

**Assigned Crew Study Guide  
Orbiter Systems**



**Space Flight Training Division  
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# Assigned Crew Study Guide Orbiter Systems



Mission Operations Directorate  
Space Flight Training Division

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Prepared by

  
Stephen Messersmith  
Training Integration Section

Approved by

  
Steven D. Williams  
Manager, Training Integration Section

**Mission Operations Directorate  
Space Flight Training Division  
Training Integration Section**

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Steve Williams	Manager, Training Integration Section	x47698
Stephen Messersmith	Book Manager/ Team Lead Office	x47534
Joaquin Andujo	Comm	x47456
Al Park	Control/Prop	x47185
Derone Jenkins-Todd	Curriculum Development	x47395
Lynda Byers	DPS/NAV	x47208
Mike Sadowski	Systems	x47335
Scott Parazynski	CB Rep	x48879

Questions regarding the organization and contents of the Assigned Crew Study Guide should be directed to one of persons listed above!

## Foreword

### Purpose

This Study Guide documents the self study material provided by the Space Flight Training Division to assigned flight crews. The purpose of the self study material is to prepare the assigned crew member for the 3000 level SST and SMS training. The Study Guide is designed to remind crewmembers of the information previously learned in their ASCAN Flow. The Study Guide material should be considered the primary preparation for 3000 level training, but any SST is available upon request.

### Scope

The Study Guide lists formal self study summaries for selected topics within orbiter core training. The self study effort is designed to refresh the crew member to the level obtained at the end of ASCAN training. Self study topics for specialty positions (Ex., rendezvous) are not included in this catalog.

It is not intended that all crewmembers use every study guide. Crewmembers should select Study Guides based upon individual crew assignments. The Training Division recommends certain study guides for particular positions and has documented these recommendations in the Study Guide Assignment Matrix found in Appendix A. It is intended that the flight Commander will review the Study Guide listing and make assignments based upon duty assignments which are particular to the flight.

### How to use the study guide document

The Study Guide booklet is arranged by discipline to correspond with the SMS console position of your training team members. Within each discipline section the individual guides are arranged in alphabetical order. The publication order does not imply the suggested order of study.

Study guide sheets include the following information:

**Source:** Training Division section which produced the guide.

**Rev:** Indicates revision date.

**Materials Referenced:** Master list of all documents, CBTs, videos, etc. referenced by the guide.

**Supplemental Materials:** Workbooks, Videos, CBTs and SSTs which are optional.

If you desire an instructor lead presentation of a specific study guide topic, prior to the Qual Lesson, please schedule the appropriate SST ASAP.

Contact your crew scheduler to schedule the lesson.

Contact your SMS training team instructor to request the lesson specific material to be taught.

**Topic Synopsis:** Indicates the scope and focus of the guide

**Performance Objectives:** Describes knowledge-based objectives that a crewmember should be able to answer in order to verify an individual's understanding of the material referenced in the Study Guide. If a crewmember's understanding of this material is weak, the crewmember should be able to answer the stated objective after studying the material cited in the referenced material which follows each objective.

**Reference:** Indicates a specific source of information pertinent to answering the performance objective. These materials include, but are not limited to: workbooks, flight rules, FDF, SSSH drawings. In some instances, the same answer may be found in more than one of the listed references.

**Exercises:** Questions and problems designed to demonstrate understanding of material referenced by performance objectives.

It is intended that all sources cited should be readily available to crew members from the MOD library, with the exception of the Flight Rules. It will be the responsibility of the Training Division to insure that the most current revision of all references (except the Flight Rules) will be kept in the library.

Crewmembers should read and consider the performance objectives for an assigned guide. If upon reading the performance objective and working the exercises the crew member feels that the study guide topic has been mastered, it is not necessary to study the reference documents. However, the reference material should be used as support if the crew member is not confident that a performance objective can be met or an exercise worked. The answers to the study guide exercises are found in Appendix E of this document. Reference material is designed to provide sufficient material to meet the objectives, any further reading is at the discretion of the crew member. Crewmembers should direct questions to the appropriate instructor on the flight's assigned training team.

As a convenience to the crew, the Study Notes and Rules of Thumb appendices from the SCOM have been re-printed in this document. They are found in Appendix C and D respectively. These items are included as supplementary material and will not be considered mandatory study material unless specifically cited in a study guide reference.

Before 3000 level SMS training commences, crewmembers are required to complete Qual Lessons in areas where it has been deemed appropriate, see Appendix A. The Qual Lesson will for some disciplines be in a desktop discussion format while for others it will be an SST. It is the responsibility of each crewmember to contact their Crew Activity Coordinator to schedule the Qual Lessons, upon completion of each discipline-specific set of Study Guides. The review of the Crew Study Guide and the scheduling of the Qual Lessons should be done as soon as possible in order to complete all the Qual Lessons prior to the start of 3000-level SMS training. If additional preparation is needed before 3000 level training, the instructor will make arrangements to schedule or recommend appropriate study material.

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# COMM

## Section 1 - Comm

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### **Materials Referenced**

Ascent Checklist
Ascent Pocket Checklist
Ascent/Entry Systems Procedures Checklist
Audio/UHF 2102 Training Manual
COMM SPECS 2157 CBT
Data Processing Systems Dictionary
Ku-Ops 2101 Training Manual
Malfunction Procedures
Orbit Operations Checklist
Reference Data
S-Bd COMM/IN 2102
SCOM
SM TM 2102

\*\* Note: The CBT's referenced are the current CBT's on the Server

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: AUDIO

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Ascent C/L, Orbit OPS C/L, Malfunction Procedures

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The onboard AUDIO system is designed to process all audio signals throughout the Orbiter. Audio signals may consist of voice, caution and warning tones and alarms, and TACAN ID tones. This system allows the communications of voice to and from MCC, throughout the cabin and to other attached systems such as the Spacelab module or Spacehab.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the configuration the Orbiter cabin audio for all phases of flight  
REF.: Ascent C/L chapter 9, Post Insertion C/L, D/O PREP
- Identify available audio loops and their capabilities.  
REF.: SCOM Section 2.4: Audio Distribution System.
- State the function of all of the related audio equipment.  
REF.: SCOM Section 2.4: Audio Distribution System.
- Locate all audio related panels and describe the function of the controls.  
REF.: SCOM Section 2.4: Audio Distribution System.
- Describe the configuration the audio system to support different orbit configurations.  
REF.: Orbit OPS C/L Chapter 2 Sections 2-2, 2-3, 2-17, 2-19 - 27
- Locate audio related recovery procedures for all phases of flight.  
REF.: Ascent Pocket C/L Section 2 Orbit Pocket C/L, Section 2 Comm Lost , Malfunction procedures Chapter 2 Section 2.1, Section 2.3a, 2-3c Entry Pocket C/L Section 2.
- Identify electrical busses that power audio panels.  
Ref.: SCOM Section 2.4: Audio Distribution System.

### EXERCISES:

1. Audio Terminal Units enable interfacing with 6 **voice** loops. TRUE or FALSE
2. List the six voice loops.
3. What is the purpose of the "ACCU/BYPASS" switch on the MIDDECK ATU?
4. The two Audio Terminal Units that are capable of receiving TACAN ID tones are
  - a. MS and PS ATUs
  - b. MS and PLT ATUs
  - c. PS and CDR ATUs
  - d. CDR and PLT ATUs
  - e. MIDDECK and MS ATUs
  - f. All ATUs

5. Match the unit on the left to the function on the right. Selections on the right may be used more than once.

1 \_\_\_ HIU

2 \_\_\_ VLHS

3 \_\_\_ ACCU

4 \_\_\_ ATU

5 \_\_\_ NSP

6 \_\_\_ S-Band PM

7 \_\_\_ Ku Band

8 \_\_\_ UHF

9 \_\_\_ S-Band FM

10 \_\_\_ HHM

11 \_\_\_ Audio center panel

12 \_\_\_ CCU

13 \_\_\_ MHA

a. allows for multiple headsets to interface to an ATU

b. Rf system used for transmitting real time voice

c. RF system used for transmitting only recorded voice and data.

d. Control for extending audio buses to docking ring, Spacelab, payload bay outlets, UHF system, and OPS recorders.

e. Combines voice with data for downlinkng, separates uplinked voice and commands.

f. Used as a remote mic in conjunction with the speaker unit.

g. This provides power to the headset mic and interfaces a headset to an ATU.

h. A light weight headset commonly used on orbit

i. Control panel that enables crewmembers to select audio loops and control keying modes

j. The onboard unit that gathers and routes audio signals throughout the orbiter.

k. Equipment that enables manual keying of voice loops.

6. Any ATU on the flight deck may be configured to route voice from MCC to the speaker unit.  
TRUE or FALSE

7. To ensure redundancy the orbiter has **three** Audio Central Control Units.  
TRUE or FALSE

8. Selection of the available Audio Central Control Units are on panel.

a. A1

b. R14

c. R10

d. C3

9. What essential buss supplies electrical power to ACCU 1?

a. ESS 2CA

b. ESS 3AB

c. ESS 1BC

10. What MAIN supplies electrical power to ACCU 2?
  - a. MAIN A
  - b. MAIN B
  - c. MAIN C
11. The higher the setting of the VOX control on the ATU, the louder you have to speak to key the mic. TRUE or FALSE
12. If the ATU power switch is taken to the AUD position you will **not** hear alarm tones on that ATU. TRUE or FALSE
13. You may use **either side** of the Hand Held Mic mic. TRUE or FALSE
14. List the redundancy capabilities of the cabin ATUs.

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: CCTV: CAMERA ASSEMBLY

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The CCTV cameras are used primarily to support on orbit activities that require visual feedback to the crew and the ground. This topic focuses on the CCTV cameras flown in the payload bay. The suggested reading material contains information necessary to become familiar with the various camera types, lens configurations, locations, and camera control

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Match camera acronyms to associated camera.  
REF.: SCOM Section 2.3: CCTV Cameras.
- Identify the capabilities of focus, zoom, and iris control.  
REF.: SCOM Section 2.3: CCTV Camera Lens Control.
- Describe the capabilities of the Pan/Tilt unit.  
REF.: SCOM Section 2.3: Pan/Tilt Units (PTUs).
- Explain how automatic light and gamma control are achieved and what they are used for.  
REF.: SCOM Section 2.3: CCTV Cameras
- Identify location the TV outlets in the crew cabin.  
REF.: SCOM Section 2.3: Pan/Tilt Unit (PTUs).
- State the camera overtemp limit.  
REF.: SCOM Section2.3: Video Processing Equipment.

### EXERCISES:

1. Match the names in column **A** to the proper acronym on column **B**.

<b>A</b>	<b>B</b>
___ Color Television Camera	1. MLA
___ Monochrome Lens Assembly	2. CTVC
___ Color Lens Assembly	3. ITVC
___ Wide Angle Lens Assembly	4. CLA
___ Intensified Television camera	5. WLA
2. Crews must not leave a camera unattended when the iris is commanded opened/close using the iris switch. This command disables automatic iris control and the camera can become damaged if it is into direct sunlight. True or False
3. A camera will continue counting during a temporary suspension in Pan/Tilt movement because there is no feedback from the Pan/Tilt Unit on the camera to suspend counting. True or False

4. The Automatic Light Control (ALC) circuitry provides for \_\_\_\_.
  - a. Better contrast & detail of bright or dimly lit objects
  - b. Manual control of camera focus
  - c. Automatic control of the lens iris
  - d. All of the above
  
5. The Gamma correction circuits can be used to provide for \_\_\_\_.
  - a. Better contrast & detail of bright or dimly lit objects
  - b. Manual control of camera focus
  - c. Automatic control of the lens iris
  - d. All of the above
  
6. Panels \_\_\_\_ are used in the cabin to provide cabin video.
  - a. A11, MO52J
  - b. A15, MO25J
  - c. O9, MO58F
  
7. A CCTV camera is considered overtemp if it exceeds a temperature of \_\_\_\_.
  - a. 10°C
  - b. 35°F
  - c. 50°C
  - d. 45°C

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** CCTV: VIDEO CONTROL UNIT and PANEL A7U

**SOURCE:** DT27/COMM

**REV.:** Oct 1997

**MATERIALS REFERENCED:** SCOM

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The Video Control Unit is the heart of the CCTV system. The VCU distributes power to many parts of the CCTV system, routes the various inputs and outputs, and provides the synchronization of the video signal. This topic focuses on the major functions of the Video Control Unit. The suggested reading material contains information necessary to become familiar with the characteristics of the remote control unit, video switching unit, and panel A7U.

**PERFORMANCE OBJECTIVES:** At the end of this lesson the trainee should be able to:

- State the location of the CCTV circuit breakers.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- Explain the purpose of the GCIL switch for the CCTV.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- State the purpose of the TV SYNC switch.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- State the purpose of the camera power talkbacks and how they are interpreted.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- State the purpose of the TV Downlink Enable/Inhibit switch.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- State the function of the TV Downlink/Sync switch.  
REF.: SCOM Section 2.3: Video Processing Equipment.
- Identify the prime communications system used to transmit video to MCC.  
REF.: SCOM Section 2.3: Description.
- Explain that the ALC and gamma PBIs on panel A7U perform different tasks in relation to CTVCs and 508 cameras.  
REF.: SCOM Section 2.3: CCTV System Summary, Section 2.3: CCTV Cameras - diagram "CCTV decal" and "ALC and GAMMA Push Button on Panel A7U".



**EXERCISE:**

1. The CCTV circuit breakers are located on panel \_\_\_\_\_.
  - a. A11
  - b. R14
  - c. R1
  - d. MI86B
2. When the GCIL TV POWER CONTROL switch is in CMD on panel A7U, the crew can configure the CAMERA POWER switch to enable camera power. True or False
3. When the TV SYNC switch is in reverse, sync generator A is tied to Main B and sync generator B is tied to Main A. True or False
4. If the camera power talkback on panel A7U reads “ON”, this ensures that the camera is powered on. True or False
5. MCC has uplink command control to configure the TV Downlink Enable/Inhibit Switch on panel A7U. True or False
6. Real time video from the orbiter to MCC is transmitted through \_\_\_\_\_.
  - a. Payload interrogator
  - b. S-Band PM
  - c. UHF
  - d. K-band
7. The ALC and gamma PBIs on panel A7U perform different tasks with the CTVCs and 508 cameras. True or False

## **CREW STUDY GUIDE TOPIC SHEET**

**TOPIC:** CCTV : COLOR TV MONITOR

**SOURCE:** DT/27

**REV.:** Oct 1997

**MATERIALS REFERENCED:** SCOM

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The orbiter CCTV color monitors allow crewmembers to view live color video from any orbiter CCTV camera. This topic focuses on monitor characteristics. The suggested reading material contains information necessary to become familiar with the characteristics of the monitor menu and switch functions.

**PERFORMANCE OBJECTIVES:** At the end of this lesson the trainee should be able to:

- Explain CCTV monitor switch functions.  
REF.: SCOM, Section 2.3: Monitors.
  
- Explain CCTV menu options.  
REF.: SCOM, Section 2.3: Monitors.
  
- Match camera acronyms to associated video processing format.  
REF.: SCOM, Section 2.3: Monitors.
  
- State the location of the video connector behind the monitor.  
REF.: SCOM, Section 2.3: Monitors.

**EXERCISES:**

1. The menu is displayed on the monitor by selecting the \_\_\_\_.
  - a. Function control
  - b. Brightness/Contrast control
  - c. Select control
  - d. Color/Tint control
  - e. a and d
  - f. a and c
  
2. The monitor menu Lens Data (L-Data) is used to enable lens data for a \_\_\_\_ camera.
  - a. 508 CLA
  - b. 508 WLA
  - c. CTVC/ITVC
  - d. 508 MLA
  
3. Match the camera type in column **A** to the video processing format type in column **B**.

<b><u>A</u></b>	<b><u>B</u></b>
___ CTVC	1. NTSC
___ 508 MLA	2. FSC
___ 508 WLA	3. B&W
___ 508 CLA	
___ ITVC	
  
4. The J3 connector, located on the rear of the monitor, provides \_\_\_\_.
  - a. Audio signals
  - b. Power
  - c. Video signals
  - d. a & c
  - e. none of the above

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Instrumentation

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Section 2.4-35, S-BD COMM/IN 2102 4-18 - 4.35.

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The orbiter instrumentation system collects data from orbiter subsystems, payloads and GPC and formats it for crew display and downlink. This crew study guide focuses on the LRUs that make up the instrumentation system. The suggested reading material contains information on DSCs, MDMs, PCMMU and TFL loading operations.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the function of the OI Dedicated Signal Conditioners (DSCs).  
REF.: SCOM, Section 2.4: Instrumentation. S-BD COMM/IN 2102 4-18 - 4.35.
- Describe the function of the OI Multiplexer Demultiplexers (MDMs).  
REF.: SCOM, Section 2.4-35, S-BD COMM/IN 2102 Section 4: Downlink Line Replaceable Units, Questions.
- Describe the function and the interfaces of the Pulse Code Modulation Master Unit (PCMMU).  
REF.: SCOM, Section 2.4-35, S-BD COMM/IN 2102 Section 4: Downlink Line Replaceable Units, Questions.
- Identify the purpose of a Telemetry Format Load (TFL) and how it affects the downlink.  
REF.: SCOM, Section 2.4-35, S-BD COMM/IN 2102 Section 4: Downlink Line Replaceable Units, Questions.
- Distinguish among the signatures for the loss of a DSC, MDM and PCMMU.  
REF.: SCOM, Section 2.4-35, S-BD COMM/IN 2102 Section 4: Downlink Line Replaceable Units, Questions.
- Locate and describe generic and flight specific information in the FDF associated with the instrumentation system.  
REF.: REF DATA, MALFUNCTION PROCEDURES VOL. I, AESP, Orbit Ops Checklist FS
- For a given instrumentation failure, identify the steps required to recover data lost due to the failure.  
REF.: MALFUNCTION PROCEDURES VOL. I, AESP, Orbit Ops Checklist FS

## EXERCISES:

1. The function of an MDM is to
  - a. receive OI data, GPC downlist and payload data and format for crew display and downlink.
  - b. acquire and convert various sensor data (temperature, rate, frequency, etc.) into 0-5 Vdc pulse.
  - c. accept data from various inputs, digitize (if required) and interleave data into a serial data stream.
  
2. The loss of a DSC causes \_\_\_\_\_ on the SYS SUMMs and several SM ALERT messages for the parameters associated with that DSC.
  - a. M's
  - b. L's
  - c. ↑'s
  - d. ↓'s
  
3. In which FDF are the flight specific TFL configurations located?
  - a. REF DATA
  - b. IFM CL
  - c. MAL PROCS
  - d. FS Orbit Ops CL
  
4. TFLs are loaded in what OPS modes?
  - a. S2, G3
  - b. G1, G9
  - c. G1, G3
  - d. S2, G9
  
5. The \_\_\_\_\_ TFL is not lost during a PCMMU power interrupt.
  - a. programmed
  - b. LDR
  - c. HDR
  - d. fixed
  
6. The FDF used to determine the OI DSC loss is \_\_\_\_\_.
  - a. REF DATA
  - b. IFM CL
  - c. MAL PROCS
  - d. a and c
  
7. TFL \_\_\_\_\_ is the fixed TFL that contains primarily OI, GNC and BFS data ( no payload data).
  - a. 128
  - b. 129
  - c. 161
  
8. The function of the PCMMU is to
  - a. receive OI data, GPC downlist and payload data and process for crew display and downlink.
  - b. acquire and convert various sensor data (temperature, rate, frequency, etc.) into 0-5 Vdc pulse.
  - c. accept data from various inputs, digitize and interleave data into a serial data stream.

9. The loss of an MDM causes \_\_\_\_\_ on the SYS SUMMS and either 'I/O ERR PCM' (ascent/entry) or 'BCE BYP OF A(B) or OA' (orbit) messages for the parameters lost with that MDM.
  - a. M's
  - b. L's
  - c. ↑'s
  - d. ↓'s
  
10. Which one of the following is NOT an output of PCMMU 1?
  - a. NSP 1
  - b. NSP 2
  - c. ops recorders
  - d. PCDECOM
  
11. What step in the TFL LOAD procedure has the PCMMU begin using TFL 184 ( the programmed HDR TFL)?
  - a. ITEM 1 EXEC
  - b. ITEM 3+184 EXEC
  - c. ITEM 4 EXEC
  - d. ITEM 2 EXEC
  
12. A \_\_\_\_\_ alters the amount GPC downlist, OI and PL/spacelab data being formatted and sent to the NSP based on mission phase and requirements
  - a. OI DSC
  - b. TFL
  - c. OI MDM
  - d. DFL
  
13. Assume the 'I/O ERR PCM' is annunciated and the SM SYS SUMMS show missing data for all parameters. To determine if a failure is at the PCMMU or at the SM GPC, the crew must \_\_\_\_\_.
  
14. The BFS will attempt an automatic I/O RESET to the PCMMU after a PCMMU or OI MDM power interrupt. TRUE or FALSE
  
15. The SM GPC will attempt an automatic I/O RESET to the PCMMU after a PCMMU or OI MDM power interrupt. TRUE or FALSE
  
16. All OI MDM primary MIAs are connected to PCMMU1 and all secondary MIAs to PCMMU2. TRUE or FALSE
  
17. If a TFL LOAD FAIL message is annunciated after the first load attempt, the PCMMU will automatically try a second time to load the same TFL. TRUE or FALSE
  
18. The PDI has a primary and a secondary port to PCMMU 1. TRUE or FALSE
  
19. An MDM power failure is recoverable by selecting the alternate PCMMU. TRUE or FALSE

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Ku-Band: Antenna Operations

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Ku-band Operations 2102 Training Manual

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** One of the primary functional units of the Ku-band system is the Deployed Assembly (DA), that consists of a Deployment Electronics Assembly containing transmitters, receivers, and amplifiers and the Deployed Mechanical Assembly that consists of a steerable parabolic antenna dish, gimbals to move the antenna, and a gyro assembly to control and monitor the movement. The pointable dish is pointed automatically and/or manually pointed to establish a Line of Sight with a TDRS satellite for COMM operations or a rendezvous target for RADAR operations. This study guide will familiarize you with nominal procedures to DEPLOY and STOW the KU DA, some contingency procedures that may need to be used if the antenna does not stow normally, and the four modes by which the antenna dish can be controlled to point towards a TDRS communications satellite or rendezvous target.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the basic functional steps and rationale involved and as well as the internal processes occurring during a nominal Ku-band antenna DEPLOY.  
REF: SCOM, Section 2.4: Ku Band System  
Ku-Band Operations 2102, Section 3, All
- Describe the basic functional steps involved and as well as internal processes occurring during a nominal Ku-band antenna STOW.  
REF: SCOM, Section 2.4: Ku Band System  
Ku-Band Operations 2102, Section 8, All
- Name the FDF book, in which, Ku Antenna Deploy and Stow procedures can be found.  
REF: Ku-Band Operations 2102, Section 3: Deployment and Section 8: Stow Operations.
- Describe the relationship between GPC commanded EL and AZ angles pointing angles and actual antenna commanded gimbal angles.  
REF: Ku-Band Operations 2102, Section 5: Gimbal Angle Transformation.
- Describe the different types of KU MASKING in RADAR and COMM modes and explain the function use of each.  
REF: Ku-Band Operations 2102 Section 5: Antenna Operations.
- Name at least two contingency procedures that might be used, if the KU antenna fails to STOW nominally.  
REF: SCOM, Section 2.4: Ku Band System.  
Ku-Band Operations 2102 Section 8: Direct Stow and Contingency Stow, Section 9: All
- Name four different types of KU antenna steering modes and describe how each one operates to point the Ku-band antenna.  
REF: SCOM, Section 2.4, Ku Band Systems.  
Ku-Band Operations 2102 Section 5: Operating Modes and Flight Anomalies.

## EXERCISES:

1. How much time does a nominal KU antenna DEPLOY require? Why might the DEPLOY take longer? What are the consequences to continued KU operations should this happen?
2. At the beginning of the deploy procedure, the KU POWER switch is verified in the OFF position and the KU CNTL switch is taken to PNL to:
  - a. prevent commanding of the KU system from the ground.
  - b. prevent the KU antenna from initializing prematurely.
3. During the KU antenna deploy sequence, the KU band antenna dish remains locked in place by antenna gimbal locking pins and cannot move.
4. Order the following steps and processes, so that they most accurately describe the sequence that occurs during a nominal KU antenna stow procedure.
  - a. EA1 commands antenna gimbal lock pins closed.
  - b. Wiggle test performed
  - c. KU PWR ON checked
  - d. MECH PWR switches activated
  - e. EA1 commands antenna to final STOW angles
  - f. Crew manually positions KU antenna close to final Stow angles
  - g. Crew normally performs KU ANT CABLE POSITIONING.
  - h. Deployed Assembly is driven to the STOW position along the STARBOARD longeron.
  - i. KU ANT switch is taken to STOW position
5. Flight Rules prohibit the stowing of the KU-band DA without confirmation that the gimbal lock pins are in place to secure the antenna dish in the correct STOW position. TRUE or FALSE
6. The \_\_\_\_\_ switch will be used only when the KU antenna will not stow via the normal stow process even though it can be verified that the GIMBAL LOCKING PINS have been set.
  - a. KU ANT DPY/STO - PNL R13L
  - b. KU ANT DIRECT STO - PNL R13L
  - c. KU PWR - PNL A1
  - d. None of the above
7. The \_\_\_\_\_ (FDF Procedure) will be used if the KU antenna will not STOW by any means.
  - a. KU ANT DIRECT STOW
  - b. KU-BD CABLE POSITIONING
  - c. KU-BD ANT JETTISON
  - d. KU-BD MANUAL ACQUISITION
8. The \_\_\_\_\_ (FDF Book) contains nominal KU DEPLOY and STOW procedures.
9. Which of the following maskings can be seen on the SM OPS 2011 - ANTENNA display?
  - a. Obscuration mask
  - b. Beta only mask
  - c. Beta + mask
  - d. All of the above



10. In the nominal COMM mode, a \_\_\_\_\_ (BETA + MASK, BETA ONLY) mode is normally used. In this mode, the KU output will be inhibited by turning the TWT OFF, whenever the KU antenna LOS for a selected TDRS points in the area
- below the obscuration mask line
  - so that the beta angle required exceeds that set in masking
  - both a and b
  - either a and b
11. Some reasons to transition to a BETA ONLY masking mode of operations include
- to provide extra protection during antenna DPLY/STOW operations
  - to provide extra protect from KU radiation to EVA crew.
  - to provide protection to raditation sensitive payloads.
  - to provide more accurate KU antenna pointing, during periods when a TDRS is OFF-THE-NOSE.
12. Match the following descriptions of KU antenna steering modes with the correct identifier.
- |   |                  |
|---|------------------|
| a. KU antenna dish is manually positioned by the crew to expected location of TDRS satellite or RNDZ target. The KU attempts to lock to a forward link signal. If none is received the antenna can be forced into a spiral SEARCH. If a forward link signal or return is detected, EA1 will enter a closed loop tracking mode, and track the signal or target until it is lost. If the signal being tracked is lost, the dish will remain stationary at its last postion.   | 1. GPC           |
| b. KU antenna dish responds to GPC commanded EL/AZ pointing angles every 2 seconds. It converts these to appropriate Alpha/Beta gimbals movements to command the antenna LOS to follow a target or TDRS.  | 2. GPC DESIGNATE |
| c. KU antenna dish only responds to MANUAL SLEW commands issued by the crew from panel A1.  | 3. AUTO TRACK    |
| d. KU antenna dish responds to GPC commanded EL/AZ angles, converts them to Alpha/Beta gimbal commands, and points the antenna LOS towards a target or TDRS. The system tries to detect a forward link signal, if note is detected in a specific amount of time a automatic spiral SEARCH is performed. If a forward link signal is detected the KU enters an automatic internal TRACK routine and will track the target or TDRS. If the forward link is lost, after a specified period of time, the KU will accept another new commanded angle from the GPC and start the same routine over. | 4. MANUAL SLEW   |
13. The KU antenna dish \_\_\_\_\_ (will, will not) respond to MANUAL SLEW commands from panel A1, if it is in GPC, or AUTO TRACK and actively tracking.

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** KU-Band System: Basic Operations

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Ku-Band Operations 2102 Training Manual

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The Ku-band system is one of five basic RF systems available on the Orbiter to support communications operations. It can be used operationally for two basic purposes and its use is restricted to certain phases of flight. This study guide will help you understand these two basic modes of operation and the capabilities of the KU system in both modes.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the two basic operational uses of the Ku-band system during a Shuttle flight.  
REF: SCOM, Section 2-4: Ku-Band Systems, Section 5.3: Rendezvous.  
KU OPS 2102, Section 1: Introduction.
- State the number of COMM downlink channels available on the Ku-band system and describe the type of data that can be downlinked on each channel.  
REF: SCOM, Section 2.4: Ku-Band Systems.  
KU OPS, Section 6: Communications Systems Component Interfaces and Data Flow, Communications Systems Capabilities.
- Describe the two different modes of KU COMM uplink operations.  
REF: SCOM, Section 2.4: Ku-Band Systems.  
KU OPS, Section 6: Communications Systems Component Interfaces and Data Flow
- Describe the two different uses of KU RADAR SENSOR data during KU RADAR operations.  
REF: KU OPS 2102, Section 7: Radar Operations and Summary.
- Name the only phase of flight when the Ku-band is operational and why.  
REF: SCOM, Section 2.4: Ku-Band Systems.  
KU OPS 2102, Section 3: Antenna Deployment.

### EXERCISES:

1. The Ku-band antenna can be safely deployed only when the Orbiter is on-orbit and the payload bay doors are opened.
2. In the COMM mode, the KU system can be operated in two modes, what data can be uplinked during KU COMM operations in mode 1, that cannot be uplinked in mode 2?
  - a. VOICE
  - b. Orbiter commands
  - c. TIPS, PADM, or payload commands
  - e. a and b only.
3. The Ku-band COMM downlink can consist of four distinct channels.



## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Ku-band: Communications Operations & GPC Displays

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Ku-band Operations 2102 Training Manual, COMM SPECS 2157 CBT

**SUPPLEMENTAL MATERIALS:** None

**TOPIC SYNOPSIS:** This study guide will allow you to review basic Ku-band operations in the communications mode. It will provide information on uplink and downlink processing of the Ku-signal by the various Ku system LRUs and explain information displayed on GPC SPECS about Ku system operations and configurations.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Explain the path of uplink and downlink communications data through the various Ku system LRUs and the basic processing done in each LRU.  
REF: SCOM, Section 2.4: Ku-Band System  
KU OPS 2102, Section 6: Overview, Communications System Component Interfaces and Data Flow, Communications System Capabilities.
- Describe the KU system information specifically displayed on SM SPEC 76.  
REF: KU OPS, Section 6: Ku-Band/Sband PM Fail Safe & Appendix C.
- Describe the Ku system information displayed on SM SPEC 2011 - ANTENNA, including CMDed vs. ACTUAL EL/AZ, the graphic mecatron projection, the LOS box, and selecting PRIME E or W TDRS.  
REF: KU OPS 2102, Section 5: Antenna Operations, Gimbal Angle Transformation, Operating Modes, & Appendix C. COMM SPECS-KU Section

### EXERCISES:

1. Order the following sequence of LRUs and processes, so that they best represent the path of forward link communications data through the Ku system?
  - a. The SPA receives the demodulated communications data, processes it, and routes it to the NSP and/or TIPS, PADM, or payload.
  - b. The EA1 receives a forward link signal, establishes lock, and demodulates the data.
  - c. At the DA, the forward link signal is received at the antenna dish and processed by the Ku receiver.
2. Other than processing the forward link communications signal, what other important function does EA1 perform?
  - a. Controls transmitter pulsing in the RADAR mode
  - b. Modulates data onto the Ku return link carrier
  - c. Controls DA antenna pointing and tracking functions
  - d. None of the above

3. Fill-in the blanks in the paragraph below with the appropriate LRU to describe the path of return link communications data through the Ku system.

The \_\_\_\_\_ receives NSP, payload, TV, and/or recorder data from Orbiter systems, modulates the data onto a Ku-band carrier frequency. The modulated carrier is routed to a TWT amplifier and transmitter located in the \_\_\_\_\_, which in turn routes the modulated/amplified carrier to the antenna on the \_\_\_\_\_.

1. DMA
2. EA2
3. SPA
4. EA1
5. DEA

4. Which of the following information is displayed on SM SPEC 76?  
(CAUTION: More than one answer may be correct)
- a. KU antenna heater temperatures
  - b. KU FRAME SYNC, when operating in forward mode 1
  - c. KU antenna masking mode selected
  - d. KU operating mode selected (COMM vs. RADAR)
  - e. KU antenna pointing mode selected
  - f. KU transmitter RF power output
- {ANSWER: a, b, d, f}
5. The EL/AZ CMD indications on SPEC 2011 - ANTENNA represent the pointing angles to a TDRS or RNDZ target as commanded by
- a. KU EA1
  - b. KU SPA
  - c. ORB GPC
  - d. Ground uplink
6. The EL/AZ ACT and the LOS box on SPEC 2011 - ANTENNA are driven by telemetry feedback to the GPC from the KU system and represent true pointing angles. TRUE or FALSE
7. During normal KU operations, if both the E and W TDRS satellite are in view, the KU antenna will continue to point to the W TDRS until it is out of view and then point to the E. What item entry on SPEC 2011, can force the KU antenna to point to the E TDRS as soon as it comes into view (Early TDRS HANDOVER)? Should this Item entry ever be done without MCC concurrence?
8. The obscuration line depicted on the graphic portion of SM SPEC 2011 - ANTENNA represents the \_\_\_\_\_ and indicates an area in which the KU system \_\_\_\_\_ (should, should not) be able to establish a two-way communications link with a TDRS satellite.
- a. BETA masking commanded
  - b. Orbiter hardware blockage area plus a 5% transition zone
  - c. area in which the KU antenna cannot be pointed because of mechanical limitations of the gimbals
  - d. software controlled area, where the KU transmitter is inhibited

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Ku-band: RADAR Operations

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Ku-band Operations 2102 Training Manual

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This study guide is intended to high-light the use of the Ku system as a source of sensor data, during normal rendezvous operations. It will help you review the names of and function of Ku system LRUs, when the KU is operating in the RADAR mode. It will also remind you of some of the basic configurations and steps required to successfully operate the KU in a RADAR mode and interface the RADAR sensor data to rendezvous navigation software.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Name the KU system LRUs and their basic function, while operating the KU system in a RADAR PASSIVE mode.  
REF: SCOM, Section 2.4: Ku-Band Systems  
KU OPS 2102, Section 7: Overview, Radar Systems, Radar Operations.
- Name the four types of sensor data provided by the KU system, when it is operating in the RADAR mode.  
REF: SCOM, Section 2.4: Ku-Band Systems  
KU OPS 2102, Section 7: Overview.
- Explain why a KU SELF TEST is normally repeated as an initial step in most rendezvous procedures.  
REF: KU OPS 2102, Section 7, Radar Operations.
- Describe approximate when, under what conditions, and how RADAR sensor data is used during the course of a standard normal rendezvous.  
REF: SCOM, Section 2.4: Ku-Band Systems  
KU OPS 2102, Section 7, & Appendix C

### EXERCISES:

1. Which of the following LRU(s) is(are) required to operate the KU system in the RADAR mode? (CAUTION: More than one answer may be correct)
  - a. EA2
  - b. EA1
  - c. DA
  - d. SPA
  - e. All of the above
2. What KU LRU is responsible for controlling such functions as transmitter frequency, RF output level, and transmitter/receiver gating logic, during normal KU RADAR operations?

3. The KU \_\_\_\_\_ (DA, EA1, EA2, SPA) is responsible for extracting and processing the RADAR return signal from a target and extracting \_\_\_\_\_ information for use by Orbiter NAV software and/or direct display on Orbiter panels.
  - a. Range
  - b. Range Rate
  - c. Angle
  - d. Angle Rate
  - e. All of the above
  
4. TRUE or FALSE - A KU SELF TEST is normally repeated as an initial step before use of the KU in the RADAR mode during a rendezvous to re-check RADAR functions not used while operating in the COMM mode.
  
5. Prior to a distance to the rendezvous target of about 150 KFT, KU panel A1 switches are configured for RADAR PASSIVE operations in \_\_\_\_\_ (GPC, GPC DESGN) antenna steering mode, and an Item 2 EXEC entry made on GNC SPEC 33 \_\_\_\_\_.
  - a. to program EA2 for rendezvous operations.
  - b. to allow transfer of Orbiter to target pointing vectors from GNC to SM GPC and to direct antenna pointing software to point to the rendezvous target.
  - c. to disable SM GPC direct KU antenna pointing, so that it can track the rendezvous target.
  - d. to enable the GNC to directly control KU antenna pointing.
  
6. When RADAR lock occurs on target returns, an ITEM 13 EXEC on GNC SPEC 33 initiates the comparison of \_\_\_\_\_ to \_\_\_\_\_ and if the comparison meets certain checks for reasonability, the \_\_\_\_\_ will be updated to match the \_\_\_\_\_ and can be used to execute subsequent burns. Use the best answers below to fill in the blanks. (CAUTION: At least one answer must be used more than once.)
  - a. RADAR sensor data
  - b. NAV calculated position and range of the target relative to the Orbiter
  - c. Orbiter State Vector
  
7. TRUE or FALSE - During the final stages of a rendezvous, particularly during MANUAL BURNS to meet BRAKING GATES, RADAR sensor data, directly from the KU, is read on panel A2 to maintain both target position relative to the orbiter and meet closure rate requirements as the distance between the target and Orbiter decreases.

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Payload Communications - Systems Overview

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Payload Comm 2102 Training Manual (PL COM 2102/Sept., 1992)

**SUPPLEMENTAL MATERIAL:** P/L Comm CBT 2157

**TOPIC SYNOPSIS:** The Payload Comm System is used to transfer information between the orbiter and its payload (s). It supports hard-line and radio frequency communications with a variety of payloads. The system is used to activate, check out, and deactivate attached, as well as, detached payloads.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the basic operational use of the Payload Comm System.  
REF.: SCOM, Section 2.4: Payload Communications Systems.
- List the basic elements (LRUs) in the Payload Comm System, and describe the function of each.  
REF.: SCOM, Section 2.4: Payload Communications Systems. PL COM 2102, Sections 1-7
- Describe the path of commands and telemetry through the LRUs of the Payload Comm System.  
REF.: PL COM 2102, Section 1
- Distinguish between the hard-line path for commanding/telemetry, and the radio frequency path.  
REF.: PL COM 2102, Section 1
- Identify the control capabilities of the payload recorder given both barber-pole and gray indications.  
REF.: PL COM 2102, Section 7
- Identify the three ways that a crew can gain control over the payload recorder.  
REF.: PL COM 2102, Section 7
- Distinguish between Coherent and Non-Coherent modulation.  
REF.: PL COM 2102, Section 2

### EXERCISES:

1. When commanding to hard-line payloads, the path is:
  - a. PL MDM  $\Rightarrow$  PI  $\Rightarrow$  PAYLOAD
  - b. PL MDM  $\Rightarrow$  PSP  $\Rightarrow$  PI  $\Rightarrow$  Payload
  - c. PSP  $\Rightarrow$  PL MDM  $\Rightarrow$  PPP  $\Rightarrow$  Payload
  - d. PSP  $\Rightarrow$  PPP  $\Rightarrow$  Payload
2. When commanding to RF payloads, the path is:
  - a. PSP  $\Rightarrow$  PL MDM  $\Rightarrow$  PPP  $\Rightarrow$  Payload
  - b. PSP  $\Rightarrow$  PPP  $\Rightarrow$  Payload
  - c. PL MDM  $\Rightarrow$  PI  $\Rightarrow$  Payload
  - d. PL MDM  $\Rightarrow$  PSP  $\Rightarrow$  PI  $\Rightarrow$  Payload



3. Fill in the blanks: The path that telemetry takes from a hard-line payload to the PCMMU is as follows:  
 Payload  $\Rightarrow$    ?    $\Rightarrow$    ?    $\Rightarrow$  PCMMU.
- PL MDM, PSP
  - PPP, PSP
  - PPP, PDI
  - PDI, OI MDM
4. Fill in the blanks: The path that telemetry takes from an RF payload to the PCMMU is as follows  
 RF Payload  $\Rightarrow$    ?    $\Rightarrow$    ?    $\Rightarrow$    ?    $\Rightarrow$  PCMMU.
- PI, PSP, PL MDM
  - PPP, PSP, PDI
  - PSP, PDI, OI MDM
  - PI, PSP, PDI
5. When the payload outputs a data rate that is not compatible with the PSP, all data received by the PI is throughput directly to the K-band signal processor. This is known as "bent pipe". True or False?
6. Match the LRU names with the functions below:
- Payload Interrogator
  - Payload Signal Processor
  - Payload Data Interleaver
  - Pulse Code Modulation Master Unit
  - Payload Patch Panel
  - RF Payload
  - Hard-line Payload
- \_\_\_\_\_ Receives data from the GPCs, the PDI, and the OI MDMs, interleaves the data, and then formats it according to programmed instructions stored within it.
- \_\_\_\_\_ Transmitter/Receiver unit which provides duplex RF communications between the Orbiter and a detachable payload.
- \_\_\_\_\_ Interfaces attached payloads to the PDI.
- \_\_\_\_\_ This box can be divided into three sections: control and configuration, command, and telemetry. It is the interface between the ground (or crew) and the attached or detached payload. It is also an interface for detached payload telemetry.
- \_\_\_\_\_ Attached payload
- \_\_\_\_\_ Receives data from multiple payloads and stores the data internally for use by the PCMMU.
- \_\_\_\_\_ Detached payload
7. Which LRU provides the received signal strength from the payload?
- PI
  - PSP
  - PCMMU
  - PDI

8. Match the labels with the functions below:
- a. Fetch Pointer Memory
  - b. PDI Data Ram
  - c. Switch Matrix
  - d. Toggle Buffer
  - e. Decom
- \_\_\_ Programmable device which routes data from any of seven input channels to any of four decoms.
- \_\_\_ Programmable devices used to identify, extract, and format portions of an assigned payload telemetry stream to be included in the Orbiter down link telemetry stream.
- \_\_\_ Tells the toggle buffer what data to output which will be interleaved with the data output from the PDI Data Ram.
- \_\_\_ Two-sided data storage device. When one side is receiving data for storage, the other side is releasing data to be sent to the PCMMU.
- \_\_\_ Device which stores payload data for display purposes.
9. It is possible to use PI 1 with PSP 2. True or False?
10. It is possible to use PCMMU 1 with Payload Comm System 1 or 2. True or False?
11. What affects do the loss of PF1 MDM have on the Payload Comm System?
- a. You can no longer load the decoms
  - b. You can no longer receive commands or telemetry from the PSP
  - c. You can no longer command to a payload through the PSP
  - d. All of the above.
12. What affects do the loss of PL 1 Bus have on the Payload Comm System?
- a. You can no longer load the decoms
  - b. You can no longer receive commands or telemetry from the PSP
  - c. You can no longer receive telemetry from a payload through the PSP
  - d. All of the above.
13. Complete the chart below indicating whether the item is an input, output, neither, or both input and output of the Payload Recorder:

Source/Destination	I - INPUT	O - OUTPUT
	N - NEITHER	B - BOTH
Payload Distribution Panel		
Ku Signal Processor		
Data/Voice from NSP		
FM Signal Processor		

14. If the Control talk back for the Payload Recorder is barber-pole, this means all ground commands are blocked out and the crew has control over the recorder. True or False?

15. Which one of the following actions will not give the control of the Payload Recorder to the crew?
- a. Real Time Command performed by crew.
  - b. Standby Crew Reset Command from INCO.
  - c. Power Cycle of PF #1 MDM.
  - d. Power Cycle of the Payload Recorder.
  - e. None of the above.
16. In a Coherent payload, the receiver and the transmitter move simultaneously. If the receiver sweeps, the transmitter sweeps proportionately. True or False?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: S-band FM

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, S-band Comm/Inst Training Manual 2102, Nov. 1993; SSSH

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The S-band FM System is designed to be a downlink system only. Since the S-Band FM system does not operate through the TDRS system, it can be used simultaneously with the S-band PM return link to a STDN ground station. The S-band FM system is able to downlink data from up to seven different sources (one at a time), but is primarily used to transmit TV and dump Operational Recorder data to the ground.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the primary purpose of the S-band FM System  
REF.: SCOM, Section 2: S-Band Frequency Modulation. S-BD Comm/In 2102, Section 6.
- State the location of the controls for the S-band FM system and how each is used.  
REF.: SCOM, Section 2: S-Band Frequency Modulation.
- List the sources for output to the S-band FM Transmitter  
REF.: SCOM, Section 2: S-Band Frequency Modulation.
- State the transmit and receive capabilities of the S-band FM Antenna System.  
REF.: SSSH, Drawing #16-2, p. 3 of 3. SCOM, Section 2: S-Band Frequency Modulation.

### EXERCISES:

1. The primary purpose of the S-Band FM system is to:
  - a. Transmit voice and selected data directly to the ground via STDN or Air Force ground stations.
  - b. Transmit and receive selected data only via STDN or Air Force ground stations.
  - c. Transmit selected data only via STDN or Air Force ground stations.
  - d. Transmit selected data only via TDRS network.
2. Controls for the S-band FM System are located:
  - a. On panel A2
  - b. On panel A1R
  - c. On panel O6
  - d. and selected by INCO only.
3. The selectable sources, via panel A1R or ground command, for the S-band FM system are:
  - a. OPS RCDR, DOD, ME, A/G1, A/G 2, UHF, PL ANLG
  - b. TV, OPS RCDR, ME, A/G 1, A/G 2, PL DIGITAL, PL RCDR
  - c. TV, OPS RCDR, ME, DOD, PL DIGITAL, PL ANALOG, PCMMU
  - d. TV, OPS RCDR, PL ANLG, PL DIGITAL, PL RCDR, ME, DOD
4. It is possible to simultaneously transmit and receive via the S-Band FM Antenna switch.  
True or False?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: S-BAND PM OPERATIONS

**SOURCE:** DT27/ COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** FDF, Sbd COMM/IN 2102, SM TM 2102, COMM SPEC 2157 CBT

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The S-band PM system is the PRIME source of Orbiter U/L voice and commanding and D/L voice and telemetry. It is used during all phases of flight through TDRSS primarily and ground stations when needed. This study guide will prepare you for 3000 level training and is written specifically towards operations in actual as well as simulated flight. The S-bd PM system includes the PM transponder, PM Power Amp, PM Preamp, Antenna Switch, Network Signal Processor (NSP) and COMSEC LRUs.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe nominal system configuration during all flight phases.  
REF.: Sbd COMM/IN 2102 Sections 2, 3 & 4, SM TM 2102, COMM SPEC 2157 CBT  
Ascent / Orbit/ Entry CLs, REF DATA, Ascent/Orbit/Entry Pocket CLs, DPS DICT
- Discriminate between nominal system operation and system failure during all flight phases.  
REF.: Sbd COMM/IN 2102 Sections 2, 3 & 4, SM TM 2102, COMM SPEC 2157 CBT  
Ascent / Orbit/ Entry CLs, REF DATA, Ascent/Orbit/Entry Pocket CLs, DPS DICT
- Describe workaround options for typical S-bd PM system failures including buss loses.  
REF.: Sbd COMM/IN 2102 Sections 2, 3 & 4, SM TM 2102, COMM SPEC 2157 CBT  
Ascent / Orbit/ Entry CLs, REF DATA, Ascent/Orbit/Entry Pocket CLs, DPS DICT
- Describe nominal Comm coverage during all flight phases.  
REF.: Sbd COMM/IN 2102 Sections 2, 3 & 4, SM TM 2102, COMM SPEC 2157 CBT  
Ascent / Orbit/ Entry CLs, REF DATA, Ascent/Orbit/Entry Pocket CLs, DPS DICT

### EXERCISES:

1. Which S-bd PM string is configured for primary operation pre-flight and used through-out the mission and which string is configured for back-up as reflected by the Panel A1 switches?
  - a. String 1 prime, String 2 b/u
  - b. String 2 prime, String 1 b/u
2. True or False: At liftoff, S-bd string 1 and 2 are configured for STDN-HI mode?
3. Ascent Comm coverage is referenced where in the FDF?
  - a. Ascent Checklist
  - b. Ascent Pocket Checklist
  - c. Ascent Checklist Flight Supplement
  - d. Ascent/Entry Systems Procedures
4. The Stored Program Command (SPC) to change the S-bd PM transponder from STDN HI to TDRS mode occurs at what MET for High and Low inclination trajectories ?
  - a. 10 min High/ 11 min Low
  - b. 11 min High/ 10 min Low
  - c. 10 min High or Low
  - d. 11 min High or Low

5. For a loss of comm during ascent, pre SPC, what is required before an S-bd PM panel/ command can be performed to establish good comm with MCC?
  - a. Nothing
  - b. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING OFF
  - c. Reconfigure Panel A1 PM transponder/ NSP to STDN-HI, TX/RCV CODING ON
  - d. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING ON
6. For a loss of comm during ascent, post SPC but pre Post Insertion CL, what is required before an S-bd PM panel/ command can be performed to establish good comm with MCC?
  - a. Nothing
  - b. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING OFF
  - c. Reconfigure Panel A1 PM transponder/ NSP to STDN-HI, TX/RCV CODING ON
  - d. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING ON
7. The SPC which modes the PM transponder to TDRS during ascent is stored where?
  - a. PL 1 MDM
  - b. BFS GPC
  - c. GCIL
  - d. GNC GPC
8. True or False: If the control element fails to execute the SPC during ascent, MCC will try to uplink a real-time command to switch to TDRS mode.
9. During ascent/ entry, what controls PM quad antenna selection based on Orbiter position and attitude?
  - a. BFS GPC
  - b. PL 1 MDM
  - c. Antenna Electronics
  - d. GNC GPC
10. True or False: If the control element fails to select the correct PM quad antenna during ascent, MCC will expect the crew to select the correct antenna manually.
11. True or False: The control element that selects the correct PM quad antenna monitors the PM mode through MDM OF3/ PCMMU to know whether to point towards TDRS or a ground site .
12. True or False: As currently configured (NASA Mode), a COMSEC power failure would affect U/L voice and commands only.
13. U/L command routing through the LRUs are:
  - a. NSP/COMSEC 1/2, FF MDM 1/3, GPCs
  - b. NSP/COMSEC 1/2, P/L MDM 1/2, GPCs
  - c. NSP/COMSEC 1/2, GCIL, FF MDM 1/3
  - d. P/L MDM 1/2, NSP/COMSEC 1/2, GPCs
14. True or False: COMSEC LRUs are hardwired to each NSP and cannot be crosstrapped therefore a COMSEC failure requires using the B/U NSP.
15. True or False: Comm config SPCs during Ascent and Entry are handled by the GNC GPC.

16. The antenna management software for orbit resides in the:
  - a. GCIL
  - b. SM GPCs
  - c. GNC GPC
  - d. Antenna Electronics 1/2
  
17. Delayed ET sep can cause:
  - a. Weak signal strength until ET sep or heads up
  - b. No D/L comm until ET sep or heads up
  - c. No U/L comm until ET sep or heads up
  - d. No U/L or D/L comm until ET sep or heads up
  
18. True or False: During an RTLS, the normal SPC is cleared and comm is through the STDN site until landing.
  
19. What bus loss will cause loss of Comm while on the prime PM system (String 2):
  - a. Main A
  - b. Main B
  - c. Main C
  - d. ESS 2AB
  
20. True or False: Anytime the message "BCE STRING X NSP" annunciates there will be a loss of Comm.
  
21. What are the consequences of a GCIL fail on S-bd PM comm:
  - a. The system is immediately configured per the back panel
  - b. MCC can no longer command the system
  - c. The system changes to high frequency if it was in low frequency
  - d. All the above
  
22. For a given GPC failure, what must happen if MCC is to have the ability to command antennas and command changes to the S-bd PM system:
  - a. A panel/ command is required
  - b. The P/L buses must be assigned to a operational GPC
  - c. The U/L block switch on panel C3 must be in Enable
  - d. There is no way to recover once a GPC has failed.
  
23. An indication that MCC has performed an early TDRSS East handover is:
  - a. Only the EAST TDRS is displayed on the ANT DISP
  - b. An item 19 OVRD on the ANT DISP
  - c. Longer than normal comm loss in the ZOE
  - d. East TDRS is selected as prime on the ANT DISP Item 13
  
24. An item 19 OVRD on the ANT DISP is used to:
  - a. Allow early TDRSS East handover
  - b. Allow uplink commanding in the ZOE
  - c. Force the Ant GMT program to point at TDRSS
  - d. Force a software panel/command
  
25. Aft panel reconfig is required prior to a PM panel/command: (Choose two)
  - a. After Ascent TDRSS handover but before Post Insertion reconfig
  - b. EI to touchdown
  - c. for Pre-sleep comm config
  - d. After De-orbit Prep reconfig but before STDN handover

26. True or False: Downlink is delayed 140 sec after a PM panel/command on orbit.
27. Power down of the PM system for a loss of 2 water loops must be done within:
- a. 30 min.
  - b. 10 min.
  - c. 1 min.
  - d. as directed by MCC
28. Prime source of communication with MCC on-orbit through the PM system is:
- a. SGLS sites
  - b. STDN sites
  - c. TDRSS satellites
  - d. UHF sites
29. True or False: S-bd TDRS mode is used during entry to prevent comm loss due to RF blackout ionization to ground sites but loss of comm can still occur under certain conditions.



## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: UHF

**SOURCE:** DT27/COMM

**REV.:** Oct. 1997

**MATERIALS REFERENCED:** SCOM, Audio/UHF 2102 Training Manual.

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** The Ultra High frequency (UHF) system provides two-way communications with the mission control center. The system is used as backup to the S-band system and as prime for Extravehicular Activity (EVA) operations. The suggested reading material contains information necessary to become familiar with the UHF configuration and operation.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State where the ground site support information for UHF is found.  
REF.: Malfunction Procedures 2.3c, Audio/UHF 2102 Training Manual.
- Explain how UHF is relayed to MCC at the TAL site.  
REF.: Audio/UHF 2102 Training Manual Section: UHF Transceiver.
- State the panel that is used to route audio from the UHF transceiver to the ACCU.  
REF.: SCOM Section 2.4: Ultra High Frequency.
- Explain the purpose of the UHF Simplex mode.  
REF.: Audio/UHF 2102 Training Manual Section: UHF Transceiver. SCOM Section 2.4: Ultra High Frequency.
- Explain the purpose of the UHF EVA mode.  
REF.: Audio/UHF 2102 Training Manual Section: UHF Transceiver. SCOM Section 2.4: Ultra High Frequency.
- Explain what the squelch is used for on panel O6.  
REF.: Audio/UHF 2102 Training Manual Section: UHF Transceiver.

### EXERCISES:

1. The \_\_\_ FDF contains information about ground sites that support UHF.
  - a. OPCL
  - b. AESP
  - c. Malfunction Procedures
  - d. OPCL
2. TAL sites relay UHF comm to MCC through the \_\_\_\_.
  - a. STDN site
  - b. IMARSAT system
  - c. SGLS site
  - d. TDRS networks

3. Panel \_\_\_\_ is used to configure routing of audio from the ACCU to the UHF transceiver.
  - a. A1L
  - b. O6
  - c. A1U
  - d. A1R
  
4. The method of transmitting on one frequency and receiving on two different frequencies is the \_\_\_\_ mode.
  - a. G T/R
  - b. SIMPLEX
  - c. OFF
  - d. EVA
  
5. The method of transmitting on one frequency and receiving on the same frequency is the \_\_\_\_ mode.
  - a. SIMPLEX + G RCV
  - b. SIMPLEX
  - c. OFF
  - d. EVA
  
6. The Squelch switch on panel O6 is normally on. TRUE or FALSE

# CONTROL

## Section 2 - Control

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OMS/RCS .....	2-18
OMS Burn Malfunctions .....	2-20
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## Materials Referenced

Abort Fam BR 2101
Approach and Landing 2101
A/E FCS 2106
Controllers 2102,
DAP 2157 (CBT)
DPS Dictionary
D/O FLT TECH 2101
D/O BURN BR 2101
D/O BURN BR 2201
Entry Aerodynamics 2101
Entry DAP Skills 2101
Entry DAP 2101
Entry Guidance 2101
Entry 2101
FCS Channels 2101
FCS Effectors 2102
FCS SST Review 2101
Flight Procedures Handbooks -
Flight Rules
GNC I/O/D 2102
Guidance and Control Sensors
and Controllers 2101
HUD 2157
MPS OPS Users Guide 2102
MPS MAL Users Guide 2102
OM/RC Burn 2106
OM/RC EPS/DPS 2106
OMS 2102
OMS OV 2101
OMS OPS 2106
OMS MAL SST 2101
OMS MAL 2106

**Materials Referenced**

OMS Targeting PT2 2201
RCS 2102 A
RCS OV 2101
RCS OPS SST 2106
RCS MAL SST 2101
RCS MAL 2106
SCOM,
Sensors 2102,
Snsrs/Cont 2106
TAEM Guidance 2101

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: ASCENT/ABORT PROCEDURES

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** Ascent/Abort Flight Procedures Handbook (FPH) “Contingency Abort Crew Procedures” and “Crew Operations”, GNC DED DISP 2157, HSI 2157, Space Shuttle Systems Handbook (SSSH) Section 20, CRT Reference Summary/DPS Dictionary, Ascent Checklist (ACL), and Flight Rules, All of Section 1 and Ascent phase of Sections 2 and 4.

**TOPIC SYNOPSIS:** This study guide focuses on a general review of ascent procedures, cockpit displays/controls, and trajectory dependent cockpit indications. The specific rationale for each procedural step will not be addressed in this study guide as they are covered in 3K level (assigned crew) training.

**PERFORMANCE OBJECTIVES:** At the end of this review, the astronaut will be able to:

- Use photos and drawings of cockpit panels/CRT displays to configure the cockpit controls according to the sequence referenced in the Ascent Checklist for any ascent/abort trajectory, as dictated by the nature and timing of failures (if any).  
REF.: Ascent/Abort FPH, Ascent Checklist, SSSH Section 20. and DPS Dictionary
- Given failures correlate the cockpit actions affecting the trajectory to their flight rule rationale.  
REF.: Ascent Checklist, and Flight Rules.
- Relate cockpit indications to guidance and flight control mode changes at abort selection or trajectory phase changes.  
REF.: CRT Reference Summary or DPS Dictionary, GNC DED DISP 2157, and HSI 2157.
- Explain the purpose of each page/cue card of the ACL.  
REF.: Ascent/Abort FPH.
- Explain when each page/cue card of the ACL is used.  
REF.: Ascent/Abort FPH.

