TBD
RECOVERY FROM DRIFT (MINIMAL FREE DRIFT RATES, NEAR TEA)	TBD	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD
ALL ABOVE MANEUVERS AT ADCO-REQUESTED MANEUVER RATE OF 0.05 DEG/SEC							
MANEUVERS FROM +XVV TO -XVV	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVERS FROM - XVV TO +XVV	TBD	TBD	TBD	TBD	TBD	TBD	TBD
RECOVERY FROM DRIFT (MINIMAL FREE DRIFT RATES, NEAR TEA)	TBD	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD

@[DN 23]

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FLIGHT RULES

10A_B8-1 STAGE USTO CONSTRAINTS (CONTINUED)

**TABLE 10A_B8-1-I - 10A STAGE USTO CONTROL CONSTRAINTS
(CONTINUED)**

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]							
UNMATED OPERATIONS USING USTO[3]	CONTROL AUTHORITY	LOADS					
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D-YPR)	
ATTITUDE HOLD							
AT OR NEAR TEA	TBD	TBD	TBD	TBD	TBD	TBD	TBD
NOT NEAR TEA, NOT NEAR 0,0,0	TBD	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD [2]	TBD
MANEUVERS REQUIRING SPECIFIC ANALYSIS							
VENTS	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CONTINGENCY OPERATIONS OR ANALYSIS AS NEEDED							
RECOVERY FROM DRIFT (NOT NEAR TEA)	TBD	TBD [1]	TBD [1]	TBD [1]	TBD [1]	TBD [1]	TBD

©[DN 23]

NOTES:

- [1] USTO ONLY GENERICALLY CERTIFIED FOR 0.05 DPS RATES.
- [2] USTO MUST BE TREATED AS A MANEUVER FOR LOADS CONSTRAINTS.
- [3] USTO OPERATIONS MAY REQUIRE SOLAR ARRAY AND SARJ FEATHERING. REFER TO RULE {10A_B2-45}, USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC][RC]. ©[DN 23]

10A_B8-2 U.S. THRUSTER ONLY PULSE PATTERN CONSTRAINTS [RC]

U.S. THRUSTER ONLY (USTO) CONTROLLERS MUST BE CONFIGURED TO FIRE WITH A MULTI-PULSE THRUSTER FIRING PATTERN.

Configuring USTO controllers from a single pulse desat pattern with 18-second delay to a three-pulse pattern with 18-second delay avoids high loads on the outboard arrays. The three-pulse firings will occur at 0, 4, and 8 seconds in the 18-second time period. This configuration must be used after the arrays are deployed, but also can be used pre-deploy.

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

ASSEMBLY OPERATIONS

10A_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 AND PLUME IMPINGEMENT 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 AND PLUME IMPINGEMENT 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 10A.

Reference: CSDL Memorandum, STS-120 Mated Shuttle/ISS and OBSS Operations DAP Modes and Constraints.

- B. THE MATED VRCS AND PRCS ALT DAP MODES WILL BE CONFIGURED WITH THE FOLLOWING PARAMETERS:

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C8-1 ORBITER DAP MODES AND PRIORITIES (CONTINUED)

1. NON-SRMS/SSRMS LOADED OPERATIONS:

	ALT [1]	VRCS [1]
ROT RATE (DEG/SEC)	≤ 0.1	≤ 0.1
ATTITUDE DB (DEG)	≥ 5.0	≥ 3.0
RATE DB (DEG/SEC)	0.07	0.05
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 [4]

NOTES:

- [1] ODS PRESSURE MUST BE ≥ 3.45 PSI.
- [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.

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		1,5-6 [1]

NOTES:

- [1] REFERENCE RULE {10A_C2-54}, DOCKED LOADS CONSTRAINTS [RI] [C], FOR CONTROL ACCEL APPLICABILITY.

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FLIGHT RULES

10A_C8-1 ORBITER DAP MODES AND PRIORITIES (CONTINUED)

C. 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

Verify that this is the correct version before use.

FLIGHT RULES

10A_C8-2 **MATED USTO CONSTRAINTS** @[DN 38]

MATED USTO CONTROL CONSTRAINTS ARE DEFINED IN TABLE 10A_C8-2-I. FOR USE IN A PARTICULAR OPERATION AT LEAST ONE "ALLOWED" FOR BOTH CONTROL AUTHORITY AND LOADS MUST BE TRUE.

TABLE 10A_C8-2-I - 10A MATED USTO CONTROL CONSTRAINTS @[DN 38]

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]						
MATED OPERATIONS USING USTO [1][2]	CONTROL AUTHORITY	LOADS				
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D- YPR)
MANEUVERS AT MANEUVER RATE IN THE PPL: 0.01 DEG/SEC						
MANEUVER FROM 10A DOCKING ATTITUDE TO +XVV POST DOCKING TEA (FOR NEG BETA CASE)	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVER FROM 10A DOCKING ATTITUDE TO -XVV POST DOCKING TEA (FOR POS BETA CASE)	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVER FROM 10A POST DOCKING TEA TO +XVV NODE 2 INSTALL TEA - [3]	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVER FROM 10A POST DOCKING TEA TO -XVV NODE 2 INSTALL TEA - [3]	TBD	TBD	TBD	TBD	TBD	TBD
MANEUVER FROM +XVV NODE 2 INSTALL TO +XVV POST STARBOARD RADIATOR DEPLOY TEA	TBD	TBD	TBD	TBD	TBD	TBD

@[DN 24]

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FLIGHT RULES

10A_C8-2

MATED USTO CONSTRAINTS (CONTINUED)

**TABLE 10A_C8-2-I - 10A MATED USTO CONTROL CONSTRAINTS
(CONTINUED)**

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]						
MATED OPERATIONS USING USTO [1][2]	CONTROL AUTHORITY	LOADS				
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D- YPR)
MANEUVER FROM - XVV NODE 2 INSTALL TO -XVV POST STARBOARD RADIATOR DEPLOY TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM +XVV POST STARBOARD RADIATOR DEPLOY TEA TO +XVV P6 OVERNIGHT PARK TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM - XVV POST STARBOARD RADIATOR DEPLOY TEA TO -XVV P6 OVERNIGHT PARK TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM +XVV P6 OVERNIGHT PARK TEA TO +XVV POST P6 SAW DEPLOY TEA	<u>TBD</u> [6]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM - XVV P6 OVERNIGHT PARK TEA TO -XVV POST P6 SAW DEPLOY TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM - XVV TO 10A UNDOCK ATTITUDE	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
RECOVERY FROM DRIFT (MINIMAL FREE DRIFT RATES, NEAR TEA) [5]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
WATER/SIMO DUMP	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>

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FLIGHT RULES

10A_C8-2

MATED USTO CONSTRAINTS (CONTINUED)

**TABLE 10A_C8-2-I - 10A MATED USTO CONTROL CONSTRAINTS
(CONTINUED)**

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]						
MATED OPERATIONS USING USTO [1][2]	CONTROL AUTHORITY	LOADS				
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D- YPR)
ALL ABOVE MANEUVERS MANEUVER RATE OF 0.05 DEG/SEC						
MANEUVER FROM 10A DOCKING ATTITUDE TO +XVV POST DOCKING TEA (FOR NEG BETA CASE)	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM 10A DOCKING ATTITUDE TO -XVV POST DOCKING TEA (FOR POS BETA CASE)	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM 10A POST DOCKING TEA TO +XVV NODE 2 INSTALL TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM 10A POST DOCKING TEA TO -XVV NODE 2 INSTALL TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM +XVV NODE 2 INSTALL TO +XVV POST STARBOARD RADIATOR DEPLOY TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM - XVV NODE 2 INSTALL TO -XVV POST STARBOARD RADIATOR DEPLOY TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>

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FLIGHT RULES

10A_C8-2

MATED USTO CONSTRAINTS (CONTINUED)

**TABLE 10A_C8-2-I - 10A MATED USTO CONTROL CONSTRAINTS
(CONTINUED)**

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]						
MATED OPERATIONS USING USTO [1][2]	CONTROL AUTHORITY	LOADS				
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D- YPR)
MANEUVER FROM +XVV POST STARBOARD RADIATOR DEPLOY TEA TO +XVV P6 OVERNIGHT PARK TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM -XVV POST STARBOARD RADIATOR DEPLOY TEA TO - XVV P6 OVERNIGHT PARK TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM +XVV P6 OVERNIGHT PARK TEA TO +XVV POST P6 SAW DEPLOY TEA	<u>TBD</u> [6]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM -XVV P6 OVERNIGHT PARK TEA TO -XVV POST P6 SAW DEPLOY TEA	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM -XVV TO 10A UNDOCK ATTITUDE	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
RECOVERY FROM DRIFT (MINIMAL FREE DRIFT RATES, NEAR TEA) [5]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
WATER/SIMO DUMP	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>

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FLIGHT RULES

10A_C8-2

MATED USTO CONSTRAINTS (CONTINUED)

**TABLE 10A_C8-2-I - 10A MATED USTO CONTROL CONSTRAINTS
(CONTINUED)**

10A USTO CONTROL USAGE MULTI-PULSE PATTERNS [0 4 8]						
MATED OPERATIONS USING USTO [1][2]	CONTROL AUTHORITY	LOADS				
		(SM-YPR)	(SM-YP + PROG-R)	(SM-R + PROG-YP)	(PROG-YPR)	(PROG R&D- YPR)
ATTITUDE HOLD						
AT OR NEAR TEA (INCLUDING SMALL MANEUVERS DUE TO ORBITER DEADBANDS)	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
NOT NEAR TEA, NOT NEAR 0,0,0 [5]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
HOLD AT 10A UNDOCK ATTITUDE	<u>TBD</u> [6]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVERS REQUIRING SPECIFIC ANALYSIS						
VENTS	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
CONTINGENCY OPERATIONS						
10° ROLL MANEUVER FROM TEA FOR SAW JETTISON CONTINGENCY AT 0.1°/SEC	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
MANEUVER FROM - XVV TEA TO LVLH (0, 90, 0) FOR CSCS SEPARATION OF DAMAGED ORBITER [4]	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>	<u>TBD</u>
RECOVERY FROM DRIFT (NOT NEAR TEA) [5]	<u>TBD</u>	<u>TBD</u> [4]	<u>TBD</u> [4]	<u>TBD</u> [4]	<u>TBD</u> [4]	<u>TBD</u>

©[DN 24]

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FLIGHT RULES

10A_C8-2

MATED USTO CONSTRAINTS (CONTINUED)

NOTES:

- [1] USTO OPERATIONS MAY REQUIRE SOLAR ARRAY AND SARJ FEATHERING. REFER TO RULE {10A_B2-45}, USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING [HC] [RC]. @[DN 24]
- [2] SOME ASSEMBLY OPERATIONS REQUIRE THRUSTER INHIBITS, REFER TO RULE {10A_C2-74}, DOCKED LOADS CONSTRAINTS [HC] [RI] [C].
- [3] CSA ANALYSIS OF SSRMS NODE 2 CONFIGURATION FOR LOADS SHOULD BE REFERENCED IN RULE {10A_C2-74}, DOCKED LOADS CONSTRAINTS [HC] [RI] [C].
- [4] USTO ONLY GENERICALLY CERTIFIED FOR 0.05 DPS RATES (OR LESS) FOR STRUCTURAL LOADS.
- [5] USTO MUST BE TREATED AS A MANEUVER FOR LOADS CONSTRAINTS.
- [6] A LOAC MAY OCCUR IF THE USTO IS INCORPORATED AND THE MNVR RATE IMMEDIATELY CHANGED TO 0.05 DPS. FIRST, INCORP USTO AND KEEP THE DEFAULT MNVR RATE OF 0.01 DPS UNTIL ISS GOES FROM 0 INERTIAL RATE UP TO AN INERTIAL RATE OF 0.01+ORBIT RATE (APPROX 12 MIN), THEN CHANGE MNVR RATE TO 0.05 DPS. THE MNVR CAN GET STARTED AT 0.01 DPS, BUT IMMEDIATELY TRYING TO GET ISS UP TO AN INERTIAL RATE OF 0.05+ORBIT RATE WILL BE TOO MUCH FOR THE USTOS TO HANDLE, AT LEAST FOR SOME OF THE POSSIBLE INITIAL XPOP ORIENTATIONS.
- [7] BUT NOT FOR ORBITER PROXIMITY OPERATIONS @[DN 24]

FLIGHT RULES

10A_C8-3

ANALYZED CMG MOMENTUM CAPABILITY DURING DYNAMIC OPERATIONS

THE RECOMMENDED USE OF THE CMG ATTITUDE CONTROL SYSTEM IS SHOWN FOR THE FOLLOWING ANALYZED OPERATIONS:

OPERATION	CCDB VERSION ID	RECOMMEND EXECUTING THE NOMINAL OPERATION:			IF THE NOMINAL OP IS NOT RECOMMENDED, CONTINUE WITH OP FOLLOWING THESE CONSTRAINTS
		WITH 4 CMG'S	WITH 3 CMG'S	WITH 2 CMG'S	
NODE 2 INSTALL	XXXXX MNVR FROM POST DOCK TEA TO NODE 2 PRE-INSTALL TEA (+XVV)	YES	TBD	TBD	TBD
	XXXXX MNVR FROM POST DOCK TEA TO NODE 2 PRE-INSTALL TEA (-XVV)	YES	TBD	TBD	TBD
	XXXXX NODE 2 PRE-INSTALL TO INSTALL (+XVV)	YES	TBD	TBD	TBD
	XXXXX NODE 2 PRE-INSTALL TO INSTALL (-XVV)	YES	TBD	TBD	TBD
P6 DEMATE TO ONP	XXXXX MNVR FROM NODE 2 INSTALL TEA TO P6 ONP TEA (+XVV)	YES	TBD	TBD	TBD
	XXXXX MNVR FROM NODE 2 INSTALL TEA TO P6 ONP TEA (-XVV)	YES	TBD	TBD	TBD
P6 INSTALL	XXXXX MNVR FROM P6 ONP TEA TO P6 PRE-INSTALL TEA (+XVV)	YES	TBD	TBD	TBD
	XXXXX MNVR FROM P6 ONP TEA TO P6 PRE-INSTALL TEA (-XVV)	YES	TBD	TBD	TBD
	XXXXX P6 PRE-INSTALL TO INSTALL (+XVV)	YES	TBD	TBD	TBD
	XXXXX P6 PRE-INSTALL TO INSTALL (-XVV)	YES	TBD	TBD	TBD
4B/2B DEPLOY	XXXXX (+XVV)	YES	TBD	TBD	TBD
	XXXXX (-XVV)	YES	TBD	TBD	TBD

©[DN 25]

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FLIGHT RULES

10A_C8-3

ANALYZED CMG MOMENTUM CAPABILITY DURING DYNAMIC OPERATIONS (CONTINUED)

The ISS GNC analysis has been completed based on the nominal Robotics Timeline or other respective products provided by the respective disciplines to define the nominal operation, such as using SSRMS coarse or vern rates. There are many variables which can result in a different momentum from what was analyzed, such as an Momentum Management CCDB controller that has not had sufficient time to settle out, unexpected external torques, updates in the attitude determination system that can cause a disturbance in the control system, and CMG Loss of Comm Failures that are automatically recovered. Thus, a momentum margin of approximately 20 percent is desired to account for these uncertainties.

The following notes are analysis that has been completed and presented to the ISS Program:

TBD (EXPECTING THE ANALYSIS TO FILL IN THE **TBD**'s AT L-6 WEEKS)

FLIGHT RULES

10A_C8-4

ORBITER/STATION ATTITUDE CONTROL AND MANEUVER CONSTRAINTS AND PRIORITIES [HC] [RC]

MATED STACK ATTITUDE CONTROL IS PER RULE {C8-51}, ORBITER/STATION ATTITUDE CONTROL AND MANEUVER CONSTRAINTS AND PRIORITIES [HC] [RC], EXCEPT FOR THE FOLLOWING: @[DN 22]

A. MATED STACK ATTITUDE CONTROL

ATTITUDE CONTROL WILL BE PROVIDED ACCORDING TO THE FOLLOWING PRIORITY LIST:

1. ISS, CMG MOMENTUM MANAGEMENT
2. ORBITER VRCS (PROP ALLOWING)
3. ISS, CMG/THRUSTER ASSIST, ATTITUDE HOLD (USTO)
4. ISS, RUSSIAN THRUSTERS ONLY
5. ORBITER ALT DAP/PRCS (PROP ALLOWING)

Use of shuttle-based attitude control conserves ISS propellant, though there are concerns with the level of protection for inadvertent thruster firing modes. The following mitigation steps have been taken: OV-104 wiring was inspected to mitigate the wire-to-wire short mode, all OV-104 RJD's were screened for Darlington Pair failures, and RJDA 1 and JDF 2 was removed and replaced with boxes known to be free of tin whiskers. The shuttle and ISS Programs have accepted this risk per NCR-ISS-063-10A.

The "tin whiskers" and wire-to-wire short inadvertent thruster firing modes are zero-fault tolerant even on VRCS. The "tin whiskers" inadvertent firing mode is a pin to pin short caused by a free-floating tin whisker coming in contact with pins inside the J1 connector of the transformer-rectifier cards inside the Reaction Jet Driver (RJD). This failure mode exceeds load limits with VRCS, but not with ALT DAP control, since the ALT DAP limits thruster firing times to 80 milliseconds. The wire-to-wire short failure mode is a short of a powered wire to a thruster valve solenoid wire. These thruster command wires are bundled with many wires, including power lines. A short to power could occur, either through direct contact due to damaged insulation, or because of arctracking of the kapton insulation. However, to screen for electrical shorts of this nature all equipment that might be powered during the course of nominal docked operations is cycled prior to docking (Rule {C2-59}, ORBITER EQUIPMENT POWER VERIFICATION [HC]). @[DN 22]

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FLIGHT RULES

10A_C8-4

ORBITER/STATION ATTITUDE CONTROL AND MANEUVER CONSTRAINTS AND PRIORITIES [HC] [RC] (CONTINUED)

The "tin whiskers," wire-to-wire short, and Darlington Pair transistor failure inadvertent thruster firing modes are all zero-fault tolerant on PRCS. The Darlington Pair failure mode could only occur while the RJD box is activated. In this failure mode, a single Darlington transistor pair failure could cause an inadvertent firing of an orbiter primary RCS jet. Testing has been done on a sample of flight and flight spare transistors, which did not identify any aging effects. Additional vibration testing has been performed on all but three RJD LRU's with no evidence of shorts that might result from particle contamination in the transistor cans. These failure modes exceed load limits if they occur in combination with an ALT DAP firing. @[DN 22]

Every effort will be made to minimize the duration of PRCS use including doing the maneuver to undock attitude under Russian control. The ability to perform reboost of the mated stack is not a certified capability of the ISS at this time. As such, shuttle ALT DAP/PRCS is the only resource available as a backup for reboost during mated operations. If the PRCS control option is utilized, ISS Environments analysis for erosion and contamination will need to be performed real time. In addition, minimizing the duration of PRCS use helps to protect against the identified failure modes that could lead to a 1.3 second inadvertent jet firing, which may exceed ISS ICS structural limits.

Use of USTO controllers preserves operational simplicity but does not necessarily introduce any efficiency from a propellant usage standpoint. Therefore, use of USTO controllers for ISS-based attitude should be prioritized above Russian thrusters, where available. @[DN 22]

The CMG Failure Investigation Team (FIT) has recommended that RS thrusters only be prioritized above CMG Thruster Assist (TA) Attitude Hold (non-USTO controller). Preliminary investigations revealed that frequent desaturations combined with high inner and outer gimbal rates could be a contributing factor to the failure. Such situations can occur during large attitude maneuvers on CMG TA and in periods of extended attitude hold. Until this can be exonerated, CMG TA for attitude hold that will generate frequent desaturations and large maneuvers on CMG TA should be the lowest priority. Reference SSP 50261-02, 8.12.3 CMG Attitude Control Constraints.

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FLIGHT RULES

10A_C8-4

ORBITER/STATION ATTITUDE CONTROL AND MANEUVER CONSTRAINTS AND PRIORITIES [HC] [RC] (CONTINUED)

- B. THE ORBITER WILL PROVIDE ATTITUDE CONTROL AND PERFORM ATTITUDE MANEUVERS FOR THE STACK UNTIL THE CAPABILITY EXISTS ON THE STATION AND AT LEAST ONE OF THE FOLLOWING ARE TRUE:
1. THE ORBITER CAN NO LONGER CONTROL THE MATED STACK.
 2. THE MISSION PRIORITIES DICTATE THAT STATION WILL PROVIDE ATTITUDE CONTROL AND/OR PERFORM MANEUVERS FOR THE FLIGHT/PHASE IN QUESTION.
 3. THE STATION CAN CONTROL THE STACK NON-PROPULSIVELY WITHIN MISSION CONSTRAINTS, EXCLUDING ATTITUDE MANEUVERS.

Nominal shuttle missions (e.g., nominal MECO and rendezvous, etc.) will provide some amount of propellant above the mission completion redline which could be used for mated attitude control and maneuvers of the stack. When practical, orbiter propellant will be used in order to conserve ISS propellant. For cases when the station can control the stack non-propulsively, it is reasonable to take advantage of this capability as long as it does not deplete station resources. This would conserve orbiter propellant for use in performing maneuvers.

Neither the orbiter nor the station will be able to control the mated stack for all configurations due to propellant or controllability limitations. A baseline plan for which vehicle is to be the "controlling vehicle" will be dictated by orbiter propellant margins, station and orbiter capabilities, and Program priorities for the "controlling vehicle" (i.e., which vehicle controls during which phase).

- C. ISS WILL NOMINALLY HOLD ATTITUDE USING CMG MOMENTUM MANAGEMENT. IF CMG MOMENTUM MANAGEMENT IS UNAVAILABLE, ORBITER VRCS OR ISS USTO ATTITUDE CONTROL ARE AVAILABLE.
 ©[DN 22]

VIPER has performed analysis and has showed that VRCS and USTO control are acceptable methods of attitude hold control. ©[DN 22]

FLIGHT RULES

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FLIGHT RULES

SECTION 9 - ELECTRICAL

SHUTTLE ONLY RULES

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ISS ONLY RULES

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JOINT SHUTTLE/ISS RULES

GENERAL

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FLIGHT RULES

SECTION 9 - ELECTRICAL

SHUTTLE ONLY RULES

10A_A9-1 PAYLOAD BAY FLOODLIGHTS

A. PAYLOAD BAY FLOODLIGHT CONSTRAINTS @[DN 50] @[CR 8828A]

OPERATION OF THE PAYLOAD BAY FLOOD LIGHTS IS LIMITED TO THE FOLLOWING CONSTRAINTS: MAXIMUM DUTY CYCLE.

<u>ORBITER ATTITUDE</u>	<u>LIGHTS 1 AND 2</u>	<u>LIGHTS 3 AND 4</u>	<u>LIGHTS 5 AND 6</u>
<u>NODE 2 IN THE PAYLOAD BAY: (NOT BAY-TO-SUN)</u>	<u>NO CONSTRAINTS</u>	<u>NO CONSTRAINTS</u>	<u>OFF AT ALL TIMES</u>
<u>NODE 2 IN THE PAYLOAD BAY: +ZSI (BAY-TO-SUN)</u>	<u>NO CONSTRAINTS</u>	<u>INTERMITTENT OPERATION ON 20 MIN/OFF 30 MIN</u>	<u>OFF AT ALL TIMES</u>
<u>NODE 2 NOT IN PAYLOAD BAY: ALL ATTITUDES</u>	<u>NO CONSTRAINTS</u>	<u>NO CONSTRAINTS</u>	<u>NO CONSTRAINTS</u>

The Payload Bay Flood Light (PBFL) operational constraints are based on PBFL 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-120 Boeing Tech. Memo No. TS-TM-07-009, dated February 16, 2007. @[CR 8828A]

B. PAYLOAD BAY FLOODLIGHTS SHOULD BE OFF 15 MINUTES BEFORE THROUGH 5 MINUTES FOLLOWING MAUI DATA TAKE ACTIVITIES.

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.

Deleted: PAYLOAD BAY FLOODLIGHT CONSTRAINTS
A. OPERATION OF THE PAYLOAD BAY FLOOD LIGHTS IS LIMITED TO THE FOLLOWING CONSTRAINTS: MAXIMUM DUTY CYCLE.
TBD @[DN 50]

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FLIGHT RULES

10A_A9-2

FUEL CELL PURGE CONSTRAINTS

FUEL CELL PURGES SHOULD NOT BE PERFORMED 15 MINUTES BEFORE THROUGH 5 MINUTES FOLLOWING MAUI OR RAMBO DATA TAKE ACTIVITIES. ©[DN 51]

The fuel cell purges could be a source of contamination to the optical data taken during a MAUI or RAMBO 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; RAMBO Payload Integration Plan, Basic + CHG 1, paragraph 4.2.2.4, May 6, 2002. ©[DN 51]

FLIGHT RULES

ISS ONLY RULES

GENERAL

10A_B9-1 POWER TRANSFER TO THE RSOS FROM THE USOS [RC]

FOLLOWING FGB SOLAR ARRAY RETRACTION, USOS TO RSOS POWER TRANSFER WILL REQUIRE TWO ARCU'S TO SUPPLY FGB POWER DEMAND. ARCU'S SHALL BE POWERED FROM DIFFERENT USOS POWER DOMAINS. @[DN 95]

The requirement for separate ARCU power sources mitigates FGB power loss and re-start issues. Reference VIPER/khrrunichev protocols 2006, VIPER-Russian Videocon 2007. @[DN 95]

A. NOMINAL ARCU/CHT CONFIGURATION BASED ON EXPECTED POWER TRANSFER TO THE RSOS IS SHOWN IN THE FOLLOWING TABLES. TABLE I GIVES THE PLANNED ARCU/CHT CONFIGURATION FOR A GIVEN ATTITUDE AND BETA ANGLE. TABLE II GIVES THE EXPECTED RS POWER DRAW FROM THE ACTIVE ARCU/CHT'S. IF RACU 6 IS POWERING POWER BUS N1RS1, POWER TRANSFER TO THE FGB INCLUDES 228 WATTS TRANSFERRED TO NODE 1 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). @[DN 94]

TABLE 10A_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 POST SOLAR ARRAY RETRACTION	+ZLV ±XVV	2	2	2	2	2	2	2	2	2	2	2	2
SM # OF CHT'S	±XVV W/O ROLL	2	2	2	2	3	3	3	3	3	3	3	3
	±XVV W/30° ROLL	2	2	2	2	2	2	2	2	2	2	2	2
	±XVV W/40° ROLL	2	2	2	2	2	2	2	2	2	2	2	1

@[DN 93]

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FLIGHT RULES

10A_B9-1

POWER TRANSFER TO THE RSOS FROM THE USOS [RC]
(CONTINUED)

**TABLE 10A_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 # OF ARCU'S POST SOLAR ARRAY RETRACTION	+ZLV ±XVV	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
SM PWR RQMT	±XVV W/O ROLL	2.76	2.82	3.0	3.36	3.84	3.96	4.38	4.44	4.80	5.10	5.28	5.40
	±XVV W/30° ROLL	3.30	3.00	2.94	2.88	2.82	2.82	2.94	2.94	3.00	3.12	3.06	2.95
	±XVV W/40° ROLL	3.60	3.26	3.00	2.82	2.76	2.82	2.82	2.82	2.64	2.46	1.92	1.44

©[DN 93]

PLANNED EXCEEDENCES OF THE RS POWER DRAW IN TABLE II MUST BE COORDINATED WITH MCC-H AT LEAST 48 HOURS IN ADVANCE OF THE EXCEEDENCE 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. Effective beta only applies to the LVLH case, and 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). 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 (Russian transfer include solar array degradation based on 12A.1 late August 06 launch).

B. FOR THE OFF-NOMINAL CASE OF HAVING TO PLACE THE 2A, 3B, 4A, OR 4B BGA OR EITHER SARJ IN A PARKED POSITION DUE TO ANOMALOUS OPERATION, 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 either BGA or SARJ is placed in a parked position, solar array power generation can be 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.

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FLIGHT RULES

10A_B9-1

POWER TRANSFER TO THE RSOS FROM THE USOS [RC]
(CONTINUED)

DOCUMENTATION: DF75 Power Analysis as reported to 9A/11A JOP, September 3, 2002. Flight 12A EPS Energy Balance for Stage Integration Review #7, May 2002.

- C. POWER TRANSFER TO THE RSOS FROM THE USOS DURING DOCKING, UNDOCKING, AND WATER DUMPS WILL BE LIMITED TO ONE SM CHT AND TWO 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 28 KW AND EACH SM CHT OUTPUT DRAWS UP TO 1.5 KW. @[DN 95]

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 AND CERTAIN MATED ASSEMBLY OPERATIONS 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. DURING P6 INSTALLATION, INITIAL CHARGING (WITH BACKFEED FROM P4) OF P6 BATTERIES, AND DEPLOYMENT OF P6 ARRAYS, POWER TRANSFER TO THE RSOS FROM THE USOS MAY BE LIMITED TO A MAXIMUM OF ONE SM CHT AND NO FGB ARCU'S AS NECESSARY TO MAINTAIN CHANNEL LOADS BELOW THE BDCU RULE LIMIT AND MAINTAIN ENERGY BALANCE. 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 an SSU is being shunted due to a Plasma Contactor Unit loss during S3/S4 initial activation, initial battery charging, and S4 array deployment at all of the possible beta angles and ISS attitudes that may be encountered. Determinations of the actual powerdown required will be made real time.

DOCUMENTATION: DF75 USOS Energy Balance Analysis, August 2002; Flight 12A EPS Energy Balance Analysis for Stage Integration Review #7, May 2002.

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FLIGHT RULES

10A_B9-1

POWER TRANSFER TO THE RSOS FROM THE USOS [RC]
(CONTINUED)

- E. FOR THE OFF NOMINAL CASE OF BEING CONSTRAINED, BY A FAILURE, TO ATTITUDE CONTROL BY THRUSTERS, 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.
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. THE BETA ANGLE IS LESS THAN -44 OR GREATER THAN +38 DEGREES.

Power analysis indicates that at high betas 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. 12A.1 Power Analysis, Russian TIM, July - August 2002. 12A.1 TIM Agreement, June 2003. @[DN 95] @[DN 94]

FLIGHT RULES

10A_B9-2

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 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, RBI'S 1, 2, 3, AND 4 CLOSURE 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

10A B9-2 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

10A_B9-2

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.

FLIGHT RULES

10A_B9-3

PLANNED P6 POWER CHANNEL DORMANCY

THE CONFIGURATION OF P6 POWER CHANNELS DURING PLANNED DORMANCY AFTER SOLAR ARRAY RETRACTION SHALL BE BASED UPON THE FOLLOWING LIST OF PRIORITIZED OPTIONS:

- A. POWER CHANNEL HARDWARE ACTIVE, WITH BATTERIES TRICKLE CHARGED.

Maintaining the dormant power channel in this configuration protects all the hardware from exceeding thermal limits and allows the dormant channel to act as another source of battery energy should a temporary BCDU loss occur on the active channel.

This configuration also minimizes hardware power cycles, Pump Flow Control Subassembly (PFCS) pump on/off cycles, and operator overhead.

1. THE MODE REGULATION SETPOINT FOR THE DORMANT CHANNEL WILL BE SET NO (MORE/LESS) THAN 6 VOLTS BELOW THAT OF THE ACTIVE CHANNEL.

Control of the mode regulation setpoint is required for two reasons.

The setpoint for the dormant channel must be low enough that the dormant channel's batteries do not discharge while the active channel's batteries are discharging. Doing so would incur voltage stability risks that might cause total loss of both channels.

The setpoint for the dormant channel must be high enough that it can provide adequate voltage should the active channel suffer temporary loss of its BCDU's.

2. THE DORMANT POWER CHANNEL'S CHARGE CURRENT PREPOSITIONED LOAD (PPL) WILL BE UPDATED TO REDUCE TRICKLE CHARGE CURRENT LEVELS TO 1 AMP.

The batteries being trickle charged should be monitored to ensure that they are charging (voltage and SOC rising towards full charge values). If any battery is showing signs of not charging (voltage and SOC not rising), then the charge current should be commanded to a value 1 Amp higher.

Continue to monitor battery voltages and SOC until all batteries are showing signs of trickle charge.

The special PPL reduces power requirements by reducing the trickle charge level to 1 Amp. The lower trickle charge current also reduces cell heating. In the event the batteries on the dormant channel are discharged due to being used as a parachute channel, PPL's with higher charge currents can be uploaded temporarily to recharge the batteries provided energy balance permits.

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FLIGHT RULES

10A_B9-3

PLANNED P6 POWER CHANNEL DORMANCY (CONTINUED)

3. THE SSU ON THE DORMANT POWER CHANNEL WILL BE POWERED OFF. THE DC RBI THAT PROVIDES CONTROL POWER TO THE POWERED DOWN SSU WILL BE LEFT OPEN, ALL OTHERS WILL REMAIN CLOSED.

The SSU requires 60 Watts when active. Since both P6 SSU's have EEPROM's with Error Correction enabled, and there are no temperature issues for the SSU's, it is most convenient to leave the SSU powered down.

- B. POWER CHANNEL HARDWARE ACTIVE, BCDU POWER CONVERTERS OFF, BATTERIES SELF-DISCHARGING. THE BATTERIES SHOULD NOT BE ALLOWED TO DROP BELOW 96 VOLTS.

This saves approximately 600 Watts, but means that the dormant power channel's batteries are no longer available as backup for the active channel's batteries. The batteries under self-discharge are expected to last for several weeks before reaching 96 Volts.

- C. BATTERIES WILL BE BOOST CHARGE WHEN REQUIRED

If the batteries drop to 96 Volts or 1.1 volts per battery cell, they must be boost charged. The P6 batteries have lost their Hydrogen "precharge" since first used on flight 4A. When the batteries are continuously cycled, the loss of this precharge is not a problem. However, industry testing of Nickel Hydrogen batteries demonstrates that they will lose capacity when stored discharged for long periods. To avoid this capacity loss, the batteries should not be allowed to drop below 96 volts or 1.1 volts per battery cell for any appreciable period of time.

When a battery voltage drops to 96 volts or 1.1 volts per battery cell, it should be recharged 10 amp hours at 10 amps charge rate or trickle charge should be restored.

- D. POWER CHANNEL HARDWARE INACTIVE, BATTERIES MAINTAINED IN "BOOST CHARGE" CONFIGURATION.

This configuration saves additional power over the other choices, but requires that hardware be power cycled repeatedly. Doing so threatens ORU reliability. Each power cycle of an ORU that contains EEPROM's without error correction enabled also requires a preemptive EEPROM refresh before the ORU is powered down.

When a battery voltage drops to 96 volts, it should be recharged 10 amp hours or trickle charge should be restored.

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FLIGHT RULES

10A_B9-3 PLANNED P6 POWER CHANNEL DORMANCY (CONTINUED)

- E. SHORT TERM DEVIATIONS FROM OPTION A SHOULD BE ACCOMPLISHED BY OPENING RBI 6 ON THE DORMANT POWER CHANNEL AND ALLOWING ITS BATTERIES TO DISCHARGE TO SUPPLY THE CHANNEL HARDWARE'S POWER REQUIREMENTS.

The batteries should be able to support the channel loads for several hours in this configuration.

10A_B9-4 PLASMA HAZARD MITIGATION DURING EVA [HC] [RC]
@[DN 43]

- A. DURING NOMINAL EVA PERIODS, HAZARD CONTROLS ARE REQUIRED AS FOLLOWS:
1. TWO PCU'S ACTIVE IN DISCHARGE MODE.
 2. ONE OF THE FOLLOWING:
 - a. CCS PCU EVA HAZARD CONTROL ENABLED
 - b. NO MORE THAN TWO ARRAYS UNSHUNTED
 - c. NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR
- B. IN THE EVENT OF PCU FAILURE DURING AN EVA, CCS PCU EVA HAZARD CONTROL, IF ENABLED, WILL SHUNT ALL ACTIVE SOLAR ARRAYS. CHANNEL LOADS WILL BE REDUCED SO THAT THE EVA MAY CONTINUE WITH ONE OR ZERO ACTIVE PCU'S AFTER ONE OF THE FOLLOWING CONFIGURATIONS HAS BEEN ESTABLISHED:
1. NO MORE THAN TWO ARRAY UNSHUNTED
 2. NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR AND UNSHUNT ALL ARRAYS

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FLIGHT RULES

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PLASMA HAZARD MITIGATION DURING EVA [HC] [RC]
(CONTINUED)

- C. IF METHODS OUTLINED IN PARAGRAPH B DO NOT ACHIEVE SATISFACTORY PREDICTED BATTERY SOC, THEN THE EVA SHOULD BE TERMINATED TO ALLOW NORMAL ARRAY OPERATIONS.
- D. IN THE EVENT OF ONE OR TWO PCU FAILURE(S) PRIOR TO AN EVA, THE EVA MAY PROCEED PROVIDED ONE OF THE FOLLOWING CONFIGURATIONS HAS BEEN ESTABLISHED:
1. NO MORE THAN TWO ARRAYS ARE UNSHUNTED.
 2. NO MORE THAN TWO ARRAYS ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR

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 provides 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 0 degrees or more 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.

Hazard Report ISS-EVA-312 identifies a catastrophic shock hazard to EVA crewmembers due to vehicle arcing through the EMU suit. Electrical currents generated by vehicle arcing may pass through an EMU suit and crewmember when the vehicle floating potential is more negative than -40V.

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.

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FLIGHT RULES

10A_B9-4

PLASMA HAZARD MITIGATION DURING EVA [HC] [RC]
(CONTINUED)

- E. IN THE EVENT AN EVA CREWMEMBER IS REQUIRED TO TRANSLATE OUTBOARD OF THE SARJ WHEN A PCU IS FAILED, AND PREFLIGHT ANALYSIS SHOWING THE ENVIRONMENTAL CONDITIONS DURING THE EVA MAY VIOLATE THE -40V REQUIREMENTS, THE USOS WILL CONTROL PLASMA ARCING WITH ONE OF THE FOLLOWING METHODS:
1. NO MORE THAN ONE ARRAY UNSHUNTED ONLY WHEN THE EVA CREWMEMBER IS POSITIONED OUTBOARD OF THE SARJ.
 2. NO MORE THAN ONE ARRAY ORIENTED LESS THAN 90 DEGREES FROM THE VELOCITY VECTOR ONLY WHEN THE EVA CREWMEMBER IS POSITIONED 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 Reddell and Leonard Kramer, August 9, 2005.

FLIGHT RULES

10A_B9-5 PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)
RADIATOR DEPLOY CONSTRAINTS AND MINIMUM
REQUIREMENTS [HC]

A. P6 PVTCS RADIATOR DEPLOY PREPARATION VERIFICATION

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 P6 PVTCS RADIATOR, ROTATION OF THE PORT TRRJ WILL BE STOPPED ONLY IF THE ETCS RADIATOR OBSTRUCTS THE VIEW OF P6 RADIATOR.

Dynamic loads due to TRRJ rotation are minimal, and therefore, not a concern during radiator deploy operations.

- b. FOR DEPLOY OF THE P6 PVTCS RADIATOR, ROTATION OF THE PORT SARJ WILL BE STOPPED AND LOCKED AT 90 DEGREES. THERE ARE NO CONSTRAINTS ON STARBOARD SARJ ROTATION.
©[DN 90]

Prior to deploy operations, rotation of the adjacent 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).
©[DN 90]

Prior to deploy operations, all applicable articulated mechanisms will be positioned to ensure significant structural clearance during the entire activity.

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FLIGHT RULES

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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/F10A, August 20, 2002, Kim Tran.

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).

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FLIGHT RULES

**10A_B9-5 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.

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 10A_B9-5-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.

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FLIGHT RULES

10A_B9-5

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.

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.

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FLIGHT RULES

10A_B9-5

PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)
RADIATOR DEPLOY CONSTRAINTS AND MINIMUM
REQUIREMENTS [HC] (CONTINUED)

2. MINIMUM REQUIREMENTS FOR TASK COMPLETION

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.

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FLIGHT RULES

10A_B9-5 PHOTOVOLTAIC THERMAL CONTROL SYSTEM (PVTCS)
RADIATOR DEPLOY CONSTRAINTS AND MINIMUM
REQUIREMENTS [HC] (CONTINUED)

3. FAILURE RESPONSE

- 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.

10A_B9-6

RESERVED @[CR 8818]

Deleted: EXCEPTIONS TO
GENERIC RULE B9-154
PARAGRAPH H BCDU OUTPUT
POWER LIMIT

FLIGHT RULES

10A_B9-7

PMCU/PVCU MANAGEMENT

WHEN ALL REMOTE TERMINALS (RT'S) ON A SINGLE 1553 BUS UNDER THE PMCU MDM ARE POWERED BY THE SAME POWER CHANNEL, THE FOLLOWING PREFERENCE SHOULD BE USED TO SELECT ANY LONG-TERM PRIMARY PVCU UNDER THE PMCU:

- A. SELECT A PVCU WHERE THE DOWNSTREAM LOADS HAVE A PARACHUTE CHANNEL ALTERNATIVE POWER SOURCE

Simultaneous PVCU failure and associated power channel failure will not cause loss of downstream power immediately; therefore, the PMCU will not fail due to loss of RT's.

- B. SELECT A PVCU POWERED BY THE SAME POWER CHANNEL AS THE PRIMARY PMCU

If the PMCU fails due to power loss at the same time as the simultaneous PVCU failure and associated power channel failure, the PMCU FDIR will not have time to activate.

The PMCU/PVCU cascading failure creates a scenario that when a PVCU failure and PMCU loss of all RT's on a single bus failure coincide, PMCU FDIR can leave the previously backup PVCU as operational, but leaves the PVM channel modes (for both lower and upper channels) as fully commanded. The PVCU will not update battery charge current setpoint or perform thermal control while in fully commanded mode. This may cause PFCS, BCDU, battery trip for thermal reasons. Current setpoints must be commanded by the operator for each BCDU manually. The operator should command the mode to Non-Solar Tracking, with BGA null mode as soon as possible. The PMCU continues to fail to diagnostics and it could be as long as 45 minutes before Redundancy Management (RM) recovers the backup PMCU. ©[DN 84 1

Additionally, the ground and/or crew must complete channel mode recovery before possible battery under-temperature condition and cross-domain channel failure due to the fully-commanded channel mode condition. This workaround may require ground or crew interaction after PMCU transition to recover PVCU insight because a non-default PVCU could be primary. Automatic load shed protection is unavailable until this recovery manual interaction is completed.

