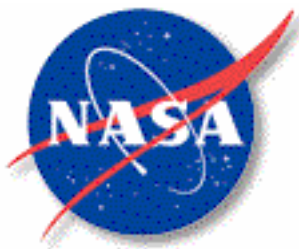


RENDEZVOUS GPO CONSOLE HANDBOOK

**Mission Operations Directorate
Flight Design and Dynamics Division**

**REVISION B PCN-2
June 27, 2005**

VERIFY THIS IS CORRECT VERSION BEFORE USE.



**National Aeronautics and
Space Administration**

**Lyndon B. Johnson Space Center
Houston, Texas**

RENDEZVOUS GUIDANCE AND PROCEDURES OFFICER CONSOLE HANDBOOK

REVISION B PCN-2
June 27, 2005

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**RENDEZVOUS GUIDANCE AND PROCEDURES OFFICER
CONSOLE HANDBOOK**

REVISION B PCN-2
June 27, 2005

APPROVED BY:

Malise M. Fletcher, Lead
Rendezvous Guidance and Procedures Group

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1.1 Rendezvous Team Duties

PURPOSE

To define the specific Mission Control Center (MCC) duties of the RNDZ GPO team console positions.

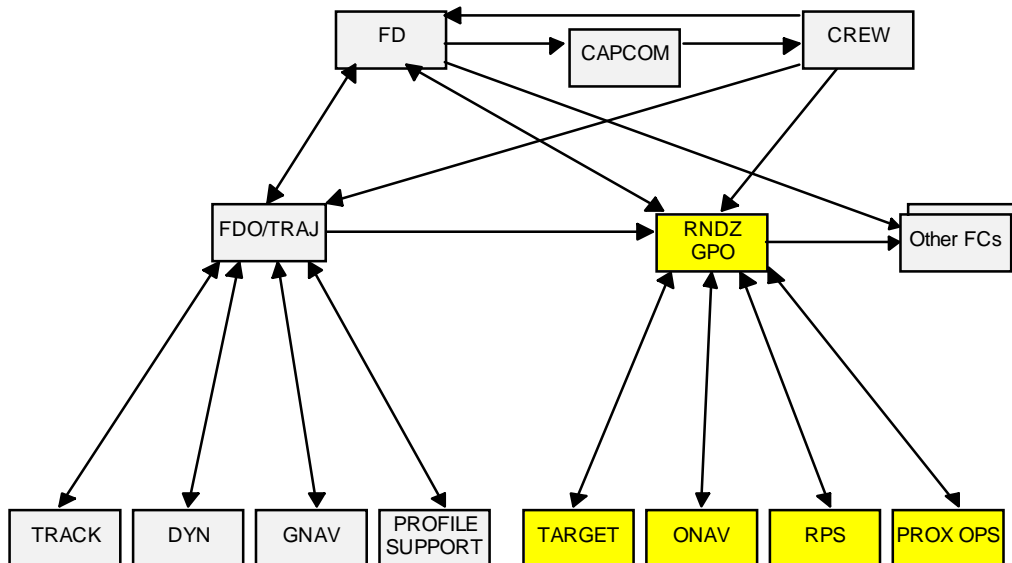
PROCEDURE

As a guide to defining interfaces, the following list highlights the specific principal duties and responsibilities of each member of the RNDZ/PROX OPS MCC team. The RNDZ GPO and RNDZ FDO are co-leads of the RNDZ/PROX OPS MCC team.

Table 1.1-1 RNDZ/Proximity Operations Team Members

Operator	Position	Call Sign
Rendezvous Guidance & Procedures Officer	RENDEZVOUS	"RON-DAY-VOO"
Rendezvous Procedure Support	RPS	"R-P-S"
Onboard Navigation	ONAV	"O-NAV"
Rendezvous Targeting	TARGET	"TAR-GET"
Proximity Operations	PROX OPS	"PROX-OPS"
Flight Dynamics Officer	FDO	"FI-DO"
Trajectory	TRAJECTORY	"TRAJ"

Figure 1.1-1 RNDZ GPO Interfaces in the Mission Control Center



RNDZ GPO Duties

RNDZ GPO Team coordination:

- Establishes priorities for RNDZ GPO team actions
- Advises Flight Director (FD, call sign "FLIGHT") on priorities of RNDZ-related actions
- Communicates with FD and other FCR positions
- Summarizes off-loop FCR discussions for MPSRs
- Conducts briefings of crew, FD, etc., pre-simulation/mission
- Reports action items, etc., post-simulation/mission
- Ensures distribution of MCC products to MPSRs
- Ensures libraries are configured
- Organizes pre-mission RNDZ GPO team meetings
- Writes RNDZ GPO post-flight report

Guidance and Navigation functions:

- Verifies proper target acquisition and sensor updates, and evaluates reasonability of external sensor updates
- Monitors and assesses onboard vector management/configuration based on RNDZ sensor data incorporation
- Uplinks covariance (COVAR) matrix and recommends crew perform COVAR reinitialize (REINIT) as needed
- Verifies proper state of the onboard guidance functions for maneuvers (Lambert vs. External Delta-V); recommends corrective action as needed.
- Monitors and evaluates onboard targeting performance, and logs and evaluates onboard MNVR solutions
- Verifies onboard target data pre-burn; recommends corrective crew action as needed.
- Monitors burns for proper attitude, engine, and residuals
- Develops and carries out contingency plans
- Maintains the current status of the onboard guidance and navigation functions, as advised by ONAV. This includes such tasks as identifying the active sub-phase, coordinating with the GNC to confirm the effect of control and sensor systems problems, and evaluating the effects on guidance of NAV updates from external or ground updates.

RNDZ procedures:

- Follows procedures execution, recommends contingency techniques and procedures
- Follows mission with attention to impacts from other technical areas
- Writes authorized changes into the RENDEZVOUS C/L

RPS Duties

- Follows progress of crew procedures, block entries and completion, checklist (C/L) page numbers, etc.
- Prepares flight notes for RNDZ GPO
- Performs failure analysis to determine impacts on RNDZ operations
- Makes recommendations on breakout strategies
- Monitors burn PADs as read up to crew
- Monitors prop numbers and impacts of OMS/RCS anomalies.
- Monitors digital autopilot (DAP) configuration and parameters
- Monitors Universal Pointing (UP) configuration and changes
- Gives team a 'heads-up' on status/actions/page numbers
- Support AOS/LOS monitoring
- Prepare evaluation of expected COMM coverage of all critical RNDZ events, identify in advance those events to occur LOS
- Maintains FCR/MPSR reference libraries for RNDZ GPO
- Takes/collects/organizes hardcopies as planned
- Analyzes DPS restringing options for impacts on RNDZ operations
- Prepares training rosters and forwards to RNDZ GPO for filing
- Starts ROSS telemetry acquisition processor for use by the RNDZ GPO team.

TARGET Duties

- Estimates trajectory effects of venting, missed burns, drag, etc.
- RNDZ GPO team lead for recording/verifying crew read-back of burn PADs
- Responsible for execution of variable downlist procedures
- Keeps records pertinent to real-time and post-mission activities.
- Compares TRAJ dispersions to pre-mission values
- Provides expertise in guidance and targeting flight software
- Performs BASE TIME management
- Monitors and advises on MNVR solution selection
- Provides midcourse 2 (MC2) targeting, monitoring, and validation
- Provides relative state estimates
- Simulates onboard targeting to allow look-ahead to anticipate reasonable onboard results
- Operates appropriate console software for relative motion predictions (expected and contingency)

ONAV Duties

- Carries out ONAV responsibilities as specified in the ONAV Console Handbook (JSC 23006) and advises the RNDZ GPO on all procedural issues.
- Monitors health of onboard NAV systems and validity of sensor data. Monitors sensor status and performance, and advise RNDZ GPO on sensor selection recommendations.
- Evaluates onboard states
- Gives status on NAV convergence
- Recommends AUTO/INHIBIT/FORCE controls executed on SPEC 33
- Advises on COVAR REINIT requirement
- Recommends Filter (FLTR) to PROP and vice versa requirements
- Suggests need for SV uplinks and FLTR/PROP selection onboard
- Advises on effects of redundancy management (RM) on NAV
- Monitors inertial measurement unit (IMU) management
- Examines the Star Tracker FOV charts generated by POINTING
- Interfaces with INCO for Radar Self Tests and Radar problems
- Provides expertise on ONAV filter operations and associated FSW working and sequencing
- Provides expertise on NAV-related procedures

PROX OPS Duties

Provide expertise on the Tools for Rendezvous And Docking (TRAD) configuration:

- Provide knowledge of the on-board hardware and software configuration and recommendations to configuration problems
- Provide knowledge of RPOP setup, execution, and operation
- Maintain expertise with nominal and off nominal TRAD related crew procedures.
- Monitor RPOP function with identical on-board I-Loads using the downlisted telemetry and provide relative motion display to the FCR
- Troubleshoot TRAD software anomalies and provide recommendations or solutions
- Maintain log of TRAD anomalies and problem resolutions
- Support RNDZ TOOLS CHECKOUT

VPOP Operation:

- Setup, execute and operate VPOP and provide display to FCR
- Maintain VPOP display with appropriate views and pertinent sensor information

Provide expertise in Proximity Operations profile:

- Provide knowledge of profile constraints and peculiarities of pre-mission design for nominal and contingency procedures

- Follow and verify crew actions and inputs
- Know Orbiter and payload official vehicle characteristics
- Know Orbiter and payload vehicle capabilities
- Know PIP requirements of main payloads and shared cargo
- Estimate how Orbiter 6-DOF effects and perturbations will affect off-nominal procedures or re-planning
- Estimate variances from pre-mission propellant budget

Analyze, anticipate, and recommend resolution in contingency scenarios:

- Provide nominal and known contingency relative motion
- Prepare necessary pre-mission simulation setups that will facilitate quick resolution to unexpected contingency scenarios
- Maintain a list of knowledgeable analysts to assist in quick turnaround analyses
- Estimate effects on propellant budget
- Recommend applicable procedural changes

Provide support for real time evaluation and revision of docking timeline

- Be knowledgeable of all flight rules related to the design of the docking timeline.
- Maintain proficiency with SADS software
- Maintain proficiency with Flight Notes system

Keep records pertinent to mission and post-mission activities:

- Maintain copies of all pertinent display information and RPOP data files
- Provide post-flight report of Proximity Operations profile with references to pre-mission planning

FDO/TRAJ Duties

The distinction between RNDZ FDO and RNDZ GPO responsibilities during a rendezvous rests on the functional differences associated with ground navigation versus orbit navigation. FDO is responsible for overall trajectory knowledge and control. FDO performs determination of Orbiter and Target state vectors based on ground tracking, and is responsible for maintenance of both healthy state vectors on the Orbiter, via uplink; FDO performs ground targeting of RNDZ burns based on these ground-derived state vectors, and is responsible for uplinking, via commands and voiced Preliminary Advisory Digitals (PADs), the resulting burn solutions. RNDZ GPO on the other hand is responsible for onboard NAV and the resulting computation of "improved" Orbiter state vectors (the "filtered" SV, or FLTR) based on sensor data (this involves maintenance of a proper COVARIANCE MATRIX on board, which also requires uplink of a CMD LOAD).

As the Orbiter-Target range decreases, responsibility shifts from RNDZ FDO to RNDZ GPO. By the time of T_i , FDO no longer can derive sufficiently accurate relative state information from ground tracking, so to continue to fulfill the ground targeting responsibilities, the FDO begins using the downlinked FLTR SV for ground computations.

RNDZ-specific FDO duties include the following:

- FDO uplinks Orbiter and target state vectors.

- FDO provides ground-targeted burns for BURN PADs and for COMMAND LOADS. These burns (NC, NH, NCC, Ti, Ti DELAY) are uplinked at least 30 minutes before TIG.
- TRAJ confirms that the desired maneuver has actually been performed to the proper accuracy. Actual delta -V values are passed to PROP.
- FDO fine-tunes separation and breakout burn sizes and advises if the "canned" burn can be improved.

PROFILE SUPPORT Duties

- FDO support for rendezvous trajectory control throughout the mission
- Provide expertise in ground RNDZ targeting
- Contingency profile analysis
- Prepares solution forms for ground-targeting maneuvers
- Compares real-time ΔV , relative states to pre-mission predictions through Ti.

MCC Interfaces

The RNDZ GPO team interfaces with other flight controllers (data flow, procedural inputs, etc.), listed alphabetically. These other specialists should have specific "RNDZ ISSUES" SCPs in their own console handbooks which contain this sort of detailed information. Other interfaces may be introduced on a flight-specific basis.

DPS

- Coordination with *DPS* is mainly in the area of GPC reconfiguration and restringing. The reconfiguration and/or restringing of GPC affect the availability of MDMs, sensors, effectors, jets, etc.
- *DPS* also uplinks the VARIABLE PARAMETER list used by the RNDZ team to gain insight into SPEC 34 ORBIT TGT parameters.

EECOM

- Coordination with *EECOM* is generally isolated to Bus failures and impacts of water dumps on STRK passes.

EGIL

- Coordination with *EGIL* is generally isolated to payload bay floodlights.

EVA

- RNDZ GPO team must be aware of impacts of EVA requirements upon the rendezvous.

FAO

- Off-nominal timelines must be coordinated with *FAO*, especially DELAYS. EVA PREP is also a scheduling impact.

GNC

- Close communication is required in monitoring the performance of ONAV-related hardware such as STRKs, IMUs, and the COAS. *GNC* designates the specific IMU to be deselected for a STRK pass, as entered on a previous burn PAD. *GNC* is also responsible for COAS calibration. Prior to navigation passes, the RNDZ team verifies the proper functioning of relevant hardware; during navigation passes, *GNC* is kept informed of any anomalies which may be due to hardware problems and thus be susceptible to workarounds; after each pass, joint evaluation of hardware performance is conducted.
- *GNC* is responsible for knowing the current available DAP loads and the current active configuration. *GNC* is the leading expert on DAP CONFIG specialist function display (SPEC 20).
- *GNC* is responsible for the functioning of both the THC and RHC hand controllers, SENSE switches, ADIs, the DAP, and DAP pushbuttons. *GNC* is also the resident expert on the S TRK/COAS CNTL specialist function display (SPEC 22).
- *GNC* is lead for all IMU issues.
- While PROP is responsible for the plumbing, *GNC* is responsible for the control authority derived from RCS jets.

INCO

- *INCO* is responsible for all Ku-band radar hardware operations and performance.
- *INCO* provides uplink of new covariance matrixes as required.
- *INCO* also monitors the RNDZ Radar (RR) self test.
- During RR NAV, *INCO* informs RNDZ GPO of all anomalies that may be associated with hardware problems.
- *INCO* may be asked about functions/data on the SM 201 (ANTENNA) display.
- *INCO* is responsible for operation of the CCTVs.
- *INCO* should inform RNDZ GPO of considerations of Ku-band jettison planning. Jettison is actually overseen by MMACS.