#### EXERCISES:

1. With an SSME failure between the press to ATO and press to MECO performance boundaries, what is the procedural flow through the ACL for orbital insertion? How does the flow change with earlier and later engine failures?
2. What is the purpose of the ACL “NO COMM MODE BOUNDARIES/SYS FLIGHT RULES” page, and when is it used?
3. When is the “ASCENT PROCEDURES” page used?
4. Assuming direct insertion MECO velocity, when are the “POST OMS 1” procedures used and why?
5. If an SSME fails before negative return and after 2 engine TAL, what is the preferred abort mode?
6. Where are the velocities located for single engine TAL and single engine OPS3 once an SSME has failed and a TAL abort has been declared?
7. Post MECO, what section of the ACL is used to verify the actual OMS target parameters displayed on the OMS maneuver execute display?

8. According to the “SYS FLIGHT RULES” page, an RTLS or TAL abort must be selected (if possible) if 2 APUs have failed and the last one is failing, why? Which abort is to be selected, TAL or RTLS?
9. According to the “ASCENT PROCEDURES” page, if TMECO is not stable within 10 seconds of MM103 activation, CSS and manual throttles is required, why?
10. What are the abort priorities for RTLS, TAL, and ATO? Where are these priorities located in the ACL?
11. What cockpit indications are used to verify any abort selection during powered flight?
12. Besides vehicle maneuvering, how are the PPA and PPD phases of RTLS guidance verified in the cockpit?
13. What cockpit indications are used to anticipate MECO?
14. What cockpit indication show PEG to be unconverged?
15. When is a contingency abort required and where are these procedures located?
16. Looking at the Contingency Abort Cue Card, are the procedures automatic or manual?
17. Using cockpit photos/drawings and the DPS dictionary, hypothetically execute the switch throws following the ATO sequence presented in the first question. Repeat the same task for an engine failure RTLS and TAL abort. From a crew task loading standpoint, which procedure is most complex? How does the complexity change for a systems abort? What about AOA?
18. Ten seconds after MM103 initialization the OMS assist burn initiates and continues unabated to completion. Assuming a nominal ascent with a guided cutoff:
  - a) What is the easiest way the crew determines how much OMS propellant is available before any OMS burns are performed?
  - b) How does the crew know if the OMS assist burn consumed the correct amount of propellant?
  - c) How is the information in a and b above useful to the crew?
19. Barring any failures, what event triggers the command to roll the vehicle heads-up during MM103? Where is this information located in the ACL?
20. What is auto del psi, is it visible in the cockpit, and what is its purpose?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Ascent Performance Boundary Calls

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** SCOM - section 6.2, Flight Rules - section 4

**SUPPLEMENTAL MATERIAL:** None

#### TOPIC SYNOPSIS: Definitions of Ascent Performance Calls

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:  
Define each of the following ascent performance boundary calls in terms of crew action required.

- 2 ENGINE (Prime TAL)  
REF.: SCOM - section 6.2, Flight Rules - section 4
- NEGATIVE RETURN  
REF.: SCOM - section 6.2, Flight Rules - section 4
- PRESS TO ATO  
REF.: SCOM - section 6.2, Flight Rules - section 4
- PRESS TO MECO  
REF.: SCOM - section 6.2, Flight Rules - section 4
- SINGLE ENGINE OPS 3 (Prime TAL Site or ACLS) 109%  
REF.: SCOM - section 6.2, Flight Rules - section 4
- SINGLE ENGINE (Prime TAL Site or ACLS) 104%  
REF.: SCOM - section 6.2, Flight Rules - section 4
- SINGLE ENGINE PRESS (to MECO) 104%  
REF.: SCOM - section 6.2, Flight Rules - section 4

#### EXERCISES:

##### Case 1

Center main engine fails between 2 ENGINE TAL and NEGATIVE RETURN.

1. What abort do you initiate?

##### Case 2

Left main engine fails at PRESS TO MECO.

1. What abort do you initiate?
2. What conditions do you expect at MECO?
3. What is the impact to the SINGLE ENGINE PRESS performance boundary?  
Subsequently, the right main engine fails 200 ft/sec prior to SINGLE ENGINE PRESS.
4. What abort do you initiate?

##### Case 3

Center main engine fails between PRESS TO ATO and PRESS TO MECO.

1. What abort do you initiate?
2. What conditions do you expect at MECO?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Orbit DAP

**SOURCE:** DT66/Control Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** GNC I/O/D 2102A 1995, DAP 2157 (CBT)

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This study guide reviews the displays, controls, and crew procedures associated with the RCS mode of the orbit DAP. The function of the DAP PBIs, RHC/THC, and SPEC 20 display are included.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the function of each of the DAP PBIs on panel C3 and A6.  
REF.: DAP 2157 Lesson 1, GNC I/O/D 2102A Section 3-D
- Determine the DAP parameters by consulting SPEC 20. Describe how the I-loaded values of a given DAP are altered.  
REF.: DAP 2157 Lesson 2, GNC I/O/D Section 3-C.
- Describe the positions of the RHC and describe how it is used for rotation maneuvers during orbit operations.  
REF.: DAP 2157 Lesson 1, GNC I/O/D 2102A Section 4.

### EXERCISES:

1. Explain 3 ways to place the DAP in free drift.
2. The 'DISC RATE' and 'PULSE' PBIs below the rotation label will have no effect when the \_\_\_\_\_ control mode is selected.
3. The \_\_\_\_\_ PBI refers to a special +Z translation, has no effect on rotations, and is mutually exclusive from 'NORM', 'PULSE', and \_\_\_\_\_ PBIs.
  - a). 'LOW Z', 'HIGH Z'
  - b). 'HIGH Z', 'LOW Z'
  - c). 'LOW Z', 'FREE'
  - d). 'HIGH Z', 'VERN'
4. Describe how to configure the DAP PBIs such that the vehicle will hold an LVLH attitude hold in roll and yaw, but is in free drift about the pitch axis.
5. Name the three positions of the RHC (while in the RCS mode of the DAP) and describe their function when the appropriate axis is in the 'DISC RATE' and 'PULSE' mode.
6. Describe how you would load DAP A2 and B5.
7. Describe how to change the I-loaded rotation rate in DAP B12 to 0.5 deg/sec.
8. Describe two ways in which you could perform a pitch maneuver of 2.0 deg/sec while maintaining an inertial attitude hold in both the roll and yaw axes.

Note: The following nomenclature was used:

All caps surrounded by single quotation marks refers to a specific DAP PBIs (ex. 'INRTL').

For DAP configurations, the control mode is listed first followed by a colon and the rotation submodes in the sequence of roll, pitch, and yaw separated by slashes (ex. INRTL: PULSE/PULSE/DISC)



## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Deorbit Burns

**SOURCE:** DT66/Control Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** ENT GUID BR 2101; ABORT FAM BR 2101; D/O BURN BR 2101; D/O FLT TECH 2101; D/O BURN BR 2201; ATO/AOA/TAL 2102 - Sec. 4; SCOM -Sec. 7.3.

**SUPPLEMENTAL MATERIAL:** OMS 2102 - Sec. 3 & 4; OMS OPS 2101/2106; OMS MAL 2106; OMS TGTING 2201; OM/RC BURN 2106; OM/RC MAL A/E 2106; OMS/RC DPS/EPS 2106; ASCENT C/L, ENTRY C/L; ENTRY FPH.

**TOPIC SYNOPSIS:** This study guide reviews those aspects of OMS/RCS burns that are unique to a deorbit burn. Emphasis is placed on D/O Burn methods and rationale; downmoding options; technical flying aspects and trajectory results.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Explain the unique PEG 4 target aspects for a deorbit burn with regard to C1, the C2 slope, HT,  $\Theta$  definition, propellant wasting, and choice of TIG.  
REF.: ATO/AOA/TAL 2102 - Sec.4; D/O BURN BR 2101
- Describe the flight trajectory resulting from a deorbit burn with regard to flight path angle; REI; TGT HP.  
REF.: ENT GUID BR 2101; D/O BURN BR 2101
- Explain the difference between steep and shallow targets.  
REF.: ENT GUID BR 2101; ABORT FAM BR 2101; D/O BURN BR 2101
- Describe results of an underburn or overburn for a nominal end-of-mission (EOM) deorbit.  
REF.: ENT GUID BR 2101; D/O BURN BR 2101
- State all the downmode options for a 2 OMS engine deorbit burn in order of preference.  
REF.: D/O BURN BR 2101; SCOM - Sec. 7.3
- Explain the D/O burn milestones as given on the DEL PAD: OMS FAIL HP, SAFE HP, ENG FAIL HP, AFT QTY 1, AFT QTY 2, FLIP HP, and AFT HP.  
REF.: D/O BURN BR 2101
- Describe the technical aspects of flying the deorbit downmodes, including use of the OMS% vs RCS Burn Time chart, the Patterson maneuver, the fast-flip for FRCS completion, and prebanking.  
REF.: ENT GUID BR 2101; D/O BURN BR 2101; D/O FLT TECH 2101; SCOM - Sec. 7.3
- Determine when a deorbit waveoff is required per the DEORBIT BURN FLIGHT RULES cards.  
REF.: D/O BURN BR 2101; SCOM - Sec. 7.3; ENTRY C/L
- Explain what procedures are required for a deorbit backout.  
REF.: D/O BURN BR 2101
- Explain the deletion of OMS He TK P LOW and N2 problems from the D/O BURN MONITOR card. Explain the inclusion of GPC set failures, IMU dilemmas, and Main bus failures to the D/O BURN MONITOR card.  
REF.: D/O BURN BR 2101
- State the 5 possible deorbit burn scenarios  
REF.: D/O BURN BR 2101; D/O BURN BR 2201

- Explain the reasons for each type of deorbit method and determine which method would be used for a given initial condition.  
REF.: D/O BURN BR 2101; D/O BURN BR 2201
- Identify the flight data file procedures required for each deorbit method.  
REF.: D/O BURN BR 2101; D/O BURN BR 2201

**EXERCISES:**

1. What is unique about the PEG 4 C2, Ht, and  $\Theta$ T for a deorbit burn?
2. How will propellant wasting affect the OMS tank landing weight constraints and orbiter C.G.?
3. An underburn will
  - A. Increase REI
  - B. Decrease REI
  - C. Not have any effect on REI.
4. State the downmode options for a 2 OMS engine deorbit burn in order of preference.
5. If the L OMS has a propellant failure exactly at L OMS FAIL HP, then what deorbit downmodes should be expected and what deorbit milestones come in to play?
6. A deorbit burn (of any type) will be continued for just 1 OMS PRPLT FAIL above SAFE HP.  
TRUE / FALSE
7. Why must RCS burns interconnected to OMS propellant be timed?
8. In the Patterson maneuver, what holds the vehicle in the correct burn attitude once the THC is pushed/pulled and the RCS jets start thrusting and thus torquing the vehicle about its C.G.?
9. The fast flip to FRCS is executed at a pitch up rate of
  - A. 1°/sec.
  - B. 3°/sec.
  - C. 5°/sec.
10. Why is prebank performed (if required) at EI-5 min/MM304 instead of during MM303?
11. If GPC 1 fails prior to OMS ignition and One-orbit late is available, will the deorbit burn be executed on time?
12. If an IMU dilemma occurs during a deorbit burn at an HP of 120 nm, how should the deorbit burn proceed and why?
13. If the R OMS N2 accumulator develops a leak during the deorbit burn resulting in an OMS N2 REG P LOW and OMS N2 TK P LOW and decreasing, what would the D/O BURN MONITOR have one do and why?
14. What are the 5 recognized deorbit scenarios?
15. If a L OMS FU TK leak developed on orbit and depleted that tank, what method of deorbit would be used and what unique set of FDF procedures would apply?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Entry Procedures

**SOURCE:** DT66/Control Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** Entry 2101, Entry Aerodynamics 2101, Entry Guidance 2101, TAEM Guidance 2101, Entry Digital 2101, Entry DAP Skills 2101, Approach and Landing 2101, Entry Flight Procedures Handbook.

**SUPPLEMENTAL MATERIALS:** None

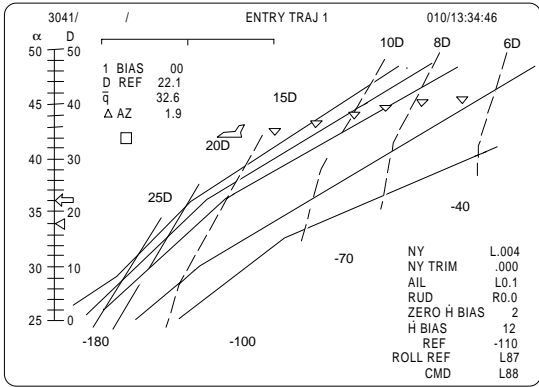
**TOPIC SYNOPSIS:** This study guide reviews the entry procedures and limitations for nominal and off-nominal entry profiles from entry interface to the approach and landing transition.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the three phases of entry from MM304 to landing.  
REF.: Entry Overview 2101
- State the transition points from Entry to TAEM and TAEM to Approach and Land guidance for nominal EOM/TAL (OPS3) and RTLS (OPS6).  
REF.: Entry Guidance 2101, TAEM Guidance 2101, Approach and Landing 2101
- State the airspeed, angle of attack (alpha), and g limits on the orbiter.  
REF.: Entry Aerodynamics 2101, Entry DAP Skills 2101
- Explain your options to correct for high and low energy situations in both Entry and TAEM.  
REF.: Entry Guidance 2101, TAEM Guidance 2101
- Locate and explain the procedures for the following off-nominal entry situations:
  - Single ADTA or No air data (Theta Limits)
  - RCS Critical (No Yaw Jet)
  - Aileron Trim SaturationREF.: TAEM Guidance 2101, Entry DAP Skills 2101

### EXERCISES:

1. Explain how downrange and crossrange parameters are controlled during the Entry and TAEM phases of flight. List the constraints of the guidance modes (e.g., thermal constraints are met by following an alpha profile.)
2. Define the transitions between the entry phases of the flight: Entry, TAEM, and Approach and Land. Describe the cockpit cues to confirm the transitions.
3. What are the orbiter entry alpha limits and where can you find them in the cockpit?
4. What are the maximum/minimum airspeed limits and are they posted on the flight deck?
5. For nominal entry, what is the maximum Flight Rule g limit on the orbiter? What cockpit cues indicate that you are approaching the g limit?
6. Given that auto guidance is good, how would you fly the following situation:



- a. Do nothing, guidance is good, Auto can fly it.
- b. Take CSS, work  

$$\text{Hdot} = \text{Hdot}_{\text{ref}} + 20(D_{\text{current}} - D_{\text{ref}})$$
 where  $D_{\text{ref}} = 13$
- c. Fly reference Hdot (CSS)

7. What are your downmode options in TAEM for low energy situations?
8. What procedure and cockpit cues are used to fly Theta Limits?
9. When should the No Yaw Jet entry mode be selected?
10. What cockpit cues indicate aileron trim and at what value does the crew take action?
11. Why does the AIL TRIM > 3° procedure have you wait until Mach < 5 to manually trim the ailerons < 1°?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: FCS

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** FCS Channels 2101, FCS SST Review 2101, A/E FCS 2106, FCS Effectors 2102

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This study guide reviews functions, procedures, and displays of the FCS.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Define each FCS switch position.  
REF.: A/E FCS SST Review 2101, FCS Effectors 2102, A/E FCS SST 2106
- Describe the results of FCS related Item entries on SPEC 53 and SPEC 51.  
REF.: A/E FCS SST Review 2101, FCS Effectors 2102, A/E FCS SST 2106
- Describe the rationale for the FCS related FDF procedures.  
REF.: A/E FCS SST Review 2101, A/E FCS SST 2106, A/E FCS SST 2106
- Use cockpit resources to diagnose FCS related failures.  
REF.: A/E FCS SST Review 2101, A/E FCS SST 2106
- Explain the concepts of commands, feedback, RM, and fault tolerance.  
REF.: FCS Channels 2101, A/E FCS SST Review 2101, A/E FCS SST 2106
- State how the body flap is different from the other aerosurfaces.  
REF.: FCS A/E SST Review 2101, FCS A/E SST 2106

### EXERCISES:

1. Describe the function of the OFF, AUTO, and OVERRIDE positions of the FCS switches.

2. Given the following signature, what is the failure? Should any actions be taken, and what feedbacks are being processed by the selection filter on each aerosurface?

XXX1/053/		CONTROLS				X DDD/HH:MM:SS		DDD/HH:MM:SS	
SEC	ACT	CK	AERO	PORT	STAT	SSME	PORT	STAT	
					1 2 3 4			1 2 3 4	
CH1	1		L	CB	1	L	P		
	2			IB	2		Y		
	3		R	CB	3	C	P		
	4			IB	4		Y		
START	5			RUD	5	R	E		
STOP	6		SPD	BRK	6		Y		
NEG	STIM					ACT/CH			
ENA	7		8	BYPASS					
			9	RESET					
LRU	AA		RG			SURF	FDBK		
	DES		DES			DES			
1	10		14			18			
2	11		15			19			
3	12		16			20			
4	13		17			21			

PASS CRT Fault Message:

“FCS Ch 2”

Master Alarm

F7 “FCS” Light

- Using the above display, mentally place a column of M’s under the SSME port STAT 4, the AERO Port Stat 4, and an M by the Surf Fdbk Des (#21) and RGA DES (#17). Given this signature in addition to the above failure, describe the failure, actions required and rationale behind the actions.
- What are the major differences between the Body Flap and the other aerosurfaces?
- What Body Flap fault message do you expect if 2 APU’s fail?
- What is the result of “ITEM 8 + 12 EXEC” on SPEC 53 and when would the crew do this?
- What is the result of “ITEM 18 EXEC” on SPEC 53?
- Why does the crew take the affected FCS channel to OFF for a GPC or MDM failure?
- If a down arrow appears by ITEM 19 on SPEC 53 with no other signatures, what is the failure?
- What is the “hole” in the FCS dual fault tolerant scheme?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Approach and Landing

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** APPR/LNDG BR 2101; APPR/LNDG 2111, HUD CBT

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** Approach and Landing

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the general trend of the A/L Constraints (dynamic pressure, flight path angle, glideslope, and crosstrack) as related to altitude in obtaining Approach and Land guidance.  
REF.: Approach and Landing 2101 Briefing
- Predict what happens to the guidance needles when you are transitioning from Prefinal to Final (outer glideslope).  
REF.: Approach and Landing 2101 Briefing, HUD CBT
- Describe the visual cues which are available to help maintain the outer glideslope.  
REF.: Approach and Landing 2101 Briefing
- Describe the control input that is required in the preflare.  
REF.: Approach and Landing 2101 Briefing
- Explain the purpose of the preflare.  
REF.: Approach and Landing 2101 Briefing
- State the primary cue for flying the Inner glideslope.  
REF.: Approach and Landing 2101 Briefing, HUD CBT
- State the three ways to steer the vehicle during rollout and which is the preferred way for the two point and three point stance.  
REF.: Approach and Landing 2101 Briefing
- Describe the four different types of drag chute deploy.  
REF.: Approach and Landing 2101 Briefing

### EXERCISES:

1. Fill out the parameters that you will be targeting for a nominal landing: (REF.: Approach and Landing 2101 quizzes)  
A/L guidance occurs at \_\_\_\_\_  
Arm the gear at \_\_\_\_\_  
Deploy the gear at \_\_\_\_\_  
Land with an Hdot of \_\_\_\_\_  
Touchdown speed of \_\_\_\_\_  
Touchdown distance down the runway \_\_\_\_\_  
Deploy Chute at \_\_\_\_\_  
Start derotation at what EAS \_\_\_\_\_  
Derotate at what rate \_\_\_\_\_  
What is the Braking profile \_\_\_\_\_  
Jettison the chute at \_\_\_\_\_

2. Is Approach and Land Guidance available in the PASS and BFS?  
REF.: Approach and Landing 2101 Briefing for impacts to A/L while on the BFS.
3. Suppose the landing crosswind is 15 kts. What kind of Drag Chute deploy do you suspect the ground would ask for and why?
  - A. Nominal Drag Chute deploy because you have not exceeded the crosswind limit for drag chute deploy.
  - B. Emergency deploy because you have exceeded the crosswind limit for drag chute deploy.
  - C. Late Deploy because the ground will try to obtain the Crosswind Landing DTO.
4. Suppose prior to landing, but below Mach 6, the crew is informed that the right outboard tire has failed and there is a strong left crosswind. What can the crew expect to happen and what response should the crew provide during landing and rollout?
5. Which of the following cues can the crew expect to occur when Approach and Land Guidance has been achieved?
  - A. MM 304 to 305 transition
  - B. Flashing "A/L" on the VERT SIT Display
  - C. Speedbrake goes closed
  - D. Body Flap goes to Trail
  - E. "CAPT" on the HUD
  - F. Pitch light goes to AUTO
6. If the PAPI's are indicating 2 red and 2 white, what is your glideslope.
  - A. 18°
  - B. 20°
  - C. 16°
7. TRUE or FALSE The preflare transitions the orbiter from the outer glideslope to the inner glideslope by arresting the descent rate from 200 fps to 12 fps and is completed by 2000'.
8. TRUE or FALSE When on the Inner Glideslope the white ball will appear to superimpose the red Bar.



## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: MPS

**SOURCE:** DT66/Control/Propulsion Section

**REV:** DEC 1997

**MATERIALS REFERENCED:** MPS OPS Users Guide 2102, MPS MAL Users Guide 2102, ASC GUID 2101 Briefing Handout, MAN ASC BR 3101 Briefing Handout

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This study guide provides the MPS related objectives that must be met by the student prior to beginning 3000 level training.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe CRM issues related to MPS..  
REF.: MPS OPS User's Guide 2102 (Section 3)
- Explain the rationale of the major steps for all nominal MPS related FDF procedures.  
REF.: MPS OPS User's Guide 2102 (Section 3)
- Describe a nominal SSME throttling profile during ascent.  
REF.: MPS OPS User's Guide 2102 (Section 2.1)
- Explain how to take MAN throttles and verify MAN throttles.  
REF.: MPS MAL User's Guide 2102 (Section 2.4)  
ASC GUID 2101 Briefing Handout  
MAN ASC BR 3101 Briefing Handout
- Explain how to return to AUTO throttles.  
REF.: MPS MAL User's Guide 2102 (Section 2.4)  
ASC GUID 2101 Briefing Handout  
MAN ASC BR 3101 Briefing Handout
- Identify the primary impact of being in MAN throttles at MECO.  
REF.: MPS MAL User's Guide 2102 (Section 2.4)  
ASC GUID 2101 Briefing Handout  
MAN ASC BR 3101 Briefing Handout
- Explain how to perform a manual MECO.  
REF.: MPS MAL User's Guide 2102 (Section 2.4)  
ASC GUID 2101 Briefing Handout  
MAN ASC BR 3101 Briefing Handout

- Given the following failures:
  1. Single or Multiple SSME Failures
  2. Single or Multiple Hydraulic and/or Electric Lockups
  3. Command Path Failure
  4. Stuck Throttles in the Bucket
  5. Data Path Failure
  6. Main Engine Helium Leak
  7. Pneumatic Helium Leak
  8. MPS Helium Leaks Post MECO
  9. Low ET LH2 Ullage Pressure
  10. ET SEP Inhibit
  11. ET SEP Switch Failures (ET SEP MAN)
  12. No MECO Confirm (MULTI MPS DATA)
  13. High LH2/LO2 Manifold Pressure Post MECO
  14. MPS Helium Regulator Failure on Entry

Answer the following questions:

1. Describe the orbiter flight deck cues associated with each of the following failures:
2. Describe the rationale behind the following MPS malfunction procedures:

REF.: MPS MAL User's Guide 2102

- Identify the only type of procedures performed where MAN throttles at 2% for a single SSME is NOT ROUTINELY required.  
(For these procedures, if MAN throttles at 2% is NOT specifically called out, it is not performed).  
REF.: MPS MAL User's Guide 2102 (Section 2.4)
- Describe the rationale behind the MPS steps of each of the following "non-MPS" related procedures:
  1. BFS Engage (ascent with previous SSME fail only)
  2. Single GPC/FA Failures (ASC PKT C/L)
  3. EPS Bus Failures (ASC PKT C/L for only those buses that also fail ALC 1, 2, or 3)
  4. Multiple GPC/FA Failures (DPS MULTI DATA PATH LOSS)
  5. Multiple Hydraulic Systems Failed (MPS CMD/HYD/ELEC Cue Card)REF.: MPS MAL User's Guide 2102 (Sections 2.7, 2.8, 2.12, 2.13)
- Identify how much time is available post ET SEP to perform the ET SEP: MPS FDLN RLF ISOL (two) - OP step in the MULT DATA PATH LOSS (AESP) procedure before a potential catastrophic rupture of the LH2 manifold.  
REF.: MPS MAL User's Guide 2102 (Section 2.13)
- Describe the rationale for the MPS DUMP INHIBIT procedure.  
REF.: MPS MAL User's Guide 2102 (Section 2.11)
- Using the FDF, prioritize multiple SSME malfunctions covered on the MPS CMD/HYD/ELEC Cue Card and explain associated actions and their timing considerations.  
REF.: MPS MAL User's Guide 2102 (Sections 1.2 - 1.6 and 2.1 - 2.2)
- Using BFS GNC SYS SUMM 1, identify the signature of an ALC 1, 2, or 3 failure. Identify the impact of these failures on the isolation of main engine helium leaks.  
REF.: MPS MAL User's Guide 2102 (Section 2.7)

- Identify the impact of FF failures on the crew’s signatures for stuck throttles, data path failures, and SSME failures.  
REF.: MPS MAL User’s Guide 2102 (Section 1.10)
- Identify the primary cue used to determine if the GPCs have recognized that an SSME has failed.  
REF.: MPS MAL User’s Guide 2102 (Section 1.5)
- Using Panel C3, identify the FF and control bus failures that affect the function of the SSME shutdown pushbuttons.  
REF.: MPS MAL User’s Guide 2102 (Section 2.6)
- Explain the impact of a single FF failure on the ability of the SSME pushbutton to shutdown an engine and to set the fail flag. Explain how to shutdown an SSME and set the fail flag if the respective shutdown pushbutton has a single commfault.  
REF.: MPS MAL User’s Guide 2102 (Section 2.6)
- Identify the C&W message associated with pushing the SSME shutdown pushbutton when one contact is failed (due to control bus or switch contact failures). Explain how to shutdown an SSME and set the fail flag in the above situations.  
REF.: MPS MAL User’s Guide 2102 (Section 2.6)

**EXERCISES:**

1. How do you take manual throttles?
  - a. Push the SBTC CSS button on the eyebrow panel.
  - b. Depress the button on the SBTC and release it when the SBTC command is within 4% of the GPC commanded throttle setting.
  - c. Depress the button on the SBTC.
2. During which procedures are “MAN throttles at 2% propellant” not routinely required for a single SSME completion?
3. If the left SSME fails after the single engine press call, and the crew subsequently has to engage the BFS, what MPS related actions should be taken?
4. You see the following signature on BFS GNC SYS SUMM 1 for the center main engine:
 

ULL P LH2	12.0↓
LO2	0.0

 What EPS bus has possibly failed and what impact would this bus have on isolating SSME helium leaks?
5. What impact will FF failures have on signatures for stuck throttles, data path failures, and SSME failures?
6. The center SSME goes into electric lockup at 3:00 minutes and performance is low. What should the crew do and when?

In addition to the above scenario, the left SSME develops a command path failure at 7:15 MET.  
Now what should the crew do and when?  
What action is required for the center engine?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: OMS/RCS

**SOURCE:** DT66/ Control/Propulsion

**REV.:** DEC 1997

**MATERIALS REFERENCED:** Flight Procedures Handbooks, OMS OV Briefing 2101, OMS OPS SST 2106; RCS OV Briefing 2101, RCS OPS SST 2106 ; OMS MAL SST 2101, OMS MAL SST 2106 ; RCS MAL SST 2101, RCS MAL SST 2106, OMS 2102 Workbook April 95, RCS 2102A Workbook November 92, SCOM, OM/RC EPS/DPS 2106.

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This Study Guide provides a list of review items regarding the concepts learned in the ASCAN OMS and RCS flows. This list of objectives will help the student to prepare to work nominal and off nominal OMS and RCS procedures. Objectives which will help the student to review how DPS and EPS malfunctions affect the OMS and RCS systems are also included.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the purpose of and rationale behind all OMS and RCS nominal procedures, including:
  - X-feeds and Interconnect procedures (OMS 2102 - Sec. 3, RCS 2102A - Sec. 4)
  - FRCS dump (SCOM - Sec. 5.4, RCS 2102A - Sec. 3)
  - Power up and powerdown of verns (SCOM - Sec. 5.2)
  - RCS Hotfire Test (SCOM - Sec. 5.3)
  - OMS and RCS switch configuration changes (OMS 2102 - Sec. 3)

REF.: Also see: Flight Procedures Handbooks, OMS and RCS OPS 2106 SSTs
- Use FDF to isolate OMS and RCS leaks.

REF.: RCS 2102A - Sec. 4, RCS MAL SST 2106
- State the impacts of OMS Propellant, Helium and Nitrogen leaks and crew actions required for each.

REF.: OMS MAL SST 2106, OMS 2102 - Sec. 4
- Explain Spec 23 actions required for changing jet priority, toggling RM on a single jet, deselecting and reselecting jets, and resetting RM.

REF.: DPS Dictionary, RCS OPS SST 2106
- Use Ref Data to determine the capabilities of the OMS and RCS after DPS and EPS failures occur.

REF.: Ref Data, OM/RC DPS/EPS 2106; OMS 2102 - Sec. 4; RCS 2102 - Sec. 4
- Use the OMS and RCS Slide rule to determine the status of the OMS/RCS valves after the occurrence of DPS and EPS failures.

REF.: OM/RC DPS/EPS 2106; OMS 2102 - Sec. 4; RCS 2102 - Sec. 4

**EXERCISES:**

1. FLC1 fails at EI-20. How does this affect your RCS jets?
2. Assume FLC1 has failed and the FRCS quantity loading is  $OX = 32\%$ , and  $Fu = 30\%$ . How will FLC1 affect the FRCS Dump and how long will the FRCS dump be?
3. What is the difference between an "ITEM 45 EXEC" and a DES INH twice on Spec 23?
4. How do you secure for an OMS leak when you are interconnected OMS to RCS?
5. A Left OMS engine N2 leak develops on Ascent. By taking the OMS Engine Switch to ARM, you determine the leak is in the N2 Tank and not the accumulator. How will this affect your OMS 2 burn?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: OMS Burn Malfunctions

**SOURCE:** DT66/ Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** OMS 2102 - Sect. 4, Engine, Nitrogen System, and Gimbal Failures. RCS 2102, Sect. 4 up to Electrical/Data Path Failures. SCOM, Sect. 2.18, Fault Detection and Identification. & Sect. 2.20, RCS Redundancy Management. OM/RC Burn 2106, OM/RC EPS/DPS 2106.

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** OMS Burns with malfunctions

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the cockpit cues and system impact differences between an ENGINE FAIL and a PROPELLANT FAIL.  
REF.: OMS 2102 Workbook
- Identify selected malfunctions which may occur during a burn and identify the appropriate FDF procedure to work in response.  
REF.: OM/RC Burn 2106
- Determine impacts due to selected EPS/DPS failures during an OMS burn.  
REF.: OM/RC EPS/DPS 2106, Flight Rules - Sections TBD
- Use the “BURN MONITOR” cue card to diagnose OMS failures.  
REF.: OMS 2102 workbook, OM/RC Burn 2106

### EXERCISES:

1. During the OMS-2 burn, a “R OMS Pc” message annunciates, a down arrow appears for the R OMS engine and one of the bipropellant valves on the right engine is less than 70% open. Is this an Engine Failure or a Propellant Failure?
2. Which of the following cues would a crew member expect to see for a fuel blockage upstream of the Fu Inlet Pressure transducer on an OMS engine. (more than one)
  - A. Inlet pressure increase
  - B. Lowers fuel injector temperature
  - C. Bipropellant valve is less than 70%
  - D. Inlet pressure decrease
  - E. OMS Fuel Injector temperature >260°F
4. What are the two C&W messages for OMS Oxidizer and Fuel blockages?
5. During an OMS 2 burn the crew notices high RCS usage (10% Total propellant in 30 seconds) and a second “R OMS GMBL” message. What is the problem and how should the crew respond?
6. If all of the Helium leaked out of the L OMS He TK, could this lead to an ENGINE FAIL or a PROP FAIL?
7. Suppose FA1 and Control Bus AB1 are both failed prior to OMS ignition. What is the impact to the OMS engines?

8. MDM's FA 1 and 2 fail during an OMS burn. What is the crew response to these failures?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: OMS-1/2 Targeting

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** DPS Dictionary, OMS Targeting 2201, OMS OPS 2106,

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This Study Guide will provide a list of review items regarding OMS 1 and OMS 2 targeting. After reviewing the list of objectives, the student should be able to use the OMS1/2 Targeting Card, the OMS 2 Targeting card and the ATO card to determine targets.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Define each item on the Maneuver Execute Display  
REF.: DPS Dictionary
- Explain when and how to use the following:
  1. OMS-2 Targeting Card (ACL 2-10)
  2. ATO Card (ACL 2-11)
  3. OMS Targets (ACL 7-1)REF.: ASCAN OMS Targeting Briefing 2201
- Describe the purpose of each cockpit resource used for OMS 1/2 Targeting and explain how these cockpit resources will be prioritized.  
REF.: OMS OPS 2106
- Determine targets for a variety of ascent cases through OMS-2.  
REF.: OMS Targeting Briefing 2201, OMS OPS 2106 SST

### EXERCISES:

1. If we want to increase our current HP to HA what type of targets do we choose?
  - (a) PEG 4
  - (b) PEG 7
2. What is the  $\Delta V$  required to change orbital altitude 1 nautical mile?
  - (a) 3.2
  - (b) 1.8
  - (c) 1.2
3. Given the attached OMS 1/2 targeting card state the following:
  - (a) OMS quantity after a full dump
  - (b) Greatest MECO velocity where an OMS 1 is still required
  - (c) Target set for an AOA / S
  - (d) OMS 1 TIG for an AT O/ ATO
  - (e) Nominal expected MECO velocity
4. True or False: The OMS 2 targeting card is used for all AOA, ATO and OMS 2 burns.
5. The ATO table is used to determine Orbit and deorbit capabilities based on Post OMS 1 \_\_\_\_\_ and \_\_\_\_\_.



---

Directions

Using the STS-63 FDF (attached), and the post MECO scenario conditions, perform OMS1/2 Targeting and answer the listed questions.

---

**Post MECO Scenario**

**Flight: STS-63**

**TMECO: 9:50**

**MECO Vi: 25530**

**AOA site: KSC**

**OMS QTY @**

**MECO: 76%**

**Ascent aborts/  
failures: CSSME  
out at Vi=13,000  
and early MECO**

1041/ /	ATO-2 MNVR EXEC	2 000/00:10:19 000/00:01:21
OMS BOTH 1* L 2 R 3 RCS SEL 4 5 TV ROLL 180 TRIM LOAD 6 P +0.4 7 LY -5.7 8 RY +5.7 9 WT 238033 10 TIG 0/00:11:31.1 TGT PEG 4 14 C1 0 15 C2 [ ]0.00000 16 HT 104.000 17 $\theta$ T 220.000 18 PRPLT [ ] 0 TGT PEG 7 19 $\Delta$ VX [+] 269.0 20 $\Delta$ VY [+] 0.0 21 $\Delta$ VZ [+]193.1 LOAD 22/TIMER 23	BURN ATT 24 R 045 25 P 018 26 Y 345 MNVR 27 REI TTA 7:41 GMBL L R P +0.4 +0.4 Y -5.7 +5.7 PRI 28* 29* SEC 30 31 OFF 32 33 GMBL CK 34	$\Delta$ VTOT 331.1 TGO 3:21 VGO X + 267.84 Y + 54.96 Z -187.13 HA HP TGT 106 + 64 CUR 67 - 54 35 ABORT TGT 1 FWD RCS ARM 36 DUMP 37 OFF 38* SURF DRIVE ON 39 OFF 40*

---

**Questions**

1. Is OMS -1 Required?
  2. Approximately how much time until the first burn?
  3. What type of OMS-1 and/or OMS-2 targets should be performed according to the OMS 1/2 Targeting Card?
  4. Per the 104 MNVR EXEC, the targets have been automatically loaded by the GPC's, are the targets good?
-

Directions Continue the exercise from the previous page using the STS-63 checklist attached.

**POST OMS 1 Scenario.** OMS 1 burn complete.

OMS quantity = 50%, per side

```

1051/ / ATO-2 MNVR EXEC 2 000/00:10:27
                                000/00:00:00
OMS BOTH 1*
  L 2
  R 3
RCS SEL 4
5 TV ROLL 180
TRIM LOAD
  6 P +0.8
  7 LY -5.8
  8 RY +5.7
  9 WT 231237
10 TIG
    0/00:55:49.1
TGT PEG 4
  14 C1 0
  15 C2 [ ]0.00000
  16 HT 104.000
  17 ØT 400.000
  18 PRPLT [ ] 0
TGT PEG 7
  19 AVX [ ]_____
  20 AVY [ ]_____
  21 AVZ [ ]_____
LOAD 22/TIMER 23

BURN ATT
  24 R
  25 P
  26 Y
MNVR 27
REI
TTA 39:06
  GMBL
    L R
    P +1.1 +0.7
    Y -5.6 +5.6
  PRI 28* 29*
  SEC 30 31
  OFF 32 33
  GMBL CK 34

AVTOT
TGO
VGO X
  Y
  Z
  HA HP
TGT 108 67
CUR 108 67

35 ABORT TGT 1

FWD RCS
  ARM 36
  DUMP 37
  OFF 38*
SURF DRIVE
  ON 39
  OFF 40*

```

**Questions**

5. Per the OMS 1/2 Targeting Checklist, what was determined as the best OMS-2 targets? According to the scenario above, is an OMS -2 downmode required?
6. What target set is to be used?
7. What MM mode is the OMS-2 burn to be performed in?
8. Given the MNVR Exec with the input and loaded targets, is the solution valid?
9. Do we have enough propellant to perform the burn and still have some to get home on?

```

1051/ / ATO-2 MNVR EXEC 2 000/00:10:27
                                000/00:00:00
OMS BOTH 1*
  L 2
  R 3
RCS SEL 4
5 TV ROLL 180
TRIM LOAD
  6 P +0.8
  7 LY -5.8
  8 RY +5.7
  9 WT 231237
10 TIG
    0/00:55:49.1
TGT PEG 4
  14 C1 0
  15 C2 [ ]0.00000
  16 HT 104.000
  17 ØT 400.000
  18 PRPLT [ ] 0
TGT PEG 7
  19 AVX [ ] 79.2
  20 AVY [ ] 0.0
  21 AVZ [ ] 20.0
LOAD 22/TIMER 23

BURN ATT
  24 R 329
  25 P 184
  26 Y 028
MNVR 27
REI
TTA 39:06
  GMBL
    L R
    P +1.1 +0.7
    Y -5.6 +5.6
  PRI 28* 29*
  SEC 30 31
  OFF 32 33
  GMBL CK 34

AVTOT 73.9
TGO :44
VGO X 72.51
  Y 2.47
  Z 17.47
  HA HP
TGT 109 106
CUR 108 67

35 ABORT TGT 1

FWD RCS
  ARM 36
  DUMP 37
  OFF 38*
SURF DRIVE
  ON 39
  OFF 40*

```



**OMS 2 TARGETING**  
(DIR INSERTION)

FAILURE	OMS 2 TARGET
OMS - 2 N2 TKs (Perform burn Single OMS Eng)	NOM
OMS - 2 OMS ENGS - 1 He TK - 1 PRPLT TK EPS - MNA & B, MNB & C MNA & C ET SEP	PEG 7; TTA = 1 CUTOFF HP = <input type="text" value="90"/>
OMS - 1 OX & 1 FU TK diff PODs - 2 OX or 2 FU Tks - 2 He TKs	AOA-S
2 FREON LOOPS [Accum Qty (↓ and decr) and/or Flow (↓)] 2 H2O LOOPS CABIN LEAK (-EQ dP/dT ≥ .08)	AOA
APU/HYD - 2↓ & 1 failing	AOA
CRYO - All O2(H2)	AOA

2-26

**OMS**

He	%	He	%
4800	90.3	3190	50
4790	90	2790	40
4390	80	2390	30
3990	70	1990	20
3590	60	1590	10

**ATO**

**NOTE**

These tables apply only after ATO OMS 1 burn  
(ITGT =

DUAL POD - OMS REQUIRED				
Includes 8.9% unusable (4.5% per pod)				
POST OMS 1 HP	ATO OMS 2 & STEEP D/O BURN (%)	MIN HP OMS 2 & SHALLOW D/O BURN (%)	AOA STEEP D/O BURN (%)	AOA SHALLOW D/O BURN (%)
95	48.4	32.1	58.5	37.0
90	48.8	29.6	53.7	31.8
85	51.4	29.7	48.3	29.2
80	54.5	30.8	43.2	27.6
75	56.7	32.2	39.5	25.6
70	57.3	33.7	38.5	23.0
65	57.8	35.0	38.1	21.0
60	58.2	36.0	38.1	19.5
55	58.9	37.1	37.2	17.8
50	—	38.2	36.1	15.7
45	—	—	—	14.7

SINGLE POD - OMS REQUIRED				
Includes 4.5% unusable				
POST OMS 1 HP	ATO OMS 2 & STEEP D/O BURN (%)	MIN HP OMS 2 & SHALLOW D/O BURN (%)	AOA STEEP D/O BURN (%)	AOA SHALLOW D/O BURN (%)
95	43.9	27.7	54.0	32.6
90	44.3	25.2	49.2	27.4
85	46.9	25.2	43.8	24.8
80	50.0	26.3	38.7	23.1
75	52.2	27.7	35.0	21.2
70	52.7	29.2	34.0	18.5
65	53.3	30.5	33.7	16.6
60	53.7	31.5	33.6	15.0
55	54.4	32.7	32.7	13.3
50	—	33.7	31.6	11.2
45	—	—	—	10.2

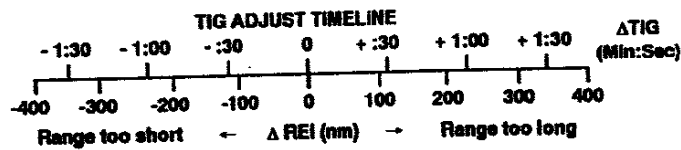
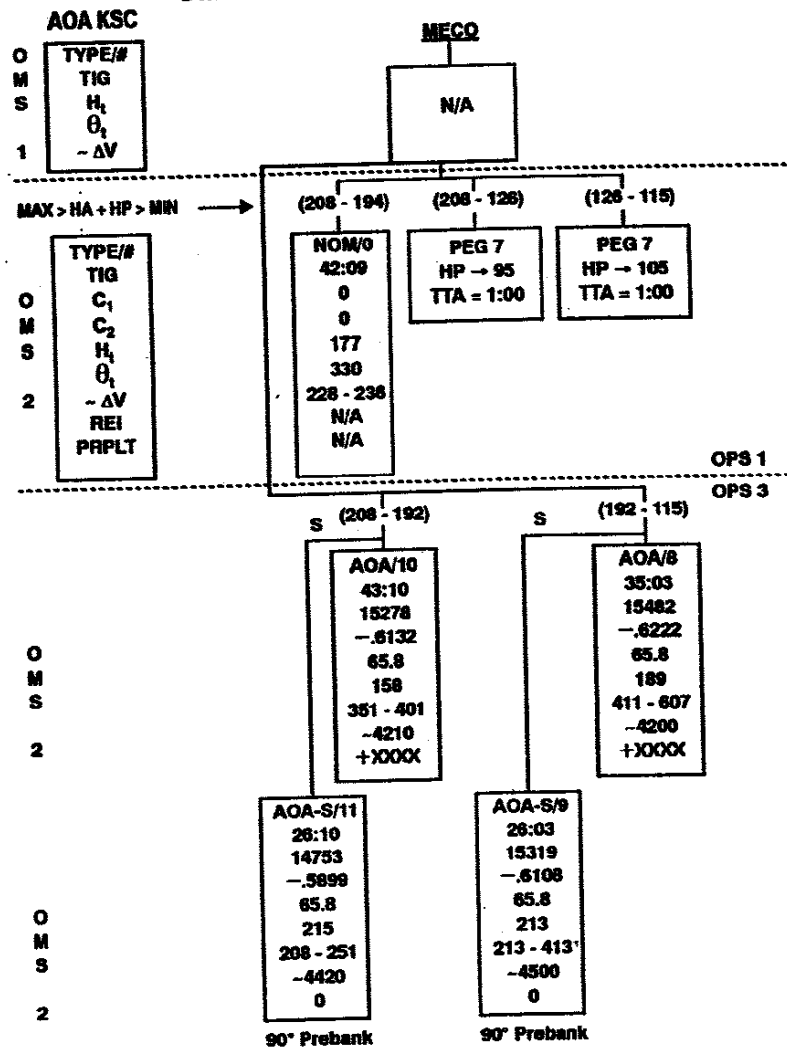
**ΔV AVAILABLE FOR OMS 2**

OMS: 5 FPS/% PER POD  
LIFTOFF BLDN PER POD   
MIXED XFD   
MAX BLDN (39%) PER POD

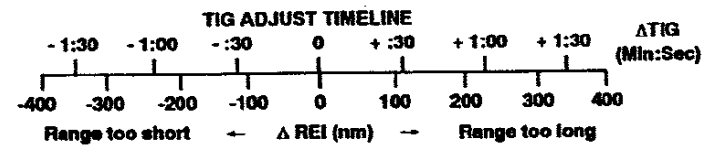
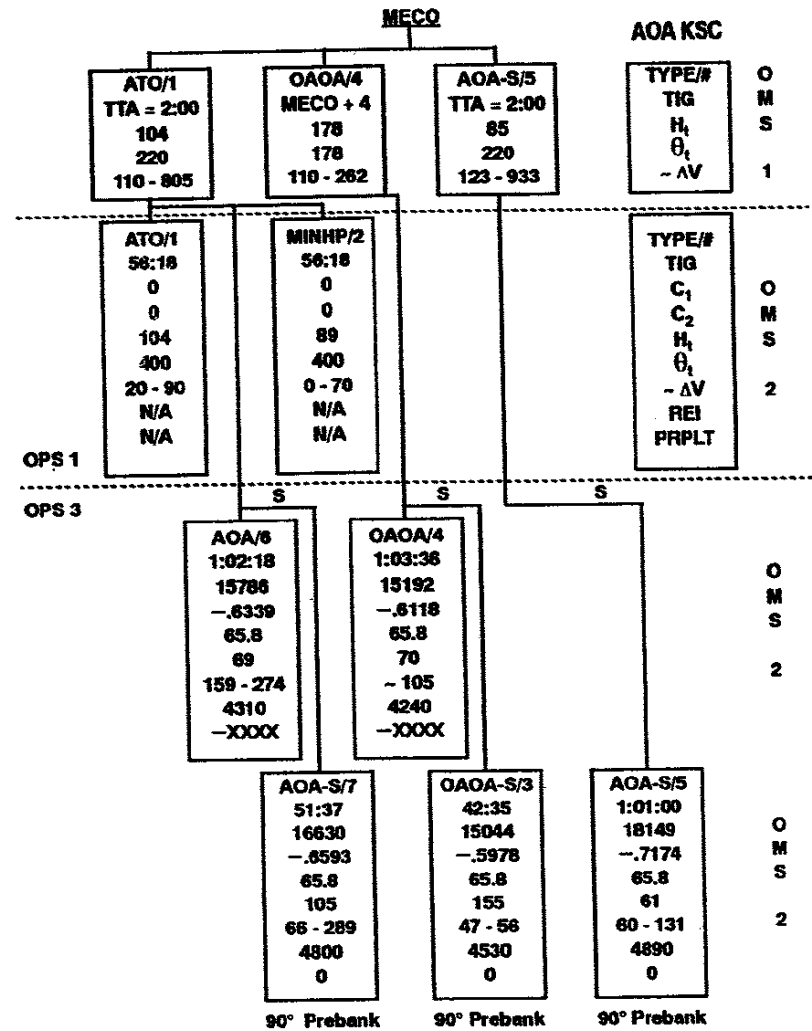
AFT RCS: ABOVE AFT QTY 1  (Rev Z)  
2  (Rev Z)

FWD RCS:  (AVAIL FOR UPHILL IF HP ≥ 70)

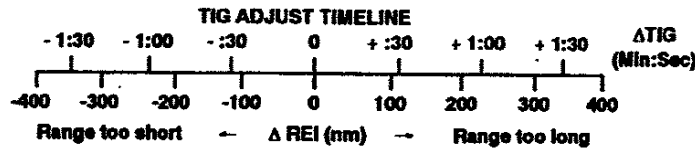
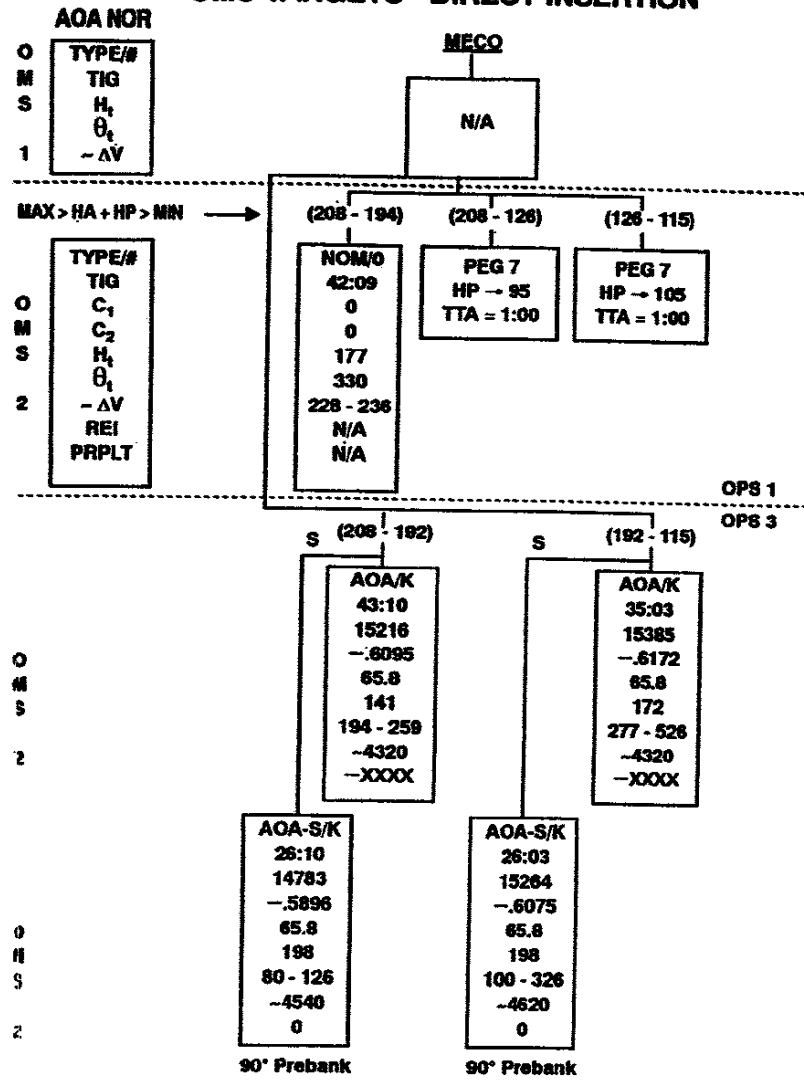
### STS-63 FLTR1 CY OMS TARGETS - DIRECT INSERTION



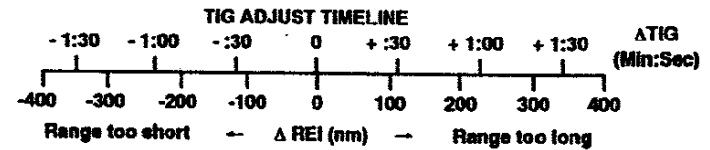
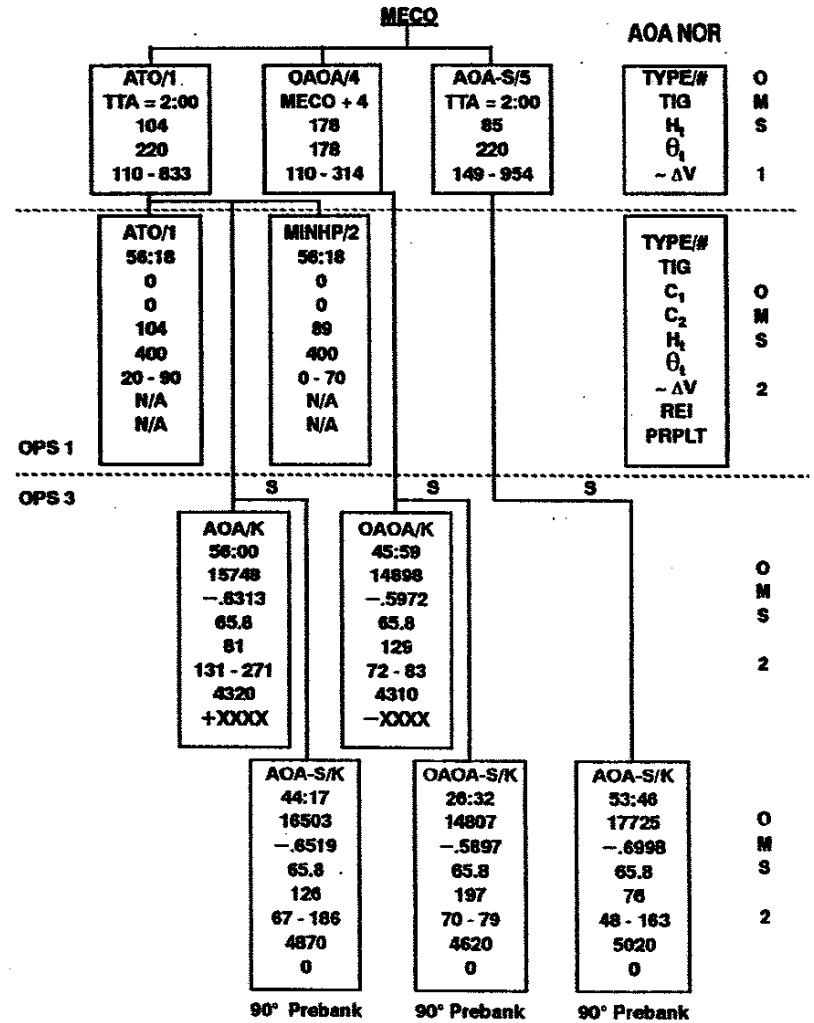
### STS-63 FLTR1 CY OMS TARGETS - W/OMS 1



**STS-63 FLTR1 CY  
OMS TARGETS - DIRECT INSERTION**



**STS-63 FLTR1 CY  
OMS TARGETS - W/OMS 1**



## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Sensors and Controllers

**SOURCE:** DT66/Control/Propulsion Section

**REV.:** DEC 1997

**MATERIALS REFERENCED:** Controllers 2102, Sensors 2102, Snsrs/Cont 2106, Guidance and Control Sensors and Controllers 2101, Flight Rules Section 8.

**SUPPLEMENTAL MATERIAL:** None

**TOPIC SYNOPSIS:** This study guide reviews functions, procedures, and displays of Sensors and Controllers. Note that the sensors discussed in this study guide focus primarily on RGA's and AA's. IMU's, ADTA, TACAN and MLS are flight control sensors covered in other Study Guides.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the different sensors that the Orbiter uses for Flight Control and in which OPS Mode/Major Mode the sensors are used.  
REF.: Guidance and Control Sensors and Controllers 2101, Sensors 2102, Snsrs/Cont 2106
- Determine what cockpit interfaces are available for sensors and controllers.  
REF.: Guidance and Control Sensors and Controllers 2101, Sensors 2102, Snsrs/Cont 2106, Controllers 2102.
- Explain the Redundancy Management Scheme for Sensors and Controllers.  
REF.: Guidance and Control Sensors and Controllers 2101, Sensors 2102, Snsrs/Cont 2106, Controllers 2102.
- State all the controllers that are available to the CDR and PLT for flight control.  
REF.: Guidance and Control Sensors and Controllers 2101, Snsrs/Cont 2106, Controllers 2102.
- Explain RGA SMRD RM.  
REF.: Guidance and Control Sensors and Controllers 2101, Snsrs/Cont 2106, Sensors 2102.
- Define the different degrees of "Fault Tolerance".  
REF.: Guidance and Control Sensors and Controllers 2101, Snsrs/Cont 2106.
- State the differences between PASS and BFS Sensors RM.  
REF.: Snsrs/Cont 2106, Sensors 2102.

**EXERCISES:**

1. What displays can be used to identify RGA and AA information during Ascent and Entry?
2. Suppose in OPS 1 AA1 develops a bias above the RM limit in the normal axis.
  1. What would the signature of the failure be?
  2. What is the Selection Scheme being used before and after this failure?
  3. What is PASS fault tolerance after the failure?
  4. Is AA1 still usable since the failure was only in the normal axis?
  5. What is BFS fault tolerance before any actions are taken by the crew?
3. Match the following terms to the correct definitions:

a. Single Fault Tolerant	a. Can sustain two failures and still fly the vehicle
b. Zero Fault Tolerant	b. Can sustain one failure and still fly the vehicle
c. Dual Fault Tolerant	c. Can sustain no failures
4. Suppose RGA 1 develops a bias and the crew deselects RGA 1 in the BFS. Then RGA 2 loses power. Predict what happens.
5. What do the Flight Rules have the crew do for 2 AA failures?
6. What Controllers are available on the Orbiter?
7. Which of the following are sensors used by Flight Control:
  - a. SRB Rate Gyro Assembly
  - b. IMU's
  - c. Accelerometer Assembly
  - d. ADTA's
  - e. Rate Gyro Assembly
  - f. All of the above
8. Suppose the L RHC develops a command bias greater than the RM limit on channel 1...
  1. What would the signature of the failure be?
  2. What is the L RHC fault tolerance after the failure?
  3. Is there an FDF procedure for this failure?
  4. What happens if subsequent to this failure FF2 fails?