FLIGHT RULES

10A_B9-8 **PVCU LOSS RESPONSE**

THE FOLLOWING ACTIONS ARE REQUIRED FOR THE AFFECTED PVM AFTER LOSS OF A SINGLE PVCU:

- A. PV ARRAY MANAGEMENT POSITIONS SHOULD BE CONSTRAINED TO ENSURE THAT UPON LOSS OF COMM TO THE REMAINING PVCU, THE BGA'S WILL BE PARKED AT THE FOLLOWING ANGLE:

MDM	BGA	ANGLE
P4 PVCU	2A	90
	4A	270
P6 PVCU	2B	270
	4B	90
S4 PVCU	1A	90
	3A	270

THIS MAY BE ACCOMPLISHED AS FOLLOWS:

1. BGA'S WILL BE PARKED AND LATCHED AT THE ANGLE SPECIFIED TO PROTECT FOR THRUSTER FIRINGS WITH A ROTATING SARJ.
2. AT HIGH BETA ANGLES, CONSIDERATION CAN BE GIVEN TO PARKING THE SARJ AT AN ANGLE THAT ALLOWS FOR BGA ROTATION TO TRACK THE SUN PROVIDED THE FOLLOWING CONDITIONS ARE MET:
 - a. FIRST COMMAND TO DIRECTED POSITION WITHIN AT THE SPECIFIED ANGLE 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

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-8

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.

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 PVCU fails, the consequences will be a complete loss of power from the affected power module.

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.

SARJ rotation is unaffected by PVCU loss as long as the SARJ is operating in the inboard mode. At low beta angles (< 45 deg), the given positions for BGA's will provide adequate power with load management. At high beta angles, it may be possible to park the SARJ and allow the BGA's to track the sun using the Angle Hold contingency setup to provide sufficient power to continue to support loads.

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 thruster firing. SARJ feathering on the alpha axis will still be possible with no operational PVCU's.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-8 PVCU LOSS RESPONSE (CONTINUED)

- B. IN THE EVENT OF PVCU LOSS ON EITHER THE P6, P4, OR S4 POWER MODULES, CRITICAL ISS FUNCTIONS SHOULD BE TRANSFERRED TO THE OTHER POWER MODULES. THE POWER MODULE WITH THE FAILED PVCU SHOULD BE USED TO PROVIDE ONLY BACKUP FUNCTIONS WHEREVER POSSIBLE. ©[DN 109]
1. IF A P6 PVCU FAILS AFTER SAW 2B HAS BEEN DEPLOYED AND CHANNEL 2B HAS BEEN ACTIVATED, ALL PRIMARY FUNCTIONS SHOULD BE TRANSFERRED TO CHANNEL 1A. CONSIDERATION WILL BE GIVEN TO TRANSFERRING ALL CHANNEL 2B LOADS TO 2A.
 2. IF A P4 PVCU FAILS BEFORE SAW 2B HAS BEEN DEPLOYED AND CHANNEL 2B HAS BEEN ACTIVATED, PRIMARY FUNCTIONS SHOULD BE TRANSFERRED TO CHANNEL 1A. CONSIDERATION WILL BE GIVEN TO TRANSFERRING ALL CHANNEL 2A LOADS TO 3A.
 3. IF A S4 PVCU FAILS, PRIMARY FUNCTIONS SHOULD BE TRANSFERRED TO CHANNEL 2A OR CHANNEL 2B. CONSIDERATION WILL BE GIVEN TO TRANSFERRING ALL CHANNEL 1A LOADS TO 4A.
 4. BOTH CHANNELS ON THE POWER MODULE WITH THE FAILED PVCU WILL BE CONFIGURED TO SLAVE MODE TO SUPPORT POSSIBLE SEAMLESS POWER CHANNEL HANDOVER UPON FAILURE OF THE SECOND PVCU. ©[DN 109]

Each PV module powers one full string of critical loads. In the event that a PVCU failure puts the operations of one power module at risk, the critical functions of ISS should be transferred to the power module that has no concerns.

In the event of PVCU failure, the MBSU's can still be used to switch loads from one power source to another. By configuring the power channels with the failed PVCU to slave mode, they are in a configuration to support seamless power channel handover to the active channels.

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FLIGHT RULES

10A_B9-8 PVCU LOSS RESPONSE (CONTINUED)

- 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.

- 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-8 PVCU LOSS RESPONSE (CONTINUED)

- 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.

- 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-8 PVCU LOSS RESPONSE (CONTINUED)

- H. DEFINE A LOAD SHED AND SAFING STRATEGY THAT COULD BE IMPLEMENTED WITHIN 30 MINUTES IN THE EVENT THE SECOND PVCU FAILS.

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.

- I. PERFORM THE FOLLOWING ASSESSMENTS TO DETERMINE WHETHER TO REVISE THE BCDU CHARGE RATE AND PVTCS FCV LOC VALUES UNTIL EXPECTED RECOVERY OF THE FIRST FAILED PVCU:
1. CONSTRAIN THE ASSESSMENT BY THE BETA REGIME UP TO THE PROJECTED DATE OF RECOVERY OF THE FIRST FAILED PVCU.
 2. 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.
 3. 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.
 4. 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.

FLIGHT RULES

CONTINGENCY SCENARIOS

10A_B9-51 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 1A

AND

CHANNEL 2B (IF CHANNEL 2B IS SUPPORTING LOADS) OR 2A (IF CHANNEL 2B IS NOT SUPPORTING LOADS) @[DN 69]

2. CHANNEL 3A

AND

CHANNEL 4B (IF CHANNEL 4B IS SUPPORTING LOADS) OR 4A (IF CHANNEL 4B IS NOT SUPPORTING LOADS)

3. CHANNEL 2A (IF CHANNEL 2B IS SUPPORTING LOADS)

AND

CHANNEL 4A (IF CHANNEL 4B IS SUPPORTING LOADS)

4. CHANNEL 2B (IF CHANNEL 2B IS NOT SUPPORTING LOADS) TO SUPPORT DORMANCY REQUIREMENTS ONLY

AND

CHANNEL 4B (IF CHANNEL 4B IS NOT SUPPORTING LOADS) TO SUPPORT DORMANCY REQUIREMENTS ONLY @[DN 69]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-51 EPS HARDWARE SCAVENGE (CONTINUED)

Channel 2B (or Channel 2A, if Channel 2B is not supporting loads) is recovered as the highest priority in order to provide power to critical equipment powered from DDCU LA2B and DDCU S02B. Channel 1A is recovered as the highest priority in order to provide power to critical equipment powered from DDCU LA1B and DDCU S01A. ©[DN 69]

Channels 3A and 4B (or Channel 4A, if Channel 4B is not supporting loads) are recovered next to provide critical systems redundancy where possible and to provide survival power to truss equipment.

Channels 2A (if Channel 2B is supporting loads) and 4A (if Channel 4B is supporting loads) are recovered next to provide redundant power.

Channels 2B (if Channel 2B is not supporting loads) and 4B (if Channel 4B is not supporting loads) are recovered last. In this case, ORU swaps are performed only to recover functionality required to maintain the dormant channel configuration. ©[DN 69]

- 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, EATCS, 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.
1. IF REQUIRED, AN INTERNAL RPCM CAN BE PLACED INTO AN EXTERNAL UTILITY RAIL.
 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B9-51

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	DDCUS LA1A/LA4A	LAP2 ISPR (EXPRESS RACK 4 AUX PWR), LAP1 ISPR (NOT POWERED)	1 & 2
LA1A4A_B	INT (LAB)	III	DDCUS LA1A/LA4A	LAS2 ISPR (HRF AUX POWER), LAS3 ISPR (MSG USER PWR)	1 & 2
LA1A4A_G	INT (LAB)	III	DDCUS LA1A/LA4A	LAO3 ISPR (NOT POWERED)	1 & 2
LA2A3B_A	INT (LAB)	III	DDCUS LA2A/LA3B	LAP4 ISPR (NOT POWERED), LAP2 ISPR (EXPRESS RACK 4 USER PWR)	1 & 2
LA2A3B_B	INT (LAB)	III	DDCUS LA2A/LA3B	LAO4 ISPR (NOT POWERED), LAO3 ISPR (NOT POWERED)	1 & 2
LA2A3B_G	INT (LAB)	III	DDCUS LA2A/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 FAN	2
S02B_D	EXT (S0)	V	DDCU S02B	S0-2 MDM SDO CARD A11, A12 CH 00-15, SO/S1 ATTACH HW	2
S03A_C	EXT (S0)	II	DDCU P13A	NODE 2/NODE 3 FEED	2
S12B_A	EXT (S1)	V	DDCU S02B/ RPCM S02B A		2
S13A_E	EXT (S1)	IV	DDCU P13A	MOBILE SERVICING CENTER (MSC) UTILITY PORT	2 & 3
S13A_F	EXT (S1)	IV	DDCU P13A	MSC UTILITY PORT	2 & 3
S01A_D	EXT (S1)	V	DDCU S01A	S0-1 MDM SDO CARD A11, A12 CH 00-15, SO/P1 ATTACH HW	2
S04B_C	EXT (S0)	II	DDCU S14B	NODE 2/NODE 3 FEED	2
S11A_A	EXT (S1)	V	DDCU S01A/ RPCM S01A A		2
S14B_E	EXT (S1)	IV	DDCU S14B	MSC UTILITY PORT	2 & 3
S14B_F	EXT (S1)	IV	DDCU S14B	MSC UTILITY PORT	2 & 3
S14B_G	EXT (S1)	V	DDCU S14B		2
P11A_A	EXT (S1)	V	DDCU S01A/ RPCM S01A A	VIDEO CAMERA SUPPORT ASSEMBLY (VCSA), EXTERNAL TELEVISION GROUPS (ETVCG)	2 & 3
P14B_E	EXT (P1)	IV	DDCU S14B	MSC UTILITY PORT	2 & 3
P14B_F	EXT (P1)	IV	DDCU S14B	MSC UTILITY PORT	2 & 3
P13A_E	EXT (P1)	IV	DDCU P13A	MSC UTILITY PORT	2 & 3
P13A_F	EXT (P1)	IV	DDCU P13A	MSC UTILITY PORT	2 & 3
P34B_C	EXT (P3)	V	DDCU S14B	P3-2 MDM HEATER AND P3 RAIL HEATERS	2
P34B_F	EXT (P3)	IV	DDCU S14B	MSC UTILITY PORT 8, UMA 1	2
P33A_C	EXT (P3)	V	DDCU P13A	P3-1 MDM HEATER AND P3 RAIL HEATERS	2
P33A_F	EXT (P3)	IV	DDCU P13A	MSC UTILITY PORT 8, UMA 2 POWER	2

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.

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ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

10A_B9-52

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 HALF-BACKED OUT AS SOON AS PRACTICAL. @[DN 111]

Half-backing out 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. A spare BCDU is available on ESP-3, and will be evaluated for replacement of the failed BCDU. @[DN 83]

Documentation: Flight 4A JOP #27, June 22, 1999. EID 05604 - MHA. @[DN 111]

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

GENERAL

10A_C9-1 POWER CONNECTION INHIBITS [HC]

WHILE CREWMEMBERS ARE MATING OR DEMATING POWER CONNECTORS, POWER INHIBITS SHOULD BE IN LINE WITH INHIBITS IN RULE {B2-1}, POWER CONNECTION INHIBITS [HC] [RC] [E] [J] [A]. 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 10A TIMEFRAME.
 ©[DN 44]

TABLE 10A_C9-1-I - NODE 1 TO NODE 2 VESTIBULE CONNECTOR MATE/DEMATE (IVA)

CONNECTOR	FUNCTION	INHIBIT REQUIRED	NOTE
W3001 TO J133	POWER TO N21A4A POWER BUS	DDCU LA1A OR LA4A CONVERTER OFF AND RPCM LA1A4A F RPC 2 OP/CL INH	[1]
W3002 TO J145	POWER TO N22A3B POWER BUS	DDCU LA2A OR LA3B CONVERTER OFF AND RPCM LA2A3B D RPC 4 OP/CL INH	[1]

©[DN 63]

TABLE 10A_C9-1-II - P6 SPARE SASA AND Z1 BSP (EVA 1)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P3 TO J3	P6 SPARE SASA HEATER POWER	RPCM Z14B B RPC 1	[1]
P4 TO J4	P6 SPARE SASA OPS POWER	RPCM Z13B B RPC 1	[1]
XA11P1D TO P1D	Z1 BSP OPERATIONAL POWER	RPCM Z13B B RPC 4	[1]
XA11P1D TO P1D	Z1 BSP HEATER POWER	RPCM Z14B B RPC 4	[1]

©[DN 63]

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FLIGHT RULES

10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)

TABLE 10A_C9-1-III - P6 DEMATE FROM Z1 (EVA 2)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P253 (W204A) TO J153	DATA - 1553 A	NONE	
P254 (W704A) TO J154	DATA - 1553 B	NONE	
P255 (W120C) TO J155	POWER TO P6 S-BAND XPDR AND SASA	RPCM Z13B B RPC 2 RPCM Z13B B RPC 3	[1]
P256 (W140C) TO J156	POWER TO P6 S-BAND XPDR AND SASA HEATERS	RPCM Z14B B RPC 2 RPCM Z14B B RPC 3	[1]
P257 (W42) TO J157	POWER TO/FROM RPCM 2B B RPC 1	RPCM 2B B RPC 1	[1, 2, 3]
P258 (W46) TO J158	POWER TO/FROM RPCM 4B B RPC 1	RPCM 4B B RPC 1	[1, 2, 3]
P259 (W01A) TO J159	POWER TO/FROM CHANNEL 2B	DCSU 2B RBI 6 MBSU 2 RBI 8	[1, 2, 4]
P260 (W08A) TO J160	POWER TO/FROM CHANNEL 4B	DCSU 4B RBI 6 MBSU 4 RBI 8	[1, 2, 4]
P261 (W11A) TO J161	DATA - P6 S-BAND BSP AND XPDR	NONE	

©[DN 63]

TABLE 10A_C9-1-IV - S1 SFU RECONFIG (EVA 2)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P752 (W5140) FROM J752 TO J703 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 4	[1]
P752 (W5140) FROM J752 TO J703 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 5	[1]
P752 (W5140) FROM J752 TO J703 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 6	[1]
P752 (W5140) FROM J752 TO J703 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 7	[1]

©[DN 63]

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FLIGHT RULES

10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)

TABLE 10A_C9-1-V - S1 SFU RECONFIG (EVA 3)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P752 (W5140) FROM J703 TO J752 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 4	[1]
P752 (W5140) FROM J703 TO J752 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 5	[1]
P752 (W5140) FROM J703 TO J752 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 6	[1]
P752 (W5140) FROM J703 TO J752 [A123]	POWER TO SFU CHARGE BANK AND RELAY	RPCM S1-1A-C RPC 7	[1]

@[DN 63]

TABLE 10A_C9-1-VI - MBSU BYPASS JUMPER RECONFIG (EVA 2)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RBI OP/CL INH	NOTE
P486 (W4007) FROM J483 TO J486	POWER TO/FROM CHANNEL 4B	MBSU 4A/4B RBI 8	
P483 (W4033) FROM J486 TO J483 [A200]	POWER TO/FROM CHANNEL 4B	MBSU 4A/4B RBI 8	
P489 (W4002) FROM J491 TO J489	POWER TO/FROM CHANNEL 2B	MBSU 2A/2B RBI 8	
P491 (W4032) FROM J489 TO J491 [A260]	POWER TO/FROM CHANNEL 2B	MBSU 2A/2B RBI 8	

TABLE 10A_C9-1-VII - RPCM S04B C R&R (EVA 2)

CONNECTOR	FUNCTION	INHIBIT REQUIRED	NOTE
RPCM S04B C	POWER TO/FROM RPCM S04B C	DDCU S14B CONVERTER OFF	[1]

@[DN 63]

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FLIGHT RULES

10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)

TABLE 10A_C9-1-VIII - NODE 2 PDGF INSTALL (EVA 2)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P623 TO J623	NODE 2 PDGF PAYLOAD POWER FEED 2	RPCM S03A C RPC 1	[1]
P104 TO J104	NODE 2 PDGF PAYLOAD POWER FEED 2	RPCM S03A C RPC 1	[1]
P623 TO J623	NODE 2 PDGF SSRMS POWER FEED 2	RPCM S03A C RPC 2	[1]
P104 TO J104	NODE 2 PDGF SSRMS POWER FEED 2	RPCM S03A C RPC 2	[1]
P622 TO J622	NODE 2 PDGF PAYLOAD POWER FEED 1	RPCM S04B C RPC 3	[1]
P102 TO J102	NODE 2 PDGF PAYLOAD POWER FEED 1	RPCM S04B C RPC 3	[1]
P622 TO J622	NODE 2 PDGF SSRMS POWER FEED 1	RPCM S04B C RPC 4	[1]
P102 TO J102	NODE 2 PDGF SSRMS POWER FEED 1	RPCM S04B C RPC 4	[1]

@[DN 63]

EVA lists P7/P5 mate to J7/J5, P6/P8 mate to J6/J8, and Loop Back Connector mate to J408.

TABLE 10A_C9-1-IX - P6 MATE TO P5 (EVA 3)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
P253 (W02) TO J153	DATA - 1553 A	NONE	
P254 (W07) TO J154	DATA - 1553 B	NONE	
P259 (W01) TO J159	POWER TO/FROM CHANNEL 2B	DCSU 2B RBI 6 MBSU 2 RBI 8	[1, 2, 4]
P260 (W08) TO J160	POWER TO/FROM CHANNEL 4B	DCSU 4B RBI 6 MBSU 4 RBI 8	[1, 2, 4]

TABLE 10A_C9-1-X - SPARE MBSU INSTALL ON ESP 2 (EVA 3)

CONNECTOR	FUNCTION	INHIBIT REQUIRED RPC OP/CL INH	NOTE
FRAM SITE 6	ESP-2 SITE 6 PRIMARY HEATERS	RPCM N1RS2-B RPC 6	[1]
FRAM SITE 6	ESP-2 SITE 6 SECONDARY HEATERS	RPCM S04B-F RPC 10	[1]

@[DN 63]

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FLIGHT RULES

10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)

TABLE 10A_C9-1-XI - PMA 2 DEMATE FROM LAB (EVA)

CONNECTOR	FUNCTION	INHIBIT REQUIRED	NOTE
W1102 P609 TO J115	SECONDARY POWER, APCU	NONE	[1]
W1101 P610 TO J117	SECONDARY POWER	NONE	[1]
W1301 P611 TO J103	DATA – RTD'S, GNC MODING	NONE	
W1103 P612 TO J106	PMA 2 SHELL HEATER SCAR	RPCM LA1B C RPC 1	[1]
W1103 P612 TO J106	PMA 2 SHELL HEATER SCAR	RPCM LA1B C RPC 2	[1]
W1103 P612 TO J106	PMA 2 SHELL HEATER SCAR	RPCM LA1B C RPC 3	[1]
W1103 P612 TO J106	PMA 2 SHELL HEATER SCAR	RPCM LA1B C RPC 4	[1]
W1103 P612 TO J106	PMA 2 SHELL HEATER 1A PMA 2 SHELL HEATER 1B PMA 2 SHELL HEATER 2A PMA 2 SHELL HEATER 2B PMA 2 SHELL HEATER 3A PMA 2 SHELL HEATER 3B PMA 2 SHELL HEATER 4A PMA 2 SHELL HEATER 4B PMA 2 SHELL HEATER 5A PMA 2 SHELL HEATER 5B	RPCM LA1B C RPC 5 RPCM LA1B C RPC 6 RPCM LA1B C RPC 7 RPCM LA1B C RPC 8 RPCM LA1B C RPC 9 RPCM LA1B C RPC 10 RPCM LA1B C RPC 11 RPCM LA1B C RPC 12 RPCM LA1B C RPC 13 RPCM LA1B C RPC 14	[1]
W1201 P613 TO J105	DATA – 1553 A, VIDEO	NONE	
W1202 P614 TO J104	DATA – 1553 B, VIDEO	NONE	
W1302 P615 TO J102	DATA – GNC MODING	NONE	
W2401 P616 TO J101	DATA – AUDIO	NONE	
W9303 J113A FROM P113	SSPTS PWR	Z13B A RPC 2	[1]
W9303 P108A FROM J108	SSPTS PWR	LA2A3B D RPC 1	[1]
W9152 P108 TO J108		LA2A3B D RPC 1	[1]
W9303 J16A FROM P16	SSPTS PWR	NONE	[5]
W9302 J114A FROM P114	SSPTS PWR	Z14B A RPC 2	[1]
W9302 P109A FROM J109	SSPTS PWR	LA1A4A D RPC 3	[1]
W9151 P109 TO J109		LA1A4A D RPC 3	[1]
W9302 J3A FROM P3	SSPTS PWR	NONE	[6]

©[DN 63]

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FLIGHT RULES

10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)

TABLE 10A_C9-1-XII - PMA 2 MATE TO NODE 2

CONNECTOR	FUNCTION	INHIBIT REQUIRED	NOTE
W1102 P609 TO J609	NONE	NONE	
W1101 P610 TO J610	NONE	NONE	
W1301 P611 TO J611	DATA - RTDS, GNC MODING	NONE	
W1103 P612 TO J612	PMA 2 SHELL HEATER 1A PMA 2 SHELL HEATER 1B PMA 2 SHELL HEATER 2A PMA 2 SHELL HEATER 2B PMA 2 SHELL HEATER 3A PMA 2 SHELL HEATER 3B PMA 2 SHELL HEATER 4A PMA 2 SHELL HEATER 4B PMA 2 SHELL HEATER 5A PMA 2 SHELL HEATER 5B	DDCU LA1A OR LA4A CONVERTER OFF RPCM N21A4A B RPC 1 RPCM N21A4A B RPC 2 RPCM N21A4A B RPC 3 RPCM N21A4A B RPC 4 RPCM N21A4A B RPC 5 RPCM N21A4A B RPC 12 RPCM N21A4A B RPC 13 RPCM N21A4A B RPC 14 RPCM N21A4A B RPC 15 RPCM N21A4A B RPC 16	[1]
W1201 P613 TO J613	DATA - 1553 A, VIDEO	NONE	
W1202 P614 TO J614	DATA - 1553 B, VIDEO	NONE	
W1302 P615 TO J615	NONE	NONE	
W2401 P616 TO J616	DATA - AUDIO	NONE	

@[DN 63]

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Verify that this is the correct version before use.

FLIGHT RULES

10A_C9-1

POWER CONNECTION INHIBITS [HC] (CONTINUED)**TABLE 10A_C9-1-XIII - NODE 2 MATE TO LAB**

CONNECTOR	FUNCTION	INHIBIT REQUIRED RBI/RPC OP/CL INH	NOTE
W7002 J143 TO J12	DATA – 1553 B	NONE	
W7011 J133 TO J1	POWER TO N21A4A POWER BUS	DDCU LA1A OR LA4A CONVERTER OFF RPCM LA1A4A D RPC 2	[1]
W7012 J145 TO J14	POWER TO N22A3B POWER BUS	DDCU LA2A OR LA3B CONVERTER OFF RPCM LA2A3B D RPC 2	[1]
W9141 P101 TO J101	DATA – NODE 2 PDGF VIDEO 1	NONE	
W9143 P102 TO J102	NODE 2 PDGF 1 POWER	RPCM S04B-C RPCS 3 & 4	[1]
W9142 P103 TO J103	DATA – NODE 2 PDGF VIDEO 3	NONE	
W9142 P104 TO J104	NODE 2 PDGF 2 POWER	RPCM S03A-C RPCS 1 & 2	[1]
W9142 P105 TO J105	DATA – NODE 2 PDGF VIDEO 2	NONE	
W9043 P660 TO J660	POWER TO DDCU N2S1B	MBSU 1 RBI 10	[1]
W9043 P661 TO J661	POWER TO DDCU N2D1B	MBSU 1 RBI 11	[1]
W9043 P662 TO J662	POWER TO DDCU N2S4A	MBSU 4 RBI 2	[1]
W9043 P663 TO J663	POWER TO DDCU N2D4B	MBSU 4 RBI 10	[1]
W9141 P664 TO J664	POWER TO S0-2 MDM SDO CARD 6A POWER TO S0-1 MDM SDO CARD 8A POWER TO S0-1 MDM SDO CARD 8B	RPCM S02B D RPC 2 RPCM S01A D RPC 4 RPCM S01A D RPC 5	[1]
W1941 P665 TO J665	DATA – NODE 2 PORT VSCA VIDEO	NONE	
W9002 P670 TO J670	POWER TO DDCU N2P2A	MBSU 2 RBI 3	[1]
W9002 P671 TO J671	POWER TO DDCU N2O2B	MBSU 2 RBI 10	[1]
W9004 P672 TO J672	POWER TO DDCU N2P3A	MBSU 3 RBI 3	[1]
W9004 P673 TO J673	POWER TO DDCU N2O3A	MBSU 3 RBI 2	[1]
W9104 P674 TO J674	POWER TO S0-1 MDM SDO CARD 6A POWER TO S0-2 MDM SDO CARD 8A POWER TO S0-2 MDM SDO CARD 8B	RPCM S01A D RPC 2 RPCM S02B D RPC 4 RPCM S02B D RPC 5	[1]
W9102 P102 TO J102	POWER TO LAB CETA LIGHT	RPCM S02B C RPC 15	[1]
W9101 P101 TO J101	POWER TO LAB CETA LIGHT HEATER	RPCM S01A C RPC 15	[1]
W9302 J3A FROM P3	SSPTS PWR	NONE	[8]
W9151 P109 FROM J109		LA1A4A D RPC 3	[1]
W9302 P109A TO J109	SSPTS PWR	LA1A4A D RPC 3	[1]
W9302 J114A TO P114	SSPTS PWR	Z14B A RPC 2	[1]
W9303 J16A TO P16	SSPTS PWR	NONE	[7]
W9152 P108 FROM J108		LA2A3B D RPC 1	[1]
W9303 P108A TO J108	SSPTS PWR	LA2A3B D RPC 1	[1]
W9303 J113A TO P113	SSPTS PWR	Z13B A RPC 2	[1]

©[DN 63]

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FLIGHT RULES**10A_C9-1 POWER CONNECTION INHIBITS [HC] (CONTINUED)**

NOTES: ©[DN 63]

- [1] ONE UPSTREAM INHIBIT REQUIRED SINCE: (A) CONNECTORS ARE SCOOP-PROOF, (B) SOCKETS ARE ON SOURCE SIDE, AND (C) DOWNSTREAM LOADS ARE BELOW 180W.
- [2] P6 INHIBITS MAY NOT BE VERIFIABLE AT THE TIME OF CONNECTOR MATING/DEMATING. THESE INHIBITS SHOULD BE VERIFIED BEFORE P6 DEACTIVATION.
- [3] ALTERNATIVE UPSTREAM INHIBITS INCLUDE DDCU 2B(4B) CONVERTER OFF OR DCSU 2B(4B) RBI 5 OPEN/CLOSE COMMAND INHIBITED.
- [4] OPENING AND CLOSE-INHIBITING OF P6-2B DCSU RBI 6, P6-4B DCSU RBI 6, MBSU 4 RBI 8, AND MBSU 2 RBI 8 ONLY ACCOMPLISH ONE INHIBIT DURING P6 DEMATE FROM Z1 AND MATE TO P5. NCR-ISS-118 HAS BEEN WRITTEN TO DOCUMENT THIS.
- [5] PER OPERATIONAL CONSTRAINT, W9303 J16A MUST BE DEMATED AFTER W9303 J113A AND W9303 P108A. NO INHIBIT IS REQUIRED SINCE NO W9303 WILL NOT BE CONNECTED TO A SOURCE DURING W9303 J16A DEMATE.
- [6] PER OPERATIONAL CONSTRAINT, W9302 J3A MUST BE DEMATED AFTER W9302 J114A AND W9302 P109A. NO INHIBIT IS REQUIRED SINCE NO W9302 WILL NOT BE CONNECTED TO A SOURCE DURING W9302 J3A DEMATE.
- [7] PER OPERATIONAL CONSTRAINT, W9303 J16A MUST BE MATED BEFORE W9303 J113A AND W9303 P108A. NO INHIBIT IS REQUIRED SINCE NO W9303 WILL NOT BE CONNECTED TO A SOURCE DURING W9303 J16A MATE.
- [8] PER OPERATIONAL CONSTRAINT, W9302 J3A MUST BE MATED BEFORE W9302 J114A AND W9302 P109A. NO INHIBIT IS REQUIRED SINCE NO W9302 WILL NOT BE CONNECTED TO A SOURCE DURING W9302 J3A MATE.

One upstream power inhibit is applied before mating either of these connectors. This inhibit is provided to protect against possible connector damage and crew hazard if electrical arcing occurs during connector mating/demating operations. Per JSC Safety Policy Letter MA2-99-170, only one upstream power inhibit is required.

Reference HR Prime-207-2A Electrical Shock of IVA Crewmember, Cause 2, Control 2. ©[DN 63]

DOCUMENTATION: Hazard Report ISS-EPS-0207-12A.1, "Electrical Shock of IVA Crewmember," Cause 2 and 3; ISS-EPS-0309-12A.1, "Electrical Arcing/Sparking Injures EVA Crewmember and/or Orbiter and/or ISS Hardware," Cause 1. MA2-99-170, Crew Mating/Demating of Powered Connectors. ©[DN 44]

FLIGHT RULES

10A_C9-2

PVTCS PFCS THERMAL CONTROL ALGORITHMS FOR P6 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:

- 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 P6 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. @[DN 110]

- 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.

FLIGHT RULES

10A C9-3 ISS TO ORBITER POWER TRANSFER

ISS WILL NOMINALLY PROVIDE POWER TRANSFER TO ORBITER BY MEANS OF TWO OR MORE STATION TO SHUTTLE POWER TRANSFER SYSTEM (SSPTS) CONVERTERS EXCEPT DURING EVA TASKS WHICH REQUIRE SSPTS CABLE POWER INHIBITS OR DURING USOS SOLAR ARRAY POWER LIMITED EVENTS. @ICR 8845]

Failures which require ISS solar arrays to be parked or contingencies which extend orbiter mission duration (such as CSCS) will change the power transfer availability and requirements.

Meeting power transfer requirements drives mission success because power transfer directly determines STS-120 duration. Since the assembly objectives are impacted by changes in mission duration, ISS must meet or exceed minimum orbiter power transfer requirements. Therefore, ISS to orbiter power transfer is categorized as maintaining mission success, as prioritized by Rule {10A B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC].

The nominal power draw for each PTU converter is 2-2.25 kW. Two converters will be powered during nominal mated operations, except where noted. ISS power availability and power channel loading during docked operations will determine which converters will be powered. ISS will transfer additional power as availability allows.

Reference: Rule {10A B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC]. @ICR 8845]

FLIGHT RULES

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FLIGHT RULES

SECTION 10 - MECHANICAL

SHUTTLE ONLY RULES

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FLIGHT RULES

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FLIGHT RULES**SECTION 10 - MECHANICAL****SHUTTLE ONLY RULES****10A_A10-1 APU LOSS DEFINITIONS [HC]**

THIS RULE SUPERSEDES RULE {A10-1A}.10, APU LOSS DEFINITIONS [HC]:
 ©[DN 142]

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. ©[DN 142]

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ISS EXPEDITIONS 15 & 16				

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FLIGHT RULES

10A_A10-1 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. ©[DN 142]

Loss of the FPIP transducer results in loss of pressure monitoring of the portion of fuel line between the FIV's and the 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.

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 (N₂H₄) Detonation and Bubble Compression in the APU; and ORBI 250, External Leakage from the APU Fuel Supply System, reference this rule. ©[DN 142]

FLIGHT RULES

10A_A10-2 APU START/RESTART LIMITS [HC]

THIS RULE SUPERSEDES RULE {A10-22H}, APU START/RESTART LIMITS [HC]: @CR8803]

FOR AN APU WITH FUEL TANK PRESSURE:

A. > 150 (141) PSIA,

1. AND FOR LOSS OF FUEL PUMP INLET PRESSURE MONITORING, IF FUEL LINE INTEGRITY:

a. IS DETERMINED WITH A HIGH DEGREE OF CONFIDENCE TO BE SOUND, THEN THE APU WILL BE USED NOMINALLY FOR ENTRY.

b. CANNOT BE DETERMINED WITH A HIGH DEGREE OF CONFIDENCE, THEN THE APU WILL BE (RE)STARTED ONLY IF REQUIRED.

c. IS LOST OR SUSPECT, THEN THE APU WILL BE (RE)STARTED IF NEEDED TO MAINTAIN:

(1) A SECOND APU/HYDRAULIC SYSTEMS FOR ELEVON OR RUDDER/SPEEDBRAKE CONTROL FROM TAEM THROUGH WHEELSTOP,

(2) THE LAST METHOD OF CONTROL FOR THE BODYFLAP, IF PRIOR TO APPROACH AND LAND INTERFACE AND ANOTHER BODYFLAP CONTROL COMBINATION CANNOT BE RECOVERED,

(3) A LAST METHOD OF GEAR DEPLOY,

(4) A LAST METHOD OF BRAKING, OR

(5) TO REGAIN NWS IF A KNOWN DIRECTIONAL CONTROL PROBLEM EXISTS. @CR8803]

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FLIGHT RULES**10A_A10-2 APU START/RESTART LIMITS [HC] (CONTINUED)**

2. THE FUEL ISOLATION VALVES MAY BE OPENED, AS NEEDED, IF:
@[CR 8803]
- 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:
- (1) A SECOND APU/HYDRAULIC SYSTEMS FOR ELEVON OR RUDDER/SPEEDBRAKE CONTROL FROM TAEM THROUGH WHEELSTOP,
- (2) THE LAST METHOD OF CONTROL FOR THE BODYFLAP, IF PRIOR TO APPROACH AND LAND INTERFACE AND ANOTHER BODYFLAP CONTROL COMBINATION CANNOT BE RECOVERED,
- (3) A LAST METHOD OF GEAR DEPLOY,
- (4) A LAST METHOD OF BRAKING, OR
- (5) 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.

With FPIP insight lost, all available data, including fuel line and component temperatures and pressures, will be evaluated. System data may indicate the presence of line leakage, though not necessarily; available methods may only allow for the detection of gross leakage. @[CR 8803]

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FLIGHT RULES

10A_A10-2

APU START/RESTART LIMITS [HC] (CONTINUED)

- A1.a *If the system was nominal prior to the loss of insight, and the nature of the loss of insight does not implicate the fuel line, then an additional failure - fuel leakage from the line - must subsequently occur before the potential for ABCD is possible. Unless there are indications of a leak in the fuel line (e.g., unexplained drop in FPIP prior to loss of the transducer, changes in fuel line heater cycling, unexplained cooling of transducers on or near the line, unexplained increase in the GG bed and injector temperatures, increase in the seal cavity drain line pressure not due to changes in the thermal environment, etc.), the FIV's can be safely opened. The pressure transducers that are used on the APU system contain multiple weld joints. After reviewing the design of the FPIP transducers, two leak paths were identified whereby hydrazine fuel could corrosively attack or short the electrical wiring of the transducer and cause a loss of insight. The first path is through the pressure cap/diaphragm weld and then onto the strain gauges mounted to the diaphragm beam. The second path is from the threaded pressure cap (undertorqued transducer installation), across the outer case of the transducer, and into the terminal connector containing the transducer wires. For both leak paths, it was agreed that the leakage would likely be observed in the FPIP prior to the hydrazine attacking the wiring and resulting in the loss of insight. The likelihood of a transducer failing due to a hydrazine attack without any precursory indications is very low. Therefore, for the sole loss of the transducer, the APU will be operated nominally. ©[CR 8803]*
- A1.b *If the loss of insight occurs during APU operation, then the line cannot be confirmed to be sound (a SOV could fail to fully reseat or static leakage into the seal cavity drain line could begin). Under these circumstances, the potential for a leak being present is low, but is sufficient to outweigh the need to have the APU operating for entry unless it is needed to meet the redundancy requirements listed under the "required" criteria.*
- A1.c *If the loss of insight occurs in conjunction with other signs of external leakage, then the APU should be managed to maintain critical capability (reference Rule {A10-27}, APU FUEL LEAKS [CIL], for further rationale on the risk trade-offs of operating a leaking APU).*
- A2.a,b,c *While the APU's are not operating, the Fuel Isolation Valves (FIV) remain closed, isolating the fuel tank from the APU and fuel lines downstream from the isolation valves. The fuel in the line is trapped between the FIV's and the Shut-Off Valve (SOV), except for a small amount that passes back to the tank via the relief valve following APU operation (due to heat soakback raising the line pressure). The pressure in the line is not static, but varies as much as 200 psi or more due to the temperature cycling of the various APU fuel system heaters. The Fuel Pump Inlet Pressure (FPIP) transducer provides the sole means of pressure monitoring (and hence line integrity) of the portion of fuel line between the FIV's and the SOV while the FIV's are closed. ©[CR 8803]*

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FLIGHT RULES

10A_A10-2

APU START/RESTART LIMITS [HC] (CONTINUED)

A decay in fuel line pressure (due to leakage externally into the aft compartment, past the fuel pump seals into the seal cavity drain, or past the SOV), may produce a hazardous surge pressure when the FIV's are subsequently reopened. The surge pressure acting at dead-ends in the fuel line may cause rapid mixing of ullage gasses and hydrazine which creates a froth. The bubbles in the froth are then adiabatically compressed by the same surge pressure pulse and in turn rapidly elevate the bubble temperatures above the autodetonation temperature for hydrazine. This process of Adiabatic Bubble Compression Detonation (ABCD) can ultimately lead to rupturing the fuel line and leaking fuel. Reference SODB, vol. I, 3.4.4.3, and Rules {A10-1}, APU LOSS DEFINITIONS [HC], and {A10-33}, APU DEFINITIONS. ©[CR 8803]

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 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.

The APU FIV's have been opened on the pad and on orbit with fuel tank pressures greater than 150 psia and FPIP between 15 and 30 psia on more than 15 occasions without any occurrences of ABCD. The FIV's were opened with a FPIP of 17 psia during STS-53 pre-launch operations. On-orbit, during STS-75, the FPIP reached 22 psia prior to opening the FIV's. Due to uncertainties in an actual ABCD event occurring at FPIP between 15 and 30 psia, the potential for an ABCD event to occur at these pressures is deemed less likely than the potential adverse effects resulting from entry without the APU running; therefore, within this pressure range the FIV's may be opened if the APU meets the "required" criteria. However, with a FPIP below 15 psia, the possibility of an ABCD event occurring is higher, so opening the FIV's to operate the APU will be accepted if needed to regain critical capability. A bias value is added to the FPIP limits to account for transducer inaccuracies. Actual FPIP transducer biases for each APU, based on data that is provided by KSC prior to each mission, should be used when applying the limits. ©[CR 8803]

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FLIGHT RULES

10A_A10-2

APU START/RESTART LIMITS [HC] (CONTINUED)

A2.d If the fuel line pressure is dropping and approaching the limit, and a corresponding increase in drain line pressure is noted, then the fuel line pressure decay can be attributed to leakage past the fuel pump seals into the seal cavity drain system. The FIV's may be opened to repressurize the fuel line in this case so as to prevent reaching the loss limit. The drain line pressure transducers will be used in lieu of the FPIP to determine that fuel line pressure remains above the limit since the drain line pressures have a much finer granularity (0.2 psi/PCM count for the drain line pressures versus 2.4 psi/PCM count for FPIP). Actual drain line pressure transducer biases for each APU, based on data that is provided by KSC prior to each mission, should be used when applying the limit. ©ICR 8803 1

Loss of the FPIP transducer results in loss of pressure monitoring of the portion of fuel line between the FIV's and the SOV while the FIV's are closed. If a leak subsequently develops then ABCD could result when the FIV's are opened. Leaving at least one of the fuel isolation valves open at APU shutdown would allow monitoring of the fuel line pressure via the fuel tank pressure transducers. Keeping a valve open continuously powers the valve solenoid, heating the fuel within the valve module and adjacent lines. During a cert qual test, a FIV module that was loaded with hydrazine was left powered (both valves open) in a vacuum test cell for 17 hours. The valve module temperature stabilized at 242 degrees F after approximately 12 hours, which is below the 250 degree F qualification limit for the valve and the 290 degree F fuel decomposition limit. However, this exceeds the 150 degree F limit for the fuel provided to the APU during startup. Reference SODB Vol. I, table 3.4.4.3-1. Though limited, the testing suggests that leaving the FIV's powered will not overheat the fuel, but additional risk may be incurred when the heated fuel is ingested at the fuel pump at APU start. Continuously powering the valve open may cause the fuel feed line heater overtemp thermostat (located on the line approximately 1 ft downstream of the FIV module) to open (set point approximately 110 degree F), disabling the fuel feed line heaters and possibly leading to fuel line freeze while the FIV remains powered. The test line and service line heaters may be similarly affected, their control thermostat (set point approximately 70 degree F) is also located near the FIV module. Note that no data exists for the maximum temperature that will result for only powering open a single FIV, but it can be expected that the temperature will be below the 242 degree F limit attained by two valves being powered. The other concern with leaving a valve open is due to the granularity of the fuel tank pressure transducers - even with a slow leak rate, a significant quantity of fuel could leak before being recognized and the FIV closed. Though the possibility for such a leak to develop is low, the potential adverse effects (free hydrazine in the aft compartment) make this solution undesirable.