MMACS

- Coordination with *MMACS* is generally isolated to In-flight Maintenance procedures (IFMs) and docking system details.

PAO

- Coordination with *PAO* is generally isolated to preflight coordination of rendezvous events and to the real-time maintenance of the Visual Proximity Operations Processor (VPOP) by PROX OPS.

PAYLOADS

Real-time interfaces with PAYLOADS includes:

- Target attitude determination at nominal and delayed RNDZ points.
- Target sighting aids such as lights.
- Target attitude control system impacts on Orbiter.
- Target sensitivity to Orbiter effects such as RCS plumes and Ku-band power levels.

- Requirements for crewmember assessment of target status (attitude, motion, configuration).

PDRS

- *PDRS* monitors the operation and status of the Remote Manipulator System.
- *PDRS* should consult RNDZ during considerations of RMS jettison planning.

POINTING

- *POINTING* supports FAO. Through determination of attitudes for future events (target track, etc.), *POINTING* provides data that RNDZ GPO can use to verify proper vehicle attitudes during these operations.
- *POINTING* can be asked questions about the functioning of UNIVERSAL POINTING (OPS 201 display).
- *POINTING* provides a star tracker field-of-view plot against the celestial background.

PROP

- *PROP* monitors propulsive maneuvers in parallel with RNDZ, as specified on the RNDZ OMS BURN procedure, the OMS 2/ORB OMS BURNS cue card, and the RCS BURN cue card. *PROP* is prime for determining ENGINE SELECT and monitoring proper crew selection on OPS 202. Planning for any required PROP system downmoding is the prime responsibility of *PROP* and FDO, based on considerations of safety and mission success criticality.
- *PROP* keeps the MCC informed of loss of OMS engines, individual RCS jets, and of entire RCS manifolds. Other failure modes include jet fail on and OMS overburn.
- *PROP* is responsible for the OMS/RCS plumbing but the control authority derived from these jets is the responsibility of GNC.

ISS MCC Interfaces

The RNDZ GPO team also interfaces with ISS flight controllers for Space Station assembly and logistics flights. The following text provides descriptions of key ISS FCR operators. Again, other interfaces may be introduced on a flight-specific basis.

ACO (Assembly and Checkout Officer)

- Experts on integration and operations of Space Station Elements and equipment transfer to/from ISS.
- Develops technical documentation and flight procedures including ISS/Shuttle Operations Checklist and Assembly Checklist.

ADCO (Attitude Determination and Control Officer)

- Overall responsibility for the integration of all GNC and Propulsion activities (U.S. and Russian), including attitude determination and control, maneuver execution, momentum management, monitoring translational burns such as reboosts, maintaining a good navigation state, maintaining mass properties of the station and ensuring onboard GNC antenna and array pointing information is provided to other systems.

- Pre-mission phase (Increment 1, post 2R), *ADCO* will perform planning and analysis using the Flight Dynamics and Planning Analysis (FDPA) tool to generate attitude timelines, short-term propellant budgets, perform maneuver analysis and momentum management studies.
- During Flight Operations, the *ADCO* position is responsible for creating and updating the attitude timeline for the two week short term plan and integrating GNC/P operations such as reboost and attitude changes.
- *ADCO* will have additional system responsibilities for the ICM when it flies.

CATO (Command And Tracking Officer)

- Similar to the Shuttle INCO position, responsible for operating the S-Band, Ku-Band, Audio, Video, and UHF systems on the International Space Station.

ODIN (Onboard Data and Information Network)

- Supports ISS command and data handling.

OPS PLAN (Operations Planner)

- Similar to Shuttle FAO, supports changes to ISS timeline.

OSO (Operations Support Officer)

- Short-term planning, product development, maintenance prioritization.
- Long-term planning including support to sparing, manifesting, & logistics.

PHALCON (Power, Heating, Articulation, Lighting and CONTROL)

- Manages the power generation, energy storage, and power distribution capabilities of the Station Electrical Power System (EPS)

RIO (Russian Interface Officer)

- Coordination with *RIO* is generally isolated to coordination of the sequence of rendezvous, docking, and undocking events.

TOPO (Trajectory Operations Officer)

The Trajectory Operations Officer (*TOPO*) is the sole real-time trajectory flight controller for the U.S. ground segment of ISS operations. There is no “back room” support assistance, except when the on-duty *TOPO* calls for assistance from DM office workers when necessary. *TOPO* responsibilities in real-time operations include:

- Maintenance and processing of best-available Station trajectory data
- Serves as trajectory authority to ISS Flight Director
- Distribution of trajectory data to ISS systems and International Partners
- Supplying data for MCC world map
- Interface with USSPACECOM for Station debris avoidance operations, including state vector transfers
- Computation of orbital debris collision probability and determination of need for evasive translation maneuvers
- Support payload operations as needed, particularly regarding state vector predictions

- Construction of uplink loads, including those for onboard rotation / nutation / precession (RNP) matrix updates, TDRS state vectors, and ISS onboard state updates
- Support reboost maneuver activity and develop maneuver requirements to ensure ISS trajectory profile satisfies rendezvous and operational altitude limits. Verifies that reboost maneuvers are successful.
- Cognizance of visiting vehicle rendezvous and proximity operations techniques and status
- Ensure a safe Station trajectory with respect to jettisoned (intentionally or accidentally) objects

THOR (Thermal Operations and Resources)

- Responsible ISS subsystems that collect, distribute, and reject waste heat from core systems and payloads.

1.2 Console Handbook Management

PURPOSE

To provide a description of the structure, maintenance and quality control process for the Rendezvous GPO Console Handbook (CHB).

PROCEDURE

1. Development of New Specific Console Procedures (SCPs)

- Individual SCPs are written by specialists in the RGPO group.
- Draft copies are peer reviewed, then, a CR is generated to incorporate the new SCP into the book.

2. Maintenance

- The CHB is maintained by the book manager as a controlled document DM-CH-08.
- The official copies (one in MS Word and one in Adobe PDF) reside on the MOD web server in the DM34 folder. The Word version is maintained for user download or printing and the PDF version is maintained for online use.
- A copy of the signature page is linked from the electronic cover page. The original signed signature page is stored in the DM ISO9000 Quality Records cabinet.
- The DM ISO 9000 Master Document List includes the RGPO CHB and specifies the name of the book manager. The DM Master Document List can be accessed from the DM Web Site. When a user selects the RGPO CHB from the Master Document List, they are sent to the CHB on the DM34 web site.

3. Change Process

- Change requests may be initiated by any RGPO group member. The initiator downloads a copy of the SCP from the web page and make the desired changes. The initiator then obtains peer review, as required, from the RGPO group and incorporates any additional changes.
- The initiator then completes an online CR form, which can be accessed from the CHB web pages. Upon submission, the CR is automatically added to the CR database and assigned the next available CR number. The CR database is maintained on the DM34 web site and is accessible by all users. The CR database also serves as a change record for each Page Change Notice (PCN) or Revision to the CHB.
- The CHB Book Manager reviews the revised SCP for accuracy and verifies that appropriate peer review has been secured. The book manager will disposition the CR as required (approved, disapproved, etc) and update the status of the CR in the CR database. The book manager will collect individual CRs and hold them until an appropriate time to publish a new PCN or revision to the CHB.

- The approved changes are grouped together into a PCN or Revision which is signed by the group lead.
- The approved changes are then incorporated into both the web based Word and PDF versions of the CHB simultaneously to ensure consistency between downloaded and online versions. The CR numbers and affected SCP numbers are included on the signed cover sheet, which is scanned into a viewable file and stored on the web site. Additionally the web site file structure and CHB main page are updated as necessary. A change log for each PCN or Rev will be automatically be viewable through the web interface to the CR database. The DM34 web curator may assist with maintenance of the CHB web site files and structure, as well as the CR database.
- The book manager submits a hardcopy of the PCN or Rev to the DM quality records custodian.

4. Document Format

Header

- The text “SHUTTLE OPS” to define applicable missions
- The name of the responsible engineer: RESP: J. Q. Public
- The title of the SCP
- The book title and JSC number, in this case “RNDZ CHB/JSC DM-CH-08”
- The date and edition of book
- The number of the SCP

Footer

- The footer contains the words “Verify this is correct version before use.” to comply with ISO 9000 standards.

Title

- Full descriptive title for SCP.

Purpose

- This defines the intention of the SCP, why it was written, for whom, and under what circumstances it is invoked.

Procedure

- This is the meat of the SCP and defines the criteria, actions, and calls to be made under the circumstances addressed by the specific SCP. It is for fast console reference; detailed rationale may follow (see below).

Background

- This is a brief summary of the situation that requires the existence of this SCP and how it fits into the overall RNDZ team operation. As appropriate, the background information may be located below each SCP subsection.

Rationale

- OPTIONAL. If additional explanation of procedure steps is deemed desirable, it can be included here. Otherwise, it may merely be a reference to other documentation, particularly the RNDZ & PROX OPS H/B, by specific section/page. Often, one may combine the Background and Rationale into one subsection.

Equations, Figures, and Tables

- These are numbered with the SCP number, hyphen, and a sequential Arabic numeral (e.g., Equation/Figure/Table 1.1-5).
- Equation captions are positioned to the right of the equation, Figure captions are positioned below the figure, and Table captions are positioned above the table.

Pagination

- Pages within each SCP are numbered with the SCP number, hyphen, and a sequential Arabic numeral (e.g., 1.2-16).
- Table of Contents are numbered with the chapter number, hyphen, and a sequential Roman numeral (e.g., 3-ii).

Text Format

The BASIC REV B publication of the Rendezvous GPO Console Handbook uses the text styles included in the template document CHB MS Word Template that is stored on the DM34 web server with the MS Word version of the document.

To attach this template to a new or existing SCP: (MS Word 97)

- On the Tools menu, click Templates and Add-Ins.
- Select the Automatically update document styles check box in the Templates and Add-Ins dialog box. This will cause the styles from the template to be incorporated into the document. Styles in the document that have the same name as those in the template will be updated to match the template styles.
- Click Attach, and then select the template file.
- Click Open.
- The document styles should be automatically updated to reflect the template.

BACKGROUND

To standardize console documentation and operator procedures, DM34 published this CHB for use by RNDZ GPO and RPS. The CHB consists of individual procedures, called SCPs. Although no MOD-wide standardized SCP format officially exists, the various discipline console handbooks (e.g., PROP, GNC, EECOM) have evolved a traditional format that has proven most useful in MCC operations. The format described here is an adaptation of these traditional formats. This format is intended as a guideline only; some SCPs, due to the nature of the topic concerned, will deviate from this format if necessary.

The Change Process outlined above is in compliance with ISO 9000 standards.

2.1 Console Management

PURPOSE

To provide guidelines for operating in a shared console mode in the Trajectory MPSR.

PROCEDURES

A smooth and mutually non-interference sharing of the MPSR consoles requires coordination and consideration in a number of areas, including environment, console-mounted documentation, inter-team communication, workstation utilization, and hardware malfunction tracking.

Environment

The Trajectory MPSR consoles are shared with Ascent/Entry flight controllers, so the normal MCC operating standards of neatness and consideration are doubly applicable here.

Console Documentation

Many items of Ascent/Entry reference are mounted on the console beneath the Plexiglas cover. If these must be moved to mount RNDZ reference materials, they should be either replaced post-RNDZ or be stored in an envelope or folder in the console mailbox. Note that the bookshelves next to the console are used by both Ascent/Entry and RNDZ. Please do not remove the binders from the room, and please replace binders on the bookshelves when finished with the materials.

Inter-Team Communication

Mailboxes are maintained at each console for the teams that share them. These are to be used for Execute Packages, Console Documentation, etc., of a flight-control nature. These are not to be used for other purposes. Please do not toss material for Ascent/Entry GPOs; bring the material back to the office or place a note on the pile drawing attention to the material. Guideline here is to handle material from previous flight or long integrated simulation.

Workstation Utilization

The physical workstations are shared between Ascent/Entry and RNDZ, just as the consoles are. Several simple guidelines regarding workstation utilization are in order.

- Consult with the Group Administrator (GA) regarding the removal of any data log files after the shift is complete. Pager numbers are located on the console underneath the Plexiglas.
- Do not alter any of the "dot" files, such as .cshrc or .xsession, in the RGPO home directory. All RGPO users share the same files, so changes affect all RGPO users.

Reference: [SCP 2.9 WORKSTATION PROBLEMS](#).

Hardware Malfunction Tracking

Each team that experiences console or workstation malfunctions and/or servicing should notify other teams who may encounter the same problem. Any console or workstation maintenance should be noted with all relevant information in the mission log.

BACKGROUND

The two consoles used by the RNDZ Team MPSR operators are also used by other teams during Ascent/Entry. The primary users of the MPSR consoles are the GNAVs, ONAVs, A/E Guidance Support, ARD Support, and LSOs.

2.2 Console Documentation

PURPOSE

To define procedures for development and maintenance of the Console Log and Job Jar.

PROCEDURES

1. Console Log Overview

- The console log contains a time-tagged brief narrative of events with entries made as events occur.
- The console log is a single continuous document for each console position. The log is continued by successive controllers so that chronological order and continuity are maintained over shift changes. The newest materials are located to the back/bottom.
- Pages are numbered consecutively from launch to landing.
- Key facts or important parameters should be circled, boxed, or highlighted.
- Once written console logs are not altered. Incorrect entries or significant information not contained in the log are summarized at the end of the log. A reference to such notes is included the margin of the log.
- Auxiliary information is included at the back of the log. Copies of flight notes, FDF changes, and display hardcopies should be collected and labeled. A reference to each item is included in the console.

2. Console Log Contents

Orbiter Configuration and Systems Anomalies

Any nominal or off nominal orbiter system information including:

- Description of all Orbiter system anomalies, even if they do not affect systems needed for rendezvous, along with the possible cause(s), and any action(s) taken.
- DPS stringing and any related changes
- GPC, bus, or MDM Failures
- Sensor failures

Target Anomalies

Any abnormal or off-nominal configurations in the target, such as

- System issues or anomalies
- Attitude
- Rates
- Venting

- Appendages

Key Events

Time of key events such as

- Rendezvous Checklist steps
- Burns (note vector sources)
- Target tally-ho
- Vbar arrival
- Grapple

Communications

Any questions, conversations, or flight notes, such as

- Air-to-Ground questions.
- Communications with payload controllers.
- References to any flight notes written and any other information called up to the crew.
- References to any FDF changes.
- References to any Flight Rules invoked.
- Parameters out of normal or expected operating range.