# DPS/NAV

## Section 3 - DPS/NAV

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Star Trackers .....	3-31
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### **Materials Referenced**

ADS 2102
Deorbit Prep FPH
DPS FAM 2102
DPS HW/SW 2102
DPS OV 2102
DPS PRINC 2102
Entry FPH
Flight Rules
FPH VOL. I
FPH VOL. II
G&C I/O/D 2102A
GNC DISP 2102
IMU 2102
NAV AIDS 2102
NAV 2102B
Orbit Operations Checklist FPH
Post Insertion FPH
S TRK/ COAS 2102
SCOM

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

# DPS

BFS Engage.....	3-3
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## **Materials Referenced**

Deorbit Prep FPH
DPS FAM 2102
DPS HW/SW 2102
DPS OV 2102
DPS PRINC 2102
Flight Rules
FPH VOL. I
FPH VOL. II
Orbit Operations Checklist FPH
Post Insertion FPH
SCOM

Facility/Media Code	Description
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2157	CBT

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** BFS Engage

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** DPS HW/SW 2102, Flight Rules, SCOM, FPH VOL. I

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the basic BFS software structure. The flight rule rationale for when the BFS should be engaged as well as the times when an engage should not be performed are also discussed. The procedures associated with a BFS engage are also addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Discuss the purpose/role of the BFS.  
REF.: SCOM, Section 2.6 - Software - Backup Flight System; DPS HW/SW 2102, Section 4 - Backup Flight Software
- Describe the BFS software structure and the concept of tracking.  
REF.: SCOM, Section 2.6 - Software - Backup Flight System; DPS HW/SW 2102, Section 4 - Backup Flight Software, and Tracking the PASS
- List and explain the rationale for the times when an engage would be desired/required.  
REF.: Flight Rules, Section 2 - Rules A2.1.2-10 and A2.1.5-8, Section 4 - Rule A4.1.2-9; SCOM, Section 6.9 - BFS Self Engage
- Explain the rationale for the times when the BFS is NO-GO for an engage.  
REF.: Flight Rules, Section 7 - Rule A7.1.2-2A and B
- Explain the times when the BFS is considered suspect.  
REF.: Flight Rules, Section 7 - Rule A7.1.2C
- List the switch configuration required for a BFS engage to be successful.  
REF.: FPH VOL. I, Section 3 - BFS ENGAGE
- Describe, in general, the major steps of the PASS RECOVERY AFTER BFS ENGAGE procedure.  
REF.: DPS HW/SW 2102, Section 4 - BFS Disengage; FDF, MAL PROC, Section 5 - FRP-4; SCOM, Section 2.6 - Software - Backup Flight System
- State the rationale for the POST BFS ENGAGE steps in the entry portion of the AESP.  
REF.: TBD
- Explain the signatures of a successful BFS engage.  
REF.: DPS HW/SW 2102, Section 4 - BFS Engage; SCOM, Section 2.6 - Software - Backup Flight Software

**EXERCISES:**

1. During ascent and entry, does the BFS perform any SM function while in STBY?
2. What OPS must the PASS be processing for BFS to track it?
3. How does the BFS receive critical GNC data pre-engaged in order to maintain a good state vector and all other information needed in case an engage is required?
4. Why must the BFS be engaged if the roll maneuver is not initiated as scheduled?
5. On orbit, the BFS was moved to GPC 2 due to a failure in GPC 5. What control bus failure will make the BFS NO-GO for an engage?
6. Why does an I/O TERM A fail high on the BFS make it suspect?
7. Why is PASS IMU reference recovery required during the PASS recovery procedure?
8. Why does the AESP POST BFS ENGAGE entry procedure have you check if any PASS GPCs are running?
9. When the BFS is STANDALONE, the BFC lights on panel F2 and F4 blink until the MSG RESET is depressed. For an engage, these lights are on. Do the lights extinguish when the MSG RESET is depressed?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: BFS Failures

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** FPH VOL. I, Flight Rules, DPS HW/SW 2102, SCOM

**SUPPLEMENTAL MATERIAL:** DPS MAL 2157 CBT, DPS RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the different failures of the BFS, software and hardware. It also discusses the recovery steps and the flight rules that address these failures.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Identify BFS GPC failures and discuss the rationale for the steps in the associated procedure.  
REF.: FPH VOL. I, Section 3 - BFS GPC FAIL; SCOM, Section 6.8 - Data Processing System - BFS Failures
- Describe the signature of the BFS failing standalone and state the crew actions.  
REF.: DPS HW/SW 2102, Section 4 - Standalone BFS; Flight Rules, Section 7 - Rule A7.1.5-1B
- Describe the signature of a BFS that has failed to STBY and state the impacts.  
REF.: DPS HW/SW 2102, Section 4 - GPC Mode Switch
- Describe an I/O TERM A failure at the BFS and describe the risks associated with this failure.  
REF.: Flight Rules, Section 7 - Rule A7.1.2-2C7

### EXERCISES:

1. What type of software will the BFS be running after a HALT transient?
2. Why does the APCL BFS GPC FAIL procedure have you PRO the BFS to OPS 302 if recovered, even if PASS is in OPS 105?
3. In the BFS GPC FAIL procedure in the APCL, EPCL (post burn) and the AESP entry, how do you know if the BFS has recovered SM only?
4. For any type of recoverable BFS failure, how do the flight rules treat this transient GPC?
5. How long is the BFS an option for an engage after going standalone on ascent and why? On entry and why?
6. Does the BFS announce I/O ERROR PL 1(2) if it fails to STBY? Which GPC has control of the payload data buses following this failure?
7. What message(s) are expected when the BFS suffers an I/O TERM A fail high? Which GPC(s) will announce the message(s)

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** DPS Nominal Procedures

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** Post Insertion FPH, Orbit Operations Checklist FPH, Deorbit Prep FPH, FDF (REF DATA), Flight Rules

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106, DPS REFR 4106

**TOPIC SYNOPSIS:** This study guide reviews the nominal DPS procedures from the Orbit OPS Checklist, Post Insertion, Deorbit Prep and Entry Checklist. The rationale for the major DPS steps in these procedures as well as how to perform the steps is addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the purpose of the following procedures and when they would be performed.  
SM CHECKPOINT INITIATE  
G2 SET CONTRACTION  
G2 SET EXPANSION  
REF.: Orbit Operations Checklist FPH, Section 4 - Procedures of similar name (procedures are outdated)
- State the rationale for all of the steps in the following procedures.
  - a) SM CHECKPOINT INITIATE
  - b) G2 SET CONTRACTION
  - c) G2 SET EXPANSIONREF.: (a, b, and c) Orbit Operations Checklist FPH, Section 4 - Procedures of similar name (procedures are outdated); (b and c) FDF - REF DATA, Section 7 - Program Notes, DPS (General) - GPC/CRT MANAGEMENT
- State the purpose of the DPS portions of the following procedures.
  - a) POST INSERTION (Block 1)
  - b) DEORBIT PREP (Blocks 4, 12)
  - c) POST LANDING
  - d) PRE/POST - SLEEP ACTIVITYREF.: (a) Post Insertion FPH, Section 2; (b) Deorbit Prep FPH, Section 1, Flight Rules, Section 7 - Rules A7.1.2-2A and A7.1.5-1; (c) TBD; (d) Orbit Operations Checklist FPH, Section 3 - Procedures by the same name (procedures may be outdated)
- State the rationale for all of the DPS related steps in the following procedures.
  - a) POST INSERTION (Block 1)
  - b) DEORBIT PREP (Blocks 4, 12)
  - c) POST LANDING
  - d) PRE/POST - SLEEP ACTIVITYREF.: (a) Post Insertion FPH, Section 2; (b) Deorbit Prep FPH, Section 1; (c) TBD; (d) Orbit Operations Checklist FPH, Section 3 - Procedures by the same name (procedures may be outdated)

**EXERCISES:**

1. If MCC uplinks a new TMBU, should you take an SM checkpoint immediately?
2. Why do the G2 SET CONTRACTION (EXPANSION) procedures have you PRO to OPS 201 if in OPS 202?
3. What is the purpose of the note at the top of the G2 SET CONTRACTION (EXPANSION)?
4. Why do you perform the G2 FD prior to the OPS 2 transitions?
5. If GPC 3 failed on ascent, which GPC would be the FD and how would you restring in step 1 of block 1 in Post Insertion?
6. Why does Block 4 of the Deorbit Prep procedure have you check if the BFS can drive a CRT? What will be done if it can not?
7. Why is an SM checkpoint taken prior to the OPS 3 reconfiguration in Block 12 of the Deorbit Prep?
8. Why is the PASS OPS 3 transition in Block 12 of the Deorbit Prep not performed all at one time?
9. What is the purpose of calling up the OPS 9 NBAT at the end of Block 12 of the Deorbit Prep?
10. What is the main DPS difference between the GO/NO-GO for EXTENDED PWR UP procedures?
11. Why, in the PRE-SLEEP ACTIVITY procedure, does the powerdown step have you turn on the BFC CRT DISP switch?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** DPS Off Nominal Procedures

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** DPS HW/SW 2102, FPH VOL. I, FPH VOL. II, FDF (Ascent Checklist, OPCL, Malfunction Procedure)

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the PAD Abort procedure and some of the off nominal DPS procedures for Orbit. The Group B power down and Freeze Dry concepts are also addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Explain, in general, the purpose for the following MAL PROC procedures, as well as the rationale for the individual steps.
    - a) GPC HDW INITIATED MEM DUMP
    - b) GPC S/W INITIATED MEM DUMP

REF.: (for a and b) DPS HW/SW 2102, Section 3 - Memory Dumps; FPH VOL. I, Section 3 - PASS/BFS HISAM and Software Dump; FDF, MAL PROC, Section 5/DPS - SSR 1 and SSR 2
  - c) GPC IPL MENU OPTION (PASS/BFS)
  - d) GPC IPL-PASS
- REF.: (for c and d) DPS HW/SW 2102, Section 3 - GPC Initialization and Recovery, Section 4 - BFS Initialization and Recovery - BFS GPC IPL; FPH VOL. I, Section 3 - BFS GPC IPL; FDF, MAL PROC, Section 5/DPS - SSR 7 and SSR 8
- Discuss the purpose of a freeze-dried GPC and the flight certified way to perform a FD.

REF.: DPS HW/SW 2102, Section 3 - Freeze-Dried GPC
- Discuss the rationale of the DPS portion of the PAD ABORT procedure.

REF.: FDF, Ascent Checklist - Pre-Launch procedures
- Discuss the rationale of the DPS and NAV steps involved in the GROUP B powerdown and powerup procedure.

REF.: FPH VOL. II, Section 11 - Priority PWRDN (out dated procedure); FDF, OPCL - Priority PWRDN Group B



**EXERCISES:**

1. Why do you assign the failed GPC as the GNC downlister in the HISAM dump procedure?
2. Why is a software dump of a good GPC performed following a GPC failure?
3. If the BFC CRT DISP switch is on during an IPL, what type of IPL will be requested?
4. During a menu option IPL, what DEU action is taken prior to taking the GPC to STBY and why?
5. Is the presence of a Master Alarm and CAM light for the IPL GPC an indication of a failure?
6. What type of software must a GPC be running to be Freeze-Dried?
7. In the RECYCLE PROCEDURES, the BFS SAFING step asks “if BFS in MM102.” How can the BFS be in MM102 and not the PASS?
8. In the RECYCLE PROCEDURES, why is safing the BFS a concern?
9. In the Group B Priority PWRDN, why do we not just power OFF a GPC and an IMU?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: FC/PL MDMs

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** DPS HW/SW 2102, DPS PRINC 2102, DPS OV 2102, Flight Rules

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106, DPS MAL 2157 CBT

**TOPIC SYNOPSIS:** This study guide reviews the basic workings of the FC and PL MDMs. It also addresses the failure signatures and recovery options.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- List the major components of an MDM and describe their function.  
REF.: DPS HW/SW 2102, Section 2 - Multiplexer-Demultiplexer
- Define the term commfault.  
REF.: DPS OV 2102, Section 4 - Commfaults
- State the purpose of an I/O RESET in the PASS and BFS.  
REF.: DPS PRINC 2102, Section 8 - Input/Output Reset
- Identify MDM failures and discriminate between failures at the MDM and failures at the GPC.  
REF.: DPS PRINC 2102, Section 10 - At the GPC, and At the MDM
- Describe port modes with respect to the MDM recovery process.  
REF.: DPS HW/SW 2102, Section 3 - Port Moding; DPS FAM 2102, Section 7 - Port Moding
- Describe what a “trade off case” is as it relates to GPCs and MDMs.  
REF.: Flight Rules, Section 2 - Rule A2.1.1-5, and Section 7 -Rule A7.1.3-12
- State the purpose of input and output cards (polling sequences).  
REF.: DPS PRINC 2102, Section 10 - Input Cards, Output Cards
- Describe how the Reference Data Book is used following a failure of an MDM card.  
REF.: DPS PRINC 2102, Section 10 - Input Cards
- Describe how the MULT DATA PATH LOSS procedure in the AESP is used following a failure of an MDM card and any other DPS failure.  
REF.: FPH VOL I, Sectin 3 - MULT DATA PATH LOSS (Outdated procedure - use notes as applicable with new procedure)

**EXERCISES:**

1. Is the A/D converter used for data going out to the IOMs or for return data going to the GPCs?
2. What is a typical signature, on the CRT, of a commfaulted device? Where is this seen?
3. If an I/O ERROR FF3 is annunciated on orbit, can you perform the first step of the procedure, the I/O RESET, to the SM GPC?
4. On orbit, without the BFS, how can you determine if an FF failure is at the GPC or at the MDM?
5. Will a port mode help if an MDM A/D converter fails? Why or why not?
6. IMU 3 and ASA 4 power failed post burn and are unrecoverable. If during MM304, FC2 at GPC 2 failed, what should be done and why?
7. What message(s) would be annunciated if FF2 card (polling sequence) 9 failed?

"BCE STRG X A"	X	X	X	X	X	X										
"BCE STRG X B"	X	X	X	X	X	X	X	X								
"BCE STRG X C"															X	X
"BCE STRG X D"									X	X	X	X	X	X	X	X
	4	6	7	9	12	15	1	14	1	3	5	8	9	11	6	14
	FF MDM Card								FA MDM Card							

8. Following a failure of both card sequences C and D of FA1, what part of the REF DATA FA1 page do you need to look at?
9. Following a failure of both card sequences C and D of FA1 and GPC 2, what part of the MULT DATA PATH LOSS procedure do you need to work?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: GPCs and Restrings

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** DPS HW/SW 2102, DPS FAM 2102, SCOM, Flight Rules, DPS PRINC 2102

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106, ASC DPS MAL 2106, ENT DPS MAL 2106, DPS MAL 2157 CBT

**TOPIC SYNOPSIS:** This study guide reviews the PASS software structure, the basic philosophy behind OPS mode recalls, and GPC synchronization. Also discussed are PASS GPC failures, restring flight rules and reasons for restrings.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the PASS software structure (including major functions, OPS, major modes, memory configuration, OPS overlay, major function base, etc...).  
REF.: DPS FAM 2102, Section 2 - PASS Software Structure; DPS HW/SW 2102, Section 3 - Primary Avionics Software System; SCOM, Section 2.6 - Software - Primary Avionics Software System (PASS)
- State the purpose of an OPS mode recall and when it can be requested.  
REF.: DPS HW/SW, Section 3 - OPS/Mode Recall - Restrings; Flight Rules, Section 2 - Rule A2.1.2-14, Ascent String Reassignment and Rule A2.1.5-4, Entry String Reassignment
- Describe the different types of GPC synchronization.  
REF.: DPS HW/SW, Section 3 - Concept and Definitions - Synchronization, and Synchronization and GPC Redundancy Management; SCOM, Section 2.6 - General Purpose Computer - GPC Modes of Operation
- State the steps a GPC goes through to load software.  
REF.: DPS FAM 2102, Section 3 - GPC Processes During an OPS Transition
- Explain GPC memory reconfiguration including redundant set contraction or expansion.  
REF.: DPS FAM 2102, Section 3 - GPC Reconfiguration Without an OPS Transition; DPS HW/SW 2102, Section 3 - Memory Reconfiguration, and OPS/Mode Recall - Restrings
- Identify GPC failures and discriminate between GPCs that have stopped running software and GPCs that have failed-to-sync.  
REF.: DPS PRINC 2102, Section 7 - GPC Failures; SCOM, Section 6.8 - Data Processing System
- Describe the risks associated with GPCs that fail-to-sync.  
REF.: Flight Rules, Section 7 - Rule A7.1.3-2, Redundant Set Split
- Describe the differences between a redundant set split and a common set split.  
REF.: HW/SW 2102, Section 3 - GPC Redundancy Management; Flight Rules, Section 7 - Rule A7.1.2-1B
- Identify a GPC SUMWORD ICC failure and state the actions that are required.  
REF.: Flight Rules, Section 7 - Rule A7.1.2-1 C2 and C3

- Identify I/O TERM failures, both A and B, and state the actions required by the crew.  
REF.: SCOM, Section 6.8 - Data Processing System
- Identify a non-universal I/O ERROR and state what should **NOT** be done after this failure.  
REF.: Flight Rules, Section 7 - Rule A7.1.3-18
- Discuss the approved reasons to perform an ascent restringing.  
REF.: Flight Rules, Section 2 - Rule A2.1.2-14A, B and E
- Discuss the approved reasons to perform an entry restringing.  
REF.: Flight Rules, Section 2 - Rule A2.1.5-4A, B, C and G
- Discuss the guidelines to be used for assigning PASS data buses with and without failures.  
REF.: Flight Rules, Section 7 - Rules A7.1.3-8, Section 2 - Rule A2.1.2-14C and D

### **EXERCISES:**

1. What type of data is maintained in the major function base?
2. What is the only exception to the rule that a memory configuration consists of system software and one OPS and why?
3. Why don't you get a "free" restringing on an RTLS when you pro from OPS 103 to OPS 601.?
4. What type of synchronization does the PASS SM GPC perform?
5. If an OPS 3 transition is requested and the software is available in one GPC's lower memory and in the upper memory of all the targeted GPCs, where will the software come from?
6. What must be done to add GPC 3 to the current redundant set for a nominal orbit configuration (GPC 3 is freeze-dried with G2 software)?
7. Will a GPC that has entered an infinite software loop continue to drive the ADI? Why or why not?
8. On ascent, pre-MECO, for a 2-on-2 set split where the BFS is tracking the PASS, what must be true to allow for a PASS set reconfiguration instead of a BFS engage?
9. If set reconfiguration is to be performed following a pre-MECO set split, what actions must be taken?
10. On orbit with a nominal GPC configuration of two G2 and one SM, which GNC machine is considered the "good" GPC following a redundant set split?
11. Why is a GPC that suffers a SUMWORD ICC failure during ascent treated as failed at the next OPS transition?
12. Can an SM GPC that has suffered an I/O TERM A failure on orbit be used for entry?
13. Is it possible to have a non-universal I/O ERROR with only 3 PASS GPCs and not have one of the GPCs fail-to-sync?
14. During the ascent portion of a TAL, a non-universal I/O ERROR is logged against FA2. What restringing should be chosen for the TAL transition?

15. Is an engagable BFS required for a restring to regain fault tolerance?
16. On a TAL, FF1 is power failed from ascent and then GPC4 fails to HALT at 100k. Is a restring desired following the GPC4 failure? Do the flight rules support restringing?
17. When less than 4 GPCs are available for the entry, in general, how are the remaining strings assigned?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Multifunction CRT Display System

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** DPS FAM 2102, DPS HW/SW 2102, SCOM

**SUPPLEMENTAL MATERIAL:** DPS RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the DEU Loads and dual commanders. It also addresses CRT assignment rules and CRT losses.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the difference between a PASS DEU Load and a BFS DEU Load.  
REF.: DPS FAM 2102, Section 5 - Display Electronics Unit IPL
- State the types of GPCs that can perform a DEU Load and where they get the DEU software.  
REF.: DPS FAM 2102, Section 5 - Display Electronics Unit IPL; DPS HW/SW 2102, Section 3 - DEU Initialization and Recovery; SCOM, Section 2.6 - Multifunction CRT Display System
- Identify a CRT that requires a DEU Load and explain the associated Malfunction Procedure.  
REF.: DPS HW/SW 2102, Section 3 - DEU Initialization and Recovery; FDF - Malfunction Procedure, DPS SSR-9, DEU IPL-PASS/BFS
- Identify dual commanders and state the dangers associated with this condition.  
REF.: DPS FAM 2102, Section 9 - GPC/CRT Key
- Identify a "POLL FAIL" and a big "X" on the CRT and state what causes these conditions.  
REF.: DPS FAM 2102, Section 9 - CRT Assignment Overview
- Describe the four ways to change CRT assignments and list them in order of priority.  
REF.: DPS FAM 2102, Section 9 - CRT Assignment Overview; DPS HW/SW 2102, Section 2 - Display Electronic Unit/Keyboard (DK) Data Bus I/O Management
- Describe the following special PASS CRT assignment rules:
  - a) >3 DEU fault message
  - b) Loss of PASS CRT interface recovery
  - c) 2 SPEC limit
  - d) Major Function SPEC limitREF.: DPS FAM 2102, Section 9 - Special CRT Assignment Rules

**EXERCISES:**

1. DEU 1 has been loaded with its software using the BFS. What is displayed when a PASS GPC tries to drive a critical format on CRT 1? What happens to inputs made to this CRT?
2. With a nominal on orbit GPC configuration (2G2, 1SM, 1FD in sleep, 1BFS in sleep), how would a DEU Load be performed?
3. Why does the DEU IPL-PASS/BFS malfunction procedure have you deassign the CRT associated with the DEU that will be loaded?
4. What crew action WILL lead to dual commanders?
5. What nominal time could you possibly see a big "X" on a CRT?
6. What happens if you misconfigure the CRT portion of the current GNC NBAT by assigning a GPC that is not running and then perform an OPS Mode Recall?
7. On orbit, the SM GPC is assigned to all three of the PASS CRTs and then fails to HALT. With a nominal on orbit GPC configuration, what is the quickest way to regain PASS CRT interface?
8. What CRT assignments during a Group B Power Down should be exercised to avoid a loss of PASS CRT interface?
9. How can you prevent a Big X and a POLL FAIL from occurring when you put a GPC to sleep?



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## **Materials Referenced**

ADS 2102
Deorbit Prep FPH
Entry FPH
Flight Rules
G&C I/O/D 2102A
GNC DISP 2102
IMU 2102
NAV AIDS 2102
NAV 2102B
Orbit Operations Checklist FPH
S TRK/ COAS 2102
SCOM
Training Data File

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Air Data System

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** ADS 2102, Entry FPH, SCOM, Flight Rules, FDF (EPCL, AESP), TDF

**SUPPLEMENTAL MATERIAL:** ENAV 2106, OGNC RVW 4106 (any ADTA discussion)

**TOPIC SYNOPSIS:** This study guide covers the shuttle Air Data System hardware, software, and crew procedures, including a comparison of PASS and BFS system operation.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Describe the Air Data Probe hardware and source of electrical power (MN, CNTL, AC).  
REF.: ADS 2102, Section 2 - Air Data Probe Assemblies; SCOM, Section 2.13 - Navigation Hardware - Air Data System
- List the steps of the air data probe deployment and verification for both PASS and in BFS.  
REF.: ADS 2102, Section 2 - Air Data Probe Assemblies, Section 6 - Probe Deploy and Air Data Management, and Section 7 - Crew Procedures; TDF, Section 2 - GNC-02, GNC-03 and GPC-05
- Describe the ADTA selection filters for both PASS and BFS.  
REF.: ADS 2102, Section 3 - Redundancy Management, Section 7 - Hardware Interface Program; FDF - ADTA RM card (EPCL)
- Identify the cause and signatures of an ADTA RM failure and an air data dilemma.  
REF.: ADS 2102, Section 3 - Redundancy Management, Section 6 - Fault Messages, Section - 7, Fault Messages
- Identify the air data parameters computed by the flight software for use in the following areas:
  - guidance and control
  - navigation
  - redundancy management (GNC SPEC 51)
  - dedicated displaysREF.: ADS 2102, Section 4 - ADTA Subsystem Operating Program
- Describe the Mach jump region and the changes to air data processing which occur in this time frame.  
REF.: ADS 2102, Section 4 - Air Data Calculation for GNC
- Identify the minimum requirements (and exceptions), as defined in the Flight Rules, for incorporating air data into GNC software processing.  
REF.: Flight Rules, A8.1.3-12 GNC Air Data System Management
- Describe navigation-derived air data (NAVDAD), default air data (DEFAD), and when each is used by PASS and BFS.  
REF.: ADS 2102, Appendix D - NAV Derived Air Data and Default Air Data

**EXERCISES:**

1. How many motors are available to drive each probe? How are the probe motors powered? What is the nominal probe deployment time?
2. Discuss the rationale for deploying the left and right air data probes separately when the BFS is engaged.
3. How does the flight software determine whether an air data probe is stowed or deployed?
4. Given the case where ADTA 2 is commfaulted, discuss how air data parameters from the remaining available ADTAs are used by PASS and BFS.
5. Identify the specific tapes on the AMI and AVVI which are driven directly by air data parameters once ADTA H and ADTA TO G&C are taken to AUTO on GNC SPEC 50.
6. Explain why manual theta limits must be flown below Mach 2 if air data is not incorporated to G&C (ADTA TO G&C).

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Dedicated Displays

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** GNC DISP 2102, SCOM

**SUPPLEMENTAL MATERIAL:** DED DISP 2157 CBT, I/O/D GNC 2102, HUD 2157 CBT

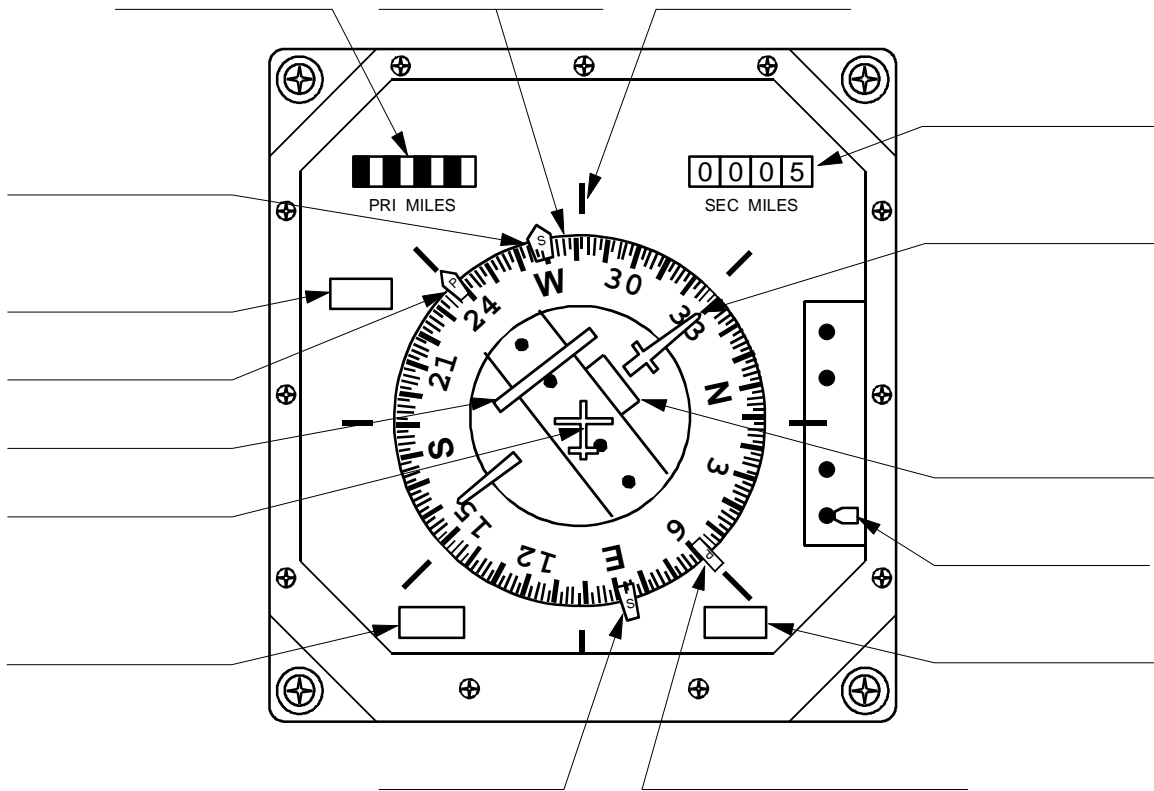
**TOPIC SYNOPSIS:** This study guide reviews the following pieces of hardware; AMI, AVVI, ADI, HSI, and the HUD.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- List and define the four parameters displayed on the AMI.  
REF.: GNC DISP 2102, Section 4 - Alpha/Mach Indicator (AMI); SCOM, Section 2.7 - Alpha/Mach Indicator
- List and define the four parameters displayed on the AVVI.  
REF.: GNC DISP 2102, Section 5 - Altitude/Vertical Velocity Indicator (AVVI); SCOM, Section 2.7 - Altitude/Vertical Velocity Indicator
- Describe the crew controls associated with the AMI and the AVVI.  
REF.: GNC DISP 2102, Section 4.2 - AMI Controls and Section 5.2 - AVVI Controls
- Describe the BFS processing of the AMI and the AVVI during Entry.  
REF.: GNC DISP 2102, Section 4.3.5 - BFS AMI Processing and Section 5.3.5 - BFS AVVI Processing
- Describe the information that the ADI supplies.  
REF.: GNC DISP 2102, Section 2 - Attitude Director Indicator (ADI); SCOM, Section 2.7 - Attitude Director Indicator (ADI)
- Identify the ADI controls for the three ADIs and state their function.  
REF.: GNC DISP 2102, Section 2.2 - ADI Controls
- List the main functions of the HSI during the entry phase.  
REF.: GNC DISP 2102, Section 3 - Horizontal Situation Indicator (HSI); SCOM, Section 2.7 - Horizontal Situation Indicator (HSI)
- Identify and interpret the eight HSI parameters.  
REF.: GNC DISP 2102, Section 3.1 - HSI Display Features
- State the purpose of the HUD during entry.  
REF.: SCOM, Section 2.7 - Head-Up Display
- Identify the HUD controls and state their functions.  
REF.: SCOM, Section 2.7 - Head-Up Display

**EXERCISES:**

1. What data does the ALPHA, MACH and EAS on the AMI and the ALT RATE and RATE on the AVVI show when the Air Data switch is in the Left or Right position? What do ACCEL on the AMI and ALT ACCEL and RDR ALT on the AVVI show?
2. BFS is engaged and both probes are deployed. The left Air Data switch is in the RIGHT position. What data is displayed on the CDR's AMI and AVVI? What data is displayed on the PLT's AMI and AVVI?
3. Which ADI control is unique to the AFT ADI and why?
4. What effect does depressing the ATT REF push-button have on the REF frame?
5. When is the ATT REF push-button typically used during a flight?
6. On the figure below, label the HSI parameters and their readings.



Heading ≅ _____	PRI BRG = _____
Course = _____	SEC BRG = _____
CDI ≅ _____	PRI RNG = _____
GSI = _____	SEC RNG = _____

7. Based on the previous HSI figure,
  - a) is the Orbiter currently on the right or left side of the extended runway centerline?
  - b) is the Orbiter above or below the desired glide slope?
  - c) what happens to the CDI if the vehicle continues at the present heading?
  
8. What data buses are each of the HUDs connected to and how do you select an alternate data bus?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Entry NAV Aids Overview

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** NAV 2102B, NAV AIDS 2102

**SUPPLEMENTAL MATERIAL:** SCOM, FDF (DPS Dictionary), ENAV 2106, OGNC RVW 4106 (any NAV discussion)

**TOPIC SYNOPSIS:** This study guide reviews the data used and the altitude/Mach of incorporation for all of the entry NAV aids. It will also discuss SPEC 50.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the parameter that DRAG H provides to Navigation and when this data is used.  
REF.: NAV OV, 2102, Section 3 - Drag Altitude (Drag H)
- List the two parameters TACAN provides to Navigation and when this data is used.  
REF.: NAV 2102B, Section 3 - Tactical Air Navigation System; NAV AIDS 2102, Section 1 - TACANs Introduction, and TACAN Usage in Navigation
- List the parameters that the Air Data System provides and when this data is used.  
REF.: NAV 2102B, Section 3 - Air Data System
- List the three parameters that MLS provides to Navigation and when this data is used.  
REF.: NAV 2102B, Section 3 - Microwave Landing System; NAV AIDS 2102, Section 2 - Microwave Landing System Usage in Navigation
- State the parameter that RA provides and when this data is used.  
REF.: NAV AIDS 2102, Section 3 - Radar Altimeter
- Explain how the Residual and the Ratio on SPEC 50 are defined for a given sensor parameter.  
REF.: NAV 2102B, Section 3 - Kalman Filtering; NAV AIDS 2102, Section 1 - TACAN CRT Displays
- Explain what the filter controls AUT, INH and FOR on SPEC 50 mean.  
REF.: NAV 2102B, Section 3 - Kalman Filtering; NAV AIDS 2102, Section 1 - TACAN CRT Displays

**EXERCISES:**

1. Which of the seven parameters supplied by the Air Data System are used by Navigation?
2. When MLS data is acquired and starts processing to update the state vector, what other NavAid information does it replace?
3. Not all three parameters for MLS are required to start processing MLS data. Which parameter is not necessary?
4. MCC has advised the crew that the NAV state is bad. On SPEC 50, the TACAN Ratio is greater than 1.0. What can be done to update the NAV state with the TACAN data?
5. The RATIO EDIT TEST will not use data if the RESID is greater than 1. What is considered a good RESID to use before questioning the data or the NAV State?
6. RA data is not used by Navigation. How does the crew use RA data?



## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: IMUs

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** IMU 2102, FDF (AESP, APCL, EPCL, Orbit OPS, Malfunction Procedures, Reference Data, Deorbit Burn Monitor Cue Card)

**SUPPLEMENTAL MATERIAL:** IMU/ST/CO 2105A, IMU/ST/COAS 2106, ENAV 2206, OGNC RVW 4106 (any IMU discussion)

**TOPIC SYNOPSIS:** This study guide reviews functions, procedures, and displays for the IMUs. The emphasis is placed on IMU Alignment procedures and the associated ORBIT OPS CHECKLIST. IMU Redundancy Management and Malfunction Procedures will be addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Explain the purpose of and how to perform the three IMU Alignments: matrix align, IMU/IMU align and star align.  
REF.: IMU 2102, Section 3 - IMU Alignment Options; FDF - ORBIT OPS, IMU Aligns
- State the three ways to cage an IMU. Explain what must be done to recover the IMU.  
REF.: IMU 2102, Section 4 - System Malfunctions; FDF - ORBIT OPS, IMU Aligns
- Explain IMU Redundancy Management schemes for PASS and BFS.  
REF.: IMU 2102, Section 4 - System Malfunctions and Section 5 - Differences in the BFS
- Identify a hardware or software BITE and state how to mask that BITE.  
REF.: IMU 2102, Section 2 - Built-In Test Equipment; MAL PROC, Section 8 (GNC) - IMU BITE/T; REF. DATA, Section 7 - Table 1: SPEC 21 IMU BITE DECODE
- Identify an IMU RM failure and an IMU dilemma. Explain the associated steps in the FDF for each procedure.  
REF.: IMU 2102, Section 4 - System Malfunctions; FDF - RM FAIL IMU and RM DLMA IMU in the AESP, APCL, EPCL, MAL PROC and Deorbit Burn Monitor Cue Card

### EXERCISES:

1. Which IMU align do we use most often and why?
2. MCC asks you to perform an unscheduled, i.e. not in the Flight Plan, IMU align. How would you determine the correct stars to use for the align?
3. If an IMU is caged, what must be done to make it usable?
4. GPC 2 power fails during the ascent part of a TAL. What IMU data does the BFS now use? After the OPS 3 transition and recovery of string 2, what IMU data does the BFS use?
5. If the BFS drops to the two level for IMUs, and all three IMUs subsequently become available, how do you get back to Mid-Value-Selecting (MVS)?
6. Why are the IMUs skewed?
7. State an IMU failure for which the BFS downmodes but the PASS does not.
8. Why do we mask false BITES?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: MLS/RA

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** NAV AIDS 2102, SCOM

**SUPPLEMENTAL MATERIAL:** NAV 2102B, ENAV 2206, OGNC RVW 4106 (any MLS/RA discussion)

**TOPIC SYNOPSIS:** This study guide reviews the hardware and the redundancy management for the MLS and the RAs.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the limits for elevation, azimuth, range and shuttle heading with respect to the runway centerline that must be met prior to processing MLS data.  
REF.: NAV AIDS 2102, Section 2 - Orbiter Microwave Landing System Software
- Describe the MLS redundancy management and selection filter schemes for PASS.  
REF.: NAV AIDS 2102, Section 2 - Redundancy Management
- Explain how the Orbiter MLS units and the MLS ground stations operate.  
REF.: NAV AIDS 2102, Section 2 - Microwave Landing System Operation; SCOM, Section 2.13 - Navigation Hardware - Microwave Landing System
- Explain how the Orbiter RAs operate.  
REF.: NAV AIDS 2102, Section 3 - Radar Altimeter Operation; SCOM, Section 2.13 - Navigation Hardware - Radar Altimeters
- Explain how the BFS uses RA data.  
REF.: NAV AIDS 2102, Section 3 - Radar Altimeter Software

### EXERCISES:

1. How can you upmode an MLS unit that has been downmoded by FDIR?
2. Where is the only place that the crew can see MLS data to try and solve an MLS dilemma?
3. If you are down to two MLS units, and you subsequently have an MLS DLMA, how do you know if the dilemma is with elevation?
4. MLS 1 has previously failed. An MLS dilemma is annunciated while going around the HAC. What parameter is in dilemma and how do you know?
5. When the BFS is engaged, how can you determine which RA is supplying data to your tape?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** NAV Overview

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** NAV 2102B, SCOM, FDF (Entry Checklist, DPS Dictionary)

**SUPPLEMENTAL MATERIAL:** OGNC RVW 4106 (any NAV topic)

**TOPIC SYNOPSIS:** This study guide is an overview of Navigation software. NAV delta 0 and voice delta states will be review as will the state vector schemes in all phases of flight. A PASS/BFS state vector transfer will also be discussed. A brief discussion of the two coordinate systems used most often in the shuttle world, M50 and LVLH will also be addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Define what a state vector is and how it is calculated in ascent, orbit and entry.  
REF.: NAV 2102B, Section 2 - Overview, and State Vector Schemes; SCOM, Section 2.13 - Description - State Vector
- Describe how the vector selector works at the 1, 2, and 3 levels for the three state vector scheme.  
REF.: NAV 2102B, Section 2 - State Vector Schemes
- Illustrate the advantage of the three state vector scheme over the single state vector scheme.  
REF.: NAV 2102B, Section 2 - Three State Vector Scheme
- Explain what a NAV delta 0 is and why it is performed.  
REF.: NAV 2102B, Section 4 - Zero Delta State Vector Update
- Describe the M50 and LVLH coordinate systems and their application to pointing the Orbiter.  
REF.: NAV 2102B, Section 1 - Mean of 1950 Coordinate System, and Local Vertical/Local Horizontal Coordinate System; SCOM, Section 2.13 - Description - Coordinate Systems
- Explain how and why you would perform a PASS/BFS state vector transfer.  
REF.: NAV 2102B, Section 4 - PASS-to-BFS State Vector Transfer
- Describe the main steps involved in performing a voice delta state update and identify when it is used.  
REF.: NAV 2102B, Section 4 - Voice Delta State Update; FDF - NAV DELTA PAD CC
- List the crew and MCC actions required to enable Rendezvous navigation.  
REF.: NAV 2102B, Section 5 - Rendezvous Navigation
- State the primary difference between PASS and BFS navigation.  
REF.: NAV 2102B, Section 5 - BFS Differences

## **EXERCISES:**

1. What is used by the navigation software to propagate the state vector?
2. What phases of flight use a single state vector scheme?
3. If IMU 1 is unavailable, how does RM determine a state vector in the single state vector scheme? In the three state vector scheme?
4. Why is the three state vector scheme not used in all phases of flight?
5. IMU 3 suffers a power transient but is recovered during entry with an IMU/IMU align. What needs to be done to use this IMU again and why?
6. If you are in an LVLH attitude hold of 0,0,0, what is your inertial rate of rotation and in what axis? Where is this information displayed onboard?
7. State the two ways that the PASS state vector can be transferred to the BFS.
8. When is the NAV DELTA PAD CC used?
9. Why do we have to enable RNDZ NAV prior to a rendezvous?
10. If the BFS state vector is bad preengage, how is it updated?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Nominal NAV Procedures

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** FDF (Orbit OPS Checklist), Orbit Operations Checklist FPH, Deorbit Prep FPH

**SUPPLEMENTAL MATERIAL:** OGNC RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the nominal navigation procedures from the Orbit OPS Checklist.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the purpose of the following procedures and when they would be performed.
  - a) IMU ALIGN - S TRK
  - b) IMU ALIGNMENT - IMU/IMU
  - c) COAS CALIBRATION, GNC 201
  - d) HUD CALIBRATION, GNC 201
  - e) FCS CHECKOUT - Part 2
  - f) DEORBIT PREP (Blocks 8 and 22)

REF.: (a - e) Orbit Operations Checklist FPH, Section 7 - Procedures by the same name; FDF, Orbit OPS Checklist - Procedures by the same name; (f) Deorbit Prep FPH, Section 1.2
  
- State the rationale for all the steps in the following procedures.
  - a) IMU ALIGN - S TRK
  - b) IMU ALIGNMENT - IMU/IMU
  - c) COAS CALIBRATION, GNC 201
  - d) HUD CALIBRATION, GNC 201
  - e) DEORBIT PREP (Blocks 8 and 22)

REF.: (a-d) Orbit Operations Checklist FPH, Section 7 - Procedures by the same name; FDF, Orbit OPS Checklist - Procedures by the same name; (e) Deorbit Prep FPH, Section 1.2
  
- State the rationale for the navigation tests in the FCS CHECKOUT - Part 2 procedure.

REF.: Orbit Operations Checklist FPH, Section 7 - FCS CHECKOUT - Part 2; FDF, Orbit OPS Checklist - FCS CHECKOUT - Part 2

### EXERCISES:

1. What does the IMU ALIGN - S TRK procedure assume has already been done prior to starting this procedure?
2. What data is the starred block of step 2 in the IMU ALIGN - S TRK procedure referring to?
3. In the starred block of step 2 in the IMU ALIGN - S TRK procedure, should you proceed with a self test on both star trackers if the correct stars are not in the Star Table?
4. Which IMUs should be aligned in step 4 in the IMU ALIGN - S TRK procedure and why?
5. Why is it necessary to verify a good alignment in the IMU ALIGNMENT - IMU/IMU procedure?

6. For a COAS or a HUD CALIBRATION, do you take a minimum of three marks to get a better average for the update?
7. What is the purpose of the verification in the COAS and the HUD CALIBRATION procedures?
8. Does the HUD calibration require the use of the P as the boresight?
9. Why is an IMU align verification required for the Deorbit Prep IMU ALIGNMENT Block 8?
10. For the IMU alignment in Block 22 of Deorbit Prep, should you select all three IMUs? Why or Why not?
11. If an ADTA shows a BITE during the HIGH or LOW TEST in the FCS CHECKOUT, should you read the BITE status from GPC memory before or after stopping the test?
12. How do you determine if an ADTA with a BITE needs to be deselected during the FCS CHECKOUT procedure?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Star Trackers

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** S TRK/ COAS 2102, IMU 2102, SCOM, FDF (REF DATA, Post Insertion), Orbit Operations Checklist FPH

**SUPPLEMENTAL MATERIAL:** IMU/ST/CO 2105A, IMU/ST/COAS 2106, OGNC RVW 4106

**TOPIC SYNOPSIS:** This study guide reviews the star tracker and COAS purpose and the star tracker hardware. Also discussed are the procedures and the SPECS associated with the star trackers.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- State the purpose of the star trackers and when they would be used.  
REF.: S TRK/ COAS 2102, Section 1 - Introduction; SCOM, Section - 2.13 - Navigation Hardware - Star Trackers
- List the two backups to the star trackers and state their function.  
REF.: S TRK/ COAS 2102, Section 7 - COAS Introduction; SCOM, Section - 2.13 - Navigation Hardware - Crew Optical Alignment Sight (COAS); Flight Rules, Section 8 - Rule A8.1.3-9
- Describe the basic star tracker hardware.  
REF.: S TRK/ COAS 2102, Section 4 - Star Tracker Hardware; SCOM, Section - 2.13 - Navigation Hardware - Star Trackers
- Discuss the rationale for the star tracker steps in the IMU ALIGN - S TRK procedure.  
REF.: Orbit Operations Checklist FPH, Section 7 - Procedure by the same name
- State the purpose of the SPEC 22 crew controls for the star trackers.  
REF.: S TRK/ COAS 2102, Section 5 - Star Tracker/COAS Control Display

### EXERCISES:

1. If the Bright Object Sensor (BOS) loses power, is the star tracker still usable?
2. When are the star trackers activated and the doors opened? When are the star trackers deactivated and the doors closed?
3. If a star tracker fails on orbit, non-recoverable, what should you do?
4. What nominal time would you calibrate the COAS?
5. When would you be likely to perform an ITEM 7(8) on SPEC 22?
6. When would you nominally expect to see OUT FOV on the status line of SPEC 22?
7. What is a star of probability align?
8. Where are the star trackers mounted and to which shuttle body axis are they approximately aligned?

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: TACANs

**SOURCE:** DT35/DPS/NAV SECTION

**REV.:** OCT 1997

**MATERIALS REFERENCED:** NAV 2102B, NAV AIDS 2102, SCOM, FDF (AESP, EPCL)

**SUPPLEMENTAL MATERIAL:** ENAV 2106, OGNC RVW 4106 (any TACAN discussion)

**TOPIC SYNOPSIS:** This study guide reviews hardware, procedures, and displays for the TACANs. The emphasis is placed on the requirements to use TACAN data and redundancy management. The PASS and BFS differences will also be addressed.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- Explain how the Orbiter TACAN units and the TACAN ground station operate.  
REF.: NAV 2102B, Section 3 - Tactical Air Navigation System; NAV AIDS 2102, Section 1 - TACAN Ground Station Hardware and Operation; SCOM, Section 2.13 - Navigation Hardware - Tactical Air Navigation
- Locate the TACAN circuit breakers and controls. State the function of each position on the TACAN MODE rotary switch.  
REF.: NAV AIDS 2102, Section 1 - TACAN Crew Controls; SCOM, Section 2.13 - Navigation Hardware - Tactical Air Navigation
- Explain the Bearing Cone of Confusion.  
REF.: NAV 2102B, Section 3 - Tactical Air Navigation System; NAV AIDS 2102, Section 1 - Redundancy Management (RM)
- Describe the TACAN redundancy management and selection filter schemes for PASS and BFS.  
REF.: NAV AIDS 2102, Section 1 - Redundancy Management (RM); FDF - TACAN RM card in the EPCL
- Identify a TACAN RM failure and a TACAN dilemma. Explain the associated steps in the FDF for each procedure.  
REF.: NAV AIDS 2102, Section 1 - Redundancy Management (RM); FDF - RM FAIL TAC and RM DLMA TAC in the AESP
- Explain the PASS TACAN SELF-TEST and how it is used.  
REF.: NAV AIDS 2102, Section 1 - Redundancy Management (RM)



## **EXERCISES:**

1. How is slant range measured by the onboard TACAN units?
2. Which data buses are used to transmit TACAN data to and from the GPCs? What is special about the TACAN/RA Input/Output Module in the MDM?
3. Do the TACAN channel numbers on the thumbwheels have to be set to the corresponding TACAN station if the TACAN MODE switch is in GPC?
4. What is the onboard indication that you have entered the Bearing Cone of Confusion?
5. How does RM determine a candidate for selection by the Selection Filter in PASS and BFS?
6. Describe the two-lock requirement for the PASS.
7. The BFS does not have a two-lock requirement like PASS. What are the two conditions that must be met to process TACAN data in the BFS?
8. What data does the BFS use at the two level? What data will the BFS use if a miscompare is found at the two level in the BFS?
9. Explain why the first step of the RM FAIL TAC and the RM DLMA TAC procedure have you check if both data good.
10. FF1 has previously failed. The message RM DLMA TAC is annunciated. What is your immediate action? Explain why.
  - A. Determine the bad TACAN unit and deselect it in BFS Only.
  - B. Determine the bad TACAN unit and deselect it in PASS and BFS.
  - C. Wait for SELF-TEST to complete prior to taking any action.
  - D. Call MCC for recommended action.

# SYSTEMS

## **Section 4 - Systems**

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## **Materials Referenced**

APU/HYD/WSB 2102
C&W 2102
C&W 2157
ECLSS 2102
ECLSS 2157
ECLSS MAL 2157
EPS 2102
EPS 2157
EPS MAL 2157
Flight Procedures Handbook - Vol. I, Rev.D, DCN-1, Sects. 1-5
MECH SYS 2102
SCOM - PCN 5
Space Shuttle Operational Flight Rules, Volume I, PCN-23,
Space Shuttle Systems Handbook, SSSH, Revision E, DCN-5

\*\* Note: The CBT's referenced are the current CBT's on the Server.

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: APU/Hydraulics

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** SCOM, APU/HYD/WSB 2102, Flight Rules sections 8, 9, and 10, SSSH section 12, PRL 2157 CBT.

**SUPPLEMENTAL MATERIAL:** APU REFR 4104, APU REVIEW 4104.

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and critical malfunction scenarios related with the APU, Hydraulic, and WSB systems. The APU controller, cooldown/restart operations, and impacts from the loss of various hydraulic systems are emphasized.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss rationale behind each nominal and AESP APU/Hyd procedure.  
REF.: Applicable Flight Procedures Handbooks  
SCOM; section 2.1, "Operations".
- determine the operational state of the APU, hydraulic system, and WSB based upon the data displayed on SM Sys Summ 2, GNC Spec 51, the panel F8 meters, and the status lights on panel F7.  
REF.: APU/HYD/WSB 2102; section 2, "APU Controls and Displays", section 3, "Hydraulic System Controls and Displays", and section 4, "Water Spray Boiler Controls and Displays".  
SCOM, switch panels and display figures, section 2.1, "Fuel Systems", "Gas Generator and Turbine", "Lubricating Oil", and "Electronic Controller".
- explain why an APU would be shutdown on ascent.  
REF.: Flight Rule A10.1.2-5C, "APU High speed Selection/Shift"
- discuss the danger of performing a pre MECO swap of WSB controllers.  
REF.: Flight Rule A9.1.4-4A.5 (plus rationale), "AC Load Management During Ascent"
- describe how the APU controller functions to control APU speed and provide Overspeed and Underspeed protection.  
REF.: SCOM; section 2.1, "Fuel Control Valves", and "Electronic Controller"  
APU/HYD/WSB 2102; section 2, "Fuel Control Valves" and, "Digital Controller".
- discuss when APU COOLDOWN and RESTART procedures should be performed.  
REF.: Flight Rule A10.1.2-2A, "APU Start/Restart Limits".
- describe why a COOLDOWN must be continuous (can't be interrupted) and the danger of doing a hot restart.  
REF.: SCOM; section 2.1, "Injector Cooling System".  
APU/HYD/WSB 2102; section 2, "Injector Cooling System".  
Flight Rule A10.1.2-2A, "APU Start/Restart Limits".
- discuss why a DIAGNOSTIC RESTART would be needed (unexplained underspeed could have been the result of two MPUs failing low).  
REF.: Flight Rule A10.1.2-6, "APU Auto Shutdown Inhibit Management"

- discuss why an APU would be restarted late (loss of oil cooling capability).  
REF.: Flight Rules A10.1.2-2F, “APU Start/Restart Limits”, A10.1.2-3B.1-9, “APU Entry Start Time”, and A10.1.2-4B, “APU Oil/Gearbox Temperature/Pressure”.
- discuss the dangers of APU fuel line heaters failed either on or off.  
REF.: APU/HYD/WSB 2102; section 2, “Heaters”.
- describe the impacts to the SSMEs when a) one hydraulic system is lost, and b) two hydraulic systems are lost on ascent.  
REF.: APU/HYD/WSB 2102; section 3, “Main Engine Throttling Valves”, “Main Engine Thrust Vector Control”.  
Flight Rule A8.1.2-11, “SSME Shutdown Due To Hydraulic System Failures”
- describe the role and operation of priority rate limiting (PRL) as it relates to entry flight control as a) one, and b) two hydraulic systems are lost.  
REF.: APU/HYD/WSB 2102; section 3, “Elevons”, “Rudder/Speedbrake and Body Flap”, “Priority Rate Limiting”, “PRL Operation”, “Miscompare”, “PRL Dilemma and Crew Interface”  
If desired: PRL 2157 CBT, “Background Information” section, “PRL Definition” and “PRL Operations” subsections.
- discuss the reasons the hydraulic main pump output pressure would be taken to “LOW”.  
REF.: SCOM; section 2.1, “Main Hydraulic Pump”, and “APU/HYD Rules of Thumb”.  
Flight Rules A10.1.2-8, “AOA APU Hydraulic Systems Operations”, A10.1.42E, “Hydraulic Leaks”, and A10.1.43B, “Hydraulic System Pressure/Temperature”  
APU/HYD/WSB 2102; section 3, “Main Pump”.
- discuss the risk incurred when pressure is lost in the hydraulic accumulator (e.g., an accumulator GN2 leak) and the result required to save the system.  
REF.: SCOM; section 2.1, “Hydraulic Reservoir”, “Hydraulic Accumulator”, and “Circulation Pump and Heat Exchanger”.  
APU/HYD/WSB 2102; section 3, “Reservoir and Accumulator”.  
Flight Rule A10.1.4-4A.1.a-b, “Hydraulic Circulation Pump Operation (CIL)”
- describe the layout of the landing gear hydraulics, and discuss which valves open automatically and when.  
REF.: APU/HYD/WSB 2102; section 3, “Nosewheel Steering”.
- discuss which hydraulic system(s) are used for a) main gear deploy, b) nose gear deploy, and c) nose wheel steering.  
REF.: APU/HYD/WSB 2102; section 3, “Landing Gear”, “Nosewheel Steering”.
- describe the impact to braking for any combination of the failure of two hydraulic systems.  
REF.: APU/HYD/WSB 2102; section 3, “Brakes”.

## EXERCISES:

1. True or False: An APU that is overheating (OIL OVERTEMP alarm) on ascent will be shut down before it seizes if it is the only APU with a problem.
2. Scenario: you see your WSB quantity dropping quickly during ascent. You should:
  - a) switch WSB controllers: in case the 1st controller was causing overspraying, that might fix it
  - b) switch WSB controllers: in case it was just be bad instrumentation from the 1st controller
  - c) both a) and b) are good reasons to switch controllers
  - d) none of the above
3. If the primary control valve loses power, what happens to a running APU?
4. Describe the sequence of events for an auto shutdown.
5. Scenario: APU 1 experiences an unexplained underspeed shutdown on the ascent side of an RTLS.  
A COOLDOWN should be started:
  - a) ASAP
  - b) ASAP post MECO
  - c) at  $M = 7$
  - d) on MCC call only
6. In the scenario above (and no other failures), when should the RESTART be attempted?
  - a) after 3.5 min. of continuous cooling
  - b) when the INJ T is  $< 400$  F.
  - c) only on MCC call
  - d) either a) or b) is acceptable
7. True or False: After a COOLDOWN (3.5 minutes of continuous cooling) has been completed, it's a good idea to terminate the COOLDOWN until a RESTART is required to save injector cooling water.
8. Reference SSSH drwg. 12.1 2-2, zones O - G. If two MPUs (magnetic pickup units) were to fail to OSL values while an APU was running, what would be the immediate result?
  - a) it depends on the combination of MPUs
  - b) an APU overspeed would result
  - c) an APU underspeed would result
  - d) an underspeed would be annunciated, but the speed would continue to be controlled.
9. Suppose the previous situation happened on an abort or entry, and other failures were present to cause an attempted RESTART on the APU with the unexplained UNDERSPEED. What happens on the RESTART attempt in this case?
  - a) it won't start
  - b) it attempts to start but then underspeeds again
  - c) it overspeeds
  - d) depends on the position of the AUTO SHUTDOWN switch.
10. Scenario: During entry an APU overheats. A second APU subsequently overspeeds. The COOLDOWN is performed at  $M=7$  and the RESTART is performed \_\_\_\_\_.
  - a) at  $M=1$
  - b) when the cooldown's complete (3.5 min. after it's started)
  - c) on MCC call only

11. Since the MCC has better insight and trend data, the crew should wait for their call before taking action for an APU fuel line heater failure during orbit.
  - a) True
  - b) False
  - c) depends on whether the heater failed ON or OFF.
12. Scenario: APU 2 underspeeds at 1:00 and hydraulic system 3 suffers a pump failure (off-scale low pressure) at 2:00 MET. What are the impacts to SSME throttling and gimbaling?
13. Continuing the scenario above, what do you expect to see for PRL status on GNC Spec 51, and what kind of response rates do you expect to have on entry?
14. Reasons for taking a hydraulic main pump to “LOW” press include (may be more than one correct answer):
  - a) reduce torque for APU startup
  - b) to keep switching valves from cycling in the event of sporadic output pressure loss
  - c) to slow a non-isolable hydraulic leak
  - d) to reduce APU fuel usage
15. Scenario: You are on orbit and receive a message that sends you to SM Sys Summ 2 to look at the hyd 2 accumulator pressure. You see that it is falling rapidly through 2100 psi. The circ pump 2 switch is in GPC. You should:
  - a) continue to monitor it, expecting the GPC to turn the circ pump on eventually
  - b) inform MCC and wait for them to command the circ pump ON
  - c) take the circ pump 2 switch ON
  - d) finish what you’re doing, and then go find the Orbit Pocket Checklist
16. At  $V_{rel} = 800$  fps, the hydraulic LANDING GEAR EXTEND ISOL VALVE should automatically come open. Procedurally, the crew checks this valve at  $M=0.7$ , and attempts to open it manually if it’s not open. What is lost if it can’t be opened?
  - a) hydraulic gear deploy
  - b) hyd sys 1 for braking
  - c) nose wheel steering
  - d) all of the above
17. In the earlier example with systems 2 and 3 lost, what is the impact to braking?