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 (N2H4) 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, reference this rule. ©ICR 8803 1

FLIGHT RULES

10A_A10-3

APU GAS GEN/FUEL PUMP HEATER MANAGEMENT

THE GAS GEN/FUEL PUMP HEATERS FOR APU 1 AND 3 WILL BE MANAGED AS FOLLOWS: @DN 143] @CR 8804]

Both the "A" and "B" GG/fuel pump heaters for each APU are comprised of two separate "strings": one string is the heater for the gas generator bed; the other string is three separate heaters connected in series for the APU fuel lines (GGVM fuel supply line and fuel pump bypass line), GN₂ filled reference line, fuel pump, and the valve module. A control thermostat provides a ground path for the three serially connected heaters. The control thermostat is mounted to the reference line. Since a short in the heaters or wiring could eliminate the control thermostat from the circuit, a second, or overtemp, thermostat is placed in series, on the power side of the string, that will take control (in a higher range) if the control thermostat fails closed or a short in the three serially connected heaters' string occurs. The overtemp thermostat is mounted on the bypass line. The valve module heaters for APU 1 and APU 3 are made from a thin Kapton film containing both the "A" and "B" heater traces, with the "B" heater running around the periphery and the "A" towards the center portion and the traces approximately 0.1 inches apart. The heater is bolted to the valve module body, sandwiched between a metal plate and an insulating blanket, with a thermal compound between the plate and the heater film. Due to the design, a gap can form between the heater film and the plate and/or the blanket that causes localized overheating. This overheating can lead to failure of the heater film and shorting of the heater element. Both the "A" and "B" valve module heaters can be affected due to the close proximity of the "A" and "B" elements. A modification to the GGVM heater is making its first flight on STS-120 APU 2. This heater is a resistive wrap design similar to the fuel line heaters, and is not subject to the failure mode of the previous design

This heater failure mode occurred on STS-121 APU 3; although, both the "A" and "B" heaters were functional on the overtemp thermostat for the entire mission. The "B" heater is thought to be more susceptible to failure since it is more likely for a delamination, gap, or loss of heat sink to form around the periphery; so the "A" heater is favored for operation subject to the constraints detailed in this rule. @CR 8804]

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FLIGHT RULES

10A_A10-3

APU GAS GEN/FUEL PUMP HEATER MANAGEMENT (CONTINUED)

A. ON ORBIT, WITH THE APU NOT OPERATING: @ICR 8804]

1. IF THE "A" VALVE MODULE/LINE HEATERS ARE CYCLING NOMINALLY OR ON THE OVERTEMP THERMOSTAT, THEN THE HEATER SWITCH WILL REMAIN SELECTED TO "A AUTO".

For nominal operation, the "A" heater is favored over the "B" per the above rationale. If the "A" heater begins cycling on the overtemp thermostat, the failure could be that the control thermostat has failed closed, or that a short (as on STS-121) has occurred. Since it is not possible to distinguish between the two signatures, the short to ground is assumed. If the "A" heater has shorted due to a gap, then it is likely the "B" heater has a gap as well (possibly a larger one); also, the "B" heater may already be damaged by the "A" heater failure. Since the "A" heater is still working, it will remain selected rather than selecting the "B" heater; selecting the "B" could lead to further damage and possible loss of both the "A" and "B" heaters.

2. IF THE "A" VALVE MODULE/LINE HEATERS FAIL OFF, THEN THE HEATER SWITCH WILL BE TAKEN TO "B AUTO".

If the "A" heater is no longer functioning, it is prudent to attempt to use the "B" heater rather than immediately resorting to mission-impacting orbiter attitude adjustment or periodic APU operation to control the APU temperature. Although a gap in the APU 3 GGVM heater element was found after the STS-121 mission when the heaters were tested and disassembled post flight at the vendor, this new GGVM heater design has flown 80 times with no issues in flight or during ground operations.

3. IF THE "A" VALVE MODULE/LINE HEATERS FAIL ON, THEN IN ORDER OF PRIORITY:

- a. THE HEATER SWITCH WILL BE TAKEN TO "B AUTO," OR
b. MANUAL HEATER CYCLING USING THE "A" HEATERS WILL BE PERFORMED.

For the "A" heater to fail on, the "A" overtemp thermostat will have to fail closed in addition to a failure of the "A" control thermostat (failed closed) or a short to ground in the "A" heater string. The APU temperature will eventually reach the FDA (200 deg F) and then the hydrazine auto detonation temperature (290 deg F). Adequate time exists after the FDA for the crew to take safing actions. Manual cycling of the heater is possible, but crew workload intensive, so the "B" heater will be tried before resorting to manual cycling. @ICR 8804]

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FLIGHT RULES

10A_A10-3

**APU GAS GEN/FUEL PUMP HEATER MANAGEMENT
(CONTINUED)**

4. IF BOTH THE "A" AND "B" VALVE MODULE/LINE HEATERS FAIL ON, THEN IN ORDER OF PRIORITY: @[CR 8804]
- a. MANUAL HEATER CYCLING WILL BE PERFORMED USING THE "A" HEATERS (PREFERRED) OR THE "B" HEATERS (IF THE "A" HEATERS SUBSEQUENTLY FAIL OFF), OR
- b. THE HEATER SWITCH WILL BE TAKEN TO "OFF" AND PERIODIC APU OPERATION WILL BE PERFORMED AND/OR ORBITER ATTITUDE ADJUSTED PER PARAGRAPH A.5 OF THIS RULE.

At least three failures must have occurred for the "A" and "B" heaters to fail on (both the "A" and "B" overtemp thermostats will have to fail closed in addition to a short to ground in the valve module heater string affecting both heaters; other scenarios require four failures). The APU temperature will eventually reach the FDA (200 deg F) and then the hydrazine auto detonation temperature (290 deg F). Adequate time exists after the FDA for the crew to take safing actions. Manual cycling of the heater, though crew workload intensive, is preferred over orbiter attitude adjustment and/or periodic operation of the APU (with the heaters turned off), due to the impact to consumables (prop and APU) and to operations (inspection, rendezvous, docked, etc.).

5. IF BOTH THE "A" AND "B" VALVE MODULE/LINE HEATERS FAIL OFF, AND IF NECESSARY TO MAINTAIN ACCEPTABLE APU TEMPERATURES (REFERENCE RULES {A10-1A}.7, APU LOSS DEFINITIONS [HC], AND {A10-30A}, LOSS OF APU HEATERS/INSTRUMENTATION [CIL]):
- a. WHILE DOCKED, THE APU WILL BE OPERATED PERIODICALLY.

The thermal environment for docked operations on this flight will not prevent the APU from freezing, and adjusting the attitude while docked is not possible; so the only method to maintain acceptable temperatures is to run the APU periodically (approximately 5 minutes out of every 10 to 12 hours). Reference Rule {10A C10-2}, APU OPERATION FOR THERMAL MANAGEMENT WHILE DOCKED [RC], for constraints to APU operation while docked to ISS.

- b. WHILE UNDOCKED, THE APU WILL BE OPERATED PERIODICALLY OR THE ORBITER ATTITUDE ADJUSTED.

Either orbiter attitude adjustment or periodic operation may be used to maintain APU temperatures while undocked. Which method is chosen is dependent on other constraints (e.g., inspection, burns, etc.). @[CR 8804]

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FLIGHT RULES

10A_A10-3

APU GAS GEN/FUEL PUMP HEATER MANAGEMENT
(CONTINUED)

- B. FOR AN "A" GAS GENERATOR BED HEATER FAILURE WHERE THE "A" VALVE MODULE/LINE HEATERS ARE STILL MAINTAINING TEMPERATURES WITHIN ACCEPTABLE LIMITS VIA THERMOSTAT CONTROL, THEN: @CR 8804]
1. ON ORBIT, THE HEATER SWITCH WILL STAY SELECTED TO "A AUTO", AND
 2. PRIOR TO ENTRY APU START, THE HEATER SWITCH WILL BE SELECTED TO "B AUTO" OR "OFF" IN ORDER TO MAINTAIN THE GAS GENERATOR INJECTOR AND BED TEMPERATURES WITHIN ACCEPTABLE START LIMITS (REFERENCE RULE {A10-22}, APU START/RESTART LIMITS [HC], PARAGRAPHS A AND E).

As discussed in the rationale above, the gas generator heater is a separate string, so it is possible for it to fail without affecting the other heater string for the lines, pump, and valve module. Since the GG bed has to be within the appropriate range only for APU start, it is acceptable to stay selected to the "A" heaters. If the GG bed heater is failed on, the bed temperature will rise to approximately 500 degrees F and level off; this does not pose a hazard. Prior to APU start, the GG bed temperature must be brought back within acceptable limits. For the failed off case, selecting the "B" heater is necessary; for the failed on case, either selecting "B" or taking the heater off can be performed (if the heater is turned off, then the supply and bypass line temperatures must be monitored to ensure these do not become too cold).

- C. PRIOR TO APU START, THE HEATER SWITCH WILL BE TAKEN TO "OFF" IF NEEDED TO ENSURE THAT THE GAS GENERATOR INJECTOR AND BED TEMPERATURES ARE WITHIN ACCEPTABLE START LIMITS AT APU START (REFERENCE RULE {A10-22A}.1.a, APU START/RESTART LIMITS [HC]).

With the "A" GAS GEN/FUEL PUMP heater selected, the injector temperature will exceed the flight rule limits for APU start for approximately 7.5 minutes out of each approximately 25 minute cycle (varies by APU; this violation does not occur with the "B" heater selected, due to the relative locations of the "A" and "B" heaters to the GG bed temperature transducer, which is used to control the heaters). To avoid a heater violation at the intended APU start time, the heater will be taken off far enough in advance to ensure acceptable temperatures, but without causing the supply or bypass lines to become too cold. Once the APU is operating, the high temperatures generated by the APU will cause the valve module/line heaters to not be needed for a significant amount of time following APU shutdown. @CR 8804]

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FLIGHT RULES

10A_A10-3 APU GAS GEN/FUEL PUMP HEATER MANAGEMENT (CONTINUED)

D. FOR ENTRY, THE HEATER SWITCH WILL BE TAKEN TO "OFF" PRIOR TO THE POST LANDING APU SHUTDOWN TIME. FOR AN APU THAT IS SHUT DOWN PRIOR TO THE NOMINAL POST LANDING SHUTDOWN TIME, THE HEATER SWITCH WILL BE TAKEN TO "OFF" WHEN PRACTICAL POST LANDING. @CR 8804]

The GAS GEN/FUEL PUMP heaters are inhibited while the APU is operating (OPERATE switch in START/RUN). Even if the valve module heater has shorted to ground, following APU shutdown, the high APU temperature should prevent the overtemp thermostat from cycling the heater on. However, to preclude the possibility of an overtemp thermostat failure, together with a short to ground, causing the heater to come on, the heater switch will be taken to "OFF" prior to shutting the APU down postlanding (heater deactivation may be performed prior to entry). If the APU shuts down prior to landing, then heater deactivation will be performed as soon as practical after landing. Per paragraph C of this rule, it is likely the heaters will have been deactivated prior to APU start, so deactivation postlanding will not be necessary. @CR 8804]

10A_A10-4 APU FUEL LEAKS [CIL] [HC] @CR 8808]

THIS RULE SUPPLEMENTS RULE {A10-27B}, APU FUEL LEAKS [CIL].
@DN 143]

ON ORBIT POST-MECO, AN APU WITH A SUSPECTED OR CONFIRMED NONISOLATABLE HYDRAZINE LEAK WILL BE OPERATED FOR THE PURPOSE OF DEPLETING ITS FUEL, UNLESS THE LEAK RATE IS SMALL AND DELAYING OPERATION WILL NOT SIGNIFICANTLY INCREASE THE TOTAL AMOUNT OF FUEL LEAKED. AN ASSESSMENT, BASED ON THE PREDICTED AMOUNT OF FUEL LEAKED BY WHEELSTOP ASSUMING THE APU IS NOT OPERATED TO FUEL DEPLETION, WILL BE PERFORMED TO DETERMINE THE RISK TO CREW SAFETY AND THE POTENTIAL FOR SIGNIFICANT VEHICLE DAMAGE. IF THE RISK IS DEEMED:

- A. UNACCEPTABLE, THEN OPERATION TO DEPLETION WILL PROCEED ASAP.
- B. ACCEPTABLE, THEN OPERATION TO DEPLETION MAY BE OMITTED SO THAT THE APU CAN BE USED FOR ENTRY. CONSIDERATION WILL BE GIVEN TO ON-ORBIT OPERATION IN ORDER TO REDUCE THE LEAK RATE WHILE MAINTAINING ENTRY SUPPORTABILITY.

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FLIGHT RULES

10A_A10-4 APU FUEL LEAKS [CIL] [HC] (CONTINUED)

For the purposes of this rule, the leak rate seen during STS-121 (approximately 1 lb/day hydrazine) is used to define a “small” leak, and is used as the criteria to decide if immediate action is needed. Leak rates significantly higher in magnitude than approximately 1 lb/day constitute an unacceptable risk and require APU operation ASAP. ©[CR 8808]

If the leak is upstream of the FIV's, then the leak is not isolatable and fuel will continue to leak into the orbiter aft compartment even with the APU shut down. A significant amount of free hydrazine in the aft compartment presents a severe safety hazard - hydrazine will attack materials in the aft compartment (e.g., Kapton wire insulation) and poses a fire risk during entry. The only method available to lessen the amount of hydrazine released is to operate the APU, which reduces both the amount of fuel that can leak and the leak rate (by lowering the driving pressure).

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There are conditions under which APU operation must be delayed or even possibly omitted. For high enough leak rates, the APU fuel tank will be depleted before the crew can work the procedure - this is a real-time determination based on fuel tank quantity, leak rate, crew activities, docked status, etc. If docked, shuttle-ISS stack attitude control is not possible if operating the APU at the maximum fuel depletion rate (which is achieved by operating with the hydraulic pump in NORM PRESS, aerosurface drive active, and the affected system's MPS/TVC isolation valve open). Reference Rule {10A_C10-2}, APU OPERATION FOR THERMAL MANAGEMENT WHILE DOCKED [RC], for constraints to APU operation while docked to ISS.

Peak loading from random vibrations on the fuel tank is approximately 18 g's during ascent, 0 g's during orbit, and approximately 7 g's during entry. If the leak started during ascent, then the entry loads, which are approximately 66 percent lower, are unlikely to increase the leak rate (though it is still possible). If the leak started on orbit, the possibility of increasing the leak rate during entry is higher, since the entry loads are much higher than orbit loads. ©[DN 143]

During STS-121, a very small leak was detected upstream of the FIV's for APU 1. The following paragraphs describe the signature and decision process that took place. ©[DN 143]

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At the time of detection, the crew was asleep, the orbiter was docked to the ISS, and the leak rate was extremely small (approximately 1 lb/day hydrazine). The FCT opted not to start the APU immediately. This decision was based on (a) the small leak rate, so delaying APU operation to deplete the fuel in the tank did not significantly increase the amount of fuel leaked into the aft compartment, and (b) shuttle-ISS stack attitude controllability issues previously mentioned. The time gained by not immediately running the APU was used to thoroughly check for any signs of the effects of fuel exposure on adjacent equipment, review ground-processing anomalies, and solicit the experience of other centers to gather experimental and analytical data on the potential effects of a small amount of free hydrazine in the aft. An evaluation of the ground-processing data revealed a leak on the GN₂ fill QD during preparation for the APU confidence run. Cycling the QD poppet stopped the leak. Leaks of this type are not uncommon during ground-processing; STS-3 launched with a known leak at the GN₂ service coupling. The spec leakage for the GN₂ fill QD is 5×10^{-3} sccs at 400 psia using helium. The QD flight cap, which provides a secondary seal, is single use and refurbished for every flight. After the tank has been filled with N₂ for flight, a soap bubble check is performed to verify there is no leakage. ©[CR 8808]

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FLIGHT RULES

10A_A10-4 APU FUEL LEAKS [CIL] [HC] (CONTINUED)

Based on the rate, the leak could have been either GN₂ or hydrazine. Unless the effects of the leaking hydrazine are detectable in the telemetry (e.g., unexplained lowered temperatures, increased heater duty cycles, loss of transducers, etc.), the only method to determine a hydrazine versus a GN₂ leak is by operating the APU to fuel depletion; at depletion the fuel tank pressure (measured on the GN₂ side of the diaphragm in the tank) will show approximately 80 psia (based on the standard fuel load), whereas the pressure will be lower than this (and will continue to decay) for a GN₂ leak. For STS-121, it would have been impossible to distinguish the leak type using this method given the small leak rate and the uncertainties caused by thermodynamic effects on the system as the fuel was removed from the tank (i.e., GN₂ cooling caused by the drop in pressure, the likelihood of fuel tank heater cycling due to the reduced mass of fuel in the tank, and the reduced leak rate with lower tank pressure). @[CR 8808]

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There were no indications of increased APU fuel tank heater duty cycles, which may be expected for hydrazine trapped under the tank insulation in proximity of the APU tank heaters control thermostats. There were also no indications of increased APU fuel line heater duty cycles, which may be expected for free hydrazine accumulation on the exterior of the fuel lines in proximity of control thermostats (leak spraying on the line). Analysis performed by the NESC indicated that a hydrazine leak will form snow immediately after it exits the leak site. Given the size of the leak on STS-121, 30 percent of the mass would vaporize and the remaining 70 percent would be hydrazine ice. NESC analysis also indicated that if the insulation was properly installed (trapping the hydrazine), an increase in the heater duty cycle would eventually occur, and definitely within the timeframe experienced during the flight. For the leak to be hydrazine, and not detectable in the heater duty cycles, the insulation would have to have been damaged or installed incorrectly, or the leak would have to be through the hydrazine fill OD. During the mission, the statement that a hydrazine leak would be evident in heater cycles was questioned based on the STS-62 anomaly, where water was trapped under the fuel line insulation prior to launch causing the fuel in the section of line to freeze post-ascent; this was not detectable in temperature measurements or heater duty cycles. At a meeting between APU PRT personnel and NESC personnel post-flight, it was agreed that a fuel line heater duty cycle increase will not occur as a result of hydrazine snow trapped under fuel line insulation when the snow is on fuel lines on the non-isolatable portion of the fuel system (up stream of the FIV's). This is because the thermostat controlling temperatures of the fuel lines on the non-isolatable portion of the fuel system is located down stream of the FIV's. The thermostat would be physically and thermally isolated from trapped snow accumulation beneath line insulation produced by a non-isolatable fuel leak. @[DN 143] @[CR 8808]

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FLIGHT RULES**10A_A10-4 APU FUEL LEAKS [CIL] [HC] (CONTINUED)**

During the mission, the APU fuel system designer noted that, assessing the fuel system as a whole, the GN₂ dynatube cast fittings may be a likely leak source due to inclusions and electro-polishing that can result in reduced thickness in the dynatube. Additionally, the GN₂ dynatube section is not heated and thermal cycling could induce cracks. The GN₂ dynatube on APU 1 was original equipment except for a small section near and including the servicing QD. While the hydrazine lines also have dynatube sections, these sections are not as old and the designer felt they were less likely to develop a leak than the GN₂ section. Another factor that pointed towards a GN₂ leak was the steady leak rate; a fuel leak is likely to be sporadic due to fuel freezing and thawing, causing a non-linear pressure decay (especially at low leak rates). [DN 143] [CR 8808]

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Also, during the mission, in-flight analysis by USA showed the pressure decay could have been caused by a heat leak on the pressurant side of the tank from insulation loss or fluid intrusion. This theory was however eventually ruled out as a cause in post-flight analysis. [CR 8808]

Hydrazine has a 4.7 percent lower flammability limit (in air, based on volume; 2.9 percent has been reported as well); below this concentration ignition cannot occur. Hydrazine has an upper flammability limit of 100 percent (i.e., pure hydrazine) and, given an ignition source, becomes flammable at this concentration level at pressures of 0.3 psia and higher, equivalent to approximately 87,000 ft altitude. Below 0.2 psia, equivalent to approximately 95,000 ft altitude, the pressure is too low to support hydrazine ignition at any mixture ratio with air. Reference AIAA Report SP-084-1999, "Special Project Report: Fire, Explosion, Compatibility, and Safety Hazards of Hypergols - Hydrazine." Although hydrazine flammability is always a concern, the consensus was that a small amount of hydrazine leaking from the tank would not be a fire concern during entry due to the location of the fuel tanks in proximity to potential hot spots in the aft compartment. For the STS-121 leak, the most probable ignition source was determined to be insulated Kapton wiring at the bottom of the aft fuselage. However, this wiring is protected by tubing that requires immersion in hydrazine for hours in order to expose the conductor.

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FLIGHT RULES

10A_A10-4 APU FUEL LEAKS [CIL] [HC] (CONTINUED)

APU 1 was used for FCS C/O and entry without incident. Operating the APU for FCS C/O lowered the pressure on the system while providing confidence that operation would not increase the leak rate. Hydrazine sniff checks performed post-landing were negative. GN₂ OD bubble soap leak checks (with and without the flight cap) also found no leakage. Postflight the tank was pressurized with helium to approximately 400 psia and mass spectrometer readings did not locate the leak. The tank was then pressurized to approximately 400 psia with GN₂ and remained pressurized for several days with no decay in tank pressure. Inspection of the OD found contamination on the GN₂ OD poppet Teflon seal (the primary seal). Damage was also found to the OD flight cap bleed port seal along with an undertorqued bleed port screw (the secondary seal). Although neither the primary seal nor the secondary seal leaked in the warm postlanding environment, the cold on-orbit environment of the unheated OD could have enabled a leak due to reduced resiliency of the Teflon seals. The APU technical community has identified this as the most probable cause of this anomaly. Postflight inspection did not identify any missing GN₂ pressurant insulation. It should be noted that the system repressurizations for leak checks postflight did disturb the OD poppet which in turn may have disturbed factors contributing to the on orbit leak. Another possible explanation for the pressure decay is GN₂ leaking across the diaphragm and dissolving into the fuel; a phenomenon similar to this has been seen in the propulsion system, causing a drop in pressure; however, postflight testing did not indicate a leak across the tank diaphragm. Reference CAR 121RF11 for a summary of the postflight investigation concluding that the observed leakage was GN₂. [@\[CR 8808 \]](#)

In addition to the post-flight discussions and investigation, WSTF testing has been proposed to investigate the behavior of hydrazine leaked under heater component insulation in a vacuum. The testing has not yet been performed.

Reference Rule {A10-27B}, APU FUEL LEAKS [CIL]. [@\[DN 143 \]](#)

Reference: Hazard reports ORBI 250, Hydrazine Leakage From the APU System Results in Catastrophic Loss, and ORBI 278, Loss of Structural Integrity due to Overpressurization of the Mid and/or Aft Fuselage, reference this rule. [@\[CR 8808 \]](#)

FLIGHT RULES

10A A10-5 ANTENNA STOW REQUIREMENT EXCEPTIONS [CIL] [HC]

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IN ADDITION TO THE EXCEPTIONS LISTED IN RULE {A10-301A}, ANTENNA STOW REQUIREMENT [HC] [CIL], FOR LOSS OF STOW REDUNDANCY THE KU-BAND SYSTEM WILL NOT BE STOWED WHILE THERE IS A REQUIREMENT FOR KU-BAND SUPPORT OF ORBITER TPS HEALTH ASSESSMENT. @[CR 8693]

The requirements of orbiter TPS health assessment, which include, but are not limited to, TPS inspections (SRMS or OBSS) and wing leading edge sensors (WLES) data downlink, are sufficient to keep the Ku-band antenna deployed, even for loss of stow redundancy. Once the requirements for Ku-band support of orbiter TPS health assessment are satisfied, Rule {A10-301A}, ANTENNA STOW REQUIREMENT [HC] [CIL], may be invoked as required. @[CR 8693]

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FLIGHT RULES

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THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION

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FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_C10-1 CBM PREMATE SEAL INSPECTION REQUIREMENT (10A) [HC]

DETAILED INSPECTIONS OF THE NODE 1 PORT ACTIVE AND NODE 2 PASSIVE COMMON BERTHING MECHANISMS MUST BE PERFORMED PRIOR TO MATING THE NODE 2 TO THE ISS. THESE INSPECTIONS SHALL OCCUR AS CLOSE TO THE MATING EVENT AS POSSIBLE AND BE DETAILED ENOUGH TO INDICATE BOTH GROSS BLOCKAGE AS WELL AS ANY FOD VISIBLE ON THE RING OR SEALS/SEAL-SUBSTRATE AT THE HIGHEST ZOOM OF THE BEST AVAILABLE CAMERA. THE INSPECTIONS SHALL USE BEST AVAILABLE VIEWS (EVA, SSRMS, PLB CAMERAS IN THAT PRIORITY ORDER):

TO BE GO FOR ELEMENT MATING, ALL OF THE FOLLOWING MUST BE TRUE:

- A. FOUR NODE 1 PORT ACBM PETAL COVERS ARE DEPLOYED AND CLEAR OF THE INTERFACE.
- B. CBM MATING CORRIDOR CLEAR OF STRUCTURAL BLOCKAGE AND IN EXPECTED CONFIGURATION.
- C. NODE 2 PCBM SEALS AND NODE 1 PORT ACBM MATING SURFACE MUST BE CLEAR OF LARGE SOLID DEBRIS THAT MIGHT CAUSE DAMAGE TO THE ACTIVE CBM DURING THE MATING.
- D. THERE MUST BE A VERY HIGH DEGREE OF CONFIDENCE IN THE ABILITY OF AT LEAST ONE PCBM SEAL TO COMPLETELY SEAL AGAINST THE ACBM INTERFACE.

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FLIGHT RULES

**10A_C10-1 CBM PREMATE SEAL INSPECTION REQUIREMENT (10A) [HC]
(CONTINUED)**

- E. IMAGERY OF ANY DAMAGE/DEBRIS/BLOCKAGE SEEN DURING ACBM OR PCBM INSPECTION SHOULD BE RECORDED/TAKEN ONBOARD TO ALLOW FOR POST FLIGHT REVIEW.

Detailed inspections of the ACBM and PCBM seal interfaces provide assurance of the condition of the two halves of the CBM interface prior to mating and thus reassurance that the CBM vestibule will successfully pressurize after the CBM is fully mated. These inspections should occur on the same day as mating if at all possible. This inspection verifies that the CBM petal covers are fully deployed and capture latches are clear of the interface. Thus, this inspection can only occur once the petals have been opened for the final time prior to the mate (i.e., opening the petals, performing an inspection, and closing the petals again does not buy you anything; you have to do another inspection, albeit possibly not as detailed, of the interface to verify the petals are deployed and mating interface clear). This inspection should not occur until after orbiter docking. The petal covers should be closed during orbiter rendezvous and docking to prevent orbiter thruster or payload bay debris from contaminating the CBM interface (same rationale as having the Lab window shutter closed during Prox Ops).

- a. *The CBM petal covers provide thermal and MM/OD protection to the Node 1 CBM radial ports when an element is not mated. The petal covers are spring loaded to deploy when the CBM capture latches are commanded open, but there is no telemetry that confirms the petal covers fully deployed. If a petal cover is not fully deployed and is caught between the two halves of the CBM during a mating, it could be crushed resulting in damage to both the ACBM and PCBM sealing surfaces. The NODE 2 can be returned to the ground for repair, but the damage to the ACBM could render this mating port permanently unusable. The NODE 2 would not be able to be pressurized should this type of damage occur. Once a petal cover is deployed, the capture latch attached to that petal pulls back away from the CBM interface. It must be verified that all four capture latches are clear of the CBM interface since it cannot be verified by telemetry alone. If the capture latch is not free of the interface, it can be caught between the two interfaces during the mate, causing the same problems as a caught petal cover.*
- b. *The CBM has a large amount of auxiliary hardware surrounding it (MM/OD panels, MLI blankets, thermal stand-off plungers, endcone jumpers, etc.). When performing a check of the petal covers and seal surfaces, a check should be done to ensure no structural hardware is seen to block the expected incoming element's translation corridor (i.e., CBM mating corridor). Reference procedure 1.504, NODE 1 CBM PREP FOR MATE, step 23, in the ISS Structures and Mechanisms book for actual crew inspection steps.*

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**10A_C10-1 CBM PREMATE SEAL INSPECTION REQUIREMENT (10A) [HC]
(CONTINUED)**

- c. *Any debris which seems to be of a metallic origin or have any hardness to it may cause permanent damage to the ACBM ring when compressed. A ground test was conducted pressing debris found on the UF-2 MPLM into an ACBM ring substrate to the same pressures found at mating. This test revealed very little damage to the ACBM and the damage was deemed acceptable by the Vehicle Control Board. This material was made up of several types of hard metal. While this damage has been deemed acceptable for the one time incident of UF-2, one should remember that the ACBM ring cannot be repaired, so damaging this hardware should not be risked. Large metallic objects should be cleaned off the ACBM prior to mating the NODE 2 as any type of damage will affect the lifetime of the ISS. The Node 1 PORT ACBM port must be used in the future to support Node 3 permanently starting at 20A. Prior to being go for mating, any large debris that will obviously cause damage to the ACBM must be cleaned off by EVA. It is undesirable to take the approach of "mate and see if we pressurize or not" as the CBM is zero-fault tolerant for demating. A failure during demate of an element where it is known that the vestibule cannot be pressurized means that that module is permanently mated to ISS. Impacts to the 10A stage are wideranging due to the 1E and 1J flights intending to attach modules onto the NODE 2. The debris which caused damage to the UF-2 NODE 2 PCBM was about the width of one CBM seal bead (0.2 in or 0.5 cm). Reference Boeing drawing 683-13531. For crew inspection procedure steps, refer to the CBM inspection criteria procedure in the ULF1.1 Joint Ops book.*
- d. *This rule allows one to be go for a mating with only one verified good seal in both the case of seal/surface damage and the case of debris on the interface. This is highly undesirable, but in some cases you will be driven to it due to lack of ability to repair damage on orbit (thus have to balance this risk against the risk of re-flying the entire mission (ascent, landing, cost/schedule to program, etc.) and if the ACBM is damaged, then never continuing the build of ISS at this port). In the case of only one verified good seal, there is still the potential that you may get additional sealing help from even a damaged seal. For the case where two seals/surfaces have some minor "soft" debris, you are allowed to press forward even though the only real risks are to the timeline (have to wait at least a day to do EVA and mate the NODE 2) and the mission priorities (some tasks may not be able to be completed and will be deferred to increment or a later flight). It should be noted that there are other single CBM failures (particularly petal failure) which would force this type EVA/mission priorities change and would not even present a choice about pressing on.*

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10A_C10-1

CBM PREMATE SEAL INSPECTION REQUIREMENT (10A) [HC] (CONTINUED)

DEBRIS (such as MLI or smaller contamination) across the braycote-greased seal beads of the PCBM or the aluminum sealing surface on the ACBM can lead to excessive leakage at the interface or prevent the completion of structural mating. Typically, one is most concerned about debris or damage that extends radially across multiple seal beads, which could cause a through-leak from the CBM vestibule through two or more beads. The CBM gasko-seal material is such that it can sometimes obtain a good seal even with some limited damage to the bead or contamination across it. In cases of scratches or damage to the seal bead itself, on-orbit repair is not possible because the seal is not EVA R&R compatible. Imagery would always be requested to document any areas of concern prior to the mating event (per the nominal procedures). If it is determined that debris on the ACBM or PCBM is of "soft" nature, mating may be attempted as long as there remains high confidence that this debris will not in any way affect more than two of the CBM seals. Every effort should be made to examine imagery of this debris and try to isolate its origin prior to proceeding with the mate. "Soft" debris is not meant to include items such as straps or MLI pieces, but rather small pieces of FOD, such as hair or dust particles. Since depressurization is a Catastrophic Crew Hazard, it is required that the design provide three seals to vacuum as this seal is being mated on orbit. Prior to committing to the mate on less than three seals, heavy consideration must be made on whether to press or defer to clean the seals via EVA (which can be done but is a timeline hit to the mission and may affect ability to complete all mission objectives on the flight).

DAMAGE: The PCBM Gasko-seals can accommodate some level of damage and still hold pressure successfully (for example a slice type cut which will be pushed back together when pressure is applied). The Seals are much more sensitive to damage at the interfaces between the seal sections or if a "chunk" of the seal is removed. In cases where at least one seal bead (and corresponding ACBM surface) is determined to definitely be good (that is, not damaged in any way) the ground can still decide to press forward as long as there remains high confidence that one CBM seal is not in any way affected by this damage. The rule allows for pressing with only one verified good seal/surface since ACBM/PCBM damage cannot be fixed on orbit, and the risk of continuing the mating is less than the risk of flying the entire mission again. In the case where one or two PCBM seals are damaged, a ground assessment of close-up imagery shots is required before proceeding. Some additional constraints (such as leaving the Node to NODE 2 hatch closed when crew is not actively using the NODE 2) would likely be considered in this case as there is potentially only one seal to vacuum. If all three seal beads are very questionable or bad, the risks of trying the mate anyway are very high and should not be attempted. If no other CBM or SSRMS components were failed, it would take two CBM failures to keep one from attempting a successful pressurization. Unfortunately, if the seals end up not holding pressure, any single CBM failure during the mate (such as a bolt failing during bolt retraction) will keep you from demating and returning the NODE 2 to Earth to try another day (though with 12 of 16 bolts engaged, the element can remain partially mated on the PORT port and left unpressurized indefinitely).

Documentation: Hazard Report ISS-ECL-0210-9A, Depressurization of ISS, Cause 1, Pressure Loss (General), and FMEA Prime 75.000, Passive Ring, Failure Mode: Leakage External, all causes, list the causes and effects of damaged seal surfaces to pressurization of the ISS. ©[DN 70]

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FLIGHT RULES

10A_C10-2

APU OPERATION FOR THERMAL MANAGEMENT WHILE DOCKED [RC]

DURING THE DOCKED MISSION PHASE, AN ORBITER AUXILIARY POWER UNIT (APU) MAY BE OPERATED PERIODICALLY FOR THE PURPOSE OF MAINTAINING APU FUEL COMPONENT TEMPERATURES WITHIN ACCEPTABLE LIMITS (REFERENCE RULES {A10-1A}.7, APU LOSS DEFINITIONS [HC], AND {A10-30A}, LOSS OF APU HEATERS/INSTRUMENTATION [CIL]). THE FOLLOWING CONDITIONS AND CONSTRAINTS APPLY: @[DN 144]

- A. ONLY A SINGLE APU MAY BE OPERATED AT A TIME.
- B. THE APU WILL ONLY BE OPERATED FOR APPROXIMATELY 5 MINUTES WITH THE ASSOCIATED SYSTEM'S HYDRAULIC MAIN PUMP IN LOW PRESS.
- C. SHUTTLE VRCS ATTITUDE CONTROL IS REQUIRED DURING APU OPERATION; SHUTTLE PRCS OR ISS ATTITUDE CONTROL ARE NOT PERMITTED.
 - 1. APU OPERATION AND ASSOCIATED VRCS ATTITUDE CONTROL WILL BEGIN ONLY AFTER THE ISS FCT VERIFIES/COMMANDS THE P4 SAW TO A SAFE DYNAMIC LOADS ZONE.
 - 2. APU OPERATION WILL NOT COMMENCE WITH THE L5L JET DESELECTED.
- D. TWO COMPLETE APDS HOOK GANGS MUST BE CLOSED.
- E. U.S. LAB WINDOWS MUST BE CLOSED DURING APU OPERATION.
- F. CREW EXERCISE IS PROHIBITED DURING APU OPERATION. PUSH LOADS FROM IVA ACTIVITIES MUST BE MINIMIZED.

APU service and bypass lines, fuel pump, and valve module temperatures can freeze, leading to line rupture and fuel leakage, for failure of the APU gas gen/fuel pump heaters. Periodic APU operation will prevent freezing of the APU: heat soakback approximately 5 minutes of operation will maintain the APU above the fuel freezing point for approximately 12 hours.

Analysis has only been performed for mated configurations with a single APU running; therefore, only a single APU maybe be operated at a time while docked. Loading analysis did not include additional loads induced by crew exercise or IVA activities; and therefore, these activities are constrained. @[DN 144]

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FLIGHT RULES

10A_C10-2

APU OPERATION FOR THERMAL MANAGEMENT WHILE DOCKED [RC] (CONTINUED)

Keeping the hydraulic main pump in low press minimizes the quantity of and thrust created by the APU exhaust, and thereby limits the effects of plumbing on the ISS and the amount of VRCS consumables that must be used to maintain the mated stack attitude. The short period of operation will preclude the need for lube oil cooling, so no water spray boiler (WSB) water/PGME exhaust will be generated. ©[DN 144]

Analysis indicates that Shuttle VRCS attitude control is the only permitted method of docked phase attitude control during APU operation. Analysis has determined that Shuttle PRCS attitude control is not possible due to PRCS jet on/off time constraints. ISS attitude control may be possible for some short duration, low thrust APU venting scenarios, but is not recommended due to the possibility of CMG desaturation and in order to minimize use of ISS propellant. Assuming that no other failures necessitate the use of extra prop consumables, then the nominal margins for STS-118 are sufficient for controlling the mated assembly during APU operation.

The L5L jet poses a plumbing concern for the P4 SAW, and therefore, the P4 SAW must be positioned in a safe zone prior to firing of the L5L jet. Loading analysis did not cover the deactivation of the L5L jet during APU operation and therefore, APU operation will be delayed until the P4 SAW can be safely positioned, thereby allowing the use of L5L. Reference Rule {10A_C2-156}, STS-118/10A JOINT MISSION USOS SOLAR ARRAY CONSTRAINT CONTINGENCY RESPONSE [HC] [RI], for deselection of L5L prior to use of verniers while docked.

Loads analysis has been completed for the STS-114 (ULF1) and STS-115 (12A) stack configuration for running an APU while docked. The change in the configuration for STS-118 (addition of S5) is not significant enough of a difference from the STS-115 configuration to warrant an additional analysis and running an APU while docked for STS-118 (10A) is not an issue from a loads perspective. The loads analysis assumes that two complete APDS hook gangs are closed. Reference "STS-118 Orbiter APU Usage During Mated Operations" memo, dated November 29, 2006 (S4460-06-ODL-0027, ESCG-4460-06-LODY-DOC-0226), and Rule {10A_B2-43}, SOLAR ARRAY POSITIONING PRIORITIES [HC] [RC], for guidelines on array positioning for contamination/erosion.

U.S. concurrence has been generically given for exposure for up to 285 lbs (typical APU fuel tank quantity while docked) of cumulative hydrazine emissions per year for U.S. segments, provided the U.S. lab windows are closed during APU operation. For the gas gen/fuel pump heater failure scenario requiring periodic APU operation while docked during STS-118, approximately 70 lbs of fuel will be exhausted worst-case (approximately 5 lbs of fuel used each run x 2 runs per day x 7 docked days). Russian concurrence for contamination of Russian segments from APU exhaust is pending.

*Rule {10A_A10-3}, APU GAS GEN/FUEL PUMP HEATER MANAGEMENT, references this rule.
©[DN 144]*

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FLIGHT RULES

CBM CONTINGENCY OPERATIONS

10A_C10-11 **RESPONSE TO CBM FAILURES** ©[ED]

- A. FOR A LAB FORWARD CBM FAILURE THAT PREVENTS DEMATING OF PMA-2, OR A NODE 1 PORT CBM FAILURE THAT PREVENTS DEMATING OF NODE 2/PMA-2 STACK, THE ELEMENT WILL BE RE-MATED AND RE-PRESSURIZED AND AN IVA IFM PERFORMED TO REPLACE THE FAILED HARDWARE.

See Rule {B10-51}, CBM FAILURE IMPACT MATRIX [HC], for failures that prevent demating.

- B. FOR FAILURES TO THE LAB FORWARD CBM THAT IMPACT FAULT TOLERANCE FOR NODE 2 MATING, ALTHOUGH THEY WILL NOT PREVENT DEMATE OF PMA-2, THE PMA-2 WILL BE RE-MATED, RE-PRESSURIZED, AND AN IVA IFM BE PERFORMED.

Critical ORU's for CBM attachment mechanisms are: Lab Fwd CBM Controller Panel Assembly, Lab Fwd CBM Capture Latch Assembly, Lab Fwd CBM Powered Bolt Actuator, Lab Fwd CBM Powered Bolt Assembly, and PMA 2 CBM Nut Assembly.

The PMA 2 APAS hatch valve will be closed on Flight 10A allowing the ISS crew to pressurize and ingress PMA 2 if required.

The point of moving PMA-2 from Lab Forward is to place the Node 2/PMA-2 stack there. If a problem is encountered before the hardware is demated, it makes better sense to fix the problem IVA than to go EVA or to mate Node 2 with reduced fault tolerance.

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FLIGHT RULES

10A_C10-11 RESPONSE TO CBM FAILURES (CONTINUED)

- B. AN EVA IFM WILL BE PERFORMED TO SWAP OUT A CBM CPA (CONTROLLER PANEL ASSEMBLY THAT CONTAINS FIVE CONTROLLERS) WITH A CPA FROM ANOTHER CBM FOR THE FOLLOWING CASES:
1. TWO LATCH CONTROLLERS OR MULTIPLE BOLT CONTROLLERS (SUCH THAT A PRESSURE SEAL OR STRUCTURAL MARGIN COULD NOT BE MAINTAINED) FAILED ON THE LAB FORWARD CBM FOLLOWING PMA 2 DEMATE BUT PRIOR TO NODE 1 PORT MATE. CPA SHOULD BE BORROWED FROM TBD CBM.
 2. ANY INTERNAL CPA FAILURE WHICH LEAVES THE ENTIRE CPA ZERO FAULT TOLERANT DURING THE BERTHING EVENT (FOR EXAMPLE AN EMI FAILURE.)

A CBM can function and provide a good pressure seal with any single controller failed. A CPA changeout puts five controllers at risk. Only if the CBM is in a condition where it cannot support a berthing or not provide a good pressure seal should a changeout be performed. Reference Rule {B10-51}, CBM FAILURE IMPACT MATRIX [HC].

If failures occur during PMA 2 demate, PMA will be remated, and changeout will occur via IVA maintenance.

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SECTION 11 - COMMUNICATIONS

SHUTTLE ONLY RULES

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JOINT SHUTTLE/ISS RULES

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SECTION 11 - COMMUNICATIONS

SHUTTLE ONLY RULES

10A_A11-1 **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.

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 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 field of view. 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 field of view is potentially facing towards the sun. The IDC 50mm lens field of view is modeled as a cone leaving the IDC lens with a 20-degree angle.

10A_A11-2 **RESERVED** ®[DN 40]

FLIGHT RULES

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THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION

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JOINT SHUTTLE/ISS RULES

10A_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 624 FT OR WHEN THE KU MAIN BEAM RADIATION IS GREATER THAN 5 DEGREES AWAY FROM THE ISS STRUCTURE.
- B. WHILE THE ISS IS WITHIN 8 DEGREES OF THE ORBITER -Z AXIS AND THE RANGE IS LESS THAN 624 FT, A "BETA ONLY" MODE WITH A BETA VALUE OF -80 DEGREES WILL PROTECT THE STATION IN THE EVENT THE KU SYSTEM IS RECONFIGURED TO COMM MODE.