The “Job Jar”

The Lead RNDZ GPO can create a “job jar” before the mission. The job jar contains a list of late-breaking actions to be performed by the team as well as a list of planned activities that should be performed on a given Flight Day. Both of these items can serve as a reminder to the Lead RNDZ GPO in organizing the activities of the RNDZ team, and it is recommended to review the contents of the job jar with the RNDZ team once before launch.

After launch, only the Lead RNDZ GPO needs to refer to the job jar. The Lead RNDZ GPO should review the job jar and place actions into the handover log. No other team member is to worry about maintaining the job jar.

2.3 DVIS Information

PURPOSE

To describe the DVIS system and the DVIS loops of interest to the Rendezvous team.

PROCEDURES

DVIS Pages

The Rendezvous team is assigned 6 total DVIS IDs with 10 pages available per ID.

- IDs 4213 1234 and 4214 1234 are reserved for FCR use at keysets 4213 and 4214. All pages are reserved as noted below.
- IDs 4702 1234 and 4703 1234 are reserved for backroom use at keysets 4702 and 4703. All pages are reserved as noted below.
- IDs 8213 1234 and 8214 1234 are available for use anywhere. Page 1 is reserved as noted below. Pages 2 through 10 can be modified by individuals as needed.

NOTE: Logging onto the keysets at the RGPO and RPS positions using the keyset number only (without the 1234 extension) brings up pages assigned to Ascent/Entry. **Please do not modify these pages.** Log out immediately and logon again using the 1234 extension.

As noted above, some of the pages are reserved for a particular team member. Do not modify pages other than your own or the group pages.

Table 2.3-1 DVIS Page Assignments

Page	Assigned To	Page	Assigned To
1	Yencharis	6	Harshman
2	O'Rourke	7	Fletcher
3	Rickerl	8	Spehar
4	Walker	9	Dunham
5	O'Dosey	10	Bigonesse
1*	Machula	6*	(open)
2*	(open)	7*	(open)
3*	(open)	8*	(open)
4*	(open)	9*	(open)
5*	(open)	10*	(open)

* applies to DVIS IDs 8213 1234 and 8214 1234 only. All others page assignments apply to DVIS IDs 4213 1234, 4214 1234, 4702 1234, and 4703 1234.

DVIS Loops of Interest

Most loops are followed by a number, indicating which FCR they support (1 or 2). The exceptions are the Air-to-Ground 1 and 2 loops; the FCR number precedes the loop. Refer to the Table 2.3-2 for more details.

Multi-Access allows the user to talk on multiple loops simultaneously. Refer to the DVIS help information available at the console.

Included at the end of this section is a blank DVIS keypad layout chart for personal use.

Configuring DVIS

Push the "CONFIGURE" button and then select the appropriate cell to be configured.

- 1) KNOWN LOOP ID Number (see Table 2.3-2)
 - a) Enter the mode for the cell.
 - 1: M - Monitor
 - 2: HM - High Monitor
 - 3: TL - Talk Listen
 - 4: TLM - Talk Listen Monitor
 - b) Enter the loop ID and press "ENTER".

- 2) UNKNOWN LOOP ID Number
 - a) Press 8 on the keypad to go to the directory.
 - b) Press the "SELECT PARTITION" button and choose the correct partition and hit "ENTER".
 - c) Press the "SELECT ALPHA LIST" button and push the correct keypad button that corresponds to the first letter of the loop name. Then press "ENTER". If there are multiple letters on a keypad button, pushing it again will select the next letter.
 - d) Highlight the correct loop ID. Push the corresponding button for the desired mode of the loop. This will take you back to the original page being configured. Press "ENTER" on the keypad to finalize the selection.

BACKGROUND

Reference: DVIS Ground Rules Loop Directory, JSC-28883

Table 2.3-2 DVIS Loops of Interest

Loop	Partition	ID	Description
1A/G 1, 1A/G2 2A/G 1, 2A/G 2	MCC	2011, 2012 3011, 3012	(FCR 1 or 2) Air-to-ground loop (1, 2)
A/G UHF 1 (2)	MCC	2013, 3013	Air-to-ground UHF-only loop, prime and backup
ADCO 1 (2)	SSC	4304, 4404	ISS FCR ADCO Loop
AFD CONF 1	MCC	2002, 3002	Auxiliary FD loop for debriefings/conferences
A/P COORD	MCC	2103, 3103	POINTING contact loop
ASMBLY OPS 1	MCC	4346	ISS Activation and Checkout Officer (ACO)
DFE	MCC	7307, 7316	Data Flow Engineer loop for playbacks
EBS SPEC EVENT	MCC	7698	Secret broadcast loop
FAO 1 (2)	MCC	2101, 3101	FAO loop
FD1 (2)	MCC	2001, 3001	Prime and backup shuttle FD loop
FM/AM	MCC	7699	Tunes
GC CALL	MCC	2022, 3022	GC loop for ground support actions
HOUSTON CONSULT MH 08	MCC	4228	Houston Consultant Group contact loop in Moscow ("Loop 8")
INCO	MCC	2301, 3301	INCO loop
ISS FD 1 (2)	SSC	4333, 4433	ISS Flight Director prime and backup loops
ISS TRAJ OPS1 (2)	SSC	4348, 4448	TOPO FCR to MPSR loop.
LANDING SUPPORT	MCC	2751	Auxiliary Trajectory MPSR loop (when not used by LSO)
MISSION AUDIO	MCC	2051	Audio patch for special feeds
MMACS 1 (2)	MCC	2801, 3801	MMACS loop
MOCR DPS/CDMS 1 (2)	MCC	2915, 3915	DPS loop
MOCR DYN 1 (2)	MCC	2707, 3707	FDO/GPO prime loop
MOCR GNC/PROP 1 (2)	MCC	2402, 3402	GNC/PROP loop
MOCR SPEC 1 (2)	MCC	2811, 3811	PDRS/EVA loop
MOCR SYS 1 (2)	MCC	2507, 3507	EECOM/EGIL/MMACS loop
MPSR DYN A 1 (2)	MCC	2761, 3761	FDO support loop
MPSR DYN B 1 (2)	MCC	2762, 3762	GPO support loop
NASA SELECT	MCC	2049	NASA Select audio feed
NAV SUPPORT	MCC	2781	GNAV loop
NBC NTWK MON	MCC	2047	NBC Commercial loop
OPS ACTION 1 (2)	MCC	2005, 3005	Payload troubleshooting loop
OPS SUPPORT 1 (2)	MCC	2204, 3204	Payload data/systems loop
PAO CALL	MCC	2039	Public Affairs Officer contact loop
PAYLOAD 1 (2)	MCC	2201, 3201	Payload Officer loop
PHALCON 1 (2)	SSC	4322, 4422	ISS Power, Heating Articulation, Lighting and Control loop
PRIME OPS 1 (2)	MCC	2203, 3203	Remote POCC loop to Payload Officer
RIO CONSULT	MCC	2342	Alternate RIO loop
RIO MOCR	MCC	2340	Main Russian Interface Officer loop
SDP DYN	MCC	7208, 7210	DYNAMICS loop
SPAN	MCC	2081	Mission Operations Integration Room (MOIR) Manager loop
TOPO1, TOPO2	SSC	4347, 4447	TOPO prime and sim loops
WSS CALL	MCC	4065	Workstation Systems Support loop for workstation problems

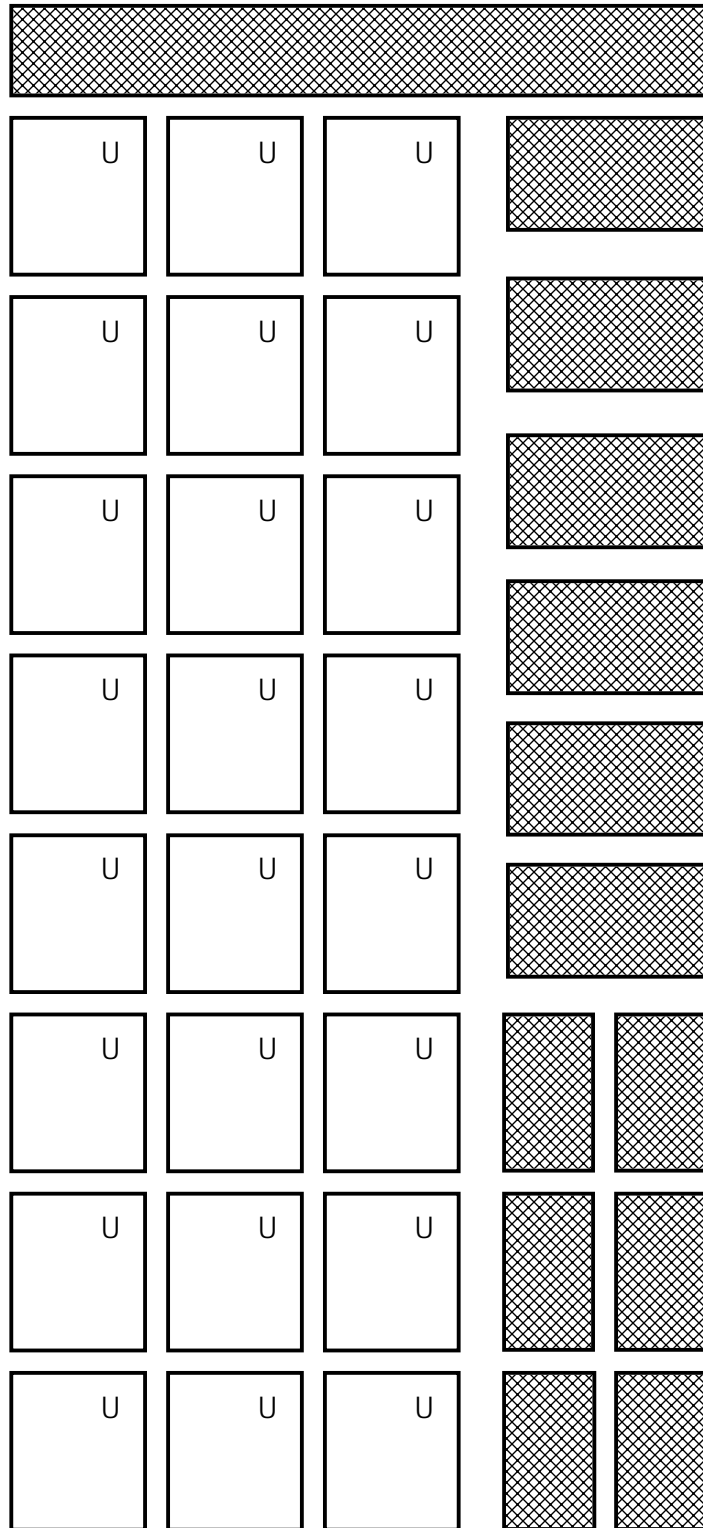


Figure 2.3-1 Personal DVIS Keypad Layout

2.4 Workstation Operations

PURPOSE

To define the steps for the initialization, display selection, and shutdown of the consoles.

PROCEDURE

1. General Workstation Initialization

Note: For workstation troubleshooting see [SCP 2.9](#).

- Check with GC regarding the workstation Activity to choose.
- Login using your personal ID. Contact Access Control and Audit (ACA) at number posted on console for password problems.
- Select the appropriate Activity and proceed with login.

2. Standard Config Initialization:

- This should happen automatically at activity selection. If it doesn't, or if you quit ROSS for some reason, it can be restarted as follows: select ROSS>Console Config>Telemetry - Standard. This will start the ROSS EXEC, ROSS GUI, and 10 ROSS streams:

00. PTM	G	- Orbiter telemetry stream
01. TCS2	S	- Trajectory Control Sensor payload telemetry stream
02. GDR	G	- Generic Data Retrieval from the Traj Server
03. PIM	G	- ISS telemetry stream (will be D for sims with no SSFT)
04. RCMP	G	- Rendezvous Computations
05. DGEN	S	- Some constants needed for calculations
06. ISUB	G	- ISP Subscribe stream from the RGPO ISP server
07. LOCI	G	- More rendezvous computations
08. SPEC	S	- ISP Subscribe stream from the DPS SPECS server (for crew keystrokes)
09. TS	G	- Some timing services that RGPOs don't need unless you start Acqmon

3. Master Config Initialization:

- This will also happen automatically at activity selection, but only if the RGPO ISP server is NOT yet running, effectively only for the first RGPO to log into the activity. If it does not, or if you stop (or de-configure) the Master Config for some reason, it can be re-started as follows: select ROSS > Console Config > Start Master. This will start the RGPO ISP server, VPOP Comps, and one ROSS stream:

10. IPUB **G** - An ISP Publish stream providing computed parameters to the RGPO ISP server for use by VPOP Comps.

- The Master Config can be moved from workstation to workstation. This can be useful in response to workstation problems.

- If the workstation running the Master Config has not failed outright, attempt to stop the Master Config gracefully by selecting ROSS>Console Config>Stop Master. If this is unsuccessful, (ISP server fails to quit), Call WSS and ask for a reboot. If the move is being done for convenience only, expect to see the ROSS ISP PUB stream go D . Also expect the RGPO ISP server quit, and everyone's ROSS ISUB streams go D until the server comes up on the new W/S. If the VPOP SGI is running the VPOP Graphics, they will crash. The VPOP user interface may also need to be re-started.
- Start the Master config on the new workstation as noted above. As long as the RGPO ISP server hasn't been down for more than a few minutes, everyone's ISUB streams should automatically re-connect.
- If VPOP Computations need to be restarted manually, select VPOP > Start VPOP Computations. Start VCR if desired ([See SECTION 2.6 Data Recording and Playbacks](#)).

3. Display Selection

- From the Rendezvous menu, choose the ROSS layout desired.
- Individual ROSS applications are available under the ROSS submenu.
- Other discipline's displays are available under the Master menu.

4. Shutdown

- Choose Logout from the window manager.

BACKGROUND

Workstations running ROSS form the basis of the monitoring software used by the Rendezvous GPOs. See the ROSS User's Guide for an in-depth explanation of the ROSS applications. Documentation of the ROSS layouts can be found in [SCP 7.3](#).

2.5 Telemetry

PURPOSE

To describe the workstation telemetry streams and the Master and Standard telemetry configurations. Also, this section serves as a quick lookup of various Telemetry Format Load (TFL) values that support rendezvous operations.

PROCEDURES

1. RGPO Master Telemetry Configuration

The RGPO master telemetry configuration is established on the RPS workstation while the rest of the RPGO team uses the RGPO standard configuration. In the master configuration two servers are established (RGPO and VPOP) which are then subscribed to by the other team workstations. The RPS also establishes a backup workstation to protect for master workstation failures. See figures 2.5-1 and 2.5-2 for RGPO master and standard telemetry configurations.