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** C&W - Caution and Warning

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** C&W 2102, SCOM, C&W 2157, SSSH

**SUPPLEMENTAL MATERIAL:** C&W REFR SST, C&W Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the Caution and Warning system. The emphasis is on interpretation of the information presented on the displays and interfaces with Electrical Power System and Environmental Control and Life Support System.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- identify the power sources for the Caution and Warning System power supplies and F7 matrix  
REF.: SCOM; section 2.2, "Class 2-C/W".  
C&W 2157  
C&W 2102; section 4, "Power Supply".
- identify which parts of the Caution and Warning system can be controlled by the MCC and which cannot  
REF.: SCOM; section 2.2, "Software (backup) Caution and Warning"  
C&W 2157  
C&W 2102; section 4, "Crew and Mission Control Center Software Interface",  
Section 8, "Overview".
- discuss the methods by which the upper and lower limits for a parameter can be changed  
REF.: SCOM; section 2.1, "Operations".  
C&W 2102; section 4, "panel R13U", section 8.
- determine, using the information on BFS SYS SUMM 1 and Panel L1, the operational state of the orbiter's smoke detection and fire suppression system  
REF.: SCOM; section 2.2, "Smoke Detection and Fire Suppression".  
C&W 2102; section 3.  
C&W 2157

**EXERCISES:**

1. Loss of the electrical bus ESS1BC does not affect the functionality of the Caution and Warning system. True or False
2. If there is a loss of power to the Primary C&W system (controlled by panel R13U and power is restored, the MCC can uplink the changes to this piece of the system while they cannot uplink changes to the part of the system accessed by SPEC 60. True or False
3. What is a TMBU?
  - A. A method by which changes can be made to the Primary (Hardware) C&W system
  - B. A method by which changes can be made to the Backup (Software) C&W system
  - C. A method by which changes can be made to the Constants in the Flight Software
  - D. All of the Above
  - E. B and C
4. If there is one smoke detection light lit on Panel L1 and there are no increasing smoke concentrations on BFS SYS SUMM 1, there is most likely a sensor failure. True or False



## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Atmospheric Revitalization System (ARS)

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** ECLSS 2102, SCOM, ECLSS 2157, ECLSS MAL 2157, Flight Procedures Handbook (FPH)

**SUPPLEMENTAL MATERIAL:** ECLSS REFR SST, ECLSS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the ARS system. The emphasis is on interpretation of the information presented on the displays and interfaces with the other ECLSS subsystems.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the configuration of the water coolant loops during ascent and on-orbit  
REF.: SCOM; section 2.9, "Operations".  
ECLSS 2102; section 3.
- discuss the method by which heat is removed from the Cabin Atmosphere  
REF.: SCOM; section 2.9, "Atmospheric Revitalization System".  
ECLSS 2102; section 3.  
ECLSS 2157
- determine the operational state of the water loops based upon the ARS Water data and Av Bay Temperatures displayed on BFS SYS SUMM 2.  
REF.: SCOM; section 2.9, "Atmospheric Revitalization System".  
ECLSS 2102; section 3.
- discuss the configuration and operation of the fans and pumps listed below associated with the Atmosphere Revitalization System (Av Bay Fans, Cabin Fans, Humidity Separators, IMU Fans)  
REF.: SCOM; section 2.9, "Operations".  
ECLSS 2102; section 3.  
ECLSS 2157
- discuss the rationale behind which fans and pumps can be swapped pre-MECO and which cannot  
REF.: SCOM; appendix C, "ECLSS".  
Flight Procedures Handbook; section 4, "All Pump and Fan Procedures".  
ECLSS 2157

### EXERCISES:

1. Which water loop is the primary source of cooling during Ascent and Orbit operations?
2. How is heat removed from the Cabin Air?
3. After receiving a Master Alarm, an SM CRT Message and viewing the F7 matrix H2O Loop light, you check the data on BFS SYS SUMM 2 and notice the Water Loop Pump pressures are both equal to 24. You check your switches and Water Loop Pump 2 in ON and Water Loop Pump 1 is OFF. What has happened?
4. How many Av Bay Fans exist for each Av Bay and how many are nominally in use at any given time?
5. If you turn off a Cabin Fan pre-MECO, it is ok to turn it back on pre-MECO. True or False

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Active Thermal Control System (ATCS)

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** ECLSS 2102, SCOM, ECLSS 2157, ECLSS MAL 2157

**SUPPLEMENTAL MATERIAL:** ECLSS REFR SST, ECLSS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the ATCS system. The emphasis is on interpretation of the information presented on the displays and interfaces with the other ECLSS subsystems.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the methods by which heat is removed from the freon loops  
REF.: SCOM; section 2.9, "Active Thermal Control System".  
ECLSS 2102; section 4.
- discuss the operation of the Flash Evaporator System's Primary and Secondary Controllers  
REF.: SCOM; section 2.9, "Active Thermal Control System".  
ECLSS 2102; section 4.  
ECLSS 2157
- determine, based upon altitude, what method of cooling is active  
REF.: SCOM; section 2.9, "Operations".  
ECLSS 2102; section 4.
- discuss the purpose of and the time required for the the radiator controller auto startup sequence  
REF.: ECLSS 2102; section 4.  
ECLSS 2157
- determine, using data on BFS SYS SUMM 2 and BFS THERMAL, the operational state of the ATCS  
REF.: ECLSS 2102; section 4.  
ECLSS 2157  
ECLSS MAL 2157

### EXERCISES:

1. Which of the following is not a method by which heat is removed from the freon loops?
  - A. Radiators
  - B. FES
  - C. Ammonia Boilers
  - D. Water/Freon Interchanger
2. The FES Primary and Secondary controllers control the freon to the same temperature. True or False.
3. If, during ascent, the EVAP OUT T in one loop rises to 120 degrees, you will be required to swap FES Controllers. True or False
4. At landing, the FES is providing cooling for the orbiter. True or False.

5. If you take the L1 switches for the Radiator Controllers to AUTO and AUTO A, you will need to wait 1 minute to determine if there is a failure in the system. True or False
  
6. An EVAP OUT T of 62 could indicate which of the following:
  - A. The Secondary Controller is operating
  - B. It is nominal end of mission landing, you are below 100,000 feet and the freon is heating up
  - C. There is a problem with the cooling system
  - D. All of the above

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Supply and Waste Water

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** ECLSS 2102, SCOM, ECLSS 2157, ECLSS MAL 2157

**SUPPLEMENTAL MATERIAL:** ECLSS REFR SST, ECLSS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the Supply and Waste Water systems. The emphasis is on interpretation of the information presented on the displays and interfaces with the other ECLSS subsystems.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the methods of pressurization for the Supply and Waste Water Tanks  
REF.: SCOM; section 2.9, "Supply and Waste Water Systems".  
ECLSS 2102; section 5.
- discuss the effects of the position of the Supply Water Crossover Valve  
REF.: SCOM; section 2.9, "Supply and Waste Water Systems".  
ECLSS 2102; section 5.  
ECLSS 2157
- discuss the purpose and methods of performing supply and waste water dumps  
REF.: SCOM; section 2.9, "Supply and Waste Water Systems".  
ECLSS 2102; section 5.  
ECLSS 2157
- determine, using the information on PASS SPEC 66, the quantity of water available on board the orbiter  
REF.: SCOM; section 2.9, "Supply and Waste Water Systems".  
ECLSS 2102; section 5.

### EXERCISES:

1. If you cannot use the nominal N2 source for pressurization of the water tanks, you can use the cabin atmosphere to pressurize the water tanks. True or False.
2. Given the following supply water tank configuration, what water tanks are feeding the FES when the Primary A Controller is being used.

TK A INLET - OP    TK B INLET - OP    TK C INLET - CL    TK D INLET - OP  
TK A OUTLET - CL    TK B OUTLET - OP    TK C OUTLET - CL    TK D OUTLET - OP  
CROSSOVER VALVE - OP

- A. Tanks B and D
- B. Tanks A and B
- C. Tanks C and D
- D. All Tanks

3. Given the above supply water tank configuration with the Crossover Valve closed, which tanks are feeding the FES if the Primary A Controller is being used?
  - A. Tank D
  - B. Tank A
  - C. Tank B
  - D. All Tanks
  
4. The Flash Evaporator System cannot be used as a method for performing waste water dumps. True or False
  
5. The value for Supply Water Tank A on SPEC 66 is 85. What does this mean?
  - A. Tank A has 85 pounds of water in it
  - B. Tank A is 85% full
  - C. Both because the tanks hold 100 pounds of water
  - D. Neither

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Pressure Control System (PCS)

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** ECLSS 2102, SCOM, ECLSS 2157, ECLSS MAL 2157, Flight Procedures Handbook (FPH)

**SUPPLEMENTAL MATERIAL:** ECLSS REFR SST, ECLSS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the PCS system. The emphasis is on interpretation of the information presented on the displays and interfaces with the other ECLSS subsystems.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the configuration of the oxygen and nitrogen lines during ascent and on-orbit  
REF.: ECLSS 2157  
ECLSS 2102; section 2.
- discuss the method by which the O2/N2 Controller determines if O2 or N2 is required in the cabin atmosphere  
REF.: SCOM; section 2.9, "Pressure Control Systems".  
ECLSS 2102; section 2.  
ECLSS 2157
- discuss when the 14.7 Regulators and 8 psi Regulators will provide O2 or N2 to the cabin  
REF.: ECLSS 2102; section 2.  
SCOM; section 2.9, "Pressure Control System".
- describe the source of data for the following parameters on BFS SYS SUMM 1: Cabin dP/dT, B/U dP/dT, and EQ dP/dT  
REF.: SCOM; appendix C, "ECLSS".  
ECLSS 2102; section 2.
- determine, using data on BFS SYS SUMM 1, the operational status of the PCS components  
REF.: SCOM; section 2.9, "Pressure Control System".  
ECLSS 2157  
ECLSS MAL 2157
- discuss the rationale behind closing the Cabin Relief Valves one at a time when troubleshooting a loss of Cabin Pressure  
REF.: Flight Procedure Handbook; "Cabin Press Leak Procedure".

### EXERCISES:

1. Mid Mission there is a procedure performed that calls for the PCS to be reconfigured. What is the purpose of and general process involved in this procedure?
2. The O2/N2 Controller determines what makeup to provide to the cabin atmosphere by examining the Partial Pressure of O2. True or False
3. If, during ascent, the cabin pressure drops below 14.7 psi, N2 will flow through the 14.7 regulator to bring the pressure back to 14.7 psi. True or False.

4. The Cabin dP/dT and the EQ dP/dT should always be the same. True or False.
5. The Cabin dP/dT reading is from a hardware sensor and the EQ dP/dT reading is a calculation. True or False.
6. A reading of 5.0H on any of the flow rates on BFS SYS SUMM 1 indicates a faulty sensor. True or False
7. If, after closing Cabin Relief Valve A, the dP/dT displayed on BFS SYS SUMM 1 is 0, this indicates \_\_\_\_\_.
  - A. Sensor Failure
  - B. Leak was isolated
  - C. Cabin Relief B malfunctioned
  - D. A foreign object may have plugged up the hole

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Electrical Power Distribution and Control (EPDC)

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** EPS 2102, SCOM, EPS 2157, EPS MAL 2157

**SUPPLEMENTAL MATERIAL:** EPS REFR SST, EPS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the EPDC system. This system includes the distribution of DC power and the generation and distribution of AC power. The emphasis is on interpretation of the information presented on the displays. Information regarding procedures is also emphasized.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- identify the power sources of an electrical bus when given the bus name  
REF.: SCOM; section 2.8, "Electrical Power Distribution and Control".  
EPS 2102; section 4.  
EPS 2157
- determine the operational status of the electrical distribution system based upon data displayed on BFS SYS SUMM 1 and the F9 meters  
REF.: SCOM; section 2.8, "Electrical Power Distribution and Control".  
EPS 2102; section 4.
- provide rationale for the steps in the BUS TIE procedure  
REF.: Flight Procedures Handbook; section 5, "Bus Tie".  
SCOM; appendix C, EPS.
- discuss the dangers associated with performing a bus tie between a good Main Bus and a shorted Main Bus  
REF.: Flight Procedures Handbook; section 5, "Bus Tie".  
SCOM; appendix C, EPS.
- discuss the method by which a Control Bus can be unpowered and how the "Three Finger Trick" works  
REF.: Flight Procedures Handbook; section 5, "CNTL Bus Volts Low".  
SCOM; appendix C, EPS.
- discuss the dangers associated with leaving a shorted control bus powered  
REF.: Flight Procedures Handbook; section 5, "CNTL Bus Volts Low".
- describe how the AC Bus Sensors operate when the switch is in each of the following positions:  
MONITOR, OFF, and AUTO  
REF.: SCOM; section 2.8, "Electrical Power Distribution and Control".  
EPS 2102; section 4.  
EPS 2157



## EXERCISES:

1. What are the power sources for ESS2CA?
2. What are the power sources for CNTLBC2?
3. Given the following BFS SYS SUMM 1 data, what is potentially wrong with the electrical system?  
FC VOLTS = 35.8  
MAIN VOLTS = 0.0  
FC AMPS = 0.0
4. If you are performing a Bus Tie and one of the Main Bus Volts is less than 20, you do not need to disconnect the AC prior to performing the bus tie. True or False
5. What is the problem with performing a bus tie between a good Main Bus and a shorted Main Bus?
  - A. Nothing
  - B. You will lose your essential bus
  - C. You will place a short on the good bus
  - D. You will lose your GPC
6. When the Main A Control Bus Reset switch on Panel R1 is held in the RESET position, the RPC associated with that switch is unpowered and no power from Main A is being provided to the Control Bus. True or False.
7. If there is a short on a control bus, you run the risk of a fire if you do not unpower the bus. True or False.
8. During Ascent, the AC Bus Sensors are in the Monitor position. During this timeframe, if there are high enough amps on an AC Bus to cause an Overload condition, the AC Bus Sensor will trip the AC Bus Offline to protect the equipment on the bus. True or False

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Fuel Cells

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** EPS 2102, SCOM, EPS 2157, EPS MAL 2157

**SUPPLEMENTAL MATERIAL:** EPS REFR SST, EPS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the Fuel Cells. The emphasis is on interpretation of the information presented on the displays. Information regarding procedures is also emphasized.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the process by which heat and water are removed from the fuel cell  
REF.: SCOM; section 2.8, "Fuel Cell System".  
EPS 2102; section 3.  
EPS 2157
- discuss the dangers associated with losing the Fuel Cell Coolant Pump or H<sub>2</sub>/Water Separator  
REF.: SCOM; section 2.8, "Fuel Cell System", "Operations".  
EPS 2102; section 3.  
EPS 2157
- determine the operational state of the Fuel Cell based upon the Fuel Cell data displayed on BFS SYS SUMM 1 and the O<sub>2</sub> Meters  
REF.: SCOM; section 2.8, "Fuel Cell System".  
EPS 2102; section 3.  
EPS MAL 2157
- describe the purpose of Fuel Cell Purges  
REF.: SCOM; section 2.8, "Fuel Cell System".  
EPS 2102; section 3.  
EPS 2157
- discuss the meaning of the Substack Delta Volt values that are seen on BFS SYS SUMM 1  
REF.: SCOM; section 2.8, "Fuel Cell System".  
EPS 2102, section 3.  
EPS 2157

### EXERCISES:

1. The \_\_\_\_\_ separates water from the H<sub>2</sub>/water mixture and sends water to the ECLSS supply water tanks.
2. The \_\_\_\_\_ uses coolant to cool H<sub>2</sub>/steam mixture coming out of the Fuel Cell stack so that water can be removed.
3. If the coolant pump ceases to operate, you have \_\_\_\_\_ (amount of time) to shut down the fuel cell before you risk a possible fire or explosion.
4. If the COOL P for Fuel Cell 1 on BFS SYS SUMM 1 reads 60, what is the pressure of the O<sub>2</sub> and H<sub>2</sub> in the Fuel Cell?

5. If the Fuel Cell Coolant Pump failed, Fuel Cell Stack Temperature (FC STACK T) would \_\_\_\_\_.
- A. Rise
  - B. Fall
  - C. Remain Static
  - D. Fluctuate randomly
6. If the O2 meter showed the FC STACK T rising and the CRT confirmed this, the PLT would \_\_\_\_\_.
- A. Disregard the indication because it is normal
  - B. Throw the switch that reduces the fuel cell temperature
  - C. Work the FC Stack T procedure, shutting down the Fuel Cell
  - D. Work the Coolant P procedure because there is something wrong with the cooling
7. The purpose of the Fuel Cell Purge process is to cleanse the fuel cells of any inert gases or contaminants to increase reaction efficiency. True or False
8. If the Substack Delta Volts for all three substacks on Fuel Cell 1 jump from their original values to 50 then back to their original values, the following has occurred.
- A. There was a temporary glitch in the performance of the fuel cell
  - B. The Cell Performance Monitor performed a self-test.
  - C. The Cell Performance Monitor found something wrong with the fuel cell and fixed it.
  - D. It is time to perform a Fuel Cell Purge.

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Power Reactant Storage and Distribution (PRSD)

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** EPS 2102, SCOM, EPS 2157, EPS MAL 2157

**SUPPLEMENTAL MATERIAL:** EPS REFR SST, EPS Review SST

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and instrumentation related to the PRSD system. The PRSD system is also called the Cryo system. The emphasis is on interpretation of the information presented on the displays. Information regarding procedures is also emphasized.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss the instrumentation available for the O2 and H2 tanks and manifolds  
REF.: SCOM; section 2.8, "PDRS".  
EPS 2102; section 2.  
EPS 2157
- determine the operational state of the PRSD based upon the Cryo data displayed on BFS SYS SUMM 2 and the O2 Meters  
REF.: EPS 2102; section 2.
- describe the purpose and functionality of the O2 Heater Current Sensors  
REF.: SCOM; section 2.8, "PRSD".  
EPS 2102; section 2.
- describe the purpose of the O2 HTR CUR SNSR CK procedure performed daily on-orbit  
REF.: EPS 2102; section 2.  
EPS 2157
- discuss how O2 heaters operate during dual mode operations  
REF.: SCOM; section 2.8, "PRSD".  
EPS 2102, section 2.  
EPS 2157

### EXERCISES:

1. When the O2 Manifold Valves are closed, the O2 Manifold is divided into 3 separate pieces. Manifold \_\_\_\_\_ is the only manifold without a pressure sensor and over-pressure relief.
2. There are two pressure sensors on cryo tanks, P and TK P. P measures the actual pressure of the tank and can be read on the O2 meter. TK P is displayed on SYS SUMM 2 and sends its data to the heater controller. True or False.
3. There is a ground call that the MCC is monitoring an O2 leak in all tanks. After the PLT closes the O2 Manifold Valves, only O2 Tank 2 pressure is falling; this is verified by the O2 meters. The only possible problem is an O2 Manifold 2 leak. True or False.
4. Why do Heater Current Sensors exist in the O2 tanks and not the H2 tanks?
5. If an O2 Heater Current Sensor trips a heater off, what indication will you receive in the orbiter?

6. The purpose of the O2 HTR CUR SNSR CK procedure performed daily is to verify that 3 of 4 sensors per tank are operational. True or False.
  
7. When a pair of O2 tanks is operating in dual mode, the heater switches are ON until both tank pressures reach their High limit, then the switches are turned OFF. True or False.

## CREW STUDY GUIDE TOPIC SHEET

### TOPIC: Mechanical Systems

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** MECH SYS 2102, SCOM, Flight Rules Section 10, SSSH Section 15.

**SUPPLEMENTAL MATERIAL:** MECH REFR 4104, MECH REVIEW 4104, PLBD 2157 CBT, and ET DOORS 2157 CBT

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and critical malfunction scenarios related with the Mechanical systems. ET door and Payload Bay Door operations are emphasized.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- discuss rationale behind each nominal Mechanical Systems procedure.  
REF.: Applicable Flight Procedures Handbooks  
MECH SYS 2102; section 2, “Vent Operations”, and “Procedures”, section 3, “ET Door Operations”, section 4, “PLBD Operations”, “PLBD Display”, and “PLBD Procedures”, section 5, “Radiator Operations”, and “Radiator Procedures”.
- determine the operational state of the active vents, ET doors, Payload Bay Doors (PLBDs), and active radiators based upon data found on GNC Spec 51, the PASS SM OPS 202 display (or BFS SM Spec 63), and talkbacks found on panels R2, R13L.  
REF.: SCOM; section 2.17, “switch panels and display figures”.  
MECH SYS 2102; section 3, “ET Door Operations”, section 4, section 5, “Radiator Operations”.
- list the different components that make up a power drive unit (PDU), and explain how they work.  
REF.: MECH SYS 2102; section 1.  
SCOM; section 2.17, “Description”.
- explain the difference between single and dual motor drive time, and explain the role of torque limiters and limit switches.  
REF.: MECH SYS 2102; section 1.
- discuss the purpose of and explain what the crew uses to interface with the active vents on the Shuttle.  
REF.: MECH SYS 2102; section 2.  
SCOM; section 2.17, “Active Vent System”.
- discuss how and when the ET doors are closed for: nominal ascent, RTLS, TAL, and AOA aborts.  
REF.: MECH SYS 2102; section 3.  
SCOM; section 2.17, “ET Umbilical System”.

- describe the sequence commanded by the Spec 51 auto ET door closure software, and when it should be used.  
REF.: SCOM; section 2.17, “ET Umbilical System”.  
 Flight Rule A10.1.13-1, “ET Umbilical Door Keypad Entry”
- discuss the appropriate ET door related actions to take when a feedline disconnect occurs on ascent.  
REF.: Flight Rule A10.1.13-3, “ET Umbilical Door Closure Delay for Disconnect Valve Failure (CIL)”.
- describe the ET door latch override capability.  
REF.: MECH SYS 2102; section 3, “Manual ET Door Closing”.  
 SCOM; section 2.17, “ET Umbilical Doors”.  
 SSSH 15.2, 2 of 3, zones L - G.
- discuss the difference between “manual” and “auto” PLBD operations.  
REF.: MECH SYS 2102; section 4, “PLBD Operations”  
 SCOM; section 2.17, “Payload Bay Door System”.
- explain the cause of a “PBD SEQ FAIL” message.  
REF.: MECH SYS 2102; section 4.  
 SCOM; section 2.17, “Payload Bay Door System”.
- explain the cause of a “PBD CONFIG” message.  
REF.: MECH SYS 2102; section 4.  
 SCOM; section 2.17, “Payload Bay Door System”.
- describe the purpose of the deployable radiators.  
REF.: MECH SYS 2102; section 5, “Overview”.

**EXERCISES:**

1. A typical PDU contains:
  - a) One AC motor with brakes
  - b) a gearbox with a switch module
  - c) shaft with bellcrank
  - d) both a) and b)
  - e) both b) and c)
2. This device is designed to protect against mechanical or structural damage in case the mechanism binds or jams:
  - a) motor brakes
  - b) torque limiters
  - c) microswitch modules
  - d) actuator timers

3. Which of the following does the crew use to interface with the vent system?
  - a) panel R2
  - b) panel R13L
  - c) Spec 51
  - d) both b) and c)
  
4. True or False: The ET door closure software initiated by a Spec 51 item entry is different from that which is initiated automatically on RTLS, TAL, and Contingency Aborts.
  
5. True or False: During a nominal ascent, a backup method of closing the ET doors is provided by the GNC software in MM 104, 105, and 106 via GNC SPEC 51 OVERRIDE.
  
6. True or False: If you should suffer a feedline disconnect on ascent, the ET doors should be shut ASAP to minimize propellant gasses from leaking.
  
7. Scenario: You have stowed the centerline latches and closed the ET doors per procedure. The left door has a "CL" talkback, but the right door still shows "barberpole" after single motor time has expired. Since you have indications that a mechanical mechanism is no longer driving, you do the right thing and stop commanding it by taking the MODE switch back to GPC and the door switches to OFF. The MCC says that they believe the door is really closed, but the forward and aft ready-to-latch (RTL) microswitches (msw's) are apparently failed. You should expect the MCC to tell you to take the MODE switch back to GPC/MAN and then \_\_\_\_\_ to resolve the situation.
  - a) cycle the door open and then closed again to see if the microswitches will clear.
  - b) take the LEFT door latch switch to LAT to take advantage of the cross-wiring.
  - c) take both the LEFT and RIGHT latch switches to LAT simultaneously.
  - d) go ahead and latch by taking only the RIGHT latch switch to LAT.
  
8. True or False: One can operate the PLBDs using only the hardware switches on panel R13L in the MANUAL mode, but either the SM OPS 202 or Spec 63 displays are required to use AUTO mode.
  
9. A manual PLBD closure has been initiated. The port door as well as the port forward and aft latches have been closed. The starboard door is in transition and has been driving for nearly 2 minutes 10 seconds. What fault message will be generated momentarily?
  - a) None
  - b) PBD SEQ FAIL
  - c) PBD CONFIG
  - d) Dilemma

XXXX/		PL BAY DOORS		XX X ODD/HH: MM: SS	
AC POWER	ON 1*				
	OFF 2				
AUTO MODE SEL	3	PBD SW-CL			
				MICRO-SW STAT	
				LATS DOORS	
				CC00 CRRRO	
				ABAB ABC	
CENTER LATCHES	MAN SEL	OP/CL	AUTO SEQ		
5-8	4	OP		0011	
9-12	5	OP		0011	
1-4	6	OP		0011	
13-16	7	OP		0011	
STBD					
FWD LATCHES	8	OP		0011	00000
AFT LATCHES	9	OP		0011	00000
DOOR	10*				
PORT					
FWD LATCHES	11	CL		1100	11110
AFT LATCHES	12	CL		1100	11110
DOOR	13	CL			
PBD SW BYPASS	14				
		OPEN	15		
		STOP	16		
		CLOSE	17		

( XX )



10. An auto PLBD opening is in progress. All latches and doors are open, up to and including the starboard door. As the port forward and aft latches begin opening, the port aft "close B" microswitch remains in the "1" state. Assuming no other failures, what indication will be observed after 30 seconds have elapsed?
- a) A dilemma
  - b) A PBD CONFIG fault message
  - c) A PBD SEQ FAIL fault message
  - d) a and b
  - e) a and c

XXXX/		PL BAY DOORS			XX X DDD/HH: MM: SS	
AC POWER	ON 1*					
	OFF 2			PBD SW-OP		
AUTO MODE	SEL 3*					
					MICRO-SW STAT	
					LATS	DOORS
					CCOO	CRRRO
					ABAB	ABC
CENTER LATCHES	MAN SEL	OP/CL	AUTO SEQ			
5-8	4	OP		0011		
9-12	5	OP		0011		
1-4	6	OP		0011		
13-16	7	OP		0011		
STBD						
FWD LATCHES	8	OP		0011	00001	
AFT LATCHES	9	OP		0011	00001	
DOOR	10	OP				
PORT						
FWD LATCHES	11	OP		0011	11110	
AFT LATCHES	12			0111	11110	
DOOR	13	CL				
PBD SW BYPASS	14					
		OPEN	15			
		STOP	16			
		CLOSE	17			

( XX )

11. True or False: The deployable radiators are deployed nominally.

## CREW STUDY GUIDE TOPIC SHEET

**TOPIC:** Landing Decel. Systems

**SOURCE:** DT48/Shuttle Systems

**REV.:** DEC 1997

**MATERIALS REFERENCED:** MECH SYS 2102, SCOM, Flight Rules Section 10.

**SUPPLEMENTAL MATERIAL:** MECH REFR 4104, MECH REVIEW 4104.

**TOPIC SYNOPSIS:** This topic reviews functions, procedures, displays, and critical malfunction scenarios related with the Landing/Deceleration systems.

**PERFORMANCE OBJECTIVES:** At the end of this review, the student will be able to:

- determine the operational state of the landing gear based upon talkbacks found on panels F6 and F8.  
REF.: SCOM; section 2.14, "Operations".  
MECH SYS 2102; section 6, "Landing Gear Proximity Sensors".
- describe the methods of landing gear deploy.  
REF.: MECH SYS 2102; section 6, "Overview", "Landing Gear Doors", "Landing Gear Hydraulics - Deployment", and "Landing Gear Proximity Sensors".  
SCOM; section 2.14, "Landing Gear".
- explain when the drag chute should be deployed and jettisoned.  
REF.: MECH SYS 2102; section 6, "Drag Chute".  
SCOM; section 2.14, "Drag Chute".  
Flight Rules A10.1.8-2A, "Drag Chute Deploy Techniques", and A10.1.8-3, "Drag Chute Deploy Constraints".
- explain the drag chute actions required when you are "Emergency Deploy".  
REF.: Flight Rule A10.1.8-2B, "Drag Chute Deploy Techniques".

### EXERCISES:

1. True or False: If hydraulic system 1 fails to release the main landing gear, a pyrotechnic actuator will automatically perform the function 1 second later.
2. The drag chute was designed to be deployed:
  - a) at 300 KEAS
  - b) In case of reduced braking capability (multiple hydraulic systems lost)
  - c) only on intact abort landings
  - d) Nominally if the crosswind is < 15 kt and the SSMEs were repositioned
3. Scenario: On entry you received an "SSME REPO FAIL" message. The Capcom tells you that you are "Emergency deploy on the chute." This means:
  - a) there is an emergency: chute is mandatory
  - b) chute should only be deployed if the CDR deems it necessary
  - c) chute should only be used if you know of an emergency, like a tire failure on rollout
  - d) b and c

# APPENDIX A

**Appendix A:** Study Guide Assignment Matrices and Quals Lessons

Recommended Assignments .....	A-1
Flight Specific Assignments .....	A-2
Qual Lessons .....	A-3

**APPENDIX A1: Study Guide Matrix - DT Recommendations**

Study Guide Topic	Crew Member	CDR	PLT	MS2	MS_	MS_	MS_
<b>1. COMM</b>							
1-1 Audio		X	X	X	X	X	X
1-2 CCTV		X	X	X	X	X	X
1-3 Instrumentation					X		
1-4 Ku-Band					X		
1-5 Payload Comm					X		
1-6 S-Band FM					X		
1-7 S-Band PM		X	X	X	X	X	X
1-8 UHF					X		
<b>2. CONTROL</b>							
2-1 Ascent/Abort Procedures		X	X	X			
2-2 Ascent Performance Calls		X	X	X			
2-3 Orbit DAP		X	X	X			
2-4 D/O Burns		X	X	X			
2-5 Entry Procedures		X	X	X			
2-6 FCS		X	X	X			
2-7 Landing		X	X	X			
2-8 MPS		X	X	X			
2-9 OMS/RCS		X	X	X			
2-10 OMS Burns with Malfunctions		X	X	X			
2-11 OMS Targeting		X	X	X			
2-12 Sensors & Controllers		X	X	X			
<b>3. DPS/NAV</b>							
<b>DPS</b>							
3-1 BFS Engage .		X	X	X			
3-2 BFS Failures		X	X	X			
3-3 DPS Nominal Procedures		X	X	X			
3-4 DPS Off-Nominal Procedures		X		X			
3-5 FC/PL MDMs		X	X	X			
3-6 GPCs and Restrings		X	X	X			
3-7 Multifunction CRT Display System		X	X	X	X	X	X
<b>NAV</b>							
3-8 Air Data System		X	X	X			
3-9 Dedicated Displays		X	X				
3-10 Entry Nav Aids Overview		X	X	X			
3-11 IMUs		X	X				
3-12 MLS/RA		X	X				
3-13 Nav Overview		X	X	X			
3-14 Nominal NAV Procedures		X	X	X			
3-15 Star Trackers		X	X				
3-16 TACANs		X	X	X			
<b>4. SYSTEMS</b>							
<b>APU/HYD</b>							
4-1 APU/Hydraulics			X	X			
<b>C &amp; W</b>							
4-2 Caution & Warning		X	X	X			
<b>ECLSS</b>							
4-3 Atmospheric Revitalization System (ARS)		X		X			
4-4 Active Thermal Control System (ATCS)		X		X			
4-5 Supply & Waste Water					X		
4-6 Pressure Control System (PCS)		X		X			
<b>EPS</b>							
4-7 Electrical Power Distribution & Control (EPDC)			X	X			
4-8 Fuel Cells			X	X			
4-9 Power Reactant Storage & Distribution (PRSD)			X	X			
<b>MECH</b>							
4-10 Mechanical Systems			X		X		
4-11 Landing/Decel Systems		X	X	X			

**NOTE**

These X's are only suggestions!

If X's appear across the entire Crew, DT suggests that everyone on the Crew should review this particular Study Guide. If an X appears in only one MS\_ column, then the MS or MS's assigned to that system on the flight should review that particular Study Guide.

**APPENDIX A2: Study Guide Matrix - Crew Specific**

Study Guide Topic	Crew Member	CDR	PLT	MS2	MS_	MS_	MS_
<b>1. COMM</b>							
1-1 Audio/UHF							
1-2 CCTV							
1-3 Instrumentation							
1-4 Ku-Band							
1-5 Payload Comm							
1-6 S-Band FM							
1-7 S-Band PM							
1-8 UHF							
<b>2. CONTROL</b>							
2-1 Ascent/Abort Procedures							
2-2 Ascent Performance Calls							
2-3 Orbit DAP							
2-4 D/O Burns							
2-5 Entry Procedures							
2-6 FCS/Sensors/Controllers							
2-7 Landing							
2-8 MPS							
2-9 OMS/RCS							
2-10 OMS Burns with Malfunctions							
2-11 OMS Targeting							
2-12 Sensors & Controllers							
<b>3. DPS/NAV</b>							
<b>DPS</b>							
3-1 BFS Engage .							
3-2 BFS Failures							
3-3 DPS Nominal Procedures							
3-4 DPS Off-Nominal Procedures							
3-5 GPCs and Restrings							
3-6 FC/PL MDMs							
3-7 Multifunction CRT Display System							
<b>NAV</b>							
3-8 Air Data System							
3-9 Dedicated Displays							
3-10 Entry Nav Aids Overview							
3-11 IMUs							
3-12 MLS/RA							
3-13 Nav Overview							
3-14 Nominal NAV Procedures							
3-15 Star Trackers							
3-16 TACANs							
<b>4. SYSTEMS</b>							
<b>APU/HYD</b>							
4-1 APU/Hydraulics							
<b>C &amp; W</b>							
4-2 Caution & Warning							
<b>ECLSS</b>							
4-3 Atmospheric Revitalization System (ARS)							
4-4 Active Thermal Control System (ATCS)							
4-5 Supply & Waste Water							
4-6 Pressure Control System (PCS)							
<b>EPS</b>							
4-7 Electrical Power Distribution & Control (EPDC)							
4-8 Fuel Cells							
4-9 Power Reactant Storage & Distribution (PRSD)							
<b>MECH</b>							
4-10 Mechanical Systems							
4-11 Landing/Decel Systems							

**APPENDIX A3: Qual Lessons**

The following is a list of all of the required Qual Lessons, their specific titles, and duration:

<b><u>Qual Lessons</u></b>	<b><u>Brief Description</u></b>	<b><u>Required Crew</u></b>	<b><u>Duration</u></b>
<b>1. OM/RC A/E Q 31006</b>	Ascent & Entry OMS & RCS Qual SST	PLT, MS2	2 hours
<b>2. OMS RCS O Q 31006</b>	Orbit OMS & RCS Qual SST	PLT, MS2	2 hours
<b>3. A MPS S&amp;C Q 31001</b>	Ascent MPS, Sensors, and Controllers Desktop Qual	CDR, PLT, MS2	2 hour
<b>4. DPS Q 31001</b>	DPS Desktop Qual	CDR, PLT, MS2	1 hour
<b>5. NAV Q 31001</b>	NAV Desktop Qual	CDR, PLT, MS2	1 hour
<b>6. OGNC QUAL 31006</b>	Orbit GNC Qual SST	CDR, PLT, MS2	2 hours
<b>7. APU/HY/EPS Q 31001</b>	APU/Hydraulic & EPS Desktop Qual	(CDR opt'l), PLT, MS2	1 hour
<b>8. ECLSS Q 31001</b>	ECLSS Desktop Qual	CDR, (PLT, opt'l) MS2	1 hour
<b>9. PLB/CW/H2O Q 31001</b>	Payload Bay Door, Caution & Warning, and Supply H2O Systems Desktop Qual	PLT, MS1, MS2, MS3, MS4	0.5 hour
<b>10. COMM/IN QUAL 31008</b>	Comm/ Instrumentation Qual SST	CDR, PLT, MS1, MS2, MS3, MS4	2 hours

For more information about Qual Lessons see Shuttle Crew Training Catalog, Section 2- Core Systems.

# **APPENDIX B**

**Appendix B:** Master List of All Reference Material .....B-1

## Referenced Documents - Master List

### Materials Referenced

A/E FCS 2106
ADS 2102
Approach and Landing 2101
APU/HYD/WSB 2102
Ascent Checklist
Ascent Pocket Checklist
Ascent/Entry Systems Procedures Checklist
Audio/UHF 2102 Training Manual
C&W 2102
C&W 2157
COMM SPECS 2157 CBT
Controllers 2102
D/O BURN BR 2101
D/O BURN BR 2201
D/O FLT TECH 2101
DAP 2157 (CBT)
Data Processing Systems Dictionary
Deorbit Prep FPH
DPS Dictionary
DPS FAM 2102
DPS HW/SW 2102
DPS OV 2102
DPS PRINC 2102
ECLSS 2102
ECLSS 2157
ECLSS MAL 2157
Entry 2101
Entry Aerodynamics 2101
Entry DAP 2101
Entry DAP Skills 2101
Entry FPH
Entry Guidance 2101
EPS 2102
EPS 2157
EPS MAL 2157
FCS Channels 2101
FCS Effectors 2102
FCS SST Review 2101
Flight Procedures Handbook VOL. I
Flight Procedures Handbook VOL. II
G&C I/O/D 2102A
GNC DISP 2102
GNC I/O/D 2102
Guidance and Control Sensors and Controllers 2101
HUD 2157
IMU 2102
Ku-Band Operations Training Manual



**Materials Referenced**

Malfunction Procedures
MECH SYS 2102
MPS MAL Users Guide 2102
MPS OPS Users Guide 2102
NAV 2102B
NAV AIDS 2102
OM/RC Burn 2106
OM/RC EPS/DPS 2106
OMS 2102
OMS MAL 2106
OMS MAL SST 2101
OMS OPS 2106
OMS OV 2101
OMS Targeting PT2 2201
Orbit Operations Checklist
Orbit Operations Checklist FPH
Post Insertion FPH
RCS 2102 A
RCS MAL 2106
RCS MAL SST 2101
RCS OPS SST 2106
RCS OV 2101
Reference Data
S TRK/ COAS 2102
S-Bd COMM/IN 2102
SCOM
Sensors 2102
SM TM 2102
Snsrs/Cont 2106
Space Shuttle Operational Flight Rules, Volume I
Space Shuttle Systems Handbook, SSSH, Revision E
TAEM Guidance 2101

Facility/Media Code	Description
2101 or 2201	Classroom (Briefing/Lecture)
2102	Workbook or Training Manual
2104, 2106, or 2108	SST
2157	CBT

# **APPENDIX C**

**Appendix C:** SCOM Study Notes .....C-1

**APPENDIX C: STUDY NOTES**

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This appendix contains a set of study notes originally developed by Ron Grabe in September 1989. They have been extensively modified and updated by several crewmembers and reviewed for technical content by the Training Division.

The purpose of these notes is to provide crewmembers with a set of critical "need-to-know" items that can be reviewed in their entirety at one sitting. The notes are directed at the PLT crew position, but should be useful for other crewmembers as well.

The Study Notes are organized alphabetically by major system. Under each system heading, notes on critical subsystems and malfunctions are presented. The text is written in Flight Data File shorthand using switch nomenclature and CRT display terminology, which results in a somewhat cryptic format. Although directed primarily toward Generic and Flight-Specific training, they should be readily understood by crewmembers who have progressed through at least part of Pilot Pool training.

Preparation for Shuttle Mission Simulator (SMS) training sessions is difficult due to the complexity of the Space Shuttle and the many flight phases that crewmembers are required to understand. A quick review of these Study Notes prior to SMS sessions should help make training more productive.

**APU/HYD****General**

- Ascent: all APUs will be kept running through MECO if possible.
  - Loss of one APU means hydraulic lock on one engine.
  - Loss of two APUs means 2 SSMEs in hydraulic lock plus loss of TVC for one SSME.
- Entry
  - Pre-TAEM, a sick APU (high oil temperature, high hydraulic temperature, pump leak P, H<sub>2</sub>O leak) may be manually shut down, cooled down, and restarted near Mach 1 to support landing.
  - Post-TAEM, APUs will generally be kept running except for high oil temperature. An APU will be shut down for high oil temperature if Mach > 1. A gearbox failure for high oil temperature is not catastrophic.

**Auto Shutdown**

- Controller will issue an auto shutdown command, if auto shutdown is enabled, for RPM less than 80% or above 129% (auto shutdown is inhibited for the first 9.5 seconds after start to allow turbine spinup).
- Auto shutdown closes secondary fuel control valve and fuel tank valves.
- An APU with an underspeed shutdown is a candidate for cooldown and restart.
- APUs with overspeed shutdown will not be restarted.
- If auto shutdown inhibited and APU speed is confirmed above 129%, manual shutdown is required as soon as possible.

**Single APU Loss**

- APU 1 means loss of nose wheel steering (OI-21 and subs, hydraulic system 2 can also be used for nose wheel steering).
- Single APU loss will not affect braking (loss of APU 3 plus either 1 or 2 means half brakes).

**Switching Valves**

- Supply either primary or one of two back-up hydraulic systems to the aerosurface actuators.
- Valve status only visible on SPEC 86 (SM OPS 2).
- During FCS checkout, check active hydraulic system selected.

**Fuel Tank**

- Supply supports about 110 minutes of operations (AOA).
- Nitrogen pre-charge required for start-up.
- Pressure displayed on panel F8 meter.
- Quantity (CRT and meter) is a PVT calculation.
- Isolation valves must be closed (de-powered) when APU is not running. No fuel cooling of solenoid valves.
  - Post APU shutdown, if fuel tank valve temperature high, pull circuit breakers.
  - Solenoid short may overtemp valves while APU is still running. Pull circuit breaker for second valve in parallel. Will keep APU running.

**Fuel Pump**

- Gear driven pump delivers fuel under pressure post start.
- "APU PUMP LK P" shows build-up of leaking oil or fuel in catch bottle. Bottle relieves overboard.

### Cooling

- GG bed cooled by separate H<sub>2</sub>O injection system for re-start. H<sub>2</sub>O system not used during normal ops.
- Cooling required for 3.5 minutes in *INJECTOR COOL* prior to start. If no cooling of GG injector apparent, do not perform re-start.
- If APU not started immediately following cool-down, injector temperature will rise again rapidly.
- Common tank for all APUs. Cooling capacity is 21 minutes.
- Fuel pump and fuel control valves are cooled passively by heat sinks and radiation shields.
- Water spray boiler cools hydraulic and lube oil.
  - Bypass valve isolates hydraulic cooling feature when not required.
  - Two controllers (A and B) use common water lines but have different spray logic.
  - Water quantity should not decrease during ascent. Pre-charge in H<sub>2</sub>O boiler immerses oil lines. No spraying until MET about 11:00.

### Hydraulic Accumulator

- Maintains pressure of about 2600 psi when APU not running (hydraulic pressure still about 65 psi).
- Prevents hydraulic pump cavitation.
- Low accumulator pressure on orbit indicates nitrogen leak or internal priority valve or unloader valve failure.

### Circulation Pump

- Two-stage pump. First stage low pressure, high volume. Second stage high pressure, low volume. High pressure fluid can be diverted to repress accumulator. Otherwise, high pressure fluid mixes with low pressure fluid.
- On orbit, automatically turns on (when pressure < 1960 psi) to maintain accumulator pressure.
- Circ pumps keep hydraulic fluid moving for thermal conditioning on orbit. Automatically turn on for low hydraulic line temperatures.
- Only one circ pump operates at a time in GPC control for electrical loads considerations. The system with low accumulator pressure has higher priority than the system with low hydraulic line temperatures. For thermal reasons, two circ pumps at a time are OK if needed to recharge two accumulators.

### Priority Rate Limiting

- Gets 3 hydraulic pressure inputs from each system.
- Crew can see 2 of the inputs on BFS SYS SUMM and F8 meter. MCC has access to all three inputs.
- Crew can also see hydraulic accumulator pressure which PRL doesn't see.
  - Use hydraulic accumulator pressure and RPM to resolve dilemma.
  - Accumulator pressure = 3000 means hydraulic system OK.
- PRL will show down arrow if declaring system down.
- SPEC 51 data:
  - AUT\* means auto logic is active
  - DES\* means manual deselection (toggle to reselect).

- For PRL ? and system good, leave auto logic selected.
  - Subsequent transducer fail may require deselect of auto logic and a manual deselect or reselect.
- For PRL down arrow and system good, deselect auto logic to reinstate hydraulic system into PRL.

#### Manual Shutdown

- Used to back up auto shutdown.
- Controller power off protects against uncommanded hot re-start.
- Must identify over or underspeed shutdown prior to controller power off (caution and warning light extinguished).

#### Ready-To-Start Talkback Gray

- Low press selected.
- H<sub>2</sub>O spray boiler ready.
- APU fuel isolation valves open.
- GG bed temperature > 190 degrees.
- APU speed below 80%.
- Underspeed immediately after start is probably caused by 9.5 second timer failure. Auto shutdown is normally disabled during first 9.5 seconds of start. *AUTO SHUTDOWN* to *INHIBIT* may allow start.

### Comm-Voice Data

#### General

- *PANEL/CMD* on panel C3 switch passes S-band control to system selected on aft panel. One step total reconfiguration to alternate system.

- Normally, INCO manages system on LRU by LRU basis. All LRUs are system 1/system 2 redundant.

#### ACCU

- Routes all audio to ATUs.
- No voice (ICOM and A/G), switch ACCUs.
- CDR and PLT can talk to each other on same ATU without an ACCU.

#### Antenna Electronics Unit

- Switches antenna per GPC or RTC command.
- BFS commands for ascent and entry.
- SM GPC command on orbit with BFS in *STBY* or *HALT*.
- Commands routed to antenna electronics 1/2 over PL MDM 1/2. No cross-strapping capability.
- Manual selection available with loss of auto select.

#### Ascent/Entry Configuration

- S-band system 2 active in STDN mode.
  - STDN sites prime for comm.
  - On orbit, 1 to 2 hour call up.
- A/G 1 and A/G 2 selected simo.
- UHF T/R on A/A loop.
- TDRS available post-MECO on ascent and TAL.
  - On ascent, stored program command will mode to TDRS.
  - Active S-band system switches automatically if INCO does not clear command, or if BFS fails.

- Manual reconfiguration of back panel to TDRS may be required post-MECO to restore comm if S-band failure, ground site failure, or BFS command failure occurs late in powered flight.

#### Encryptor, Transponder, and Power Amp

- In-line LRUs.
- Power amp and preamp not required if reconfigured to STDN low mode.
- Encryption is normally on uplink only.
  - Encryptor dedicated to one NSP. Not selectable separately.
  - Bypass selected for encryption failure.

#### NSP

- Processes uplink and downlink (voice, commands, and data), except UHF which bypasses NSP.
- Failure means no S-band voice, commands or data to/from ground.
  - "I/O ERROR NSP X" where X = active FF MDM (1 or 3). Could be just command failed. Check data/voice with MCC.

### Cryo

#### General

- Separate transducers for CRT digitals and overhead meters.
- CRT data goes off scale low for big leaks.

#### Heaters

- Each tank has A and B heaters.
- Separate controls/logic for O<sub>2</sub> and H<sub>2</sub> heaters.

- O<sub>2</sub> heaters have two elements with two current sensors per heater.
- Crew insight into sensor status in OPS2 only.
- If any current sensor trips (short), that heater is disabled.
- Heater logic (applies separately to O<sub>2</sub> and H<sub>2</sub>)
  - Both tanks in a ganged pair must have low P before heaters in either tank are turned on.
  - Only one high P is needed to turn both heaters off.
  - During leak isolation, pressure in good tank may prevent heaters in leaking tank from coming on with both tanks' heaters enabled.
  - Control points for heaters:
    - H<sub>2</sub> tank 1 and 2 pressure = 203 to 223
    - O<sub>2</sub> tank 1 and 2 pressure = 811 to 846
  - Tank 3, 4, and 5 set points slightly higher so tank 3, 4, and 5 will preferentially feed on orbit with all tanks in AUTO.

#### Leaks

- First step in ascent and entry cryo leak procedure is to determine number of tanks with pressure decreasing.
  - Only one tank leaking, leave configuration as is (manifold isolation valves open). Leak is a tank leak. Isolating tank will starve its fuel cell.
  - If all tanks decreasing, close manifold valves to isolate leak. Must react quickly for large multi-tank leaks.
  - If leak internal to fuel cell 3, need to reopen manifold valves ASAP. Manifold 3 does not have a relief valve.

## DPS

### General

- It is important to be able to identify GPC failures, for MCC often has little insight. Crew information affects MCC analysis and planning for subsequent failures (both DPS and non DPS).
  - When using the *GPC MODE* switch, remove your hand between positions. On past missions, there have been problems with the switch being in two positions at the same time. This problem can occur on other orbiter switches also. It is good practice to always pause slightly in each switch detent to ensure the contacts are made and recognized by the GPCs.
  - Always clear fault message line as soon as messages have been seen. This will avoid missing annunciations of subsequent failures.
  - Resume SPECS and DISPs from CRTs when not in use or prior to switching to another major function on that CRT.
  - Hard assign CRTs (both PASS and BFS) via PASS CRT keyboard (BFS will DK listen). Dual CRT commanders can be caused by trying to assign a CRT to BFS that a PASS GPC is still driving.
  - When moding PASS GPCs into the common set (i.e., STBY to RUN), always pause 10 seconds before making switch throws to avoid possible fail-to-sync and ensure proper common set initialization.
- Before OPS transitions and restrings, verify the NBAT. Check proper *MAJOR FUNCTION* and GPC switch configuration.
  - Ensure the correct memory configuration is displayed prior to making NBAT changes.
  - Dynamic flight
    - Use the cue card.
    - Must take failed GPC to *HALT* (or *STBY, HALT*) prior to OPS MODE RECALL.
    - Must deselect IMU on failed GPC for OPS 3 restring, then follow OPS MODE RECALL with NAV DELTA ZERO update prior to IMU RESELECT.
    - Deselect surface feedbacks prior to OPS MODE RECALL. Reselect following OPS MODE RECALL.
    - Follow OPS MODE RECALL with BFS I/O RESET (or PRO to OPS 3 if TAL).
    - Avoid assignment of all three CRTs to the same GPC, especially on orbit.
    - Keep hands off of everything during OPS transitions, especially switches and CRT keyboards.

### BFS Engage

- Post BFS engage, check to ensure that all active PASS GPCs have recognized the engage (both *MODE* and *OUTPUT* talkbacks are barberpole). If not, take the offending GPC to *HALT* (or power it off) immediately to avoid I/O problems on the flight critical strings.

### Restranging

- Deassign CRTs from Fail To Sync GPCs and reassign to good GPCs to avoid inadvertent entries.



- In general, port moding is preferred over restrung to regain lost capability.
- Prior to EI-5, restrung for any failed GPC.

### Set Split

- 2 on 2 or 2 on 1 on 1 split during ascent
  - Engage BFS.
  - If desired, the PASS set can be reconfigured pre-MECO if BFS is tracking and no additional complicating failures are present, rather than engaging the BFS.
    - Treat simplex machines or undesired set as failed GPCs.
    - BFS engage required on ascent for MPS commands if simplex machines or undesired set cannot be taken to HALT pre-MECO.
    - Restrung may be performed with MCC coordination, in accordance with Flight Rules.
  - Be prepared for BFS engage if sets begin force fight or total set split.
- BFS engage decisions for set splits.
  - On seeing multiple GPC fault and CAM lights, call "SET SPLIT".
  - Check BFS and PASS GNC SYS SUMM.
  - If BFS tracking 2 PASS GPCs, check them for 1 IMU, 2 FCS channels, 1 RGA, and 1 AA. Minimum for good PASS set. BFS engage will be required for MPS commands on ascent if simplex computer is failed to sync and cannot be taken to HALT.
  - If BFS standalone, check PASS if time permits. Time available is based on NAV state without IMU data:

Powered flight - 10 seconds  
 Entry - 45 seconds  
 Orbit - plenty of time.

- Distribute CRTs among different GPCs. On orbit, ensure all CRTs are not assigned to the SM GPC or a single GNC OPS GPC. Loss of the GPC with all CRTs loses PASS CRT interface.

### ECLSS

#### General

- During ascent, only switch avionics bay fans and freon pumps. Water pumps may be switched if avionics bay temps are increasing out of limits.
- NH<sub>3</sub> Boiler A/B control based on temperature in freon loop 1/2.
  - If no flow in freon loop, must use NH<sub>3</sub> boiler corresponding to good loop.
  - If slightly degraded flow in loop with NH<sub>3</sub> boiler selected, undertemp may result in degraded loop, if NH<sub>3</sub> boiler controlling based on temp in good loop. Select NH<sub>3</sub> boiler for loop with degraded flow.

#### Cabin Pressure

- First reaction to cabin leak is to close cabin relief isolation valves one at a time.
- Double check leak indications with MCC. May be due to cabin expansion or thermal effects.
- N<sub>2</sub>/O<sub>2</sub> leak into cabin will cause rise in cabin pressure and for O<sub>2</sub> leak, PPO<sub>2</sub> will also rise (O<sub>2</sub> concentration available on orbit).
- dP/dT on meter and CRT come from dP/dT sensor.
- EQ dP/dT is calculated from cabin pressure sensor by BFS and standardized to a 14.7 cabin. EQ dP/dT is used when available to make ascent abort decisions for cabin leak. Backup dP/dT is also calculated from cabin pressure, but not standardized for a 14.7 cabin.

**EPS****General**

- Do not reset popped circuit protection device (RPC or circuit breaker) without consulting MCC.
- For critical actions, MCC may call for momentary reset of failed control or essential bus while crew holds switch for affected system in desired position (three finger trick).

**AC Bus**

- Surge on AC bus can cause main engine controller to trip off line. Avoid actuation or switching of AC powered equipment during powered flight unless called for in malfunction procedures.
  - Loads that can be switched in powered flight:
    - Avionics bay fans
    - Freon pumps
    - H<sub>2</sub>O loops (only for an avionics bay temp high)
- AC bus sensors OFF on ascent to protect SSMEs for:
  - Loss of first engine
  - Loss of SSME controller redundancy on any engine
  - Loss of a single AC phase (takes down an SSME controller on two engines)
  - When AC bus sensors are OFF, no hardware caution and warning lights will illuminate (no AC VOLTS or AC OVERLOAD light).
- AC voltage high
  - Ride until MECO unless volts exceed 130, or affected main engine controllers are lost.
  - Trip bus off line with AUTO TRIP selection on bus sensor.

- AC phase shift/phase-to-phase short (three-phase motors stop)
  - Verified by multi-phase amps high.
  - Multiple three-phase motors fall off line, fuel cell pump, Freon pump, H<sub>2</sub>O pump.
  - Take individual phases off line separately to find bad phase.
- If AC bus sensor in AUTO TRIP, AC phase will be automatically disconnected for either an AC overload or high AC volts.
- If AC bus sensor in MONITOR, will get hardware caution and warning, but will not get AUTO TRIP feature.
- AC bus sensor uses different transducer than one feeding F9 meter or CRT.
- AC bus sensor needs to see rapid rise or delta amps to issue an AC OVERLOAD indication.

**Bus Tie Actions**

- If re-establishing power to a main bus (main bus volts < 20), always unpower the AC inverters before tying to a good bus (prevents surges). Use long form bus tie procedure on cue card.
- If a tie results in a short, immediately untie.
- Never tie 3 main buses during powered flight. OK post-MECO, on orbit, and entry.
- Never tie into a short.
- Payload primary bus can be used to tie Main B to Main C (back door bus tie), or connect FC3 to Main C.
- Unless absolutely necessary, do not bus tie in first stage.

**Fuel Cell**

- Coolant pump and H<sub>2</sub> pump both driven by same AC bus and both pumps controlled by fuel cell ECU and START/STOP switch.

- Coolant pump draws 0.5 amps, H<sub>2</sub> pump draws 0.3 amps.
- Coolant pump delta P indication
  - Ground can see immediately if loss of fuel cell coolant pump is real (stop/start to check run current not required).
  - No comm, can stop fuel cell and check for 0.8 amp drop. This indicates both pumps were running (bad sensor). Restart gives full recovery (should see 0.8 amp increase).
- START switch sends pump start commands
  - Pressure should be sensed in 3 seconds. *Delta P* talkback goes gray.
  - *READY FOR LOAD* talkback requires 30 second timer and good heaters.
  - Delta P relay failure may prevent fuel cell ECU from latching on fuel cell start command. *DELTA P* talkback won't stay gray. OK to hold *START* switch in *START*. After 30 seconds, second relay should latch command on (can release *START* switch).
- Coolant pump failure stagnates coolant loop
  - Stack T measured at outlet of stack. May actually decrease immediately after coolant pump failure.
  - Exit T measured in H<sub>2</sub>/H<sub>2</sub>O loop.
  - If H<sub>2</sub> pump running, exit T will progressively increase after coolant pump failure.
  - Nine minutes of run time available after coolant pump failure, assuming normal fuel loading.
- O<sub>2</sub> is entirely consumed. H<sub>2</sub> is circulated continuously through power section and condenser.
  - H<sub>2</sub>O is drawn out of stack by mixing with H<sub>2</sub>.
- H<sub>2</sub>O is separated at the H<sub>2</sub>/H<sub>2</sub>O pump.
- Dual gas regulator maintains proper pressure of reactants (about 60 psia). O<sub>2</sub> pressure feeds coolant loop accumulator.
- Dual gas regulator problem indicated by COOL P HIGH/LOW. Tie buses and monitor fuel cell for degradation.
- If O<sub>2</sub> reactant valve closes, coolant pressure will drop.
- Failure of the H<sub>2</sub>/H<sub>2</sub>O pump will lead to fuel cell flooding since water is not removed.
  - Ascent and entry: PH status fail followed by slow degrade and exit temperature decreasing may be first signatures of flooding.
  - Indicated on orbit by H<sub>2</sub> pump status fail.
- Crossover (uncontrolled O<sub>2</sub> and H<sub>2</sub>O mixing)
  - Highly unlikely to happen rapidly without warning signs.
  - Fuel cell delta volts increasing is a warning.
  - PH high may occur, but not necessarily.
  - Fuel cell degradation will eventually occur.
- Separate PH sensor for each fuel cell and common sensor in H<sub>2</sub>O manifold.
  - PH fail may indicate pending breakdown of Fuel Cell matrix (fuel cell crossover). Potential explosive mixing of H<sub>2</sub> and O<sub>2</sub>.
  - High fuel cell delta volts provides confirming cue.
  - Assume matrix failure for PH fail and bus tie as soon as possible. Problem may be an H<sub>2</sub>/H<sub>2</sub>O pump failure.
  - Common PH sensor can confirm individual fuel cell sensor. Will annunciate about 10 minutes after individual fuel cell PH (common PH only seen by crew on orbit).

- In normal configuration, redundantly powered loads are load shared.
  - Hot running fuel cell (real STACK T high) will grab more than its share of the load. Indication is high amps.
  - Flooding (real EXIT T low) will cause fuel cell to shed load.
- Water output of all fuel cells feeds common manifold.
  - Water expulsion for fuel cell is preferentially: Tank A (primary), Tank B (alternate), Dumped overboard (relief).
  - FC H<sub>2</sub>O LINE HTR controls heaters on each fuel cell primary and alternate path.
  - FC RELIEF LINE HTR controls heaters on each fuel cell relief line.
  - Each fuel cell relief line merges into one common manifold that vents H<sub>2</sub>O overboard.

- Purge process pumps extra O<sub>2</sub> and H<sub>2</sub> through fuel cell.
  - Removes contaminants.
  - Excess O<sub>2</sub> and H<sub>2</sub> dumped overboard. All three fuel cell purge lines merge into one O<sub>2</sub> and one H<sub>2</sub> manifold.
  - Purge only one fuel cell at a time.
- Nominal load is 7 kw per fuel cell. For powerdown operations, 13 kw OK on one fuel cell for 4 hours.