AS AN ALTERNATIVE, FOR RANGES GREATER THAN 350 FT WHILE THE STATION IS WITHIN 8 DEGREES OF THE ORBITER -Z AXIS, A "BETA ONLY" MODE WITH A BETA VALUE OF +21 DEGREES CAN BE USED WITH THE FOLLOWING RF PROTECT BOX; HOWEVER, THE BOX WILL PREVENT LOCK-ON WHEN THE KU IS IN RADAR MODE:

BOX B1 = -35<AZ<35 -35<EL<35 (MODULES/STRUCTURE)

FOR RANGES LESS THAN 350 FT AND WITHIN THE 8-DEGREE ISS APPROACH CORRIDOR, THE RF PROTECT BOX MUST BE CHANGED TO:

BOX B2 = -70<AZ<45 -62<EL<75 (MODULES/STRUCTURE)

IF THE ISS IS NOT WITHIN 8 DEGREES OF THE ORBITER -Z AXIS OR WITHIN THE APPROACH CORRIDOR, THE KU WILL REMAIN IN OR WILL BE TAKEN TO STBY UNTIL THE APPROPRIATE -Z AXIS OR CORRIDOR CONDITIONS ARE MET.

- C. PRIOR TO S3/S4 INSTALL, WHILE THE SHUTTLE IS DOCKED TO ISS AND NO EVA OR RMS 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 AS DEFINED BELOW:

BOX C1 = -12<AZ<45 -62<EL<75 (MODULES/STRUCTURE)

BOX C2 = -30<AZ<-7 -27<EL<40 (ISS AIRLOCK/SSRMS POSITION IN STOWED POSITION)

BOX C3 = -70<AZ<-25 -12<EL<40 (S0 AND S1)

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10A_C11-1 ORBITER KU-BAND CONFIGURATION (CONTINUED)

- D. DURING EVA AND SSRMS OPERATIONS, THE KU SYSTEM WILL BE OPERATED AS DEFINED IN PARAGRAPH C, WITH THE ADDITION OF THE FOLLOWING RF PROTECT BOX:

BOX D1 = -86<AZ<-7 -27<EL<40 (EVA/SSRMS OPERATIONS)

AFTER S3/S4 INSTALL, THE KU SYSTEM WILL BE OPERATED AS DEFINED IN PARAGRAPH C, WITH THE ADDITION OF THE FOLLOWING RF PROTECT BOX:

BOX D2 = -86<AZ<-65 -4<EL<18 (S3 AND S4)

The ISS radiation limit, as defined in Rule {C11-4}, SHUTTLE KU-BAND RADIATION LIMITS, is 20 V/m. The EVA radiation exposure level, as defined in Rule {A11-7}, KU-BAND OPERATIONS DURING EVA, is also 20 V/m that is established by the EMU specifications. Twenty V/m is reached at 624 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. Real-time management of the masking schemes may be used to increase KU-band return link in zones that do not violate the above restrictions, but are undesirably masked by one of the RF Protect Boxes listed.

Unplanned SSRMS motion creates risk of direct Ku-band radiation in excess of SSRMS limits while the Shuttle Ku system is operated in the comm mode.

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.

FLIGHT RULES

10A_C11-2

LCS RADIATION RESTRICTIONS

- A. SHUTTLE COMMUNICATIONS SYSTEMS RESTRICTIONS DURING LASER CAMERA SYSTEM (LCS) SCANNING OPERATIONS:
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) USAGE DURING LCS SCANNING OPERATIONS.
 3. THERE ARE NO RESTRICTIONS FOR S-BAND STRING 2 (P6) USAGE DURING LCS SCANNING OPERATIONS.

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FLIGHT RULES

10A_C11-2 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.

S-band string 1 is the planned primary string during the STS-120/10A mission. S-band string 2 may be utilized during the joint mission timeframe. While 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 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.

FLIGHT RULES

10A_C11-3

SHUTTLE KU-BAND RADIATION LIMITS [HC] [RC]

WHILE OPERATING IN THE RADAR MODE OR COMMUNICATIONS MODE, THE FOLLOWING KU-BAND CONFIGURATIONS MUST BE MET: @[DN 158]

A. TO PROTECT THE ISS AND THE ISS KU-BAND ANTENNA, THE KU-BAND RADAR MODE WILL BE CONFIGURED TO RADIATE AT OR BELOW THE FOLLOWING POWER LEVELS FOR THE RANGES INDICATED:

1. LOW POWER: NO CLOSER THAN 43 FEET (13.1 METERS)
2. MEDIUM POWER: NO CLOSER THAN 171 FEET (52.1 METERS)
3. HIGH POWER: NO CLOSER THAN 681 FEET (207.5 METERS)

The ISS Ku-band antenna radiation limit is 13.2 V/m (NSTS 21000-IDD-ISS) and in order to prevent the shuttle from violating this limit, the Ku-band, while in the radar mode, will be operated per the indicated power level versus range constraints.

The SM Lira Antenna has additional constraints that are less restrictive than the ISS Ku-band Antenna for RADAR mode: Medium power should not be operated within 57 ft (17.2 m) and High power should not be operated within 225 ft (68.5 m). The rule lists the most restrictive constraints, the ISS Ku-band antenna, which will protect the ISS SM Lira Ku-band Antenna.

B. DURING ALL RENDEZVOUS, PROXIMITY, AND DOCKED OPERATIONS THE KU-BAND COMMUNICATIONS MODE WILL BE CONFIGURED FOR THE FOLLOWING CONSTRAINTS:

1. WITHIN 102 FT (31 M): KU-BAND OBSCURATION MASKS WILL BE UTILIZED TO PRECLUDE KU-BAND MAIN BEAM RADIATION WITHIN 5 DEGREES OF THE ISS STRUCTURE, (EXCLUDING SOLAR ARRAYS AND RADIATORS), SSRMS, EVA CREWMEMBERS, AS WELL AS PROTECTING THE SSO KU-BAND ANTENNA FROM REFLECTED RADIATION.
2. WITHIN 486 FT (148 M): THE ORBITER KU-BAND SYSTEM SHALL NOT DIRECTLY OR BY REFLECTION, ILLUMINATE THE BORESIGHT OF THE ISS KU-BAND ANTENNA.
3. WITHIN 765 FT (233 M): THE ORBITER KU-BAND SYSTEM SHALL NOT DIRECTLY ILLUMINATE THE BORESIGHT OF THE ISS KU-BAND ANTENNA. @[DN 158]

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FLIGHT RULES

10A_C11-3

SHUTTLE KU-BAND RADIATION LIMITS [HC] [RC] (CONTINUED)

The implementation of this rule will protect the shuttle Ku-band 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. ©[DN 158]

The ISS radiation limit is 125 V/m, and in order to prevent the shuttle from violating this limit, the Ku-band will be operated per the masking scheme while in communications mode. With the narrow beam width of the orbiter Ku-band system, the 5-degree zone around the ISS will ensure low incident radiation of the ISS modules. Additional OCAD data is found in ICOM-01 and ORBI-511.

Thirteen point two V/m is reached at 765 ft away from the Ku antenna, and 125 V/m is reached at 102 ft away from the ISS structure. At 486 ft, 26.2 V/m is reached. Forty point zero V/m direct radiation is reached at 318 ft away from the ISS SM Ku antenna; 253 ft for reflected radiation.

FOR ALL UNANALYZED EVA TRANSLATIONS, SRMS, SSRMS, OR RENDEZVOUS/PROXIMITY OPERATIONS, THE KU-BAND SYSTEM WILL BE IN STBY OR TRAVELING WAVE TUBE (TWT) INHIBIT.

The EMU exposure level, as defined in SVHSET 20353 "EMU EMC Certification Test Report" from Hamilton Sundstrand (November, 1999), is 250 V/m. The keep out zone distance is defined in EV7-04-3037 "ISS USOS and SSO Antennas RF Exposure Keep Out Zone Databook" (July, 2004).

Unplanned SSRMS or SRMS motion creates risk of direct shuttle Ku-band radiation in excess of SSRMS or SRMS limits while the shuttle Ku-system is operated in the comm mode. Changes to the masking schemes and/or shuttle Ku-band system configuration beyond what is contained herein may be necessary to respond to real-time situations. ©[DN 158]

FLIGHT RULES

SECTION 12 - ROBOTICS

SHUTTLE ONLY RULES

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GO/NO-GO CRITERIA

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FLIGHT RULES

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FLIGHT RULES

SECTION 12 - ROBOTICS

SHUTTLE ONLY RULES

10A_A12-1 SRMS OVERNIGHT PARK

THE SRMS IS NOMINALLY LEFT AT PRE-CRADLE OVERNIGHT BETWEEN FLIGHT DAYS 1 AND 3 AND BETWEEN FLIGHT DAYS 5 AND 8.

Due to the compressed crew schedule for the duration of the mission, the SRMS will be left at the pre-cradle position overnight after On-Orbit Init on flight day 1 until the completion of OBSS Handoff from SSRMS to SRMS on flight day 3 and again after OBSS Handoff from SRMS to SSRMS on flight day 5 until the completion EVA3 on flight day 8. This will save approximately 4 man-hours of crew time, while consuming an additional 78 watts continuous power (approximate) during the overnight periods. The total additional power consumption is estimated to be 9.4-kWh.

10A_A12-2 SRMS AND ORBITER BOOM SENSOR SYSTEM (OBSS) PARK

A. THE SRMS MAY BE PARKED AT PRE-CRADLE FOR DOCKING.

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 {A12-73}, MRL CONSTRAINTS, CANNOT BE MET PRIOR TO DOCKING, CONSIDERATION WILL BE GIVEN TO PARKING THE SRMS WITH OBSS AT THE HANDOFF POSITION FOR RENDEZVOUS/DOCKING AS AN ALTERNATIVE TO JETTISON. @[DN 18]

Analysis has shown that the SRMS with the OBSS in the Handoff position is an acceptable configuration to withstand docking-only loads (does not analyze rendezvous/prox ops). 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 {A12-73}, MRL CONSTRAINTS. Rendezvous and proximity operations loads have not been fully analyzed. Real-time MER consultation would be required before proceeding with rendezvous/prox ops in this SRMS/OBSS configuration. The Handoff position is not an acceptable position for OMS burns. For OMS burns, the SRMS may be able to remain grappled to the OBSS while berthed with a single MRL latched. OMS burns with OBSS grappled by SRMS with one MRL latched has not yet been analyzed. As of the July 31, 2006 Robotics Analysis Working Group (RAWG), consideration of obtaining management approval for this analysis was being discussed. @[DN 18]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_A12-2

SRMS AND ORBITER BOOM SENSOR SYSTEM (OBSS) PARK (CONTINUED)

- 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 an acceptable configuration 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. Reference Rule {10A_C2-46}, UNDOCKING SEPARATION BURNS WITH SRMS/OBSS IN THE HANDOFF POSITION, for allowable separation burn sizes.

- D. FOR AN EMERGENCY SEP, THE SRMS/OBSS MAY BE MANEUVERED TO A CONTINGENCY UNDOCK CONFIGURATION (SY = +85.0, +36.7, -22.8, -2.0, -0.5, -72.0 = WR) FOR UNDOCKING AND THE JETTISON POSITION (SY = -22.5, +40.0, -25.0, +5.0, 0.0, 0.0 = WR) AFTER THE +X TRANSLATION AT 150 FT ON THE VBAR. (THESE CONFIGURATIONS HAVE NOT BEEN ANALYZED BY EG OR ER.)

Due to the contingency nature of the scenario, Robotics Engineering (code ER), has not performed a complete analysis for the emergency separation case.

With respect to shuttle attitude control, Code EG (Draper Laboratory) has performed a preliminary screening with no issues identified. Due to the contingency nature of the scenario, a full certification has not been performed.

- E. THE SRMS WITH THE OBSS MAY BE PARKED OVERNIGHT UNATTENDED AT THE NODE 2 VIEWING POSITION WHILE DOCKED.

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 Node 2 Viewing position. Rule {A12-2}, UNATTENDED RMS CONSTRAINTS, allows a loaded SRMS to be parked overnight unattended for high priority payloads.

FLIGHT RULES

ISS ONLY RULES

10A_B12-1 **UNPOWERED MSS SURVIVAL TIMES DURING MT TRANSLATIONS**

THE UNPOWERED SURVIVAL TIMES FOR MSS COMPONENTS ON THE MBS DURING THE MT TRANSLATIONS PLANNED FOR THE 10A MISSION ARE **TBD**.

10A_B12-2 **MT LOCATION CONSTRAINTS FOR STAGE EVAS 2 AND 3**

THE MT SHALL BE TRANSLATED TO WS7 PRIOR TO THE START OF STAGE EVAS 2 AND 3.

Placing the MT at worksite 7 provides the EVA crew members with the clearances required for removal of the fluid umbilicals.

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_C12-1 SSRMS/OBSS REBERTH CONSTRAINTS [HC] [C]

THE FOLLOWING CONSTRAINTS SHALL BE APPLIED TO THE SSRMS BERTHING OF THE OBSS INTO THE PAYLOAD BAY:

- 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.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C12-1 SSRMS/OBSS REBERTH CONSTRAINTS [HC] [C] (CONTINUED)

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 pre-load 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.

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.

10A_C12-2 PAYLOAD BAY CLEARANCE CONSTRAINTS

FOR NODE 2 UNBERTH, THE MPM'S (BOTH PORT AND STARBOARD), THE SRMS, AND THE OBSS SHALL BE IN THE FOLLOWING CONFIGURATIONS:

- A. MPM'S (PORT AND STARBOARD) - FULLY DEPLOYED.
- B. SRMS - PRE-CRADLE (AT A MINIMUM).
- C. OBSS - UNBERTHED AND CLEAR OF THE PAYLOAD BAY.

Analysis for previous flights with similar size payloads (MPLM on STS-114) showed that with MPM's fully deployed, but the SRMS cradled and the OBSS berthed, there is a maximum of 3 inches (7.6 cm) of clearance between the SRMS/OBSS and the payload trunnions during the payload unberth operations. Reference DX24 clearance analysis report D43230-04-006/ARF-04-042.

FLIGHT RULES

10A_C12-3 SSRMS SUPPORT FOR ORBITER FOCUSED INSPECTION

FOR FOCUSED INSPECTION OPERATIONS ON FD5, THE SSRMS SHALL REMAIN ON THE LAB PDGF AT THE FOCUSED INSPECTION VIEWING POSITION.

The nominal plan for FD5 is for the SSRMS to reberth the OBSS in the PLB after any required focused inspection operations. This is to free the SRMS end-effector for P6 relocation support. The SRMS may not be able to position the OBSS sensors to achieve the desired image resolution with the SSRMS on the Lab PDGF due to clearance concerns between the SRMS elbow and the SSRMS shoulder joints.

10A_C12-4 THROUGH 10A_C12-20 RULES ARE RESERVED

FLIGHT RULES

GO/NO-GO CRITERIA

10A_C12-21 SRMS GO/NO-GO CRITERIA

THIS TABLE DOES NOT CONTAIN ANY FLIGHT SPECIFIC FLIGHT RULE EXCEPTIONS.

CONTINUE OPERATIONS IF:				
	OBSS OPERATIONS (HIGH PRIORITY)	P6 OPERATIONS (HIGH PRIORITY)	EVA SUPPORT (HIGH PRIORITY)	FLIGHT RULES REF.
A. SHOULDER BRACE REL (1)	0 ↓ [6]			{A12-91}
B. JETTISON SYSTEM (2)	1 ↓	1 ↓	1 ↓	{A12-181}
C. MPM STOW MOTORS (2)	2 ↓ [6]	2 ↓ [6]	2 ↓ [6]	{A12-72}
D. MRL LAT CAP (3)	3 ↓ [5]	3 ↓ [5]	3 ↓ [5]	{A12-73}
E. PORT MPM (4) STOWED INDICATIONS (8)			[2]	{A12-72}
F. STBD MPM (3) STOWED INDICATIONS (6)			[8]	{A12-72}
G. PORT MPM (4) DEP INDICATIONS (8)	SHOULDER 1 ↓	SHOULDER 1 ↓	SHOULDER 1 ↓	{A12-72}
H. STBD MPM (3) DEP INDICATIONS (6)	FORWARD 1 ↓	FORWARD 1 ↓	FORWARD 1 ↓	{A12-72}
I. PORT MRL'S LATCHED (3)			1 ↓	{A12-73}
J. STBD MRL'S LATCHED (3)			0 ↓	{A12-73}
K. AUTO MODE				
L. MANUAL AUG MODE (1)	4 ↓ [7]	4 ↓ [7]	4 ↓ [7]	{A12-111}
M. DIRECT MODE (1)				{A12-111}
N. SINGLE MODE (1)				
O. BACKUP MODE (1)				{A12-111}
P. BRAKES (6)	0 ↓	0 ↓	0 ↓	{A12-115}
Q. AUTO BRAKES (1)	0 ↓ [3]	0 ↓ [3]	0 ↓ [3]	{A12-116}
R. CAPTURE & RIGIDIZE (2)	1 ↓	1 ↓	1 ↓	{A12-161}
S. DERIGIDIZE (2)	2 ↓	2 ↓	2 ↓	{A12-161}
T. RELEASE (2)	2 ↓ [6]	2 ↓ [6]	2 ↓ [6]	{A12-161}
U. BACKUP, RELEASE (1)				{A12-161}
V. RMS AND OBSS THERMAL	REQUIRED	REQUIRED	REQUIRED	{A12-3}

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C12-21 SRMS GO/NO-GO CRITERIA (CONTINUED)

NOTES:

- [1] CONTINUE OPERATIONS IF ONE FAILURE WILL NOT RESULT IN THE INABILITY TO LATCH AT LEAST TWO MRL'S.
- [2] ONE AT THE SHOULDER AND ONE AT EITHER THE MID OR AFT PEDESTAL IS REQUIRED.
- [3] OPERATIONS IN DIRECT AND BACKUP CAN CONTINUE WITH THE LOSS OF AUTOBRAKES.
- [4] RMS SYSTEM REDUNDANCY OR JETT REDUNDANCY IFM REQUIRED.
- [5] 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.
- [6] EVA CAPABILITY EXISTS FOR THE FOLLOWING CONTINGENCIES:
 - SHOULDER BRACE RELEASE
 - MPM DEPLOY/STOW
 - RMS STRAPDOWN
 - GRAPPLE FIXTURE (GF) RELEASE
- [7] ONE OF SINGLE, DIRECT, OR BACKUP REQUIRED FOR UNCRADLING, DAMAGE ASSESSMENT/REPAIR, AND JETTISON.
- [8] ONE AT THE FORWARD AND ONE AT EITHER THE MID OR AFT PEDESTAL IS REQUIRED.

FLIGHT RULES

SECTION 13 - AEROMEDICAL

THERE ARE NO FLIGHT-SPECIFIC STS-120/10A RULES FOR THIS SECTION

FLIGHT RULES

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FLIGHT RULES

SECTION 14 - SPACE ENVIRONMENT

THERE ARE NO FLIGHT-SPECIFIC STS-120/10A RULES FOR THIS SECTION

FLIGHT RULES

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FLIGHT RULES

SECTION 15 - EXTRAVEHICULAR ACTIVITY (EVA)

SHUTTLE ONLY RULES

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ISS ONLY RULES

THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION.....15-2

JOINT SHUTTLE/ISS RULES

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FLIGHT RULES

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FLIGHT RULES

SECTION 15 - EXTRAVEHICULAR ACTIVITY (EVA)

SHUTTLE ONLY RULES

10A_A15-1 ~~RESERVED~~ @[CR 8852]

Deleted: KEEP-OUT ZONE FOR
EVA OPERATIONS NEAR THE LDRI
OR LCS [HC]

10A_A15-2 ORBITER EVA OPERATIONS NEAR S-BAND ANTENNAS

EVA OPERATIONS MAY NOT BE CONDUCTED WITHIN 0.5 METERS OF THE ORBITER S-BAND QUAD ANTENNA, 0.2 METERS OF THE ORBITER S-BAND PAYLOAD ANTENNA, AND 0.1 METERS OF THE ORBITER S-BAND HEMI ANTENNA UNLESS STEPS HAVE BEEN TAKEN TO PREVENT THAT ANTENNA FROM RADIATING. @[DN 153]

An S-band dipole antenna's "near field" is generally considered to extend approximately 0.5, 0.2, and 0.1 meters respectively from the antenna in all directions. This Keep-out Zone is for EMU's configured with the Space-to-Space EMU Radio. If an antenna is totally inhibited (e.g., PI turned OFF or S-band FM forced to the lower antenna by crew switch), then the EVA crewmember is not at risk in approaching these antennas. Since an S-band PM antenna could begin radiating without warning, the crewmember must stay the indicated distance away to ensure his/her safety.

Reference Documentation: United Technology/Hamilton Sunstrand Engineering Memorandum EMUM-0463.

This Rule is a flight specific exception to Rule {A15-25}, ORBITER EVA OPERATIONS NEAR S-BAND ANTENNAS. @[DN 153]

STS-120/10A 09/25/07 FINAL EVA 15-1
ISS EXPEDITIONS 15 & 16

Verify that this is the correct version before use.

FLIGHT RULES

ISS ONLY RULES

THERE ARE NO STS-120/10A ISS ONLY RULES FOR THIS SECTION

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_C15-1 EVA GUIDELINES

- 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:
1. REMAINING SUIT CONSUMABLES
 2. CREW PHYSIOLOGY
 3. MISSION PRIORITIES
 4. IMPACT ON NOT COMPLETING THE EVA
 5. LENGTH OF REMAINING TASKS COMPARED TO SCHEDULED EVA TIME REMAINING
 6. REMAINING CREW DAY
 7. CHEMICAL CONTAMINATION OF THE EMU BY HYDRAZINE (N₂H₄, MMH, OR UDMH), AMMONIA, OR OXIDIZER @[DN 72]
- B. FOR STS-120, AFTER CONSIDERATION OF THE CRITERIA IN PARAGRAPH A, THE EVA WILL BE EXTENDED AS FOLLOWS:

Extension of the EVA violates crew day length scheduling constraints, resulting in reduced presleep, sleep, and/or post-sleep time for the crew. This impact should only be accepted for tasks critical to station element survival or for tasks which are major impacts to downstream flights.

1. FOR EVA 1, UP TO THE EXTENT ALLOWED BY EMU CONSUMABLES AND/OR CREW PHYSIOLOGICAL CONDITION TO PERFORM THE TASKS REQUIRED PRIOR TO SAW DEPLOY AND TO PROVIDE A QUICK-RESPONSE MANUAL DEPLOYMENT OF THE S4 PHOTOVOLTAIC RADIATOR.

All EVA Solar Array Wing (SAW) preparation tasks must be completed prior to the IV commanded deployment of the SAW's. SAW deployment will need to be deferred until after EVA2 if these tasks are not completed during EVA1, with FD7 being the earliest opportunity for SAW deploys. This will result in the loss of other mission objectives.

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FLIGHT RULES

10A_C15-1 EVA GUIDELINES (CONTINUED)

The photovoltaic radiator (PVR) on S4 has experienced higher than anticipated deployment times on the ground due to an apparent increased resistance in the system. EVA monitoring of the on-orbit deployment is required to allow for a quick response to manually deploy the PVR. Once the radiator is in the uncinched and unwinded configuration, Rule {10A_C2-54}, DOCKED LOADS CONSTRAINTS, allows for ISS or VRCS attitude control. However, this is considered an uncertified configuration and, since increased resistance has been observed in this radiator during ground deployment/retraction, the likelihood that the radiator will not deploy via IV commands is considered greater than previously deployed radiators. To protect against being in an uncertified condition for almost 2 days until the radiator can be deployed with the PGT on EVA2, EVA1 will be extended to the extent possible to allow for an IV attempt and subsequent EV attempt at deploying the radiator. The length of time the EVA crew will need to wait for this IV attempt is only expected to be on the order of 10 minutes.

Since EVA1 and EVA2 are not back-to-back EVA's, there is some flexibility in the timeline to ensure the crew is given adequate sleep time after EVA1.

2. FOR EVA2, UP TO THE EXTENT ALLOWED BY EMU CONSUMABLES AND/OR CREW PHYSIOLOGICAL CONDITION TO COMPLETE ENOUGH OF THE SARJ PREP TASKS THAT THERE IS SUFFICIENT TIME PREDICTED IN EVA3 TO COMPLETE SARJ PREP AND CLEAR THE TRANSLATION PATH IN PREPARATION FOR 10A.1

If too many of the SARJ prep tasks are deferred to EVA3, resulting in deletion of some or all of the tasks necessary to clear the translation path to WS#1, this will have a significant impact to the 10A stage or 10A.1 flight.

3. FOR EVA3, UP TO THE EXTENT ALLOWED BY EMU CONSUMABLES AND/OR CREW PHYSIOLOGICAL CONDITION TO CLEAR THE TRANSLATION PATH IN PREPARATION FOR 10A.1

Not completing some or all of the tasks necessary to clear the translation path to WS#1 will have a significant impact.

FLIGHT RULES

10A_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 {10A_C2-13}, 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 10A.

- B. THE FOLLOWING UNSCHEDULED AND CONTINGENCY EVA'S MAY BE PERFORMED BY THE SHUTTLE CREW:
1. OPEN/CLOSE PRLA.
 2. DEPLOY PORT OR STBD MANIPULATOR POSITIONING MECHANISM (MPM). @[DN 76]
 3. RELEASE SRMS SHOULDER BRACE.
 4. SRMS/SSRMS FRGF/PDGF/EFGF RELEASE
 5. MANUAL RELEASE OF Z1 CAPTURE LATCH
 6. P6 TRUSS CAPTURE USING PAYLOAD RETENTION DEVICES
 7. CONTINGENCY RELEASE OF P6 RTAS FROM Z1
 8. COMPLETE RTAS MATING USING EVA CONTINGENCY BOLTS @[DN 76]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C15-2 UNSCHEDULED/CONTINGENCY EVA (CONTINUED)

9. MANUAL DEPLOY OF AN S1 RADIATOR @[DN 76]
10. MANUAL UNCINCH OF AN S1 RADIATOR
11. MANUAL DEPLOY AND RETRACT OF THE SOLAR ARRAY WINGS
12. MANUAL UNLATCH/LATCH/RE-SPOOL OF THE P6 SOLAR ARRAY BLANKET BOXES
13. MANUAL DEPLOY AND RETRACT OF THE P6 PV RADIATOR
14. PV RADIATOR RE-CINCH
15. MANUALLY OVERRIDE THE BETA GIMBAL ANTI-ROTATION LATCH.
16. CLEAR/RESTRAIN CBM CAPTURE LATCH.
17. REMOVE AND REPLACE CBM CONTROLLER PANEL ASSEMBLY.
18. REMOVE AND REPLACE CENTER DISK COVER.
19. MANUALLY OPEN/CLOSE CBM PETAL.
20. REMOVE AND REPLACE CBM CAPTURE LATCH.
21. REMOVE AND REPLACE CBM PETAL.
22. REMOVAL OF CBM RTL
23. EVA-ASSISTED DEPLOYMENT/RETRACTION OF P6 SAW
24. BGA MANUAL ROTATION
25. RETURN DLA TO LAUNCH POSITION.
26. REMOVE AND REPLACE BMRRM.
27. BACK OUT BATTERY CHARGE/DISCHARGE UNIT (BCDU). @[DN 76]

Required to allow remaining BCDU's to charge batteries at full charge rate

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C15-2 UNSCHEDULED/CONTINGENCY EVA (CONTINUED)

28. MANUALLY RELEASE AND JETTISON SOLAR ARRAY WING. @[DN 76]
 29. INSTALL MSS EXTENSION CABLE.
 30. REMOVE AND REPLACE ECU.
 31. REMOVE AND REPLACE PFCS.
 32. REMOVE AND REPLACE DCSU.
 33. REMOVE AND REPLACE MBSU.
 34. REMOVE AND REPLACE PV DDCU.
 35. REMOVE AND REPLACE MSS ACU, MCU, OR CRPCM.
- 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. KU-BAND GIMBAL ALIGNMENT
 4. PLB DOOR CLOSURE
 5. STOW RADIATORS.
 6. PERFORM SRMS JOINT ALIGNMENT, TIEDOWN, PORT OR STBD MPM MANUAL STOW, OR OBSS EVA-ASSISTED MRL LATCHING.
 7. TPS INSPECTION AND/OR REPAIR @[DN 76]

FLIGHT RULES

10A_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.
P5/P6 MATING SURFACES	PINCH POINT	REFERENCE 10A EVA CHECKLIST FS.
SASA/FSE MATING SURFACES	PINCH POINT	REFERENCE 10A EVA CHECKLIST FS.
PDGF CURVIC COUPLING	SHARP EDGES	REFERENCE 10A EVA CHECKLIST FS.
Z1/P6 UMBILICALS	ELECTRICAL ARCING/MOLTEN METAL	REFERENCE RULE {10A_C9-1}, POWER CONNECTION INHIBITS [HC]. INHIBITS MUST BE IN PLACE WHILE THE EVA CREW IS HANDLING THE CONNECTORS.
P5/P6 UMBILICALS	ELECTRICAL ARCING/MOLTEN METAL	REFERENCE RULE {10A_C9-1}, POWER CONNECTION INHIBITS [HC]. INHIBITS MUST BE IN PLACE WHILE THE EVA CREW IS HANDLING THE CONNECTORS.
P6 RADIATOR DEPLOY	MOVING HARDWARE / INADVERTENT COLLISION	REFERENCE 10A EVA CHECKLIST FS.
RPCM	SHARP EDGES	REFERENCE 10A EVA CHECKLIST FS.
SOLAR ARRAY BLANKET BOXES	SHARP EDGES	REFERENCE 10A EVA CHECKLIST FS.
S1 (P1) RADIATOR BEAM	INADVERTENT COLLISION/KICK LOADS	REFERENCE RULES {B15-15}, EVA KEEP-OUT ZONES [HC] [RC] [E], AND {B18-351}, TRRJ DLA CONFIGURATION MANAGEMENT [HC].

©[DN 73]

DOCUMENTATION: Hazard Report ISS-EVA-314, EVA Crewmember Exposure to Arcing/Sparking and Electrical Shock Hazards from Solar Array Panels. Hazard Report ISS-EVA-312, Electric shock to EVA crew resulting from EMU arcing in Plasma. Hazard Report ISS-EVA-302, EVA Crewmember Exposure to Sharp Edges/Corners, Pinch Points and Entanglement/Entrapment. ©[DN 73]

FLIGHT RULES

10A_C15-4 EVA KEEP-OUT ZONES

THE FOLLOWING ARE FLIGHT-UNIQUE EVA KEEP-OUT ZONES, WHICH ARE TO BE OBSERVED IN ADDITION TO THE KEEP-OUT ZONES DEFINED IN RULE {B15-15}, EVA KEEPOUT ZONES [HC] [RC] [E]: @[CR 74]

ISS SYSTEM	KEEP-OUT ZONE	CONDITION
SOLAR ARRAY BLANKET BOXES	SABB LATCH MECHANISM [1]	SABB UNLATCHING OR LATCHING
	UNDERSIDE OF SABB [2]	ANY

NOTES:

- [1] 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 REPORTS ISS-EVA-0302-12A, JANUARY 3, 2002.
- [2] 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 KEEP-OUT ZONE. IF THE EVA CREWMEMBER IS REQUIRED TO APPROACH THIS AREA, THEY WILL EXERCISE CAUTION. DOCUMENTATION: HAZARD REPORTS ISS-EVA-0302-12A, JANUARY 3, 2002. @[DN 74]

FLIGHT RULES

10A_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.

10A_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

SECTION 16 - POSTLANDING

THERE ARE NO FLIGHT SPECIFIC STS-120/10A RULES FOR THIS SECTION

FLIGHT RULES

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FLIGHT RULES

SECTION 17 - LIFE SUPPORT

SHUTTLE ONLY RULES

THERE ARE NO STS-120/10A SHUTTLE ONLY RULES FOR THIS SECTION
.....17-1

ISS ONLY RULES

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FLIGHT RULES

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FLIGHT RULES

SECTION 17 - LIFE SUPPORT

SHUTTLE ONLY RULES

THERE ARE NO STS-120/10A SHUTTLE ONLY RULES FOR THIS SECTION

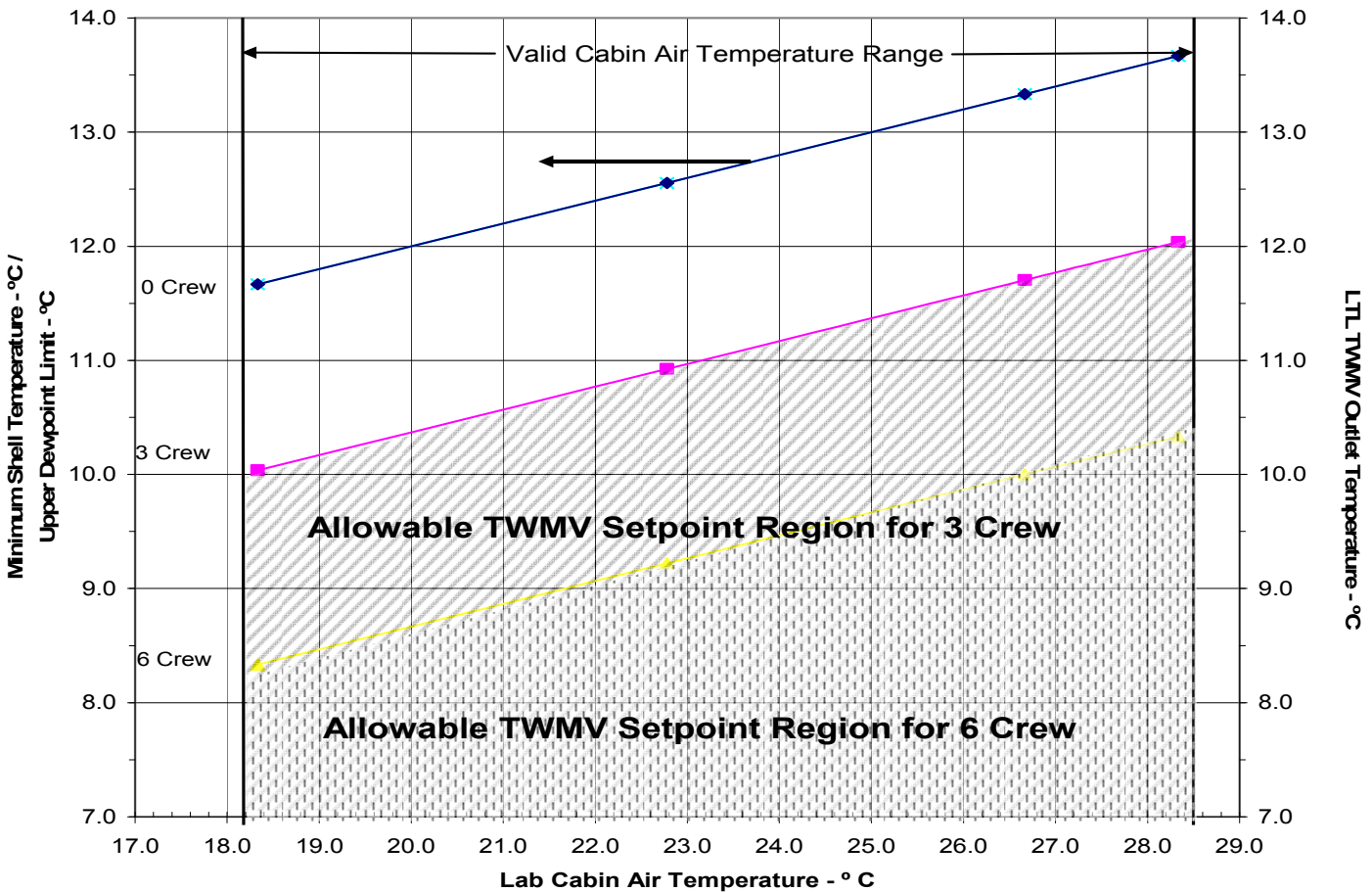
FLIGHT RULES

ISS ONLY RULES

10A_B17-1 ISS DEWPOINT LIMITS AND ACTIONS [RC]

A. THE U.S. SEGMENT DEWPOINT SHALL NOMINALLY BE MAINTAINED BELOW THE MINIMUM SHELL TEMPERATURE OF THE U.S. LABORATORY MODULE. THE MINIMUM SHELL TEMPERATURE IS DETERMINED FROM THE LAB CABIN AIR TEMPERATURE AS SHOWN IN FIGURE 10A_B17-1-I:

FIGURE 10A_B17-1-I - U.S. LAB SHELL TEMPERATURE VS U.S. LAB AIR TEMPERATURE



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FLIGHT RULES

10A_B17-1 ISS DEWPOINT LIMITS AND ACTIONS [RC] (CONTINUED)

1. THE PRESENCE OF CONDENSATION ON THE EXPOSED SURFACES OF ANY OF THE OXYGEN/NITROGEN RECHARGE EQUIPMENT IS NOT A CONSTRAINT TO THE OPERATION OF THAT EQUIPMENT.

2. LOW TEMPERATURE LOOP (LTL) SETPOINTS AND THREE-WAY MIX VALVE (TWMV) OUTLET TEMPERATURES CASE SPECIFIC THERMAL ANALYSES REFERENCED IN RULE {B17-160}, LTL SETPOINTS FOR ECLSS OPERATIONS [RI], SHALL SUPERSEDE THIS RULE.

ISS humidity is not directly controlled to a setpoint. The nominal dewpoint range is manageable between 40 deg F and 60 deg F and is controlled by the SM air conditioners and LTL TWMV outlet temperature as adjusted by the commanded setpoint of the LTL TWMV.

A December 2001 SINDA/FLUINT ECLS analysis was performed to redefine a more constraining upper dewpoint limit for XVV/XPOP attitudes than the specification limit of 60 deg F as defined in SSP 41000. It was determined from the analysis that in XVV and XPOP attitudes, lab shell temperatures can fall as low as 53 deg F/11.7 deg C and condensation becomes a concern. The analysis determined a relationship between cabin air temperature and the necessary LTL TWMV outlet temperature to prevent condensation on the lab structure. The analysis indicated a range of minimum shell temperatures in XVV/XPOP for arbitrary boundary limits of cabin air temperatures. Refer to Rule {B17-8}, CABIN TEMPERATURE MANAGEMENT [RC] [E], for cabin air temperature limits. ©[DN 57]

CABIN AIR TEMPERATURE	MINIMUM PREDICTED SHELL TEMPERATURE
18.3°C (65°F)	11.7°C (53°F)
28.5°C (83°F)	13.3°C (56°F)

©[DN 57]

It further identified a margin in dewpoint that must be protected based on crewmember metabolic loading.

CREW SIZE	MINIMUM PREDICTED SHELL TEMPERATURE DELTA
3	1.7°C (3°F)
6	3.3°C (6°F)

Linear interpolation may be used to obtain intermediate values of air temperature and minimum predicted shell temperature. By deriving the minimum predicted shell temperature from cabin air temperature and providing a margin of crewmember metabolic load, a new LTL TWMV outlet temperature can be obtained. This assumes THOR applies a 0.6 deg C/1 deg F. TWMV temperature control accuracy to the LTL TWMV outlet temperature to obtain the new setpoint.

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FLIGHT RULES

10A_B17-1 ISS DEWPOINT LIMITS AND ACTIONS [RC] (CONTINUED)

This December 2001 SINDA/FLUINT ECLS analysis that is reflected in this rule is treated as a generic response for the valid temperature range of 65 deg F-80 deg F. In lieu of having a specific case for a particular cabin temperature setpoint, the values of minimum shell temperature and LTL TWMV setpoints will suffice until an exact case can be known.

As an example to implement this rule, assume that a current air temperature setpoint for a crew of three is 25 deg C/75 deg F and the maximum allowable LTL TWMV outlet temperature is at 11.3 deg C/52.4 deg F. The use of the chart indicates that the maximum allowable dewpoint is 13 deg C/55.4 deg F. As can be deduced, there is adequate margin between TWMV outlet temperature and the maximum allowable dewpoint of 1.7 deg C/3 deg F for a crew of three. The margin assures no condensation on the structure with crew metabolic activity. In the event the air temperature setpoint requires a change to e.g., 21 deg C/69.8 deg F, the chart indicates that the maximum allowable dewpoint is 12.2 deg C/54 deg F. In order to protect the shell from condensation, the contribution from crew metabolic load (1.7 deg C/3 deg F) is deducted from the maximum allowable dewpoint to arrive at the maximum allowable LTL TWMV outlet temperature. This new LTL TWMV outlet temperature is required to be less than or equal to 12.2 deg C - 1.7 deg C = 10.5 deg C/50.9 deg F, until a case specific analysis dictates otherwise.

As a secondary concern to shell condensation as mentioned above, the U.S. segment TCS Moderate Temperature Loop (MTL) is normally controlled above 61 deg F (63 deg F \pm 2 deg F control band). Since the MTL lines are not insulated from the cabin atmosphere, and the MTL heat exchangers are not designed as condensing heat exchangers, the cabin atmosphere dewpoint should be maintained below the MTL temperature to ensure that water does not condense on the MTL lines or heat exchangers.

The MCA cannot measure ppH₂O due to it having been intentionally desensitized to water vapor so the unit could meet specification accuracies for the other major constituents. The Velocicalc, a U.S. handheld calibrated instrument, can measure dewpoint directly. There is no known dewpoint accuracy for this device from the manufacturer; however, the instrument has a rated humidity accuracy of \pm 3 percent and temperature has a rated accuracy of \pm 0.5 deg F. With these two rated accuracies, a derived dewpoint accuracy of \pm 3 deg F is obtained for conditions near the ISS operating temperature (65 deg F -83 deg F) and ISS humidity level (25 percent-75percent) on the ISS. As a result of the Velocicalc being certified for criticality 3, no real time calls will be made from this instrument.

Reference: TSI Incorporated (makers of Velocicalc) Homepage at <http://www.tsi.com/vent/products/velocicalc/velocplusspec.shtml>

Exposed surface temperatures which are lower than the cabin atmosphere dew point as a direct result of recharge oxygen, nitrogen and water operations supplied by the orbiter are exempt from the preclude condensation requirement.

DOCUMENTATION: Chit ISS0135/STS-108_013 Dewpoint Control in the USOS Segment, SSP 41000 System Specification for the ISS. Section 3.2.1.1.2 Capability: Condition Atmosphere and Section 3.7.1.3.2.2 Control Atmosphere Moisture.