2. Stream Descriptions:

- RPUB: RGPO publication stream – writes to RGPO server (on RPS W/S)
- VPUB: VPOP publication stream – writes to VPOP server (on RPS or Prox Ops W/S)
- RSUB: subscription stream – reads from RGPO server
- VSUB: subscription stream – reads from VPOP server
- VCR: user created stream to record or playback telemetry data. See SCP 2.6 Data Recording and Playbacks for details.
- Data Acquisition (DACQ) Streams: All DACQ data (except GDR) is broadcast on the MCC LAN and a DACQ listener, running on each workstation, extracts the MSIDs desired by that workstation. This extracted data is then passed onto the individual DACQ streams as listed below.
 - PTM: The bulk of the RGPO data comes from this stream. This is the main Orbiter downlist that comes from the Front End Processor (FEP) – no MOC is required for this data.
 - PPM: Payload and TCS stream(s).
 - GDR: Data from the MOC/Trajectory Server including state vectors.
 - DGEN: Data Generation Stream. Used to set constants required by other ROSS applications. This includes T1 TIG slots, TCS unit IDs, Orbiter/Target weight, CD and area.
 - RCMP: Rendezvous Computation Stream written in C language. Computes Orbiter LVLH attitude, LVLH position, time, etc.

- LOCI: Used for other rendezvous computations that have not yet been ported to the C language for RCMP including Time to 150 and 135kft, high data rate jet firing alarms, Radar data (gimbal angles, etc.). (The LOCI applications are written in an interpreted script language called oc (pronounced "oak").

3. Troubleshooting:

Failure of RPS Master workstation:

Assuming the RPS backup workstation is still operating normally:

- RPS calls WSS on WSS CALL loop to notify of problem and obtain concurrence to reboot workstation.
- RPS attempts to restart the workstation
- RGPO team members either wait for restart of the RPS workstation
-- OR --
- Change their subscription to the backup RPS workstation:
 - Double click on RSUB stream
 - Change SOURCE to RGPO2
 - Reconnect stream

Note: The backup workstation configuration does not currently include VPOP computations (i.e. sunrise, sunset clocks, TCS IF to IF data). To regain this data the users must be subscribed to the RPS prime workstation.

General Telemetry Problems:

- The spinning ICON on the ROSS GUI tells you that both the ROSS executive and ROSS GUI are running.
- Status indicators for each streams are interpreted as follows:

Table 2.5-1 ROSS Stream Status

Indicator	Meaning
G	Good
S	Static
D	Disconnected
I	Initializing
O	Time Overrun (stream taking too long)
T	Stream is terminating
A	Attention required by user

- Holding the mouse over the status indicator for a given stream brings up a popup that indicates how many parameters were processed by the stream over the last cycle.
- The ISPMON application tells you if the ISPNUL servers are running
- If an SUB or PUB stream comes up disconnected, then most likely the associated server is not running. Once the server is started, the stream should automatically reconnect.

Figure 2.5-1 RGPO Master Configuration – RPS Workstation

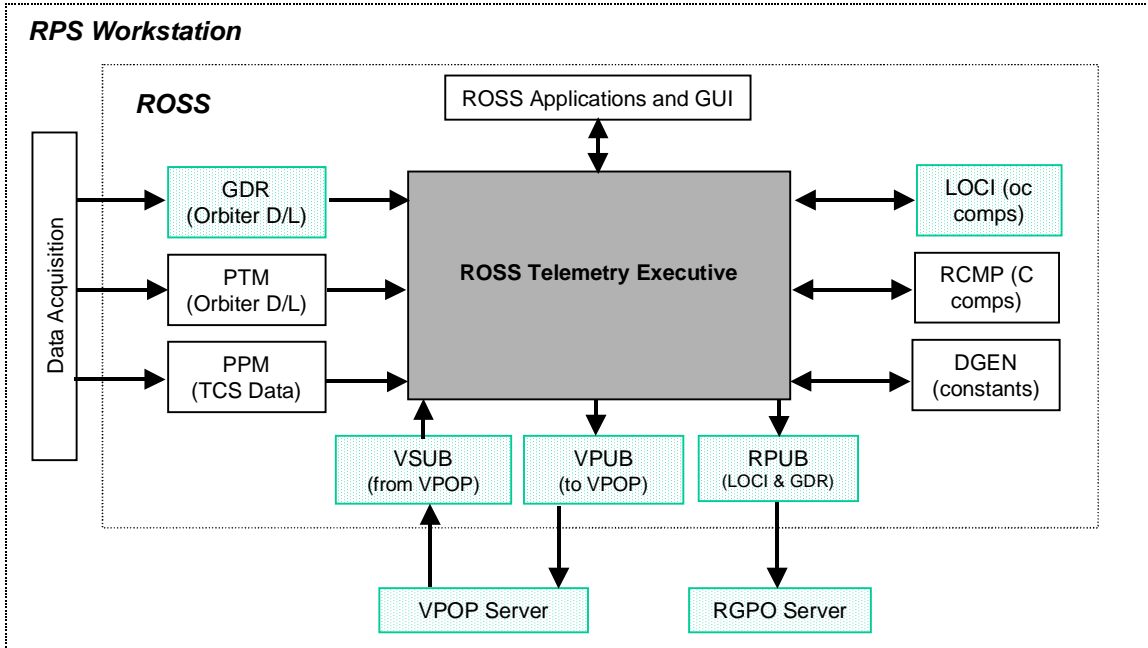
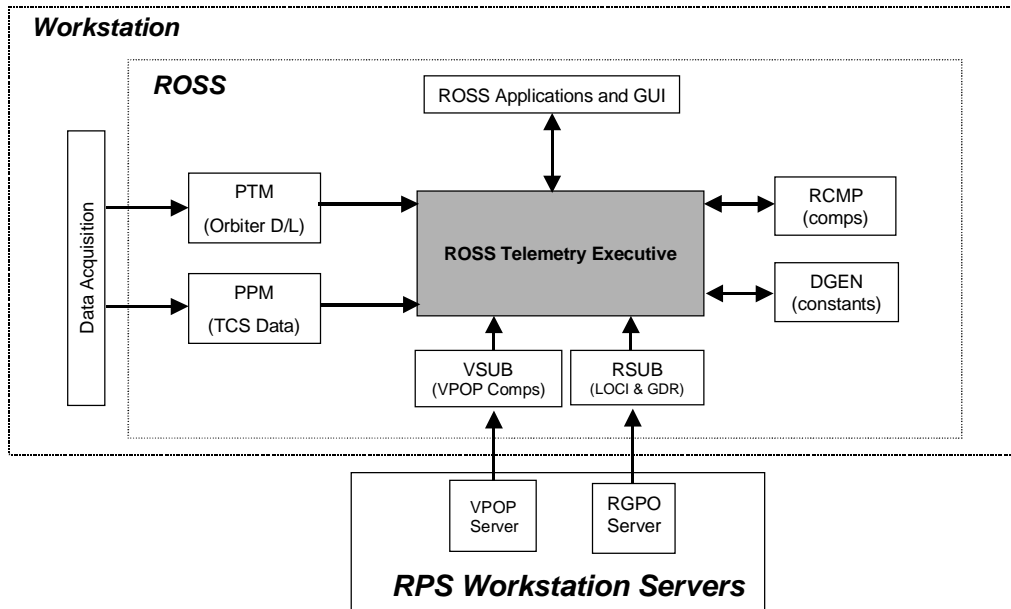


Figure 2.5-2 RGPO Standard Telemetry Configuration
RGPO and Other User W/S



BACKGROUND

Telemetry Formats

The TFL is basically a set of instructions for storing each telemetry parameter in a specific location in the formatter RAM. There are standard characteristics of the format that do not change between flights, as well as flight-specific format characteristics. Telemetry formats are built in the PCMMU telemetry formatter and are determined by the Telemetry Format Load (TFL) that is supplied to the PCMMU by the SM application, which, in turn, retrieves the TFL from the Mass Memory Unit (MMU) during the TFL load process.

Flight-specific TFLs can be found on the Portable Onboard Computer Control Board page at <http://ranger.jsc.nasa.gov/DL2/poccb/index.html>. The generic and flight-related requirements and planned usage for all TFLs can be also found in Space Shuttle Telemetered and Recorded Data Format Requirements. TFL requirements are summarized in Section 5 of the Payload Management (PM) Flight Software Requirements (FSR) for each flight. The presence of an MSID within a TFL can be determined by an MIS query as described in Section 49.2.1.2. See Table 2.5-2 for an example of flight-specific TFLs for STS-108.

Table 2.5-2 STS-108 TFLs for Various Operations

Application	Packet ID	TFL Stream	TFL Support ₁	Output for Prime config (on WinDecom PGSC) ₂	Output for RMS config (on WinDecom PGSC) ₂
3D Orbiter	15	GNC	129,161,164,179,184,185,192,199,203,205,206,211,212	Net, 1, 2	Net, 1, 2
	17	GNC	129,161,164,179,184,185,192,199,203,205,206,211,212	Net, 1, 2	Net, 1, 2
Cabin Leak	23	OI	161,184,188,205 (164,192,199,211,212) ₄	Net, 1, 2	Net, 1, 2
	24	SM	161,184,188,205 (179,185,203,206) ₄	Net, 1, 2	Net, 1, 2
FCMS	32,33,34	FCMS	Any	Net, 1, 2	Net, 1, 2
Packet Display Program	All avail	any	All available	Net, 1, 2	Net, 1, 2
POC Plot					
RSAD	27	SM	161,179,184,185,188,203,205,206	Net, 1, 2	Net, 1, 2, 4
RPOP	40	GNC	129,161,164,179,184,185,192,199,203,205,206,211,212	Net, 1, 2, 4	Net, 1, 2
Water Dump	28	OI	129,161,164,184,188,192,199,205,211,212	Net, 1, 2	Net, 1, 2
WorldMap	15	GNC	129,161,164,184,192,199,205,211,212	Net, 1, 2	Net, 1, 2
Time Vector	30	OI	(179,185,203,206) ₄	Net, 1, 2	Net, 1, 2
Server			129,161,164,184,192,199,205,211,212 (188) ₄		

₁ Only HDR ascent, on-orbit, and entry TFLs listed. TFL 129 is an ascent and fixed TFL and TFL 164 is an entry TFL. Reference Document JSC-19478-108 (PL Mngt Level C Flight S/W Requirements)

₂ Prime Config: Network; COM1 and COM2 @ 38400 Baud; COM4 @ 9600 Baud

RMS Config: Network; COM1 and COM2 @ 38400 Baud, and COM4 @ 19200 Baud

₃ 10.2 Depress uses only packet 35 as default. If needed, can be manually switched to use packet 25 and 30.

₄ Application may not receive all required packets when configured in any of these TFLs shown in parentheses

Table 2.5-3 Packet IDs

Packet ID	Description
15	Orbiter and target state vectors Radar range and range rate data Quaternion Angular rate
17	Attitude error M50 to LVLH quaternion
22	RCS quantities OMS He pressures
23	GMT and MET Non-prop consumables Cabin dP/dT Cabin pressure
24	Non-prop consumables
25	Cabin dP/dT Cabin pressure PPO2
27	RMS parameters
28	Supply/waste H2O parameters
30	GMT and MET
32	Fuel cell #1 subcell voltages
33	Fuel cell #2 subcell voltages
34	Fuel cell #3 subcell voltages
35	Cabin dP/dT Cabin pressure PPO2 A, B, C External airlock pressure Overboard airlock pressure GMT and MET
40	Orbiter and target state vectors Radar range and range rate data Quaternion Angular rate DAP info

2.6 Data Recording and Playbacks

PURPOSE

To specify techniques and rationale for telemetry and video playback.

PROCEDURES

1. Telemetry Playback During a Flight

Reference: FCOH SOP 4.5.

- Coordinate GMT/MET interval of playback with RNDZ GPO Team.
- Coordinate with INCO to determine at what time the data for the requested interval will be dumped, and verify that the dump has taken place.
- Complete Mission Data Request Form (MDRF) and send to GC.
- Verify with GC that the data has arrived at the MCC and is available for playback.
- Coordinate with GC as necessary to define how data will be viewed – i.e. what the new activity name will be, which workstations the data will be sent to, etc.
- Coordinate with other disciplines that might be interested in the playback data.

Background:

Playback of Orbiter data may be of interest to the RNDZ team as follows:

- Playback of LOS Events
Depending on TDRS and ground site coverage, some events might occur during LOS periods. These include navigation passes, onboard targeting, and propulsive maneuvers. If anomalies arise during the event in question, a playback can be requested. This may allow for identification of the anomaly and subsequent modification of procedures, if required. Both the ODRC and realtime telemetry playback are options for obtaining this data.
- Playback of AOS Events
Events that occurred AOS may be revisited via playback to process and display telemetry in different formats, on different displays, or with attention placed in other areas. ROSS log file delog, ODRC, or realtime telemetry playback are all viable options for obtaining this data.

2. Post Flight/Sim Full Telemetry Data Playback:

Reference FCOH Sections 10.1 and 10.2.

- Call the sim recorder group at x35981.
- Ask them the tape numbers for the sim or flight timeframe (provide applicable GMT begin and end times).
- Request a 30-day hold on those tapes.

- Call TOCCS lab representative.
- Request/schedule a comp run on the OPS side (not CDE).
- Give him/her the tape numbers.
- Tell him/her if you need a MOC (if a FDO wants to be involved).
- During the playback, configure the workstation as for flight / sim and record ROSS data if desired.

Background:

This procedure is for playing back all downlinked telemetry from a sim or flight. Generic simulation tapes are maintained for 7 days, flight specific sim tapes are maintained until the flight launches, mission tapes are maintained until the next flight of that vehicle.

3. ROSS Telemetry Recording (VCR)

- Right Mouse Click on the spinning globe.
- Select New Stream.
- Select VCR for Stream Type.
- Select RECORDER for VCR Type.
- Log file name will default to ACTIVITY_GMT (ex: SSP096_185:XX:XX:XX.log). If you input your own file name, be sure to include the preceding path info as well (/users/rgpo/ross/log) or your VCR stream will not connect.
- Press CONNECT.
- If not automatically recording, press the RECORD button on the VCR CONTROLS, make sure that the record counter starts increasing.
- DISMISS the screen (be sure to open and stop recording when data recording is no longer needed).
- If your log file needs to be preserved, such as actual flight data or interesting sim cases, open an XTERM window and navigate using cd to ~rgpo/ross/log. Rename your log file per the following naming convention:

STSXXX-FDYY-payload-event.log

STSXXX – STS flight number (STS097, STS112)

FDYY = Flight Day number (i.e. FD03, FD11)

payload = name of payload (i.e. ISS, SPARTAN, HST)

event = a simple high-level description of what was happening (i.e. rndz, undock, deploy)

- Compress the log files using the command: **gzip STSXXX-FDYY-payload-event.log**

Provide a list of the flight log files to any TOCCS lab Group administrator and request that they be archived to the IPS archive server.