#### Main Bus Short

- Fuel cell will overheat in time. Amps high, fuel cell and main volts low.
  - Short before the fuel cell main bus switch will have high amps and will not drop when fuel cell is isolated from main bus. Fuel cell and main volts will remain low. Should be treated like a fuel cell short.

- Fuel cell internal short. Amps low, fuel cell and main volts low.
- Fuel cell inadvertent disconnect. Amps low (should be zero), fuel cell volts greater than 32, main volts near zero. OK to attempt reconnect.

## GNC

### BCE STRG X "D" Fail

- Will commfault feedback on affected FCS channel.
- Command path on that channel will remain good.
- Ports will not pop unless feedback goes bad under "D" failure.

### Body Flap Commands

- Go out on FCS channels 1, 2, and 3 only.
- Each channel uses separate hydraulic system.
- FDIR is QMVS.

### FCS Channels

- Each channel equally supplies every actuator (TVC and aerosurface).
- Each channel should get same command from GPCs.
- Never have more active channels on one GPC than another
- Position feedbacks on aerosurfaces for each channel.
  - Feedbacks go to FDIR to determine surface position for GPC computations.
  - Feedbacks also used individually in closed loop servo to position each FCS channel's input to actuator. Inputs are summed hydraulically.

- Port bypass, or port pop, is an electro-mechanical means to remove bad command/avoid force fights. Feedback deselection is a software means to avoid a bad input into the selection filter.
- A bad feedback will result in a bad actuator input for that FCS channel. Result will be a port pop (bypass), removing input.
- Single port pop with no other failures: no action.
- Two failures on any surface/TVC actuator. Take good channels to *OVERRIDE*. Protects remaining two channels from port pop if a force fight develops (wrong channel might port pop). Take 2 seconds between switch throws to *OVERRIDE*.
- All port pop indications should be verified with MCC.
- If verified, single port pops may be bypassed in software on SPEC 53. Allows taking channel to *OVERRIDE* later if subsequent failures on other channels.
- Feedback deselection on SPEC 53 deselects all feedbacks on channel, and terminates FDIR on all aerosurfaces.
- If there are two failures on the same actuator, take the remaining FCS channels to *OVERRIDE*.
- Feedback RM for aerosurfaces.
  - PASS uses first 3 inputs (channels 1, 2, and 3).
  - RM will throw out a bad feedback and substitute channel 4.
  - RM shuts down after first manual or auto deselect, including commfault.
  - PASS FDIR will never pass a commfaulted feedback.
- PASS may lose control if 3 feedbacks erroneous due to combination of commfaults, channels off, or bad feedbacks on individual surface.
- Any *OFF* channel should have feedbacks deselected. If channel is recovered, reselect feedback after channel is taken to *ON*.
- Always maintain two good commands and one good feedback on each aerosurface.
- In OPS 6, only works in MM 602 and 603.
- BFS feedback RM.
  - Selection filter uses feedbacks on all four channels.
  - No redundancy management.
  - Only manual downmoding of selection filter.
  - Selection filter uses IMVS.
- ASA power fail.
  - Results in all ports bypassed and zero voltage feedback input to GPCs.
  - Deselect feedbacks on channel with an ASA power fail if failure is confirmed. On board signature is not conclusive.

#### FCS Channel Switches

- *OFF* bypasses ports on all actuator inputs for given FCS channel (turns off command). Also sends zero voltage feedback to FDIR.
- *AUTO* allows port popping to bypass bad FCS channel.
- *OVERRIDE* inhibits port pop on associated channel.
- Pause between all FCS channel switch position changes. Switches are break before make. Switch actuation can result in momentary loss of channel.

### FDIR

- PASS FDIR for the RGAs, AAs, and aerosurfaces terminates after the first failure, and crew management of the selection filter is required. However, PASS has an RGA SMRD FDIR that will continue to deselect any power failed RGAs. For the BFS selection filter, crew management is always required. Proper selection filter management is required for proper control.

### GPC and MDM Failures

- Take associated FCS channel OFF.
- Removes what may be a command latched at the MDM.
- Also requires deselection of feedback (SPEC 53). Feedback to GPCs would be zero voltage if I/O restored.

### IMU

- SPEC 21 shows IMU status.
  - OFF, BITE, blank in status field.
  - Mode designated by \*: STBY (caged) or OPER (operate)
- GPC send operate command through FF MDMs.
  - IMU returns status (operate discrete) over FF MDM card A.
  - IMU returns digital data over FF MDM serial I/O card
  - STBY and power off conditions available on SPEC 21 after "BCE STRG X IMU", but not after FF MDM lost.
- GPC or FF MDM port failure.
  - IMU will maintain operate command. Commands and output of MDMs are latched at last value.

- IMU will operate without pulse torquing compensation. Should maintain reasonable align for several hours.
- FF power cycle.
  - HAINS IMU can maintain OPER CMD LATCH for approximately 8 seconds.
- FF power fail.
  - IMU loses operate command and goes to STBY (upon recovery of I/O).
  - In STBY IMU spins down and cages.
  - FF 1,2,3 power failure signature (following "I/O ERROR FF X") is loss of SSME Pc tape (ascent). Deselect IMU PASS and BFS after FF power fail (IMU will come back caged when I/O regained). PASS will automatically deselect a commfaulted IMU in OPS 3.
- BCE STRG IMU.
  - Could be result of IMU losing power. SPEC 21 (orbit and entry only) shows IMU status OFF, mode STBY.
  - Could be loss of IMU data to the FF MDM (serial I/O card down). Status and data blank on SPEC 21. Mode will still show operate, received over card A.
- Standby mode.
  - If IMU has moded to STBY, it will begin startup sequencing once the operate discrete is restored.
  - Transient power fail, causes startup sequence which cages IMU (approximately 90 seconds).
  - When IMU completes startup sequence (caged), it will mode to operate and be available to selection filter (PASS and BFS). Hence, any caged IMU should be deselected (PASS and BFS), if not already.

- PASS selection filter.
  - Any IMU not commfaulted (M) or deselected is a candidate.
  - An IMU in STBY is not a candidate.
  - Attitude selection is MVS at 3 level.
  - Downmode or upmode to 2 level. Maintain previously selected if available. Otherwise lowest numbered IMU.
  - Velocity is MVS at 3 level (component basis). Averaged at 2 level.
- PASS RM.
  - Either attitude or velocity fail removes IMU from selection filter.
  - PASS will not RM fail an IMU for a BITE (H/W or S/W) at 3 level.
  - IMU with BITE will fail RM if dilemma at 2 level.
  - If IMU miscompare at 2 level and PASS sees no BITE, IMU dilemma declared. Manual deselection required to break dilemma. Use MCC or deselect IMU. BFS is prime selecting to break tie.
- BFS RM and selection
  - Only commfaults, power loss, hardware BITE, and manual deselect will remove an IMU from candidacy.
  - Selection is MVS at 3 level.
  - Once downmoded to 2 level, BFS will only upmode to 3 level if taken through OPS 0 and up to OPS 3.
  - Selection on downmode to 2 level is lowest numbered IMU.
  - At 2 level, BFS can be taken off lowest numbered IMU with deselect followed by reselect.
- BFS uses first deselected, last reselected logic after MVS broken.
- IMU deselected for H/W BITE will not be upmoded if other IMUs lost.
- Can only recover IMU with a H/W BITE if it is IMU 3 and the BFS is moded through OPS 0 (and IMUs 1 and 2 are deselected).
- BFS will stay on an IMU with a H/W BITE if it is already on that IMU, and all others are not candidates.
- IMU dilemma
  - If MCC comm available, ask MCC which IMU to deselect (PASS and BFS).
  - No comm, deselect lowest numbered IMU in PASS. BFS will use lowest numbered.
  - Let NAV run to determine which IMU is better.

#### Nav aids

- For TACAN and ADTA management, talk to MCC before incorporating. Without communication, use the NO COMM TACAN MGMT and ADTA MGMT cue card.

#### SBTC/RHC

- During ascent, only the PLT SBTC is active. To get manual throttles, the PLT must depress the takeover button and then match the commanded throttle setting.
- During entry, both SBTCs are active. Manual speed brake control is selected by depressing the takeover button.
- For ascent, manual RHC control is available only in PASS and must be both PITCH and ROLL/YAW axes.
- For entry, manual RHC control is available in either PITCH or ROLL/YAW in PASS. BFS is always manual.

## Instrumentation

### General

- MDM loss results in parameters showing Ms.
- Signal conditioner loss shows data on respective parameters as L.
- Loss of OI MDM does not affect data to meters, but some digital data may be lost. DSC loss will affect most meters.
- OI DSC loss section of REF DATA is accurate only for DSC parameters, not MDMs.

### Data

- Runs through signal conditioners and/or MDMs
  - Data from OI MDMs goes through PCMMU for most SM data.
  - PCMMU swap reads alternate ports on OI MDMs.
  - OR, OL, and OF DSCs (GNC data) go directly through MDMs to GPCs.

## Mechanical Systems

### General

- ET doors and latches, vent doors, star tracker doors, air data probes, payload bay doors and latches, RMS latching gear, and payload retention latches are powered by dual AC motors linked through a differential.
  - One motor fail results in double actuation time. Actuation times are listed in the FDF.
  - Most actuators have dual microswitch pairs for open and close indications.
- Failed mid motor controllers or popped circuit breakers on MA73C are a frequent cause of payload bay door, ET door, or vent door single motor ops. Chart in post insertion book lists circuit breakers and motors affected.

## Payload Bay Doors

- *PL BAY DOOR SYS ENABLE* switches only enable payload bay doors. Other systems in payload bay use *PAYLOAD BAY MECH POWER* switches to allow operation.
- "PAYLOAD BAY DOOR CONFIG" message means a microswitch is indicating differently than required by software for auto operations. Can occur any time during auto open/close sequence. May require manual door operation.
- "PAYLOAD BAY SEQUENCE FAIL" message caused by failure of proper microswitch indications within single motor actuation time. Can occur during auto sequence.

### ET Doors

- Close automatically in OPS 304 if TAL flag is set in software. Always double check doors closed before AOA OPS 3 transition or TAL flag set before late TAL OPS3 transition. No software backup to close doors in OPS 3 without TAL flag set. Only available in OPS 1.

## MPS

### General

- Propellant (PRPLT) numbers on ASCENT TRAJ display calculated by guidance, not measured directly from tank.
- SSME will consume about 4% propellant per engine per minute at 104% throttles.
  - Total fuel consumption 1% every 5 seconds with 3 engines.
- Consumption is 2.5% per engine per minute at 65% throttles.
  - Total fuel consumption 1% every 8 seconds with 3 engines.
- Actual throttle setting in bucket will vary with SRB performance.



- Loss of an APU will cause hydraulic lockup. CMD PATH fail message post-MECO is possible. No action required.
- Selection of manual maximum throttles (109%) is not to be taken lightly. Estimated risk is increased by a factor of ten.

#### Command Path

- Command path failures require a manual shutdown with AC switches and MPS pushbuttons. This will create a data path fail.
- Engine with command path fail may not get guided shutdown command and will not shutdown with pushbutton only.

#### Data Path

- Must determine engine and command status.
  - Loss of acceleration indicates engine down.
  - Down arrows (↓) in  $\text{GH}_2$  pressure and  $\text{GO}_2$  temperature indicate engine is down.
  - Helium  $dP/dT > 40$  for a few seconds, then zero indicating engine shutdown.
- If SSME down, use push button to mode guidance, then AC bus sensor OFF.
- Assume bad command path until throttling is observed. No comm – assume command path.
- Engine shutdown auto *ENA/INH* logic inhibits shutdown for redline exceedance (limits) for a data path failure. *ENA/AUTO* resets limits to ENABLE. Crew has no indication of actual limit status. MCC does have status.
- Engine with data path fail will get a shutdown command if GPCs see other 2 SSME's with  $P_c < 30\%$ . Two  $P_c < 30$  plus data path sets MECO confirm. MECO confirm will shut down engine if still running behind data path, even if before guided MECO.
- Engine with a data path fail will not display a red status light after engine shutdown (pre-BFS engage).  $P_c$  meter will also be inaccurate.

#### Engine Failure

- First priority is to ensure GPCs recognize it.
  - Check for CRT message "SSME FAIL L (C, R)". If no message, depress pushbutton.
- When time permits, *AC BUS SENSORS - OFF*.
- If second SSME fail:
  - Check interconnect for single engine roll control.
  - Check SERC ON on ASCENT TRAJ.
  - Contingency abort actions if appropriate.

#### Entry

- If MPS caution and warning during entry, check BFS SYS SUMM 1 reg pressure and close appropriate regulator. Helium reg fail high and subsequent venting could be catastrophic.
- MPS caution and warning for low helium reg not expected for normal entry. Might occur on RTLS due to additional helium usage.

#### Helium Leaks

- Non-isolatable leak requires interconnect at 1150 psi.
  - Use previously failed SSME helium supply, if available.
  - Interconnect to pneumatics results from *IN-OPEN*.
  - Return all helium interconnect valves to *GPC* post-MECO.
- Non-isolatable leak may require SSME manual shutdown using pushbutton. Helium available may not support zero-g shutdown at MECO.
  - Shutdown must be with pushbutton (hydraulic cutoff) to conserve helium.

- Helium interconnect may be called for to allow SSME to run to MECO. Interconnect may be well before 1150 psi cue.
- Crew assumes shutdown is required at velocity on MPS cue card unless MCC advises that helium is adequate for zero-g shutdown.
- If MPS helium reg pressure starts to drop due to helium depletion, limits must be enabled to prevent catastrophic main engine shutdown (given the proper scenario).
- MPS pneumatic helium leak with leak in accumulator requires steps to repress accumulator at TMECO minus 30 seconds.
- Loss of ALC 1, 2, 3/APC 4, 5, 6 causes the A helium isolation valve to close for the C,L,R engines.
  - Helium leak isolation must not be attempted on the affected engine.
  - LH<sub>2</sub>/LO<sub>2</sub> ullage pressure indications on BFS GNC SYS SUMM display will go to 12.0↓/0.0 for engine with ALC/APC failure.

#### Manual Shutdown

- Required for manual throttles, command path, and some stuck throttle cases.
- Low level cutoff will still work in manual throttle mode if command path is good.
- If any doubt about shutdown function, use AC switches and follow with push buttons to inform GPCs of shutdown.
- Shutdown with AC switches no-ops the MPS dump for affected SSME. Manual inerting may be required.
- When manual SSME shutdown is required, use the AC switches followed by the push button except for:
  - Shutdown with push button(s) only for manual MECO. Never shutdown with AC switches and push buttons at MECO.

- Shutdown with push button for helium leak.
- Use push button to mode guidance when GPCs don't know SSME is already down.

#### Manual Throttle

- CSS requires manual throttle, which requires manual shutdown.
  - Manual MECO for uphill cases at target V<sub>T</sub>.
  - Shutdown TAL and RTLS cases at BFS cutoff cue. This cue is based on NAV and indicates cutoff when on R-V line.
- Any manual MECO, depress 3 push buttons to ensure MECO confirmed.
- Secondary shutdown cue is PASS/BFS TMECO on TRAJ display.

#### MECO Confirmed Flag

- Set by any of the following:
  - Three shutdown commands with engine safing flags set (no data failures, 3 Pc's < 30%).
  - One data path plus 2 Pc's < 30%.
  - Manually depress 3 push buttons. PASS sets MECO confirm for three push buttons pushed separately or together. Can power cycle any FF MDM associated with bad control bus (printed near push button).
  - OPS 104 PRO (OPS 602 PRO will not set MECO confirm).
  - Fast sep.

#### Net Positive Suction Pressure

- Requirement for engines down.
- If two engines are running, throttling at 3-g will bring good engines below 91% (OK for shutdown).

- Single engine press to TAL, ATO, or MECO
  - Manual throttle back to 67% at 2% propellant remaining.
  - Manual cutoff at guidance cue required.
  - If low level sensors uncovered, fuel depletion cutoff will be commanded.
  - NPSP requirements will be protected.
- FF/push button fault: must create data path fail with AC switches and depress push button.
- Control bus fault: AC switches (data path), power cycle associated FF MDM, depress push button.
- BFS requires good FF and control bus to mode guidance.

### Pc Gauges

- Data for Pc gauges and status lights:
  - Left: FF2
  - Center: FF1
  - Right: FF3
- Pc on gauge goes to zero for MDM power fail. Freezes for port failure.
- Status lights go out for power failures and freeze for port failures.

### Status Lights

- Amber = data path, electronic (fuel flow or Pc sensors) or hydraulic lockup.
- Red = engine in shutdown or redline exceedance.
- Second engine fail with limits inhibited may show amber plus "MPS ELEC" message in SMS. Likely cues "real world" are data path fail and loss of acceleration. Red light for limit exceedance also possible.

### SSME Push Buttons

- Control two functions, shutdown and GPC recognition.
- Push button shutdown requires good command path and no push button faults. Command path fail takes out push button for shutdown.
- GPC recognition of SSME fail (to mode guidance) may be accomplished with push button if no switch faults.

### Stuck Throttles

- Command paths always require manual shutdown.
- With hydraulic and electric lockups, shutdown hydraulic.
- With two hydraulic lockups caused by hydraulic systems failures, shutdown highest priority from the cue card based on ATVC loss.
- One hydraulic or electric, only shutdown with three engines running, uphill, and performance low.
- Stuck throttle shutdown cues of 23K, 22.5K and 24.5K for three engine uphill, TAL, and two engine uphill correspond roughly to 30 seconds before MECO.

## OMS

### General

- Standard insertion OMS-1 burn at MECO+2 is critical.
  - Take status of OMS engines post-MECO following FA/GPC failures coupled with ALC/MN or CNTL bus failures.
  - If one engine not available, re-target for single engine burn.
  - Restraining not allowed by flight rules to regain dual OMS engine capability if 4 +X jets still available for redundancy.

- Underspeed at MECO, always burn OMS-1 at TTA = 2 for optimum efficiency.
- For large underspeed at MECO (> 500 fps), supplement a single OMS engine with 4 RCS +X jets.
- Gauging active only with at least one OMS engine burning. Otherwise, overhead and aft quantity readings dormant.
- Overhead gauging ceases actual measurement between 45 and 30%.
  - Software routine decrements quantity with engine burning. Software assumes single engine flow rates.
  - Pick up accurate readings when aft probes active below 30% prop.
- If only one pod prop is available and 2 engines, feeding both engines from one pod is certified.
- OMS probes are historically inaccurate.

#### Burn Cues

- PASS MNVR display decrements TTG 2 seconds per display update.
- BFS MNVR display decrements TTG 1 second per display update.
- At ignition
  - Check Pc.
  - Check ball valves approach 100%.
  - Check fuel injector temperatures = about 220 degrees.
  - Monitor engine inlet pressures.

#### Delta V Available

- 1% OMS prop (either side or total) = 6 fps delta V.
- 1% RCS (either side or total) = 1 fps delta V.
- 2 fps required for 1 nm HP change.

#### DPS Failures

- FA 3(4) failures commfault L(R) ARM/PRESS switches.
  - Guidance will not downmode to 1 OMS or RCS burns when switch turned off.
  - Guidance needles in error.
  - DAP remains in TVC DAP on downmode to RCS. This results in sluggish control.
- Set split or IMU dilemma, terminate burn if above safe HP. Determine bad IMU post burn by which IMU accel is not zero.

#### Thrust Loss

- At first indication of OMS thrust loss (usually Pc low), check for OMS engine down arrow. PASS requires Pc low and loss of acceleration for down arrow.
- BFS shows down arrow with loss of Pc only. Pc transducer fail will give false engine down cue.
- Check for ball valve fail. If not confirmed and ignition path is good, must assume prop fail. Cue card procedure will identify engine or prop fail.
- Orbiter will initially yaw into dead engine and then yaw into good engine.
- Know without doubt which engine is down before turning engine off.
- Ensure prop or engine fail identified.
- Simple OMS engine fail, crossfeed at 1/2 delta V.
  - Protect aft quantity. Crossfeed at minimum on PRPLT PAD.
  - Maintain good flow path to prop source.
  - For OMS-1 with large delta V, interconnect failed OMS to RCS and supplement with 4 +X RCS.

- For prop fail, consider engine lost. Use cue card to determine proper course of action.
- If both engines down, complete burn with RCS.
  - Interconnect good OMS prop to RCS, note OMS helium pressure, convert to burn time, and time RCS burn.
  - FA failures may cause only 2 +X jets available. Required burn time is almost doubled.
  - OMS gauging not active without an OMS engine burning.
  - Must protect RCS system from helium ingestion at OMS prop depletion.
  - For any prop failure, isolate bad prop from crossfeed lines.

#### Leaks

- Tank leaks must be confirmed with decreasing inlet pressure.
  - Tank leaks may be isolated by closing tank isolation valves.
  - If inlet pressures goes to zero and tank stable, inlet line leak.

#### Gimbals

- Trim for 2 engine burns has parallel thrust vectors.
- Single engine burn trim is through CG.
- Gimbals move to trim position 15 seconds prior to TIG.

#### Nitrogen System

- Used to open ball valves and supply purge post burn.
- If N<sub>2</sub> tank fail, but good reg P available, save engine for deorbit.
- If reg P fails, ball valves will close and engine will fail.

#### OMS Dumps

- Time the dump. System failures can prevent automatic cutoff.

#### RCS

##### General

- Talkbacks get hardware fuel and oxidizer inputs (no MDMs involved).
  - Inputs must agree for open or close indication.
  - Miscompare results in barberpole.
  - RCS helium isolation valves are magnetically latched open. A and B valves are mounted next to each other at various helium tanks. Occasionally the vibration of operating a valve can jar the adjacent valve out of the open position. Crew procedures account for this. A momentary barberpole talkback may occur when an adjacent valve is operated.
- Quantity calculations are PVT determination based on helium in prop tank.
  - PASS calculation allows for substitution of inputs.
  - If any helium leakage, prop calculation will be erroneous.

##### Crossfeed

- Master crossfeed available in PASS OPS 1, 3, and 6.
  - *TANK ISOL* and *CROSSFEED* switches must always be returned to *GPC* to protect master crossfeed sequence.
  - Master crossfeed selection valves have simo jet firing limit, even if auto crossfeed not used (all OPS, both PASS and BFS).
- Auto crossfeed sequence in PASS OPS 1, 3, and 6.

- Initiates crossfeed in response to low pressure in prop tank.
- Protects against helium reg fail low (primarily for ET SEP).

### Dumps

- OMS prop interconnected dumps
  - Smart interconnect handles FA MDM and EPS failures for intact dumps.
  - Dump time compensated for inactive manifolds.
  - Time the dump. System failures can prevent automatic OMS cutoff.

### Heaters

- Pod heater, crossfeed line heaters, and jet thruster heaters (by manifold ) on panel A14.
- Turned on post insertion. Some heaters redundant and switchable.

### Interconnect

- RCS crossfeed requires check of left to right tank pressures.
- OMS to RCS interconnect requires low delta pressure and OMS tank pressure higher than RCS tank pressure.
- OMS PRES ENABLE must be toggled off when breaking interconnect. Software computation assumes OMS prop feeding when L or R OMS has \*.

### Jet Availability

- Monitor on SPEC 23.
- Software considers a jet available (no DES\*) unless:
  - Deselected by RM.
  - Manifold status in software = closed.

- Manual DES item entry.
- RM will not deselect more than jet deselect limit.
  - Intialized at 2 per pod.
  - Limit does not apply to manual deselect or vernier jets.

### Jet RM

- BFS RM is inactive (display and PASS monitor), unless engaged.
- Any detected RCS fault lights RCS JET caution and warning light.
- For jet fail ON, RM does not auto deselect.
- On the PASS, a jet fail OFF is auto deselected by RM. In the BFS, only the first jet fail OFF is auto deselected and only if it is not previously failed ON.
- Fail LEAK results in PASS auto deselect. Not available in BFS.

### Leaks

- Isolation during ascent and entry
  - Always confirm decreasing helium pressure (CRT and meter) before isolating.
  - Confirm talkbacks reflect switch throws.
  - Reselect GPC position of *TANK ISOL* and *XFEED* switches.
  - Monitor prop remaining. Crossfeed before quantity reaches zero.
  - Helium leaks invalidate quantity computations.
  - Auto crossfeed may be used to open/close valves if manual switch functions lost due to control bus failures.
- Confirmed jet fail LEAK, do not reselect jet since leaking prop will probably freeze in jet.

- RCS secure for leak isolation performed by first closing the manifold isols, then isolating from the bottom of the panel working up. When re-opening, must ensure prop supply before manifolds opened.

#### Manifold RM

- Software looks at open and close discretes.
- Any indeterminate combination results in "CL?".
- Crew can override manifold status on SPEC 23.
- SPEC 51, ITEM 7 overrides all manifolds in hardware "?" to open. No effect on manifold with commfaults.
- RCS RM loss occurs with "BCE STRG X B" (forward), or "BCE STRG X D" (aft). Manifold goes CL?.

#### Manual Reselection

- ITEM entry to remove \* in DES column.
- Will not work if deselect due to manifold closure.
- Does not reset RM. Jet will not RM fail for same fault.
- DES INH item entry reprioritizes jets and disables RM auto deselect. Does not reselect jet.
- Double DES INH resets jet RM (toggling RM).
- ITEM 45 resets RM of all available jets at once. No effect on deselected jets.

#### On Orbit Burns

- Normally 2 jet burns.
- Will downmode to 1 jet burn if no jets available on one side.

#### OPS 1 and 3 Burns

- Aft RCS burns use 4 jets and downmode to 3, 2, and 1.
- Forward RCS burns use 3 jets and downmode to 2 and 1.
- Asymmetric +X burns require a lot of propellant for attitude control.

#### Tank Press High

- Indication of helium reg failure.
  - Close both helium regs to minimize helium loss.
  - Monitor low prop tank pressure and repress to protect manifold pressure. Jets will fail OFF if manifold pressure < 190.

#### Valves

- Prop valves are AC with control bus for switch power. Will operate on 2 phases if 1 phase lost.
- Helium valves are DC with control bus for switch power.

#### Vernier Jets

- Two side-firing forward jets.
- Two side-firing aft, two down-firing aft.
- Only aft side-firing jet can be lost and still have vernier mode (may still be lost for RMS loaded operations).

# **APPENDIX D**

**Appendix D:** SCOM Rules of Thumb .....D-1



**APPENDIX D: RULES OF THUMB**

This appendix is a compilation of the rules of thumb from the body of this manual. Topics are organized alphabetically keyed on commonly used acronyms and abbreviations.

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### **APU/HYD**

- APU fuel usage rates vary with loading, but average 1% per minute (3 to 3.5 lbs/minute). Usage rates are reduced by about half if the hydraulic main pump is taken to low pressure (*HYD MAIN PUMP PRESS* switch on panel R2 set to *LOW*), as is done during the abort once around deorbit coast period.
- The APU injector cooling tank shared by all three APUs contains enough water for 21 minutes of continuous flow. This is enough for six complete 3.5-minute hot restart injector cooling cycles.
- If all water spray boiler cooling is lost to the lube oil after an APU reaches full operating temperatures, only 4 to 5 minutes of operating time are available before bearing seizure occurs.

### **Ascent**

- Monitor roll program on the ADI and BFS ASCENT TRAJ display.
- Before L/O +90 seconds, BFS engage is the crew's only option for loss of guidance and/or control. After 90 seconds, the crew can try CSS.
- Monitor the trajectory on the ASCENT ADI cue card and the PASS and BFS TRAJ displays. The Shuttle bug and predictors should follow the nominal trajectory line. Also monitor the HSI for the inertial velocity to be in the desired orbit insertion plane.
- Monitor guidance convergence by observing PASS and BFS TMECOs converging to expected time.
- If the crew takes CSS, they should take manual throttles. If the crew takes manual throttles, manual shutdown is required unless a low level shutdown occurs due to low performance. The cue for MECO is the BFS MECO cutoff bug or planned MECO  $V_I$  minus 150 fps.
- Use OMS 1 TGTING cue card for system problems and OMS 1/2 TGTING cue card for performance problems to determine proper OMS 1 and 2 targets.

### **CCTV System**

- When the VCU is powered on, the crew must wait 10 seconds before any CCTV commands can be accepted. This time is used to initialize the VCU.
- Always wait at least 4 seconds after powering off a camera before powering it back on. This gives the iris enough time to fully close.
- Always wait at least 4 seconds after switching from the RMS wrist camera to the RMS elbow camera before switching back to wrist, and vice versa. This gives the iris enough time to fully close.
- When ejecting OAST VTR tapes, always wait at least 10 seconds after selecting *STOP* before you attempt to eject the tape. Never unpower the OAST VTR while it is in a mode other than *STOP*. Either of these will result in tape breaking or fouling.
- Never leave a payload bay camera in a manual mode (either semi- or full) while in direct sunlight or any bright light. Damage to the camera will result.
- If neither you nor Mission Control is using a camera for extended periods, power it off to conserve energy and to keep it cool.

### **Communications System**

- When the TDRS has an elevation of greater than +70 degrees or less than -60 degrees relative to the orbiter (as shown on OPS 201), there is a risk of degraded communications as the orbiter nose or tail blocks line of sight between the orbiter antenna and the TDRS.
- Power amplifiers are specified to have a minimum power output of 100 watts. Flight experience has shown that a good downlink can be sustained with a power output of 65 watts.
- Payload interrogator output power, when in low power mode, will read zero. This measurement is meaningless as the output power is too small to be output by the instrumentation system.

### *C/W System*

- The *SENSOR RESET* switch on panel L1 should be pressed when smoke concentration goes below 1.8. This prevents masking of alarms.
- When panel R13U is not in use, the *PARAMETER SELECT* thumbwheels should be set to a value greater than 119.
- Crewmembers should reset fault messages as quickly as possible after review to avoid covering other messages.
- The fault summary should be reviewed regularly to avoid missed fault messages.

### *DPS*

- Always deassign CRTs from fail to sync GPCs and reassign to good GPCs to avoid inadvertent entries (NBATs/restrings, burn targets, etc.).
  - Before OPS transitions and restrings, always verify the appropriate NBAT is what you want it to be; never assume that it is correct! Also check the proper major function and GPC switch configuration. Post OPS transitions and restrings, check good configuration with SPEC 6.
  - Make sure you have the correct memory configuration called up before you start making NBAT changes.
  - During OPS transitions, keep "hands off" everything, including all switches and CRT entries.
  - Always clear the Fault Message line as soon as you have seen the message; otherwise, you will likely miss subsequent annunciations from other failures.
  - Post BFS engage, check to ensure that all active PASS GPCs have recognized the engage (both *MODE* and *OUTPUT* talkbacks are barberpole). If not, take the offending GPC to *HALT* (or if this doesn't work, power it *OFF*) immediately to avoid I/O problems on the flight critical strings.
  - It is a very good idea to resume SPECS and DISPs from CRTs when not using them or before going to another major function on that CRT.
- When moding PASS GPCs into the common set (i.e., *STBY-RUN*), always pause 10 seconds before making switch throws to avoid a possible fail-to-sync and to ensure proper common set initialization.
  - It is important to be able to identify GPC failures, for Mission Control often has little insight. The information you provide will affect Mission Control analysis and its ability to plan for subsequent failures (both DPS and non DPS).
  - Always hard assign CRTs (both PASS and BFS) via PASS CRTs (BFS will DK listen). You can cause dual CRT commanders if you try to assign BFS a CRT that a PASS CRT is still driving.
  - Always distribute your CRTs among different GPCs. On orbit, always be sure SM is not on all CRTs at the same time; if you lose SM, you also lose PASS CRT interface. The same applies for single GPC GNC OPS configuration.
  - When using the *GPC MODE* switch, always take your hand off between positions. On past missions, there have been problems with the switch being in two positions at the same time. This problem can occur on other orbiter switches too. It is a good idea to always pause slightly in each switch detent to ensure the contacts are made and recognized by the GPCs.
  - The *CRT SEL* switch should always be checked before making a keyboard entry, and data should always be checked on the CRT scratch line before it is entered.
  - When moving GPC mode switches from *RUN* to *STBY* or *STBY* to *RUN*, refrain from moving any other GPC monitored switches for 10 seconds.

### *ECLSS*

#### NOTE

Numbers presented here are for typical orbit power and heat loads and may vary significantly depending on attitude and power loading.

- Supply water tanks fill at about 1.5 percent per hour depending on fuel cell load (.8 lb/kW hr + 16 lb over 1%; 14 kW typical orbit power load).
- Water tanks empty at about 100 percent per hour for a water dump, about 50 percent per hour when using the FES high load evaporator for cooling with payload bay doors closed, and about 16 percent per hour when using the FES topping evaporator for supply water dumps on orbit with the doors open.
- On-orbit cold soak is good for 20 to 30 minutes of cooling. Prelaunch Freon conditioning is good for 2 to 3 minutes of cooling.
- NH<sub>3</sub> boiler supply is good for 25 minutes of ground cooling.
- A single cryo O<sub>2</sub> tank is good for about 2 to 3 days of orbit usage depending on crew size and power level. H<sub>2</sub> tanks are sized to match O<sub>2</sub> usage.
- A single LiOH canister is usable for about 48 man-hours.
- For an off-nominal trajectory, check that guidance is working to put the guidance box back on the Shuttle bug (zero range error) within the trajectory envelope.
- Attempt to contact MCC before taking CSS.
- If you must take CSS:
  - Control range by controlling drag.
  - Control drag by controlling H-dot.
  - Control H-dot by controlling H-double dot.
  - Control H-double dot by controlling bank angle.
  - Control everything slowly by small corrections.

### EPS

### Entry

- 2 OMS: TGO  $\approx \Delta VTOT/2$ .
- 1 OMS: TGO  $\approx \Delta VTOT$ .
- RCS: TGO  $\approx 1.7 \times \Delta VTOT$ .
- As an approximation, 1 degree of bank change produces 0.7 ft/sec<sup>2</sup> H-dot change. Large bank errors cause corresponding errors in H-dot, allowing a phugoid to develop more quickly.
- A 1 degree change in alpha produces a 1.7 ft/sec<sup>2</sup> drag change, which is equal to an 8 degree roll change.
- Prior to the first bank, monitor vehicle attitude at 0 degrees bank and 40 degrees alpha.
- First bank (flight path angle capture) should occur at a drag acceleration of approximately 3 fps<sup>2</sup> and/or q-bar of approximately 8 psf.
- Monitor the trajectory on the ENTRY ALPHA cue card, and the PASS and BFS TRAJ displays:
- The Shuttle bug superimposed on guidance box superimposed on nominal trajectory line.
  - Actual drag equal to reference drag.
  - Appropriate bank angle, H-dot, range and altitude.
- *Never* close a circuit breaker or reset an RPC found out of configuration without MCC coordination.
- Loss of cooling to a fuel cell requires crew action within 9 minutes to prevent a catastrophic loss of crew/vehicle due to possible fuel cell fire and explosion.
- Any interruption of continuous ac power during ascent may result in the loss of main engine controller redundancy. Reconfiguration of ac powered equipment prior to MECO should be avoided.
- *Never* connect or reconnect power to a known shorted or failed component; this includes switch throws, circuit protection device resets, or bus ties.
- Fuel cell run limit prior to shutdown for loss of cooling is 9 minutes at a 7 kW nominal load. Run time varies inversely with fuel cell load.
- Three oxygen and hydrogen tanks are good for up to 8 days on orbit; five oxygen and hydrogen tanks are good for up to 12 days on orbit; eight oxygen and hydrogen tanks are good for up to 18 days on orbit. Duration varies with crew complement and power load.
- A fuel cell hydrogen pump uses 0.3 amps/AC phase; a coolant pump uses 0.5 amps/AC phase.

## EVA

- Always use "make before break" tether protocol.
- Don't use the glove as a hammer.
- EVA crewmember must remain tethered at all times.
- Slow and deliberate motion provides much greater stability than quick, jerky motions.
- Body positioning is 90 percent of the task.
- Each EVA crewmember should check out his or her own EMU.

## GNC

- The PASS FDIR for the RGAs, AAs, and aerosurfaces terminates after the first failure. After the first failure, crew management of the selection filter is required. For the BFS selection filter, crew management is always required. Proper selection filter management is required for proper control.
- For FCS channel management:
  - Never have more active channels on one GPC than another.
  - If there are two failures on the same actuator, take the remaining FCS channels to *OVERRIDE*.
  - Always maintain two good commands and one good feedback on each aerosurface.
  - Delay 2 seconds between switch throws when moving FCS *CHANNEL* switches to *OVERRIDE*.
  - Port bypass, or port pop, is a mechanical means to avoid force fights; feedback deselection is a software means to avoid a bad input into the selection filter.
- For ascent, only the pilot's SBTC is active. To get manual throttles, the pilot must depress the *TAKEOVER* button and then match the commanded throttle setting. Manual rotational control is available only in PASS and must be both pitch and roll/yaw.
- For entry, both SBTCs are active. To get manual speed brake, the CDR or pilot must depress the *TAKEOVER* button. Manual

rotational control is available in either pitch or bank in PASS, and required in both axes in BFS.

- For TACAN and ADTA management, talk to MCC before incorporating.
- Without communication, the crew will use the NO-COMM TACAN MGMT and ADTA MGMT cue card.

## Landing/Deceleration System

- Landing gear should not be deployed at equivalent airspeeds greater than 297 knots.
- $\pm 1$  knot of touchdown speed corresponds to  $\pm 100$  feet of distance.

## Lighting System

- Power consumption of cockpit lighting can be as much as 1 to 2 kW with all lights on.
- When payload bay floodlights are turned off, they should remain unpowered for 10 to 16 minutes prior to repowering.

## Mechanical Systems

- Always use a timer when operating mechanical systems, noting either dual or single motor time. Do not continue driving if greater than the single motor time has elapsed without the mechanism reaching the desired state.

## MPS

- Direct insertion MECO is usually close to 8 minutes 30 seconds.
- For three engines at 104 percent, fuel consumption is about 1 percent propellant/5 seconds. For three engines at 65 percent, fuel consumption is about 1 percent/8 seconds.
- An SSME will consume approximately 4 percent propellant per engine per minute at 104 percent. Propellant remaining is displayed on the ASCENT TRAJ display and is a guidance-calculated number.
- When an engine fails, the helium  $dP/dT$  is greater than 40 for several seconds, due to engine shutdown, and then it goes to zero. This is a good crosscheck to confirm engine shutdown.

- The selection of max throttle is not to be taken lightly. It increases the risk of catastrophic failure of an SSME by 10 times.
- Five ways to set MECO confirmed are: three Pc's less than 30, two Pc's less than 30 plus one data path failure, three SSME PBs, OPS 104 PRO, and FAST SEP.
- PASS will downmode a commfaulted *MAIN ENGINE SHUT DOWN* push button and allow the push button to safe an engine under a data path failure. BFS does not allow this. If a *MAIN ENGINE SHUT DOWN* push button is commfaulted in BFS, it is inoperative.
- An OPS 602 PRO does not set MECO confirmed.
- BFS requires all three *MAIN ENGINE SHUT DOWN* push buttons SIMO to set MECO confirmed; PASS only requires to see the PBs once.
- To shut an engine down, both contacts on the *MAIN ENGINE SHUT DOWN* push button must be good. If one contact is commfaulted, the button can be used to set the safing flag on an engine that failed under a data path failure. If a contact is power-failed, the button is inoperative unless it is commfaulted.
- An SSME command path failure must always be shut down manually with the A/C switches and PBs.
- An SSME FAIL C (L, R) message indicates that the GNC software has recognized an engine shut down. Two of these messages will enable single engine roll control mode.
- An engine in data path failure will never display a red *MAIN ENGINE STATUS* light, pre-engage.
- There are no direct indications to the crew of limit shutdown enable/inhibit status. The status is available to Mission Control, or it can be deduced by the crew.
- Limits must be enabled on an engine when the helium regulator pressure begins to decay due to a helium leak. An SSME will almost certainly fail catastrophically if there is insufficient helium, and limit shutdown is inhibited.
- Manual shutdown of hydraulically or electrically locked SSME is dependent on which issues the performance call, due to low-level C/O sensor timing.
- Actual throttle levels on the first stage throttle bucket can vary due to SRB thrust level dispersions. This is an artifact of "first stage adaptive guidance."
- Loss of an APU means hydraulic lockup. SSME CMD C (L, R) messages are possible post-MECO. No action is necessary.
- 23 k, 22.5 k, and 24.5 k  $V_I$  are about 30 seconds before MECO on the three-engine uphill, TAL, and two-engine uphill cases respectively. Note that  $V_I$  indication is lost to the crew post-engage.
- *MPS ENGINE POWER* switches look very similar to *He ISOLATION* switches and are located close together on panel R2. *Use caution.*
- Shutdown with A/C switches will always cause a data path failure.
- Loss of ALC 1, 2, 3 (APC 4, 5, 6) will cause SSME helium isolation A to close on the C, L, R SSME with no direct indication to the pilot. Do not attempt subsequent helium leak isolations.

### OMS

- 1 percent of OMS propellant
  - = 6 fps  $\Delta V$
  - = 3 n.m.  $\Delta H_p$
  - = 130 lbs (80 lbs oxidizer, 50 lbs fuel)
  - uses 40 psi of helium for long burns.
- One OMS engine causes approximately 1 fps<sup>2</sup> acceleration.
- For OMS ignition, there must be power and command to at least one coil on both control valves.
- OMS TVC requires an enable discrete from the FF MDM, and commands from the FA MDM.
- FUEL INJECTOR TEMP message may be a signature of a bad temperature transducer or a fuel blockage.

- CHAMBER PRESSURE message may be a signature of a bad pressure transducer or an oxidizer blockage.
- There are several failures that inop OMS FDI (FA MDM commfault or Pc transducer failed high).
- Always check redundant sources to confirm any malfunction.
- An OMS engine failure post-MECO should be signified by a down arrow on the MNVR display.
- Max blowdown on the OMS is approximately 39 percent.
- 1,000 lbs of OMS (approximately 8 percent) moves the X c.g. 1.5 inches aft and the Y c.g. 0.5 inches left or right.
- Max OMS quantity for landing = 21 percent.

### *Orbit*

- In propellant-limited situations, use the following guidelines:
  - Stay in VERN as much as possible.
  - To conserve forward RCS, use TAIL ONLY control mode.
  - During prox ops, when controlling out-of-plane errors, start as early as possible, wait for the node to make inputs to null rates, watch the deadbands, and do not fight orbital mechanics effects.
- TRAJECTORY:
  - NC: sets up 2-rev transfer to Ti (usually retrograde)- NCC: 1st Onboard, based on 2 ST Passes, Targets to Ti
  - Ti: 1st to target intercept, uses RADAR Data (usually posigrade)
  - MC1-4: Trim Burns Targeted to intercept
  - OOPN: Usually between MC1 and MC2, Tgt and Orb co-planar (Y = 0)
  - Ti Delay: Football, Posigrade (2 x Ti DVX)
    - NEED: New Ti TIG
    - LOAD new Base Time
    - Start FDF at NCC intermediate solution (may not burn new NCC).

### SOURCE OF ERRORS

Attitude maneuvers and jet cross coupling  
 Burn trims  
 Orbiter Vents (APU, FES, etc.)  
 Drag uncertainties.

- ST PASSES:

- DES IMU (Prime sel IMU for Attitude at 2 level)
- Monitor RESIDS < .05 (Star Lock - BREAK TRACK)
- 1st PASS:
  - Assumes on PROP
  - Gives Criteria to select FLTR
- 2nd PASS:
  - Assumes FLTR
  - Verify 1st PASS
  - Gives Criteria to do FLTR to PROP.

### SOURCE OF ERRORS

Prime selected IMU going bad  
 Star tracker bias  
 Maneuvers and length of time since last SV update  
 Taking marks on a star  
 Either IMU accelerometer going bad.

- RADAR PASS:

- Use if < 135 k (Range eclipsing)
- Procedure handles either FLTR or PROP selected
- Gives criteria to select FLTR -or- to do FLTR to PROP
- Verifies star tracker passes
- INH angles during maneuvers to burn attitude
- RR MODE = ATRK during maneuvers to burn attitude.

### SOURCE OF ERRORS

Range eclipsing  
 EL/AZ greater than 30 deg  
 Ku biases (Range).

- TARGETING:
  - Load BASE TIME (Ti TIG) to TGT SET #1
  - Load TGT SET (ITEM 1 +)
  - Verify
  - Compute (ITEM 28)
  - Plot T1 Position
  - MC2 (El Angle for ILOS rates = 0 approach)
    - Note Nominal Time
    - Compute TIG Change
    - TIG will be new BASE TIME
    - 3 and +7 limits for lighting.
- NAV MANAGEMENT:
  - FLTR to PROP (before taking DATA)
    - After new sensor acquisition
    - Reacquisition of Sensor Data
  - RNDZ NAV enable creates the PROP
  - Always have a FLTR vector
  - COMM FAULT or suspect bad data INHIBIT then ask questions.
- BURNS:
  - POSIGRADE: TVR = 0
  - RETROGRADE: TVR = 180
  - < 4 - Multi-Axis (DAP:LVLH)
  - > 4 - +X Mnvr to Attitude (DAP:INTL)
  - > 6 - OMS
  - TRANS: NORM until VGO < 1 fps then PULSE
  - VGO Z is negative: Burn Z, X, Y
  - Preliminary solution for NCC and Ti can be considered the PROP solution.
- PTG/DAP MANAGEMENT:
  - -Z target track
  - A/VERN - Attitude hold (.2 deg/sec and 1 deg deadband)
  - B/PRI - Maneuver (.5 deg/sec and 2 deg deadband)
  - TRANS PULSE = .1 RNDZ and .05 Prox Ops
  - Config for VBAR at +RBAR
- PROX OPS DAP - when stable (VBAR).
- SYSTEMS CONCERNS (single point):
  - GNC GPC FAIL:
    - 2 required for Ti and PROX OPS
    - RNDZ NAV disables at OPS MODE RECALL
    - Saves FLTR Vector when RNDZ NAV Disables
    - CNCL pointing (TGT ID = 1) before OPS MODE recall
  - MDM FF3:
    - Loss of VERN (1-2-3 rule)
    - RADAR to NAV panel A2 is still good
    - Y Tracker
  - MDM FA1 or 2:
    - Loss of VERNs (1-2-3 rule)
  - MDM FF1:
    - Z tracker
  - PL 1:
    - Auto Ku Pointing (KU MODES: GPC and GDSG lost)
  - Loss of IMU 2 - Restraining 1221.
- Expending about 35 to 40 lb of RCS propellant to maintain attitude results in a cross-coupling translation of 1 fps in -Z direction.
- .3 fps posigrade or retrograde = .9 nm downtrack/rev.
- 1 fps posigrade or retrograde =:
  - 16 kft downtrack/rev
  - 3.5 kft radial/.5 rev
  - .5 nm altitude change (HA or HP).
- 1 fps radial =:
  - 3.5 kft downtrack/.5 rev
  - 900 ft radial/.25 and .75 rev (decoupled from the other axis).
- 1 fps Out Of Plane = 900 ft/.5 rev (decoupled from the other axis)
- (SMA error) x (-10) = ft/rev downtrack error.
- High +Z DV for MC2-4 = short trajectory.
- MC2 Positive TIG slip = Early sunrise.
- TGT EL ANG message = Very short case.



- High in COAS = Short traj (subtract from ADI pitch for THETA)
- High at Ti (> 1.4 deg) = MC2 TIG slip should be positive.
- ORB RATE = .06 deg/sec; 4 deg/min; 360 deg/90 min; 1.1 mr/sec.
- Ti done at orbital noon -3 min.
- +Y = South or going South.
- Sep Rate = 10 x delta H.
- (3/2) WAV for Coeliptic.
- During arm cradling, periodically check all joint angles to make sure that joints that you have already aligned to zero have not moved. During soft stop, position hold does not work; therefore, external forces can move joints out of desired alignment.
- CCTV cameras have a tendency to malfunction at the most inconvenient times. Expect this and know how to perform all operations without cameras.
- Develop a scan pattern that encompasses window, CCTV, and panel status.
- Never rotate the *MODE* switch through *DIRECT* while the brakes are on. This actually puts the arm in mode, and sets you up for a possible runaway if a *SINGLE/DIRECT DRIVE* switch failure occurs or is present.
- Verify the *RATE* switch setting by feel and talkback status. This should be done *EVERY TIME* prior to moving the arm, regardless of mode.
- Make sure you know the proper definitions of "cradling," "stowing," and "berthing."
- Rates for berthing/unberthing: Usually maintain rates at about 0.4 to 0.5 ft/sec between Z = 414 and -438. For Z < -438 (away from the bay), rates can be increased somewhat.
- For berthing or unberthing of payloads with keel trunnions: the keel pin enters/exits the AKA when the longeron trunnions are at the top of the built-in 8-inch PRLA guides.

### PDRS

- Whenever there are both talkbacks and CRT displays that reflect microswitch status, they should **ALWAYS** both be checked during any operation affecting them.
- Whenever troubleshooting RMS malfunctions in the long-form MAL book, always **READ AHEAD**. The MALs have a knack for having page breaks in extremely bad locations, and if you don't know what you're supposed to look for before you turn the page, you could be in trouble.
- The hand controllers are rate-proportional and are extremely sensitive. They should be held in such a way that you can control the full range of inputs without ever stopping to rearrange your hand. Care must be taken to not overcontrol the inputs. A good practice is to slowly and steadily input a desired command, wait patiently until you see the reactions of that command on the arm, and as the desired motion is achieved, slowly back off the input. Ideally, you should reach the axis detent at the same time the arm achieves the desired position and attitude.
- MPM motion may cease during deployment or stowage before the expected microswitches are made. This is due to the fact that the last part of travel in either direction is when the overcenter lock is locking. Therefore, don't turn off the *PORT RMS* switch when visible motion stops. Wait for the microswitches.
- Practice safety habits, the most important of which are brakes on, then power off (if required) for abnormal joint response and use *EE CC* for abnormal *EE* ops during the specified conditions.

### RCS

- 1% RCS prop = 1 fps  $\Delta V$ .
- 1% RCS prop = 22 lbs.
- 1,000 lbs of ARCS prop moves X c.g. 1.2 in, X c.g.  $\pm 0.4$  in.
- 1,000 lbs of FRCS prop moves X c.g. -3.5 in.
- ARCS max blowdown qty 24%.
- FRCS max blowdown qty 22%.
- Loss of a single downfiring vernier jet is loss of vernier mode.
- If fuel tank pressure is 20 psi higher than the oxidizer tank pressure, then verniers are no-go.

- Always secure the RCS from the manifolds to the helium tanks.
- Always open the RCS from the helium tanks to the manifolds.

### TAEM

- A 100 ft difference in gear deploy altitude equals about 250 ft of touchdown energy. Gear deploy should not be delayed past 200 feet altitude.
- 90 ft of touchdown distance corresponds to 1 knot of airspeed.
- TAEM guidance uses pitch to control range, bank angle to control ground track, and speed brake to control q-bar.
- Overhead HAC with NEP allows the most downmode options for energy.
- Fly theta limits at Mach 2 (NLT Mach 1.5) if air data is not incorporated to G&C. Maximum bank angle is 50 degrees. Speed brake should be controlled manually when flying theta limits.
- Manual HAC techniques are only used when requested by Mission Control. To execute the manual HAC procedure, fly 220 to 230 KEAS and follow roll commands. At 120 degrees turn to go, resume flying pitch and roll guidance.
- For an early gear deploy, immediately close the speed brake.
- OGS is 19 degrees lightweight (< 220,000 lbs) and 17 degrees heavyweight (> 220,000 lbs). Aimpoint is 7,500 ft nominal and 6,500 close-in. Touchdown speed is 205 knots heavyweight and 195 knots lightweight and short field speed brake.
- At main gear touchdown, manually deploy the speed brake. Start derotation at 185 KEAS at approximately 2 degrees per sec. At nose gear touchdown, manually back up WOW.
- During training, pilots should strive for a threshold crossing height of 15 to 20 feet on nominal approaches. Touchdown goals are airspeed within 5 knots of the target value, sink rate within structural limits, negligible lateral drift, and minimal RHC activity. A good target value for sink rate is 3 fps or less, insuring ample margin before violating limits.
- With NWS in *GPC* or *DIRECT*, the orbiter will tend to turn into a crosswind. With NWS *OFF*, the orbiter will tend to turn away from a crosswind.
- If the orbiter is landing with a known failed tire, the second tire on that axle is expected to fail during derotation at the point of maximum loading.
- If both main gear tires fail on one side, the orbiter will tend to turn toward that side. The turning moment due to crosswind can either reinforce or reduce this effect.
- If the turning moments due to tire failure and crosswind are in the same directions, large control inputs will probably be required.
- If the turning moments due to tire failure and crosswind are in opposite directions, the control inputs required to counteract tire failure will be reduced. In this situation, pilots must be careful not to overcontrol. A good rule of thumb is to be more cautious with the rudder pedals, matching the crosswind turning tendency.
- Flight Rules call for landing with an existing crosswind on the same side as a known or expected bad tire.

ASCENT	DESCENT	PROPELLANT															
<p><u>Ascent Performance Margin Management Reserve Req. (lbs)</u> Pre Flight Design Requirements Document = 3500 Flight Design Requirements Document = 2500 Cargo Integration Review = 1500 Flight Planning Stowage Review = 1500 FPR = 4652</p> <p><b>ORBIT</b></p> <p>1 hr launch delay = change in orbital noon by 4 minutes</p> <p><u>Ascending node</u> 28.5 deg - 1st ascending node ls @ Long = 173.38 East 57 deg = 121.55 West</p> <p><b>MISCELLANEOUS</b></p> <p><u>Orbiters</u> OV101 - Enterprise OV102 - Columbia OV103 - Discovery OV104 - Atlantis OV105 - Endeavor OV102 weighs 7000 lbs more than OV103/104</p> <p>Min planned flt duration = 96 hours</p> <p><u>Max/Min Beta Angle</u> Max = 23.5 + orbital inclination Min = 23.5 - orbital inclination</p> <p><u>Time</u> CDT = GMT - 5 hr CST = GMT - 6 hr Daylight savings time from 1st Sunday in April to last Sunday in October</p>	<p><u>Xcg Limits</u> FWD = 1076.7 in (RTL5 = 1079.0 in) AFT = 1109.0 in CONT AFT = 1119.0 in</p> <p><u>D/O Delta V's</u> Descending approach is worst case ΔV 90 deg prebank will decrease ΔV - 10 ft/s (function of altitude)</p> <p>If Xcg &gt; 1091.5: 1 in Xcg = 2.2 miles If Xcg &lt; 1091.5: 1 in Xcg = 1.1 miles As Xcg increases (more aft), XR decreases 1 nm XR = 5780 lbs EI weight 1 nm XR = 4.38 nm D/O altitude As altitude and weight increase, XR increases As inclination increases, XR increases (non-linear) As temp increases, XR increases (non-linear)</p> <p><u>Touchdown speeds</u> 185 kts if TD weight &lt; 200 k lbs 195 kts if 200 K lbs &lt; TD weight &lt; 220 k lbs 205 kts if TD weight &gt; 220 k lbs</p> <p>10 kts slower if short field speed brake guidance mode is used</p> <p>Derotation 185 KGS with beep trim 175 with RHC (manual derotation)</p> <p><u>Mass Moment</u> MM = TD Weight * (1172.3 - Xcg)/12 If MM &gt; 1.4 M ft-lbs Concrete desire If MM &gt; 1.55 M ft-lbs Concrete required Note: If TD Xcg not known, use Xcg @ M = 3.5 + 1.5 in</p> <p><u>Landing Weight Limits</u> EOM 230 k lbs RTL5 240 k lbs * TAL 240 k lbs * AOA 240 k lbs *</p> <p><u>Noctilucent Clouds</u> If Inc &gt; 50, do not enter on descending opportunity June through August.</p> <p><b>RENDEZVOUS</b></p> <p>1 deg of phasing/hour = 10 nm of Δheight 1 deg of phasing = 60 nm 17.5 ft/s burn changes other side of orbit 10 nm 440 ft/s burn will change plane by 1 deg of wedge 1 deg of ΔRAAN occurs for each relative lap</p>	<p>1 deg of plane change = 440 ft/s</p> <p><u>OMS philosophy</u> 1 ft/s = 21.8 lbs OMS @ 220 k lbs .1/6% 1.78 ft/s = 1 nm</p> <p><u>Maximum OMS load</u> OV102 = 25156 lbs OV103/4 = 25064 lbs Min = 10800 lbs Max OMS ballast = 4000 lbs 1% OMS = 130 lbs/side</p> <p><u>Hard Ballast</u> OV102 - can be installed in the aft compartment OV103/104 - Bay 13</p> <p><u>RCS philosophy</u> 1 ft/s = 25 lbs (+ X) or 35 - 40 lbs (multi axis) @ 220 K lbs Max burn = 250 sec = 55 fps Full FRCS = 2446 lbs ET blowdown offload = 2225 lbs Min FRCS - 1862 lbs Full ARCS = 4970 lbs (over 100%) 1% ARCS = 22 lbs/side</p> <p><u>INTERCONNECT logic</u> If OMS &lt; 14,000 lbs, I/C off If OMS &gt; 17,000 lbs, I/C on If 14 K &lt; OMS &lt; 17 k, analysis req.</p> <p><b>ECS - N2</b></p> <p><u>OV102</u> 6.28 lbs/day for 4 person crew @ 14.7 psi add .114 lbs/day for additional crewmember 4.35 lbs/day for 4 person crew @ 10.2 psi add .079 lbs/day for additional crewmember</p> <p><u>OV103/4</u> 5.28 lbs/day for 4 person crew @ 14.7 psi add .114 lbs/day for additional crewmember 3.66 lbs/day for 4 person crew @ 10.2 psi add .079 lbs/day for additional crewmember</p> <table border="0"> <tr> <td></td> <td><u>Dry wt</u></td> <td><u>Fully loaded wt</u></td> </tr> <tr> <td>N2</td> <td>83 lbm</td> <td>143 lbm</td> </tr> </table> <p><b>EPS</b></p> <p>.09 lbm Hydrogen = 1 kwh .7 lbm Oxygen = 1 kwh .07 lbm Oxygen/hour = cabin leak rate</p> <table border="0"> <tr> <td></td> <td><u>Dry wt</u></td> <td><u>Fully loaded wt</u></td> </tr> <tr> <td>H2</td> <td>227 lbm</td> <td>319 lbm</td> </tr> <tr> <td>O2</td> <td>215 lbm</td> <td>996 lbm</td> </tr> </table>		<u>Dry wt</u>	<u>Fully loaded wt</u>	N2	83 lbm	143 lbm		<u>Dry wt</u>	<u>Fully loaded wt</u>	H2	227 lbm	319 lbm	O2	215 lbm	996 lbm
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\* Orbiter Engineering Memo VE3-90-096.