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FLIGHT RULES

10A_B17-1 ISS DEWPOINT LIMITS AND ACTIONS [RC] (CONTINUED)

- B. THE FGB DEWPOINT WILL NOMINALLY BE MAINTAINED BELOW THE FGT HEAT EXCHANGER COOLANT TEMPERATURE OR 3 DEGREES C BELOW THE COLDEST SHELL TEMPERATURE, WHICHEVER IS LOWER.

The nominal upper limit for FGB dewpoint is 60 deg F (56.4 deg F)/15.6 deg C (13.6 deg C). Nominal ppH₂O sensor error for the Russian segment is ±1.6 mmHg. These limits will avoid condensation on the FGB heat exchangers or the module shell. Note that FGB shell temp sensor T82/10 sensor should not be used to determine the coldest shell temperature. This sensor is known to be biased low.

- C. THE SERVICE MODULE DEWPOINT WILL NOMINALLY BE MAINTAINED BELOW 60 DEG F (56.4 DEG F)/15.6 DEG C (13.6 DEG C).

The service module dewpoint limit of 15.6 deg C is defined by the service module thermal system technical descriptions.

- D. THE DEWPOINT INSIDE ESA SEGMENTS WILL NOMINALLY BE MAINTAINED BELOW 16 DEG C.

The Columbus module is equipped with two humidity sensors that are accurate to within ±5 percent which can be used to extrapolate dewpoint measurement in the USOS. The Columbus module must have a dewpoint below 16 deg C as this is the lowest of the operational temperature range of the subsystem coldplates and the plenum to which the ISP racks are connected.

- E. THE FOLLOWING HUMIDITY CONTROL DEVICES WILL NOMINALLY OPERATE SIMULTANEOUSLY IN A MODE THAT CAN COLLECT CONDENSATION:

1. ONE SERVICE MODULE CKB
2. ONE U.S. LAB CCAA
3. NODE 2 CCAA
4. ONE COLUMBUS MODULE AIR CONDITIONING (AC) UNIT

The CKB, CCAA's and the AC unit will be needed to ensure the correct temperature and humidity for the entire station and the IP modules. As each IP module is activated, it will be responsible for its own humidity removal. The water removed from the air inside the IP modules will be collected in the U.S. lab water tank.

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FLIGHT RULES

10A_B17-1 ISS DEWPOINT LIMITS AND ACTIONS [RC] (CONTINUED)

F. IF THE DEWPOINT CANNOT BE MAINTAINED BELOW THE LIMITS FOR ANY OF THE ISS MODULES, ONE OR MORE OF THE FOLLOWING ACTIONS WILL BE TAKEN (IN PRIORITY ORDER):

1. ACTIVATE ALL U.S. SEGMENT COMMON CABIN AIR ASSEMBLIES (CCAA).
2. ACTIVATE ALL SERVICE MODULE CKB UNITS (IN WATER REMOVAL MODE) AND ACTIVATE NODE AFT PORT IMV FAN AND UQ1 FAN IF NOT OPERATING.
3. ACTIVATE THE REDUNDANT COLUMBUS AC UNIT.
4. MINIMIZE CREW EXERCISE AND/OR PRESENCE IN THE AFFECTED MODULE(S).

The CKB can be operated in a cooling mode that does not remove water from the air. The CKB units will need to be in water removal mode to affect the dewpoint. The IP modules use independent thermal control loops from the USOS; so, power permitting, activating backup humidity removal devices in the IP modules would aid in reducing the station dewpoint.

5. RAISING THE MTL SETPOINT TO KEEP THE MTL TEMPERATURE ABOVE THE DEWPOINT MAY ALSO BE CONSIDERED. HOWEVER, THE EFFECT OF INCREASING THE MTL TEMPERATURE ON AVIONICS COOLING MUST ALSO BE EVALUATED IN REAL TIME TO DETERMINE IF THIS IS POSSIBLE.

DOCUMENTATION: Engineering judgment.

FLIGHT RULES

10A_B17-2 ISS STAGE EVA ATMOSPHERE REQUIREMENTS [RC] [E]

- A. BEFORE THE START OF PREBREATHE FOR A STAGE EVA FROM THE ISS JOINT AIRLOCK, WITH ALL STATION HATCHES OPEN, THE FOLLOWING ATMOSPHERE REQUIREMENTS MUST BE MET:
1. IF EXERCISE PREBREATHE/OVERNIGHT CAMPOUT PROTOCOL IS TO BE USED:
 - a. TOTAL PRESSURE MUST NOT EXCEED 736 MMHG (14.24 PSI).
⑥[DN 66]
 - b. OXYGEN CONCENTRATION MUST NOT EXCEED 22.0 PERCENT.
 2. IF IN-SUIT PREBREATHE PROTOCOL IS TO BE USED:
 - a. TOTAL PRESSURE MUST NOT EXCEED 758 MMHG (14.65 PSI).
 - b. OXYGEN CONCENTRATION MUST NOT EXCEED 23.8 PERCENT.

The stack pressure and oxygen concentration will increase due to approximately 20 - 23 lbs of oxygen introduction from Prebreathe Hose Assembly (PHA) usage during the ISS EVA prebreathe and overnight campout protocols and the addition of gas to the stack during joint airlock and crewlock depress activities. All three prebreathe protocols introduce 3 - 5 lbs of oxygen during the EMU suit purge period. If the stack pressure is not reduced below the indicated pressures prior to the start of prebreathe for a stage EVA or EVA series, the cabin pressure may increase above the nominal total pressure of 770 mmHg (14.9 psi) during the pre-EVA activities mentioned above. The nominal pressure range is defined in Rule {B17-2}, TOTAL PRESSURE MANAGEMENT [RC]. If the total pressure were to exceed the positive pressure relief threshold of the ISS Pressure Control Assembly (777 mmHg/15.03 psi), an automatic vent would be initiated to reduce cabin pressure. The oxygen concentration of the atmosphere must not breach the ISS fire threshold as a result of nominal EVA preparations (reference Rule {B17-3}, OXYGEN PARTIAL PRESSURE MANAGEMENT [HC] [RC] [E] [A]). A total stack volume of 15306 cubic feet was assumed in the generation of this rule (shuttle and MPLM not present).

- B. INSTRUMENTATION ERROR WILL BE CONSIDERED WHEN DETERMINING OXYGEN LEVELS, IN ACCORDANCE WITH RULE {B17-15}, USE OF OXYGEN PARTIAL PRESSURE SENSORS [RC] [E].

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FLIGHT RULES

10A_B17-2

ISS STAGE EVA ATMOSPHERE REQUIREMENTS [RC] [E]
(CONTINUED)

- C. TO MAINTAIN CABIN PRESSURE AND OXYGEN CONCENTRATION BELOW THE ABOVE REQUIREMENTS, THE FOLLOWING ACTIONS SHALL BE TAKEN PRIOR TO THE START OF PREBREATHE FROM THE ISS JOINT AIRLOCK.
1. ELEKTRON OPERATION SHALL BE TERMINATED OR TRANSITIONED TO THE LOWEST O₂ PRODUCTION MODE.
 2. ISS PRESSURE CONTROL ASSEMBLY (PCA) GAS INTRODUCTIONS SHALL BE PROHIBITED EXCEPT AS REQUIRED FOR ISS EVA PREPARATIONS.
 3. PROGRESS/ATV GAS INTRODUCTIONS SHALL BE PROHIBITED.
 4. TTK OPERATIONS SHALL BE PROHIBITED.

More oxygen is introduced during the ISS EVA prebreathe protocol and related depresses of a single EVA than is consumed metabolically. To avoid breaching the oxygen fire threshold or exceeding the nominal cabin pressure operating range during the EVA or subsequent EVA preparations, all devices that introduce oxygen and nitrogen must be managed appropriately prior to and during a single EVA or EVA series.

- D. A PARTIAL DEPRESS AND/OR INTRODUCTION OF NITROGEN WILL BE PERFORMED AS REQUIRED TO MAINTAIN THE ATMOSPHERE REQUIREMENTS SPECIFIED IN PARAGRAPH A.

DOCUMENTATION: Engineering judgment, in SSP-50643-A, Operations Interface Procedures, Volume A, NASA/Rosaviakosmos, section A7.3.

Reference Rules {B17-2}, TOTAL PRESSURE MANAGEMENT [RC], and {B17-3}, OXYGEN PARTIAL PRESSURE MANAGEMENT [HC] [RC] [E] [A].

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FLIGHT RULES

10A_B17-2 ISS STAGE EVA ATMOSPHERE REQUIREMENTS [RC] [E] (CONTINUED)

- E. BEFORE THE START OF A STAGE EVA FROM THE RUSSIAN SEGMENT, THE TOTAL PRESSURE MUST BE GREATER THAN 750 MMHG (14.5 PSIA) WITH ALL STATION HATCHES OPEN.

The mated stack pressure will decrease as a result of the depressurizations associated with a nominal RS based EVA. If the stack pressure prior to the EVA is less than 750 mmHg (14.5 psia), the pressure may decrease below the minimum pressure allowed in Paragraph G after the EVA. In a contingency situation, additional depressurization/equalization cycles of the DC1 module may become necessary, which will lead to additional air losses. In this case, there is a greater risk of the cabin pressure falling below the minimum pressure limit. A prompt repress using USOS resources may be performed before the segments are equalized to prevent the pressure from falling below the minimum pressure limit. ISS gas resources will be used following an EVA to return the cabin pressure to within flight rule limits.

DOCUMENTATION: ECLSS/SOZH Operations Interface Procedure.

Reference Rules {B17-2}, TOTAL PRESSURE MANAGEMENT [RC].

- F. FOLLOWING AN ORLAN EVA, A PRESSURE RANGE ON ISS OF 720 MMHG - 724 MMHG (13.9 PSIA - 14.0 PSIA) IS ALLOWED AS A DEVIATION FROM RULE {B17-2}, TOTAL PRESSURE MANAGEMENT [RC], FOR A DURATION OF UP TO 3 DAYS PRIOR TO REQUIRING A STACK REPRESS.

Cabin pressure as low as 720 mmHg (13.9 psia) is acceptable for a short period of time following an Orland EVA to avoid driving the crew EVA day length to an unacceptable duration (with only two crewmembers and the associate USOS and RS systems reconfiguration required prior to egress, the EVA day length is already greater than 22 hours). Upon DC-1 repressurization following ingress, vehicle total cabin pressure is predicted to be approximately 730 mmHg (14.12 psia) due to expected losses of atmosphere during DC-1 depressurization. This lower pressure limit will allow planning flexibility immediately following the EVA.

FLIGHT RULES

10A_B17-3

USOS UNMANNED ECLSS CONFIGURATION DURING SOYUZ RELOCATION

EQUIPMENT NOT SPECIFICALLY MENTIONED SHALL REMAIN IN THE NOMINAL CONFIGURATION.

A. LAB

1. AFT AND FWD HATCHES WILL BE CLOSED WITH MPEV'S CLOSED AND UNCAPPED.
2. IF THE BD AIR DUCT IS DISCONNECTED FROM THE PMA 1 AIR DUCT, THE LAB IMV AFT PORT FAN WILL BE DEACTIVATED AND UNPOWERED.
3. IMV AFT PORT, FWD PORT, AND AFT STBD VALVES WILL REMAIN OPENED, POWERED AND ENABLED.

B. AIRLOCK

1. IV HATCH WILL REMAIN OPEN.
2. EQUIPMENT LOCK EMERGENCY MPEV WILL BE OPENED AND THE VENT AND RELIEF ISOLATION VALVE (VRIV) WILL REMAIN CLOSED.

C. NODE 1

1. AFT, STBD, AND FORWARD HATCHES WILL BE CLOSED WITH MPEV'S CLOSED AND UNCAPPED.
2. IF THE BD AIR DUCT IS DISCONNECTED FROM THE PMA 1 AIR DUCT, THE IMV AFT PORT FAN WILL BE DEACTIVATED AND UNPOWERED.
3. IMV STARBOARD AFT FAN WILL REMAIN ACTIVATED.
4. THE STARBOARD FORWARD AND AFT STARBOARD IMV VALVES WILL BE OPENED.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-3

USOS UNMANNED ECLSS CONFIGURATION DURING SOYUZ RELOCATION (CONTINUED)

D. NODE 2

1. AFT HATCH WILL BE CLOSED WITH THE MPEV CLOSED AND UNCAPPED.
2. THE AFT PORT IMV VALVE WILL REMAIN OPEN, POWERED, AND ENABLED.
3. THE AFT STARBOARD IMV VALVE WILL BE OPENED.

E. PMA 1: GRILLE COVER WILL REMAIN CLOSED.

This isolated U.S. segment provides for all modules as a contiguous volume. This configuration allows Lab PCA PPR functionality to the contiguous volume via opened IMV valves. Isolation response software provides for the capability to isolate all modules by closure of IMV valves in the event of an emergency condition.

Node 1 IMV Aft Port fan is deactivated due to the disconnection of the PMA 1 IMV duct from the BД 1 as long as the FGB GA-PMA 1 hatch is closed. This disconnected end has no inlet filter and continued IMV airflow could potentially ingest FOD causing fan damage and debris buildup. A cap did exist as part of 2A delivery but was lost during the Increment 1. Lab IMV Aft Port fan is disconnected to prevent stalling the fan. If deemed necessary, reactivation of IMV fans can be performed to ascertain conditions in the USOS segment in the event of a contingency, such as gaseous leak into USOS.

The emergency MPEV is configured to an Opened position to provide (1) an alternate means of relieving pressure in the airlock in the event of a gaseous O₂ or N₂ leak (requires opening of A/L PCA VRIV) and (2) to provide a possible EVA return path whereby the airlock can be depressurized remotely by MCC-H.

No IMV valves exist at the Airlock IV hatch interface and the Airlock IV hatch remains opened to provide PPR access in the event of leakage from the UIA.

Node 1 IMV Aft Starboard and Starboard Forward valves are opened to provide an air return path since the corresponding hatches are closed.

The Node 2 IMV Af Starboard valve is opened to provide an air return path since the corresponding hatches are closed.

Reference: Engineering judgment.

FLIGHT RULES

10A_B17-4

ECLSS EQUIPMENT SCAVENGE PRIORITY

- A. SMOKE DETECTORS WILL BE SCAVENGED IN THE FOLLOWING PRIORITY ORDER TO RECOVER SINGLE STRING SMOKE DETECTION CAPABILITY.

SD	COMMENTS
MPLM	SD WILL BE SCAVENGED JUST PRIOR TO MPLM CLOSEOUT FOR RETURN.
EXPRESS RACK SPARE SD	STORED SMOKE DETECTOR
NODE 1 SD2	NODE 1 CABIN SMOKE DETECTION WILL BE 0 FT
NODE 2 SD1	NODE 2 CABIN SMOKE DETECTION WILL BE 0 FT
LAB PD1	LAB CABIN SMOKE DETECTION WILL BE 0 FT
AL DUCT	AIRLOCK CABIN WILL BE 0 FT

MPLM smoke detection is not needed once the MPLM is closed out for return. Node 1 SD2 is less critical than Node 1 SD1 since it is serviced by a separate MDM and power channels than the Cabin fan which is also necessary for Node1 smoke detection capability. Node 2 SD1 is less critical than Node 2 SD2 since it is serviced by a separate MDM than the Node 2 CCAA which is also needed for Node 2 smoke detection capability.

- B. IMV FANS WILL BE SCAVENGED IN THE FOLLOWING PRIORITY ORDER TO RECOVER IMV CAPABILITY:

IMV FAN	COMMENTS
NODE 1 PORT FWD	WILL BE NEEDED FOR CIRCULATION WITH CUPOLA OR MPLM DOCKING TO NODE PORT INTERFACE
LAB FWD STBD	AFTER NODE 2 ACTIVATION, THE LAB FWD STBD FAN WILL NOMINALLY BE OFF, SINCE SUFFICIENT RETURN FLOW IS PASSED THROUGH THE OPEN HATCHWAY
LAB AFT PORT	SLIGHTLY DEGRADES NODE TO LAB IMV; HOWEVER, CCAA INDUCED IMV FLOW THROUGH THE LAB AFT STBD INTERFACE MEETS NODE TO LAB IMV REQUIREMENTS.

@[DN 67]

- C. IMV VALVES WILL BE SCAVENGED IN THE FOLLOWING PRIORITY ORDER TO RECOVER IMV CAPABILITY.

IMV VLV	COMMENTS
NODE 1 DECK FWD	WILL ONLY BE SCAVENGED IF MPLM IS PRESENT AND INTERFACE CAN BE LEAK CHECKED PRIOR TO MPLM UNBERTHING.
NODE 1 AFT STBD	NOT NOMINALLY NEEDED, BUT USED IN EMERGENCY RESPONSE TO FEED RS LEAK.
NODE 1 STBD FWD	NOT NOMINALLY NEEDED, BUT USED IN EMERGENCY RESPONSE TO RAPIDLY EQUALIZE WITH AIRLOCK.

FLIGHT RULES

10A_B17-5 ACTIONS FOR LOSS OF ISS VENTILATION [RC]

- A. FOR LOSS OF THE SM BBIXO FAN, ONE OF THE FOLLOWING WILL BE DONE (IN PRIORITY ORDER) :
1. THE FAN WILL BE REMOVED AND REPLACED WITH AN ONBOARD SPARE.
 2. THE AIR DUCT WILL BE DISCONNECTED FROM THE FAN AND SECURED IN THE SM-PIXO.
- B. FOR LOSS OF THE FGB UCB-1 CIRCULATION FAN, ONE OF THE FOLLOWING WILL BE DONE (IN PRIORITY ORDER) :
1. THE UCB-1 FAN WILL BE REMOVED AND REPLACED WITH ON-BOARD SPARE.
 2. AIR DUCT 1 FLEXIBLE DUCT SEGMENT WILL BE DETACHED FROM THE UCB-1 FAN AND CONNECTED TO AIR DUCT 2.
 3. BD 1 (AIR DUCT 1) FLEXIBLE DUCT SEGMENT 17KC-7664-70-01 WILL BE DISCONNECTED FROM UCB-1 AND SECURED IN THE FGB-PGO.

Both Node 1 Aft Port IMV Fan and the FGB UCB-1 Fan must be operating simultaneously in order to keep the U.S. segment within the required ppO₂ and ppCO₂ specifications. Without either fan, no air exchange or degraded air exchange exists between modules and ppO₂ and ppCO₂ will not be controlled in the USOS.

Option 1 regains all capability by replacing the lost fan with a pre-positioned on-board spare.

Option 2 regains partial airflow between the modules by putting the UCB-2 and Aft Port IMV Fan in series.

Option 3 regains partial airflow between the modules by reducing the amount of duct work attached to the still operating Node 1 Aft Port Fan while still allowing some air exchange with the FGB-PGO.

Option 4 provides localized air circulation in the Node. This option would most likely be used in conjunction with another option if some areas of the Node contained stagnant air.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-5 ACTIONS FOR LOSS OF ISS VENTILATION [RC]
(CONTINUED)

- C. FOR LOSS OF THE NODE 1 IMV AFT PORT FAN, ONE OF THE FOLLOWING WILL BE DONE:
1. THE NODE 1 IMV AFT PORT FAN WILL BE REMOVED AND REPLACED PER RULE {B17-156}, ECLSS EQUIPMENT SCAVENGE PRIORITY.
 2. IF A POWER FEED CAUSED THE LOSS OF THE AFT PORT FAN, IT WILL BE CONFIGURED TO DRAW POWER FROM AN ALTERNATE RPCM VIA PIN KIT.

The same rationale applies to a failure of the Node 1 Aft Port IMV Fan as to a failure of the FGB U/B-1 Circulation Fan; see the rationale for paragraph B.

- D. FOR LOSS OF THE NODE 1 CABIN FAN, IN ADDITION TO FOLLOWING THE GUIDELINES IN RULE {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E], ONE OR MORE OF THE FOLLOWING WILL BE DONE:
1. THE ISS PORTABLE FAN ASSEMBLY (OR ANY OTHER AVAILABLE MEANS OF PORTABLE ISS VENTILATION) WILL BE SECURED IN NODE 1 AND ACTIVATED TO CIRCULATE AIR.
 2. IF A POWER FEED CAUSED THE LOSS OF THE CABIN FAN, IT WILL BE CONFIGURED TO DRAW POWER FROM AN ALTERNATE RPCM VIA PIN KIT. IN THIS CASE, RULE {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E], DOES NOT APPLY.

The primary function of the Node 1 Cabin Fan is to provide for air circulation and smoke detection in the Node 1 volume.

The primary risks associated with the loss of the Cabin Fan are the potential for CO2 pockets to develop in the Node and the lack of smoke detection. None of the workarounds in this rule, with the exception of Option 2, restores airflow over the two Node 1 Smoke Detectors and thus the guidelines in Rule {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E], paragraph C, must be heeded. ©[DN 64]

Option 1: Restores limited air circulation in Node 1.

Option 2: Restores full functionality including Node 1 smoke detection.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-5 ACTIONS FOR LOSS OF ISS VENTILATION [RC]
(CONTINUED)

- E. FOR LOSS OF LAB IMV AFT PORT FAN, IF ANY U.S. SEGMENT MODULE PPCO₂ OR PPH₂O READING DOES NOT MEET SPECIFICATIONS IN RULE {B17-5}, CO₂ PARTIAL PRESSURE LIMITS AND ACTIONS [HC] [RC] [H], ONE OF THE FOLLOWING WILL BE DONE:
1. THE LAB IMV AFT PORT FAN WILL BE REMOVED AND REPLACED PER RULE {B17-156}, ECLSS EQUIPMENT SCAVENGE PRIORITY.
 2. IF A POWER FEED CAUSED THE LOSS OF THE AFT PORT FAN, IT WILL BE CONFIGURED TO DRAW POWER FROM AN ALTERNATE RPCM VIA PIN KIT.
 3. IF MPLM INGRESS OPERATIONS ARE IN PROGRESS, THE LAB CCAA'S WILL BE OPERATED IN DUAL OPS MODE TO ASSIST IN IMV AIR EXCHANGE WITH THE MPLM.

Loss of the Lab Aft Port Fan will cause degraded air mixing between the Lab and the rest of ISS which will result in degraded O₂ provision to the Lab and degraded CO₂ removal (by Vozdukh) from the Lab. Until flight data is available, it is unknown how much effect the fan failure will have on ppH₂O in the other USOS modules, hence the check before action is taken.

- F. FOR LOSS OF A LAB CCAA, THE FOLLOWING WILL BE DONE:
1. THE ALTERNATE LAB CCAA WILL BE ACTIVATED.
 2. IF THE LAB1S6 CCAA IS LOST WHILE MPLM INGRESS OPERATIONS ARE IN PROGRESS, THE NODE 1 DECK FWD TO MPLM IMV JUMPER WILL BE INSTALLED, THE NODE 1 DECK FWD AND MPLM OVHD FWD IMV VALVES WILL BE OPENED, AND THE LAB AFT PORT IMV FAN WILL BE ACTIVATED.

At least one of two Lab CCAA's must be operating at all times to provide sufficient intramodule ventilation and humidity removal in the Lab. LAB1P6 is the primary Lab CCAA and LAB1S6 is backup. Reference Rule {B17-158}, CCAA MANAGEMENT.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-5 ACTIONS FOR LOSS OF ISS VENTILATION [RC] (CONTINUED)

During MPLM ingress operations, the LAB1S6 CCAA will be assisting the IMV flow between the MPLM and Lab. This IMV is critical to control humidity and temperature inside the MPLM. If the LAB1S6 CCAA fails, some of the function can be made up by activating the Lab Aft Port IMV Fan and positioning valves to allow flow.

Source: (1) SSP-41163 Russian Segment Specification, paragraph 3.2.1.1.1.2.2b; (2) ISS PMA 1 ECLSS Verification Analysis Report MDC 97H0377B; and (3) engineering judgment.

- G. FOR LOSS OF THE AIRLOCK CCAA, THE ISS PORTABLE FAN ASSEMBLY (OR ANY OTHER AVAILABLE MEANS OF PORTABLE ISS VENTILATION) WILL BE SECURED IN THE AIRLOCK AND ACTIVATED TO CIRCULATE AIR.

This will regain at least partial cabin air mixing inside the Airlock. In this case, humidity and temperature control functions provided by the Airlock CCAA have been lost.

- H. FOR LOSS OF THE NODE 2 CCAA, IN ADDITION TO FOLLOWING THE GUIDELINES IN RULE {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E], THE ISS PORTABLE FAN ASSEMBLY (OR ANY OTHER AVAILABLE MEANS OF PORTABLE ISS VENTILATION) MAY BE SECURED IN NODE 2 AS A MEANS TO CIRCULATE AIR IN THE MODULE.

The primary function of the Node 2 CCAA is to provide for air circulation and smoke detection in the Node 2 volume.

The primary risks associated with the loss of the Node 2 CCAA are the potential for CO₂ pockets to develop in Node 2 and the lack of smoke detection. None of the workarounds in this rule restores airflow over the two Node 2 Smoke Detectors and thus the guidelines in Rule {B17-202}, ACTIONS FOR CABIN SMOKE DETECTION LOSS [E], must be heeded.

- I. FOR LOSS OF THE NODE 1 IMV STBD AFT FAN, ONE OF THE FOLLOWING WILL BE DONE:
1. THE STBD AFT FAN WILL BE REMOVED AND REPLACED PER RULE {B17-156}, ECLSS EQUIPMENT SCAVENGE PRIORITY.
 2. IF A POWER FEED CAUSED THE LOSS OF THE STBD AFT FAN, IT WILL BE CONFIGURED TO DRAW POWER FROM AN ALTERNATE RPCM VIA PIN KIT.

Failure of the Node STBD AFT IMV Fan degrades IMV exchange with the Airlock and prevents adequate ppO₂ and ppCO₂ control.

FLIGHT RULES

10A_B17-6 METOX REGENERATION OPERATING CONSTRAINTS [HC] [RC]

A. PRIOR TO METOX REGENERATION ACTIVITIES, THE FOLLOWING EQUIPMENT CONFIGURATIONS AND INITIAL AIRLOCK CO₂ CONCENTRATION LIMITS MUST BE ESTABLISHED:

1. THE BMP MUST BE OPERATING IN THE SCRUB (ОЧИСТКА) MODE ONLY. REGENERATION MODE OF THE BMP MUST NOT OCCUR DURING METOX REGENERATION.

If the BMP is in the regeneration mode, it operates on only one cartridge and its productivity decreases. Both cartridges are needed to ensure maximum trace contaminant removal capability.

2. THE TCCS MUST BE OPERATIONAL.

TCCS IS ONLY REQUIRED FOR THE FIRST 10 HOURS OF THE METOX REGEN WHEN THE METOX IS ACTUALLY REGENERATING.

The TCCS must be operational for Metox Regen activities (when METOX is actually regenerating). TCCS is not required for the 4 hour cool down period. In addition, it is acceptable to operate the TCCS with the Catox Heaters deactivated since the Charcoal Bed Assembly (CB) is only required to remove any contaminants generated during the Metox Regeneration period.

DOCUMENTATION: E-mail from Jay Perry to DF83 Jason Barbour, "TCCS/Metox Feedback- RE: 12A.1 Power Down List & Times," November 6, 2006. Telecon with Tatiana Zharkovah and DF83 Jason Barbour, November 9, 2006.

3. FOR A CREW OF FOUR OR MORE, THE CDRA IS REQUIRED FOR METOX REGENERATION WITH OR WITHOUT THE VOZDUKH.

FOR A CREW OF THREE OR LESS, THE CDRA IS DESIRED BUT NOT MANDATORY FOR REGENERATION PROVIDED VOZDUKH IS ACTIVE AND AS LONG AS THE EXPECTED CO₂ AT METOX INITIATION IS BELOW 6 MMHG.

4. THE MCA IS NOT REQUIRED FOR METOX REGENERATION.

The productivity of the Vozdukh system is approximately 1.5 times less than the CDRA system. On-orbit data has shown that the Vozdukh alone cannot fully sustain CO₂ removal in the ISS modules (and shuttle) for certain crew sizes (> 4) while performing a Metox regeneration at the same time. Therefore, CDRA is required for Metox regeneration for crew sizes equal to or greater than 4 regardless if shuttle is present or not.

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FLIGHT RULES

10A_B17-6 METOX REGENERATION OPERATING CONSTRAINTS [HC] [RC] (CONTINUED)

For stages operations with three crewmembers, CDRA could be nominally activated. However, in the event of a CDRA failure, Vozdukh operation is sufficient to handle the load of the Metox regeneration activity. This assumes nominal IMV exchange and short term CO₂ level below 6 mmHg across the entire ISS. The amount of CO₂ rejected by two Metox canisters is 3.7 lbs [1], which results in a peak PPCO₂ elevation of approximately 1.6 mmHg [2] across the entire ISS. Therefore, initial CO₂ would have to be 6.0 mmHg in order not to violate the 7.6-mmHg upper limit (short duration). A single Metox canister has the capacity to hold up to 1.85 lbs/0.83 kg of CO₂.

Notes:

[1] FCA/PCA specification of 1.85 lbs CO₂ per canister x 2 canisters = 3.7 lbs.

[2] Assuming an ISS volume of 15,306 ft³/433 m³, 3.7lbs = 0.312 psi = 1.6mmHg.

Real-time monitoring of CO₂ in the airlock is desirable but not mandatory. Assuming active and sufficient IMV flow exchange, peak CO₂ levels in the airlock can be estimated from initial CO₂ readings from alternate instrumentation such as CDMK, or SM Gas Analyzer. Hence, MCA is not required for this activity.

Reference: Increment 9, Chit 1804.

5. IF THE CO₂ CONCENTRATION EXCEEDS OR IS EXPECTED TO EXCEED 10 mmHG IN THE AIRLOCK OR THE CREW EXPERIENCES SYMPTOMS AT ANY TIME DURING METOX REGENERATION, THE CREW SHOULD LEAVE THE AIRLOCK UNTIL CO₂ LEVELS ARE IN ACCORDANCE WITH RULE {B13-53}, PPCO₂ CONSTRAINT [RC] [E].

There is no explicit initial limit for CO₂ concentration in the airlock when commencing a Metox regeneration. However, whether the CDRA is operating alone or the CDRA is operating with the Vozdukh, if initial CO₂ concentrations are below 6 mmHg at the start of a Metox regeneration event, the CO₂ concentration will not, in practice, exceed 10 mmHg for the duration of the Metox regeneration. This assumes a regeneration with two Metox canisters.

Reference Hazard Report HR ISS-ECL-0021, IVA Crewmember Exposure to Excessive CO₂. ©[DN 55]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

**10A_B17-6 METOX REGENERATION OPERATING CONSTRAINTS [HC] [RC]
(CONTINUED)**

- B. THE METOX REGENERATOR INLET AIR TEMPERATURE DURING REGENERATION MUST BE MAINTAINED BELOW 15 DEG C (59 DEG F). TO SATISFY THESE CONSTRAINTS, THE FOLLOWING ACTIONS WILL BE TAKEN:
1. FOR ISS ATTITUDE OF +XVV AT BETA ANGLE BELOW -30 DEG, OR -XVV AT BETA ANGLE ABOVE +30 DEG, THE AIRLOCK CABIN TEMPERATURE (INDICATED BY CCAA INLET TEMPERATURE SENSORS) PRIOR TO THE BEGINNING OF METOX REGEN MUST BE AT A TEMPERATURE BELOW 20 DEG C (68 DEG F) AND THE AIRLOCK CCAA WILL BE CONFIGURED FOR MAXIMUM COOLING AND SHALL HAVE A TEMPERATURE SETPOINT NO GREATER THAN 18 DEG C (65 DEG F).
 2. FOR ALL OTHER ISS ATTITUDES, THERE IS NO CONSTRAINT AND THE AIRLOCK CABIN TEMPERATURE SETPOINT CAN BE SET PER CREW'S COMFORT LEVEL (NOMINALLY SET TO 25 DEG C/77 DEG F.)

The Airlock Metox Regenerator is located in the cabin air rack (A/LIA1) adjacent to the Common Cabin Air Assembly (CCAA). The Metox Regenerator was certified to an inlet air temperature upper limit of 10 deg C (50 deg F) based on initial estimates of LTL operation. Hamilton Sundstrand believes there is ample margin in the as-designed on-orbit cooling to accommodate up to a 9 deg F increase in the specified maximum air inlet temperature. This results in a maximum air inlet temperature of 15 deg C (59 deg F).

There is no instrumentation that measures Metox Regenerator Inlet Air Temperature. The air used to cool the Metox Regenerator is taken from the CCAA downstream of the heat exchanger (the coldest part of the airstream). During its operation (regeneration phase), the Metox Regenerator dissipates approximately 780 watts. Although most of the Regenerator components are insulated, the cabin air rack temperature increases during its operation.

Prior to Summer of 2005, a commanded cabin temperature setpoint of 18 deg C (65 deg F \pm 3 deg F) ensures sufficient passive cooling such that none of the equipment in the rack exceeds its upper operating thermal limits. This was done because ground testing indicated significant heat-leak from the hot regenerator oven (approximately 240-300 watts), but the Summer 2005 METOX temperature survey performed by the Increment 11 crew indicated the heat leak is exaggerated in a 1-g environment. The consequence of this lower cabin air temperature setpoint was colder air environment in the airlock and, as a result, the crew objected to this environment.

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FLIGHT RULES

10A_B17-6

METOX REGENERATION OPERATING CONSTRAINTS [HC] [RC] (CONTINUED)

As a result of the Summer 2005 METOX temperature survey, the temperature data from within the METOX/CCAA rack indicated that a nominal airlock cabin temperature set point range of 65 - 80 deg F will not compromise equipment in the rack during a METOX regeneration event. Due to the lack of METOX temperature data when ISS is in +XVV at beta angle below -30 degrees, the pre-existing constraint still applies until a temperature survey during hot orbital attitudes can be performed. The airlock experiences the same thermal environment at an attitude of -XVV and beta angle above +30.

The ± 3 deg F significance is the PIDS requirement to control the cabin aisleway from a selected temperature setpoint. There is no direct telemetry for the Metox Regenerator inlet air temperature or the internal rack temperature. Configuring LTL and resetting cabin temperature setpoint 1 hour prior to the planned Metox activity provides sufficient time to attain an 18 deg C/65 deg F environment in the airlock.

Reference: Increment 12 Chit 3382; Increment 13 Chit 4045; Hamilton Sundstrand Engineering Memo EVAM-0297; and Increment 13 Chit 4168.

3. THE LTL THREE WAY MIX VALVE (TWMV) OUT TEMPERATURE WILL BE MAINTAINED AT OR BELOW AN INDICATED 13.3 DEG C (56 DEG F) FOR THE FIRST 10 HOURS OF THE 14-HOUR REGENERATION PERIOD.

Based on worst-case HX airflows and the HX Effectiveness Curves, the required LTL temperature to support the Metox regeneration will be the Metox canister inlet air requirement minus 3 deg F. In order for the Metox Regenerator inlet air temperature to be no higher than 15 deg C (59 deg F), the LTL coolant flowing through the heat exchanger must be below 13.3 deg C (56 deg F). Nominal LTL coolant temperature will always satisfy this requirement, so there is nominally no reconfiguration of the LTL required for a Metox Regeneration.

Reference: Increment 13 chit 4045.

Reference Rule {B17-160}, LTL SETPOINTS FOR ECLSS OPERATIONS [RI].

- C. THE LTL AND A/L CCAA TEMPERATURE SETPOINT IS ALLOWED TO BE RESET TO THE NOMINAL SETPOINT AFTER 10 HOURS OF METOX REGENERATION. REFERENCE RULE {B17-160}, LTL SETPOINTS FOR ECLSS OPERATIONS [RI].

Ten hours into a 14-hour regeneration cycle is the duration when nominal heating cycle ceases and the cooldown phase initiates. Crew comfort may drive a necessity to warm up the airlock in order to conduct operations in a warm environment.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-6 **METOX REGENERATION OPERATING CONSTRAINTS [HC] [RC]**
(CONTINUED)

There is no concern with leaving the Metox Regenerator in standby mode, which powers off an internal cooling fan for the controller. Crew has verified sufficient air flow from the CCAA to the Metox Controller while in standby mode.

Reference: Increment 14 Chit 4213.

D. AIRLOCK CCAA WET INDICATIONS ARE NOT A CONSTRAINT TO METOX REGENERATOR OPERATIONS.

Transient water carryover has no significant repercussions to the Metox system in either the absorbing mode or the regenerating mode.

DOCUMENTATION: Engineering judgment; Boeing Short Sheet AL-ECLS-33 Airlock THC Subsystem May 16, 2002; PTCS Analysis - Airlock METOX: Cabin Air Rack Environment, Darin S. Boyer, April 10, 2002; Metox inlet air temperature constraint per Dwg SVHS822000, "Metal Oxide Regenerator;" Airlock on-orbit thermal analysis, CS-28V64-DSB-051/00 Rev. A; CHIT STS-104_7A ISS0307, LTL Water Temps during METOX Operation; CHIT STS-105_7A.1 ISS0140, AL CCAA Operations during MetOx regeneration; CHIT STS-113_017 ISS0131, engineering analysis of 9A DTO flight data; and fax from S. Romanov, RSC-Energia, dated November 26, 2002, fax reference F-1/057-5042, CHIT STS-105_7A_1 ISS0140, Airlock CCAA Operations during METOX Regeneration, Short Sheet ECLS-005.

10A_B17-7 **RESERVED** ©[DN 65]

FLIGHT RULES

10A_B17-8

LAB/NODE 2 VESTIBULE LEAK CHECK

- A. THE LAB/NODE 2 CBM VESTIBULE WILL BE PRESSURIZED TO 260 MMHG/5 PSIA VIA EQUALIZATION WITH THE ISS STACK THROUGH THE LAB FORWARD HATCH MPEV AND INTERNAL SAMPLING ADAPTER SAMPLE PORT. AFTER A 10-MINUTE WAIT PERIOD FOR THERMAL STABILIZATION, A 30-MINUTE LEAK CHECK WILL BE PERFORMED.

The vestibule will initially be pressurized to 257 mmHg/5 psia to save gas resources in case of a vestibule leak, and to avoid Node 2 NPRV cracking due to Node 2 air cooling prior to Node 2 activation.

- B. FOR LEAK RATES LESS THAN 5 MMHG IN 30 MINUTES (0.15 LBM/HR AT 14.7 PSIA), THE ISS STACK WILL BE COMPLETELY EQUALIZED WITH THE LAB/NODE 2 VESTIBULE. IF THE ISS STACK PRESSURE DROPS BY 10 MMHG (0.1 PSIA) DURING EQUALIZATION, THE EQUALIZATION WILL BE TERMINATED, AND A NODE 2 LEAK SUSPECTED.

Five mmHg in 30 minutes (0.05 lbm/hr) is a detectable leak rate using the ISA instrumentation and accounting for thermal uncertainties. Equalization with the ISS stack should lower the ISS stack cabin pressure by approximately 5mmHg. Allowing for errors and uncertainties, if the ISS stack pressure drops by 10mmHg during equalization, Node 2 must have a leak which resulted in NPRV's cracking during vestibule pressurization.

- C. FOR LEAK RATES GREATER THAN 5 MMHG IN 30 MINUTES (0.15 LB/HR AT 14.7 PSIA) AND LESS THAN THOSE SUPPORTABLE FOR 8 HOURS BY ISS CONSUMABLES, THE VESTIBULE WILL BE PRESSURIZED VIA THE LAB FORWARD MPEV. THE LEAK WILL THEN BE FED UNTIL THE CBM LEAK REPAIR KIT CAN BE INSTALLED.

Installation of the CBM seal kit is expected to take 8 hours. For detectable leaks supportable with ISS resources, the seal kit will be installed.

- D. FOR LEAK RATES GREATER THAN THOSE SUPPORTABLE BY ISS CONSUMABLES MARGIN FOR 8 HOURS, NODE 2 WILL BE REBERTHED.

For leak rates greater than those supportable by gas margins, there is no option other than re-berthing the Node 2 module.

- E. IF THE LAB/NODE 2 VESTIBULE LEAKS TO VACUUM DURING THE LEAK CHECK, A VESTIBULE LEAK WILL BE ASSUMED.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-8 LAB/NODE 2 VESTIBULE LEAK CHECK (CONTINUED)

- F. IF THE LAB/NODE 2 VESTIBULE LEAKS DOWN TO A STABLE PRESSURE ABOVE VACUUM, A NODE 2 LEAK WILL BE ASSUMED. CONSUMABLES MARGIN WILL BE USED TO ATTEMPT TO PRESSURIZE NODE 2 AND VESTIBULE TO HIGHER THAN THE NPRV CRACK PRESSURE.
1. IF THE LAB/NODE 2 VESTIBULE PRESSURE HOLDS AT A PRESSURE HIGHER THAN THE NPRV CRACK PRESSURE ABOVE VACUUM, A NODE 2 AFT PPRV/NPRV LAUNCH WILL BE ASSUMED. CONSUMABLES MARGIN WILL BE USED TO ATTEMPT TO PRESSURIZE NODE 2 AND VESTIBULE TO HIGHER THAN THE NPRV CRACK PRESSURE.
 2. IF THE LAB/NODE 2 VESTIBULE LEAKS DOWN TO NO LESS THAN THE NPRV CRACK PRESSURE ABOVE VACUUM, ANOTHER NODE 2 LEAK PATH, INCLUDING THE FORWARD PPRV/NPRV VALVES, IS INDICATED.

Node 2 NPRV's crack at or prior to 5.2 mm/hg (0.058 to 0.1 psi). A failed PPRV/NPRV on the Node 2 Aft allows to attempt to pressurize the combined Node 2 module/vestibule, as consumables allow. ©[DN 141]

FLIGHT RULES

10A_B17-9

NODE 1/NODE 2 VESTIBULE
PRESSURIZATION/DEPRESSURIZATION AND LEAK CHECKS

- A. THE NODE 1/NODE 2 CBM VESTIBULE WILL BE PRESSURIZED TO 260 MMHG/5 PSIA VIA EQUALIZATION WITH THE ISS STACK THROUGH THE NODE PORT HATCH MPEV AND INTERNAL SAMPLING ADAPTER SAMPLE PORT. AFTER A 10-MINUTE WAIT PERIOD FOR THERMAL STABILIZATION, A 10-MINUTE LEAK CHECK WILL BE PERFORMED.