Background:

The ROSS telemetry will be recorded, however, non-ROSS telemetry (i.e. crew keystrokes, Onboard Fault Summary (OFS)) will not be recorded.

4. ROSS Telemetry Playback (VCR)

- On DNAV, Select TELEM TOOLS > ROSS Playback.
Telemetry will be initiated, VPOP computations will be initiated and a VCR stream will be created.
- Select the VCR stream.
- Select the appropriate log file. It should default to the correct folder. Select the right name for the log file. Note: the normal path to log files is ~rgpo/ross/log.
- Press CONNECT the data will start flowing to all ROSS alarms. All data should be flowing to all ROSS alarms and paramplots currently displayed.

5. ODRC Data Retrieval

See SCP 9.7 MEWS HELP NOTES.

6. DVIS Voice Loop Data Retrieval

- Only the left-hand DVIS (4213) is recorded for flights, so make sure any loops you want recorded are active on that DVIS. It is unclear what, if anything is recorded for sims.
- Obtain a Mission Data Request Form (MDRF) from the GC console.
- Complete MDRF and deliver to the Voice Control group on the first floor of the old MCC.
- Specify the GMT of the start and end of the desired information as well as the DVIS console number(s) of interest.
- Once the Voice Control group place a MDRF number on the MDRF, take your copy of the MDRF and wait for delivery of tape.

7. Video Tape Recorder (VTR) Playback

- Coordinate the times at which the docking video will be downlinked from the Orbiter. This should be coordinated with the Flight Affairs Officer (FAO). Note that the time will vary based on crew workload. This is normally done several hours after docking. Make sure you note the exact GMT of when the playback occurs, for use in the following steps.
- Fill out a Mission Data Request Form (MDRF), which can be found in hard-copy format only at the Ground Control (GC) console.
- When filling out the form, be sure to request Shuttle Downlink (or other video source as necessary) during the appropriate GMT timeframe. Leave your office number as a contact.
- Submit the form back to GC, who will fax the request to Houston TV personnel in Building 8.
- When Houston TV calls to let you know the video is ready, go to Building 8 to pick it up. It is convenient to use the door facing the duck pond. The tape should be in VHS format. If after hours, use the buzzer to the right of the door to ring the attendant (and note that it only buzzes for as long as you're holding it down).

2.7 MSKs/TV Channels of Interest

PURPOSE

- To list the RF and Picture-in-Picture channels for VPOP and RPOP.
- For historical purposes: to list the old MSKs of interest to the Rendezvous team.

PROCEDURE

VPOP/RPOP Video Channels

The Visual Proximity Operations Processor (VPOP) and the Rendezvous Proximity Operations Program (RPOP) outputs are directed via hardware to video switcher units that provide the data to the rest of the flight control team over RF TV or via the workstation application "Picture in Picture."

Table 2.7-1 RPOP and VPOP Video Channels

Application	Picture-in-Picture	B30S RF TV
RPOP	47	51
VPOP	34	44

MSKs of Interest

For the historical record, a list of MSKs of interest is provided below. Many of the MSKs listed below have been superseded by workstation applications. Examples are SPECS from DPS (replaces 1346/7 SCRATCHPAD), and FAULT from DPS (replaces 1345 FAULT 1). One notable exception to this rule at present is FDO who is still MSK-based.

Table 2.7-2 MSKs of Interest

MSK	Description	MSK	Description
0901	ANT MGMT A	1107	PROP RNDZ
2330	ATTITUDE TIMELINE	1882	RMA STATUS
0421	COVARIANCE	0482	RMD [<i>Relative Motion Digitals</i>]
2756	DAP ERROR ATT	1888	RNDZ PROX OPS
2744	DAP ERROR RATE	1102	RCS DETAILS
2626	DATA FLOW ENGINNERING	1024	RMS STATUS
0476	DMT [<i>Detailed Maneuver Table</i>]	0480	RNDZ EVAL TABL
1305	FAULT 1	1346	SCRATCHPAD HISTORY 1
1404	GNC CONTROL	1347	SCRATCHPAD HISTORY 2
1405	GNC SENSORS - ORB	2747	ST FOV [<i>Star Tracker Field-of-View</i>]
1414	IMU SUMMARY	0461	SUNRISE/SET (GMT)
0964	KU RADAR SM [<i>Self-Test</i>]	0462	SUNRISE/SET (PET)
0962	RDR/COMM STATUS	1875	SUPERSIGHTER
0549	ONAV ORB STAT	0459	TDRS AOS/LOS (GMT)
0790	ORBITER E/S POINTING	0458	TDRS AOS/LOS (PET)
1879	POINTING SUMMARY	0372	VECTOR COMPARE
0455	PSAT (GMT) TGT		
0456	PSAT (PET) TGT		

2.8 Facility Problems

PURPOSE

To describe procedures and points of contact for facility problems. Refer to SCP 2.9 WORKSTATION PROBLEMS for details on workstations.

PROCEDURE

Report problem immediately to contact listed in table 2.8-1. Contact GC on GC CALL for any equipment, procedural, or processing problem. Identify console number, keyset number, etc., as appropriate.

If applicable, document problem as soon as possible using a [Anomaly Report](http://usa10.unitedspacealliance.com/tx/drts/) (AR) (<http://usa10.unitedspacealliance.com/tx/drts/>). Refer to

DM-SW-01 [DM GAF FDD User Involvement in the Formal MCC Software Life Cycle](http://mod.jsc.nasa.gov/dm/division/documents/DM-SW-01.doc) (<http://mod.jsc.nasa.gov/dm/division/documents/DM-SW-01.doc>) section 4.1.2.2 AR Process for AR submission details.

Table 2.8-1 Points of Contact for Facilities Problems

Console Equipment/Support Data Flow Problems	Contact Position	DVIS loop or Extension
Workstations	GC (FCR) WSS (MPSR)	GC CALL WSS CALL
TSTAC	VIDEO DSS/FSM	x36931 or x31818 x35615 or x35665
RPOP/VPOP Video	GC	GC CALL
Air conditioning	GC	GC CALL
Lighting/power	GC	GC CALL
DVIS Keyset	HOUSTON VOICE	VOICE CONTROL

Note for RPS: When communicating with any facilities personnel, refer to yourself as "RENDEZVOUS SUPPORT" instead of RPS. They will then understand who you are and will be much more helpful.

BACKGROUND

GC "owns" the facility and thus is the primary point-of-contact for any problems with the facility. Certain problems can be referred directly to the subsystem specialist.

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2.9 Workstation Problems

PURPOSE

To describe recovery procedures for workstation problems.

PROCEDURES

Problem During Mission Support Time-Critical Phases

- Do not reboot the workstation.
The reason that a problematic workstation is not immediately rebooted is that WSS can often gather information on workstation problems through remote means. Key diagnostic data is destroyed when a workstation is rebooted.
- Immediately contact Ground Controller (GC) on GC CALL and report problem.
- Log problem in console log. Note the time, workstation ID, and a brief description of the problem.
- Move to backup workstation.
- When time permits, proceed with non time-critical actions, below.

Problem During Non Time-Critical Phases and Simulations

- Do not reboot the workstation..
- Contact Workstation Software Support (WSS) on WSS CALL and report problem.
- If you believe the problem is with a DM application, contact the RGPO Group Administrator (GA).
- If possible, expand Advisory Services to full screen and do a screen print. Repeat with DXConsole.
- Check with other workstation users for similar behavior.

Submitting an Anomaly Report

Refer to DM-SW-01 [DM GAF FDD User Involvement in the Formal MCC Software Life Cycle](http://mod.jsc.nasa.gov/dm/division/documents/DM-SW-01.doc) (<http://mod.jsc.nasa.gov/dm/division/documents/DM-SW-01.doc>) section 4.1.2.2 AR Process for AR submission details. For a TSTAC AR:

- Function Group: MCC: H/W Maint
- System: STANDALONE
- Application/Subsystem: CTHPC
- Sub-Subsystem: PC

BACKGROUND

GC is responsible for the overall health of the workstation hardware and operating system, assisted by WSS. The GA is responsible for the system administration of the Trajectory MPSR workstations, involving the general software configuration. The ROSS Application Sponsor is the resident expert on ROSS problems.

2.10 RGPO Preflight Checklist

PURPOSE

Provide direction for the lead of the Rendezvous Team prior to real-time flight operations.

PROCEDURE

Prior to start of sims

Tag-up with team. Go over pertinent flight rules, changes in procedures, crew preferences, expectations for team, etc.

Inside L-15 days

1. Complete the Configuration Checklist for the MCC.
2. Tag-up with PROP on "actual" vs. "budgeted" prop usage.
3. On the Orbit Trainer or SES, both RGPO and RPS go fly a rendezvous.
4. Hold RGPO team meeting within 2 weeks of launch, cover any issues with the flight.
5. Develop Job Jar for the shifts to work.
6. Set up directory/file structure on the flight directory.
7. Make copy of timelines, spreadsheets and other files that are required on the V: drive and on the MPSR C: drive, in case servers become inaccessible.
8. Develop Flight Rule summary for flight specific, Volume C & Volume A rules.
9. Have a complete Rendezvous book with all PCNs/errata completed.
10. Create a notebook for the console log, data book, Rendezvous Checklist and other FDF articles. Sections of the console log should contain, but not limited to:
 1. Console Log
 2. SADS Data
 3. Flight notes/Messages
 4. Burn Pads
 5. Execute Packages
 - Miscellaneous Data Copy of the RGPO tag-up notes
 - Beeper list (everyone, not just Cindy's beeper list)
 - Shift schedule

(continued)

6. Other FDF Articles

- Flight specific Rules
- Volume C rules
- JOIP
- On-Orbit ICD
- Vehicle Config Data Book
- Flight specific Orbit console handbook

11. Coordinate with Prox Ops on rendezvous tools checkout support.

BACKGROUND

All applicable software items on the RGPO DNAV pulldown menu should be verified using the Flight Load Checklist (FLC) between L-30 days and L-15 days. The FLC must be performed using a "CERT" ("MIS" or "SIM") activity for the flight of interest. If possible, applications should be used during a simulation run to verify functionality. It is the responsibility of the discipline to identify or arrange for an appropriate activity in which to perform the FLC. The objective of the FLC is to ensure that all required applications are available and properly configured in their flight support environment. This objective is met by actually running the applications on some representative input data and observing the results to be consistent within the context of available data and functions exercised. No qualitative or specific criteria are required to either prove or document success. There is no expectation to either execute or verify all of the functionality associated with each application. This check relies on the engineering judgment and training of the operator executing the FLC to select which functions to exercise and subsequently determine that the application appears to perform properly. **As such, the operator executing the FLC must be a prime user from the responsible discipline.** This checklist must minimally document each application on the RGPO DNAV pulldown menu and exhibit a pass/fail indication. It is responsibility of discipline to reconcile incompletes or failures via waivers, workarounds or resolutions. Any such actions should be documented with the FLC. It is responsibility of the discipline to accept the results of the FLC and archive all the associated documentation for future reference (for at least 3 months after launch).

2.11 Execute Packages

OVERVIEW

The Execute Package is created by the Planning Shift FAO based upon inputs supplied by the rest of the flight control team. It contains information to be uplinked to the crew as well as to be distributed to the controllers on the ground. Information such as a news summary, lighting and event summary for rendezvous, checklist changes, mass properties updates, and Earth observations deltas are contained in the package.

PROCEDURE

The type of information to change is covered by SCP 2.12 PLANNING SHIFT OPERATIONS.

- During or before the Orbit 2 to Orbit 3 shift handover, determine the input cutoff time.
- Coordinate scope and format of the changes with FAO. Determine whether to provide inputs as "WAS...IS..." or as new timeline/procedure pages
 - Provide a line-by-line correction in the following format, if feasible:
In the RENDEZVOUS C/L, page x-x, Block/Step xx:
WAS: xxx
IS: xxx
 - If the number of changes is too extensive for this format, produce new timeline/procedure pages and send to FAO, placing change bars next to the changes
- The updates can be submitted by copying a Word or other electronic file into the FAO inbox directory or by other arrangements made with FAO.
- FAO and his/her backroom will take the inputs and generate the execute package.
- The execute package can be reviewed via the PC application Joint Execute Package Development and Integration (JEDI). This application can be accessed from the JSC-MAS home page under the following tabs.

For missions use the **Mission: STS Users > Tools > JEDI** tabs.

For sims select the **Sim 1, Sim 2, or Sim 3** button, and then the **STS Users > Tools > JEDI** tabs

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2.12 Planning Shift Operations

PURPOSE

The following defines the duties of the Rendezvous GPO and his team on the planning shift prior to the nominal day of rendezvous. Many of these tasks may be performed at any time after launch; however, the planning shift prior to the day of rendezvous is responsible for ensuring the completion of these tasks.

PROCEDURE

The Rendezvous GPO team will review and/or perform the following during planning shifts:

1. **Impact Assessment and Workarounds of Anomalies**

Review all systems and other anomalies to determine impacts assessments on

- planned procedures
- timelines
- Flight Rules

Consult with other FCR operators as needed for specific inputs to changes needed to day-of-RNDZ procedures, other FDF items, or Flight Rules in the following areas:

- DPS hardware/software faults - DPS
- Communication coverage anomalies - INCO
- MCC hardware/software faults - GC
- Crew health and human factors - SURGEON
- Onboard FDF status (checklists, overlays, etc.) - FAO
- Preliminary PROP "bingo" PAD and prop margins - PROP
- Flight performance of IMUs, STRKs, Ku-Band - GNC, INCO
- SR/SS, TDRS handover, Pointing concerns (sun, stars, etc.) - POINTING

2. **Actual Trajectory Lighting and Communications Coverage**

- After final trajectory is determined, use Sunrise/Sunset tables to verify event times fall in the proper places in the existing timelines. Example: Ti burn should be at sunset minus 28 minutes, approximately.
- Use TDRS coverage tables to be aware of where events fall relative to LOS periods. Also, verify that handovers may be shifted to optimize communications around certain events.
- Work with RPS to generate new AOS/LOS and Sunrise/Sunset timeline pages for Rendezvous Checklist. Note: If these changes are minor, use as a console reference only.

- Review lighting and communication coverage at least 1 orbit past planned end of RNDZ activities.