# **APPENDIX E**

**Appendix E:** Master List of Study Guide Questions and Answers ..... E-1

**Section 1 - Comm**

**Audio ..... 1-2**

1. Audio Terminal Units enable interfacing with 6 **voice** loops. TRUE or FALSE  
{ANSWER: } TRUE
  
2. List the six voice loops.  
{ANSWER:}    1. A/G 1  
                  2. A/G 2  
                  3. A/A  
                  4. ICOM A  
                  5. ICOM B  
                  6. PAGE
  
3. What is the purpose of the “ACCU/BYPASS” switch on the MIDDECK ATU?  
{ANSWER:} Routes caution and warning alert tones to the mid deck speaker even if the ACCU has failed.
  
4. The two Audio Terminal Units that are capable of receiving TACAN ID tones are
  - a. MS and PS ATUs
  - b. MS and PLT ATUs
  - c. PS and CDR ATUs
  - d. CDR and PLT ATUs
  - e. MIDDECK and MS ATUs
  - f. All ATUs
 {ANSWER: } d
  
5. Match the unit on the left to the function on the right. Selections on the right may be used more than once.
 

<ol style="list-style-type: none"> <li>1 ___ HIU</li> <li>2 ___ VLHS</li> <li>3 ___ ACCU</li> <li>4 ___ ATU</li>   <li>5 ___ NSP</li> <li>6 ___ S-Band PM</li>   <li>7 ___ Ku Band</li> <li>8 ___ UHF</li> <li>9 ___ S-Band FM</li>   <li>10 ___ HHM</li> <li>11 ___ Audio center panel</li>   <li>12 ___ CCU</li> <li>13 ___ MHA</li> </ol>	<ol style="list-style-type: none"> <li>a. allows for multiple headsets to interface to an ATU</li> <li>b. Rf system used for transmitting real time voice</li> <li>c. RF system used for transmitting only recorded voice and data.</li> <li>d. Control for extending audio buses to docking ring, Spacelab, payload bay outlets, UHF system, and OPS recorders.</li> <li>e. Combines voice with data for downlinkng, separates uplinked voice and commands.</li> <li>f. Used as a remote mic in conjunction with the speaker unit.</li> <li>g. This provides power to the headset mic and interfaces a headset to an ATU.</li> <li>h. A light weight headset commonly used on orbit</li> <li>i. Control panel that enables crewmembers to select audio loops and control keying modes</li> <li>j. The onboard unit that gathers and routes audio signals throughout the orbiter.</li> <li>k. Equipment that enables manual keying of voice loops.</li> </ol>
--	---

  
 {ANSWER: }    1. k   2. h   3. j   4. I   5. e   6. b   7. b   8. b   9. c   10. f   11. d   12. g   13. a
  
6. Any ATU on the flight deck may be configured to route voice from MCC to the speaker unit. TRUE or FALSE  
{ANSWER: } FALSE, only the MS ATU (OS ATU on OV 102).

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7. To ensure redundancy the orbiter has **three** Audio Central Control Units.  
TRUE or FALSE  
{ANSWER: } FALSE, only two
8. Selection of the available Audio Central Control Units are on panel.  
a. A1  
b. R14  
c. R10  
d. C3  
{ANSWER: } d
9. What Essential Bus supplies electrical power to ACCU 1?  
a. ESS 2CA  
b. ESS 3AB  
c. ESS 1BC  
{ANSWER: } a
10. What MAIN Bus supplies electrical power to ACCU 2?  
a. MAIN A  
b. MAIN B  
c. MAIN C  
{ANSWER: } c
11. The higher the setting of the VOX control on the ATU, the louder you have to speak to key the mic. TRUE or FALSE  
{ANSWER: } FALSE, just the opposite.
12. If the ATU power switch is taken to the AUD position you will **not** hear alarm tones on that ATU. TRUE or FALSE  
{ANSWER: } TRUE
13. You may use **either side** of the Hand Held Mic mic. TRUE or FALSE  
{ANSWER: } FALSE, only the side with the buttons facing you.
14. List the redundancy capabilities of the cabin ATUs.  
{ANSWER: } CDR to PLT  
PLT to CDR  
MS to PS  
AIRLOCK to MIDDECK (OV 102)  
Airlock to Middeck & PS (OV 103, 104, 105)

CCTV ..... 1-5

CCTV: CAMERA ASSEMBLY

1. Match the names in column **A** to the proper acronym on column **B**.
- |                                   |         |
|-----------------------------------|---------|
| ___ Color Television Camera       | 1. MLA  |
| ___ Monochrome Lens Assembly      | 2. CTVC |
| ___ Color Lens Assembly           | 3. ITVC |
| ___ Wide Angle Lens Assembly      | 4. CLA  |
| ___ Intensified Television camera | 5. WLA  |
- {ANSWER: 2 = Color Television Camera, 1 = Monochrome Lens Assembly, 4 = Color Lens Assembly, 5 = Wide Angle Lens Assembly, 3 = Intensified Television camera. The camera acronyms are used to identify flight specific camera configuration in the TV activation cue card and in various photo TV FDF.}

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2. Crews must not leave a camera unattended when the iris is commanded opened/close using the iris switch. This command disables automatic iris control and the camera can become damaged if it is into direct sunlight. True or False  
{ANSWER: True, the manual iris command disables the automatic light control circuitry removing automatic iris control and the camera is vulnerable to damage from direct sunlight.}
  
3. A camera will continue counting during a temporary suspension in Pan/Tilt movement because there is no feedback from the Pan/Tilt Unit on the camera to suspend counting. True or False  
{ANSWER: True, Pan/Tilt angles can be displayed as alphanumeric on the monitor menu and this information can be incorrect because the camera pan/tilt clutch could slips and yet the camera counter remains counting. This affects the accuracy of camera pointing in support of payload activities.}
  
4. The Automatic Light Control (ALC) circuitry provides for \_\_\_\_.
  - a. Better contrast & detail of bright or dimly lit objects
  - b. Manual control of camera focus
  - c. Automatic control of the lens iris
  - d. All of the above{ANSWER: c, the automatic light control is the preferred mode of operation when the crew leaves cameras unattended because the iris will automatically close if sunlight passes through the viewing are of the camera.}
  
5. The Gamma correction circuits can be used to provide for \_\_\_\_.
  - a. Better contrast & detail of bright or dimly lit objects
  - b. Manual control of camera focus
  - c. Automatic control of the lens iris
  - d. All of the above{ANSWER: a, the GAMMA setting is a good feature to use in conditions with lighting problems.}
  
6. Panels \_\_\_\_ are used in the cabin to provide cabin video.
  - a. A11, MO52J
  - b. A15, MO25J
  - c. O9, MO58F{ANSWER: c, the TV video ports are used by the crew to route video inside the crew compartment for downlink TV.}
  
7. A CCTV camera is considered overtemp if it exceeds a temperature of \_\_\_\_.
  - a. 10°C
  - b. 35°F
  - c. 50°C
  - d. 45°C{ANSWER: d, the crew can monitor the camera temperature on the CCTV monitors and cameras will be powered off if it exceeds 45°C.}

CCTV: VIDEO CONTROL UNIT and PANEL A7U

1. The CCTV circuit breakers are located on panel \_\_\_\_.
  - a. A11
  - b. R14
  - c. R1
  - d. MI86B{ANSWER: b, The circuit breakers are opened an ascent and close on orbit. The circuit breakers remain closed for the entire mission.}

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2. When the GCIL TV POWER CONTROL switch is in CMD on panel A7U, the crew can configure the CAMERA POWER switch to enable camera power. True or False  
{ANSWER: True, the GCIL drivers prevent the crew and MCC from activating or deactivating the VCU simultaneously.}
  
3. When the TV SYNC switch is in reverse, sync generator A is tied to Main B and sync generator B is tied to Main A. True or False  
{ANSWER: True, the sync generator has redundant oscillators. Sync generator A runs when MNA is powering the RCU and generator B runs when MNB is powering the RCU. All CCTV command run on the sync signal and commands are lost if the sync generator is failed.}
  
4. If the camera power talkback on panel A7U reads “ON”, this ensures that the camera is powered on. True or False  
{ANSWER: False, the camera power talkback indicates the status of a 28V DC discrete signal that enables a RPC to provide power to the camera. This talkback can be misleading and the best way to see if the camera is powered is when video is received from the camera.}
  
5. MCC has uplink command control to configure the TV Downlink Enable/Inhibit Switch on panel A7U. True or False  
{ANSWER: False, this switch can be used to ensure that no video is downlinked during “sensitive” missions operations.}
  
6. Real time video from the orbiter to MCC is transmitted through \_\_\_\_\_.
  - a. Payload interrogator
  - b. S-Band PM
  - c. UHF
  - d. K-band{ANSWER: d, the crew transmits real time and recorded video to either the S-band FM or Ku-band communications systems. The FM system is used as backup and it has very limited ground site support.}
  
7. The ALC and gamma PBIs on panel A7U perform different tasks with the CTVCs and 508 cameras. True or False  
{ANSWER: True, the crew uses the regular ALC and GAMMA push button nomenclature to operate the 508 and 506 camera operations. A color decal was created to assist crews to operate the CTVC cameras due to the added features associated with the cameras.}

CCTV : COLOR TV MONITOR

1. The menu is displayed on the monitor by selecting the \_\_\_\_\_.
  - a. Function control
  - b. Brightness/Contrast control
  - c. Select control
  - d. Color/Tint control
  - e. a and d
  - f. a and c{ANSWER: f, the crews interface with this menu to configure graphical camera data. The menu is be displayed for 10 seconds after the last command is executed.}
  
2. The monitor menu Lens Data (L-Data) is used to enable lens data for a \_\_\_\_ camera.
  - a. 508 CLA
  - b. 508 WLA
  - c. CTVC/ITVC
  - d. 508 MLA{ANSWER: c, this data is static when a video source other than a CTVC or ITVC is displayed on the monitor.}



APPENDIX E: Master List of Study Guide Questions and Answers

3. Match the camera type in column **A** to the video processing format type in column **B**.

<u>A</u>	<u>B</u>
___ CTVC	1. NTSC
___ 508 MLA	2. FSC
___ 508 WLA	3. B&W
___ 508 CLA	
___ ITVC	

{ANSWER: 1 CTVC, 2 508 MLA, 2 508 WLA, 2 508 CLA, 3 ITVC. The crew member can determine the camera configuration by identifying the format displayed on the menu. The monitor automatically determines the video format from data embedded in the CCTV camera video and it displays the associated format on the menu display when the MODE option is in AUTO selection (default setting)}.

4. The J3 connector, located on the rear of the monitor, provides \_\_\_\_.
- a. Audio signals
  - b. Power
  - c. Video signals
  - d. a & c
  - e. none of the above
- {ANSWER: c, crew members use this connection to route video from the monitor to the VTR for recording operations.}

**Instrumentation ..... 1-11**

1. The function of an MDM is to
- a. receive OI data, GPC downlist and payload data and format for crew display and downlink.
  - b. acquire and convert various sensor data (temperature, rate, frequency, etc.) into 0-5 Vdc pulse.
  - c. accept data from various inputs, digitize (if required) and interleave data into a serial data stream.
- {ANSWER: c }
2. The loss of a DSC causes \_\_\_\_\_ on the SYS SUMMs and several SM ALERT messages for the parameters associated with that DSC.
- a. M's
  - b. L's
  - c. ↑'s
  - d. ↓'s
- {ANSWER: b }
3. In which FDF are the flight specific TFL configurations located?
- a. REF DATA
  - b. IFM CL
  - c. MAL PROCS
  - d. FS Orbit Ops CL
- {ANSWER: d }
4. TFLs are loaded in what OPS modes?
- a. S2, G3
  - b. G1, G9
  - c. G1, G3
  - d. S2, G9
- {ANSWER: d }

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5. The \_\_\_\_\_ TFL is not lost during a PCMMU power interrupt.
- a. \_\_\_\_\_ programmed
  - b. \_\_\_\_\_ LDR
  - c. \_\_\_\_\_ HDR
  - d. \_\_\_\_\_ fixed
- {ANSWER: d}
6. The FDF used to determine the OI DSC loss is \_\_\_\_\_.
- a. \_\_\_\_\_ REF DATA
  - b. \_\_\_\_\_ IFM CL
  - c. \_\_\_\_\_ MAL PROCS
  - d. \_\_\_\_\_ a and c
- {ANSWER: a}
7. TFL \_\_\_\_\_ is the fixed TFL that contains primarily OI, GNC and BFS data ( no payload data).
- a. \_\_\_\_\_ 128
  - b. \_\_\_\_\_ 129
  - c. \_\_\_\_\_ 161
- {ANSWER: b}
8. The function of the PCMMU is to
- a. \_\_\_\_\_ receive OI data, GPC downlist and payload data and process for crew display and downlink.
  - b. \_\_\_\_\_ acquire and convert various sensor data (temperature, rate, frequency, etc.) into 0-5 Vdc pulse.
  - c. \_\_\_\_\_ accept data from various inputs, digitize and interleave data into a serial data stream.
- {ANSWER: a}
9. The loss of an MDM causes \_\_\_\_\_ on the SYS SUMMS and either 'I/O ERR PCM'(ascent/entry) or 'BCE BYP OF A(B) or OA' (orbit) messages for the parameters lost with that MDM.
- a. \_\_\_\_\_ M's
  - b. \_\_\_\_\_ L's
  - c. \_\_\_\_\_ ↑'s
  - d. \_\_\_\_\_ ↓'s
- {ANSWER: a}
10. Which one of the following is NOT an output of PCMMU 1?
- a. \_\_\_\_\_ NSP 1
  - b. \_\_\_\_\_ NSP 2
  - c. \_\_\_\_\_ ops recorders
  - d. \_\_\_\_\_ PCDECOM
- {ANSWER: c}
11. What step in the TFL LOAD procedure has the PCMMU begin using TFL 184 ( the programmed HDR TFL)?
- a. \_\_\_\_\_ ITEM 1 EXEC
  - b. \_\_\_\_\_ ITEM 3+184 EXEC
  - c. \_\_\_\_\_ ITEM 4 EXEC
  - d. \_\_\_\_\_ ITEM 2 EXEC
- {ANSWER: d}

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12. A \_\_\_\_\_ alters the amount GPC downlist, OI and PL/Spacelab data being formatted and sent to the NSP based on mission phase and requirements
- a. OI DSC
  - b. TFL
  - c. OI MDM
  - d. DFL
- {ANSWER: b }
13. Assume the 'I/O ERR PCM' is annunciated and the SM SYS SUMMS show missing data for all parameters. To determine if a failure is at the PCMMU or at the SM GPC, the crew must \_\_\_\_\_.
- {ANSWER: Bring the BFS to standby and assign it a CRT to check if parameters are also missing on the BFS. If they are the failure is at the PCMMU. If not the failure is at the SM GPC}
14. The BFS will attempt an automatic I/O RESET to the PCMMU after a PCMMU or OI MDM power interrupt. TRUE or FALSE
- {ANSWER: True}
15. The SM GPC will attempt an automatic I/O RESET to the PCMMU after a PCMMU or OI MDM power interrupt. TRUE or FALSE
- {ANSWER: False. The BFS performs an automatic I/O RESET after a PCMMU power interrupt but SM does not. A crewmember must perform an ITEM 5 on SPEC 62 or an SM I/O RESET to reestablish communication between the SM GPC and the PCMMU.}
16. All OI MDM primary MIAs are connected to PCMMU1 and all secondary MIAs to PCMMU2. TRUE or FALSE
- {ANSWER: True}
17. If a TFL LOAD FAIL message is annunciated after the first load attempt, the PCMMU will automatically try a second time to load the same TFL. TRUE or FALSE
- {ANSWER: False. The procedure has the crew attempt another TFL load.}
18. The PDI has a primary and a secondary port to PCMMU 1. TRUE or FALSE
- {ANSWER: False. The PDI has two ports, one connected to PCMMU1 and another to PCMMU2.}
19. An MDM power failure is recoverable by selecting the alternate PCMMU. TRUE or FALSE
- {ANSWER: False. If the failure is the whole MDM, data is not recovered by switching to the alternate PCMMU. If the failure is at the MDM primary port, data is recoverable with a PCMMU swap.}

**Ku-Band ..... 1-14**

**Ku-Band: Antenna Operations**

1. How much time does a nominal KU antenna DEPLOY require? Why might the DEPLOY take longer? What are the consequences to continued KU operations should this happen?
- {ANSWER: About 23 seconds. SINGLE MOTOR DEPLOY. Discontinue use, if STOW is SINGLE MOTOR also}
2. At the beginning of the deploy procedure, the KU POWER switch is verified in the OFF position and the KU CNTL switch is taken to PNL to:
- a. prevent commanding of the KU system from the ground.
  - b. prevent the KU antenna from initializing prematurely.
- {ANSWER:b}

APPENDIX E: Master List of Study Guide Questions and Answers

3. During the KU antenna deploy sequence, the KU band antenna dish remains locked in place by antenna gimbal locking pins and cannot move.  
{ANSWER: TRUE}
  
4. Order the following steps and processes, so that they most accurately describe the sequence that occurs during a nominal KU antenna stow procedure.
  - a. EA1 commands antenna gimbal lock pins closed.
  - b. Wiggle test performed
  - c. KU PWR ON checked
  - d. MECH PWR switches activated
  - e. EA1 commands antenna to final STOW angles
  - f. Crew manually positions KU antenna close to final Stow angles
  - g. Crew normally performs KU ANT CABLE POSITIONING.
  - h. Deployed Assembly is driven to the STOW position along the STARBOARD longeron.
  - i. KU ANT switch is taken to STOW position{ANSWER: c, g, f, i, e, a, b, d, h}
  
5. Flight Rules prohibit the stowing of the KU-band DA without confirmation that the gimbal lock pins are in place to secure the antenna dish in the correct STOW position. TRUE or FALSE  
{ANSWER: TRUE}
  
6. The \_\_\_\_\_ switch will be used only when the KU antenna will not stow via the normal stow process even though it can be verified that the GIMBAL LOCKING PINS have been set.
  - a. KU ANT DPY/STO - PNL R13L
  - b. KU ANT DIRECT STO - PNL R13L
  - c. KU PWR - PNL A1
  - d. None of the above{ANSWER: b}
  
7. The \_\_\_\_\_ (FDF Procedure) will be used if the KU antenna will not STOW by any means.
  - a. KU ANT DIRECT STOW
  - b. KU-BD CABLE POSITIONING
  - c. KU-BD ANT JETTISON
  - d. KU-BD MANUAL ACQUISITION{ANSWER: c}
  
8. The \_\_\_\_\_ (FDF Book) contains nominal KU DEPLOY and STOW procedures.  
{ANSWER: ORB OPS CHECKLIST}
  
9. Which of the following maskings can be seen on the SM OPS 2011 - ANTENNA display?
  - a. Obscuration mask
  - b. Beta only mask
  - c. Beta + mask
  - d. All of the above{ANSWER: a}
  
10. In the nominal COMM mode, a \_\_\_\_\_ (BETA + MASK, BETA ONLY) mode is normally used. In this mode, the KU output will be inhibited by turning the TWT OFF, whenever the KU antenna LOS for a selected TDRS points in the area
  - a. below the Obscuration mask line
  - b. so that the beta angle required exceeds that set in masking
  - c. both a and b
  - d. either a and b{ANSWER: BETA + MASK, c}

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11. Some reasons to transition to a BETA ONLY masking mode of operations include
- a. to provide extra protection during antenna DPLY/STOW operations
  - b. to provide extra protect from KU radiation to EVA crew.
  - c. to provide protection to radiation sensitive payloads.
  - d. to provide more accurate KU antenna pointing, during periods when a TDRS is OFF-THE-NOSE.
- {ANSWER: b & c}
12. Match the following descriptions of KU antenna steering modes with the correct identifier.
- |   |                  |
|---|------------------|
| a. KU antenna dish is manually positioned by the crew to expected location of TDRS satellite or RNDZ target. The KU attempts to lock to a forward link signal. If none is received the antenna can be forced into a spiral SEARCH. If a forward link signal or return is detected, EA1 will enter a closed loop tracking mode, and track the signal or target until it is lost. If the signal being tracked is lost, the dish will remain stationary at its last position.  | 1. GPC           |
| b. KU antenna dish responds to GPC commanded EL/AZ pointing angles every 2 seconds. It converts these to appropriate Alpha/Beta gimbals movements to command the antenna LOS to follow a target or TDRS.  | 2. GPC DESIGNATE |
| c. KU antenna dish only responds to MANUAL SLEW commands issued by the crew from panel A1.  | 3. AUTO TRACK    |
| d. KU antenna dish responds to GPC commanded EL/AZ angles, converts them to Alpha/Beta gimbal commands, and points the antenna LOS towards a target or TDRS. The system tries to detect a forward link signal, if none is detected in a specific amount of time a automatic spiral SEARCH is performed. If a forward link signal is detected the KU enters an automatic internal TRACK routine and will track the target or TDRS. If the forward link is lost, after a specified period of time, the KU will accept another new commanded angle from the GPC and start the same routine over. | 4. MANUAL SLEW   |
- {ANSWER: a/3, b/2, c/3, d/1}
13. The KU antenna dish \_\_\_\_\_ (will, will not) respond to MANUAL SLEW commands from panel A1, if it is in GPC, or AUTO TRACK and actively tracking.
- {ANSWER: will not}

KU-Band System: Basic Operations

1. The Ku-band antenna can be safely deployed only when the Orbiter is on-orbit and the payload bay doors are opened.
- {ANSWER: TRUE}
2. In the COMM mode, the KU system can be operated in two modes, what data can be uplinked during KU COMM operations in mode 1, that cannot be uplinked in mode 2?
- a. VOICE
  - b. Orbiter commands
  - c. TIPS, PADM, or payload commands
  - e. a and b only.
- {ANSWER: c}

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3. The Ku-band COMM downlink can consist of four distinct channels.  
{ANSWER: FALSE}
4. Match the KU COMM downlink channels with the types of data on each channel.
- |         |   |
|---------|---|
| 1. CH 1 | a. TV, PL ANLOG, PL DIG, PL INTEG, PL MAX |
| 2. CH 2 | b. PL INTRG, PL DIG, OPS RDCR, PL RCDR    |
| 3. CH 3 | c. ORB NSP - VOICE and TELEMETRY          |
| 4. CH 4 | d. MAIN ENGINE DATA                       |
|         | e. No such channels exists                |
- {ANSWER: 1/c, 2/b, 3/a, 4/e}
5. During rendezvous operations, when the Ku-band system is being used in the RADAR mode, RADAR data is used to provide \_\_\_\_\_ information for updating the Orbiter calculated navigation data.
- Target angle and angle rate
  - Range
  - Range Rate
  - All of the above
- {ANSWER: d}

Ku-band: Communications Operations & GPC Displays

1. Order the following sequence of LRUs and processes, so that they best represent the path of forward link communications data through the Ku system?
- The SPA receives the demodulated communications data, processes it, and routes it to the NSP and/or TIPS, PADM, or payload.
  - The EA1 receives a forward link signal, establishes lock, and demodulates the data.
  - At the DA, the forward link signal is received at the antenna dish and processed by the Ku receiver.
- {ANSWER: c, b, a}
2. Other than processing the forward link communications signal, what other important function does EA1 perform?
- Controls transmitter pulsing in the RADAR mode
  - Modulates data onto the Ku return link carrier
  - Controls DA antenna pointing and tracking functions
  - None of the above
- {ANSWER: c}
3. Fill-in the blanks in the paragraph below with the appropriate LRU to describe the path of return link communications data through the Ku system.
- The \_\_\_\_\_ receives NSP, payload, TV, and/or recorder data from Orbiter systems, modulates the data onto a Ku-band carrier frequency. The modulated carrier is routed to a TWT amplifier and transmitter located in the \_\_\_\_\_, which in turn routes the modulated/amplified carrier to the antenna on the \_\_\_\_\_.
- DMA
  - EA2
  - SPA
  - EA1
  - DEA
- {ANSWER: 3, 5, 1}

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4. Which of the following information is displayed on SM SPEC 76?  
(CAUTION: More than one answer may be correct)
  - a. KU antenna heater temperatures
  - b. KU FRAME SYNC, when operating in forward mode 1
  - c. KU antenna masking mode selected
  - d. KU operating mode selected (COMM vs. RADAR)
  - e. KU antenna pointing mode selected
  - f. KU transmitter RF power output{ANSWER: a, b, d, f}
  
5. The EL/AZ CMD indications on SPEC 2011 - ANTENNA represent the pointing angles to a TDRS or RNDZ target as commanded by
  - a. KU EA1
  - b. KU SPA
  - c. ORB GPC
  - d. Ground uplink{ANSWER: c}
  
6. The EL/AZ ACT and the LOS box on SPEC 2011 - ANTENNA are driven by telemetry feedback to the GPC from the KU system and represent true pointing angles. TRUE or FALSE  
{ANSWER: TRUE}
  
7. During normal KU operations, if both the E and W TDRS satellite are in view, the KU antenna will continue to point to the W TDRS until it is out of view and then point to the E. What item entry on SPEC 2011, can force the KU antenna to point to the E TDRS as soon as it comes into view (Early TDRS HANDOVER)? Should this Item entry ever be done without MCC concurrence?  
{ANSWER: Item 11 EXEC, NO}
  
8. The Obscuration line depicted on the graphic portion of SM SPEC 2011 - ANTENNA represents the \_\_\_\_\_ and indicates an areas in which the KU system \_\_\_\_\_ (should, should not) be able to establish a two-way communications link with a TDRS satellite.
  - a. BETA masking commanded
  - b. Orbiter hardware blockage area plus a 5% transition zone
  - c. area in which the KU antenna cannot be pointed because of mechanical limitations of the gimbals
  - d. software controlled area, where the KU transmitter is inhibited{ANSWER: b, should not}

Ku-band: RADAR Operations

1. Which of the following LRU(s) is(are) required to operate the KU system in the RADAR mode?  
(CAUTION: More than one answer may be correct)
  - a. EA2
  - b. EA1
  - c. DA
  - d. SPA
  - e. All of the above{ANSWER: a, b, c}
  
2. What KU LRU is responsible for controlling such functions as transmitter frequency, RF output level, and transmitter/receiver gating logic, during normal KU RADAR operations?  
{ANSWER: EA2}

APPENDIX E: Master List of Study Guide Questions and Answers

3. The KU \_\_\_\_\_ (DA, EA1, EA2, SPA) is responsible for extracting and processing the RADAR return signal from a target and extracting \_\_\_\_\_ information for use by Orbiter NAV software and/or direct display on Orbiter panels.
- a. Range
  - b. Range Rate
  - c. Angle
  - d. Angle Rate
  - e. All of the above
- {ANSWER: e}
4. TRUE or FALSE - A KU SELF TEST is normally repeated as an initial step before use of the KU in the RADAR mode during a rendezvous to re-check RADAR functions not used while operating in the COMM mode.
- {ANSWER: TRUE}
5. Prior to a distance to the rendezvous target of about 150 KFT, KU panel A1 switches are configured for RADAR PASSIVE operations in \_\_\_\_\_ (GPC, GPC DESGN) antenna steering mode, and an Item 2 EXEC entry made on GNC SPEC 33 \_\_\_\_\_.
- a. to program EA2 for rendezvous operations.
  - b. to allow transfer of Orbiter to target pointing vectors from GNC to SM GPC and to direct antenna pointing software to point to the rendezvous target.
  - c. to disable SM GPC direct KU antenna pointing, so that it can track the rendezvous target.
  - d. to enable the GNC to directly control KU antenna pointing.
- {ANSWER: b}
6. When RADAR lock occurs on target returns, an ITEM 13 EXEC on GNC SPEC 33 initiates the comparison of \_\_\_\_\_ to \_\_\_\_\_ and if the comparison meets certain checks for reasonability, the \_\_\_\_\_ will be updated to match the \_\_\_\_\_ and can be used to execute subsequent burns. Use the best answers below to fill in the blanks. (CAUTION: At least one answer must be used more than once.)
- a. RADAR sensor data
  - b. NAV calculated position and range of the target relative to the Orbiter
  - c. Orbiter State Vector
- {ANSWER: a, b, c, a or b, a, c, a}
7. TRUE or FALSE - During the final stages of a rendezvous, particularly during MANUAL BURNS to meet BRAKING GATES, RADAR sensor data, directly from the KU, is read on panel A2 to maintain both target position relative to the orbiter and meet closure rate requirements as the distance between the target and Orbiter decreases.
- {ANSWER: TRUE}

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**Payload Comm ..... 1-23**

1. When commanding to hard-line payloads, the path is:
- a. PL MDM ⇒ PI ⇒ PAYLOAD
  - b. PL MDM ⇒ PSP ⇒ PI ⇒ Payload
  - c. PSP ⇒ PL MDM ⇒ PPP ⇒ Payload
  - d. PSP ⇒ PPP ⇒ Payload
- {ANSWER: d}
2. When commanding to RF payloads, the path is:
- a. PSP ⇒ PL MDM ⇒ PPP ⇒ Payload
  - b. PSP ⇒ PPP ⇒ Payload
  - c. PL MDM ⇒ PI ⇒ Payload
  - d. PL MDM ⇒ PSP ⇒ PI ⇒ Payload
- {ANSWER: d}



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3. Fill in the blanks: The path that telemetry takes from a hard-line payload to the PCMMU is as follows: Payload ⇒   ?   ⇒   ?   ⇒ PCMMU.
- a. PL MDM, PSP
  - b. PPP , PSP
  - c. PPP , PDI
  - d. PDI , OI MDM
- {ANSWER: c}

4. Fill in the blanks: The path that telemetry takes from an RF payload to the PCMMU is as follows RF Payload ⇒   ?   ⇒   ?   ⇒   ?   ⇒ PCMMU.
- a. PI , PSP, PL MDM
  - b. PPP, PSP, PDI
  - c. PSP, PDI, OI MDM
  - d. PI, PSP, PDI
- {ANSWER: d}

5. When the payload outputs a data rate that is not compatible with the PSP, all data received by the PI is throughput directly to the K-band signal processor. This is known as "bent pipe". True or False?
- {ANSWER: True}

6. Match the LRU names with the functions below:
- a. Payload Interrogator
  - b. Payload Signal Processor
  - c. Payload Data Interleaver
  - d. Pulse Code Modulation Master Unit
  - e. Payload Patch Panel
  - f. RF Payload
  - g. Hard-line Payload

\_\_\_\_\_ Receives data from the GPCs, the PDI, and the OI MDMs, interleaves the data, and then formats it according to programmed instructions stored within it.

\_\_\_\_\_ Transmitter/Receiver unit which provides duplex RF communications between the Orbiter and a detachable payload.

\_\_\_\_\_ Interfaces attached payloads to the PDI.

\_\_\_\_\_ This box can be divided into three sections: control and configuration, command, and telemetry. It is the interface between the ground (or crew) and the attached or detached payload. It is also an interface for detached payload telemetry.

\_\_\_\_\_ Attached payload

\_\_\_\_\_ Receives data from multiple payloads and stores the data internally for use by the PCMMU.

\_\_\_\_\_ Detached payload

{ANSWER:d, a, e, b, g, c, f}

7. Which LRU provides the received signal strength from the payload?
- a. PI
  - b. PSP
  - c. PCMMU
  - d. PDI
- {ANSWER: a}

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8. Match the labels with the functions below:

- a. Fetch Pointer Memory
- b. PDI Data Ram
- c. Switch Matrix
- d. Toggle Buffer
- e. Decom

\_\_\_\_\_ Programmable device which routes data from any of seven input channels to any of four decoms.

\_\_\_\_\_ Programmable devices used to identify, extract, and format portions of an assigned payload telemetry stream to be included in the Orbiter down link telemetry stream.

\_\_\_\_\_ Tells the toggle buffer what data to output which will be interleaved with the data output from the PDI Data Ram.

\_\_\_\_\_ Two-sided data storage device. When one side is receiving data for storage, the other side is releasing data to be sent to the PCMMU.

\_\_\_\_\_ Device which stores payload data for display purposes.

{ ANSWER: c, e, a, d, b }

9. It is possible to use PI 1 with PSP 2. True or False?

{ ANSWER: False }

10. It is possible to use PCMMU 1 with Payload Comm System 1 or 2. True or False?

{ ANSWER: True }

11. What affects do the loss of PF1 MDM have on the Payload Comm System?

- a. You can no longer load the decoms
- b. You can no longer receive commands or telemetry from the PSP
- c. You can no longer command to a payload through the PSP
- d. All of the above.

{ ANSWER: c }

12. What affects do the loss of PL 1 Bus have on the Payload Comm System?

- a. You can no longer load the decoms
- b. You can no longer receive commands or telemetry from the PSP
- c. You can no longer receive telemetry from a payload through the PSP
- d. All of the above.

{ ANSWER: a }

13. Complete the chart below indicating whether the item is an input, output, neither, or both input and output of the Payload Recorder:

Source/Destination	I - INPUT	O - OUTPUT
	N - NEITHER	B - BOTH
Payload Distribution Panel		
Ku Signal Processor		
Data/Voice from NSP		
FM Signal Processor		

{ ANSWER: I, O, N, O }

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14. If the Control talk back for the Payload Recorder is barber-pole, this means all ground commands are blocked out and the crew has control over the recorder. True or False?  
{ANSWER: False }
15. Which one of the following actions will not give the control of the Payload Recorder to the crew?  
a. Real Time Command performed by crew.  
b. Standby Crew Reset Command from INCO.  
c. Power Cycle of PF #1 MDM.  
d. Power Cycle of the Payload Recorder.  
e. None of the above.  
{ANSWER: d }
16. In a Coherent payload, the receiver and the transmitter move simultaneously. If the receiver sweeps, the transmitter sweeps proportionately. True or False?  
{ANSWER: True }

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**S-Band FM ..... 1-27**

1. The primary purpose of the S-Band FM system is to:  
a. Transmit voice and selected data directly to the ground via STDN or Air Force ground stations.  
b. Transmit and receive selected data only via STDN or Air Force ground stations.  
c. Transmit selected data only via STDN or Air Force ground stations.  
d. Transmit selected data only via TDRS network.  
{ANSWER: C. The S-band system is for downlink data only }
2. Controls for the S-band FM System are located:  
a. On panel A2  
b. On panel A1R  
c. On panel O6  
d. and selected by INCO only.  
{ANSWER: b }
3. The selectable sources, via panel A1R or ground command, for the S-band FM system are:  
a. OPS RCDR, DOD, ME, A/G1, A/G 2, UHF, PL ANLG  
b. TV, OPS RCDR, ME, A/G 1, A/G 2, PL DIGITAL, PL RCDR  
c. TV, OPS RCDR, ME, DOD, PL DIGITAL, PL ANALOG, PCMMU  
d. TV, OPS RCDR, PL ANLG, PL DIGITAL, PL RCDR, ME, DOD  
{ANSWER: d }
4. It is possible to simultaneously transmit and receive via the S-Band FM Antenna switch.  
True or False?  
{ANSWER: True. The hemi antenna switch has a port that can route RF television from the astronaut's extravehicular mobility unit (EMU) to the orbiter's CCTV system. An extravehicular mobility unit can transmit TV on one hemi antenna/antenna switch path to the orbiter while the S-band FM system is routing FM downlink telemetry to the ground on the other hemi antenna/antenna switch path. }

**S-Band PM ..... 1-28**

1. Which S-Bd PM string is configured for primary operation pre-flight and used through-out the mission and which string is configured for back-up as reflected by the Panel A1 switches?
  - a. String 1 prime, String 2 b/u
  - b. String 2 prime, String 1 b/u

{ ANSWER: b } Rationale: String 2 is in operation and string 1 is powered off until a C3 panel/command picks up the panel A1 config which powers string 1 on and string 2 off.
  
2. True or False: At liftoff, S-Bd string 1 and 2 are configured for STDN-HI mode?
 

{ ANSWER: True } Rationale: String 2, which is operating, is in STDN-HI mode from launch to TDRS handover because comm is through the ground site at the Merritt Island Launch Area (MILA) facility and string 1, as configured on panel A1, is also in STDN-HI mode so that if a panel/cmd is needed during powered flight, the crew does not have to change switches.
  
3. Ascent Comm coverage is referenced where in the FDF?
  - a. Ascent Checklist
  - b. Ascent Pocket Checklist
  - c. Ascent Checklist Flight Supplement
  - d. Ascent/Entry Systems Procedures

{ ANSWER: c } Rationale: Comm Coverage of the Ascent CL FS lists the comm coverage for all possible ascents.
  
4. The Stored Program Command (SPC) to change the S-Bd PM transponder from STDN HI to TDRS mode occurs at what MET for High and Low inclination trajectories ?
  - a. 10 min High/ 11 min Low
  - b. 11 min High/ 10 min Low
  - c. 10 min High or Low
  - d. 11 min High or Low

{ ANSWER: a } Rationale: The SPC is timed to change the S-bd PM to TDRS mode 30 sec prior to losing ground station coverage. This occurs at 10 min for a high inclination and 11 min for a low inclination trajectory.
  
5. For a loss of comm during ascent, pre SPC, what is required before an S-bd PM panel/ command can be performed to establish good comm with MCC?
  - a. Nothing
  - b. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING OFF
  - c. Reconfigure Panel A1 PM transponder/ NSP to STDN-HI, TX/RCV CODING ON
  - d. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING ON

{ ANSWER: a } Rationale: Panel setup is for STDN-HI, same as operating string
  
6. For a loss of comm during ascent, post SPC but pre Post Insertion CL, what is required before an S-bd PM panel/ command can be performed to establish good comm with MCC?
  - a. Nothing
  - b. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING OFF
  - c. Reconfigure Panel A1 PM transponder/ NSP to STDN-HI, TX/RCV CODING ON
  - d. Reconfigure Panel A1 PM transponder/ NSP to TDRS mode, TX/RCV CODING ON

{ ANSWER: d } Rationale: SPC modes operating system to TDRS but panel is in STDN-HI
  
7. The SPC which modes the PM transponder to TDRS during ascent is stored where?
  - a. PL 1 MDM
  - b. BFS GPC
  - c. GCIL
  - d. GNC GPC

{ ANSWER: b } Rationale: The payload busses ,which are used to send commands to the GCIL to mode the S-bd, are controlled by the BFS GPC during ascent.

APPENDIX E: Master List of Study Guide Questions and Answers

8. True or False: If the control element fails to execute the SPC during ascent, MCC will try to uplink a real-time command to switch to TDRS mode.  
{ ANSWER: True } Rationale: If the GPC fails and the SPC does not execute, MCC will try to uplink to the GNC GPC if it has control of the Payload busses.
9. During ascent/ entry, what controls PM quad antenna selection based on Orbiter position and attitude?  
a. BFS GPC  
b. PL 1 MDM  
c. Antenna Electronics  
d. GNC GPC  
{ ANSWER: a } Rationale: During ascent, the BFS contains the antenna management software which sends commands to the antenna electronics to select the best antenna based on Orbiter position and attitude
10. True or False: If the control element fails to select the correct PM quad antenna during ascent, MCC will expect the crew to select the correct antenna manually.  
{ ANSWER: False } Rationale: APCL says manual antenna select if “no comm”, INCO will inhibit GPC selections then uplink the correct antenna and tell crew “if comm lost then manual antenna”.
11. True or False: The control element that selects the correct PM quad antenna monitors the PM mode through MDM OF3/ PCMMU to know whether to point towards TDRS or a ground site .  
{ ANSWER: True } Rationale: The antenna management software must know which mode the transponder is in order to correctly point to the ground or TDRS. It monitors the rotary switch position which is fed to the PCMMU by MDM OF 3. If the MDM or PCMMU fails and the transponder is moded, the antenna management software will not see it and continue pointing to the last mode.
12. True or False: As currently configured (NASA Mode), a COMSEC power failure would affect U/L voice and commands only.  
{ ANSWER: True } Rationale: Only the uplink is encrypted. It is encrypted to protect the uplink commands but since voice is also part of the uplink, it too gets encrypted. So a COMSEC failure would affect only the U/L.
13. U/L command routing through the LRUs are:  
a. NSP/COMSEC 1/2, FF MDM 1/3, GPCs  
b. NSP/COMSEC 1/2, P/L MDM 1/2, GPCs  
c. NSP/COMSEC 1/2, GCIL, FF MDM 1/3  
d. P/L MDM 1/2, NSP/COMSEC 1/2, GPCs  
{ ANSWER: a } Rationale: NSP1/COMSEC 1 are hardwired to FF MDM 1 which is assigned to a GNC GPC (normally GPC 1 on Asc/ Entry) and NSP2/ COMSEC 2 are hardwired to FF MDM 3 which is also assigned to a GNC GPC (normally GPC 3 on Asc/Entry).
14. True or False: COMSEC LRUs are hardwired to each NSP and cannot be crosstrapped therefore a COMSEC failure requires using the B/U NSP.  
{ ANSWER: True } Rationale: COMSEC LRUs are not GCIL controlled switches and are not crosstrapable.
15. True or False: Comm config SPCs during Ascent and Entry are handled by the GNC GPC.  
{ ANSWER: False } Rationale: Comm config SPCs are stored in the BFS during ascent and entry because it has control of the payload busses used to send commands to the GCIL.

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16. The antenna management software for orbit resides in the:  
a. GCIL  
b. SM GPCs  
c. GNC GPC  
d. Antenna Electronics 1/2  
{ANSWER: b } Rationale: On-orbit the SM function including antenna management is performed by the SM GPC.
17. Delayed ET sep can cause:  
a. Weak signal strength until ET sep or heads up  
b. No D/L comm until ET sep or heads up  
c. No U/L comm until ET sep or heads up  
d. No U/L or D/L comm until ET sep or heads up  
{ANSWER: d } Rationale: If the S-bd is trying to use a lower antenna, the ET will prevent U/L or D/L comm.
18. True or False: During an RTLS, the normal SPC is cleared and comm is through the STDN site until landing.  
{ANSWER: True} Rationale: The normal SPC is cleared. Analysis from DTO 700-13 (STS 81 & 86) show viable S-Band direct link between MILA and SSO for the worst case RTSL. Therefore, handing over to S-Band TDRS during powered flight is not necessary
19. What bus loss will cause loss of Comm while on the prime PM system (String 2):  
a. Main A  
b. Main B  
c. Main C  
d. ESS 2AB  
{ANSWER: c } Rationale: Prime S-bd ,string 2, is powered by Main C. Think “C for Comm”
20. True or False: Anytime the message “BCE STRING X NSP” annunciates there will be a loss of Comm.  
{ANSWER: False } Rationale: It may be only a loss of serial I/O interface between the NSP and the GPC i.e. loss of commanding which may or may not be recovered with a GNC I/O reset.
21. What are the consequences of a GCIL fail on S-bd PM comm:  
a. The system is immediately configured per the back panel  
b. MCC can no longer command the system  
c. The system changes to high frequency if it was in low frequency  
d. All the above  
{ANSWER: d } Rationale: A GCIL failure will immediately config all comm systems (S-Bd PM, FM, Payload, Ku-Bd, and CCTV) to the panel configuration. These switches will function even though the panel/ cmd switch is in cmd. Ground command becomes impossible with no GCIL decoder to interpret them. If S-Bd PM is flown in low frequency, there is no panel switch to select a frequency. The GCIL defaults to high frequency for a GCIL failure. So even if the panel is in the correct configuration when the failure occurred, the frequency change will prevent communication with the ground. Spec 76 is used to see the freq selected. The malfunction procedures, No S-Band Voice TDRS, leads to the steps to change frequencies through SPEC 1, assuming keyboard command to GCIL is working.
22. For a given GPC failure, what must happen if MCC is to have the ability to command antennas and command changes to the S-bd PM system:  
a. A panel/ command is required  
b. The P/L buses must be assigned to a operational GPC  
c. The U/L block switch on panel C3 must be in Enable  
d. There is no way to recover once a GPC has failed.  
{ANSWER: b } Rationale: The payload busses are used to send commands to the GCIL and select antennas

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23. An indication that MCC has performed an early TDRSS East handover is:
- Only the EAST TDRS is displayed on the ANT DISP
  - An item 19 OVRD on the ANT DISP
  - Longer than normal comm loss in the ZOE
  - East TDRS is selected as prime on the ANT DISP Item 13
- {ANSWER: **d** } Rationale: West TDRS is normally prime as indicated by an \* next to West Item 13 on the Ant Disp This selection forces Ant Mgmt software to use the West TDRS until it goes over the horizon and then to look for the East TDRS. Early handover, whether selected by ground or crew, will be indicated by an \* next to East TDRS Item 14 which forces Ant Mgmt to use the East TDRS when it comes in to view even though the West is still useable.
24. An item 19 OVRD on the ANT DISP is used to:
- Allow early TDRSS East handover
  - Allow uplink commanding in the ZOE
  - Force the Ant GMT program to point at TDRSS
  - Force a software panel/command
- {ANSWER: **c** } Rationale: as IO MDM OF3 failure could fail such that Antenna Management would not change to look for TDRS. The override tells the SM ant management to point for TDRS.
25. Aft panel reconfig is required prior to a PM panel/command: (Choose two)
- After Ascent TDRSS handover but before Post Insertion reconfig
  - EI to touchdown
  - for Pre-sleep comm config
  - After De-orbit Prep reconfig but before STDN handover
- {ANSWER: **a & d** } Rationale: During these periods, SPCs have been executed that commands the operating system to a different mode than is currently selected for the backup system as configured by the panel A1 switches. Therefore a panel/ cmd without changing the panel switches to match the operating system would cause a loss of comm.
26. True or False: Downlink is delayed 140 sec after a PM panel/command on orbit.
- {ANSWER: **True** } Rationale: The backup power-amp is taken out of standby to save power. If a panel/ cmd is executed, the backup power amp will require a 140 sec to warm-up before D/L is possible through the S-Bd PM system. During ascent/entry, the backup power amp is in standby and no warmup is needed.
27. Power down of the PM system for a loss of 2 water loops must be done within:
- 30 min.
  - 10 min.
  - 1 min.
  - as directed by MCC
- {ANSWER: **b** } Rationale: PM system LRUs must be unpowered within 10 minutes of lose of cooling or they will burn up. The most likely to fail is the power amps.
28. Prime source of communication with MCC on-orbit through the PM system is:
- SGLS sites
  - STDN sites
  - TDRSS satellites
  - UHF sites
- {ANSWER: **c** } Rationale: Ground sites are considered as backup only during on-orbit. Unless an EVA, rendezvous, deploy or retrieve is taking place, ground sites should be considered unavailable for a minimum of 4 hours from an emergency situation.

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29. True or False: S-bd TDRS mode is used during entry to prevent comm loss due to RF blackout ionization to ground sites but loss of comm can still occur under certain conditions.  
{ANSWER: True } Rationale: Descending node entry roll reversals can sometimes point a lower antenna towards a TDRS. Lower antennas are exposed to ionization which prevents U/L or D/L. The comm blackout will last as long as the roll reversal points a lower antenna to the satellite.

**UHF ..... 1-32**

1. The \_\_\_ FDF contains information about ground sites that support UHF.  
a. OPCL  
b. AESP  
c. Malfunction Procedures  
d. OPCL  
{ANSWER: c, the crew member should be familiar with the UHF site locations because UHF is used in case of an orbiter emergency when no other means of communication exists. UHF is also required for orbiter power downs due to power or cooling because the UHF system requires less power and generates less heat in the orbiter.}
2. TAL sites relay UHF comm to MCC through the \_\_\_\_.  
a. STDN site  
b. IMARSAT system  
c. SGLS site  
d. TDRS networks  
{ANSWER: b, IMARSAT is prime for TAL weather/conditions and once the go for launch has been called, the weather channel is released to MCC for emergency UHF comm TAL coverage. This capability exists at up to three TAL sites.}
3. Panel \_\_\_\_ is used to configure routing of audio from the ACCU to the UHF transceiver.  
a. A1L  
b. O6  
c. A1U  
d. A1R  
{ANSWER: d, it is important to know where this panel exists for EVA configuration requirements.}
4. The method of transmitting on one frequency and receiving on two different frequencies is the \_\_\_\_ mode.  
a. G T/R  
b. SIMPLEX  
c. OFF  
d. EVA  
{ANSWER: d, the EVA mode allows EVA crew members to communicate with the IV crew member at the same time. This simulates a duplex mode of operations.}
5. The method of transmitting on one frequency and receiving on the same frequency is the \_\_\_\_ mode.  
a. SIMPLEX + G RCV  
b. SIMPLEX  
c. OFF  
d. EVA  
{ANSWER: b, in the simplex mode the receiver is muted when the transmitter is keyed so it will not lock on the transmit signal and damage the receiver from the high power transmitted signal.}
6. The Squelch switch on panel O6 is normally on. TRUE or FALSE  
{ANSWER: True, the squelch protects against background noise, but you may select off if you think that the uplink signal is broken.}



**Section 2 - Control**

**Ascent/Abort Procedures ..... 2-3**

1. With an SSME failure between the press to ATO and press to MECO performance boundaries, what is the procedural flow through the ACL for orbital insertion? How does the flow change with earlier and later engine failures?  
 {ANSWER: No Comm Mode Boundaries → Ascent Procedures → OMS 1/2 TGTING → OMS 1 Burn (if req'd) → OMS 1 Burn Monitor (if req'd) → Post OMS1 Burn Procedures → OMS 2 Targeting → ATO (if applicable) → OMS Targets → Post OMS1 Burn Procedures → OMS 2 Burn Cards → Post OMS 2 Burn Procedures. The dedicated TAL and RTLS pages are referenced with an earlier engine failure. With a later failure the flow is close to the ATO flow (above) except OMS burn targets are different}
  
2. What is the purpose of the ACL “NO COMM MODE BOUNDARIES/SYS FLIGHT RULES” page, and when is it used?  
 {ANSWER: The “no comm mode boundaries” are referenced when engine failures occur to determine what trajectory performance is available as a function of inertial velocity. The “sys flight rules” are referenced when multiple system failures occur necessitating either an RTLS or TAL abort. This is the first page that starts the flow through the rest of the checklist when failures occur.}
  
3. When is the “ASCENT PROCEDURES” page used?  
 {ANSWER: This page is referenced for normal cockpit actions for any trajectory where a continuation to orbit can be attempted. Once MECO occurs the “OMS 1/2 TGTING” page is referenced for initial OMS target identification as a function of available OMS propellant and MECO inertial velocity. The reminder to check OMS targets is on this page.}
  
4. Assuming direct insertion MECO velocity, when are the “POST OMS 1” procedures used and why?  
 {ANSWER: The “ascent procedures” page provides directions to the post OMS 1 section once an OMS 1 burn has been verified as not required. The “post OMS 1” procedures reconfigure the systems used for ascent for orbit operations and prepares the guidance, navigation, control, and propulsion systems for the OMS-2 burn.}
  
5. If an SSME fails before negative return and after 2 engine TAL, what is the preferred abort mode?  
 {ANSWER: TAL, as called for by the flight rules.}
  
6. Where are the velocities located for single engine TAL and single engine OPS3 once an SSME has failed and a TAL abort has been declared?  
 {ANSWER: The applicable TAL Redesignation Cue Card.}
  
7. Post MECO, what section of the ACL is used to verify the actual OMS target parameters displayed on the OMS maneuver execute display?  
 {ANSWER: Section 7, “OMS TGTS”.}
  
8. According to the “SYS FLIGHT RULES” page, an RTLS or TAL abort must be selected (if possible) if 2 APUs have failed and the last one is failing, why? Which abort is to be selected, TAL or RTLS?  
 {ANSWER: At least one APU/hydraulic system is required for landing; therefore, the abort mode affording the earliest landing time is selected.}

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9. According to the “ASCENT PROCEDURES” page, if TMECO is not stable within 10 seconds of MM103 activation, CSS and manual throttles is required, why?  
{ANSWER: Flight rules stipulate this is an indication that guidance has failed to converge on an accurate solution; thereby, preventing automatic guidance from satisfying the MECO target conditions. When guidance is inaccurate, the vehicle must be flown manually under manual throttles to MECO.}
10. What are the abort priorities for RTLS, TAL, and ATO? Where are these priorities located in the ACL?  
{ANSWER: ATO, then TAL, then RTLS. This ordering of priorities is not located anywhere in the ACL, it is stated in the flight rules. It is important that this priority fault-down be understood in order to properly use the ACL.}
11. What cockpit indications are used to verify any abort selection during powered flight?  
{ANSWER: The ASCENT TRAJ title will change to ATO, TAL, or RTLS TRAJ, depending on the abort selected and an OMS dump will start.}
12. Besides vehicle maneuvering, how are the PPA and PPD phases of RTLS guidance verified in the cockpit?  
{ANSWER: The GUID parameter on the RTLS TRAJ stops counting down and indicates PPA when PPA is to begin and flyback guidance initiated. The cutoff bug at the top of the RTLS TRAJ will indicate PPD when PPD is begun and terminal guidance to MECO is initiated.}
13. What cockpit indications are used to anticipate MECO?  
{ANSWER: The velocity tape approaches the MECO velocity specified on the “ASCENT PROCEDURES” page with the cutoff bug on the ASCENT TRAJ alive and heading to the C/O tic mark.}
14. What cockpit indication show PEG to be unconverged?  
{ANSWER: Stowed ADI needles.}
15. When is a contingency abort required and where are these procedures located?  
{ANSWER: Anytime multiple engines suffer failures where an abort to either a TAL or RTLS site is not possible as indicated in the ‘NO COMM MODE BOUNDARIES’ page. The contingency abort procedures are located on a dedicated cue card available to all ascent flight deck crew members.}
16. Looking at the Contingency Abort Cue Card, are the procedures automatic or manual?  
{ANSWER: Automatic after either MECO confirmed is set (3 out) or after the contingency abort item entries are executed (2 out), as indicated by the check marks on the cue card. The only exception are Bermuda or ECAL aborts where manual techniques are required during entry.}
17. Using cockpit photos/drawings and the DPS dictionary, hypothetically execute the switch throws following the ATO sequence presented in the first question. Repeat the same task for an engine failure RTLS and TAL abort. From a crew task loading standpoint, which procedure is most complex? How does the complexity change for a systems abort? What about AOA?  
{ANSWER: The ATO is most complex because it requires tasks associated with choosing OMS targets with procedures scattered throughout the ACL; whereas, RTLS and TAL have dedicated pages. A basic RTLS or TAL abort is further complicated for systems failures because these types of aborts typically involve multiple failures which must be managed in parallel with the abort itself. AOA is basically an ATO further complicated by the ensuing entry activities.}

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18. Ten seconds after MM103 initialization the OMS assist burn initiates and continues unabated to completion. Assuming a nominal ascent with a guided cutoff:
- What is the easiest way the crew determines how much OMS propellant is available before any OMS burns are performed?
  - How does the crew know if the OMS assist burn consumed the correct amount of propellant?
  - How is the information in a and b above useful to the crew?
- {ANSWER: The easiest, most non-intrusive method for determining post MECO OMS quantity is to use the O3 meters. The bottom of the OMS 1/2 targeting page specifies the post nominal OMS assist propellant quantity; therefore, proper consumption is verified by comparing O3 quantity to the quantity on the OMS 1/2 targeting page. Crew timing of the OMS assist burn is not a correct answer because this is intrusive to powered flight activities and is protecting for a 3 failure scenario (bad gauges, no comm, and bad OMS assist burn software). The knowledge of post MECO OMS propellant is required to properly target the subsequent OMS burn(s). }
19. Barring any failures, what event triggers the command to roll the vehicle heads-up during MM103? Where is this information located in the ACL?
- {ANSWER: The heads-up roll is commanded when the vehicle achieves the I-loaded velocity specified on the Ascent Procedures page of the ACL. }
20. What is auto del psi, is it visible in the cockpit, and what is its purpose?
- {ANSWER: Auto del psi is an algorithm used to adjust first stage yaw steering for ground-up rendezvous missions to account for variations in time of liftoff. Without close scrutiny, it is doubtful auto del psi steering would be noticed in the cockpit because of load relief steering. The purpose of auto del psi is to cause the open loop guidance algorithm of first stage to steer in a more closed loop fashion to maximize performance to orbit. The vehicle must steer toward a specific target plane for ground-up rendezvous missions. Without auto del psi, the open loop nature of first stage guidance will not steer toward the specific plane until second stage when launching at any time other than the in-plane time. }

**Ascent Performance Calls .....2-5**

Case 1

Center main engine fails between 2 ENGINE TAL and NEGATIVE RETURN.

1. What abort do you initiate?  
{Answer:} TAL (Flight Rule A4.1.2-7(C)(4))

Case 2

Left main engine fails at PRESS TO MECO.

1. What abort do you initiate?  
{Answer:} None
  
2. What conditions do you expect at MECO?  
{Answer:} No worse than design underspeed; possibly a nominal MECO. All two-engine calls are based on two sigma low performance on the remaining SSME's. Two sigma low performance will result in the design underspeed. Nominal or better performance may result in a nominal MECO. The difference between nominal and two sigma low is approximately 130 ft/sec.
  
3. What is the impact to the SINGLE ENGINE PRESS performance boundary?  
{Answer:} It will be delayed significantly; usually it will occur at approximately 21,000 ft/sec.

Subsequently, the right main engine fails 200 ft/sec prior to SINGLE ENGINE PRESS.

4. What abort do you initiate?  
{Answer:} TAL

Case 3

Center main engine fails between PRESS TO ATO and PRESS TO MECO.

1. What abort do you initiate?  
{Answer:}. ATO
  
2. What conditions do you expect at MECO?  
{Answer:}. Should be between design underspeed and nominal MECO. The only difference between PRESS TO ATO and PRESS TO MECO is the dump.

**Orbit DAP .....2-6**

1. Explain 3 ways to place the DAP in free drift.  
{ANSWER:} Depress the 'FREE' PBI; Configure the DAP to INRT: PULSE/PULSE/PULSE: or LVLH: PULSE/PULSE/PULSE}
  
2. The 'DISC RATE' and 'PULSE' PBIs below the rotation label will have no effect when the \_\_\_\_\_ control mode is selected.  
{ANSWER:} AUTO}
  
3. The \_\_\_\_\_ PBI refers to a special +Z translation, has no effect on rotations, and is mutually exclusive from 'NORM', 'PULSE', and \_\_\_\_\_ PBIs.
  - a). 'LOW Z', 'HIGH Z'
  - b). 'HIGH Z', 'LOW Z'
  - c). 'LOW Z', 'FREE'
  - d). 'HIGH Z', 'VERN'
 {ANSWER:} (b) 'HIGH Z', 'LOW Z'}

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4. Describe how to configure the DAP PBIs such that the vehicle will hold an LVLH attitude hold in roll and yaw, but is in free drift about the pitch axis.  
{ANSWER: LVLH: DISC/PULSE/DISC}
  
5. Name the three positions of the RHC (while in the RCS mode of the DAP) and describe their function when the appropriate axis is in the 'DISC RATE' and 'PULSE' mode.  
{ANSWER: Detent, Within the soft stop, Beyond the soft stop  
'DISC RATE': Detent is attitude hold, within soft stop is a discrete rate rotation, beyond the soft stop is accel or continuous jet firings, within the soft stop after accel is free drift.  
'PULSE': Detent is free drift, within the soft stop results in a single rotational pulse followed by free drift, beyond the soft stop is accel or continuous jet firings}
  
6. Describe how you would load DAP A2 and B5.  
{ANSWER: ITEM 1 + 2 EXEC and ITEM 2 + 5 EXEC}
  
7. Describe how to change the I-loaded rotation rate in DAP B12 to 0.5 deg/sec.  
{ANSWER: ITEM 4 +12 EXEC, ITEM 50 + 0.5 EXEC, and ITEM 5 EXEC. }
  
8. Describe two ways in which you could perform a pitch maneuver of 2.0 deg/sec while maintaining an inertial attitude hold in both the roll and yaw axes.  
{ANSWER: (a) Select INRTL: DISC/PULSE/DISC and deflect the RHC in pitch and return to detent the number of times necessary to reach 2 deg/sec (ex. if the rotational pulse is 0.2, the RHC must be deflected 10 times)  
b) Select 2.0 rotation rate on SPEC 20, configure the DAP to INRTL: DISC/DISC/DISC, and deflect and hold the RHC within the softstop in the pitch axis while leaving the roll and yaw axes in the detent. }

Note: The following nomenclature was used:

All caps surrounded by single quotation marks refers to a specific DAP PBIs (ex. 'INRTL').