The vestibule will initially be pressurized to 257 mmHg/5 psia to save gas resources in case of a vestibule leak, and to avoid Node 2 NPRV cracking due to Node 2 air cooling prior to Node 2 activation.

- B. FOR LEAK RATES LESS THAN 5 MMHG IN 10 MINUTES (0.15 LBM/HR AT 14.7 PSIA), THE ISS STACK WILL BE COMPLETELY EQUALIZED WITH THE NODE 1/NODE 2 VESTIBULE. IF THE ISS STACK PRESSURE DROPS BY 10 MMHG (0.1 PSIA) DURING EQUALIZATION, THE EQUALIZATION WILL BE TERMINATED, AND A NODE 2 LEAK SUSPECTED.

Five mmHg in 30 minutes (0.05 lbm/hr) is a detectable leak rate using the ISA instrumentation and accounting for thermal uncertainties. Equalization with the ISS stack should lower the ISS stack cabin pressure by approximately 5mmHg. Allowing for errors and uncertainties, if the ISS stack pressure drops by 10mmHg during equalization, Node 2 must have a leak which resulted in NPRV's cracking during vestibule pressurization.

- C. FOR LEAK RATES GREATER THAN 5 MMHG IN 10 MINUTES (0.15 LB/HR AT 14.7 PSIA) AND LESS THAN THOSE SUPPORTABLE FOR 2 HOURS BY ISS AND ORBITER CONSUMABLES (UP TO REDLINES FOR WEATHER DAYS AND ORBITER REPRESS REQUIREMENT), THE VESTIBULE WILL BE PRESSURIZED VIA THE NODE 1 PORT MPEV. THE LEAK WILL THEN BE FED FOR THE DURATION OF REQUIRED NODE 2 INGRESSED ACTIVITIES.

Activities requiring Node 2 ingress while berthed to Node 1 require 2 hours to complete. Consideration should be given to performing only the highest priority activities depending on leak rates and available consumables.

- D. FOR LEAK RATES GREATER THAN THOSE SUPPORTABLE BY ORBITER/ISS CONSUMABLES MARGIN FOR 2 HOURS, NODE 2 WILL BE REBERTHED.

For leak rates greater than those supportable by gas margins, there is no option other than re-berthing the Node 2 module.

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FLIGHT RULES

10A_B17-9

NODE 1/NODE 2 VESTIBULE

PRESSURIZATION/DEPRESSURIZATION AND LEAK CHECKS
(CONTINUED)

- E. IF THE NODE 1/NODE 2 VESTIBULE LEAKS TO VACUUM DURING THE LEAK CHECK, A VESTIBULE LEAK WILL BE ASSUMED.
- F. IF THE NODE 1/NODE 2 VESTIBULE LEAKS DOWN TO A STABLE PRESSURE ABOVE VACUUM, A NODE 2 LEAK WILL BE ASSUMED.
1. IF THE NODE 1/NODE 2 VESTIBULE PRESSURE HOLDS AT A PRESSURE HIGHER THAN THE NPRV CRACK PRESSURE, A NODE 2 AFT PPRV/NPRV FAILURE ON LAUNCH WILL BE ASSUMED. CONSUMABLES MARGIN WILL BE USED TO ATTEMPT TO PRESSURIZE NODE 2 AND VESTIBULE TO HIGHER THAN THE NPRV CRACK PRESSURE.
 2. IF THE NODE 1/NODE 2 VESTIBULE LEAKS DOWN TO LESS THAN THE NPRV CRACK PRESSURE BUT ABOVE VACUUM, ANOTHER NODE 2 LEAK PATH, INCLUDING THE FORWARD PPRV/NPRV VALVES, IS INDICATED.

Node 2 NPRV's crack at or prior to 5.2 mm/hg (0.058 to 0.1 psi). A failed PPRV/NPRV on the Node 2 Aft allows to attempt to pressurize the combined Node 2 module/vestibule, as consumables allow. ©[DN 141]

FLIGHT RULES

10A_B17-10 CONSTRAINTS FOR SPHERES TEST SESSIONS [HC] [RC]

A. GO/NO-GO MATRIX FOR SYNCHRONIZED POSITION HOLD, ENGAGE REORIENT, EXPERIMENTAL SATELLITES (SPHERES) TEST SESSIONS:
 @[DN 58]

EQUIPMENT	REQUIRED CONFIGURATION
CDRA	ON [1]
MCA	ON [2]
LAB CCAA	ON [3]
AL CCAA	OFF (ON)[4]
N1 CABIN FAN	ON [5]
N1 IMV STBD AFT FAN	ON [6]

NOTES:

- [1] CDRA MUST BE OPERATING IN DUAL-BED OR SINGLE-BED MODE REGARDLESS OF THE NUMBER OF SATELLITES TESTED. PER AGREEMENTS WITH RS AND U.S. ECLSS COMMUNITIES, THE CDRA IS REQUIRED FOR REMOVAL OF CO2 EXPELLED BY SPHERES IN THE U.S. SEGMENT.
- [2] ACTIVE CO2 MONITORING OF THE MODULE WHERE THE SPHERES TEST SESSION IS HELD IS REQUIRED. THE SPHERES PAYLOAD EXPELS CO2 INTO NODE 1 OR THE U.S. LAB, DEPENDING ON WHERE IT IS DEPLOYED. RAPID SAMPLING OF THE MODULE IS PREFERABLE, BUT NOT REQUIRED.
- [3] THE CDRA NOMINALLY USES CONDITIONED LAB CCAA AIR FOR OPERATION. THE CCAA'S PROVIDE INTRAMODULE VENTILATION FOR THE LAB AND U.S. AIRLOCK. REFERENCE RULES {B17-158}, CCAA MANAGEMENT, AND {B17-307}, CARBON DIOXIDE REMOVAL ASSEMBLY (CDRA) MANAGEMENT.
- [4] IF ANY CREW ACTIVITY OCCURS IN THE AIRLOCK DURING OR AFTER THE SPHERES TEST SESSION ON THE SAME CREWDAY AS THE SPHERES ACTIVITY, AIRLOCK CCAA OPERATION IS REQUIRED. CREWMEMBER ACTIVITY IN THE AIRLOCK DURING AND AFTER A SPHERES TEST SESSION MAY CAUSE EXPOSURE TO POCKETS OF ELEVATED LEVELS OF CO2 IF THE AIRLOCK CCAA IS NOT ACTIVATED.
- [5] THE NODE 1 CABIN FAN IN CONJUNCTION WITH A LAB CCAA PROVIDES IMV BETWEEN NODE 1 AND THE U.S. LAB. THE NODE 1 CABIN FAN ALSO PROVIDES INTRAMODULE VENTILATION. REFERENCE RULE {B17-401}, NODE-1 CABIN FAN MANAGEMENT.
- [6] THE NODE 1 IMV STARBOARD AFT FAN PROVIDES IMV BETWEEN THE U.S. AIRLOCK AND NODE 1. REF RULE {B17-157}, ACTIONS FOR LOSS OF ISS VENTILATION [RC]. @[DN 58]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-10 CONSTRAINTS FOR SPHERES TEST SESSIONS [HC] [RC] (CONTINUED)

- B. AT THE INITIALIZATION OF A SPHERES TEST SESSION, THE CO₂ LEVEL IN THE MODULE WHERE THE SPHERES TEST SESSION IS HELD SHALL BE BELOW THE FOLLOWING LEVELS WHEN CORRECTED FOR KNOWN MEASUREMENT ERRORS AS DEFINED BY RULE {B17-17}, USE OF CO₂ PARTIAL PRESSURE SENSORS [RC]. @[DN 58]

NUMBER OF CREW	NUMBER OF SPHERES	INITIAL CO ₂ LEVEL (MMHG)
2	1	< 5.2
2	2	< 4.9
2	3	< 4.7
3	1	< 4.9
3	2	< 4.7
3	3	< 4.4

Numbers in the table above protect the ISS PPCO₂ from reaching 6 mmHg and are generated from ECLSS Resource Utilization Planning and System Modeling (RUPSM) analysis “SPHERES_MODEL_LAB: Single bed ops CDRA_30 CFM IMV_.5 tank” performed on October 3, 2006. The numbers in the table were created by taking the model’s delta PPCO₂ from the start of a SPHERES session until the beginning of an adsorbing CDRA half cycle, and subtracting that from 6 mmHg. The model showed that a functioning CDRA, IMV, and intramodule ventilation, over a period of approximately 4 hours, reduces the PPCO₂ spike generated by SPHERES. The RUPSM model was based on the following assumptions: CDRA operating in single-bed mode, SPHERES sessions initiated immediately after the CO₂ adsorb cycle, 30 CFM IMV flow between U.S. Airlock and Node 1, 80 CFM flow between the U.S. Lab and Node 1, no IMV with the RS, perfect intramodule ventilation, crewmember exercising in the U.S. Lab during 2-hour SPHERES test session while one or two crewmember(s), depending on crew size, is monitoring the experiment in the U.S. Lab. The assumption that there is no IMV with the RS protects for a collapsed duct somewhere between the RS and U.S. Segment. 30 CFM IMV flow between the U.S. Airlock and Node 1 and 80 CFM IMV flow between the U.S. Lab and Node 1 protects for severely degraded IMV flow. This assumed case was considered to account for lack of immediate insight into IMV throughout the ISS. An identical analysis was conducted for Node 1, and showed that the delta PPCO₂ would be slightly lower than in the U.S. Lab. The numbers in the table are based on the U.S. Lab analysis results, because they are more conservative than the Node 1 numbers. To meet initial CO₂ constraints, CDRA activation may need to be planned several hours in advance.

Reference Rules {B13-53}, PPCO₂ CONSTRAINT [RC] [E], and {B17-17}, USE OF CO₂ PARTIAL PRESSURE SENSORS [RC]. @[DN 58]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B17-10 CONSTRAINTS FOR SPHERES TEST SESSIONS [HC] [RC] (CONTINUED)

C. METOX REGENERATION SHALL NOT OCCUR DURING A SPHERES TEST SESSION. @[DN 58]

Due to the SPHERES expelling CO₂ into the atmosphere, the additional CO₂ load resulting from MetOx regeneration is restricted.

D. SPHERES OPERATIONS SHALL BE STOPPED IF CONSTRAINTS IN RULE {B13-53}, PPCO2 CONSTRAINT [RC] [E], CANNOT BE MET.

Reference Rule {B13-53}, PPCO2 CONSTRAINT [RC] [E].

Synchronized Position Hold, Engage Reorient, Experimental Satellites (SPHERES) is a DOD payload that tests formation flying and will perform various maneuvers with one to three small "satellites" that will fly in Node 1 or the U.S. Lab. Each test session will last approximately 3 hours. Each satellite is propelled by one CO₂ canister (tank) containing 170 grams/0.375 lbs of CO₂ at 830 psia. The canister may be changed out during the session if the session was initiated with a used canister. Thrusters on the satellite expel CO₂ with a thrust of 0.25 N into the cabin at a rate of 0.17 kg/hr/0.37 lbm/hr per satellite. In practice, however, 0.037 kg/hr/0.13 lbm/hr is the average CO₂ introduction rate per satellite. Based on these capabilities:

NUMBER OF SATELLITE(S) IN SESSION	TOTAL MASS OF CO ₂ EXPELLED INTO ISS ATMOSPHERE AFTER 3 HRS (KGS/LBMS)	CO ₂ MASS FLOW RATE (KG/HR/LBM/HR)
1	0.11/0.24	0.037/0.082
2	0.22/0.48	0.074/0.16
3	0.33/0.73	0.11/0.24

DOCUMENTATION: Toxicology Group Memo 587, February 6, 2001; ISS ECLSS Group Memo EC-02-174, November 19, 2002; Hazard Report SPHERES-8, Control 1.2; and SPHERES ICD SSP-57251, NASA/JSC Dave Williams email to DF83/Whitney Maples, September 7, 2003, ZR/JSC Mark E. Adams email to Boeing/Bruce Wright, May 19, 2005, and ZR/JSC Mark E. Adams email to DF83/Michael Kammerdiener October 10, 2006. @[DN 58]

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_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) TOPPING FES OPERATIONS. SUPPLY WATER DUMPS USING THE FES ARE ALLOWED BUT CONSTRAINED PER RULE {10A_C2-85}, MATED FES DUMP CONSTRAINTS.
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 H₂O as required. It will be enabled at all times during the docked phase. Nominal Topping FES ops are allowed anytime. Supply water dumps using the FES are constrained per Rule {10A_C2-85}, MATED FES DUMP CONSTRAINTS, in order to not interfere with critical momentum management periods. The vacuum venting is required to provide venting of WCS, wet trash, RCRS, and fuel cell generated H₂.

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.

To minimize the number of nozzle dump occurrences and the associated attitude changes, supply water nozzle dumps should be performed simultaneously with wastewater 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 wastewater dumps.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C17-1 SHUTTLE VENT MANAGEMENT [RC] (CONTINUED)

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 wastewater dumped while docked, a wastewater 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.
 - c. REFER TO RULE {10A_B2-45}, [USOS NOMINAL SOLAR ARRAY CONSTRAINTS PLANNING \[HC\] \[RC\]](#). @CR8859]

Minimizing the quantity of wastewater dumped reduces the potential for ISS contamination. Sufficient waste quantity will be dumped to provide enough ullage in the waste tank to accommodate wastewater generation until a dump opportunity is available post undocking.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C17-1 SHUTTLE VENT MANAGEMENT [RC] (CONTINUED)

- d. 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.

- 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.

To minimize the number of nozzle dump occurrences and the associated attitude changes, CWC dumps should be performed in conjunction with supply and/or wastewater dumps when possible. CWC-only dumps may be performed, when required, if attitude constraints or timeline activities do not allow for dumping adjacent to supply and/or wastewater dumps.

- 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 wastewater in CWC's will not be considered as a method of minimizing the amount of wastewater dumped while docked. Engineering judgment.

FLIGHT RULES

10A_C17-2

ISS JOINT AIRLOCK PRE-EVA ATMOSPHERE REQUIREMENTS [RC] [E]

A. BEFORE THE START OF PREBREATHE FOR AN EVA OR EVA SERIES FROM THE ISS JOINT AIRLOCK WHILE THE SHUTTLE IS DOCKED WITH HATCHES OPEN BETWEEN VEHICLES, THE FOLLOWING ATMOSPHERE REQUIREMENTS MUST BE MET:

1. TOTAL PRESSURE MUST NOT EXCEED 746 MMHG (14.43 PSI).
2. OXYGEN CONCENTRATION MUST NOT EXCEED 22.0 PERCENT.

The mated stack pressure and oxygen concentration will increase due to approximately 20 - 23 lbs of oxygen introduction from PHA usage during the ISS EVA prebreathe protocol and the addition of gas to the stack during Joint Airlock and Crewlock depress activities. If the mated stack pressure is not reduced below 744 mmHg (14.40 psi) prior to the start of prebreathe for an EVA or EVA series, the cabin pressure may increase above the nominal total pressure of 770 mmHg (14.9 psi) during the pre-EVA activities mentioned above. The nominal pressure range of ISS is defined in Rule {B17-2}, TOTAL PRESSURE MANAGEMENT [RC]. If the total pressure was to exceed the positive pressure relief threshold of the ISS Pressure Control Assembly (777 mmHg/15.03 psi), an automatic vent would be initiated to reduce cabin pressure. The oxygen concentration of the atmosphere must not breach the ISS fire threshold as a result of nominal EVA preparations, reference Rule {B17-3}, OXYGEN PARTIAL PRESSURE MANAGEMENT [HC] [RC] [E] [A]. The excess oxygen will be used as metabolic O₂ makeup. A combined stack volume of 18232 cubic feet was assumed in the generation of this rule (19822 cubic feet if MPLM is installed). The above requirements are applicable whether or not an MPLM is present.

B. TO MAINTAIN CABIN PRESSURE AND OXYGEN CONCENTRATION BELOW THE ABOVE REQUIREMENTS, THE FOLLOWING ACTIONS SHALL BE PERFORMED AS REQUIRED PRIOR TO THE START OF PREBREATHE FOR A SINGLE EVA OR AN EVA SERIES:

1. ELEKTRON OPERATION SHALL BE TERMINATED OR TRANSITIONED, IF REQUIRED, TO THE LOWEST O₂ PRODUCTION MODE.
2. THE SHUTTLE OXYGEN BLEED ORIFICE VALVE WILL BE CLOSED.
3. THE SHUTTLE PRESSURE CONTROL SYSTEM 14.7 PSI REGULATORS WILL BE CLOSED.
4. ISS PRESSURE CONTROL ASSEMBLY (PCA) GAS INTRODUCTIONS SHALL BE TERMINATED EXCEPT AS REQUIRED FOR ISS EVA PREPARATIONS.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C17-2 ISS JOINT AIRLOCK PRE-EVA ATMOSPHERE REQUIREMENTS
[RC] [E] (CONTINUED)

5. PROGRESS GAS INTRODUCTIONS SHALL BE TERMINATED.
6. TTK OPERATIONS SHALL BE TERMINATED.

More oxygen is introduced during the ISS EVA prebreathe protocol and related depresses of a single EVA than is consumed metabolically. To avoid breaching the ISS oxygen fire threshold or exceeding the nominal cabin pressure operating range during the EVA or subsequent EVA preparations, all devices that introduce oxygen and nitrogen must be managed appropriately prior to and during a single EVA or EVA series.

- C. A PARTIAL DEPRESS AND/OR INTRODUCTION OF NITROGEN WILL BE PERFORMED AS REQUIRED TO MAINTAIN ATMOSPHERE REQUIREMENTS SPECIFIED IN PARAGRAPH A.

DOCUMENTATION: Engineering judgment.

Reference Rules {C17-4}, ISS ATMOSPHERIC REPLENISHMENT [RC], {B17-2}, TOTAL PRESSURE MANAGEMENT [RC], and {B17-3}, OXYGEN PARTIAL PRESSURE MANAGEMENT [HC] [RC] [E] [A].

FLIGHT RULES

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FLIGHT RULES

SECTION 18 - THERMAL

SHUTTLE ONLY RULES

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ISS ONLY RULES

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JOINT SHUTTLE/ISS RULES

THERE ARE NO JOINT SHUTTLE/ISS RULES FOR THIS SECTION.....18-19

FLIGHT RULES

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FLIGHT RULES**SECTION 18 - THERMAL****SHUTTLE ONLY RULES****10A_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-120:

DESCRIPTION	TEMPERATURE MEASUREMENT NO'S	STS-120 MAX LIMIT, DEG F
PLBD	V37T1000	74.0
	V37T1006	74.0
	V37T1002	77.0
	V37T1004	77.0
PORT (STBD)	V09T1012(14)	90.1
	V09T1724(20)	109.9
	V09T1030(28)	65.6
	V34T1106(08)	116.9
	V34T1102(04)	64.9
TOP	V09T1524	42
	V09T1004	89.8
	V09T1024	89.8
BOTTOM	V09T1624	141.1
	V09T1702	104.7
	V09T1000	107.6
	V09T1002	107.6
	V09T1016	155.3
	V09T1022	148.3
	V34T1110	112.3
	V34T1112	113.3

©[DN 17]

These are the STS-120 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-120 Flight Design Product DSCT-29, dated March 12, 2007. ©[DN 17]

FLIGHT RULES

ISS ONLY RULES

10A_B18-1 RULES APPLICABLE TO NODE 2 ITCS MANAGEMENT

THE FOLLOWING GENERIC FLIGHT RULES ON LAB ITCS MANAGEMENT ARE ALSO APPLICABLE TO NODE 2 ITCS MANAGEMENT:

- A. RULE {B18-4}, SFCA LOSS DEFINITION
- B. RULE {B18-5}, LTL, MTL AND MTL REGEN HX TWMV LOSS DEFINITION, NOTING THAT MTL REGEN IS REPLACED WITH LTL REGEN.
- C. RULE {B18-51}, SFCA MANAGEMENT

@[DN 80]

FLIGHT RULES

10A_B18-2 MANUAL TRRJ POSITIONING

A. THE TRRJ WILL NOMINALLY OPERATE IN AUTOTRACK MODE. WHEN AUTOTRACK IS UNAVAILABLE OR UNDESIRABLE, AND THE ISS IS IN AN APPROVED LVLH ATTITUDE, THE TRRJ CAN BE POSITIONED AS INDICATED IN THE FOLLOWING TABLES. THERE IS NO TIME LIMIT ASSOCIATED WITH THE CONSTRAINTS IN THE POSITIONING TABLES.

1. TABLE 10A_B18-2-I PROVIDES S1 TRRJ POSITIONING WHEN THE LOOP A ETCS IS ACTIVE AT A NOMINAL FLOWRATE:

TABLE 10A_B18-2-I - S1 TRRJ - TBD

BETA ANGLE [2]	GAMMA ANGLE [1]														
	-105	-90	-75	-60	-45	-30	-15	0	15	30	45	60	75	90	105
75	TBD														
62.5															
50															
37.5															
25															
12.5															
0.5															
-13															
-25															
-38															
-50															
-63															
-75															

BLANK = RECOMMENDED POSITION

bMF = MARGINALLY ACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

MF = UNACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

NOTES:

- [1] FOR THE BOUNDARIES BETWEEN POSITIONS THAT ARE RECOMMENDED AND THOSE THAT ARE NOT RECOMMENDED, THE OPERATOR SHOULD SURROUND THE NOT RECOMMENDED AREA WITH A ±6-DEGREE TOLERANCE. FOR -XVV ATTITUDES, DATA FOR THE OPPOSITE BETA ANGLE SIGN SHOULD BE USED. FOR EXAMPLE, TO OBTAIN POSITION FOR -XVV BETA = 75, THE OPERATOR WOULD USE THE +XVV BETA = -75 DATA.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B18-2 MANUAL TRRJ POSITIONING (CONTINUED)

2. TABLE 10A_B18-2-II AND 10A_B18-2-V PROVIDES S1 TRRJ POSITIONING WHEN THE LOOP A ETCS IS NOT ACTIVE (NO FLOW) :

TABLE 10A_B18-2-II - S1 TRRJ STAGNANT - TBD

BETA ANGLE [2]	GAMMA ANGLE [1]														
	-105	-90	-75	-60	-45	-30	-15	0	15	30	45	60	75	90	105
75	TBD														
62.5															
50															
37.5															
25															
12.5															
0.5															
-13															
-25															
-38															
-50															
-63															
-75															

BLANK = RECOMMENDED POSITION

bMF = MARGINALLY ACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

MF = UNACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

NOTES:

[1] FOR THE BOUNDARIES BETWEEN POSITIONS THAT ARE RECOMMENDED AND THOSE THAT ARE NOT RECOMMENDED, THE OPERATOR SHOULD SURROUND THE NOT RECOMMENDED AREA WITH A ±6-DEGREE TOLERANCE. FOR -XVV ATTITUDES, DATA FOR THE OPPOSITE BETA ANGLE SIGN SHOULD BE USED. FOR EXAMPLE, TO OBTAIN POSITION FOR -XVV BETA = 75, THE OPERATOR WOULD USE THE +XVV BETA = -75 DATA.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B18-2 MANUAL TRRJ POSITIONING (CONTINUED)

3. TABLE 10A_B18-2-III PROVIDES P1 TRRJ POSITIONING WHEN THE LOOP B ETCS IS ACTIVE AT A NOMINAL FLOWRATE:

TABLE 10A_B18-2-III - P1 TRRJ - TBD

BETA ANGLE [2]	GAMMA ANGLE														
	-105	-90	-75	-60	-45	-30	-15	0	15	30	45	60	75	90	105
75	TBD														
63															
50															
38															
25															
13															
1															
-13															
-25															
-38															
-50															
-63															
-75															

BLANK = RECOMMENDED POSITION

bMF = MARGINALLY ACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

MF = UNACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

NOTES:

[1] FOR THE BOUNDARIES BETWEEN POSITIONS THAT ARE RECOMMENDED AND THOSE THAT ARE NOT RECOMMENDED, THE OPERATOR SHOULD SURROUND THE NOT RECOMMENDED AREA WITH A ±6-DEGREE TOLERANCE. FOR -XVV ATTITUDES, DATA FOR THE OPPOSITE BETA ANGLE SIGN SHOULD BE USED. FOR EXAMPLE, TO OBTAIN POSITION FOR -XVV BETA = 75, THE OPERATOR WOULD USE THE +XVV BETA = -75 DATA.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B18-2 MANUAL TRRJ POSITIONING (CONTINUED)

4. TABLE 10A_B18-2-IV PROVIDES P1 TRRJ POSITIONING WHEN THE LOOP B ETCS IS NOT ACTIVE (NO FLOW):

TABLE 10A_B18-2-IV - P1 TRRJ STAGNANT - TBD

BETA ANGLE [2]	GAMMA ANGLE [1]														
	-105	-90	-75	-60	-45	-30	-15	0	15	30	45	60	75	90	105
75	TBD														
63															
5															
38															
25															
13															
1															
-13															
-25															
-38															
-5															
-63															
-75															

BLANK = RECOMMENDED POSITION

bMF = MARGINALLY ACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

MF = UNACCEPTABLE DUE TO POTENTIAL FOR DAMAGE CAUSED BY RADIATOR MANIFOLD FREEZING

NOTES:

- [1] FOR THE BOUNDARIES BETWEEN POSITIONS THAT ARE RECOMMENDED AND THOSE THAT ARE NOT RECOMMENDED, THE OPERATOR SHOULD SURROUND THE NOT RECOMMENDED AREA WITH A ±6-DEGREE TOLERANCE. FOR -XVV ATTITUDES, DATA FOR THE OPPOSITE BETA ANGLE SIGN SHOULD BE USED. FOR EXAMPLE, TO OBTAIN POSITION FOR -XVV BETA = 75, THE OPERATOR WOULD USE THE +XVV BETA = -75 DATA.

Rationale: **TBD**

DOCUMENTATION: **TBD**

FLIGHT RULES

10A_B18-3

NODE 2 SFCA DELTA PRESSURE SENSOR PROTECTION

A SYSTEM FLOW CONTROL ASSEMBLY (SFCA) WILL BE INHIBITED AND THE SFCA MOD VALVE WILL BE PLACED IN THE FULL OPEN POSITION PRIOR TO ANY OF THE FOLLOWING OPERATIONS ON AN OPERATING LOOP:
©[DN 120]

- A. DEMATING A QD TO A NODE 2 RACK
- B. INCREASING PUMP SPEED (INCLUDING PPA STARTUP)
- C. REMOVING A PPA GAS TRAP
- D. REMOVING A PPA FILTER

If Node 2 ITCS flow is terminated to any Node 2 rack, the SFCA modulating valve cannot compensate quickly enough and the SFCA delta pressure increases. When the delta pressure reaches 131 kPa (19 psid), FDIR software reduces the speed of the affected PPA in order to reduce the delta pressure and ensure that the delta pressure sensor is not damaged. The delta pressure sensor can be damaged at 386 kPa (56 psid); however, the sensor is only calibrated to 131kPa, so the FDIR software takes action at 131 kPa. PPA startups can also result in an SFCA delta pressure > 131 kPa (19 psid) which will trigger FDIR software that reduces the speed of the affected PPA.

Analysis also shows that removing the PPA gas trap, removing the PPA filter, or increasing the PPA pump speed (even by small amounts) also risk tripping the SFCA Overpress FDIR limit of 131 kPa (19 psid).

Inhibiting the SFCA and positioning the modulating valve in the full open position minimizes SFCA delta pressure by maximizing SFCA bypass flow. Note that flow to systems racks is degraded in this configuration. Rack outlet temperatures should be monitored to verify that loads are receiving sufficient cooling. If the SFCA software is shutdown, then automatic Node 2 ITCS activations automatically place the modulating valve in the full open position. ©[DN 134]

DOCUMENTATION: Node 2 Systems 1 and Node 2 Systems 2 CSCI Software Requirements Specification, Rev F, and Internal Systems R2 CSCI Software Requirements Specification, Rev D.
©[DN 120]

FLIGHT RULES

10A_B18-4

NODE 2 ITCS MANAGEMENT WITH LTL REGEN TEMPERATURES BELOW CABIN DEWPOINT

IF THE NODE 2 LTL REGENERATIVE HEAT EXCHANGER CANNOT MAINTAIN ITS OUTLET TEMPERATURES ABOVE THE CABIN DEWPOINT DUE TO LOW NODE 2 LTL HEAT LOADS, THEN INCREMENTALLY REDUCE THE SPEED OF THE LTL ITCS PUMP UNTIL LTL REGEN HX OUT TEMP > NODE 2 CABIN AIR DEWPOINT TEMPERATURE. DO NOT ALLOW LTL SFCA MODULATION VALVE DELTA PRESSURE TO GO BELOW TBD KPA (TBD PSID).

Reducing pump speed reduces the flow rate through the regenerative heat exchanger which increases the LTL temperature. SFCA delta pressure must be maintained above TBD kPa (TBD psid) in order to ensure that all LTL rack loads receive adequate flow. ©[DN 115]

DOCUMENTATION: Engineering judgment.

FLIGHT RULES

10A_B18-5

NODE 2 THREE WAY MIX VALVE (TWMV) MANAGEMENT

A. IF THE NODE 2 LTL TWMV IS DECLARED LOST, THEN THE FOLLOWING ACTIONS MAY BE TAKEN TO ENSURE HEAT REJECTION FOR OPERATIONAL COMPONENTS:

1. THE LTL REGEN TWMV WILL REMAIN ENABLED AND THE LTL TWMV WILL BE INHIBITED IF REQUIRED. THE LTL TWMV WILL BE POSITIONED VIA COMMAND AS REQUIRED TO ENSURE THAT THE LTL REGEN TWMV CAN CONTROL LTL REGEN HX OUT TEMPERATURE.

The only purely LTL load on the Node 2 LTL is the Node 2 CCAA. All other Node 2 LTL loads are downstream of the LTL Regen HX. The LTL TWMV will be placed at a position such that the LTL Regen TWMV is able to control the LTL Regen HX Out Temp, i.e. such that the inlet temperature of the LTL Regen HX (not telemetered) is less than the LTL Regen HX Out Temp. If required the LTL TWMV can be manually positioned by the crew.

B. IF THE NODE 2 MTL TWMV IS DECLARED LOST, THEN ACTION WILL BE TAKEN UNDER CERTAIN CONDITIONS:

1. CONDITIONS REQUIRING ACTION ARE AS FOLLOWS:
 - a. MTL TWMV OUTLET TEMPERATURE INCREASES ABOVE 22.8 DEG C (73 DEG F).
 - b. OR MTL TWMV OUTLET TEMPERATURE DECREASES BELOW 15.6 DEG C (60 DEG F).
 - c. OR THE MTL TWMV OUTLET TEMPERATURE SENSOR HAS FAILED.
2. REQUIRED ACTIONS ARE AS FOLLOWS:
 - a. THE MTL TWMV WILL BE INHIBITED IF REQUIRED. THE MTL TWMV WILL BE POSITIONED VIA COMMAND AS REQUIRED TO ENSURE THAT THE NODE 2 MTL RACKS RECEIVE PROPER COOLING.
 - b. IF THE MTL TWMV CANNOT BE COMMANDED, THEN VALVE WILL BE MANUALLY POSITIONED BY THE CREW.
 - c. IF THE MTL TWMV CANNOT BE MANUALLY POSITIONED, THEN NODE 2 MTL LOADS MAY NEED TO BE POWERED OFF.

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B18-5

NODE 2 THREE WAY MIX VALVE (TWMV) MANAGEMENT
(CONTINUED)

Action is taken at an MTL TWMV outlet temperature of 22.8 deg C (73 deg F) because a 5.6 deg C (10 deg F) rise in MTL setpoint temperature causes an undesirable rise in the temperature of coldplated components on the MTL. The MTL TWMV can be manually positioned by the crew. If the valve cannot be manually positioned, then in order to keep the Node 2 MTL racks within their operational range, Node 2 MTL loads may need to be reduced.

- C. IF THE NODE 2 LTL REGEN TWMV IS DECLARED LOST, THEN THE LTL REGEN TWMV WILL BE COMMANDED TO THE FULL FLOW THRU POSITION. IF RACK OUTLET TEMPERATURES INDICATE THAT RACK COOLING IS NOT ADEQUATE, THEN THE LTL REGEN TWMV WILL BE POSITIONED VIA COMMAND TO REDUCE LOOP TEMPERATURES.

If the Node 2 LTL Regen TWMV is lost, then the LTL Regen TWMV will be placed in the flow thru position such that the performance of the regenerative heat exchanger is maximized. This configuration is preferred as it is simple to implement and results in acceptable MTL temperatures for the Node 2 LTL racks. Unacceptably high Node 2 LTL rack temperatures will be apparent from increasing rack outlet temperatures.

DOCUMENTATION: Engineering judgment.

FLIGHT RULES

10A_B18-6

NODE 2 ITCS LOOP MANAGEMENT WITH A LEAK

- A. IF A LEAK CANNOT BE ISOLATED AND IS NOT TO VACUUM, THE LEAKING LOOP'S ACCUMULATOR WILL BE DEPRESSURIZED AND THE LEAKING LOOP WILL BE SHUT DOWN. NODE 2 AVIONICS ON THE LEAKING LOOP WILL BE SHUTDOWN PRIOR TO REACHING THEIR HIGH TEMPERATURE LIMITS. ©[DN 135]

A leak can be isolated by disconnecting QD's at a rack interface panel supply and return lines. If the leak is not in rack plumbing then it cannot be isolated. Shutting the loop down and depressurizing the accumulator eliminates the pressure feeding the leak. Note that leak FDIR software will perform the above actions automatically if it detects accumulator quantities below leak shutdown limits. If the leak is detected by Leak FDIR software, then Fail Recovery software is automatically inhibited.

- B. IF A LEAK IS LOCATED IN A RACK, THE RACK WILL BE ISOLATED AND AVIONICS IN THE RACK WILL BE SHUTDOWN.

If the leak is determined to be in a rack, disconnecting the appropriate QD's isolates the leak and allows for continued loop operations, if the leaking rack does not contain the DDCU's powering the ITCS PPA for that loop. Avionics which are no longer receiving cooling in the isolated rack will need to be unpowered to prevent violating temperature limits.

- C. IF THE LEAK IS TO VACUUM, THE LEAKING IFHX AND ITS PPA WILL BE ISOLATED. THE AFFECTED LOOP WILL BE SHUT DOWN.

If a leak is determined to be outside the cabin to vacuum, then the only credible leak location is the IFHX itself or the IATCS supply and return lines external to the pressurized volume. Disconnecting the QD's for the leaking loop's PPA is the most immediate way to ensure that ISS atmosphere is not drawn through the gas trap to vacuum. For the LTL, QD's in the Port Aft Cone and Starboard Aft Cone can be used to isolate the external ITCS lines and the IFHX from the remainder of the loop; however, when these QD's are disconnected, the LTL fluid circuit cannot be completed. For the MTL, a QD in the overhead alcove (TWMV Inlet B) and a QD in the Port Fwd Cone can be used to isolate the external ITCS lines and the IFHX from the remainder of the loop; again, when these QD's are disconnected, the MTL fluid circuit cannot be completed. ©[DN 135]

DOCUMENTATION: Engineering judgment and Internal Systems R2 CSCI Software Requirements Specification, Rev D. USOS SODF Procedure 5.111 Node2 Component Thermal Constraints (SODF:TCS:References)

FLIGHT RULES

10A_B18-7 NODE 2 ITCS LOOP MANAGEMENT WITH BELLOWS LEAK

IF AN NODE 2 ACCUMULATOR SUFFERS A BELLOWS LEAK, THE AFFECTED LOOP WILL REMAIN OPERATING AS LONG AS THE PPA IS NOT DECLARED LOST BY FLIGHT RULE B18-66 {IATCS PPA MANAGEMENT}.

A bellows leak can result in an accumulator's nitrogen charge leaking into the cabin or in the leaking of the nitrogen across the bellows into the ITCS coolant. In either case, leak detection capability for the affected loop is significantly degraded. A bellows leak into the ITCS coolant causes the accumulator quantity to go to the 75 percent neutral point and remain there even if an ITCS or IFHX leak occurs. Reference Flight Rule 10A_B18-11 {Loss of Node 2 Accumulator Quantity Insight} for impacts to the loss of ITCS and IFHX leak detection ability.

DOCUMENTATION: Engineering judgment.

10A_B18-8 NODE 2 ITCS LOOP MANAGEMENT WITH PPA FILTER BLOCKAGE

IF A PPA FILTER BECOMES BLOCKED AND DELTA PRESSURE READINGS INDICATE THE CHECK VALVE IS RELIEVING AROUND THE FILTER, THE FILTER WILL BE SCHEDULED FOR REPLACEMENT.

If the filter clogs sufficiently to cause the check valve to relieve (7.8 ± 0.5 psid (53.8 ± 3.4 kPa) crack pressure, the contamination causing the clog is being passed to the rest of the loop. Therefore, the filter will need to be replaced.

DOCUMENTATION: Engineering judgment.

FLIGHT RULES

10A_B18-9

NODE 2 ITCS LOOP MANAGEMENT WITH GAS TRAP BLOCKAGE

IF THE GAS TRAP BECOMES BLOCKED AND DELTA PRESSURE READINGS INDICATE THE CHECK VALVE IS RELIEVING AROUND THE GAS TRAP, THE GAS TRAP WILL BE SCHEDULED FOR REPLACEMENT. ANY OPERATION THAT MIGHT INTRODUCE GAS INTO THE SYSTEM (SYSTEM MAINTENANCE, ETC.) WILL BE DELAYED UNTIL THE GAS TRAP IS REPLACED.

If the gas trap clogs sufficiently to cause the check valve to relieve (7.0 ± 0.5 psid (48.3 ± 3.4 kPa) crack pressure), entrained gas bubbles may reach the pump and the gas trap will need to be replaced. If there are scheduled actions prior to gas trap replacement that could introduce additional gas into the system (such as rack installations or loop maintenance), they will need to be delayed until an unclogged gas trap is put into the affected loop in order to avoid potential pump cavitation. If there are no scheduled actions that could introduce additional gas into the system, then operating on a pump with a clogged gas trap is considered acceptable if the delta pressure readings indicate the check valve is properly relieving around the gas trap

DOCUMENTATION: Engineering judgment.

FLIGHT RULES

10A_B18-10

NODE 2 ITCS NIA MANAGEMENT

- A. THE NODE 2 ITCS NIA STATE WILL BE INHIBITED AT ALL TIMES.
 @[DN 32]

The Nitrogen Interface Assembly (NIA) state determines if the NIA software will automatically perform a repress of an ITCS accumulator when the Pump Inlet Pressure reaches 124 kPa (18 psia). Due to the situation described in paragraph D of the rule, the NIV's will remain nominally unpowered. For that reason, automatic represses would be unsuccessful and would only result in nuisance alarms. The NIA state will therefore remain inhibited and repressing a loop will only be performed by operator command. The NIA state defaults to inhibited upon initialization of the primary internal MDM.

- B. PRIOR TO INITIATING A NODE 2 NIA REPRESS, THE PUMP SPEED FOR THE ACCUMULATOR BEING REPRESSED WILL BE VERIFIED TO BE LESS THAN OR EQUAL TO **TBD** RPM. @[DN 32]

*To prevent a NIA regulator failure combined with a second failure from causing an over-pressurization of the ITCS during a NIA repress, the ITCS pump which corresponds to the accumulator being repressed will be verified to be at or below **TBD** rpm prior to initiating the repress. If the NIA regulator functions properly, the pump inlet pressure will be 193 kPa (28 psia) or less. However, if the regulator fails, the pump inlet pressure may be as high as 345 kPa (50 psia). Having the ITCS pump running at **TBD** rpm or less equates to a pump delta pressure of **TBD** kPa (**TBD** psia) or less. Thus, the pressure at the outlet of the pump is protected for its **TBD** kPa (**TBD** psia) limit should a second failure (e.g., a pump dead-head) occur while the pump inlet pressure is at **TBD** kPa (**TBD** psia).*

- C. FOLLOWING A NIA REPRESS, IF THE PUMP INLET PRESSURE IS GREATER THAN 193 KPA, THE PUMP INLET PRESSURE WILL BE REDUCED TO LESS THAN 193 KPA BY USING THE ACCUMULATOR VENT VALVE.

The NIA regulator is designed to control between 159 kPa (23 psia) and 193 kPa (28 psia). If the pump inlet pressure following a repress is above 193 kPa, then the NIA Accumulator Vent Valve (AVV) will be manually cycled to lower the pump inlet pressure to less than 193 kPa. The purpose is to keep the pump inlet pressure below the highest expected value that could lead to ITCS over-pressurization.

*The maximum design pressure of the ITCS (for the pump outlet) is 793 kPa (115 psia). The point at highest pressure in the ITCS loop is at the outlet of the pump. The maximum delta pressure across the Node 2 pump is while operating is **TBD** kPa (**TBD** psid). Therefore, by verifying that the ITCS repress leaves the pump inlet pressure at 193 kPa (28 psia) or below, the pressure at the outlet of the pump will be kept to **TBD** kPa (**TBD** psia) or below.*

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B18-10 NODE 2 ITCS NIA MANAGEMENT (CONTINUED)

D. EXCEPT FOR WHEN PERFORMING A REPRESS OR STARTING THE PPA SOFTWARE, THE RPC FOR THE NODE 2 LTL AND MTL NIA NITROGEN INTRODUCTION VALVE (NIV) WILL BE OPEN AT ALL TIMES. @[DN 140]

As found in testing at KSC, the Node 2 NIA valves can inadvertently change position when commands are being sent to the Node2 PPA or NIA. To prevent a NIV from inadvertently opening during execute of Node2 Leak Recovery ITCS (LRITCS) software, the RPC's for the Node LTL and MTL NIV will be left open. The RPC can be reclosed when performing a PPA accumulator repress. Powering the NIV during PPA Software Startup (which also occurs during loop activation) allows the NIV position to be updated correctly. @[DN 140]

Documentation: KSC IPR-913

FLIGHT RULES

10A_B18-11

LOSS OF NODE 2 ACCUMULATOR QUANTITY INSIGHT

IF INSIGHT IS LOST INTO THE NODE 2 LTL OR MTL ACCUMULATOR, THE AFFECTED LOOP WILL BE LEFT OPERATING AND ITS IFHX WILL BE LEFT IN FLOWTHROUGH. IN ADDITION, THE NODE 2 MODULE WILL NOT BE EVACUATED/ISOLATED.