3. MCC Software

- Reboot the workstations.
- Verify that the correct version of ROSS is available under DNAV.
- Start ROSS Telemetry services.
- Verify that CRANS, SPECS, FAULT, and ELOG can be executed from DNAV.

4. Celestial Background Check

- Coordinate with FAO and/or POINTING on the generation of celestial sphere background plots for star tracker passes (planned and post-Ti contingency). This is to anticipate possible bright celestial object passage in the star tracker field-of-view.
- Review beta angle, type of approach to the target, and sunrise/sunset times for the manual phase. This is to advise crew of possible bright object near the target.

5. Procedure Changes

- Review all procedure blocks that are relocated or added to the Rendezvous C/L for compatibility in DAP and Universal Pointing selections, arising from RMS, EVA, or system anomaly recovery steps.
- Try to minimize attitude maneuvers during the rendezvous phase to reduce dispersions in the trajectory. Coordinate TVR for all burns with FDO.
- Avoid planned FREE DRIFT and maneuvers from TGT TRACK attitude during navigation passes.

6. Target Features

Consult with Payload Officer to determine the following, if applicable:

- Target appendage status (PROX OPS and RMS clearance concern).
- Target attitude control system status (PROX OPS and RMS piloting concern).
- Target communications system status (Command timeline concern).
- Target power status (Payload ACS health concern).

7. Console Checkout

As time allows, verify the following:

- Console lights
- Workstation monitors
- VPOP and RPOP video connections
- Voice loops
- DVIS pages

8. Execute Package Preparation

See SCP 2.11 EXECUTE PACKAGES for details on how to prepare inputs for the execute package.

- Provide FAO with early estimates of the scope and size of Rendezvous GPO inputs to the package.
- Review the Rendezvous team's pre-flight submissions for the package, including checklist corrections and updates, flight rule modifications, etc.
- Submit items to FAO as soon as the materials are available so that processing can begin.
- Retain copies of all submitted materials for reference.

9. Electronic Timeline Page Uplink Preparation

This procedure describes how to generate rendezvous timeline pages for uplink.

- Prepare timeline pages as desired in MS Word.
- Verify that your PC has both the Cyrillic and Arial Box fonts loaded. One way to do this is to review the timeline pages and verify that each of the fonts looks correct on screen. Another way is to open the Fonts folder under the Control Panel and verify that Cyrillic and Arial Box are present.
- Print the desired pages on either the MPSR Pentium or the RGPO console Pentium using the "Print to File" print driver. This driver should be selectable from the pull-down list in the Print... box. If this driver is not available, see the instructions below for loading it.
- Copy the resulting PostScript (.prn) file to FAO's inbox directory. FAO's backroom will convert the file to a format that can be uplinked to the TIPS printer onboard. If there is any confusion with the FAO backroom, inform them that the file should be converted to a PCX file. This essentially amounts to an electronically scanned page, much as if you faxed a document directly from your PC.
- Ask FAO for a final TIPS printout of the file from their backroom. Verify that the file transferred and printed properly.
- The FAO backroom will take care of getting the timeline into EDP for review.

Installing the "Print to File" driver (if required per instructions, above).

Use the standard Windows 95 "add printer" wizard. Pick any printer to install -- the Traj1 printer is fine. Install the HP LaserJet 4P/4MP PostScript driver for the printer. Name the driver "Print to File". Upon exit from the printer wizard, right click on the printer "Print to File" to bring up Properties and make the following modifications:

- Under the Details tab, type "FILE:" (no quotes) into the "print to the port" field.
- Under the PostScript tab, select the PostScript output format "Archive format".

10. Execute Package Review

- Check all rendezvous procedural updates.
- Verify proper entry and exit between Flight Plan and Rendezvous Checklist.

- Verify all burn times (and especially base time).
- Verify accuracy of times, sequences, and relative order of all other events mentioned in both the Rendezvous Checklist and the Flight Plan.
- Verify the accuracy of rendezvous events and the attitude timeline along the bottom of the Summary Timeline.
- Verify other team's inputs for effects on the rendezvous procedures and timelines.

11. Rendezvous Team Handover Report

Review log and prepare a summary of the following for the on-coming Rendezvous GPO per SCP 2.2 CONSOLE DOCUMENTATION:

- Mission status.
- Orbiter systems summary.
- Payload status summary.
- Actions taken as noted above.
- Jobs complete.
- Jobs in work and their status.
- Jobs remaining.
- Any open actions remaining.

BACKGROUND

The main product of the planning shift is the FAO's Execute Package, the uplink message that amends the preflight FDF, in accordance with the subjects discussed above. Everything that can be sent up early should be. Coordinate these activities pre-flight with the Execute Shift Rendezvous GPO to ensure that the proper material is covered. The secondary product is a package of preparatory material for the on-coming RNDZ GPO team supporting the execute shift.

2.13 Shift Handovers

PURPOSE

To define procedures to be used by the team to allow an effective and orderly shift handover.

PROCEDURE

1. Shift Handover

Actions for the Outgoing RNDZ GPO are as follows:

- Contact incoming replacements in the event of shift schedule changes.
- Organize late-arriving plots, hardcopies, flight notes, FDF changes, and the console log.
- Complete a handover log summarizing events from the shift (per instructions in the next section).
- Remain on console until dismissed by the outgoing FD.
- Clear the MCC when handover is complete.

Actions for the Incoming RNDZ GPO are as follows:

- Review plots, console hardcopies, flight notes, and console logs.
- Review the handover log for specific actions to be performed on the upcoming shift.
- Prepare a brief written handover briefing to give to the oncoming FD.

2. Handover Log

Creating a new handover log:

- Create the directory U:\WORK\GPO\STS-XXX\HANDOVER, where STS-XXX is the mission being supported. This is done once during a mission.
- Double-click on the file U:\WORK\GPO\HANDOVER.DOC and complete the information in the dialog box that should pop up immediately
-- OR --
- Open a previous handover file from your flight, double click on the bar at the top of the document labeled “**Double Click on this bar to perform a shift change**”, and complete the information in the dialog box
- Either step automatically creates a new filename based upon the information you enter into the dialog box.
- The outgoing RGPO should type the shift handover information in the boxes provided, one each for the following topics:

Orbiter Anomalies

Summarize key Orbiter anomalies at a level appropriate for a handover briefing to the incoming FD. Place a reference to entries in the console log for more details, if required.

Payload Anomalies

Summarize key target anomalies that may impact rendezvous operations, again at a level appropriate for a handover briefing to the incoming FD. Place a reference to entries in the console log for more details, if required.

MCC/Console Anomalies

Summarize important anomalies related to building facilities.

Actions/Things to Do

List specific actions to be performed by the oncoming team during the upcoming shift. The Lead RGPO can list actions to be performed during the upcoming Flight Day. If a previously-listed task is not completed, leave the task here with a status update for the oncoming team. Only the Lead RGPO can delete actions without providing a resolution.

Completed

Move completed actions from the above section to this section, along with any notes concerning the resolution of the action. List any unassigned tasks completed in this section also. The Lead RGPO can delete entries from here as needed.

Notes

List any items here that do not fit into any of the above categories.

BACKGROUND

The RNDZ Phase execute shift is usually preceded by a planning shift and may be followed by an additional shift to support RMS berthing, EVA activities, or deploy. Typical rendezvous events occur with Orbit 3 as planning, Orbit 1 as execute, and Orbit 2 as the additional shift, but these may vary on a flight-specific basis. Proper documentation and handover activities are critical to smooth console operations. They are also critical to reconstructing flight events to support post-flight analysis and investigations.

The handover log is to serve as an aid to guide the oncoming RNDZ GPO in preparing a handover briefing to the oncoming FD and to serve as a guide for activities to perform on the upcoming shift. As such, it must be clear and concise.

The Microsoft Word template for the electronic handover log is located at

\\S:\Divisions\DM\Private\DM34\Documents\forms\handover.dot

2.14 Variable Parameter Requests

PURPOSE

This procedure explains how and when to submit the Variable Parameter Display Request form. This also includes information on where to obtain the HAL addresses.

Reference: Target Console Handbook section 3.2.3:
<http://usa1.unitedspacealliance.com/usahou/orgs/48-30/chb/OFDCHB.htm>

PROCEDURES


Overview:

The variable parameters list allows data not on the downlist to be downlisted from the orbiter. For rendezvous operations, Target generally requests through DPS support that the T1 TIG for onboard-targeted maneuvers be downlinked. This allows Target to confirm that the I-loads are correct and to determine the MC2 TIG slip without having the crew read down the TIG from SPEC 34. The T1 TIG is downlinked as the hexadecimal equivalent of the MET seconds.

Figure 2.14-1 shows an example of a completed VP Request Form. When the form is completed, three copies must be submitted to the DPS Support position. This can be done prior to the first sim or at the beginning of the first sim. Once the final load is built, the following forms are submitted prior to flight to DF2.

- the completed form
- a copy of the HALSTAT data showing the address. The HAL address for the T1 TIG can be found on the FSW Product CD for the specific flight.
- a table of the coverage times, as shown, if there is more than 1 span to be monitored

Figure 2.14-1 Example Variable Parameter Display Request form



USA
United Space Alliance

Variable Parameter Display Request

Submit 3 copies to DPS SPT

Requesting Discipline: **Rendezvous/Target** Name: **Dawn M. Gabriel** GMT: _____

Major Function/Operations:
 GNC 1 GNC 2 GNC 3 GNC 8 GNC 9 SM 2 SM 4

Coverage
 Snapshot(s) of Data Monitor for a Span of Time

Retention
 Current Flight/SIM only All Flight/SIMS

FROM: Specify Coverage: *(Reference Events or GMT's)*
NCC - 1 hour TO: Specify Coverage: *(Reference Events or GMT's)*
Post MC4

HAL Name	Address	K	BIAS	TYPE (2)	SLOT (3)
CGZV_T_MAN	E 4 D 4			FXS	
	E 4 D 5				

NOTES: (1) Optional Fields - Required for viewing on MSK 1352 (2) Type is FXS (Fixed-point) or FLS (Floating-point) (3) DPS Usage Only

Rationale:
Eliminate crew read down of orbit tgt (spec 34) data

Title (3) G N C V P S P E C 3 4 D A T A	DSM: (3) 230	DPS Signature (3)
--	-----------------	-------------------

STS-77 VP Request

Requesting Discipline: Rendezvous

Point of Contact: Tom Snyder (282-2832)

Event	Required VP Start Times (MET)	Required VP Stop Times (MET)
SPARTAN/IAE	(NCC-1 hr) 02/00:00:00.0	(MC4+1.5 hr) 02/04:45:00.0
PAMS-STU Proxyvous (P0)	(NCC-1 hr) 03/00:00:00.0	(VBN-P0+1.5 hr) 03/04:54:00.0
PAMS-STU Rendezvous 1 (P1)	(NCC-1 hr) 05/18:10:00.0	(VBN-P1+1.5 hr) 05/22:58:00.0
PAMS-STU Rendezvous 2 (P2)	(NCC-1 hr) 06/18:10:00.0	(VBN-P2+1.5 hr) 06/23:00:00.0

Note: all event start and stop times are based on the planned liftoff day and time. Actual MET start and stop times may vary if the launch slips, however, the times listed above should account for any slip.

3.1 DPS / EPDC

PURPOSE

To identify impacts from Data Processing System or Electrical Power Distribution and Control system failures.

PROCEDURES

DPS

For DPS Dictionary see: \\Jsc-mod-fs9\fd\Books\Current Published Documents\Generic\DPS Dictionary\Start Use On STS-101\Dps_gj5.pdf

1. DPS Definitions

- Common Set: all PASS GPCs that are processing PASS software and communicating with one another. May be running different application software.
- Redundant Set: Subset of common set made up of GPCs that are simultaneously receiving identical inputs, performing identical calculations and generating identical outputs.
- Simplex GPC: Operates independently. May or may not be part of CS. (BFS is not part of CS)
- SM: A simplex machine which communicates with other GPCs but is not part of the RS. For Rendezvous the SM is used only for radar acquisition of target (not for tracking).

2. RS Expansion or Contraction (or OPS Mode Recall)

- Rel Nav is disabled due to transition through Ops 0 (see SCP 4.2 RENDEZVOUS NAV SAFING & IMPACTS).
- Can only happen in X01.
- The target set of the NBAT is changed.
- The NBAT is invoked upon the OPS mode recall.

3. GPC Stringing / Restrung Planning

- Obtain the string configuration from DPS or from the DPS Overview Display on the workstation.
- Select appropriate DPS Stringing Chart 1212, 1221, 1122, or 1233 and update CRANS as applicable. Note: If the stringing is something else, such as 1232, use the chart with the closest pattern.

Note: The DPS Stringing charts reveal the relationships between GPC string assignments and the LRUs driven. The 14 RCS jet groups are listed according to string with PRCS and VRCS in separate tables. Any GPC string assignments resulting in "vulnerable" jet groups (i.e., driven from a single GPC) are annotated. An MDM table is provided at the bottom for quick assessment of system losses in the event of MDM failures.

- Mark current RCS Jets and other systems failures on chart and in CRANS.
- Determine translational or rotational losses or other vulnerabilities with stringing and jet losses.

Note: +Z translations MUST be one-fault tolerant to approach within 250 feet of the target. LOW Z counts as an added level of redundancy as long as it is not lost with the same failure that will take NORM Z.

Reference: Flight Rule A2.1.3-18.

- Be aware of impacts to IMUs, NAV sensors, DAP buttons, Hand Controllers and Flight Rules with the stringing.

4. DPS System Failures:

GPC Loss

- If flying triple G2 (stringing 1233) and GNC GPC fails:
For loss of verns: DAP PRI/AUTO
Likely Restraining xyxy – no impact to RNDZ NAV or Pointing
- Ti and PROX OPS: Two GNC GPCs are required at Ti and within 200 feet of the target. If a GPC fails, must evaluate which state vector should be saved if the failure occurred during sensor pass. If the PROP vector is better, a PROP to FLTR will be needed before the redundant set expansion. This is because the FLTR vector will be copied upon enabling RNDZ NAV to create the PROP. The target state vector becomes static until RNDZ NAV is enabled so a target track before RNDZ NAV is enabled might cause a large maneuver on UNIV PTG and will result in GPC computational errors.
- SM Loss: The SM is required for Ku Antenna Pointing using the GPCs. If the Antenna is already locked on the target, loss of the SM will probably not result in loss of lock. Reference: SCP 3.7 Figure 3.7-1.
- Note: With lowered cabin pressure (i.e. preparation for EVA), may have to operate with two GNC GPCs instead of three due to decreased heat dissipation capabilities.