For DAP configurations, the control mode is listed first followed by a colon and the rotation submodes in the sequence of roll, pitch, and yaw separated by slashes (ex. INRTL: PULSE/PULSE/DISC)

**D/O Burns ..... 2-7**

1. What is unique about the PEG 4 C2, Ht, and  $\Theta$ T for a deorbit burn?  
{ANSWER: C2 is the slope of the target velocity line ( $V_H, V_V$ ) at Entry Interface (EI) and must be negative to give a proper entry flight path angle; HT is defined as EI and is therefore always 400,000 ft or 65.832nm;  $\Theta$ T for OPS 3 is defined to be the angle from the orbital point of TIG to EI.}
  
2. How will propellant wasting affect the OMS tank landing weight constraints and orbiter C.G.?  
{ANSWER: Propellant wasting ensures that the OMS tanks are drained below the landing weight constraint of 22% (particularly for an AOA deorbit), it normally takes the tanks down to approximately 5% remaining. The function can also be used to manage the orbiter X C.G., by leaving a designated amount of OMS propellant as ballast. Anything over the nominal 5% will move the C.G. aft, while less than 5% moves it forward.}
  
3. An underburn will
  - A. Increase REI
  - B. Decrease REI
  - C. Not have any effect on REI.{ANSWER: B. REI will decrease for an underburn. If the deorbit TGT HP is not reached (underburn), then the orbiter is in a "higher" elliptical orbit and Entry Interface will be further downrange. Thus the range from Entry Interface to the landing site will be less.}

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4. State the downmode options for a 2 OMS engine deorbit burn in order of preference.  
{ANSWER: Downmode from 2 OMS → 1 OMS → AFT RCS → FWD RCS → Prebank → landing site redesignation (if available)}
5. If the L OMS has a propellant failure exactly at L OMS FAIL HP, then what deorbit downmodes should be expected and what deorbit milestones come in to play?  
{ANSWER: The burn will continue on the R OMS to depletion. Then AFT RCS (THC +X) will be used until AFT QTY 1. The orbiter should now be at FLIP HP, so a fast flip will be executed and the FWD RCS will be burned to depletion (THC -X). The resulting delta between CUR and TGT HP will require prebank at the 3-sigma thermal limit (around 85°-110° & circled on the prebank tables in the Entry C/L) to the backup site (if available, otherwise the primary site).}
6. A deorbit burn (of any type) will be continued for just 1 OMS PRPLT FAIL above SAFE HP.  
TRUE / FALSE  
{ANSWER: False This statement is not always true. For a 2 OMS BURN or Unbalanced, the burn will be continued only as long as it is below the corresponding OMS FAIL HP. For all other burns, the burn will always be stopped for a PRPLT FAIL above SAFE HP to allow time for a more optimum entry trajectory to be targeted with the remaining orbital  $\Delta V$ . Exceptions to this are AOA, Emergency or Contingency deorbits where it is critical to bring the orbiter home.}
7. Why must RCS burns interconnected to OMS propellant be timed?  
{ANSWER: Because OMS gauging only works when OMS engines are burning. In order to avoid starving RCS jets of propellant, the burn must be timed.}
8. In the Patterson maneuver, what holds the vehicle in the correct burn attitude once the THC is pushed/pulled and the RCS jets start thrusting and thus torquing the vehicle about its C.G.?  
{ANSWER: The 3° attitude deadband in the TRANS DAP will hold the vehicle in place.}
9. The fast flip to FRCS is executed at a pitch up rate of
  - A. 1°/sec.
  - B. 3°/sec.
  - C. 5°/sec.{ANSWER: B. 3°/sec up. Until VGOX is negative and VGOZ = +1/4  $\Delta V_{TOT}$ .}
10. Why is prebank performed (if required) at EI-5 min/MM304 instead of during MM303?  
{ANSWER: At EI-5 min, the orbiter is taken to MM304 (i.e., entry flight control). At that time the vehicle is maneuvered about the stability axis (velocity vector) rather than the body axis. Prebank MUST be done about the velocity vector in order to avoid exceeding the 3-sigma thermal limit on the vehicle.}
11. If GPC 1 fails prior to OMS ignition and One-orbit late is available, will the deorbit burn be executed on time?  
{ANSWER: No, the deorbit burn will be delayed up to one orbit in order to allow for a restrig. This is per the DEORBIT BURN FLIGHT RULES for loss of one GPC.}
12. If an IMU dilemma occurs during a deorbit burn at an HP of 120 nm, how should the deorbit burn proceed and why?  
{ANSWER: Per the D/O BURN MONITOR, the burn will be stopped for an IMU dilemma above SAFE HP (nominally 85 nm). Safe HP guarantees a 24 hour orbit in order to put the IMUs in their most optimum configuration for entry navigation. A correct navigation state vector is essential to put the vehicle on the proper entry flight path at Entry Interface. Once the burn is terminated with HP > SAFE HP, the backout procedures on page 3-31 of the entry checklist will be worked to wait out the deorbit delay.}

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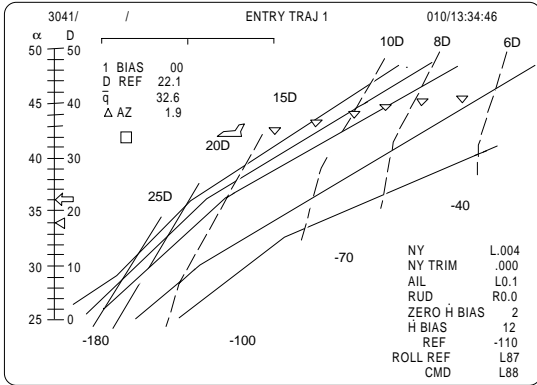
13. If the R OMS N2 accumulator develops a leak during the deorbit burn resulting in an OMS N2 REG P LOW and OMS N2 TK P LOW and decreasing, what would the D/O BURN MONITOR have one do and why?  
{ANSWER: There are no specific procedures for OMS N2 problems located on the D/O BURN MONITOR card. If the leak rate is large enough, the result of losing OMS N2 will be ball valve closure on the affected engine and thus an OMS ENG FAIL which falls under the OMS Pc LOW category of the monitor card. All other burns protect loss of N2 in order to save enough for a last firing of the engine on the deorbit burn. Since this IS the deorbit burn, no action is required.}
14. What are the 5 recognized deorbit scenarios?  
{ANSWER: 2 OMS, 1 OMS, RCS, UNBALANCED PRPLT, and MIXED XFEED deorbit burns}
15. If a L OMS FU TK leak developed on orbit and depleted that tank, what method of deorbit would be used and what unique set of FDF procedures would apply?  
{ANSWER: A MIXED XFEED deorbit would be needed in order to balance the OX propellant in each of the OMS pods and keep the orbiter Y C.G. in the envelope. The MIXED XFEED deorbit burn would apply and OMS SSR-1 in the malfunction procedures would be used to send GPC commands to open the FU valves in the R pod and the OX valves in the L pod. In this case, loss of the L OMS FU TK would require use of Table 6 in OMS SSR-1.}

**Entry Procedures ..... 2-9**

1. Explain how downrange and crossrange parameters are controlled during the Entry and TAEM phases of flight. List the constraints of the guidance modes (e.g., thermal constraints are met by following an alpha profile.)  
{ANSWER: During entry (MM304), downrange energy is controlled with drag. Drag is controlled by altitude through bank angle, not pitch. Increasing bank increases descent rate, getting you into more dense air, increasing drag. Angle of attack is fixed in a  $\pm 3^\circ$  corridor due to thermal constraints. Increasing or decreasing alpha within that corridor provides small drag changes. Bank angle also provides turning for crossrange capability. Roll reversals are designed to keep the landing site within crossrange capability. In TAEM (MM305), pitch controls glideslope (reference altitude) and roll maintains groundtrack. Pitch is referenced to g's (Nz) and limited by airspeed (dynamic pressure.) Roll is limited by bank angle and g's.}
2. Define the transitions between the entry phases of the flight: Entry, TAEM, and Approach and Land. Describe the cockpit cues to confirm the transitions.  
{ANSWER: The Entry phase begins with the Deorbit Burn. This targets the Entry Interface (EI) point at 400,000 feet altitude and about 4200 NM from the landing site. MM304 is enabled by the crew at EI-5 minutes. Entry Traj 1 will be the GNC display called up. Closed loop guidance begins at a drag of 3 fps<sup>2</sup> (about 265,000') and the "guidance box" ( ) and drag arrow ( $\Leftarrow$ ) will appear on Entry Traj 1. In OPS 3, TAEM (MM305) begins at Mach 2.5 when Vert Sit 1 replaces Entry Traj 5. In OPS 6, GRTLs, TAEM begins at Mach 3.2. Approach and Land guidance begins at 10,000' if constraints are met or is forced at 5000'. A flashing "A/L" will appear on PASS Vert Sit 2. Note: There is no A/L guidance in BFS.}
3. What are the orbiter entry alpha limits and where can you find them in the cockpit?  
{ANSWER: The only FDF stating alpha limits is the Entry Alpha cue card. It lists the limits as  $\pm 3^\circ$  from reference between Mach 23 and 5. For  $M < 5$  the limits on the cue card are less. The crew must remember that at Mach 2 to Mach 1 the limit is  $15^\circ$  max to protect against pitch up divergence LOC. Subsonic limits are 0-20°, but are not in the FDF. See flight Rule A4.1.5-7}

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4. What are the maximum/minimum airspeed limits and are they posted on the flight deck?  
 {ANSWER: Airspeed limits are not listed in FDF. For nominal entry profiles, max airspeed is 321 KEAS for Mach < 1. With air data incorporated, the EAS tape will not show greater than 333 regardless of actual airspeed. Minimum airspeed is a factor of max alpha, to protect against pitch up divergence.}
  
5. For nominal entry, what is the maximum Flight Rule g limit on the orbiter? What cockpit cues indicate that you are approaching the g limit?  
 {ANSWER: 2.5 g for orbiter weights < 211,000 lbs. Ramps down to 2.12 for weights 211k - 250k lbs. Caution and Warning will annunciate the "HIGH G" message with an SM Alert at 2.01g.}
  
6. Given that auto guidance is good, how would you fly the following situation:



- a. Do nothing, guidance is good, Auto can fly it.
- b. Take CSS, work  
 $Hdot = Hdot_{ref} + 20(D_{current} - D_{ref})$  where  $D_{ref} = 13$
- c. Fly reference Hdot (CSS)

{ANSWER: b. Your max allowable drag right now is 13. Auto is commanding a drag of 22, violating thermal limits. Fly less Hdot than Hdot<sub>ref</sub>, decreasing drag to 13 fps<sup>2</sup>. It will take longer to get to nominal energy, but you will not burn up.}

7. What are your downmode options in TAEM for low energy situations?  
 {ANSWER: Close the Speedbrake, fly max L/D alpha, select MEP, select Straight-In, change runways, shrink the HAC (flying low on the HAC will get this automatically)}
  
8. What procedure and cockpit cues are used to fly Theta Limits?  
 {ANSWER: Take CSS below Mach 2 and fly the ADI error needles (follow guidance) as long as guidance does not take you outside of the Nose Hi/Low theta (θ) limits on the Vert Sit displays. If guidance would have you fly outside of Nose Hi/Low, use the Vert Sit nominal traj line, the shuttle bug, and your Nav glideslope indicators to maintain a nominal TAEM profile while keeping within theta limits.}
  
9. When should the No Yaw Jet entry mode be selected?  
 {ANSWER:
  - Any time during entry that total aft RCS propellant quantity (L+R) = 0 and jets fail OFF.
  - If qbar ≥ 20 and MACH > 6 and total aft RCS propellant quantity < 10%.}



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10. What cockpit cues indicate aileron trim and at what value does the crew take action?  
{ANSWER: “AIL L(R)X.X” in the lower right corner of Entry Traj and Vert Sit displays aileron trim. You can also read Aileron deflection (trim) on the SPI during steady-state flight. The AIL TRIM > 3° procedure is worked at a value of 3.0°.  
Note: There is no caution and warning annunciation of Aileron Trim.}
11. Why does the AIL TRIM > 3° procedure have you wait until Mach < 5 to manually trim the ailerons < 1°?  
{ANSWER: The rudder activates at Mach 5. If you manually trim the ailerons prior to rudder activation the yaw jets will fire to pick up the trim load. The ailerons will then retrim, through the trim integrator, in response to the jet firings. This will result in the ailerons trimming out to their original value and the wasting of RCS propellant.}

**FCS ..... 2-11**

- Describe the function of the OFF, AUTO, and OVERRIDE positions of the FCS switches.  
 {ANSWER: The OVERRIDE position prevents ports from bypassing due to high secondary ΔP. The AUTO position (nominal operation on ascent and entry) supplies power for commands, ASA feedback and the isolation valve. The OFF position removes power supply to the ATVC/ASA black boxes. It leaves power to the isolation valve intact to ensure all the ports on that channel bypass. ASA feedback into the GPC goes to null value (zero volts).}
- Given the following signature, what is the failure? Should any actions be taken, and what feedbacks is RM processing?

```

XXX1/053/          CONTROLS          X DDD/HH:MM:SS
                                DDD/HH:MM:SS

SEC ACT CK      AERO PORT STAT      SSME PORT STAT
                1 2 3 4              1 2 3 4
  CH1 1         L OB 1                 L P
    2 2         IB 2                   Y
    3 3         R OB 3                   C P
    4 4         IB 4                   Y
START 5         RUD 5                   R P
STOP 6         SPD BRK 6                 Y

NEG STIM      ACT/CH
ENA 7         8 BYPASS
              9 RESET

LRU  AA      RGA  SURF FDBK
     DES      DES  DES
  1  10      14   18
  2  11      15   19 ↓
  3  12      16   20
  4  13      17   21
    
```

PASS CRT Fault Message:  
 "FCS Ch 2"  
 Master Alarm  
 F7 "FCS" Light

{ANSWER: RIB channel 2 bypassed due to a feedback bias (as opposed to a command bias). This is the first failure, therefore, no action is required. FDIR has kicked out channel 2 feedback, substituted channel 4 feedback into the RM scheme, and then quit for the RIB aerosurface. The RIB selection filter is now mid-value selecting channels 1, 3 and 4. FDIR is still running on all other aerosurfaces and their selection filters are mid-value selecting channels 1, 2, and 3 (4 in standby)}

- Using the above display, mentally place a column of M's under the SSME port STAT 4, the AERO Port Stat 4, and an M by the Surf Fdbk Des (#21) and RGA DES (#17). Given this signature in addition to the above failure, describe the failure, actions required and rationale behind the actions.  
 {ANSWER: This signature would indicate FA4 has failed in addition to the RIB channel 2 feedback bias. The RIB selection filter downmodes for commfaults so it will average channels 1 and 3. Though FDIR on all other aerosurfaces was holding channel 4 feedback in standby, this is counted as the first failure and FDIR has now quit on ALL aerosurface feedbacks. The crew would take channel 4 to OFF and take channels 1 and 3 to override since any further channel failures could induce a one-on-one force fight on RIB. A one-on-one force fight may cause a loss of control if the good port bypasses. By taking a channel to override the good port cannot bypass due to a force fight.}

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4. What are the major differences between the Body Flap and the other aerosurfaces?  
{ANSWER:  
1. There are no switching valves so an APU takes out that channel (i.e., APU 1 failed takes Body Flap Channel 1).  
2. The Body Flap has no ports to bypass.  
3. The RM Scheme uses all 4 feedbacks in a QMVS selection filter, whereas the other aerosurfaces use the first 3 position feedback biases with channel 4 as a substitute.}
5. What Body Flap fault message do you expect if 2 APU's fail?  
{ANSWER: "BODY FLAP FAIL" message meaning that the body flap is not moving commanded rate. PRL may temporarily cut off hydraulic flow to the body flap in order to provide hydraulics to the aerosurfaces since they are more important for control.}
6. What is the result of "ITEM 8 + 12 EXEC" on SPEC 53 and when would the crew do this?  
{ANSWER: The crew would have manually bypassed LOB Channel 2. This would only be done on MCC call because there are no FDF procedures to manually bypass a port.}
7. What is the result of "ITEM 18 EXEC" on SPEC 53?  
{ANSWER: This would manually deselect channel 1 feedbacks for all aerosurfaces. FDIR would quit on all aerosurfaces substituting feedback channel 4 into the RM scheme (except for body flap which was already using position feedback bias for channel 4 in a QMVS)}
8. Why does the crew take the affected FCS channel to OFF for a GPC or MDM failure?  
{ANSWER: To ensure ports have bypassed behind the commfaulted status.}
9. If a down arrow appears by ITEM 19 on SPEC 53 with no other signatures, what is the failure?  
{ANSWER: The position feedback into RM is bad and FDIR has deselected the feedback (the crew would not know which aerosurface). The feedback must be good into the ASA because none of the ports bypassed on any of the aerosurfaces on that channel. The ground can tell the crew which aerosurface the position feedback is bad on.}
10. What is the "hole" in the FCS dual fault tolerant scheme?  
{ANSWER: In FCS, dual fault tolerance assumes that one channel is bypassed before another failure occurs (i.e., FCS cannot sustain 2 simultaneous failures). For example: If FCS channels 1 and 2 obtain simultaneous command biases on the same actuator then a 2 on 2 force fight would result. The two biased channels (1&2) may bypass the two good channels.}



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6. If the PAPI's are indicating 2 red and 2 white, what is your glideslope.  
A. 18°  
B. 20°  
C. 16°  
{ANSWER: B. 3 red and 1 white would indicate an 18° glideslope }
7. TRUE or FALSE The preflare transitions the orbiter from the outer glideslope to the inner glideslope by arresting the descent rate from 200 fps to 12 fps and is completed by 2000'.  
{ANSWER: F. Preflare occurs at 2000' and is completed by 500'. The rest of the statement is true. A smooth pull-up by the CDR during the preflare is required. }
8. TRUE or FALSE When on the Inner Glideslope the white ball will appear to superimpose the red Bar.  
{ANSWER: T. If above the Inner Glideslope the white ball will appear below the red bar and vice versa for below the inner glideslope. }

**MPS .....2-15**

1. How do you take manual throttles?  
a. Push the SBTC CSS button on the eyebrow panel.  
b. Depress the button on the SBTC and release it when the SBTC command is within 4% of the GPC commanded throttle setting.  
c. Depress the button on the SBTC.  
{ANSWER: B. To return to AUTO throttles the crew would push the SBTC AUTO button on the eyebrow panel. }
2. During which procedures are "MAN throttles at 2% propellant" not routinely required for a single SSME completion?  
{ANSWER: Contingency Abort procedures }
3. If the left SSME fails after the single engine press call, and the crew subsequently has to engage the BFS, what MPS related actions should be taken?  
{ANSWER: Main engine Limits to Inhibit }
4. You see the following signature on BFS GNC SYS SUMM 1 for the center main engine:  
ULL P LH2      12.0↓  
          LO2      0.0  
What EPS bus has possibly failed and what impact would this bus have on isolating SSME helium leaks?  
{ANSWER: It is a signature of an ALC1 failure. Center SSME helium leaks should not be isolated. }
5. What impact will FF failures have on signatures for stuck throttles, data path failures, and SSME failures?  
{ANSWER: The loss of an FF fails the associated main engine Pc meter and status light (FF's 1,2, and 3 affect C, L and R respectively). The Pc meter and/or Main engine status light are no longer valid indications for stuck throttles, data path failures, or SSME failures. }

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6. The center SSME goes into electric lockup at 3:00 minutes and performance is low.  
What should the crew do and when?  
{ANSWER: Shut down the center engine pushbutton only at Vi=23K.}

In addition to the above scenario, the left SSME develops a command path failure at 7:15 MET.  
What should the crew do now? and when?  
What action is required for the center engine?  
{ANSWER: Shutdown the left SSME ac/pb at Vi=23K. No action required on the Left main engine.}

**OMS/RCS ..... 2-18**

1. FLC1 fails at EI-20. How does this affect your RCS jets?  
{ANSWER: FRCS manifold 1 jets are lost due to a loss of driver power.}
2. Assume FLC1 has failed and the FRCS quantity loading is OX = 32%, and Fu = 30%.  
How will FLC1 affect the FRCS Dump and how long will the FRCS dump be?  
{ANSWER: The dump will be a two jet dump for 1 minute and 46 seconds. Because RCS quantity gauging is based on a PVT calculation, the quantities are not accurate during a dump. Therefore, **Dump should be stopped using time as a cue not quantity.** The quantity could actually show a negative number during a dump prompting the crew to stop the dump at the quantity cue , however this would result in some prop being left in the tank. }
3. What is the difference between an "ITEM 45 EXEC" and a DES INH twice on Spec 23?  
{ANSWER: Item 45 will reset RM for all jets that are not deselected. A DES INH twice will reset RM for that individual jet only **AND place it last priority.**}
4. How do you secure for an OMS leak when you are interconnected OMS to RCS?  
{ANSWER: Per the Orbit Pocket Checklist "OMS TK P (Fu or Ox) LOW" procedure steps 10 and 11:  
Close the RCS MANF ISOLs  
Close the RCS XFEEDs  
Close the affected OMS XFEEDs  
Close the affected OMS TK ISOLs  
Close the affected OMS He PRESS/VAP ISOL valves.}
5. A Left OMS engine N2 leak develops on Ascent. By taking the OMS Engine Switch to ARM, you determine the leak is in the N2 Tank and not the accumulator. How will this affect your OMS 2 burn?  
{ANSWER: The engine will be used for the burn if it is determined that at the end of the burn there would still be enough Nitrogen in the tank to fully pressurize the accumulator for the de-orbit burn (check with MCC.) For a large Nitrogen Tank leak that depletes the tank to less than 470 psi prior to the OMS 2 burn, there would not be sufficient Nitrogen in the tank to replenish the engine at the end of the OMS 2 burn. In that case the engine would not be used and the accumulator pressure would be preserved for the de-orbit burn. Flight Rule A6.1.2-17K}

**OMS Burn Malfunctions ..... 2-20**

1. During the OMS-2 burn, a “R OMS Pc” message annunciates, a down arrow appears for the R OMS engine and one of the bipropellant valves on the right engine is less than 70% open. Is this an Engine Failure or a Propellant Failure.  
{ANSWER: Engine Failure. }
  
2. Which of the following cues would a crew member expect to see for a fuel blockage upstream of the Fu Inlet Pressure transducer on an OMS engine. (more than one)
  - A. Inlet pressure increase
  - B. Lowers fuel injector temperature
  - C. Bipropellant valve is less than 70%
  - D. Inlet pressure decrease
  - E. OMS Fuel Injector temperature >260°F{ANSWER: D, E. This failure is considered a Propellant Failure.}
  
4. What are the two C&W messages for OMS Oxidizer and Fuel blockages?  
{ANSWER: A “L(R) OMS Pc” message (PASS) will annunciate for an Ox blockage. A “L(R) OMS Temp” message (BFS) will annunciate for a Fuel blockage.}
  
5. During an OMS 2 burn the crew notices high RCS usage (10% Total propellant in 30 seconds) and a second “R OMS GMBL” message. What is the problem and how should the crew respond?  
{ANSWER: The crew should determine that the R OMS engine has BOTH primary and secondary gimbal failures which is causing the excessive RCS usage. The R OMS engine should be considered an ENGINE FAILURE. The crew should take the R OMS to OFF and crossfeed at 1/2 ΔVTOT.}
  
6. If all of the Helium leaked out of the L OMS He TK, could this lead to an ENGINE FAIL or a PROP FAIL.  
{ANSWER: Propellant Fail if the OMS propellant quantity is large (ullage is small). }
  
7. Suppose FA1 and Control Bus AB1 are both failed prior to OMS ignition. What is the impact to the OMS engines?  
{ANSWER: The Left OMS engine is failed. FA1 takes Ball valve 1 from coil 2 and the Control Bus AB1 takes Ball valve 1 and 2 from Coil 1, therefore, no ignition path to the L OME}
  
8. MDM’s FA 1 and 2 fail during an OMS burn. What is the crew response to these failures?  
{ANSWER: The crew is expected to perform a manual shutdown of both OMS engines. FA 1 and 2 failures (assuming they are commfaults and not power fails) during a burn latch the GPC fire commands to both engines.}

**OMS 1/2 Targeting ..... 2-22**

1. If we want to increase our current HP to HA what type of targets do we choose?
  - (a) PEG 4
  - (b) PEG 7{ANSWER: b. Peg 7 Targets (also known as external  $\Delta V$  targets) are used to add or subtract an orbital velocity and do not target a specific point in space. }
  
2. What is the  $\Delta V$  required to change orbital altitude 1 nautical mile?
  - (a) 3.2.
  - (b) 1.8
  - (c) 1.2.{ANSWER: b. 1 nautical mile equals 1.8 fps in  $\Delta V$ . }
  
3. Given the attached OMS 1/2 targeting card state the following:
  - (a) OMS quantity after a full dump
  - (b) Greatest MECO velocity where an OMS 1 is still required
  - (c) Target set for an AOA / S
  - (d) OMS 1 TIG for an ATO/ ATO
  - (e) Nominal expected MECO velocity{ANSWER: See attached card }
  
4. OMS 2 Targeting Card  
True or False: The OMS 2 targeting card is used for all AOA, ATO and OMS 2 burns.  
{ANSWER: False, it is only for direct insertion. }
  
5. ATO Card:  
The ATO table is used to determine Orbit and deorbit abilities based on Post OMS 1 \_\_\_\_\_  
and \_\_\_\_\_.  
{ANSWER: Hp and OMS quantity. }



6.

Directions

Using the STS-63 FDF (attached), and the post MECO scenario conditions, perform OMS1/2 Targeting and answer the listed questions.

**Post MECO Scenario**

**Flight:** STS-63

**TMECO:** 9:50

**MECO Vi:** 25530

**AOA site:** KSC

**OMS QTY @**

**MECO:** 76%

**Ascent aborts/  
failures:** CSSME  
out at Vi=13,000  
and early MECO

1041/ /	ATO-2 MNVR EXEC	2 000/00:10:19 000/00:01:21
OMS BOTH 1*	BURN ATT	ΔVTOT 331.1
L 2	24 R 045	TGO 3:21
R 3	25 P 018	VGO X + 267.84
RCS SEL 4	26 Y 345	Y + 54.96
5 TV ROLL 180	MNVR 27	Z -187.13
TRIM LOAD	REI	HA HP
6 P +0.4	TTA 7:41	TGT 106 + 64
7 LY -5.7	GMBL	CUR 67 - 54
8 RY +5.7	L R	
9 WT 238033	P +0.4 +0.4	35 ABORT TGT 1
10 TIG	Y -5.7 +5.7	
0/00:11:31.1	PRI 28* 29*	FWD RCS
TGT PEG 4	SEC 30 31	ARM 36
14 C1 0	OFF 32 33	DUMP 37
15 C2 [ ] 0.00000	GMBL CK 34	OFF 38*
16 HT 104.000		SURF DRIVE
17 ΘT 220.000		ON 39
18 PRPLT [ ] 0		OFF 40*
TGT PEG 7		
19 ΔVX [+] 269.0		
20 ΔVY [+] 0.0		
21 ΔVZ [+ ] 193.1		
LOAD 22/TIMER 23		

**Questions**

- Is OMS -1 Required?  
{ANSWER} Yes. HA<95 and HA + HP = 13, therefore from the OMS 1/2 Targeting Card it can be seen that an OMS 1 burn is required.
- Approximately how much time until the first burn?  
{ANSWER} 5:41. From the top of the OMS 1/2 Targeting Card, we can see that the burn will be at TTA = 2:00. Current TTA = 7:41.
- What type of OMS-1 and/or OMS-2 targets should be performed according to the OMS 1/2 Targeting Card?  
{ANSWER} Again, from the OMS 1/2 Targeting Card, the burn will be ATO/ATO target set 1.
- Per the 104 MNVR EXEC, the targets have been automatically loaded by the GPC's, are the targets good?  
{ANSWER} NO. From the STS-63 Flight Cycle page OMS Targets - W/OMS 1, we see that Ht and θt are correctly loaded and the ΔV is within the 110 - 805 fps range. However, the TIG is incorrect. The correct TIG should be 10:19 + 5:41 = 16:00. The TIG can be loaded with an Item 12 + 16 + 0 EXEC and then an Item 22 EXEC, Item 23. EXEC.

APPENDIX E: Master List of Study Guide Questions and Answers

7.

**Directions** Continue the exercise from the previous page using the STS-63 checklist attached.

**POST OMS 1 Scenario.** OMS 1 burn complete.

OMS quantity = 50%, per side

1051/ /	ATO-2 MNVR EXEC	2 000/00:10:27 000/00:00:00
OMS BOTH 1*		
L 2	BURN ATT	
R 3	24 R	ΔVTOT
RCS SEL 4	25 P	TGO
5 TV ROLL 180	26 Y	VGO X
TRIM LOAD	MNVR 27	Y
6 P +0.8		Z
7 LY -5.8	REI	
8 RY +5.7	TTA 39:06	
9 WT 231237	GMBL	HA  HP
10 TIG	L    R	TGT
0/00:55:49.1	P +1.1 +0.7	CUR 108  67
TGT PEG 4	Y -5.6 +5.6	
14 C1 0		
15 C2 [10.00000	PRI 28* 29*	35 ABORT TGT 1
16 HT 104.000	SEC 30 31	
17 ΘT 400.000	OFF 32 33	FWD RCS
18 PRPLT [ ] 0		ARM 36
TGT PEG 7	GMBL CK 34	DUMP 37
19 ΔVX [ ] _____		OFF 38*
20 ΔVY [ ] _____		SURF DRIVE
21 ΔVZ [ ] _____		ON 39
LOAD 22/TIMER 23		OFF 40*

**Questions**

5. Per the OMS 1/2 Targeting Checklist, what was determined as the best OMS-2 targets? According to the scenario above, is an OMS -2 downmode required?

{ANSWER} The target set is ATO/ATO. No downmode will be required for the OMS 2 burn. This can be seen by checking the ATO card after the ATO OMS 1 burn. With an Hp of 67, approximately 57% OMS propellant is required for an ATO OMS 2 burn and a Steep deorbit burn. Given that we have 50% propellant per side, our total propellant is 100% which is more than sufficient.

6. What target set is to be used?

{ANSWER} ATO target set 1 is used for the OMS 2 burn

7. What MM is the OMS-2 burn to be performed in?

{ANSWER} The burn will be performed in MM105.

8. Given the MNVR Exec with the input and loaded targets, is the solution valid?

{ANSWER} The ΔVTOT of 73.9 is within the range given on the OMS Targets Card. The TIG, however, should be changed to 56:18 per the OMS Targets Card. The targets must then be reloaded with an Item 22 EXEC and Item 23 EXEC.

9. Do we have enough propellant to perform the burn and still have some to get home on?

{ANSWER} Yes. We have sufficient propellant for an ATO OMS 2 burn and a steep deorbit burn.

1051/ /	ATO-2 MNVR EXEC	2 000/00:10:27 000/00:00:00
OMS BOTH 1*		
L 2	BURN ATT	
R 3	24 R 329	ΔVTOT 73.9
RCS SEL 4	25 P 184	TGO :44
5 TV ROLL 180	26 Y 028	VGO X 72.51
TRIM LOAD	MNVR 27	Y 2.47
6 P +0.8		Z 17.47
7 LY -5.8	REI	
8 RY +5.7	TTA 39:06	
9 WT 231237	GMBL	HA  HP
10 TIG	L    R	TGT 109 106
0/00:55:49.1	P +1.1 +0.7	CUR 108  67
TGT PEG 4	Y -5.6 +5.6	
14 C1 0		
15 C2 [10.00000	PRI 28* 29*	35 ABORT TGT 1
16 HT 104.000	SEC 30 31	
17 ΘT 400.000	OFF 32 33	FWD RCS
18 PRPLT [ ] 0		ARM 36
TGT PEG 7	GMBL CK 34	DUMP 37
19 ΔVX [ ] 79.2		OFF 38*
20 ΔVY [ ] 0.0		SURF DRIVE
21 ΔVZ [ ] 20.0		ON 39
LOAD 22/TIMER 23		OFF 40*

**Sensors & Controllers.....2-29**

1. What displays can be used to identify RGA and AA information during Ascent and Entry?  
 {ANSWER: PASS SYS SUMM 1, SPEC 53, BFS SPEC 51. The only display that shows controller information is PASS SYS SUMM 1.}
  
2. Suppose in OPS 1 AA1 develops a bias above the RM limit in the normal axis.
  1. What would the signature of the failure be?
  2. What is the Selection Scheme being used before and after this failure?
  3. What is PASS fault tolerance after the failure?
  4. Is AA1 still usable since the failure was only in the normal axis?
  5. What is BFS fault tolerance before any actions are taken by the crew?  
 {ANSWER: 1. SM alert, Message “RM FAIL ACC”, ↓ on SYS SUMM 1, and a ↓ on SPEC 53.  
 2. Selection Filter is now MVSing AA’s 2,3, and 4. Before the failure it was IMVSing all 4 AA’s.  
 3. FDIR has quit, Selection Filter is MVSing and is single fault tolerant (Fail Safe)  
 4. No. FDIR has kicked out the entire AA so both the lateral and normal axis are downmoded to MVSing.  
 5. After the failure, but before any actions are taken by the crew the BFS is IMVSing 3 good values and 1 bad value. Therefore, it is Fail Critical, meaning another failure could feed bad data to the BFS, if engaged. Remember there is no FDIR in the BFS so the crew would be expected to manually deselect AA1 in the BFS per the procedure.}
  
3. Match the following terms to the correct definitions:
 

a. Single Fault Tolerant	a. Can sustain two failures and still fly the vehicle
b. Zero Fault Tolerant	b. Can sustain one failure and still fly the vehicle
c. Dual Fault Tolerant	c. Can sustain no failures

{ANSWER: a=b  
b=c  
c=a

Please read all of Flight Rule A8.1.1-4 }
  
4. Suppose RGA 1 develops a bias and the crew deselects RGA 1 in the BFS. Then RGA 2 loses power. Predict what happens.  
 {ANSWER: Since it is a power failure SMRD FDIR will annunciate the failure and deselect RGA 2. RGA SMRD will downmode an RGA when it power fails even if RGA FDIR has quit. RGA RM is exactly the same as AA RM except there exists an additional FDIR called SMRD FDIR. In this situation the RGA RM scheme would automatically downmode to AVGing RGA’s 3 & 4.}
  
5. What do the Flight Rules have the crew do for 2 AA failures?  
 {ANSWER:  
 Take Pitch CSS @ Nz Hold Phase (OPS 6),  
 Take Pitch CSS @ TAEM (OPS 3 or OPS 6),  
 Take NWS to OFF}
  
6. What Controllers are available on the Orbiter?  
 {ANSWER: RHC’s, THC’s, SBTC’s and RPTA’s.}

APPENDIX E: Master List of Study Guide Questions and Answers

7. Which of the following are sensors used by Flight Control:
- a. SRB Rate Gyro Assembly
  - b. IMU's
  - c. Accelerometer Assembly
  - d. ADTA's
  - e. Rate Gyro Assembly
  - f. All of the above
- {ANSWER: f. Reference "Air Data System" and "IMUs" Study Guide for more information on IMU's and ADTA's.}
8. Suppose the L RHC develops a command bias greater than the RM limit on channel 1...
1. What would the signature of the failure be?
  2. What is the L RHC fault tolerance after the failure?
  3. Is there an FDF procedure for this failure?
  4. What happens if subsequent to this failure FF2 fails?
- {ANSWER:
1. SM alert (1st fail only), "L RHC" message, and a ↓ on SYS SUMM 1.
  2. Unlike the AA's and RGA's you are fail safe at the two level. The worst failure at this point will put the left RHC in dilemma, BUT you have another RHC.
  3. No. The crew takes no action unless there is a 2nd RHC channel failure, since we are still fail safe.
  4. Now the selection filter will pass through channel 3 data. The L RHC will still operate on the last good channel, but will be fail critical - a bad output could cause a loss of control. It would be recommended that the L Flight Controller Power be taken to OFF to put the system back in a Fail Safe mode.}

**Section 3 - DPS/NAV**

**DPS**

**BFS Engage..... 3-3**

1. During ascent and entry, does the BFS perform any SM function while in STBY?  
 { ANSWER: } Yes. The BFS SM software runs continually whenever the BFS is in the RUN or STBY mode; however, the BFS does not have control of the PL buses when it is in STBY.
  
2. What OPS must the PASS be processing for BFS to track it?  
 { ANSWER: } OPS 1, 3, or 6.
  
3. How does the BFS receive critical GNC data pre-engaged in order to maintain a good state vector and all other information needed in case an engage is required?  
 { ANSWER: } The BFS listens over the flight critical data buses to listen commands from PASS and to data coming back from the MDMs. The BFS must be synchronized with the PASS GPCs so that it will know when to receive GNC data over these buses.
  
4. Why must the BFS be engaged if the roll maneuver is not initiated as scheduled?  
 { ANSWER: } The crew cannot fly manually without over stressing the vehicle during first stage load relief, therefore, the BFS must be engaged.
  
5. On orbit, the BFS was moved to GPC 2 due to a failure in GPC 5. What control bus failure will make the BFS NO-GO for an engage?  
 { ANSWER: } Control AB3 will cause the loss of engage discrettes in GPC's 1, 2, and 4. Without these engage discrettes, the BFS is considered failed, thus, NO-GO for engage.
  
6. Why does an I/O TERM A fail high on the BFS make it suspect?  
 { ANSWER: } The I/O TERM A and the I/O TERM B share a common internal receiver. An I/O TERM A failure could be a single discrete failure or could be a failure of the common internal receiver. Pre-engaged, there is no way to tell if the I/O TERM B discrete has failed high since it is already in this state. The BFS could not take control of the flight critical data buses in an engage case if this discrete was failed. Therefore, in this case, the BFS is suspect.
  
7. Why is PASS IMU reference recovery required during the PASS recovery procedure?  
 { ANSWER: } All of the PASS GPCs will be IPL'd during this procedure and will therefore be loaded with a default knowledge of the IMUs attitude. The IMU reference recovery is required to give the PASS GPCs knowledge of the IMU's attitude.
  
8. Why does the AESP POST BFS ENGAGE entry procedure have you check if any PASS GPCs are running?  
 { ANSWER: } Certain systems failures, such as Control Bus AB3, inhibit a GPCs ability to recognize an engage. If this is the case, both the PASS and the BFS will think they are in control of the flight critical data buses. The PASS GPCs that did not see the engage should be taken to HALT ASAP (to stop dual commanders on the FC data busses).
  
9. When the BFS is STANDALONE, the BFC lights on panel F2 and F4 blink until the MSG RESET is depressed. For an engage, these lights are on. Do the lights extinguish when the MSG RESET is depressed?  
 { ANSWER: } No. The lights will stay on until the BFS is disengaged.

**BFS Failures ..... 3-5**

1. What type of software will the BFS be running after a HALT transient?  
{ANSWER: } The BFS will be running OPS 0 software after this type of transient and will have to be moded to GNC OPS 3 by the crew.
2. Why does the APCL BFS GPC FAIL procedure have you PRO the BFS to OPS 302 if recovered, even if PASS is in OPS 105?  
{ANSWER: } After the BFS is recovered from a transient failure, it will be PRO'd to OPS 3 to support any OMS burns. The BFS is not certified to be recovered back into OPS 1 because some of the "flags" that nominally get set will not be set if you manually PRO the BFS through OPS 1. The BFS in OPS 3 is able to track the PASS while it is in OPS 1.
3. In the BFS GPC FAIL procedure in the APCL, EPCL (post burn) and the AESP entry, how do you know if the BFS has recovered SM only?  
{ANSWER: } If the BFS is able to drive a CRT, it is considered recovered. If you attempt to PRO the BFS to OPS 301 and the display shows up then goes away and is replaced with the BFS OPS 0 base page, the BFS is SM only. The BFS must be able to track at least two FC strings to be able to PRO it to OPS 301.
4. For any type of recoverable BFS failure, how do the flight rules treat this transient GPC?  
{ANSWER: } The BFS will be suspect for engage.
5. How long is the BFS an option for an engage after going standalone on ascent and why? On entry and why?  
{ANSWER: } As a rule of thumb, the BFS is only an option for 10 seconds on ascent and 45 seconds on entry after it has gone standalone. The BFS is not getting any data over the FCs, so it goes on internal time and propagates its own state vector from its last known position and velocity. It does not take long for the BFS state vector to become unusable.
6. Does the BFS announce I/O ERROR PL 1(2) if it fails to STBY? Which GPC has control of the payload data buses following this failure?  
{ANSWER: } The BFS will not announce the I/O ERROR message for this failure, however, on the BFS SYS SUMM, the PL data buses will have down arrows. The failure is the same as if the crew took the BFS mode switch to STBY. The BFS software gives up control of the payloads as requested. Following this failure, the PASS GPC that was assigned the PL data buses will take control and MCC can command as required through this GPC.
7. What message(s) are expected when the BFS suffers an I/O TERM A fail high? Which GPC(s) will announce the message(s)  
{ANSWER: } Both the I/O ERROR PL 1 and I/O ERROR PL 2 messages will be announced by the BFS if the BFS was in control of the PL buses at the time of the failure.

**DPS Nominal Procedures ..... 3-6**

1. If MCC uplinks a new TMBU, should you take an SM checkpoint immediately?  
{ANSWER: } No. Procedurally you would perform a checkpoint during the pre-sleep procedure.
2. Why do the G2 SET CONTRACTION (EXPANSION) procedures have you PRO to OPS 201 if in OPS 202?  
{ANSWER: } Set contractions and expansions can only be performed in the X01 major modes.
3. What is the purpose of the note at the top of the G2 SET CONTRACTION (EXPANSION)?  
{ANSWER: } It protects for a potential GPC fail-to-sync.

APPENDIX E: Master List of Study Guide Questions and Answers

4. Why do you perform the G2 FD prior to the OPS 2 transitions?  
{ ANSWER: } It demonstrates the capability to retrieve software from the MMUs and load it into a GPC, providing confidence in the MMUs.
5. If GPC 3 failed on ascent, which GPC would be the FD and how would you restring in step 1 of block 1 of Post Insertion?  
{ ANSWER: } GPC 2 would be the FD. The restring in step 1 would be 1414.
6. Why does Block 4 of the Deorbit Prep procedure have you check if the BFS can drive a CRT? What will be done if it can not?  
{ ANSWER: } The BFS is powered up to ensure that it can interface properly with at least one forward CRT. The flight rules consider the BFS failed if no forward CRT interface exists since the crew would have no interface with the BFS. Pre-TIG, if the BFS is considered failed, it will be reloaded into a GPC that has not experienced any failures. The BFS is checked early in the Deorbit Prep time frame because moving the BFS is a time consuming task that needs to be accomplished prior to the burn.
7. Why is an SM checkpoint taken prior to the OPS 3 reconfiguration in Block 12 of the Deorbit Prep?  
{ ANSWER: } This checkpoint is performed in case a transition back to OPS 2 is required (e.g., a 24 hour deorbit wave-off).
8. Why is the PASS OPS 3 transition in Block 12 of the Deorbit Prep not performed all at one time?  
{ ANSWER: } By accomplishing the OPS 3 reconfiguration in the following three steps, one GPC is always guaranteed to have OPS 3 software. The first step is the transition of GPCs 1 and 2 to OPS 3. Next, the BFS is taken to OPS 3. After the BFS is up and running, the SM is taken to OPS 0. Third, the remaining PASS GPCs are added to the existing PASS G3 set. (Also avoids a set expansion during an OPS transition, which would violate an OPS note.)
9. What is the purpose of calling up the OPS 9 NBAT at the end of Block 12 of the Deorbit Prep?  
{ ANSWER: } This NBAT is called up to verify the correct string assignment for post landing or to make any changes based on the current stringing.
10. What is the main DPS difference between the GO/NO-GO for EXTENDED PWR UP procedures?  
{ ANSWER: } If you are GO for EXTENDED PWR UP, a restring is performed to give GPC 1 all the strings. Then GPCs 2,3 and 4 are taken to HALT and then to OFF. If NO-GO, all of the GPCs are taken to HALT and egress follows.
11. Why, in the PRE-SLEEP ACTIVITY procedure, does the powerdown step have you turn on the BFC CRT DISP switch?  
{ ANSWER: } This switch is used to allow you to take the last CRT to STBY without logging an I/O ERROR CRT message and annunciating an SM ALERT. This way, if you think you heard an alarm annunciate in the middle of the night, you can look at the SM ALERT light for verification. Since the SM ALERT light was not lit when you went to sleep but is now illuminated, you have a new problem.

**DPS Off-Nominal Procedures ..... 3-7**

1. Why do you assign the failed GPC as the GNC downlister in the HISAM dump procedure?  
{ANSWER: }The data from the HISAM dump will go through the same toggle buffer as the GNC downlist. Therefore, in order to avoid downlist conflict, the failed GPC is selected as the downlist GPC and this causes the downlist GPC to stop downlisting.
  
2. Why is a software dump of a good GPC performed following a GPC failure?  
{ANSWER: }A software dump is performed to dump the contents of a good GPC that was running in the same RS or CS at the time of the failure. This aids MCC in failure analysis since there are synchronization logs in the good GPC which can yield information about the type of failure.
  
3. If the BFC CRT DISP switch is on during an IPL, what type of IPL will be requested?  
{ANSWER: }A menu option IPL. This switch will let the GPC being IPL'd know what type of IPL is being requested.
  
4. During a menu option IPL, what DEU action is taken prior to taking the GPC to STBY and why?  
{ANSWER: }To perform a menu option IPL, the DEU must be reloaded with software from the mass memory. The GPC being moded to STBY will perform this action. The menu option IPL expects this action and will not continue without it.
  
5. Is the presence of a Master Alarm and CAM light for the IPL GPC an indication of a failure?  
{ANSWER: }No. These are nominal indications and actually let the crew know that the IPL is proceeding normally. The absence of these indications probably indicates that the IPL process is not working. These annunciations are because the watch dog timer has timed out during the IPL.
  
6. What type of software must a GPC be running to be Freeze-Dried?  
{ANSWER: }A GPC can only be running OPS 0 software in order to be freeze-dried. An attempt to FD a GPC running applications software would result in an ILLEGAL ENTRY.
  
7. In the RECYCLE PROCEDURES, the BFS SAFING step asks "if BFS in MM102." How can the BFS be in MM102 and not the PASS?  
{ANSWER: }PASS and BFS have a different set of criteria for moding from one major mode to another. For example, for the MM101 to MM102 transition, if the BFS sees the SSME's > 90% for 3.2 seconds, it will transition to MM102 even if the engines are no longer running. PASS will not transition.
  
8. In the RECYCLE PROCEDURES, why is safing the BFS a concern?  
{ANSWER: }Safing the BFS is only a concern if it has moded into MM102. It is a concern in this mode because SRB Separation Sequence is generally initiated at this time frame. But, for the sequence to be initiated by the BFS during a pad abort scenario, three criteria must be met. The BFS must be in MM102, must be engaged, and there must be a failure of the MECO command flag to be set, which gets set in a pad abort once the Backup Events Controller sees all 3 SSME chamber pressures < 30%. Therefore, it would require two other failures to initiate SRB SEP, so BFS safing in MM102 is just a precautionary method.
  
9. In the Group B Priority PWRDN, why do we not just power OFF a GPC and an IMU?  
{ANSWER: }This is a "nominal" orbit powerdown. We reduce Orbiter loads by putting the GPC to sleep and putting the IMU in STBY. This preserves them in case there is a need to use the GPC and the IMU again in the near future. If the GPC was powered OFF, it would require an IPL to guarantee a healthy computer. If the IMU was powered OFF, MCC would like to have 24 hours of run time prior to using it. Some of the more drastic emergency powerdowns sacrifice these pieces of equipment to save on Orbiter loads.





**GPCs and Restrings ..... 3-12**

1. What type of data is maintained in the major function base?  
{ANSWER: } The major function base maintains the software and the data that are common to all OPS within a given major function. For example, the orbiter state vector is contained in the GNC major function base.
2. What is the only exception to the rule that a memory configuration consists of system software and one OPS and why?  
{ANSWER: } Memory configuration 1 is loaded with both OPS 1 (ascent) and OPS 6 (RTL5) since there would be no time to load in new software for an RTL5 abort.
3. Why don't you get a "free" restring on an RTL5 when you pro from OPS 103 to OPS 601.?  
{ANSWER: } A restring can only be accomplished when you perform an OPS transition that requires new software to be loaded or when you recall the OPS you are currently in. Since the RTL5 software is resident in the ascent OPS 1 software, you do not get a "free" restring with this transition.
4. What type of synchronization does the PASS SM GPC perform?  
{ANSWER: } The SM GPC is always simplex and since it is a PASS computer, it performs common set synchronization.
5. If an OPS 3 transition is requested and the software is available in one GPC's lower memory and in the upper memory of all the targeted GPCs, where will the software come from?  
{ANSWER: } The source of the software will be the GPC with the software in lower memory. If no GPC had the software in lower memory, then the upper memory or the archive is checked and then, lastly, the MMUs.
6. What must be done to add GPC 3 to the current redundant set for a nominal orbit configuration (GPC 3 is freeze-dried with G2 software)?  
{ANSWER: } GPC 3 needs to be brought from HALT to STBY to RUN. The NBAT will need to include GPC 3 in the target set. The OPS needs to be OPS 201 for set expansions or contractions and then an OPS 201 PRO has to be entered to the GNC set.
7. Will a GPC that has entered an infinite software loop continue to drive the ADI? Why or why not?  
{ANSWER: } This GPC has software quit and will not drive the ADI. For a software quit, the GPC is continuously running the same code over and over and can not continue to perform the other functions it was performing prior to entering this loop.
8. On ascent, pre-MECO, for a 2-on-2 set split where the BFS is tracking the PASS, what must be true to allow for a PASS set reconfiguration instead of a BFS engage?  
{ANSWER: } The PASS set reconfiguration must be completed pre-MECO and there are no additional complicating failures present.
9. If set reconfiguration is to be performed following a pre-MECO set split, what actions must be taken?  
{ANSWER: } HALT the simplex or nonpreferred GPC's and manually shut down the engine(s) with command path(s). Restrings only in accordance with flight rules.
10. On orbit with a nominal GPC configuration of two G2 and one SM, which GNC machine is considered the "good" GPC following a redundant set split?  
{ANSWER: } The procedure has you assume that the GPC with the most IMUs is the "good" GPC and run the failure procedure for the other former redundant GPC, since it is impossible to determine which GPC has really failed without further troubleshooting.

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11. Why is a GPC that suffers a SUMWORD ICC failure during ascent treated as failed at the next OPS transition?  
{ANSWER: } This GPC is likely to fail-to-sync at the OPS transition and should therefore be removed prior to attempting the transition.
12. Can an SM GPC that has suffered an I/O TERM A failure on orbit be used for entry?  
{ANSWER: } Yes, this GPC just can not be used as the BFS. An I/O TERM A failure only effects the payload and launch data buses and therefore is not a concern for GNC software.
13. Is it possible to have a non-universal I/O ERROR with only 3 PASS GPCs and not have one of the GPCs fail-to-sync?  
{ANSWER: } Yes. If at least two of the GPCs detect a problem, but not all of the GPCs, then you will have a non-universal I/O situation.
14. During the ascent portion of a TAL, a non-universal I/O ERROR is logged against FA2. What restrung should be chosen for the TAL transition?  
{ANSWER: } String 2 should be “unstrung.” The NBAT would be 1034.
15. Is an engagable BFS required for a restrung to regain fault tolerance?  
{ANSWER: } The BFS is required when restrunging is performed as a precaution against the low probability occurrence that the restrung action may result in loss of the PASS set. The only time it is not required is when a restrung is performed to regain critical capability.
16. On a TAL, FF1 is power failed from ascent and then GPC4 fails to HALT at 100k. Is a restrung desired following the GPC4 failure? Do the flight rules support restrunging?  
{ANSWER: } A restrung is desired to regain NWS for the TAL. FF1 takes out NWS1 and GPC4 takes out NWS2. The restrung is approved with Flight Rule A2.1.5-4C1 which states that NWS is required at all abort sites.
17. When less than 4 GPCs are available for the entry, in general, how are the remaining strings assigned?  
{ANSWER: } The remaining strings are distributed to minimize the loss of critical functions for a subsequent GPC failure. A list of functions to protect is shown in Flight Rule A7.1.3-8C.

**Multifunction CRT Display System ..... 3-15**

1. DEU 1 has been loaded with its software using the BFS. What is displayed when a PASS GPC tries to drive a critical format on CRT 1? What happens to inputs made to this CRT?  
{ANSWER: } The CRT will be mostly blank with some jumbled information at the top or bottom of the display. Inputs made to this display are valid, however, the normal feedback that the input was made is not available on this display.
2. With a nominal on orbit GPC configuration (2G2, 1SM, 1FD in sleep, 1BFS in sleep), how would a DEU Load be performed?  
{ANSWER: } The PASS SM GPC would be used to load the DEU since it has the necessary software to request the load from the MMUs.
3. Why does the DEU IPL-PASS/BFS malfunction procedure have you deassign the CRT associated with the DEU that will be loaded?  
{ANSWER: } The CRT is deassigned to prevent a low probability problem that can cause the load to fail when the DEU Load is requested.
4. What crew action WILL lead to dual commanders?  
{ANSWER: } Assigning the BFS to drive a PASS CRT using the GPC/CRT on a CRT controlled by the BFS.

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5. What nominal time could you possibly see a big “X” on a CRT?  
{ANSWER: } When the SM is being loaded, a big “X” can be expected. The DEU is not updated during the loading of the SM checkpoint data. Even if a checkpoint is not being retrieved, a few seconds is still allocated for it, causing the Big X.
6. What happens if you misconfigure the CRT portion of the current GNC NBAT by assigning a GPC that is not running and then perform an OPS Mode Recall?  
{ANSWER: } The MF switch logic will assign the lowest numbered GNC GPC as the commander of the CRT, in the absence of a valid NBAT assignment. It is not possible to deassign a currently assigned CRT with an OPS transition or OPS Mode Recall.
7. On orbit, the SM GPC is assigned to all three of the PASS CRTs and then fails to HALT. With a nominal on orbit GPC configuration, what is the quickest way to regain PASS CRT interface?  
{ANSWER: } Take the FD GPC from HALT, pausing in STBY, up to RUN. This GPC will not see any other PASS GPC commanding a CRT and will automatically take control of the forward three CRTs.
8. What CRT assignments during a Group B Power Down should be exercised to avoid a loss of PASS CRT interface?  
{ANSWER: } The CRTs that are powered down should be set to different Major Functions (MF). For example, CRT 1 powered OFF in GNC, CRT 2 powered OFF in SM and then CRT 4 can be powered ON or OFF and in any MF. This way, the loss of the GNC or SM software will not result in a total loss of PASS CRT interface.
9. How can you prevent a Big X and a POLL FAIL from occurring when you put a GPC to sleep?  
{ANSWER: } The CRT will need to be reassigned prior to taking the GPC down to STBY. The easiest way to do this is to move the CRT major function switch to a supported major function. This way, another GPC will take over the CRT and then when the GPC is taken to STBY, no Big X and POLL FAIL.

**NAV**

**Air Data System ..... 3-18**

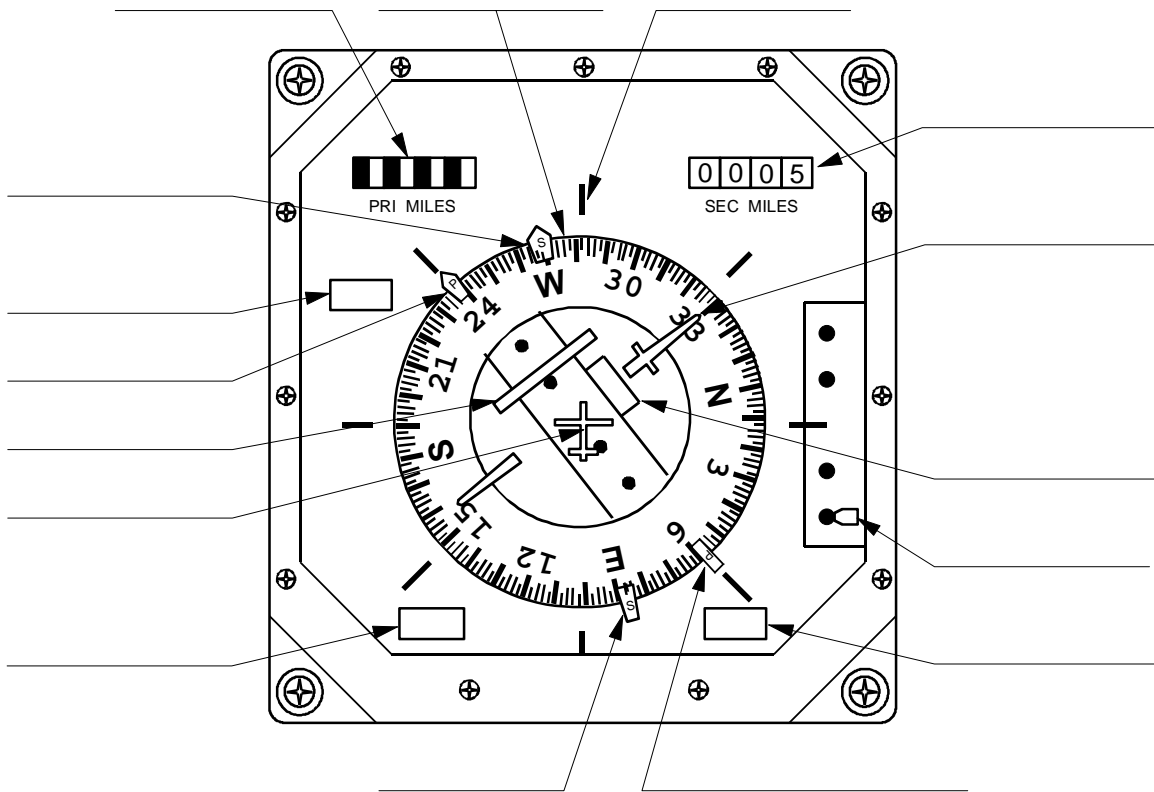
1. How many motors are available to drive each probe? How are the probe motors powered? What is the nominal probe deployment time?  
 {ANSWER: } Each air data probe is redundantly powered by two 3-phase AC motors. Dual motor deploy time is 15 seconds; 30 seconds for single-motor time.
  