Loss of insight into a Node 2 accumulator quantity occurs when either the quantity sensor fails or with failure of the N2-1 or N2-2 MDM. The N2-1 MDM is tied to the MTL accumulator quantity and the N2-2 MDM is tied to LTL accumulator quantity. ©[DN 33]

Loss of insight into the Node2 LTL or MTL accumulator quantity means the loss of ability to detect Node2 IFHX leaks. However, the hazard control for keeping the crew safe from IFHX leaks is not the IFHX leak detection software, but is actually the design for minimum risk of the IFHX hardware. Another option for responding to a loss of detection of IFHX leaks would be to bypass the affected IFHX and shut down its Node2 ITCS loop, which would require unpowering the 1/4 channel of Node2, JEM and COL for the MTL IFHX or unpowering the 2/3 channel of Node2, JEM and COL for the LTL IFHX. Another option would be to leave the IFHX in flowthrough and to isolate the crew from the modules in which insight was lost, i.e. close the Node 2 Aft Hatch. The risk of not having IFHX leak detection and relying on the design for minimum risk of the IFHX hardware is considered preferable to either of the other two options above. However, if the Node 2, JEM and COL modules are planned to be unoccupied for a period of time, the Node2 Aft Hatch may be closed and IMV between Node 2 and the U.S. LAB may be terminated. ©[DN 152]

Additionally, the onboard software ability to detect Node 2 ITCS leaks will also be lost. The only option for preventing the possibility of an ITCS leak would be to shutdown and depress the ITCS loop without quantity insight, which would required unpowering the 1/4 channel of Node2, JEM and COL for the MTL or unpowering the 2/3 channel of Node2, JEM and COL for the LTL. This risk of not having ITCS leak response software is considered acceptable when weighed against the impacts of this option. Also, ITCS leaks may be deduced from low inlet pressure if that insight is not also lost. ©[DN 33]

This rule assumes that no other off-nominal ITCS or ETCS performance which could effect the likelihood for IFHX or ITCS leaks has occurred.

Documentation: Engineering judgment and ISS Hazard Report ISS-TC S-1255-AC – “Structural failure of the Heat Exchanger (HX) core ammonia/water barrier leads to ammonia contamination of the ISS habitable environment.” ©[DN 152]

FLIGHT RULES

10A_B18-12

NODE 2 CCAA H₂O VALVE CONSTRAINTS

- A. AT LEAST ONE OF THE NODE 2 CCAA H₂O VALVES WILL BE OPEN AT ALL TIMES.

There are two Node 2 CCAA H₂O valves, the normal valve and the bypass valve. If both the normal valve and the bypass valve are closed at the same time, the flow to the Node 2 LTL racks will be deadheaded.

- B. RPC'S FOR THE NODE 2 CCAA H₂O VALVES WILL BE CLOSED FOR NO MORE THAN 60 SECONDS AT A TIME.

No valve positioning commands exist for the Node 2 CCAA H₂O valves. The valves are moved by closing and then opening RPC's associated with the desired position. For example, to move the normal valve from open to close, the RPC for the closed position would be closed, which activates the valve motor to move the valve from open to closed. If the RPC is left closed for more than 60 seconds, then the valve motor could be damaged.

If MCC-H is changing the position of the Node 2 CCAA H₂O valves, then time-tag commands will nominally be used to ensure the RPC is not closed for more than 60 seconds.

*Documentation: **TBD***

FLIGHT RULES

10A_B18-13

NODE 2 ITCS PPA MANAGEMENT

A NODE2 ITCS PPA WILL BE SHUT DOWN UNDER THE FOLLOWING CONDITIONS: ©[DN 80]

A. PPA ACCUMULATOR QUANTITY \leq 20 PERCENT.

When the accumulator is \leq 20 percent, voids may be created in the water loop which can cause pump cavitation. Maintaining at least 2 inches of coolant in the accumulator eliminates the concern of cavitation due to air bubbles in the system. Two inches of coolant is equivalent to approximately 130 cubic inches (19 percent).

B. PPA OUTLET FLOW CANNOT BE MAINTAINED ABOVE 226.8 KG/HR (500 LBM/HR) .

The pump normally operates with a flow of 1361 kg/hr (3000 lbm/hr). The minimum operational flow rate recommended by the manufacturer is 226.8 kg/hr (500 lbm/hr). If the loop flow rate degrades, then the Node 2 loop must be shutdown and equipment cooled by that loop will need to be shutdown to prevent overheating.

C. PPA INLET P + DELTA P > 689.4 KPA (100 PSIA) UNLESS THE HIGH PRESSURE IS CAUSED BY AN IFHX NH₃ LEAK.

689.4 kPa (100 psia) is the maximum operating pressure of the Node2 ITCS. This pressure will only be exceeded if the Nitrogen Interface Assembly is operating incorrectly and the accumulator is unable to relieve or there has been an ammonia leak across the Interface Heat Exchanger (IFHX). Exceeding 100 psi (689.4 kPa) may cause leakage through the gas trap, so the pump should be shut down. A pump will be allowed to continue to operate if the high pressure affects is caused by a confirmed IFHX NH₃ leak.

DOCUMENTATION: Engineering judgment. ©[DN 80]

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

THERE ARE NO JOINT SHUTTLE/ISS RULES FOR THIS SECTION

FLIGHT RULES

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FLIGHT RULES

SECTION 19 - PAYLOADS

SHUTTLE ONLY RULES

THERE ARE NO FLIGHT-SPECIFIC STS-120/10A RULES FOR THIS SECTION.....19-1

ISS ONLY RULES

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FLIGHT RULES

SECTION 19 - PAYLOADS

SHUTTLE ONLY RULES

THERE ARE NO FLIGHT-SPECIFIC STS-120/10A RULES FOR THIS SECTION

FLIGHT RULES

ISS ONLY RULES

10A_B19-1 ACOUSTIC LIMITATIONS ON PAYLOADS

- A. 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: @[DN 59]

SCENARIO	POWERED TIME CONSTRAINT
HRF RACK1, PC	UNLIMITED
HRF RACK1, PC, SLAMMD	8 HOURS PER DAY
HRF RACK1, PC, WORKSTATION 2	8 HOURS PER DAY
HRF RACK1, PC, WORKSTATION 2, SLAMMD	8 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND	4.5 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND, COOLING STOWAGE DRAWER	4 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND, WORKSTATION 2	4 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND, WORKSTATION 2, SLAMMD	4 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND, WORKSTATION 2, COOLING STOWAGE DRAWERS 1 & 2	3 HOURS PER DAY
HRF RACK1, PC, ULTRASOUND, WORKSTATION 2, COOLING STOWAGE DRAWERS 1 & 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

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_B19-1 ACOUSTIC LIMITATIONS ON PAYLOADS (CONTINUED)

- B. MSG-SAME ACOUSTIC LIMITS: SAME EXPERIMENT HARDWARE IS LIMITED TO OPERATING A TOTAL OF 7 HOURS PER DAY. @[DN 59]
- C. ELITE-S2 ACOUSTIC LIMITS: THE FOLLOWING TABLE LISTS THE OPERATIONAL SCENARIOS AND TIME LIMITATIONS FOR ELITE-S2 THAT ARE NECESSARY TO MEET ACOUSTIC LIMITS:

SCENARIO	POWERED TIME CONSTRAINT
ONLY IMU (NO CAMERAS)	2.2 HOURS PER DAY
IMU AND CAMERAS	1.8 HOURS PER DAY

@[DN 59]

Acoustic limits are exceeded.

*DOCUMENTATION: Stage 10A Payload Guidelines and Constraints Report, dated **TBD***

FLIGHT RULES

10A_B19-2

ISS PAYLOAD POWER INTERRUPTION CONSTRAINTS

POWER TO U.S. LAB EXPRESS RACK 4 SHALL NOT BE INTERRUPTED FOR MORE THAN 30 MINUTES TO PREVENT IRRECOVERABLE LOSS OF SCIENCE WHEN CGBA SAMPLES ARE PRESENT. @[DN 60]

PAYLOAD	LOSS OF POWER IMPACT
CGBA	CGBA WILL LOSE SAMPLE VIABILITY WITHIN 30 MINUTES DUE TO LOSS OF TEMPERATURE CONTROL. NOTE: THE CGBA UNITS ARE LOCATED IN ER4, AND LOSS OF POWER RULE APPLIES ONLY WHEN CGBA SAMPLES ARE PRESENT.

The biological samples stored in CGBA are temperature sensitive. Temperature excursions will be detrimental to science. Payload hardware requires limited unpowered time to maintain temperature.

Upon loss of power, CGBA is expected to maintain an acceptable environment for up to 30 minutes and return to stable temperature control following power restoration. Outside that temperature range, the samples will begin to deteriorate, thereby diminishing the science return. The degree of deterioration cannot be determined until the PI performs post-flight examination. If the 30-minute unpowered limit is exceeded, the required response is to restore power as soon as possible and reestablish temperature control in the nominal range.

DOCUMENTATION: *Increment 15 Payload Execute Planning Groundrules and Constraints, dated TBD. @[DN 60]*

FLIGHT RULES

10A B19-3 MELFI POWER DOWN REQUIREMENTS

- A. THE MELFI BRAYTON MACHINE IS REQUIRED TO BE POWERED DOWN FOR THE FOLLOWING ACTIVITIES: @[CR 8815]
1. PLANNED ITCS TRANSITIONS
 2. PLANNED INT MDM TRANSITIONS
- B. THE ENTIRE MELFI RACK IS REQUIRED TO BE POWERED DOWN FOR SOYUZ RELOCATIONS.
- C. MELFI MAY SAFELY CONTINUE TO OPERATE DURING NOMINAL ACCELERATIVE ACTIVITIES (I.E., DOCKING/UNDOCKING, REBOOST, ATTITUDE MANEUVERS). IN THE EVENT OF ADDITIONAL ACCELERATIVE ACTIVITIES, THE MELFI TEAM SHALL PROVIDE FINAL DETERMINATION WHETHER THE BRAYTON MACHINE SHOULD BE ALLOWED TO CONTINUE OPERATIONS.

ITCS and INT MDM transitions cause a momentary (approximately 60 seconds) interruption in the LTL water flow. The MELFI Brayton cannot be operated without water flow and must be powered down during this activity.

The MELFI rack is sensitive to high LTL inlet temperatures. During Soyuz relocations, the LTL temperatures can reach as high as 17 degrees. This temperature is higher than the MELFI design specifications; therefore, the rack must be entirely deactivated.

ESA has provided relief for certain ISS disturbances. Disturbances that are not covered will have to be reviewed on a case by case basis.

DOCUMENTATION: MEL-ESA-LDP-2007.05.10 (Removal of MELFI Payload Regulations concerning ISS Maneuvers). @[CR 8815]

FLIGHT RULES

10A 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 FOR THE FOLLOWING SITUATIONS: @[CR 8815]

- A. RACK COOLDOWN FROM AMBIENT TEMPERATURES
- B. RECOVERY FROM SOYUZ RELOCATIONS
- C. RECOVERY FROM OFF-NOMINAL POWERDOWNS THAT EXCEED 8 HOURS

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 sufficient cool down time 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. In addition, it is important to allow MELFI sufficient cool down time to recover from extended power downs, like Soyuz Relocations, to restabilize and provide the science inside the rack with the coldest temperatures possible. 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 8815]

10A B19-5 MELFI PAYLOAD POWER INTERRUPTION CONSTRAINT

THE BRAYTON MACHINE IN THE MELFI RACK SHALL NOT BE POWERED OFF FOR MORE THAN 8 HOURS, WITH THE EXCEPTION OF SOYUZ RELOCATIONS, TO PREVENT IRRECOVERABLE LOSS OF SCIENCE. @[CR 8815]

The samples contained in the MELFI Rack require a stable thermal environment. The rack was designed to maintain a temperature of less than -68 deg C during an 8-hour poweroff period. Outside that temperature range, the samples will begin to deteriorate, thereby diminishing the science return. The science samples contained inside MELFI must be able to withstand a minimum 8-hour power off constraint. The actual poweroff constraint will be determined real time.

During Soyuz relocations, the LTL temperatures are raised higher than the rack operational limits for extended durations. Planning considerations are made to keep the power down times to a minimum, but they will exceed the required maximum of 8 hours.

DOCUMENTATION: MELFI Flight Model Users Manual, Document # MELFI-MA-03000-0435-MMT, Issue 4, Rev 1, dated December 19, 2006. @[CR 8815]

FLIGHT RULES

JOINT SHUTTLE/ISS RULES

10A_C19-1 EXPRESS RACK 4 DOCKED PAYLOAD POWER CONSTRAINTS

THE MAXIMUM POWER REQUIRED FOR EXPRESS RACK 4:

- A. PRIOR TO PAYLOAD TRANSFERS: 681 WATTS @[DN 61]
- B. AFTER PAYLOAD TRANSFERS TO ISS: 681 WATTS
- C. AFTER PAYLOAD TRANSFER TO SHUTTLE: 681 WATTS

	PRIOR TO PL TRANSFERS		AFTER PL TRANSFERS TO ISS		AFTER PL TRANSFERS TO SHUTTLE	
PAYLOAD						
	ALTEA-DOSI	86 W	ALTEA-DOSI	86 W	ALTEA-DOSI	86 W
	KU-REC	77 W	KU-REC	77 W	KU-REC	77 W
	CGBA	143 W	CGBA	143 W	CGBA	143 W
EXPRESS RACK	RACK	375 W	RACK	375 W	RACK	375 W
TOTAL	TOTAL	681 W	TOTAL	681 W	TOTAL	681 W

NOTE: ALL VALUES ARE PEAK POWER DEMAND.

[1] EXPRESS RACK POWER USING 760 LAPTOP, POWER WITH A31P LAPTOP IS 395W. @[DN 61]

FLIGHT RULES

10A_C19-2

MELFI DOCKED POWER CONSTRAINTS

- A. THE BRAYTON MACHINE IN THE MINUS EIGHTY LABORATORY FREEZER FOR ISS (MELFI) RACK SHALL NOT BE POWERED OFF FOR MORE THAN 8 HOURS TO PREVENT IRRECOVERABLE LOSS OF SCIENCE. @[ED]

The crystals, plants, or solution in these experiments are temperature sensitive. Temperature excursions will be detrimental to science. Payload hardware requires limited unpowered time to maintain temperature.

MELFI: The samples contained in the MELFI require a stable thermal environment. The rack was designed to maintain a temperature of less than -68 deg C during an 8-hour poweroff period. Outside that temperature range, the samples will begin to deteriorate, thereby diminishing the science return. The science samples contained inside MELFI may have requirements such that the poweroff constraint is longer than 8 hours; however, there will never be less than 8 hours. The actual poweroff constraint will be determined real time.

DOCUMENTATION: Increment 14 Payload Execute Planning Groundrules and Constraints, dated June 28, 2006.

- B. THE MAXIMUM POWER REQUIRED FOR MELFI IS 1050W.

POWER DRAW FOR MELFI IS DEPENDANT ON LTL TEMPERATURE AND FLOW RATE IDENTIFIED IN 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 and power requirement.

DOCUMENTATION: MELFI FLIGHT MODEL USER MANUAL, Issue 4, September 1, 2004.

FLIGHT RULES

10A_C19-3

PAYLOAD TIMELINE CONSTRAINTS

- A. PERCEPTUAL MOTOR DEFICITS IN SPACE (PMDIS) DATA SESSIONS MUST OCCUR WITHIN 96 HOURS AFTER LAUNCH, OR LATER AT THE DISCRETION OF PAYLOAD CUSTOMER. @[DN 62]
- B. THE PMDIS SUBJECT MAY NOT PERFORM EXERCISE WITHIN 20 MINUTES PRIOR TO THE PMDIS DATA SESSION.

Since the PMDIS hardware is located on ISS and the participants are orbiter crewmembers, the activity must be scheduled after docking but before the end of Flight Day 5. After 96 hours, the subject's brain begins to adapt to the environment of microgravity. This experiment will help determine if the perceptual-motor deficit is due to factors related to space sickness, sleep deprivation, or brain adaptation of the central nervous system. Exercise within 20 minutes of the data session will affect the central nervous system and, thus, impacts the data.

- C. THE FOLLOWING PAYLOAD ACTIVITIES SHALL BE SCHEDULED AS CLOSE TO HATCH CLOSURE AS POSSIBLE, IN THE PRIORITY LISTED BELOW (HIGHEST-PRIORITY PAYLOAD SHOULD BE CLOSEST TO HATCH CLOSURE) :
 - 1. DOUBLE COLDBAG PACKING WITH NUTRITION AND ISS COLD ENCLOSURE PCM AUGMENTING CAPSULES (ICEPAC'S) FROM MELFI. MULTIPLE COLDBAG SAMPLE PACKING TASKS SHALL BE SCHEDULED SERIALLY, NOT IN PARALLEL.
 - 2. INTEGRATED IMMUNE BLOOD DRAW (LONG DURATION SUBJECT)
 - 3. CGBA SCIENCE INSERT (CSI) HABITAT REMOVAL AND TRANSFER TO ORBITER

The double coldbag returns with the shuttle. The samples in MELFI and ICEPAC belts (also in MELFI) are placed in a double coldbag for return. Nutrition blood and urine sample preservation is dependent on maintaining their temperature below ambient. The ICEPAC's are a phase change material (PCM) that is designed to keep the samples as cold as is possible. Nutrition blood and urine sample preservation is dependent on maintaining a specific sample temperature (below ambient) from packing through landing until unpacking at the landing site, so double coldbag packing must occur no earlier than 129 hours prior to the latest protected landing. Packing multiple coldbags in parallel shall be avoided due to access constraints on MELFI dewars and because packing them in parallel could result in longer ambient times for the samples. @[DN 62]

THIS RULE CONTINUED ON NEXT PAGE

FLIGHT RULES

10A_C19-3

PAYLOAD TIMELINE CONSTRAINTS (CONTINUED)

The integrated immune blood samples are returned at ambient conditions and, therefore, have a very limited shelf life. The blood draw for the long duration subject(s) should, therefore, occur as close to hatch closure as possible to preserve sample integrity. ®[DN 62]

The CSI Habitat (CHAB) unit is removed from the CGBA unit on ISS. It contains living specimens (c. Elegans) which need to be placed in a controlled thermal environment (22 deg C) to control growth rate. If they become too warm, the growth rate increases exponentially causing the food to be consumed too early. This degrades the quality of the science. The CHAB should be removed from the CGBA unit no more than 5 days from nominal landing.

D. THE FOLLOWING PAYLOAD ACTIVITIES SHALL BE SCHEDULED AS CLOSE TO LANDING AS POSSIBLE, IN THE PRIORITY LISTED BELOW (HIGHEST-PRIORITY PAYLOAD SHOULD BE CLOSEST TO LANDING) :

INTEGRATED IMMUNE BLOOD DRAW (SHORT DURATION SUBJECT) (SDBI 1900)

The integrated immune blood samples are returned at ambient conditions and therefore have a very limited shelf life. The blood draw for the long duration subject(s) should therefore occur as close to hatch closure as possible to preserve sample integrity. ®[DN 62]

FLIGHT RULES

ACRONYMS AND ABBREVIATIONS

A/G	AIR-TO-GROUND
A/L	AUTOLAND; AIRLOCK
A/R	ASCENDING RIGHT
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
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 DAP	ALTERNATE DIGITAL AUTO PILOT
ALT	ALTERNATE, ALTITUDE
AMCS	ATTITUDE MEASUREMENT AND CONTROL SYSTEM
AMP(S)	AMPERE(S)
AOA	ABORT ONCE AROUND; <u>AGE OF AIDING</u>
AOI	AREA OF INTEREST
AOPROC	ATOMIC OXYGEN PROCESSING EXPERIMENT
AOS	ACQUISITION OF SIGNAL
APAS	ANDROGYNOUS PERIPHERAL ATTACHMENT SYSTEM
APC	ADVANCE PROCESS CONTROLLER
APCU	ASSEMBLY POWER CONVERTER UNIT
APE-B	AURORAL PHOTOGRAPHY EXPERIMENT-B
APFR	ARTICULATING PORTABLE FOOT RESTRAINT
APM	ATTITUDE PROCESSOR MODULE
APU	AUXILIARY POWER UNIT

FLIGHT RULES

ARCS	AFT RCS
ARCU	AMERICAN TO RUSSIAN CONVERTER UNIT
ARD	ABORT REGION DETERMINATION
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
BCDU	BATTERY CHARGE/DISCHARGE UNIT
BD	BAND
BFS	BACKUP FLIGHT SYSTEM
BGA	BETA GIMBAL ASSEMBLY
BGTS	BETA GIMBAL TRANSITION STRUCTURE
BIA	BUS INTERFACE ADAPTER
BMRRM	BEARING, MOTOR, ROLL RING MODULE
BRIC	BIOLOGICAL RESEARCH IN CANISTERS
BRK	BREAK
BRKOUT	BREAKOUT
BTS	BOLT TIGHT SWITCH
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

FLIGHT RULES

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
CBCS	CENTERLINE BERTHING CAMERA SYSTEM
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
CHAB	CSI HABITAT
CHAWS	CHARGE ANALYSIS AND WAKE STUDIES
CHT	SEE ARCU
<u>CIA</u>	<u>CONTROLLER INTERFACE ADAPTER</u>
CIC	CREW INTERFACE COORDINATOR
CID	COMPUTER INTERFACE DEVICE
CIL	CRITICAL ITEMS LIST
CIO	CUSTOMER INTEGRATION OFFICE
CIP	CUSTOMER INTERFACE PANEL
CIR	CARGO INTEGRATION REVIEW
CIRC	CIRCULARIZATION
	CIRCUIT INTERRUPT DEVICE
	CIRCUIT ISOLATION DEVICE
CITE	CARGO INTEGRATION TEST EQUIPMENT
CK	CHECK
CLA	CAMERA AND LIGHT ASSEMBLY
CLPA	CAMERA, LIGHT, AND PAN/TILT ASSEMBLY
CM	COMBUSTION MODULE
CMC	CAROUSEL MOTOR CONTROLLER
CMD	COMMAND

FLIGHT RULES

CMG	CONTROL MANAGEMENT GYROSCOPE
CMIX	COMMERCIAL MDA ITA EXPERIMENT
CMT	CARGO MANAGEMENT TEAM
CNTCS	CONTACTS
CNTL	CONTROL
CO	CARBON MONOXIDE
CO ₂	CARBON DIOXIDE
COAS	CREW OPTICAL ALIGNMENT SITE
COF	PATRICK AIR FORCE BASE (TACAN)
COMM	COMMUNICATIONS
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
CPU	CENTRAL PROCESSING UNIT
CR	CHANGE REQUEST
CR/IM	COMMERCIAL REFRIGERATOR/INCUBATOR MODULE
CRIM	COMMERCIAL REFRIGERATOR INCUBATOR MODULE
CRIT	CRITICALITY
CRT	CATHODE RAY TUBE
CRYO	CRYOGENICS
<u>CSCS</u>	<u>CONTINGENCY SHUTTLE CREW SUPPORT</u>
CSI	CGBA SCIENCE INSERT
CSM	CARGO SYSTEMS MANUAL
CSR	CUSTOMER SUPPORT ROOM
CW	CLOCKWISE
CWEA	CAUTION AND WARNING ELECTRONICS ASSEMBLY
D	DAY
D&C	DISPLAY AND COMMAND
D/C	DISPLAY AND CONTROL
D/L	DESCENDING LEFT
D/R	DESCENDING RIGHT
DAP	DATA ACQUISITION PLAN
DAPCS	DATA ACQUISITION AND PROCESS CONTROL SYSTEM
DB	DATA BASE
DC	DIRECT CURRENT
DCSU	DIRECT CURRENT SWITCHING UNIT
DCU	DIRECT COMMAND UNIT

FLIGHT RULES

DDCU	DC-DC CONVERTER UNIT
DDS	DIGITAL DATA SYSTEM
DEACT	DEACTIVATION
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
	DIGITAL AUTOPILOT
DIST	DISTRIBUTION
DJOPS	DEGRADED JOINT OPS PATCH
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
DS	DUAL STRING
DSC	DISCRETE
DSM	DIGITAL SELECT MATRIX
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
EATCS	EXTERNAL ACTIVE THERMAL CONTROL SYSTEM

FLIGHT RULES

EBIT	END TO END BERTHING INTEGRATION TEAM
ECG	ECHOCARDIOGRAPHY
ECLIPSE	EQUIPMENT FOR CONTROLLED LIQUID PHASE SINTERING EXPERIMENT
ECLSS	ENVIRONMENTAL CONTROL AND LIFE SUPPORT
<u>ECO</u>	<u>ENGINE CUTOFF</u>
ECS	ENVIRONMENTAL CONTROL SYSTEM
ECU	ELECTRONICS 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
EFE	ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM
EFGF	ELECTRICAL FLIGHT GRAPPLE FIXTURE
<u>EGBM</u>	<u>EQUILIBRIUM GLIDE BOUNDARY MARGIN</u>
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
EMU	EXTRAVEHICULAR MOBILITY UNIT
ENA	ENABLE
ENBL	ENABLE ENVIRONMENTAL CONTROL UNIT
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
ETRO	ESTIMATED TIME OF RETURN TO OPERATION
ETVCG	EXTERNAL TELEVISION CAMERA GROUPS
EUV	EXTREME ULTRAVIOLET
EVA	EXTRAVEHICULAR ACTIVITY
EVAL	EVALUATE

FLIGHT RULES

	EVALUATION
EVN	EVENTS
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
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
FD0	FLIGHT DYNAMICS OFFICER
FDA	FAULT DETECTION AND ANNUNCIATION
PDF	FLIGHT DATA FILE
FDIR	FAULT DETECTION, ISOLATION, AND RECOVERY
FE	FLIGHT EXPERIMENT
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
FHRC	FLEX HOSE ROTARY COUPLER
FIM	FLIGHT INTEGRATION MANAGER
FIV	FUEL ISOLATION VALVES
FLT	FLIGHT
FM	FREQUENCY MODULATION
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
FPR	FLIGHT PERFORMANCE RESERVE
FPS	FEET PER SECOND

FLIGHT RULES

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
<u>GMEM</u>	<u>GPS MEMORY WRITE</u>
GMT	GREENWICH MEAN TIME
GN ₂	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
GSE	GROUND SUPPORT EQUIPMENT
GSFC	GODDARD SPACE FLIGHT CENTER
GVL	GENERAL VIBRATION LAB
GYRO	GYROSCOPE
H ₂ O	WATER
HA	HEIGHT ADJUST
HAC	HEADING ALIGNMENT CONE
HBR	HYDROGEN BROMIDE
HCN	HYDROGEN CYANIDE
HE	HELIUM

FLIGHT RULES

HEDS	HUMAN EXPLORATION AND DEVELOPMENT OF SPACE
HF	HYDROGEN FLUORIDE
HFA	HUMAN FACTORS ASSESSMENT
HGA	HIGH GAIN ANTENNA
HH	HITCHHIKER
HH-JR	HITCHHIKER JR
HKU	HOUSEKEEPING UNIT
HOSC	HUNTSVILLE OPERATIONS SUPPORT CENTER
HP	HEIGHT OF PERIGEE
HPDU	HEATER POWER DISTRIBUTION UNIT
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
HUD	HEADS UP DISPLAY
HX	HEAT EXCHANGER
HYD	HYDRAULICS
HZ	HERTZ
I	INHIBIT
I/F	INTERFACE
I/O	INPUT/OUTPUT
ICD	INTERFACE CONTROL DOCUMENT
ICEPAC	ISS COLD ENCLOSURE PCM AUGMENTING CAPSULE
ICH	INTERCHANGER
ICU	INTERIM CONTROL UNIT
IDC	ISIS DIGITAL CAMERA
IDRD	INCREMENT DEFINITION AND REQUIREMENTS DOCUMENT
IEA	INTEGRATED EQUIPMENT ASSEMBLY
IEH	INTEGRATED ELECTROLYSIS UNITS
IEH-1	INTERNATIONAL EXTREME ULTRAVIOLET HITCHHIKER
IFM	IN-FLIGHT MAINTENANCE
IMAPS	INTERSTELLAR MEDIUM ABSORPTION PROFILE SPECTROGRAPH
IMC	ISS MANAGEMENT CENTER
IMCA	INTEGRATED MOTOR CONTROLLER ACTUATOR
IMU	INERTIAL MEASUREMENT UNIT
IN	INCHES
INCO	INTEGRATED COMMUNICATIONS OFFICER
INFLT	IN-FLIGHT

FLIGHT RULES

INIT	INITIAL
INST	INSTRUMENTATION
INSTR	INSTRUMENTATION
IP	INTEGRATING PLAN
IPDS	INDEPENDENT PAYLOAD DATA STREAM
IREDD	INTERIM RESISTIVE EXERCISE DEVICE
IRMA	INTEGRATED RISK MANAGEMENT APPLICATION
ISO	ISOLATION
ISOL	ISOLATION
ISS	INTERNATIONAL SPACE STATION
ITCS	INTERNAL THERMAL CONTROL SYSTEM
ITEPC	INTER MARS TEPC
ITS	INTEGRATED TRUSS SEGMENT
ITVC	INTENSIFIED TELEVISION CAMERA
IVA	INTRAVEHICULAR ACTIVITY
IVT	INTERFACE VERIFICATION TEST

JET	JETTISON
JIS	JOINT INTEGRATED SIMULATION
JOIP	JOINT OPERATIONS INTERFACE PROCEDURES
JSC	LYNDON B. JOHNSON SPACE CENTER
JURe	JOINT UNDERSPEED RECOVERY

KBPS	KILOBITS PER SECOND
KCA	KU-BAND COMMUNICATIONS ADAPTER
KEAS	
KGS	KILOGRAMS
KM	KILOMETERS
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	KILOWATT(S)

L&L	LAUNCH AND LANDING
LAB	LABORATORY
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
LCS	LASER CAMERA SYSTEM

STS-120/10A	09/25/07	FINAL	ACRONYMS	A-10
ISS EXPEDITIONS 15 & 16				

Verify that this is the correct version before use.

FLIGHT RULES

LDRI	LASER DYNAMIC RANGE IMAGER
LED	LIGHT EMITTING DIODE
LHCP	LEFT HAND CIRCULARLY POLARIZED
LIGHTSORB	LIGHT ADSORPTION
LIOH	LITHIUM HYDROXIDE
LO	LOW
LOAC	LOSS OF ATTITUDE CONTROL
<u>LON</u>	<u>LAUNCH ON NEED</u>
LOS	LOSS OF SIGNAL
LRR	LAUNCH READINESS REVIEW
LSSM	LAUNCH SITE SUPPORT MANAGER
LSSP	LAUNCH SITE SUPPORT PLAN
LTA	LAUNCH TO ACTIVATION
LTL	LOW TEMP LOOP
LTS	LIGHTS
LTU	LOAD TRANSFER UNITS
LVLH	LOCAL VERTICAL/LOCAL HORIZONTAL
MA	MILLIAMPS
MADS	MODULAR AUXILIARY DATA SYSTEM
MAGR	MINIATURE AIRBORNE GPS RECEIVER
MAL	MALFUNCTION
MAN	MANUAL
MAPS	MASTER ANALYSIS PLAN AND SCHEDULE
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
MD	MIDDECK
MDA	MATERIAL DISPERSION APPARATUS
MDF	MINIMUM DURATION FLIGHT
MDK	MIDDECK
MDM	MODULATOR/DEMULATOR

FLIGHT RULES

	MULTIPLEXER/DEMULTIPLEXER
MDSSC	MCDONNELL DOUGLAS SPACE SYSTEMS CORPORATION
MECH	MECHANICAL
MECO	MAIN ENGINE CUTOFF
MEL	MINIMUM EQUIPMENT LIST
MELFI	MINUS EIGHTY LABORATORY FREEZER FOR ISS
MEPSI	MICRO-ELECTROMECHANICAL SYSTEM-BASED PICO SATELLITE INSPECTOR
MER	MISSION EVALUATION ROOM
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
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
MPM	MANIPULATOR POSITIONING MECHANISM
MPS	MAIN PROPULSION SYSTEM
MPSR	MULTIPAYLOAD SUPPORT ROOM
MRL	MANIPULATOR RETENTION LATCH
MS	MISSION SPECIALIST
MSB	MOST SIGNIFICANT BIT
MSFC	MARSHALL SPACE FLIGHT CENTER
MSG	MESSAGE
MSX	MID-COURSE SPACE EXPERIMENT
MT	MOBILE TRANSPORTER
MTM	MOC TELEMETRY MESSAGES
MTR	MOTOR
MTSAS	MODULE TRUSS ATTACHMENT SYSTEM

FLIGHT RULES

MTU	MASTER TIMING UNIT
N/A	NOT APPLICABLE
N ₂	NITROGEN
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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 ₃	AMMONIA
NIH	NATIONAL INSTITUTE of HEALTH
NIH-R	NATIONAL INSTITUTE OF HEALTH - RODENTS
NIV	NITROGEN INTRODUCTION VALVE
NLT	NOT LATER THAN
NM	NAUTICAL MILES
NMI	NAUTICAL MILES
NMS	NEUTRAL MASS SPECTROMETER
NOM	NOMINAL
NORM	NORMAL
NPC	PLANE CHANGE MANEUVER
<u>NRTT</u>	<u>NEARLY REPEATED TIME TAG</u>
NSTS	NATIONAL SPACE TRANSPORTATION SYSTEM
NTA	NITROGEN TANK ASSEMBLY
NVR	NONVOLATILE RESIDUE
O&C	OPERATIONS AND CHECKOUT
O ₂	OXYGEN
OCA	OPERATIONAL COMMUNICATIONS ADAPTER
OCAS	OPERATOR-COMMANDED AUTO SEQUENCES
OCF	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
OGS	OXYGEN GENERATION SYSTEM
OIU	ORBITER INTERFACE UNIT
OME	ORBITAL MANEUVERING ENGINE
OMS	ORBITAL MANEUVERING SYSTEM

FLIGHT RULES

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
ORFEUS	ORBITING RETRIEVABLE FAR AND EXTREME ULTRAVIOLET SPECTROMETER
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/T	RATIO OF PRESSURE TO TEMPERATURE
P/TV	PHOTO/TELEVISION
PADM	PORTABLE AUDIO DATA MODEM
PAO	PUBLIC AFFAIRS OFFICER
PARE	PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT
PATH	POSTFLIGHT ALTITUDE TRAJECTORY HISTORY
<u>PBFL</u>	<u>PAYLOAD BAY FLOOD LIGHT</u>
PBD	PAYLOAD BAY DOOR
PBIT	PASSIVE BUILT IN TEST ERROR
PCD	POCC CAPABILITIES DOCUMENT
PCG-STES	PROTEIN CRYSTAL GROWTH - SINGLE LOCKER
PCM	PHASE CHANGE MATERIAL
PCM	PULSE CODE MODULATION
PCMMU	PULSE CODE MODULATION MASTER UNIT
PCR	PAYLOAD CHECKOUT ROOM
PCS	PORTABLE COMPUTER SYSTEM
PCU	POWER CONTROL UNIT
PDGF	POWER AND DATA GRAPPLE FIXTURE
PDI	PAYLOAD DATA INTERLEAVER
PDIP	PAYLOAD DATA INTERFACE PANEL
PDMIS	PERCEPTUAL MOTOR DEFICITS IN SPACE

FLIGHT RULES

PDRS	PAYLOAD DEPLOYMENT AND RETRIEVAL SYSTEM
PDU	POWER DISTRIBUTION UNIT
PF	PAYLOAD FORWARD
PFCS	PUMP FLOW CONTROL SUBASSEMBLY
PFDF	PAYLOAD FLIGHT DATA FILE
PFR	PAYLOAD FOOT RESTRAINT; PORTABLE FOOT RESTRAINT
PGHM	PAYLOAD GROUND HANDLING MECHANISM
PGME	PROPYLENE GLYCOL MONOMETHYL ETHER
PGSC	PAYLOAD GENERAL SUPPORT COMPUTER
PGT	PISTOL GRIP TOOL
PH	HYDROGEN ION CONCENTRATION
PHE	POCC HAZARDOUS ENHANCEMENT
PHRR	PAYLOAD HIGH RATE RECORDER
PI	PAYLOAD INTEGRATOR
PICOSAT	SMALL SATELLITE
PILOT	PORTABLE INFLIGHT LANDING OPERATIONS TRAINER
PIM	PLASMA INTERACTION MODEL
PIP	PAYLOAD INTEGRATION PLAN
PL OPS	PAYLOAD OPERATIONS
PL SYS	PAYLOAD SYSTEMS
PL	PAYLOAD
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
	PUMP MODULE
PMA	PRESSURIZED MATING ADAPTER
PMBT	PROPELLANT MEAN BULK TEMPERATURE
PMCR	PAYLOAD MANAGEMENT COUNTDOWN REVIEW
PMCU	POWER MANAGEMENT AND CONTROL UNIT
PMDIS	PERCEPTUAL MOTOR DEFICITS IN SPACE
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
POWG	PAYLOAD OPERATIONS WORKING GROUP
PPA	PUMP PACKAGE ASSEMBLY

FLIGHT RULES

PPCO	PARTIAL PRESSURE OF CARBON MONOXIDE
PPCO ₂	PARTIAL PRESSURE OF CARBON DIOXIDE
PPF	PAYLOAD PARAMETER FRAME, PAYLOAD PROCESSING FACILITY
PPM	PARTS PER MILLION
PPO ₂	PARTIAL PRESSURE OF OXYGEN
PPS	PAYLOAD PRELAUNCH SIMULATION
PPU	POWERFUL PROCESSING UNIT
<u>PRA</u>	<u>PROBABILISTIC RISK ANALYSIS</u>
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 OPS	PROXIMITY OPERATIONS
PROX	PROXIMITY
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 GAGE
PSP	PAYLOAD SIGNAL PROCESSOR
PSR	PAYLOAD SAFETY REVIEW
PSRP	PAYLOAD SAFETY REVIEW PANEL
PTB	PAYLOAD TIMING BUFFER
PTI	PROGRAMMED TEST INPUT
PTU	PAN TILT UNIT
PTU	PRECISION TIMING UNIT
PV	PHOTOVOLTAIC
PVCE	PHOTOVOLTAIC CONTROLLER ELEMENT
PVCU	PHOTOVOLTAIC CONTROLLER UNIT
PVM	PHOTOVOLTAIC MODULE
PVR	PHOTOVOLTAIC RADIATOR
PVRGF	PHOTOVOLTAIC RADIATOR GRAPPLE FIXTURE
PVTCS	PHOTOVOLTAIC THERMAL CONTROL SYSTEM
PWR	POWER, PAYLOAD WATER RESERVOIR

QA QUALITY ASSURANCE

FLIGHT RULES

QD	QUICK DISCONNECT
QDM	QUICK DON MASK
QTY	QUANTITY
R	RATE
RACU	RUSSIAN-TO-AMERICAN POWER CONVERTER UNIT
RAD	RADIATION ABSORBED DOSE
	RAM SIDE SENSOR
RAM	RANDOM ACCESS MEMORY
RAMBO	RAM BURN OBSERVATION
RAWG	ROBOTICS ANALYSIS WORKING GROUP
RBAR	RADIUS VECTOR
RBVM	RADIATOR BEAM VALVE MODULE
RCA	REACTION CONTROL ASSEMBLY
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
RFI	RADIO FREQUENCY INTERFERENCE
RHC	ROTATIONAL HAND CONTROLLER
RHEED	REFLECTION HIGH ENERGY ELECTRON DIFFRACTION
RIO	RUSSIAN INTERFACE OFFICER
RLY	RELAY
RMA	REMOTE MANIPULATOR ASSISTED
RME's	RISK MITIGATION EXPERIMENTS
RMS	REMOTE MANIPULATOR SYSTEM
RNDZ	RENDEZVOUS
RNG	RANGE
ROT	ROTATION, ROTATIONAL
RP	MCC-M SHIFT FLIGHT DIRECTOR
RPC	REMOTE POWER CONTROLLER
RPCM	REMOTE POWER CONTROL MODULE

FLIGHT RULES

RPCM	REMOTE POWER CONTROLLER MODULE
RPM	RBAR PITCHOVER MANEUVER
	<u>RENDEZVOUS PITCH MANEUVER</u>
	REVOLUTIONS PER MINUTE
RPOCC	REMOTE POCC
RPODR	RENDEZVOUS AND PROXIMITY OPERATIONS DESIGN REFERENCE
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
RSSI	RECEIVED STRENGTH SIGNAL INDICATOR
RT	RATE; REMOTE TERMINAL
RTAS	ROCKETDYNE TRUSS ATTACHMENT SYSTEM
RTD	RESISTIVE TEMPERATURE DETECTOR
RTL	READY TO LATCH
R-T-L	READY-TO-LATCH
RTL5	RETURN TO LAUNCH SITE
RTN	RETURN
RTS	REMOTE TRACKING STATION
RX	RECEIVER

S	STARBOARD
S/W	SOFTWARE
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
SAW	SOLAR ARRAY WINGS
SC	SPACECRAFT COMPUTER
SCA	SHUTTLE CARRIER AIRCRAFT
SCG	SOLUTION CRYSTAL GROWTH
SCIU	SIGNAL CONTROL INTERFACE UNIT
SCU	SERVICE AND COOLING UMBILICAL
SDA	STANDARD DOOR ASSEMBLY

FLIGHT RULES

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
SFCA	SYSTEM FLOW CONTROL ASSEMBLY
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
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
SP	SIGNAL PROCESSOR
SPAS	SHUTTLE PALLET SATELLITE
SPASP	SMALL PAYLOAD ACCOMODATIONS SWITCH PANEL
SPC	STORED PROGRAMMED COMMAND
SPDA	SECONDARY POWER DISTRIBUTION ASSEMBLY
SPEC	SPECTROMETER
SPEE	SPECIAL PURPOSE END EFFECTOR
SPIF	SHUTTLE POCC INTERFACE FACILITY
SPOC	SPAS PAYLOAD OPERATIONS CONTROL CENTER
SPRD	SINGLE PALLET ROTATION DEVICE
SR	SUPPORT REQUIREMENTS
SRB	SOLID ROCKET BOOSTER
SRMS	SHUTTLE REMOTE MANIPULATOR SYSTEM
SS	SINGLE-STRING
SSAS	SEGMENT TO SEGMENT ATTACHMENT SYSTEM
SSME	SPACE SHUTTLE MAIN ENGINE
SSP	SPACE SHUTTLE PROGRAM
<u>SSPTS</u>	<u>STATION TO SHUTTLE POWER TRANSFER SYSTEM</u>
SSRMS	SPACE STATION REMOTE MANIPULATOR SYSTEM
SSU	SEQUENTIAL SHUNT UNIT
SSV	SPACE SHUTTLE VEHICLE; SEQUENTIAL STILL VIDEO
STA	SHUTTLE TRAINING AIRCRAFT

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FLIGHT RULES

STA-KEEP	STATIONKEEP
<u>STAMPS</u>	<u>SPACECRAFT TRAJECTORY ANALYSIS AND MISSION PLANNING SYSTEM</u>
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
TAGS	TEXT AND GRAPHICS SUBSYSTEMS
TAL	TRANSATLANTIC/TRANSOCEANIC ABORT LANDING
TBD	TO BE CONSIDERED
TBD	TO BE DETERMINED
TBR	TO BE RESOLVED
TBS	TO BE SUPPLIED
TC	TEST CONNECTOR
	TOPOLOGICAL CAPTURE
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
TEG	TRIETHYLGALLIUM
TEL	TELEMETRY
TEMP	TEMPERATURE
TES-2	THERMAL ENERGY STORAGE-2
TFL	TELEMETRY FORMAT LOAD
TGHR	TIME-CRITICAL GROUND HANDLING EQUIPMENT

FLIGHT RULES

THC	TRANSLATIONAL HAND CONTROLLER
TI	PHASE INITIATION
	TIME OF IGNITION
	TRANSITION INITIATION
TIG	TIME OF IGNITION
TK	TANK
TLE	TIMELINE ENGINEER
TLM	TELEMETRY
TM	TELEMETRY
TMU	TEMPERATURE MEASUREMENT UNIT
TOP	TECHNICAL OPERATING PROCEDURES
TPG	TOTAL PRESSURE GAGE
TPL	TRANSFER PRIORITY LIST
TPS	THERMAL PROTECTION SYSTEM
TPS	THERMAL PROTECTION SYSTEM
TRAD	TOOLS FOR RENDEZVOUS AND DOCKING
TRAN(S)	TRANSLATION(S)
TRRJ	THERMAL RADIATOR ROTARY JOINT
TSA	TOOL STOWAGE ASSEMBLY
<u>TSEP</u>	<u>THERMAL/STRUCTURAL ENVELOPE PROGRAM</u>
TT&C	TELEMETRY, TRACKING, AND CONTROL
TT-0	TAKE-OFF POWER
<u>TTOL</u>	<u>THERMAL TRADE-OFF LINE</u>
TV	TELEVISION
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
USTO	U.S. THRUSTER(S) ONLY
UVSTAR	ULTRAVIOLET SPECTROGRAPH TELESCOPE FOR ASTRONOMICAL RESEARCH
V	VOLTS; VELOCITY
V/M	VOLTS PER METER
VAA	VIEWPORT ADAPTER ASSEMBLY
VAC	VACUUM
VATF	VIBRATION AND ACOUSTIC TEST FACILITY
VBAR	ALONG THE VELOCITY VECTOR
VCP	VIDEO CAMERA PORT
VDS	VIDEO DISTRIBUTION SYSTEM

FLIGHT RULES

VERN	VERNIER
VGO	VELOCITY GO
VGOX	VELOCITY GO IN X DIRECTION
VIP	VACUUM ION PUMPS
VIS	VISIBLE
VLV	VALVE
VP	VIEWPORT
VPF	VERTICAL PROCESSING FACILITY
VPU	VIDEO PROCESSING UNIT
VRCS	VERNIER REACTION CONTROL SYSTEM
VSSA	VIDEO SYSTEM SUPPORT ASSEMBLY
W/I	WITHIN
WBSAAMD	WIDEBAND STAND ALONE ACCELERATION MEASUREMENT DEVICE
WCCS	WIRELESS CREW COMMUNICATION SYSTEM
WCCU	WIRELESS COMM UNIT
WCS	WASTE COLLECTION SYSTEM
WDC'S	WATCH DOG CIRCUITS
WETA	WIRELESS VIDEO SYSTEM EXTERNAL TRANSCEIVER 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
WLP	WIDE LANGMUIR PROBE
WS	WORKSITE
WSB	WATER SPRAY BOILER
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

FLIGHT RULES

ZCG	ZEOLITE CRYSTAL GROWTH
ZLV	Z-AXIS LOCAL VERTICAL
ZOE	ZONE OF EXCLUSION
ZSI	Z-AXIS SOLAR INERTIAL

FLIGHT RULES

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FLIGHT RULES

APPENDIX B - CHANGE CONTROL

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FLIGHT RULES

APPENDIX B

CHANGE CONTROL

1.0 INTRODUCTION

Flight rules are critical to the safe and successful conduct of human spaceflight. In order to provide the necessary rigor in developing and maintaining the associated documents, a formal change control process has been established.