MDM Loss: Reference MAL DPS 5.3

- Some apparent MDM failures may be caused by GPC or stringing problems.
- Expect multiple I/O ERROR messages and I/O RESETS while the crew attempts recovery. I/O resets take a minimum of 8 seconds to complete.
CAUTION: I/O RESETS will cause IMU swaps when one IMU is deselected.
- MDM power cycle may cause the associated IMU to "cage." A caged IMU can be recovered with an IMU-IMU align.
- PORT MODING may recover the MDM, lead to the loss of the related FF/FA MDM or (rarely) result in a GPC failure.
- MDM Card Failures will cause partial loss of MDM data. Serial and input card errors will result in a "BCE STRG X" error message; output card errors give no message.

- If failure recovery is not possible, determine the RNDZ capability lost or degraded (NAV, PROX OPS, MNVRs, etc.).
- MDM PL1 Sends KU pointing commands from the SM GPC to the Radar
- MDM FF3 Loss of FF3 puts you in a Radar Fail case. FF3 sends radar data from the KU to the GNC GPCs. The digital displays on A2 are hard wired to the RR. Loss of FF3 also results in loss of Verns.

EPDC

EPDC Bus Failures

MN Bus Failure:

- Wait for bus tie attempt – may not be done if short is found depending on where the short is. Otherwise may isolate the short and reestablish the remainder of the bus.
- Main DC buses may be cross-tied to recover redundancy after a Flight Critical bus loss.
- Confirmed shorts will result in shut down of all or part of the affected bus.
- Reference BUS FAILURES chart to determine impacts to rendezvous systems.

1212

■ Vulnerable to GPC failure

PRIMARIES		Jet Group													
String	GPC	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	F1F	F1L		F1U		F1D	R1A	L1A	L1L	R1R	L1U	R1U		
2	2	F2F		F2R	F2U	F2D		R3A	L3A	L3L	R3R			L3D	R3D
3	1			F4R		F4D				L2L	R2R	L2U	R2U	L2D	R2D
4	2	F3F	F3L		F3U		F3D			L4L	R4R	L4U	R4U	L4D	R4D
VERNIERS															
1	1									L5L				L5D	
2	2										R5R				R5D
3	1					F5R	F5L								
4	2														

Attitude Mnv	Jet Group													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+Pitch					1	1					1	1		
-Pitch				1									1	1
+Roll												1	1	
-Roll											1			1
+Yaw		1								1				
-Yaw			1						1					

Translation	Jet Group														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
+X							1	1							
-X	2														
+Y		1			1	1			1						
-Y			1		1	1				1					
+Z				1							1	1			
-Z						1	1							2	2
LO Z	2							1	1						
PCT						1	1							1	1

Degraded Translations	Jet Group														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
+X							1	OR 1							
-X	1														
-Z						1	1							1	1

MDM / String	GPC	IMU	STRK	RR	DAP Lts	DAP pb				ADI Att Ref pb	THC		RHC Aft
						Fwd		Aft			Fwd	Aft	
						Cntl	Axes	Cntl	Axes				
1	1	1	-Z		Fwd	A	A	C		Left	A	A	A
2	2	2				B	B			Right	B	B	B (p/y)
3	1	3	-Y	RR>Nav	Aft	C		A	A	Aft	C	C	C
4	2							B	B				B (roll)

Figure 3.1- DPS Stringing Scheme 1212

1122

■ Vulnerable to GPC failure

PRIMARIES		Jet Group													
String	GPC	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	F1F	F1L		F1U		F1D	R1A	L1A	L1L	R1R	L1U	R1U		
2	1	F2F		F2R	F2U	F2D		R3A	L3A	L3L	R3R			L3D	R3D
3	2			F4R		F4D				L2L	R2R	L2U	R2U	L2D	R2D
4	2	F3F	F3L		F3U		F3D			L4L	R4R	L4U	R4U	L4D	R4D
VERNIERS															
1	1											L5L			L5D
2	1										R5R				R5D
3	2					F5R	F5L								
4	2														

Attitude Mnvr		Jet Group													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
+Pitch						1	1					1	1		
-Pitch					1									1	1
+Roll													1	1	
-Roll												1			1
+Yaw			1								1				
-Yaw				1						1					

Translation		Jet Group													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X								1	1						
-X		2													
+Y			1			1	1			1					
-Y				1		1	1				1				
+Z					1							1	1		
-Z						1	1							2	2
LO Z		2						1	1						
PCT						1	1							1	1

Degraded Translations		Jet Group													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X								1	1						
-X		1													
-Z						1	1							1	1

MDM / String	GPC	IMU	STRK	RR	DAP Lts	DAP pb				ADI Att Ref pb	THC		RHC Aft
						Fwd		Aft			Fwd	Aft	
						Cntl	Axes	Cntl	Axes				
1	1	1	-Z		Fwd	A	A	C		Left	A	A	A
2	1	2				B	B			Right	B	B	B (p/y)
3	2	3	-Y	RR>Nav	Aft	C		A	A	Aft	C	C	C
4	2							B	B				B (roll)

Figure 3.1-2 DPS Stringing Scheme 1122

1221

■ Vulnerable to GPC failure

PRIMARIES		Jet Group													
String	GPC	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	F1F	F1L		F1U		F1D	R1A	L1A	L1L	R1R	L1U	R1U		
2	2	F2F		F2R	F2U	F2D		R3A	L3A	L3L	R3R			L3D	R3D
3	2			F4R		F4D				L2L	R2R	L2U	R2U	L2D	R2D
4	1	F3F	F3L		F3U		F3D			L4L	R4R	L4U	R4U	L4D	R4D
VERNIERS															
1	1									L5L				L5D	
2	2										R5R				R5D
3	2					F5R	F5L								
4	1														

Attitude Mnvr	Jet Group													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+Pitch					1	1					1	1		
-Pitch				1									1	1
+Roll												1	1	
-Roll											1			1
+Yaw		1								1				
-Yaw			1						1					

Translation	Jet Group													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X							1	1						
-X	2													
+Y		1			1	1			1					
-Y			1		1	1				1				
+Z				1							1	1		
-Z					1	1							2	2
LO Z	2						1	1						
PCT					1	1							1	1

Degraded Translations	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X							1	OR 1						
-X	1													
-Z					1	1							1	1

MDM / String	GPC	IMU	STRK	RR	DAP Lts	DAP pb				ADI Att Ref pb	THC		RHC Aft
						Fwd		Aft			Fwd	Aft	
						Cntl	Axes	Cntl	Axes				
1	1	1	-Z		Fwd	A	A	C		Left	A	A	A
2	2	2				B	B			Right	B	B	B (p/y)
3	2	3	-Y	RR>Nav	Aft	C		A	A	Aft	C	C	C
4	1							B	B				B (roll)

Figure 3.1-3 DPS Stringing Scheme 1221

1233

PRIMARIES		Jet Group													
String	GPC	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	F1F	F1L		F1U		F1D	R1A	L1A	L1L	R1R	L1U	R1U		
2	2	F2F		F2R	F2U	F2D		R3A	L3A	L3L	R3R			L3D	R3D
3	3			F4R		F4D				L2L	R2R	L2U	R2U	L2D	R2D
4	3	F3F	F3L		F3U		F3D			L4L	R4R	L4U	R4U	L4D	R4D
VERNIERS		Jet Group													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1									L5L				L5D	
2	2									R5R					R5D
3	3					F5R	F5L								
4	3														

Attitude Mnvr	Jet Group													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+Pitch					1	1					1	1		
-Pitch				1									1	1
+Roll												1	1	
-Roll											1			1
+Yaw		1								1				
-Yaw			1						1					

Translation	Jet Group													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X							1	1						
-X	2													
+Y		1			1	1			1					
-Y			1		1	1				1				
+Z				1							1	1		
-Z					1	1							2	2
LO Z	2						1	1						
PCT					1	1							1	1

Degraded Translations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+X							1	OR 1						
-X	1													
-Z					1	1							1	1

MDM / String	GPC	IMU	STRK	RR	DAP Lts	DAP pb				ADI Att Ref pb	THC		RHC Aft
						Fwd		Aft			Fwd	Aft	
						Cntl	Axes	Cntl	Axes				
1	1	1	-Z		Fwd	A	A	C		Left	A	A	A
2	2	2				B	B			Right	B	B	B (p/y)
3	3	3	-Y	RR>Nav	Aft	C		A	A	Aft	C	C	C
4	3							B	B				B (roll)

Figure 3.1-4 DPS Stringing Scheme 1233

Reference: Reference Data Book, Generic Rev E, July 8, 1999

FF1	A	PNL F6 (FWD L ADI) Sws (eight) IMU 1 Status
	B	F RCS MANF 1 JET RM CNTLRs/PBIs/SWs: - AFT DAP CNTL: chnl 3* - AFT RHC: chnl 1 - AFT SENSE sw: chnl 1 - AFT THC: chnl 1 - FWD DAP AXES: chnl A - FWD DAP CNTL: chnl 1
	S	IMU 1 NSP 1 -Z STRK
	O	-Z STRK FWD DAP LIGHTS
FF2	A	IMU 2 Status PNL F8 (FWD R ADI) Sws
	B	F RCS MANF 2 JET RM CNTLRs/PBIs/SWs: - AFT SENSE: chnl 2 - AFT RHC (pitch, yaw only): chnl 2 - AFT THC: chnl 2 - FWD DAP AXES: chnl B - FWD DAP CNTL: chnl 2 - FWD THC: chnl 2
	S	IMU 2
	O	F RCS MANF 2 JETS IMU 2
FF3	A	IMU 3 Status PNL A6 DISP (AFT ADI) Sws (three)
	B	F RCS MANF 4 JET RM MANF 5 JET RM CNTLRs/PBIs/SWs: - AFT ATT REF - AFT DAP AXES: chnl A - AFT DAP CNTL: chnl 1 - AFT RHC: chnl 3 - AFT SENSE sw: chnl 3 - AFT THC: chnl 3 - FWD DAP CNTL: chnl 3 - FWD THC: chnl 3
	S	IMU 3 - Y STRK RNDZ RADAR
	O	F RCS Manf 5 Jets F RCS Manf 4 Jets IMU 3 -Y STRK DISPLAYS - AFT DAP LIGHTS
FF4	B	F RCS MANF 3 JET RM CNTLRs/PBIs/SWs: - AFT DAP AXES: chnl B - AFT DAP CNTL: chnl 2 - AFT RHC (roll only): chnl 2
	O	F RCS MANF 3 JETS

FA1	D	L RCS MANF 5 JET RM L, R RCS MANF 1 JET RM
	O	L RCS MANF 5 JETS L, R RCS MANF 1 JET vlvs
FA2	D	L, R RCS MANF 3 JET RM
	O	R RCS MANF 5 JETS L, R RCS MANF 3 JET vlvs
FA3	D	L, R RCS MANF 2 JET RM
	O	L, R RCS MANF 2 JETS
FA4	D	L, R RCS MANF 4 JET RM
	O	L, R RCS MANF 4 JETS

PL1	GPC KU ANTENNA POINTING
PL2	CCTV U/L COMMANDS

NOTES:

DAP AXES

- Bottom 3 rows of pbi (18 pbi)
- Three redundant I/O channels per pbi (1, 2, 3)

DAP CNTL

- Top row of pbi (6 pbi)
- Two redundant I/O channels per pbi (A, B)

AFT SENSE Sw

- Three redundant I/O channels (1, 2, 3)

KEY:

A, B, C, D: BCE Input Cards
S: Serial I/O Cards
O: GPC Output

Note: The technically correct nomenclature for MDM PL1 is MDM PF1. Since the crew procedures and Caution & Warning refer to PF1 as PL1, we chose to use PL1 to remain consistent with the crew.

Figure 3.1-5 MDM-LRU Relationship by I/O Card

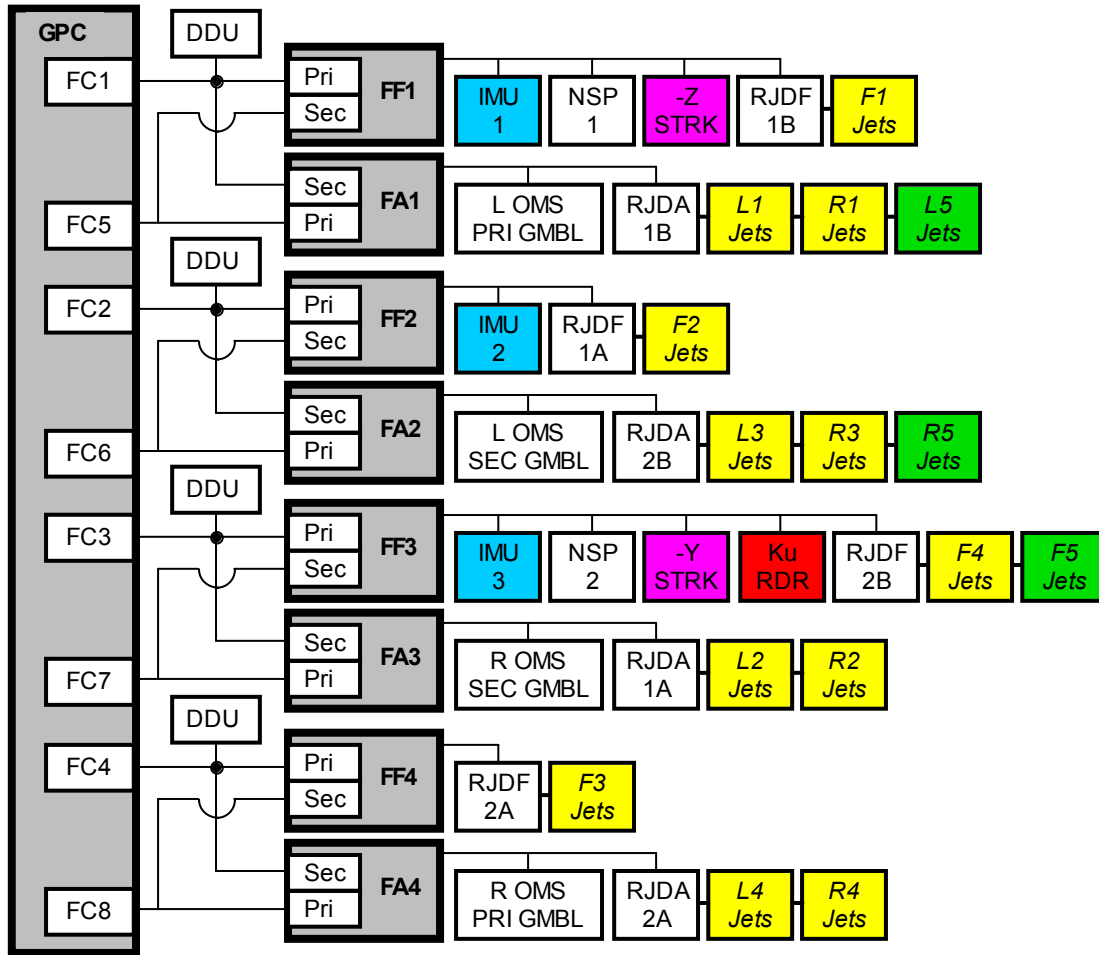


Figure 3.1-6 MDM-LRU Relationship by Port Assignment

Reference: Reference Data Book, Generic Rev E, July 8, 1999

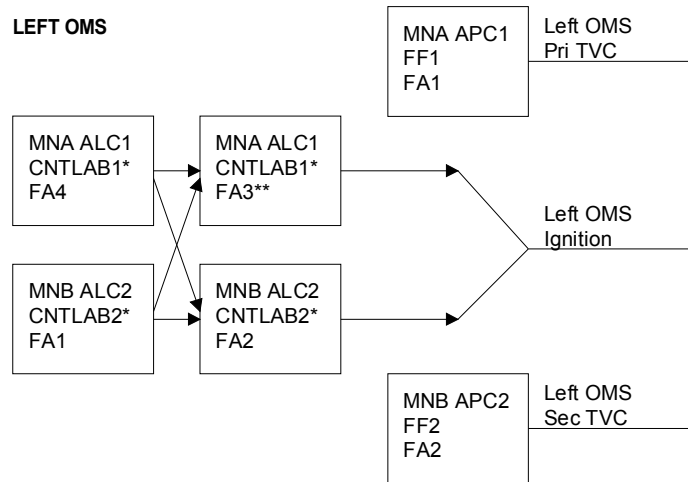
Note: This table has the same format as the associated table in the Reference Data Book. Those items directly pertaining to RGPO responsibilities are included. See Ref Data Book for additional system losses.