2. Discuss the rationale for deploying the left and right air data probes separately when the BFS is engaged.  
 {ANSWER: } On the BFS, the Panel F6 / F8 Air Data switch cannot be used to check the status of the deploy discretes for each probe due to the fact that the BFS software will not drive OFF flags to the AMI and AVVI. The first probe must also be evaluated prior to deploying the second probe since the BFS will display the average of both probes when the air data switch is taken to the Left or Right position and BFS SPEC 51 does not have ADTA data.
  
3. How does the flight software determine whether an air data probe is stowed or deployed?  
 {ANSWER: } The flight software checks the status of DEPLOY and STOW discretes (2 sets per probe), which are based on the position of limits switches within each probe assembly. A probe is considered deployed when DEPLOY=ON and STOW=OFF for at least one set of discretes associated with a given probe. Note that the BFS does not consider STOW discretes, and needs only one DEPLOY=ON to consider a probe deployed.
  
4. Given the case where ADTA 2 is commfaulted, discuss how air data parameters from the remaining available ADTAs are used by PASS and BFS.  
 {ANSWER: } PASS will average the single output from ADTA 4 on the right probe with the averaged data from ADTAs 1 and 3 on the left probe. BFS, however, is only capable of using the output of the lowest numbered available ADTA on each probe. Therefore, it will average the output from ADTA 1 on the left probe with the output from ADTA 4 on the right probe.
  
5. Identify the specific tapes on the AMI and AVVI which are driven directly by air data parameters once ADTA H and ADTA TO G&C are taken to AUTO on GNC SPEC 50.  
 {ANSWER: }               On the AMI, tapes driven by air data are ALPHA, M/VEL, and EAS.  
                               On the AVVI, tapes driven by air data are ALT RATE and ALT.
  
6. Explain why manual theta limits must be flown below Mach 2 if air data is not incorporated to G&C (ADTA TO G&C).  
 {ANSWER: } In the absence of air data below V=1500 fps, flight control software uses default air data which assumes a constant alpha (7.5 deg). Qbar is derived from an I-loaded table as a function of navigation ground-relative velocity. Flight Rule 8-56D states that "the crew must follow theta limits on the VERT SIT display because guidance no longer limits alpha by protecting the low-qbar boundary, and displayed alpha is no longer reliable." Maintaining vehicle pitch between the NOSE HI and NOSE LO region ensures that alpha is within acceptable limits, thus maintaining energy within acceptable limits.

**Dedicated Displays**

..... **3-20**

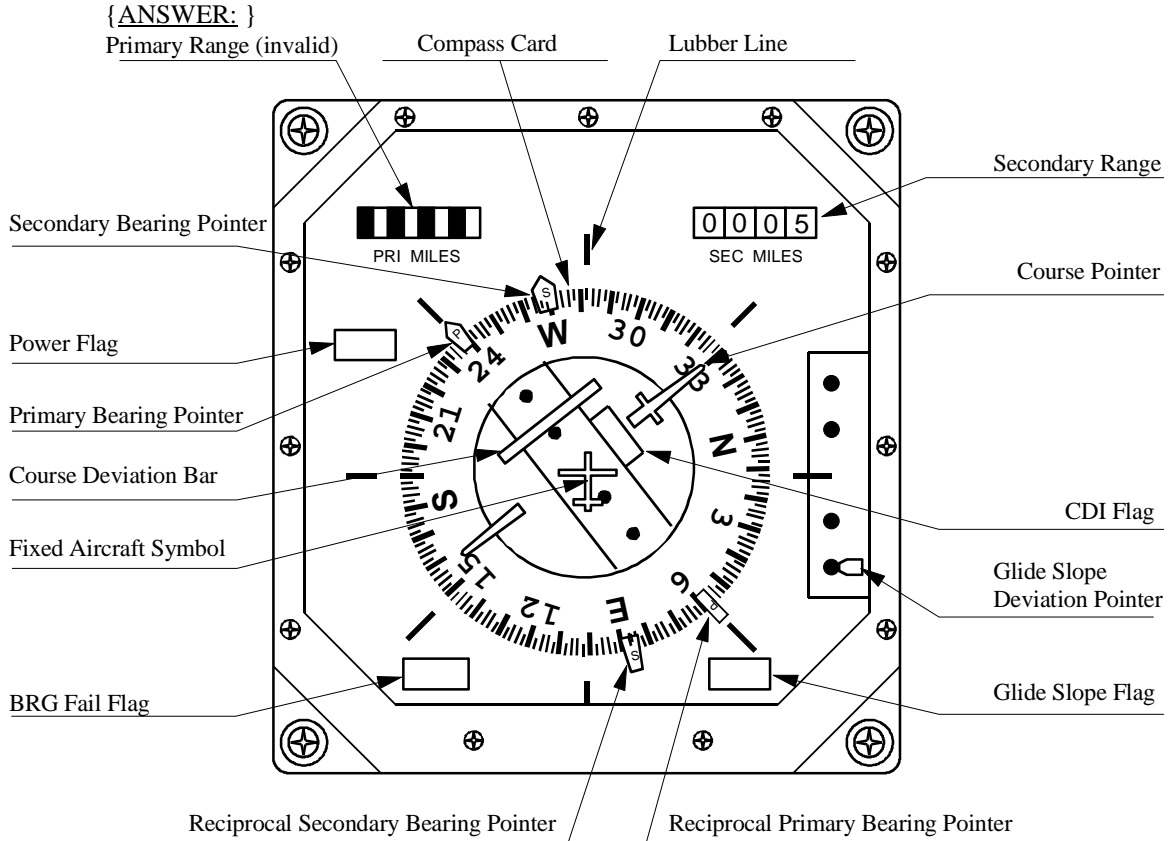
1. What data does the ALPHA, MACH and EAS on the AMI and the ALT RATE and RATE on the AVVI show when the Air Data switch is in the Left or Right position? What do ACCEL on the AMI and ALT ACCEL and RDR ALT on the AVVI show?  
{ANSWER: } The ALPHA, MACH, EAS, ALT RATE and RATE will display the data associated with the probe that is selected. The ACCEL, ALT ACCEL and RDR ALT are not affected by the Air Data switch.
2. BFS is engaged and both probes are deployed. The left Air Data switch is in the RIGHT position. What data is displayed on the CDR's AMI and AVVI? What data is displayed on the PLT's AMI and AVVI?  
{ANSWER: } Both of the AMIs and AVVIs will display the average of one ADTA from each probe. The PLT's AMI and AVVI are slaved to the CDR's during a BFS engage.
3. Which ADI control is unique to the AFT ADI and why?  
{ANSWER: } The ADI Sense Switch is unique to the AFT ADI because only this ADI has selectable control axes. The forward ADIs are always +X.
4. What effect does depressing the ATT REF push-button have on the REF frame?  
{ANSWER: } Depressing the ATT REF push-button will redefine the REF initial frame along the Orbiter body axes at the instant the push-button is depressed.
5. When is the ATT REF push-button typically used during a flight?  
{ANSWER: } This push-button is used to mark on stars during a HUD or a COAS calibration as well as any time the crew desires a "0,0,0" starting point.

6. On the figure below, label the HSI parameters and their readings.



Heading  $\cong$  \_\_\_\_\_  
 Course = \_\_\_\_\_  
 CDI  $\cong$  \_\_\_\_\_  
 GSI = \_\_\_\_\_

PRI BRG = \_\_\_\_\_  
 SEC BRG = \_\_\_\_\_  
 PRI RNG = \_\_\_\_\_  
 SEC RNG = \_\_\_\_\_



Heading $\cong$ 282 degrees _____	PRI BRG = 238 degrees _____
Course = 330 degrees _____	SEC BRG = 270 degrees _____
CDI $\cong$ 6 degrees _____	PRI RNG = invalid _____
GSI = 5000 feet _____	SEC RNG = 5 nautical miles _____

7. Based on the previous HSI figure,
- is the Orbiter currently on the right or left side of the extended runway centerline?
  - is the Orbiter above or below the desired glide slope?
  - what happens to the CDI if the vehicle continues at the present heading?
- { ANSWER: } a) The Orbiter is to the right of the runway.  
 b) The Orbiter is above the glide slope.  
 c) The CDI will move to the center if the vehicle continues at the present heading.
8. What data buses are each of the HUDs connected to and how do you select an alternate data bus?
- { ANSWER: } The left HUD is connected to Flight Critical (FC) data bus 1 and 2. The right HUD is connected to FC data bus 3 and 4. The data bus select switch can be used to select an alternate data bus. A selection of 1 or 3 on the data bus select switch will connect the HUD to the lower numbered FC and a selection of 2 or 4 will select the higher numbered FC on either the left or the right.



**Entry Nav Aids Overview**

..... **3-23**

1. Which of the seven parameters supplied by the Air Data System are used by Navigation?  
{ANSWER: } Only the barometric altitude. The other six parameters are used by the G&C software.
2. When MLS data is acquired and starts processing to update the state vector, what other NavAid information does it replace?  
{ANSWER: } TACAN range and bearing and Air Data altitude are replaced by MLS azimuth, range and elevation in the filtered state vector.
3. Not all three parameters for MLS are required to start processing MLS data. Which parameter is not necessary?  
{ANSWER: } Elevation data is incorporated into NAV only if valid, but elevation data is not necessary for azimuth and range data to be used.
4. MCC has advised the crew that the NAV state is bad. On SPEC 50, the TACAN Ratio is greater than 1.0. What can be done to update the NAV state with the TACAN data?  
{ANSWER: } The crew can force the TACAN data by executing an ITEM 21 (FOR). This causes the filter to bypass the ratio edit test, forcing the filter to update the state vector with the sensor data regardless of the sensor ratio.
5. The RATIO EDIT TEST will not use data if the RESID is greater than 1. What is considered a good RESID to use before questioning the data or the NAV State?  
{ANSWER: } A good RESID is considered to be 0.3 or less.
6. RA data is not used by Navigation. How does the crew use RA data?  
{ANSWER: } The RA data is seen by the crew on the AVVI and on the Head-Up Display and is used for display purposes only.

**IMUs..... 3-25**

1. Which IMU align do we use most often and why?  
{ANSWER: } A Star Tracker IMU align is used most often because it uses an external source of data and is the best choice for fine tuning IMUs.
2. MCC asks you to perform an unscheduled, i.e. not in the Flight Plan, IMU align. How would you determine the correct stars to use for the align?  
{ANSWER: } You would use the day-night cycle from the Flight Plan to determine where you are in the cycle. Then you would use the STAR PAIRS in the Flight Supplement Orbit OPS PTG section to determine which set of stars will be available in the near future. (Each tick mark is equal to five minutes). You would then use the STAR PAIRS PAD, found in the same section, to find the M50 attitude for these two stars. Once in attitude, proceed with a nominal Star Tracker IMU align.
3. If an IMU is caged, what must be done to make it usable?  
{ANSWER: } The IMU must be taken to Operate E and then realigned using another IMU as a reference.
4. GPC 2 power fails during the ascent part of a TAL. What IMU data does the BFS now use? After the OPS 3 transition and recovery of string 2, what IMU data does the BFS use?  
{ANSWER: } After the failure of GPC 2, the BFS will begin to prime select IMU 1. After the recovery of string 2 and the transition to OPS 3, the BFS will continue to prime select IMU 1.
5. If the BFS drops to the two level for IMUs, and all three IMUs subsequently become available, how do you get back to Mid-Value-Selecting (MVS)?  
{ANSWER: } The only way to get the BFS back to MVS after it has begun to prime select an IMU is to pro the BFS through OPS 0 and then back to OPS 3.
6. Why are the IMUs skewed?  
{ANSWER: } The three IMUs are skewed to optimize fault detection (particularly at the two level).
7. State an IMU failure for which the BFS downmodes but the PASS does not.  
{ANSWER: } The BFS will downmode an IMU that has suffered a Hardware BITE.
8. Why do we mask false BITES?  
{ANSWER: } If MCC determines that a BITE on an IMU is false, that BITE will be masked. This is to prevent this IMU from being automatically considered failed if an IMU DLMA should occur in the future. An IMU with an unmasked BITE in a DLMA will be failed regardless.

**MLS/RA..... 3-26**

1. How can you upmode an MLS unit that has been downmoded by FDIR?  
{ANSWER: } You cannot. This MLS unit cannot be upmoded after being declared failed by FDIR.
2. Where is the only place that the crew can see MLS data to try and solve an MLS dilemma?  
{ANSWER: } The HSI is the only place this data is displayed for the crew. The MLS raw data is downlinked to MCC by the PCMMU telemetry.
3. If you are down to two MLS units, and you subsequently have an MLS DLMA, how do you know if the dilemma is with elevation?  
{ANSWER: } Once MLS range and azimuth data are valid, the residuals and ratios for both TACAN and Air Data vanish. If an MLS dilemma is annunciated and the TACAN and Air Data residuals/ratios remain blank, then the dilemma is an elevation dilemma because the range and azimuth data are still valid.

4. MLS 1 has previously failed. An MLS dilemma is announced while going around the HAC. What parameter is in dilemma and how do you know?  
{ANSWER: } The dilemma is in range. While going around the HAC, the only MLS data which is considered valid is range data. The azimuth and elevation data are not valid because the Orbiter is outside 55 deg with respect to the runway centerline.
5. When the BFS is engaged, how can you determine which RA is supplying data to your tape?  
{ANSWER: } You cannot. The BFS will output RA data to both AVVIs of the first RA to lock on. The BFS does not read the RA select switch position. MCC does not get RA telemetry data for the BFS so they cannot help either.

**Nav Overview .....3-27**

1. What is used by the navigation software to propagate the state vector?  
{ANSWER: } The standard equations of motion along with information from the IMUs, the NAV sensors, and the software models of force (gravity, drag, vent, etc.).
2. What phases of flight use a single state vector scheme?  
{ANSWER: } Ascent, Orbit, Rendezvous, Pre-land and RTLS phases of shuttle flight; in other words, all phases except for the OPS 3 Entry phase.
3. If IMU 1 is unavailable, how does RM determine a state vector in the single state vector scheme? In the three state vector scheme?  
{ANSWER: } The selection filter will average the total velocity components in the single state vector scheme.  
The selection filter will use the average of the two available filtered state vectors in the three state vector scheme.
4. Why is the three state vector scheme not used in all phases of flight?  
{ANSWER: } This scheme requires much more software processing than the single state scheme in order to maintain the three independent states.
5. IMU 3 suffers a power transient but is recovered during entry with an IMU/IMU align. What needs to be done to use this IMU again and why?  
{ANSWER: } The state vector for IMU 3 is no longer valid, however, the accelerations from IMU 3 are valid. Therefore we need to fix the IMU 3 state vector. We can do this by performing a NAV Delta 0 on SPEC 50 prior to reselecting IMU 3. This will replace all three IMU state vectors with a copy of the user state vector. Once IMU 3 has a good state vector it can be reselected to be used by the selection filter.
6. If you are in an LVLH attitude hold of 0,0,0, what is your inertial rate of rotation and in what axis? Where is this information displayed onboard?  
{ANSWER: } You would see a rotation rate of approximately -0.067 deg/sec in the pitch axis on the UNIV PTG display. This corresponds to rotating 360 deg over 90 minutes.
7. State the two ways that the PASS state vector can be transferred to the BFS.  
{ANSWER: } A PASS state vector is transferred to the BFS when the crew manually performs a PASS-to-BFS state vector transfer via Item entry on BFS SPEC 50 or whenever the BFS software is moded from OPS 0 to OPS 3.
8. When is the NAV DELTA PAD CC used?  
{ANSWER: } This pad is used when a voice delta state update is requested. One crew member should write down the deltas on this pad as they are being called up.

9. Why do we have to enable RNDZ NAV prior to a rendezvous?  
{ANSWER: } The REL NAV software maintains an accurate estimate of both the Orbiter and the target state vectors. Without this software, we have no onboard way of maintaining a target state vector.
10. If the BFS state vector is bad preengage, how is it updated?  
{ANSWER: } MCC will typically uplink state vector updates to PASS then has the crew update the BFS state vector by performing a PASS-to-BFS state vector transfer.

**Nominal Nav Procedures ..... 3-29**

1. What does the IMU ALIGN - S TRK procedure assume has already been done prior to starting this procedure?  
{ANSWER: } The procedure assumes that an attitude maneuver has been performed to pick up a set of navigation stars.
2. What data is the starred block of step 2 in the IMU ALIGN - S TRK procedure referring to?  
{ANSWER: } The starred block is referring to the data in the star table not the IMU delta ANGs that are mentioned in the previous line of the procedure.
3. In the starred block of step 2 in the IMU ALIGN - S TRK procedure, should you proceed with a self test on both star trackers if the correct stars are not in the Star Table?  
{ANSWER: } Yes you should. The sentence “if preceding checks are good” applies to the preceding starred steps. If these steps are good, then you do not know what is wrong with the star trackers so you perform a self test. In general, performing a self test will never hurt. This portion of the IMU ALIGN procedure is confusing at best and is currently being reworked by training and flight control personnel.
4. Which IMUs should be aligned in step 4 in the IMU ALIGN - S TRK procedure and why?  
{ANSWER: } All available IMUs should be aligned to preclude the possibility of an IMU RM FAIL since the RM threshold is reset following any IMU align.
5. Why is it necessary to verify a good alignment in the IMU ALIGNMENT - IMU/IMU procedure?  
{ANSWER: } The pulse torquing part of an IMU alignment is open loop. The GPC sends out the needed commands and assumes that the pulse torquing has occurred and then sets the IMU ANG delta X, Y and Z to 0. If the pulse torquing was not completed, this verification process would show large IMU ANG delta X, Y and Z (approx. 1 deg).
6. For a COAS or a HUD CALIBRATION, do you take a minimum of three marks to get a better average for the update?  
{ANSWER: } No. Each successive mark overrides the previous mark. The last mark will be used for the update. Several marks are taken to ensure a bias consistency.
7. What is the purpose of the verification in the COAS and the HUD CALIBRATION procedures?  
{ANSWER: } The verification is performed to ensure that the update performed is accurate enough for a COAS or a HUD alignment, if required.
8. Does the HUD calibration require the use of the P as the boresight?  
{ANSWER: } No. The P was chosen to be used and the flight controllers are expecting it. Any point could be used as far as the software is concerned.
9. Why is an IMU align verification required for the Deorbit Prep IMU ALIGNMENT Block 8?  
{ANSWER: } This entry alignment is considered critical and therefore requires a verification align.

10. For the IMU alignment in Block 22 of Deorbit Prep, should you select all three IMUs? Why or Why not?  
{ANSWER: } No. The purpose of this block is not to align the IMUs but to reset the IMU RM threshold.
11. If an ADTA shows a BITE during the HIGH or LOW TEST in the FCS CHECKOUT, should you read the BITE status from GPC memory before or after stopping the test?  
{ANSWER: } The GPC memory address should be read prior to stopping the test. A reading of the address after the test is stopped would give you data without a BITE present.
12. How do you determine if an ADTA with a BITE needs to be deselected during the FCS CHECKOUT procedure?  
{ANSWER: } If the data in the GPC memory matches the data listed in the starred block, the ADTA is fine and does not need to be deselected.

**Star Trackers ..... 3-31**

1. If the Bright Object Sensor (BOS) loses power, is the star tracker still usable?  
{ANSWER: } Yes, however you will have to manually open the shutter to acquire stars. The IMU align procedures protect you from leaving the shutter manually open and potentially damaging the electronics.
2. When are the star trackers activated and the doors opened? When are the star trackers deactivated and the doors closed?  
{ANSWER: } Post Insertion Block 11 opens the doors and activates them. Deorbit Prep Block 13 powers off the star trackers and closes the doors.
3. If a star tracker fails on orbit, non-recoverable, what should you do?  
{ANSWER: } You should perform a HUD calibration within 24 hours if one has not previously been performed.
4. What nominal time would you calibrate the COAS?  
{ANSWER: } None. The COAS would only be calibrated if you had already lost a star tracker and the cabin pressure had changed since the HUD calibration.
5. When would you be likely to perform an ITEM 7(8) on SPEC 22?  
{ANSWER: } This would be most useful during target tracking operations when an incorrect target is being tracked.
6. When would you nominally expect to see OUT FOV on the status line of SPEC 22?  
{ANSWER: } OUT FOV will be displayed after the star is put into the S TABLE.
7. What is a star of probability align?  
{ANSWER: } This align uses stars that are already in the S TABLE instead of maneuvering to an attitude to collect stars.
8. Where are the star trackers mounted and to which shuttle body axis are they approximately aligned?  
{ANSWER: } The star trackers are mounted to the NAV base. They are approximately aligned with the -Y and the -Z body axis.

**TACANs..... 3-32**

1. How is slant range measured by the onboard TACAN units?  
{ANSWER: } The onboard TACAN units emit signals that are received by the TACAN ground station, where they are turned around and sent back to the onboard TACAN unit. The onboard unit measures the round-trip time of the signal and multiplies it by the speed of light. The result is the TACAN unit's measurement of slant range.
2. Which data buses are used to transmit TACAN data to and from the GPCs? What is special about the TACAN/RA Input/Output Module in the MDM?  
{ANSWER: } The flight critical (FC) data buses are used to transmit data to the GPCs through the flight forward (FF) MDMs. The TACANs and the RAs are connected to a special IOM in the MDM that does not require an I/O RESET when the units are powered ON. The GPCs will automatically upmode the TACANs and RAs when power is on.
3. Do the TACAN channel numbers on the thumbwheels have to be set to the corresponding TACAN station if the TACAN MODE switch is in GPC?  
{ANSWER: } No. When the TACAN MODE is in GPC, the channel selection is automatically controlled by the GNC software.
4. What is the onboard indication that you have entered the Bearing Cone of Confusion?  
{ANSWER: } The TACAN's bearing is not a candidate for RM processing and the ratio/residuals for bearing will blank on SPEC 50.
5. How does RM determine a candidate for selection by the Selection Filter in PASS and BFS?  
{ANSWER: } The following criteria is used to determine candidacy: Applies to both PASS and BFS: 1) not powered off; 2) not manually deselected; 3) not commfaulted; 4) not in the Bearing Cone of Confusion; and 5) not experiencing multiple of 40 DEG bearing glitches at the three level. The following apply ONLY to PASS: 6) not currently failed; 7) not involved in SELF-TEST at the two level; and 8) two-lock requirement satisfied.
6. Describe the two-lock requirement for the PASS.  
{ANSWER: } The TACAN software for PASS requires that two units lock on in both range and bearing when two or more parameters are candidates for the selection filter. The two lock requirement goes away for range after 30 seconds of processing by NAV.
7. The BFS does not have a two-lock requirement like PASS. What are the two conditions that must be met to process TACAN data in the BFS?  
{ANSWER: } At least two TACANs must be tuned to the same station as seen on SPEC 50 and at least one TACAN must be locked on.
8. What data does the BFS use at the two level? What data will the BFS use if a miscompare is found at the two level in the BFS?  
{ANSWER: } The BFS will use the lowest numbered TACAN unit. The BFS does not have FDIR, however, if a miscompare exists between the two available TACAN units, the BFS will not use any data. This is referred to as a silent dilemma because no annunciation occurs.
9. Explain why the first step of the RM FAIL TAC and the RM DLMA TAC procedure have you check if both data good.  
{ANSWER: } If there was a transient miscompare that either caused a FAIL or a DLMA, and the current data does not support the declared failure, the failed parameter or the DLMA situation can be reset. A failed parameter may be reselected by deselecting and then reselecting the failed LRU.

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10. FF1 has previously failed. The message RM DLMA TAC is annunciated. What is your immediate action? Explain why.

- A. Determine the bad TACAN unit and deselect it in BFS Only.
- B. Determine the bad TACAN unit and deselect it in PASS and BFS.
- C. Wait for SELF-TEST to complete prior to taking any action.
- D. Call MCC for recommended action.

{ANSWER: } C.) is the correct answer. No action should be taken until the PASS SELF-TEST has had time to complete. A manual deselection of a TACAN will deselect both parameters where as the SELF-TEST will only deselect the parameter that is bad.

**Section 4 - Systems**

**APU/HYD**

**APU/Hydraulics..... 4-2**

1. True or False: An APU that is overheating (OIL OVERTEMP alarm) on ascent will be shut down before it seizes if it is the only APU with a problem.  
{ANSWER: False. An APU SHUTDOWN will only be performed during powered flight in two cases: 1) the APU has already done an auto shutdown, and 2) there is a confirmed overspeed condition.}
  
2. Scenario: you see your WSB quantity dropping quickly during ascent. You should:
  - a) switch WSB controllers: in case the 1st controller was causing overspraying, that might fix it
  - b) switch WSB controllers: in case it was just bad instrumentation from the 1st controller
  - c) both a) and b) are good reasons to switch controllers
  - d) none of the above{ANSWER: d. You should not switch WSB controllers during ascent unless you experience an oil overtemp (the case of the previous exercise), because they are AC powered equipment. Switching AC powered equipment pre MECO is generally discouraged since the SSME controllers are AC powered. For reason a) above, the procedure allows you to turn off the BLR PWR. That will stop the overspraying if that was in fact happening. For b), you will get a different quantity reading on the other controller because it uses different pressure and temperature sources to feed the quantity calculation. But that hardly justifies switching an AC powered piece of equipment pre MECO!}
  
3. If the primary control valve loses power, what happens to a running APU?  
{ANSWER: Since the primary control valve is open when unpowered, the turbine will accelerate to 113%, where the speed will be controlled by the secondary control valve. The FDA will annunciate “APU \_ SPD HI”.}
  
4. Describe the sequence of events for an auto shutdown.  
{ANSWER: When the controller sees the turbine speed > 129% or < 80%, it will initiate an auto shutdown if the APU AUTO SHUTDOWN switch is in “ENA”. Simultaneously power is removed from the fuel tank valves and secondary control valve causing them all to shut, which causes the APU to spin down from fuel starvation. Appropriate FDA will accompany this event. The “HYD PRESS” light on F7 will also come on as the hydraulic pressure drops.}
  
5. Scenario: APU 1 experiences an unexplained underspeed shutdown on the ascent side of an RTLS. A COOLDOWN should be started:
  - a) ASAP
  - b) ASAP post MECO
  - c) at M = 7
  - d) on MCC call only{ANSWER: b. A COOLDOWN should always be performed for an unexplained underspeed. Normally this occurs at M = 7, but M = 7 is never achieved on an RTLS. Therefore the COOLDOWN should be initiated as soon as possible post MECO. (A pre MECO cooldown would rarely be considered, and would be on MCC call only.)}



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6. In the scenario above (and no other failures), when should the RESTART be attempted?
- a) after 3.5 min. of continuous cooling
  - b) when the INJ T is < 400 F.
  - c) only on MCC call
  - d) either a) or b) is acceptable
- {ANSWER: c. A RESTART will only be attempted a) to regain NWS when required (like it is on an abort - but in this case hyd 2 is supplying NWS), b) to regain redundant landing gear deploy capability (two pyro methods remain in this case), and c) to have two good hyd systems for flight control on entry. None of these conditions are met in this case, so one would not expect to do a RESTART. Since MCC has better insight than the crew, it should only be done on MCC call in this case.}
7. True or False: After a COOLDOWN (3.5 minutes of continuous cooling) has been completed, It's a good idea to terminate the COOLDOWN until a RESTART is required to save injector cooling water.
- {ANSWER: False. Within seconds of terminating a cooldown on a hot APU (recently running), heat soakback from the gas generator bed will cause the injector branch passages to soar back up to dangerously high levels. If a COOLDOWN is terminated for any reason, another complete 3.5 minute COOLDOWN is required before it will be safe to attempt a RESTART. Otherwise, detonation of the gas generator bed is likely on the RESTART attempt.}
8. Reference SSSH drwg. 12.1 2-2, zones O - G. If two MPUs (magnetic pickup units) were to fail to OSL values while an APU was running, what would be the immediate result?
- a) it depends on the combination of MPUs
  - b) an APU overspeed would result
  - c) an APU underspeed would result
  - d) an underspeed would be annunciated, but the speed would continue to be controlled.
- {ANSWER: c. Two of the three MPUs reading "0" would mean that 3 of the 4 speed control channels would have "0" values. Since this is < 80%, an underspeed would result (and the APU would auto shutdown if AUTO SHUTDOWN was ENabled.) Realize that no one has any insight into the cause of this *unexplained* underspeed. This is just one possible scenario of the many that could cause an underspeed. }
9. Suppose the previous situation happened on an abort or entry, and other failures were present to cause an attempted RESTART on the APU with the unexplained UNDERSPEED. What happens on the RESTART attempt in this case?
- a) it won't start
  - b) it attempts to start but then underspeeds again
  - c) it overspeeds
  - d) depends on the position of the AUTO SHUTDOWN switch.
- {ANSWER: c. Again, 3 of the 4 speed control channels see the speed as "0", so both the primary and secondary control valves will be commanded open to try to speed the turbine up to their respective control speeds. The turbine will continue to accelerate as fuel flows unimpeded into the GG bed until one of two results occurs depending on whether auto shutdown was enabled or not: a) in INH the turbine comes apart, or b) in ENA a contained overspeed shutdown occurs. This restart attempt in ENA is called a DIAGNOSTIC RESTART, and is reflected in the RESTART procedure for just this case. If the restart is unsuccessful but did not overspeed, at least you know that the cause of the original underspeed was not a dual MPU failure. A second cooldown and restart attempt, this time in INH, can then be attempted. Realize however that the odds of recovering an APU that suffered an unexplained underspeed are very poor regardless of the position of the auto shutdown switch.}

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10. Scenario: During entry an APU overheats. A second APU subsequently overspeeds. The COOLDOWN is performed at M=7 and the RESTART is performed \_\_\_\_\_.
- a) at M=1
  - b) when the cooldown's complete (3.5 min. after it's started)
  - c) on MCC call only
- {ANSWER: a. An APU that has no cooling can only last about 5 min. before the gearbox seizes. This corresponds to an altitude of about 50 K and M=1. The APU *should* be restarted in this case to maintain two hyd systems for flight control during entry.}
11. Since the MCC has better insight and trend data, the crew should wait for their call before taking action for an APU fuel line heater failure during orbit.
- a) True
  - b) False
  - c) depends on whether the heater failed ON or OFF.
- {ANSWER: b. Regardless of the failure, appropriate crew action is time critical. If the heater failed on, the line can overheat very rapidly and the fuel in the line can detonate. If the heater failed off, freezing can occur within 20 minutes. Crew members should realize that any APU fuel line temp type message should be given high priority.}
12. Scenario: APU 2 underspeeds at 1:00 and hydraulic system 3 suffers a pump failure (off-scale low pressure) at 2:00 MET. What are the impacts to SSME throttling and gimbaling?
- {ANSWER: Both the Left and Right SSMEs will suffer hydraulic lockup and be stuck at the throttle setting they had at the time of the respective failures. The right SSME will lose gimbaling capability (and will incidentally have to be shut down early).}
13. Continuing the scenario above, what do you expect to see for PRL status on GNC Spec 51, and what kind of response rates do you expect to have on entry?
- {ANSWER: Hyd systems 2 and 3 will have down arrows next to them on Spec 51. This means the PRL software considers two hydraulic systems lost (which is the case), and is using single system rates. In summary, the maximum rates commanded of the elevons by the GPCs for elevator and aileron functions will be 13.9 deg/sec, vice the normal 20 deg/sec. Max rudder rate commanded will be 7 deg/sec, vice the normal 14 deg/sec. From the pilot's perspective, the response will be more sluggish than normal.}
14. Reasons for taking a hydraulic main pump to "LOW" press include (may be more than one correct answer):
- a) reduce torque for APU startup
  - b) to keep switching valves from cycling in the event of sporadic output pressure loss
  - c) to slow a non-isolable hydraulic leak
  - d) to reduce APU fuel usage
- {ANSWER: All of the above. Answers a) and c) should be obvious. For b), remember that each elevon (and virtually every other hydraulic actuator) is fed by more than one hydraulic system. Switching valves determine which system will normally power an actuator, but if the supply pressure falls in that system, the switching valve will switch over to the next system. In the case where the output pressure on the primary system is sporadic, the switching valve will cycle. When a switching valve cycles rapidly, it can tear itself apart. By taking the system to low pressure, the switching valve switches over to the secondary system, but doesn't cycle back and forth. For d), think of reducing the pump output pressure as reducing the resistance to the turbine spinning. If the turbine has less resistance, a shot of fuel is required less frequently to keep it spinning near the control speed. Hence, less fuel is being used. Having the hyd pump in LOW press cuts the fuel usage rate by more than half.}

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15. Scenario: You are on orbit and receive a message that sends you to SM Sys Summ 2 to look at the hyd 2 accumulator pressure. You see that it is falling rapidly through 2100 psi. The circ pump 2 switch is in GPC. You should:
- a) continue to monitor it, expecting the GPC to turn the circ pump on eventually
  - b) inform MCC and wait for them to command the circ pump ON
  - c) take the circ pump 2 switch ON
  - d) finish what you're doing, and then go find the Orbit Pocket Checklist
- {ANSWER: a. You should be spring-loaded to turn the circ pump ON if necessary to save the hyd system, but in the meantime you should go find the OPCL. You will find that it has you turn the pump ON if the pressure is below 1930 psi. Since the switch is normally configured to GPC, and the GPC will command the pump on when the pressure gets to 1960 psi, you should expect that you won't be required to make a switch throw. However, you should monitor that the pump does get turned on automatically the first time just to make sure. If it doesn't and you haven't manually turned it on, the hyd system will eventually be declared lost, making the mission MDF.}
16. At  $V_{rel} = 800$  fps, the hydraulic LANDING GEAR EXTEND ISOL VALVE should automatically come open. Procedurally, the crew checks this valve at  $M=0.7$ , and attempts to open it manually if it's not open. What is lost if it can't be opened?
- a) hydraulic gear deploy
  - b) hyd sys 1 for braking
  - c) nose wheel steering
  - d) all of the above
- {ANSWER: a. Using fig. 3-7 in the APU/HYD 2102 TM, you can see that hyd sys 1 must get through the LANDING GEAR EXTEND ISOL VALVE (and also the LG EXT VLV) before deploying the main gear. The nose gear could be deployed with sys 2, but the BRAKE ISOL VLV 2 would have to be manually opened early since it doesn't normally come open until WOW. Hyd sys 1 only goes through the BRAKE ISOL VLV 1 for braking, and system 2 can still provide NWS through the NWS switching valve.}
17. In the earlier example with systems 2 and 3 lost, what is the impact to braking?
- {ANSWER: You will have half brakes. System 2 is primary for half the brakes and system 3 is backup for all the brakes. So half the brake pucks have neither a primary nor secondary source of hydraulic pressure available, leaving only half the braking power than is normally available.}

**C & W**

**Caution & Warning..... 4-6**

1. Loss of the electrical bus ESS1BC does not affect the functionality of the Caution and Warning system. True or False  
{ANSWER: False.}
  
2. If there is a loss of power to the Primary C&W system (controlled by panel R13U and power is restored, the MCC can uplink the changes to this piece of the system while they cannot uplink changes to the part of the system accessed by SPEC 60. True or False  
{ANSWER: False. }
  
3. What is a TMBU?
  - A. A method by which changes can be made to the Primary (Hardware) C&W system
  - B. A method by which changes can be made to the Backup (Software) C&W system
  - C. A method by which changes can be made to the Constants in the Flight Software
  - D. All of the Above
  - E. B and C{ANSWER: E}
  
4. If there is one smoke detection light lit on Panel L1 and there are no increasing smoke concentrations on BFS SYS SUMM 1, there is most likely a sensor failure. True or False  
{ANSWER: True.}

ECLSS

**Atmospheric Revitalization System (ARS)..... 4-8**

1. Which water loop is the primary source of cooling during Ascent and Orbit operations?  
{ANSWER: Water Loop 2; Loop 1 is used for backup}
2. How is heat removed from the Cabin Air?  
{ANSWER: The cabin air is passed through an Air/Water Heat Exchanger that transfers cabin heat to the water loops.}
3. After receiving a Master Alarm, an SM CRT Message and viewing the F7 matrix H2O Loop light, you check the data on BFS SYS SUMM 2 and notice the Water Loop Pump pressures are both equal to 24. You check your switches and Water Loop Pump 2 in ON and Water Loop Pump 1 is OFF. What has happened?  
{ANSWER: For whatever reason, the H2O Loop 2 has stopped.}
4. How many Av Bay Fans exist for each Av Bay and how many are nominally in use at any given time?  
{ANSWER: 2 Av Bay Fans per Av Bay and only 1 is used at a time}
5. If you turn off a Cabin Fan pre-MECO, it is OK to turn it back on pre-MECO. True or False  
{ANSWER: False.}

**Active Thermal Control System (ATCS)..... 4-9**

1. Which of the following is not a method by which heat is removed from the freon loops?
  - A. Radiators
  - B. FES
  - C. Ammonia Boilers
  - D. Water/Freon Interchanger{ANSWER: D. The water/freon interchanger places heat into the freon loop so it can be sent overboard.}
2. The FES Primary and Secondary controllers control the freon to the same temperature. True or False.  
{ANSWER: False}
3. If, during ascent, the EVAP OUT T in one loop rises to 120 degrees, you will be required to swap FES Controllers. True or False  
{ANSWER: False. One EVAP OUT T high indicates a sensor problem.}
4. At landing, the FES is providing cooling for the orbiter. True or False.  
{ANSWER: False.}
5. If you take the L1 switches for the Radiator Controllers to AUTO and AUTO A, you will need to wait 1 minute to determine if there is a failure in the system. True or False  
{ANSWER: False.}
6. An EVAP OUT T of 62 could indicate which of the following:
  - A. The Secondary Controller is operating
  - B. It is nominal end of mission landing, you are below 100,000 feet and the freon is heating up
  - C. There is a problem with the cooling system
  - D. All of the above{ANSWER: D.}

**Supply & Waste Water.....4-11**

1. If you cannot use the nominal N2 source for pressurization of the water tanks, you can use the cabin atmosphere to pressurize the water tanks. True or False.  
{ANSWER: True.}
  
2. Given the following supply water tank configuration, what water tanks are feeding the FES when the Primary A Controller is being used.  
TK A INLET - OP    TK B INLET - OP    TK C INLET - CL    TK D INLET - OP  
TK A OUTLET - CL    TK B OUTLET - OP    TK C OUTLET - CL    TK D OUTLET - OP  
CROSSOVER VALVE - OP  
  
A. Tanks B and D  
B. Tanks A and B  
C. Tanks C and D  
D. All Tanks  
{ANSWER: A. }
  
3. Given the above supply water tank configuration with the Crossover Valve closed, which tanks are feeding the FES if the Primary A Controller is being used?  
A. Tank D  
B. Tank A  
C. Tank B  
D. All Tanks  
{ANSWER: C }
  
4. The Flash Evaporator System cannot be used as a method for performing waste water dumps. True or False  
{ANSWER: True. Don't want to contaminate the FES}
  
5. The value for Supply Water Tank A on SPEC 66 is 85. What does this mean?  
A. Tank A has 85 pounds of water in it  
B. Tank A is 85% full  
C. Both because the tanks hold 100 pounds of water  
D. Neither  
{ANSWER: B. }

**Pressure Control System (PCS).....4-13**

1. Mid Mission there is a procedure performed that calls for the PCS to be reconfigured. What is the purpose of and general process involved in this procedure?  
{ANSWER: Nominally, the orbiter uses PCS System 1 for the first half of the mission and PCS System 2 for the second half. The procedure changes the switches on Panels L2 and MO10W from system 1 to system 2.}
  
2. The O2/N2 Controller determines what makeup to provide to the cabin atmosphere by examining the Partial Pressure of O2. True or False  
{ANSWER: True}
  
3. If, during ascent, the cabin pressure drops below 14.7 psi, N2 will flow through the 14.7 regulator to bring the pressure back to 14.7 psi. True or False.  
{ANSWER: False. During ascent, the 14.7 psi regulators on MO10W are closed.}
  
4. The Cabin dP/dT and the EQ dP/dT should always be the same. True or False.  
{ANSWER: False.}

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5. The Cabin dP/dT reading is from a hardware sensor and the EQ dP/dT reading is a calculation.  
True or False.  
{ANSWER: True.}
6. A reading of 5.0H on any of the flow rates on BFS SYS SUMM 1 indicates a faulty sensor.  
True or False  
{ANSWER: False.}
7. If, after closing Cabin Relief Valve A, the dP/dT displayed on BFS SYS SUMM 1 is 0, this indicates \_\_\_\_\_.
- A. Sensor Failure
  - B. Leak was isolated
  - C. Cabin Relief B malfunctioned
  - D. A foreign object may have plugged up the hole
- {ANSWER: B.}

EPS

**Electrical Power Distribution & Control (EPDC)..... 4-15**

1. What are the power sources for ESS2CA?  
{ANSWER: Fuel Cell 2 through a switch and a fuse and Mains C and A through an RPC}
2. What are the power sources for CNTLBC2?  
{ANSWER: Mains B and C through RPCs (switches on R1) and Main A through a fuse and circuit breaker (on R14)}
3. Given the following BFS SYS SUMM 1 data, what is potentially wrong with the electrical system?  
FC VOLTS = 35.8  
MAIN VOLTS = 0.0  
FC AMPS = 0.0  
{ANSWER: Fuel Cell Disconnect}
4. If you are performing a Bus Tie and one of the Main Bus Volts is less than 20, you do not need to disconnect the AC prior to performing the bus tie. True or False  
{ANSWER: False. If the Main Bus Volts are less than 20, a long form bus tie is required. This procedure disconnects the AC prior to the bus tie and reconnects the AC after the bus tie.}
5. What is the problem with performing a bus tie between a good Main Bus and a shorted Main Bus?  
A. Nothing  
B. You will lose your essential bus  
C. You will place a short on the good bus  
D. You will lose your GPC  
{ANSWER: C}
6. When the Main A Control Bus Reset switch on Panel R1 is held in the RESET position, the RPC associated with that switch is unpowered and no power from Main A is being provided to the Control Bus. True or False.  
{ANSWER: True}
7. If there is a short on a control bus, you run the risk of a fire if you do not unpower the bus. True or False.  
{ANSWER: True}
8. During Ascent, the AC Bus Sensors are in the Monitor position. During this timeframe, if there are high enough amps on an AC Bus to cause an Overload condition, the AC Bus Sensor will trip the AC Bus Offline to protect the equipment on the bus. True or False  
{ANSWER: False. With the AC Bus Sensor in monitor, the overload will annunciate but will not trip the AC Bus offline.}

**Fuel Cells..... 4-17**

1. The \_\_\_\_\_ separates water from the H<sub>2</sub>/water mixture and sends water to the ECLSS supply water tanks.  
{ANSWER: H<sub>2</sub> pump/water separator}
2. The \_\_\_\_\_ uses coolant to cool H<sub>2</sub>/steam mixture coming out of the Fuel Cell stack so that water can be removed.  
{ANSWER: Condenser}



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3. If the coolant pump ceases to operate, you have \_\_\_\_\_ (amount of time) to shut down the fuel cell before you risk a possible fire or explosion.  
{ANSWER: 9 minutes }
4. If the COOL P for Fuel Cell 1 on BFS SYS SUMM 1 reads 60, what is the pressure of the O<sub>2</sub> and H<sub>2</sub> in the Fuel Cell?  
{ANSWER: O<sub>2</sub> pressure is 60 because the accumulator maintains the pressure of the coolant at the same pressure of the oxygen. The dual gas regulator maintains the H<sub>2</sub> pressure slightly lower than that of the O<sub>2</sub>. }
5. If the Fuel Cell Coolant Pump failed, Fuel Cell Stack Temperature (FC STACK T) would \_\_\_\_\_.  
A. Rise  
B. Fall  
C. Remain Static  
D. Fluctuate randomly  
{ANSWER: B. Fall; FC STACK T measures the temperature of the coolant leaving the stack. When the coolant is not moving, due either to a failure of the pump or an electrical failure, the sensor will not effectively measure the stack T. It will actually fall because of the proximity of the sensor to the cryo preheaters. In addition, the EXIT T will rise slightly indicating the increase in temperature of the stack. }
6. If the O<sub>2</sub> meter showed the FC STACK T rising and the CRT confirmed this, the PLT would \_\_\_\_\_.  
A. Disregard the indication because it is normal  
B. Throw the switch that reduces the fuel cell temperature  
C. Work the FC Stack T procedure, shutting down the Fuel Cell  
D. Work the Coolant P procedure because there is something wrong with the cooling  
ANSWER: C. When there is a problem with the temperature of the stack, you run the risk of a fire or explosion when the fuel cell gets too hot. The PLT should work the procedure associated with the sensor that is out of limits, in this case, the FC STACK T and will end up shutting down the fuel cell. }
7. The purpose of the Fuel Cell Purge process is to cleanse the fuel cells of any inert gases or contaminants to increase reaction efficiency. True or False  
{ANSWER: True. The fuel cells are purged periodically to flush contaminants out of the stack. These contaminants are carried overboard by the excess hydrogen and oxygen used during the purge. }
8. If the Substack Delta Volts for all three substacks on Fuel Cell 1 jump from their original values to 50 then back to their original values, the following has occurred.  
A. There was a temporary glitch in the performance of the fuel cell  
B. The Cell Performance Monitor performed a self-test.  
C. The Cell Performance Monitor found something wrong with the fuel cell and fixed it.  
D. It is time to perform a Fuel Cell Purge.  
{ANSWER: B. Every 7.5 minutes, the Cell Performance Monitor performs a self-test. During this operation, the substack delta volts will read 50. If the self-test fails, the delta volts will read 500. If the self-test passes, the Cell Performance Monitor will resume monitoring fuel cell operations. }

**Power Reactant Storage and Distribution (PRSD) ..... 4-19**

1. When the O2 Manifold Valves are closed, the O2 Manifold is divided into 3 separate pieces. Manifold \_\_\_\_\_ is the only manifold without a pressure sensor and over-pressure relief.  
{ANSWER: 3; the center manifold}
2. There are two pressure sensors on cryo tanks, P and TK P. P measures the actual pressure of the tank and can be read on the O2 meter. TK P is displayed on SYS SUMM 2 and sends its data to the heater controller. True or False.  
{ANSWER: False}
3. There is a ground call that the MCC is monitoring an O2 leak in all tanks. After the PLT closes the O2 Manifold Valves, only O2 Tank 2 pressure is falling; this is verified by the O2 meters. The only possible problem is an O2 Manifold 2 leak. True or False.  
{ANSWER: False. The other possibility is a Fuel Cell Leak. A tank leak would be characterized by only one Tank P falling in the beginning or the ECLSS supply line.}
4. Why do Heater Current Sensors exist in the O2 tanks and not the H2 tanks?  
{ANSWER: Even though H2 is flammable, there is no oxidizer to allow it to burn. O2 will burn.}
5. If an O2 Heater Current Sensor trips a heater off, what indication will you receive in the orbiter?  
{ANSWER: SM Alert and a down arrow on SPEC 68 for the heater current sensor that tripped off.}
6. The purpose of the O2 HTR CUR SNSR CK procedure performed daily is to verify that 3 of 4 sensors per tank are operational. True or False.  
{ANSWER: False. All heater current sensors should function correctly.}
7. When a pair of O2 tanks is operating in dual mode, the heater switches are ON until both tank pressures reach their High limit, then the switches are turned OFF. True or False.  
{ANSWER: False. To place a pair of tanks into dual mode, the heater switches are in the AUTO position. The heaters will then turn on and off according to the pressures in the tanks.}

MECH

**Mechanical Systems ..... 4-21**

1. A typical PDU contains:
  - a) One AC motor with brakes
  - b) a gearbox with a switch module
  - c) shaft with bellcrank
  - d) both a) and b)
  - e) both b) and c){ANSWER: b. A typical PDU contains a gearbox with a switch module.}
  
2. This device is designed to protect against mechanical or structural damage in case the mechanism binds or jams:
  - a) motor brakes
  - b) torque limiters
  - c) microswitch modules
  - d) actuator timers{ANSWER: b. Torque limiters are designed to protect against mechanical or structural damage in case the mechanism binds or jams.}
  
3. Which of the following does the crew use to interface with the vent system?
  - a) panel R2
  - b) panel R13L
  - c) Spec 51
  - d) both b) and c){ANSWER: c. The crew interfaces with the vent system using Spec 51.}
  
4. True or False: The ET door closure software initiated by a Spec 51 item entry is different from that which is initiated automatically on RTLS, TAL, and Contingency Aborts.  
{ANSWER: False. The software routine is exactly the same. Spec 51 is just a manual way of initiating the entire routine. Remember that this is completely open loop, however, and does not use any feedback as to whether the previous command executed successfully before going to the next command.}
  
5. True or False: During a nominal ascent, a backup method of closing the ET doors is provided by the GNC software in MM 104, 105, and 106 via GNC SPEC 51 OVERRIDE.  
{ANSWER: True. But realize that the software closure is open loop with no feedback - therefore, if one of the latches doesn't drive initially, it will continue to charge through the rest of the sequence driving whatever will move. On an AOA there just isn't time to do a lot of troubleshooting, so it is permissible to try the software override. Any other time, though, it is preferable to wait and give the MCC some time to analyze the data and come up with a plan of action.}
  
6. True or False: If you should suffer a feedline disconnect on ascent, the ET doors should be shut ASAP to minimize propellant gasses from leaking.  
{ANSWER: False. Procedurally, the first line says to check w/ MCC if that failure occurs. Flight rules require a full rev of bottom-sun, so that the heat from the sunshine can help expedite the escape of any propellant gasses from cryo still trapped in the feedline(s). Therefore, ET door closure will be delayed until that can be accomplished.}

## Appendix E: Master List of Study Guide Questions and Answers

7. Scenario: You have stowed the centerline latches and closed the ET doors per procedure. The left door has a “CL” talkback, but the right door still shows “barberpole” after single motor time has expired. Since you have indications that a mechanical mechanism is no longer driving, you do the right thing and stop commanding it by taking the MODE switch back to GPC and the door switches to OFF. The MCC says that they believe the door is really closed, but the forward and aft ready-to-latch (RTL) microswitches (msw’s) are apparently failed. You should expect the MCC to tell you to take the MODE switch back to GPC/MAN and then \_\_\_\_\_ to resolve the situation.
- cycle the door open and then closed again to see if the microswitches will clear.
  - take the LEFT door latch switch to LAT to take advantage of the cross-wiring.
  - place both the LEFT and RIGHT latch switches in the LAT position.
  - go ahead and latch by taking only the RIGHT latch switch to LAT.

{ANSWER: c. Reference SSSH 15.2, 2 of 3, zones O - G. The two failed RTL msw’s are found in G-6. Note that bubbles 18 and 19, which come off of these two msw’s, are used to enable the right door uplock motors (zones D-2 and D-7). But note also that bubbles 22 and 23 (zones H-6 and H-7) come in from the L LATCH SW (zones L-3 and L-6) to provide an alternate source of power to bubbles 18 and 19. Therefore, to power the R DOOR LATCH motors, you need either the R DOOR RTL msw’s, or the L LATCH SW to be in LAT. While this allows you a method of latching the door for a msw failure, it also allows you to latch the latches before the door has been closed. Therefore, care should always be taken to coordinate with the MCC when time permits with ET door problems. They can see the status of the 3rd RTL msw, the two limit switches inside the PDU, and the motor drive times to help them diagnose whether the door is really closed or not. }

8. True or False: One can operate the PLBDs using only the hardware switches on panel R13L in the MANUAL mode, but either the SM OPS 202 or Spec 63 displays are required to use AUTO mode.

{ANSWER: False. MANUAL mode simply means that the crewmember manually SELECTS which mechanism(s) to drive. AUTO mode means that the GPC SELECTS which mechanism(s) to drive. In either case, a GPC and one of the aforementioned displays need to be up to select the desired mechanism(s) in MANUAL mode, or to tell the GPC to select them for you in AUTO mode. Regardless of which mode is used to select the mechanism(s) to command, there are also two switches which can give the command: the hardwired switch on panel R13L, and the software switch which is items 14 - 17 on either display. Whether the hardware or software switch is used has no bearing on whether one is using AUTO or MANUAL mode, i.e. either switch can be used with either mode. There is no capability to operate PLBDs without an SM GPC running. }

Appendix E: Master List of Study Guide Questions and Answers

9. A manual PLBD closure has been initiated. The port door as well as the port forward and aft latches have been closed. The starboard door is in transition and has been driving for nearly 2 minutes 10 seconds. What fault message will be generated momentarily?
- None
  - PBD SEQ FAIL
  - PBD CONFIG
  - Dilemma

```

XXXX/          PL BAY DOORS          XX X DDD/HH: MM: SS

AC POWER      ON 1*
              OFF 2
AUTO MODE SEL 3
              PBD SW-CL
              MICRO-SW STAT
              LATS DOORS
              CCOO CRRRO
              ABAB  ABC
CENTER LATCHES |MAN|OP/CL| AUTO |
                |SEL|      |  SEQ |
                5- 8 | 4 |  OP  |
                9-12 | 5 |  OP  |
                1- 4 | 6 |  OP  |
                13-16| 7 |  OP  |
STBD
  FWD LATCHES  | 8 |  OP  |
  AFT LATCHES  | 9 |  OP  |
  DOOR          |10*|
PORT
  FWD LATCHES  |11 |  CL  |
  AFT LATCHES  |12 |  CL  |
  DOOR          |13 |  CL  |
              |
PBD SW BYPASS 14      OPEN 15
                   STOP 16
                   CLOSE 17
    
```

( XX )

{ ANSWER: a. No fault messages are generated while in Manual mode. }



**Landing/Decel Systems..... 4-25**

1. True or False: If hydraulic system 1 fails to release the main landing gear, a pyrotechnic actuator will automatically perform the function 1 second later.  
{ANSWER: True. The pyros will deploy the gear if the proximity sensors say that they are still in the wheel wells 1 sec. after both the gear “ARM” and “DOWN” discretes have been set. That gives hydraulic system 1 one second to deploy them.}
  
2. The drag chute was designed to be deployed:
  - a) at 300 KEAS
  - b) In case of reduced braking capability (multiple hydraulic systems lost)
  - c) only on intact abort landings
  - d) Nominally if the crosswind is < 15 kt and the SSMEs were repositioned{ANSWER: d. Some benefits of the drag chute are that braking is less critical and directional control is improved; orbiter stability is improved; rollout distance is reduced; brake life is extended; and main gear strut loads are reduced (decreasing the risk of tire failure) at WONG.}
  
3. Scenario: On entry you received an “SSME REPO FAIL” message. The Capcom tells you that you are “Emergency deploy on the chute.” This means:
  - a) there is an emergency: chute is mandatory
  - b) chute should only be deployed if the CDR deems it necessary
  - c) chute should only be used if you know of an emergency, like a tire failure on rollout
  - d) b and c{ANSWER: d. Note that FR 10-92 B. reads (to paraphrase), when Emergency Deploy, the chute WILL be deployed for a list of emergencies (TAL/ELS, leaking/flat tire, etc.), but otherwise its deployment is still at the crew’s discretion if they feel it “could provide some additional benefit.”}

# **APPENDIX F**

**Appendix F:** Evaluation Forms .....F-1



# ASSIGNED CREW STUDY GUIDE EVALUATION FORM

**Lesson Title:** \_\_\_\_\_  
(write title above)

The Space Flight Training Division is interested in any comments which will improve our study guide products. We do not expect feedback on every lesson and you need not respond to all questions. Please be as specific as possible in responding to the questions that you do elect to answer. Feel free to use the reverse side of this form or additional paper if you wish to give more extensive feedback.

If you choose to give feedback on multiple lessons we request that you use a new form for each lesson. Only a few copies of this form have been provided, please make additional copies as needed. **Return the completed forms to DT68/Team Lead Office which will forward your comments to the appropriate instructor.**

1	Did the study guide cover the topic content well? Comments: _____ _____ _____
2	Were the objectives clear, accurate, and appropriate for the topic? Comments: _____ _____
3	Were the references clear and appropriate for the stated objectives? Comments: _____ _____
4	Were the objectives and exercises helpful in preparing you for the qual lessons (where appropriate) ? Comments: _____ _____
5	Were the exercise answers and explanations meaningful and appropriate? Comments: _____ _____
6	Do you recommend any changes? If so, please describe. _____ _____ _____
7	Any other comments? _____ _____ _____

Name : \_\_\_\_\_  
Phone Number: \_\_\_\_\_  
Date: \_\_\_\_\_

**Note: You may submit this feedback anonymously. However, we appreciate your name and phone number in case we have further questions about your feedback.**

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DEPT. 4331 PROCEDURE CHANGE REQUEST (PCR)

AFFECTED DOCUMENT TITLE: Assigned crew study DOCUMENT #: DOP-4331-015  
Guide Orbiter System  
ORIGINATOR: Stephen Messersmith PHONE: 47534 DATE OF REQUEST: 12-15-97

DESCRIPTION OF CHANGE [include procedure title(s) and number(s) where applicable]:

Updates for OI-26

REASON FOR CHANGE:

Updates for OI-26

ARE OTHER 4331 AREA(S) AFFECTED?:  YES  NO  
IF YES, WHICH AREA(S)?:

\* ARE OTHER 4330 DEPT(S) AFFECTED?:  YES  NO  
IF YES, WHICH DEPT(S)?:

ORIGINATOR Stephen Messersmith

DATE 12-15-97

(THIS SECTION WILL USUALLY BE FILLED OUT AT THE IRB - POST STAFF MEETING)

MEETING DATE N/A

BOOK MGR. Stephen Messersmith

DATE 12-15-97

SIG. AUTHORITY Stephen Williamson

DATE 12-15-97

4331 DOC. CTLR. Jan M'Connell

DATE 12/15/97

DATE OF ACTUAL DOCUMENT CHANGE: 12/15/97  
(as appears on document)

NEW REVISION NUMBER: A  
(as appears on document)

DOES THIS CHANGE REQUIRE A SELS UPDATE?  YES  NO  
IF YES, ROUTE TO 4330 DOC. CTLR.

4330 DOC. CTLR.: Jan M'Connell for Stacie Hughes  
(Signing & dating of this line reflects SELS entry updated.)

DATE 12/18/97

IF OTHER DEPT(S) AFFECTED, ROUTE TO TFPP COORDINATOR

TFPP COORDINATOR \_\_\_\_\_  
(Signing & dating of this line reflects TFPP agenda assignment.)

DATE \_\_\_\_\_