This change control process document (Appendix B) is common to all generic flight rules volumes and mission-specific annexes. Note, however, that the process differs for generic rules and mission-specific annex rules. Where appropriate, separate sections are used to cover each type of rules document.

1.1 PURPOSE

This appendix describes the change process for generic and mission-specific flight rules. The process is intended to promote consistency in coordination, submittal, evaluation, and approval of change requests (CR's) to flight rules and their associated rationale.

1.2 EFFECTIVITY

This change control appendix was updated on September 17, 2007.

Deleted: July 11

1.3 WORKFLOW TOOL

Workflow is a web-based database tool that is used to submit and route change requests (CR's) for all flight rules documents. The Workflow database also provides a permanent record of all change traffic. Workflow is accessed via the **Flight Rule CR System** link on the Flight Director Office's Flight Rules homepage, at <http://mod.jsc.nasa.gov/da8/Default.aspx>.

Help, Frequently Asked Questions, and a Complete User's Guide are available via the Workflow main menu.

NOTE: Workflow is simply a tool that is used to facilitate changes to flight rules. The responsibility for CR coordination lies with the individuals and organizations involved in the process, as described in the subsequent sections of this change control appendix.

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1.4 WORKFLOW ENROLLMENT

To use Workflow, users must be “enrolled” in the database by providing their full name, mail code, domain user ID, telephone number, and e-mail address to their Division database editors (JSC Domain), trusted domain database editors (external domains), or to the Book Manager listed on the Preface page of the flight rules documents.

Enrollment is also available for users outside the JSC Domain/trusted domains, if it is required for them to support the flight rules change process. These users should contact their MOD counterparts who will sponsor them in the AutoCAR system. A short description of the AutoCAR process is as follows:

The MOD sponsor will access the AutoCAR application and select AutoCAR Access Message. They will supply the user's First Name, Last Name, e-mail address, and in the comments field, they will place a justification for access by this user to the Workflow system. The user will receive an e-mail from the AutoCAR system that includes a URL, ID, and password. The user should login and supply all information requested. If their supervisor is not already part of the AutoCAR system, they will be asked to provide contact information. The AutoCAR system will issue an e-mail requesting that supervisor's information. Once the supervisor is enrolled as a Supervisor in AutoCAR, the user can then return to AutoCAR and complete the access request form. Once complete, the request will be routed to the proper personnel who approve access to Workflow, starting with the user's supervisor. NOTE: The AutoCAR system may be used to request access to many MOD systems, but to enroll in Workflow, MOE - WORKFLOW must be selected.

1.5 FLIGHT RULES DATABASE (FRDB) ACCESS

In addition to the electronic version of the flight rules available on the Flight Director Office website at <http://mod.jsc.nasa.gov/da8/Default.aspx>, rules may also be accessed using a new tool, the Flight Rules Database (FRDB). Efforts are underway to make FRDB more widely available to users outside JSC but, at this time, only JSC personnel and those in the Mission Control Center with JSC-MAS accounts can access this tool, which is designed to allow users to search, review, generate reports, and print as required. Access to this tool may be obtained via the Flight Director Office website at http://mod.jsc.nasa.gov/Da8/rules/frdb_install.html.

FLIGHT RULES

2.0 CHANGE REQUEST (CR) PROCESS

NOTE: Successful execution of the flight rules CR process is critically dependent on each participant clearly understanding the change control process itself, as well as their specific roles and responsibilities. The Workflow system simply provides a mechanism to facilitate submittal and routing of CR's. The responsibility for timely and complete CR coordination, evaluation, and approval lies entirely with the individuals involved, as described herein.

This section details the change processes for flight rules. Due to the differences in the way that generic and mission-specific flight rule CR's are handled, separate sections are included for each.

In general, the flight rules change process starts when the need is identified (by anyone in the technical community) to change or delete an existing flight rule or to add a new rule. **The CR initiator's role is key to successful execution of the process, since it is their responsibility to ensure that the change is coordinated with all affected organizations (both internal and external to MOD).** Once initial coordination is complete, the proposed CR is routed through coordinators within the initiator's organization before being submitted to the Flight Director Office for further processing, evaluation, and approval. It is primarily during evaluation and approval that the process differs between generic and mission-specific CR's. Each step in the process is described in greater detail, below.

Also described in this section are several special considerations that need to be taken into account for certain types of rules, an outline of the process for rule changes that are identified during real-time operations, definitions of flight rule deviations, waivers, and violations (and how each are handled), and specific roles and responsibilities of key participants in the flight rules change process.

FLIGHT RULES

2.1 CHANGES TO GENERIC FLIGHT RULES

Throughout this section, key participants are denoted by all capital letters. Roles and responsibilities for each of these participants are described in section 2.5 of this document.

2.1.1 CR Submittal - Generic Rules

- A. INITIATOR prepares new or updated flight rule document using Microsoft Word:
1. **NEW RULE:** For new flight rule submittals, the rule and its associated rationale must be phrased exactly as it is intended to appear in the flight rules document. Thus, it is recommended that the initiator cut and paste an existing flight rule as the basis for the new rule to ensure proper document formatting. While not mandatory, this will help ensure that the rule will appear properly after approval and also assists greatly in the editing process.
 2. **UPDATED RULE:** For changes to existing rules, the proposed changes must be made obvious. The initiator should cut and paste the existing flight rule into a new document, accept all revisions (to provide a clean basis for the proposed changes), activate change tracking, make the change, and resave the new version in a user directory. This will ensure that the updates are captured to facilitate evaluation and approval, as well as to clearly indicate the changes when the new version of the rule is published.
 3. **DELETED RULE:** When deleting an entire rule, a copy of the rule should be attached for reference, but strikethroughs are not required.
- B. INITIATOR prepares a Workflow CR form for the new or updated flight rule. On the form, note that the "document date" field is automatically filled in with the last publication date of the version of the rules volume to which the change is being made. The Microsoft Word document file (produced above) containing the new or modified rule is attached to the CR form. Obviously, no file attachment is needed for rule deletions. The INITIATOR coordinates the change with all disciplines affected by the CR and then submits the CR to their organization's DIVISION CR COORDINATOR.
- C. DIVISION CR COORDINATOR reviews and approves the CR, resulting in formal submittal to the Flight Director Office. The purpose of this step is to ensure full and proper coordination within and external to the initiator's organization before the CR is formally submitted to the Flight Director Office. Each organization must establish its own process for this step, which is expected to include peer review, internal management review, and appropriate coordination with other affected disciplines, where applicable. Note that any time a CR is "approved with modification" during this step, it is the responsibility of the DIVISION CR COORDINATOR to ensure that the INITIATOR is aware of the changes made after their original submittal. This step is performed electronically via Workflow. A disposition of approve (or approve with modification) by the DIVISION CR COORDINATOR results in the CR being automatically submitted to the Flight Director Office.
- D. **NOTE FOR NON-MOD ORGANIZATIONS:** While organizations outside of MOD are welcome to independently submit CR's directly to the Flight Director Office, they are encouraged to submit them through the appropriate MOD division to ensure proper review and coordination with the flight control discipline responsible for that rule section.

FLIGHT RULES

2.1.2 CR Evaluation - Generic Rules

- A. DA8 FLIGHT RULES CR COORDINATOR assigns the CR to the appropriate DA8 SECTION COORDINATOR. The FD Mission Assignments document can be accessed on the DA8/Flight Director homepage at <http://mod.jsc.nasa.gov/da8/Default.aspx>.
- B. DA8 SECTION COORDINATOR reviews the CR for technical merit, clarity, and completeness. Questions and additional changes are coordinated directly with the initiator, and if necessary, additional internal peer review and evaluation may be performed. Once the DA8 SECTION COORDINATOR is satisfied that the CR is ready for evaluation by the Flight Rules Control Board (FRCB) (which may involve revisions to the CR), mandatory evaluators are selected, IP impacts are identified, and concurrence on the CR is provided. This concurrence automatically reassigns the CR to the DA8 FLIGHT RULES CR COORDINATOR for further processing.
- C. DA8 FLIGHT RULES CR COORDINATOR assigns the CR for approval at a future FRCB and sends it (via Workflow) to all board members and any other evaluators that were selected by the DA8 SECTION COORDINATOR.

NOTE: CR's must arrive at this step no later than 3 weeks prior to the next FRCB to be included on the agenda for that meeting. CR's submitted after the deadline may be scheduled on the agenda at the discretion of the Board Chair.

- D. FRCB MEMBERS/OTHER EVALUATORS review the CR and provide their evaluation/disposition via the Workflow System. Where applicable, this review must include an assessment of impact to CIL retention rationale and related Orbiter or payload hazard reports (reference section 2.3). 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 FRCB agenda.

NOTE: It is the responsibility of each FRCB member to coordinate their response such that their disposition accurately and completely reflects the formal position of their organization.

FLIGHT RULES

2.1.3 CR Approval - Generic Rules

- A. GENERAL: All generic CR's are dispositioned by the FRCB as approved, approved with modification, disapproved, or deferred. The FRCB will consider each CR based on its impact on operations, its impact on documented hazard controls or CIL retention rationale, and its technical justification. Approved or Approved with Mod CR's will be incorporated into the next page change notice (PCN) or revision to the associated rules volume. Disapproved CR's will be returned to the initiator along with the reason for disapproval, and may be appealed to the Level II Program Office, if desired. If all mandatory concurrences have not been received, or if additional data or analysis is deemed necessary by the board, then a CR will be deferred. Deferred CR's will be rescheduled for a subsequent FRCB meeting.
- B. Each CR is deemed significant and will be presented and discussed at the FRCB:
 - 1. IP DESIGNATIONS: When rules are deemed to be significant to an IP, the addition of the IP designation to the rules will be discussed at the appropriate JOP. Once all rules have been identified for a Volume, a list will be sent to the Book Manager listing those rules. The Book Manager will ensure that the designations are added to the rule titles and marked as editorial changes. These rules will be added to the next PCN publication.
 - 2. OTHER EDITORIAL CHANGES: Editorial changes, to correct typographical errors if there are no other changes on the page concerned, do not require FRCB disposition.
- C. DOCUMENTATION OF CR DISPOSITION: FRCB minutes are published to document the disposition of each CR discussed at that board meeting, new action items assigned, and status of existing action items.
- D. POST-FRCB PROCESSING: CR's will be processed by the Book Manager, acting on behalf of the FRCB Chair, in accordance with the FRCB CR disposition status documented in the minutes.

Deleted: will be classified in one of the following categories for FRCB processing

Deleted: 1. SIGNIFICANT CHANGES: Whenever mandatory evaluators are selected by the DA8 Section Coordinator, the CR is automatically considered "significant" and the initiator (or designated representative) is required to present and discuss the proposed change at the FRCB meeting. These CR's are identified on the agenda with an asterisk. After the presentation, the board chair will poll the board members for approval and provide final disposition of the CR. Associated action items (if any) will be assigned at this time.¶
 2. MINOR CHANGES: For format-only changes, or when no mandatory review assignments have been made, the FRCB Chairman may approve the CR without formal presentation to the board as long as an approved disposition was received from all board members during the evaluation process. Each board member has the authority to disagree with this disposition, however, and the initiator (or designated representative) is expected to be present at the meeting to discuss the change in the event this occurs.¶
 3

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- E. FINAL APPROVAL: CR's to generic rules volumes are collected by the Flight Director Office into either PCN's or complete revisions. The PCN or revision is then scheduled for final approval at the appropriate Program board meeting.

Five days before the respective board is convened, the DA8 Editor sends an e-mail note to a predetermined contact list that the Advance Copy, which contains the rules that will be briefed to that board, has been posted on the Flight Director Office website at <http://mod.jsc.nasa.gov/Da8/>.

At the Board meeting, the DA8 VOLUME COORDINATOR briefs the contents of the document, with emphasis on significant changes and issues that affect Program policies. The Board Chair polls the board and issues final disposition and actions, as necessary.

1. Volume A: Approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Shuttle Program (PRCB).
2. Volumes B, D, E, F: Approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Station Program (SSPCB).
3. Volume C: Approved by the Chief, Flight Director Office; Director, Mission Operations; Manager, Space Shuttle Program; and Manager, Space Station Program (JPRCB).

FLIGHT RULES

2.2 CHANGES TO MISSION-SPECIFIC ANNEX FLIGHT RULES

Throughout this section, key participants are denoted by all capital letters. Roles and responsibilities for each of these participants are described in section 2.5 of this document.

An initial version (called "Basic") of the mission-specific flight rules annex is prepared for each mission's Flight Operations Review (FOR) data pack and placed under configuration control (reference section 3.1.2). The FOR website can be accessed at <http://mod.jsc.nasa.gov/for/fordn/FORDNweb.html>. At FOR, changes are processed and approved via Discrepancy Notice (DN), resulting in a post-FOR "Basic, Revision" nomenclature. All subsequent changes to the annex documents are then processed via CR, as described in this section.

2.2.1 CR Submittal - Mission-Specific Annex Rules

- A. INITIATOR prepares new or updated flight rule document using Microsoft Word:
1. **NEW RULE:** For new flight rule submittals, the rule and its associated rationale must be phrased exactly as it is intended to appear in the flight rules document. Thus, it is recommended that the initiator cut and paste an existing flight rule as the basis for the new rule to ensure proper document formatting. While not mandatory, this will help ensure that the rule will appear properly after approval and also assists greatly in the editing process.
 2. **UPDATED RULE:** For changes to existing rules, the proposed changes must be made obvious. The initiator should cut and paste the existing flight rule into a new document, accept all revisions (to provide a clean basis for the proposed changes), activate change tracking, make the change, and resave the new version in a user directory. This will ensure that the updates are captured to facilitate evaluation and approval, as well as to clearly indicate the changes when the new version of the rule is published.
 3. **DELETED RULE:** When deleting an entire rule, it is not necessary to attach the rule with strikethroughs shown.
- B. INITIATOR prepares a Workflow CR form for the new or updated flight rule. On the form, note that the "document date" field is automatically filled in with the last publication date of the version of the rules annex to which the change is being made. The Microsoft Word document file (produced above) containing the new or modified rule is attached to the CR form. Obviously, no file attachment is needed for rule deletions. The INITIATOR coordinates the change with all disciplines affected by the CR and then submits the CR to their organization's DIVISION CR COORDINATOR.
- C. DIVISION CR COORDINATOR reviews and approves the CR, resulting in formal submittal to the Flight Director Office. The purpose of this step is to ensure full and proper coordination within and external to the initiator's organization before the CR is formally submitted to the Flight Director Office. Each organization must establish its own process for this step, which is expected to include peer review, internal management review, and appropriate coordination with other affected disciplines, where applicable.

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Note that any time a CR is "approved with modification" during this step, it is the responsibility of the DIVISION CR COORDINATOR to ensure that the INITIATOR is aware of the changes made after their original submittal). This step is performed electronically via Workflow. A disposition of approve (or approve with modification) by the DIVISION CR COORDINATOR results in the CR being submitted and routed to the Lead Flight Director for that mission for disposition.

NOTE FOR NON-MOD ORGANIZATIONS: While organizations outside of MOD are welcome to independently submit CR's directly to the Flight Director Office, they are encouraged to submit them through the appropriate MOD division to ensure proper review and coordination with the flight control discipline responsible for that rule section.

2.2.2 CR Evaluation - Mission-Specific Annex Rules

- A. The Workflow DATABASE EDITORS have assigned the LEAD FLIGHT DIRECTORS to their respective missions. Therefore, the Workflow System automatically assigns the CR to the appropriate LEAD FLIGHT DIRECTOR for that mission.

NOTE: From this point on, the mission-specific annex CR process differs greatly from the generic CR process.

- B. LEAD FD reviews the CR for technical merit, clarity, and completeness. Questions and additional changes are coordinated directly with the initiator, and if necessary, additional internal peer review and evaluation may be performed.
- C. LEAD FD then conducts a community review of the CR, with representation appropriate for the change. The LEAD FD has the responsibility and authority to select only those evaluators that they deem mandatory based on the nature of the change. The evaluation itself may be conducted by any means: verbally, e-mail, in small group meetings, or in Flight Techniques Panel/Joint Operations Panel meetings. It is the LEAD FD's responsibility during this step to ensure that all affected organizations and IP's are included in the evaluation, which is essentially equivalent to the entire FRCB process for generic CR's. Once the evaluation is complete, and any identified changes have been made, the CR is ready for approval.

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2.2.3 CR Approval - Mission-Specific Rules

- A. LEAD FD approves the CR, following the completion of the evaluation process above.
- B. FINAL ANNEX COMPILATION: After "Basic, Revision A" publication (post-FOR, reference section 3.1.2), CR's are collected and incorporated to produce the "Final" annex book (or, as necessary, revisions to the "Final" book or PCN's to the "Final" book). The resulting document is scheduled for final approval at the appropriate Program board: PRCB, SSPCB, or JPRCB.
1. Shuttle-only annexes: Approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Shuttle Program (via PRCB).
 2. ISS-only annexes: Approved by the Chief, Flight Director Office; Director, Mission Operations; and Manager, Space Station Program (via SSPCB).
 3. Joint Shuttle/ISS annexes: Approved by the Chief, Flight Director Office; Director, Mission Operations; Manager, Space Shuttle Program; and Manager, Space Station Program (via JPRCB).

- C. FINAL ANNEX APPROVAL: CR's are collected by the Flight Director Office into either a Final revision or PCN's. The revision or PCN is then scheduled for final approval at the appropriate Program board meeting.

An "Advance" copy of the Final document and PCN's is provided for review, by the affected Program Board members, 5 working days prior to the scheduled Board presentation. Note that in some cases CR's may be received and processed after Advance Copy distribution.

At the Board meeting, the LEAD FD briefs the contents of the revision or PCN, with emphasis on significant changes and mission-specific issues that affect Program policies. The Board Chair polls the board and issues final disposition and actions, as necessary.

- D. SUBSEQUENT PCN'S: L-2 weeks to L-2 days, subsequent PCN's will be briefed to the L-2 Day MMT meeting.

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2.3 SPECIAL CONSIDERATIONS

Several special cases of flight rules require unique considerations when processing CR's related to them. These include critical items list items, hazard controls, and mission specific exceptions.

2.3.1 Critical Items List (CIL) Identification

Some flight rules provide controls for Orbiter CIL items. The title of these rules will contain a "[CIL]" tag (including brackets) to clearly identify this relationship. The use of the "[CIL]" tag will be limited to subjects with approved CIL's in place. Additionally, the "documentation" part of the rationale will include CIL references only when the CIL is driving the core rationale for the flight rule. When a change to a CIL-related flight rule is submitted, its impact (if any) on the associated CIL retention rationale must be assessed before it can be approved. If a change to the retention rationale is required, then the change will not be incorporated until a corresponding change to the impacted CIL retention rationale is approved by the Shuttle Programs. The Space Shuttle Program Critical Items List can be accessed at <http://usa1.unitedspacealliance.com/hq/warehouse/ssp/>.

2.3.2 Hazard Control (HC) Requirements

Some flight rules provide controls for identified Orbiter or ISS hazards. These rules are identified in their titles by an "[HC]" tag and are limited to subjects with approved Operational Control Agreement Documents (OCAD's) or approved Hazard Reports (for Russian subjects) in place. HC-related flight rule rationale will be included only when an OCAD or Hazard Report is driving the core rationale for the flight rule. When a CR to an HC-designated flight rule is submitted, its impact (if any) on the associated OCAD or Hazard Report must first be assessed before the CR can be approved.

If a change to the associated OCAD or Hazard Report is required, then the flight rule CR will not be approved until the corresponding change to the impacted OCAD or Hazard Report is approved by the Shuttle or ISS Program, as appropriate. Note: Editorial changes that solely add the HC designation to a rule title, or add a Hazard Report reference to a rule rationale, will not be accepted; HC will only be added when a technical change is being made or when a new rule is being processed. The Space Shuttle Program Hazard Reports can be accessed at <http://usa1.unitedspacealliance.com/hq/warehouse/ssp/>.

NOTE: Editorial changes (via Flight Operations Review (FOR) Discrepancy Notice (DN) or CR) that solely add the [HC] designation to a rule title, or add a Hazard Report reference to a rule rationale, will not be accepted by the Flight Director Office. When a DN or CR is submitted to change an existing rule or to add a new rule, then the [HC] designation and/or hazard report references are expected as part of those change requests.

NOTE: When a rule is referenced within another rule, IP designators, Hazard Report [HC], or Critical Items List [CIL] notations are not required to be added after the title.

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2.3.3 Mission-Specific Exceptions

Shuttle: Per rule A1-55, Conflicting Flight Rules, some generic Shuttle flight rules have the recurring potential for flight-specific options or exceptions. In those cases, the options or exceptions are documented in the associated mission-specific flight rules annex. Per Space Shuttle Program direction, mission-specific exceptions to any other generic Shuttle flight rules must be processed and approved as a permanent change or as a deviation to the applicable generic flight rules.

ISS: Per rule B1-54, Conflicting Flight Rules, mission/increment-specific rules in the flight rules annex that are identified as exceptions to generic rules take precedence. The ISS Program has deemed that approval of the annex rule constitutes agreement with the exception.

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2.4 REAL-TIME CR'S, DEVIATIONS, WAIVERS, AND VIOLATIONS

Flight rules are written to establish pre-planned decisions and reduce the amount of discussion and rationalization when responding to off-nominal situations in real time. In some cases, flight rules are also used to document and provide ready reference to real-time operations policy, especially during time-critical flight phases involving multiple organizations. While every attempt is made to develop rules that are complete and accurate, there are times when flight rules must be changed in real time, deviated from, or waived. There may also be times when a published rule is violated. The purpose of this section is to define those conditions, how they will be documented, and when each applies.

2.4.1 Real-Time Flight Rule CR's

Real-time flight rule changes are those that are required while the associated vehicle is in flight, and when conditions are such that the change is needed in the short-term and cannot be processed in a timely manner using normal CR procedures. For Space Shuttle missions, this is from launch minus 2 days through landing. For continuous ISS operations, the Increment Lead Flight Director will determine whether the Real-Time process is needed, based upon when the change is needed for operational use.

Since the Real-Time Flight Rule change process is initiated by the on-console Flight Control Team, the procedures for the associated CR's may be found in the Shuttle and ISS Flight Control Operations Handbooks (FCOH), JSC-26843 and JSC-29229, respectively. These documents may be found at: <http://mod.jsc.nasa.gov/Da8/FCOH/index.htm>.

2.4.2 Flight Rule Deviations

A flight rule deviation is a special case Real-Time Flight Rule change, required when the intent of a flight rule will be met for a future, planned activity or situation, but the engineering constraint value(s) published in the associated rule will not be met for some reason. The deviation shall be documented using either the Real-Time Flight Rule CR process (reference 2.6.1, above) as a "limited use" change to the applicable flight rule, along with the appropriate rationale, or via MCC chit per ISS FCOH SOP 2.40 (Flight Note, Anomaly Report, and CHIT Communications). Note that deviations apply only in real time and are not applicable for permanent changes, since otherwise the change would simply be written via the normal CR (or Real-Time CR) process. (Forward work remains to synchronize Shuttle and ISS FCOH procedures, after which this section will be revised, as appropriate.)

2.4.3 Flight Rule Waivers

A flight rule waiver is a special case Real-Time Flight Rule change, required when a flight rule (or section of a flight rule), in its entirety, will not be enforced for a future, planned activity or situation. This differs from a deviation in that a waiver results in the rule not applying at all. The waiver shall be documented using either the Real-Time Flight Rule CR process (reference 2.6.1, above) as a "limited use" statement that the associated flight rule is not applicable for the specific situation at hand, along with the appropriate rationale, or via MCC chit per ISS FCOH SOP 2.40 (Flight Note, Anomaly Report, and CHIT Communications). Note that waivers apply only in real time and are not applicable for permanent changes, since otherwise the change would simply be written via the normal CR (or Real-Time CR) process.)Forward work remains to synchronize Shuttle and ISS FCOH procedures, after which this section will be revised, as appropriate.)

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2.4.4 Flight Rule Violations

A flight rule violation occurs when a limit documented in a rule has been exceeded, or when it is known that an exceedance will occur in a timeframe that does not allow action to be taken to avoid it. Note that the "action to be taken" could involve either actual physical reconfiguration of the vehicle (e.g., attitude maneuver, shutdown of an affected system, activation of heaters, etc.) or processing of deviation or waiver documentation. The violation shall be documented via MCC Anomaly Report (AR) to document that the associated flight rule was not honored for the applicable situation, along with the appropriate rationale or explanation. Note that violations apply only in real time for cases where a rule limit was exceeded without prior discussion or agreement. Follow-on work after a violation has occurred may include engineering analysis/evaluation to determine the extent of vehicle damage incurred (if any) or evaluation of potential permanent changes to flight rules (if applicable). In any case, the violation must be documented and raised to Program management, such that lessons learned may be compiled and corrective or preventive actions taken to avoid similar situations in the future.

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2.5 KEY ROLES AND RESPONSIBILITIES

As with any process, the execution is dependent on all participants understanding their roles and responsibilities. This section provides brief descriptions of those roles and responsibilities for key players that are referred to throughout this document.

2.5.1 Initiator

NOTE: The INITIATOR'S role is key to the successful execution of the entire flight rules CR process, since it is their responsibility to ensure that the change is fully coordinated with all affected organizations (both internal and external to MOD) prior to submittal.

Any individual in the technical community may initiate a Flight Rule CR. All initiators will precoordinate with the other disciplines, internal and external to MOD, affected by their CR prior to submitting it for approval. In most cases, after initial coordination is complete the CR will be submitted to a "Division CR Coordinator" who will verify that the appropriate discipline-level review has taken place before the CR is formally input to the Flight Director Office. After submittal, initiators are expected to periodically review the status of their CR to determine whether any reviewers have approved with mod or disapproved their change. The initiator must work with reviewers to attempt to come to an agreement on changes to the CR prior to the FRCB. The initiator is also responsible for coordinating with the applicable Flight Techniques Panel (FTP)/Joint Operations Panel (JOP) chair to present changes to the panel(s).

Initiators from external organizations outside of MOD are allowed to directly and independently submit CR's, but they are fully responsible for coordinating with the MOD discipline responsible for that rules section. Thus, external initiators are encouraged to submit their inputs via their MOD counterparts.

2.5.2 Division CR Coordinator

The Division CR Coordinator is the individual within each MOD Division through whom all CR's are routed. Note that each Division is responsible for determining their own internal process to accomplish this coordination. Also note that, in some cases, the Division coordinator role may be delegated to one or more coordinators at other management levels (e.g., Branch). For the purpose of this change control appendix, the term "Division CR Coordinator" is used throughout, for consistency, although it refers to whichever level has been chosen by each organization.

2.5.3 DA8 Section Coordinator (Generic CR's only)

The Flight Director Office establishes individual Flight Directors as the primary and backup DA8 points-of-contact for coordination of changes to each section within the document. The FD Mission Assignments document can be accessed on the DA8/Flight Director homepage at <http://mod.jsc.nasa.gov/da8/Default.aspx>. The following roles and responsibilities are associated with these DA8 Section Coordinators:

- A. Coordinates with applicable group lead(s) to identify the forward plan for updates, including changes required for the next flight(s)/increment(s), changes that should be "promoted" from flight specific annexes, changes for new hardware/capabilities, etc.

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- B. Coordinates planned changes that have applicability to multiple sections with the DA8 Volume Coordinator (section 2.5.4) to package CR's efficiently (e.g., adding IP designator, etc.), and communicates expected change volume to the DA8 Volume Coordinator.
- C. Reviews CR's and verifies adequate coordination before approving or approving with modification. This includes verifying that the initiator has coordinated with other disciplines (as appropriate), verifying FTP/JOP review of philosophical changes (when applicable), and ensuring that the next several Lead Flight Directors are aware of philosophical and major changes.
- D. Dispositions CR's in their assigned section.

2.5.4 DA8 Volume Coordinator (Generic CR's only)

An individual Flight Director is named to perform overall coordination within DA8 for each generic Flight Rules volume. The FD Mission Assignments document can be accessed on the DA8/Flight Director homepage at <http://mod.jsc.nasa.gov/da8/Default.aspx>. Their roles and responsibilities are as follows:

- A. Works with DA8 Section Coordinators to develop a plan for page change notices (PCN's)/Revisions (e.g., when to publish, what content will be included, etc.).
- B. Creates presentation charts for review at the appropriate board meeting:
 1. Flight Operations Integrated Control Board (FOICB)/Program Requirements Control Board (PRCB) - Volume A, Space Shuttle Operational Flight Rules
 2. Multilateral Operations Integration Control Board (MOICB)/Space Station Program Control Board (SSPCB) - Volumes B, ISS Generic Operational Flight Rules; D, Soyuz/Progress ISS Joint Flight Rules; E, Automated Transfer Vehicle (ATV)-ISS Joint Flight Rules; or F, H-II Transfer Vehicle (HTV)-ISS Joint Flight Rules

or

 3. Joint Mission Integration Control Board (JMICB)/Joint Program Requirements Control Board (JPRCB) (Volume C, Joint Shuttle-ISS Operational Flight Rules).
- C. Reviews presentation charts with DA8 Assistant to the Chief for Shuttle (Volumes A, C) and DA8 Assistant to the Chief for ISS (Volumes B, C, D, E, F), provides courtesy copies to DA8 Chief, MOD Director, MOD Deputy Director, MOD Shuttle Manager (Volumes A, C), and MOD Station Manager (Volumes A, B, C, D, E, F).
- D. Coordinates with the DA8 Program Integration team to schedule Program review.
- E. Presents charts at Program review.
- F. Signs PCN's/Revisions.

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2.5.5 Lead Flight Director (Mission-Specific Annex CR's only)

The Lead Flight Director's role is critical for mission-specific changes. Due to the sometimes rapid development of operations philosophies and techniques in the pre-mission preparation timeframe, the FRCB process is not used. The Lead Flight Director has the authority, as delegated from the Programs, to approve flight rules CR's directly. In doing so, the Lead Flight Director is therefore responsible for verifying that proper coordination has been done with all Program elements, in lieu of the FRCB. When required, this coordination may be done through mission-specific Flight Techniques Panel meetings, Joint Operations Panel Meetings, and other meetings/discussions as deemed necessary. For joint Shuttle/ISS flight rules, both the Shuttle Lead FD and the ISS Lead FD work in concert to accomplish this coordination.

2.5.6 DA8 Flight Rules CR Coordinator (Generic CR's only)

The DA8 Flight Rules CR Coordinator is responsible for facilitating all generic CR traffic in Workflow and for scheduling CR's at the FRCB.

2.5.7 FRCB Members/Other Evaluators

It is the responsibility of each FRCB member to coordinate their evaluation such that their disposition accurately and completely reflects the formal position of their organization. CR evaluators (FRCB member or other evaluator) will inform the CR initiator when disapproving or approving with modification so that the CR Initiator has an opportunity prior to the FRCB to resolve any issues or disagreements.

NOTE: Prior to each FRCB meeting, it is critical that each FRCB member fully understand, and have the authority to speak for, their organization's position with respect to each CR scheduled for disposition at that meeting.

2.5.8 DA8 Flight Rules Book Manager

- A. Generic CR's Only - The DA8 Generic Flight Rules Book Manager coordinates the CR's after disposition at the FRCB.
- B. Mission-Specific CR's Only - The DA8 Annex Flight Rules Book Manager coordinates the CR's after disposition by the Lead Flight Directors.

FLIGHT RULES

2.6 CHANGE REQUEST PROCEDURES

This appendix defines the overall process for flight rules change control, including key definitions and roles and responsibilities. The actual, mechanical procedures for operation of the Workflow system for flight rules CR's are available in Workflow itself. After logging into Workflow, they may be accessed by selecting "HELP," then "User's Guides," then the "FRCR User's Guide" link.

The FRCR User's Guide is extremely detailed and contains comprehensive, step-by-step procedures from CR submittal through approval, implementation, publication, and distribution. Specific procedures are provided for each step and for each type of user: Initiator, Reviewer, Group Lead, Branch Chief, Flight Rules Control Board (FRCB) Representative, Flight Director, FRCR Coordinator, FRCB Chair, etc. Separate sections are provided for generic and mission-specific CR's. Mandatory inputs, optional inputs, overall responsibilities, and special points of interest are noted for each step/user.

NOTE: Any personnel involved in the Flight Rules change process must be very familiar with both the Workflow FRCR User's Guide described above and this change control appendix, especially with respect to the sections applicable to their current role(s) in the CR process.

FLIGHT RULES

3.0 FLIGHT RULES DOCUMENT MANAGEMENT

3.1 DOCUMENT PUBLICATION

3.1.1 Generic Flight Rules Document Publication

Publication of All Flights documents (Volumes A, B, C, D, E, and F) originating as either initial documents or complete revisions are scheduled periodically based on historical change traffic and to facilitate ease in document maintenance.

After initial release of generic volumes in their “Final” form, subsequent revisions will be in the form of PCN’s, depending on CR traffic and mission requirements.

The current schedule for each document may be obtained from the appropriate Book Manager.

3.1.2 Mission-Specific Annex Flight Rules Document Publication

Initial publication of annexes will be in “Basic” form and provided for the Flight Operations Review (FOR) data pack distribution at approximately L-4 months for Space Shuttle only missions and at L-5 months for Joint Shuttle/ISS missions. Post-FOR, the flight rules will be published in “Basic, Revision” form and distributed in time to support flight-specific simulations. The “Final” approval process takes place at approximately L-1 month. Subsequent PCN’s may be processed as long as they are initiated no later than L-2 weeks. After that point, 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. Prior to liftoff, PCN’s will be presented to the L-2 Mission Management Team (MMT) or Tanking MMT meetings instead of the Shuttle Program Board so that these changes are available in the MCC at L-1 day. After liftoff, changes will be presented at the MMT meetings. After Shuttle landing, changes will be presented to the International Space Station Mission Management (IMMT) meetings, per JSC-29279, FCOH Station Operations, SOP 2.6, Real-Time Flight Rules Changes.

The current schedule for any specific annex document may be obtained from the appropriate Book Manager or Lead Flight Director. The milestone table below is used by the DA8 Flight Rules Support Group to determine publication dates.

Deleted: Shuttle and ISS Milestones for Flight Rules Publication¶
¶ Milestone ... [1]

STS-120/10A 09/25/07 FINAL CHANGE CONTROL B-19
ISS EXPEDITIONS 15 & 16

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FLIGHT RULES

MILESTONES FOR FLIGHT RULES ANNEX PUBLICATIONS

Milestone	Joint Shuttle/ISS
<u>Start Process</u>	<u>L - 8 months</u>
<u>Preliminary</u>	<u>L - 7 months</u>
<u>Basic</u>	<u>L - 5 months</u>
<u>FOR</u>	<u>L - 4 months</u>
<u>Basic, Rev A</u>	<u>L - 3 months</u>
<u>Final</u>	<u>L - 2 months</u>
<u>CR Cutoff-Submitted to FD</u>	<u>L - 2 months</u>
<u>FD Cutoff to Bk Mgr</u>	<u>L - 7 weeks</u>
<u>Advance Copy</u>	<u>L - 6 weeks</u>
<u>To JPRCB & Print</u>	<u>L - 5 weeks</u>
<u>PCN-1</u>	<u>L - 1 month</u>
<u>CR Cutoff-Submitted to FD</u>	<u>L - 1 month</u>
<u>FD Cutoff to Bk Mgr</u>	<u>L - 3 weeks</u>
<u>Advance Copy</u>	<u>L - 2 weeks</u>
<u>To JPRCB & Print</u>	<u>L - 1 week</u>
<u>Launch</u>	<u>L - 0 month</u>
<u>Real-Time CR's</u>	<u>During Increment</u>

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3.2 DOCUMENT DISTRIBUTION

Hard copy publications will be printed and distributed through normal administrative channels. Electronic access via the Flight Director Office web site is encouraged. All of the current Flight Rules documents are available at <http://mod.jsc.nasa.gov/da8/Default.aspx>.

WARNING

While web links to the Flight Rules web site are permissible, documents downloaded from that location are not to be placed on other systems.

The JSC Flight Director Office is the only official disseminator of these documents.

FLIGHT RULES

3.3 QUALITY ASSURANCE REVIEWS

3.3.1 Flight Rules Document Accuracy QA

All flight rules documents are reviewed for technical accuracy not less frequently than once a year. Division representatives to the FRCB oversee this review. Due to the high usage of flight rules during mission operations and simulations, and the resulting high volume of change traffic, additional reviews occur as a matter of ongoing business in between the formal reviews.

3.3.2 Flight Rules Change Process QA

This flight rules change control appendix is reviewed for process evaluation not less frequently than once every 2 years.

3.3.3 CR Nonconformance Reporting

If an error is discovered while reviewing an incorporated flight rule CR, the Book Manager must be notified of the nonconformance as soon as possible. The Book Manager will initiate the processing of an "errata" PCN to correct the error, and will document the nonconformance using internal DA8 and USA processes. A verified nonconformance will result in the initiation of a metric input and follow-up corrective action, as appropriate.

FLIGHT RULES

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Shuttle and ISS Milestones for Flight Rules Publication

Milestone	Shuttle Only	Shuttle/ISS
Start Process	L - 7 months	L - 8 months
Preliminary	N/A	L - 7 months
Basic	L - 4 months	L - 5 months
FOR	L - 3 months	L - 4 months
Basic, Rev A	L - 2 months	L - 3 months
Final	L - 1 month	L - 1 month
PCN	L - 2 weeks	L - 2 weeks
Pen & Ink	L - 2 days	L - 2 days
Launch	L - 0 months	L - 0 months
Real-Time CR's	During Flight	During Increment