BUS LOST	CRITICAL EQUIPMENT LOST	CRITICAL REDUNDANCY LOST	INSTRUMENTATION / OTHER LOSSES	OMS/RCS AFFECTED
DA1				
FPC 1	DEU/CRT 1		MCIU	
FLC 1	F RCS Manf 1 Jets			
AC 1		IMU Fan A	-Y STRK SYS 1 Door Mtr OMS/RCS Prplt Qty (Gauging)	
APC 4				
APC 1	L OMS Pri TVC R OMS Sec TVC			L Manf 5 Jets
ALC 1			L, R RCS Manf 2 Jet Htrs OMS Qty Gauging	L Manf 5 Jets L OMS Eng P vlv Pos
O14	L Instr Pwr		Fwd Mission Timer IMU Fan Sensor -Z STRK Aft Event Timer	
O14 & A8			RMS Pri Pwr	F1 Manf RJDs (if sw off)
R14	UHF Pwr Amp (xmit)		CCTV Mon 1 Aft PLB Cameras	
MPC 1			RMS Pri Pwr RMS Pri Pwr PLB Floodlights O/H Docking Lights	
MMC1 MMC3			RMS Redun MRL	
DA2				
FPC 2	DEU/CRT 2			
FLC2	F2 Manf Jets			
AC2		IMU Fan B	A2 Digitals (ΦC)	
APC 5				
APC2	L OMS Sec TVC		Aft MNB Bus PWR	R RCS Manf 5 Jets
ALC 2			L OMS Qty Gauging	R RCS Manf 5 Jets
O15	R INST Pwr		Fwd Event Timer -Y STRK	
O15&A8				F2 Manf RJDs (if Sw OFF)
R14	Ku System (Comm & Rdr)		Fwd Cameras CCTV Mon 2 RMS Cameras	
MPC 2	Ku System (Comm & Rdr)		Mid Port Floodlight Fwd Stbd Floodlight RMS Backup Power	
DA3				
FPC 3	DEU/CRT 3 / 4		PL Primary MN C Pwr Ku Radar	
FLC3	F RCS Manf 4 Jets			F5 Manf Jets
AC3		IMU Fan C	IMU Fan Signal Conditioner COAS Light (ΦA)	
APC6				
APC3	R OMS Pri TVC			
ALC3			R OMS Qty Gaging	
O16 RJD				F4 Manf RJDs (if F3 and F4/5 sw OFF)
R14			Ku Signal Processor EVA/Keel Cameras	
MPC 3			Mid Stbd Floodlight Aft Port Floodlight	

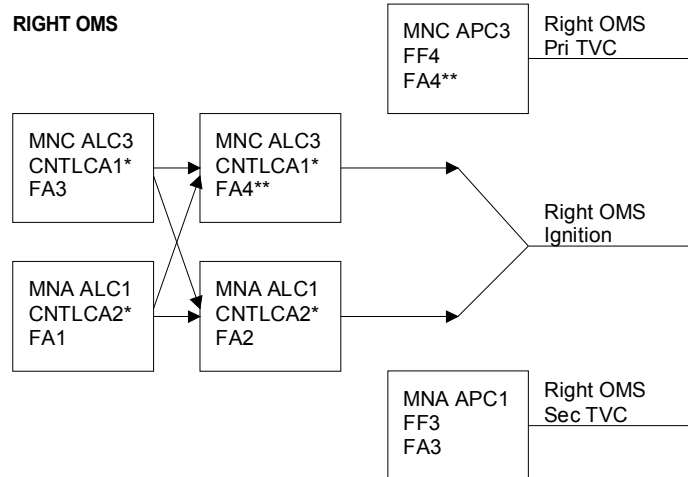
Figure 3.1-7 Main Bus Loss

AB1	CRT 1 Manf F1 RJDs (if SW OFF) L ADI Att Ref pb	BC1	F, L, R RCS Manf 5 Jets Manf F2 RJDs (if SW OFF) R ADI Att Ref pb	CA1	CRT 3 Manf F3 RJDs (if SW OFF) A ADI Att Ref pb RMS Spotlight Docking Light
AB2	F RCS Manf 1 Jets Manf L5 RJDs (if SW OFF) L ADI Att Ref pb L ADI sws Aft DAP – cntl pbs chnl 3	BC2	CRT 2 F, L, R Manf 5 Jets Manf F2 RJDs (if SW OFF) R ADI Att Ref pb R ADI sws Aft DAP – cntl pbs chnl 2 Aft DAP – axes pbs (18)	CA2	CRT 4 F RCS Manf 3 Jets A ADI Att Ref pb A ADI sws Aft DAP – cntl pbs chnl 1 Aft DAP – axes all pbs (18)
AB3	Fwd DAP – cntl pbs chnl 1 Fwd DAP – axes pbs (18)	BC3	Manf F4 RJDs (if SW OFF) Manf F5 RJDs (if SW OFF) Fwd DAP – cntl pbs chnl 2 Fwd DAP – axes pbs (18)	CA3	F RCS Manf 4 Jets Fwd DAP – cntl pbs chnl 3

Figure 3.1-8 Control Bus Loss



* If CNTLAB1 or AB2 (CA1 or CA2) failed and ignition path still exists at OMS fail, assume L(R) OMS ↓ is PRPLT FAIL
 ** If FA3(4) or Pc failed high and L(R) OMS fail, no guidance downmode after OMS ENG switch OFF (TGO slow, ADI needles in error, 6 ft/s underburn)



If two FA MDMs lost:		
MDMs	Preburn: ENG-OFF	During Burn: MAN SHUTDN
1,2 1,3 1,4	LEFT (TVC) RIGHT (IGN) LEFT (IGN)	BOTH LEFT RIGHT
2,3 2,4 3,4	LEFT (IGN) RIGHT (IGN) RIGHT (TVC)	RIGHT LEFT BOTH

Figure 3.1-9 OMS FAILURES Cue Card

3.2 DAP

PURPOSE

To serve as a quick reference for Digital Auto Pilot information.

PROCEDURE

DAP Panel redundancy management (RM):

- The 6 PBIs on the top row are all 3 contact pushbuttons and use standard three level RM.
- Remaining PBIs are 2 contact and use standard two level RM.

DAP Configuration Notes:

Table 3.2-1 DAP Notes

Setting	Description
AUTO (automatic)	<ul style="list-style-type: none"> • Attitude defined by Universal Pointing or Orbit Burn Guidance • ROT DISC RATE and PULSE: disabled although their lights may be illuminated. • Manual selection of DISC or PULSE has no effect • Moving the RHC: downmode from AUTO to INRTL • If no auto maneuver, pointing or tracking option is being processed, AUTO will initiate an inertial attitude hold.
INRTL (manual inertial)	<ul style="list-style-type: none"> • Initiates attitude hold in any axis that has DISC RATE selected. • ROT DISC RATE and PULSE: AUTOMATICALLY MODED TO DISC RATE • Any axis moded to PULSE will go to free drift.
LVLH (manual)	<ul style="list-style-type: none"> • LVLH Hold for each axis – IF – DISC RATE ON • ROT DISC RATE and PULSE: AUTOMATICALLY MODED TO DISC RATE • Any axis moded to PULSE will go to free drift.
FREE	<ul style="list-style-type: none"> • ROT DISC RATE / PULSE: AUTOMATICALLY MODED TO PULSE • Crew can not select DISC RATE in any axis
Automatic Moding to FREE	<p><u>IMU Failure</u></p> <ul style="list-style-type: none"> • If there is no IMU data being received by the DAP, it will downmode to FREE with Rot Pls, Pls, Pls • When 1+ IMU is recovered DAP will remain in FREE / Rot Pls,Pls, Pls until crew takes action <p><u>Loss of VERNs</u></p> <ul style="list-style-type: none"> • Anything that causes VERN Failure (i.e. some MDM failures) downmodes the DAP to FREE.
VERN Failure	<ul style="list-style-type: none"> • Loss of any of the four down firing jets (F5R, F5L, R5D, L5D) • DAP reconfig fault message generated
PRI	<ul style="list-style-type: none"> • Deflecting THC causes DAP to upmode to PRI.
ALT	<ul style="list-style-type: none"> • Attitude control: Uses primary jets with fewer jet firings of a smaller duration and selectable delay between firings to allow attitude control when verniers are lost. • For attitude mnvrs, ALT is preferred over VERN because of its lower translational coupling and is preferred over PRI because of its more efficient jet selection logic. • # Jets: maximum number of PRI jets that fire simultaneously while in ALT. This applies to rotations only. Deflecting THC causes DAP to up mode to PRI.
VERN	<ul style="list-style-type: none"> • Uses only vernier jets for attitude control
LOW Z	<ul style="list-style-type: none"> • Fires 2 aft and 2 fwd firing jets to produce +Z motion. • Inhibits up firing jets for attitude control. • Increases fuel consumption by a factor of 10 • Used with small range rate and only when required for plumbing concerns (more)

High Z	<ul style="list-style-type: none"> • Due to RCS cross coupling: <ul style="list-style-type: none"> • An out-of-plane correction will increase closure • “Walks” the orbiter in toward the target – induces a pitch moment • Final braking is done in Norm Z for better control. • Fires all 9 up firing jets and is used for emergency back away.
PCT	<ul style="list-style-type: none"> • Requires one fwd down firing jet per side and one down firing jet in each aft pod. • This requirement is met as long as $\pm Y$ and $-Z$ translational capability exists.
During OMS Engine Firing	There is no RCS response to THC inputs while the DAP is in TVC mode (engines are on).

DAP A vs B

A7/B7 RNDZ:	B has higher ROT RATE in both PRI and VERNs A has higher TRANS and ROT PLS
A8/B8 TERMINAL PHASE:	A has higher TRANS and ROT PLS
A9/B9 PROX OPS:	A has higher TRANS and ROT PLS
A10/B10 DOCKING:	A has higher TRANS and ROT PLS

Prox Ops

DAP A/B is a crew choice item. DAP B is not required but since small inputs are expected due to the benign environment of stationkeeping, DAP B is usually preferred. AUTO is required to maintain the +Vbar attitude during the approach. Maintaining the +Vbar attitude provides a correct reference for maintaining the approach corridor (inside 250 ft CG-to-CG).

VERNs are preferred for the approach because the smaller deadband, finer control and absence of up firing jets produce less plume impingement and propellant usage than PRI/NORM Z or PRI/LOW Z. In addition, vernier jets produce significantly less cross coupling into -Z (closing rate) acceleration than PRI LOW Z, which greatly reduces the probability that braking burns will be required on Rbar approaches and reduces the number of braking burns on Vbar approaches. If VRCS fails, the downmode is to PRI since ALT has not been certified for use in the manual phase.

Due to loads concerns, only DAP B should be used inside 150 ft. Of course, DAP A may be used at the pilot’s discretion, to avoid collision, correct unsafe relative motion, or simply to return to the pilot’s “comfort zone.”

Corridor Sep with Vern Fail

ALT DAP should be used for VERN failed corridor seps to 450 ft. Earlier analysis had shown that the PRI DAP mode might result in the Orbiter “stalling” while backing out to 450 ft.

3.3 POINTING

PURPOSE

To give a quick lookup table for various combinations of Orbiter body pointing vectors and omicron.

PROCEDURE

Values and Limits

The following table lists the possible values for TGT ID (UNIV PTG, ITEM 8). The most common TGT ID values for rendezvous operations are 1 and 2, although 4 is sometimes used during deploy operations.

Table 3.3-1 UNIV PTG Target IDs

TGT ID	Description
1	Target Track (RNDZ NAV must be enabled)
2	Center of Earth
3	Point on Earth Surface
4	Center of Sun
5	Celestial target
6-10	Unassigned (will give ILLEGAL ENTRY if entered)
11-110	Navigation stars

The following table lists the possible values for the Orbiter body pointing vector (UNIV PTG, ITEM 14). Values 1 thru 4 contain preset values for pitch and yaw to point the BPV in the described direction.

Table 3.3-2 UNIV PTG Body Vectors

BPV	Description
1	+X Orbiter Body Axis
2	-X Orbiter Body Axis
3	-Z Orbiter Body Axis (~ -Z STRK Boresight)
4	-Y STRK Boresight
5	Selectable

The following table describes the limits on the pitch, yaw, and omicron values (UNIV PTG, ITEM 15 thru ITEM 17).

Table 3.3-3 UNIV PTG Body Vector and Omicron Limits

Component	Range
Pitch	0 to 360 deg
Yaw	0 to 90 and 270 to 360 deg
Omicron	0 to 360 deg

Target Track

The following figures illustrate the orientation of the Orbiter on the VBAR when executing a target track with a star tracker. Examples are shown for both star trackers (-Z/-Y) with 4 values of omicron (0, 90, 180, 270) in two possible Orbiter-TGT geometries (Orbiter trailing the TGT and Orbiter leading the TGT).

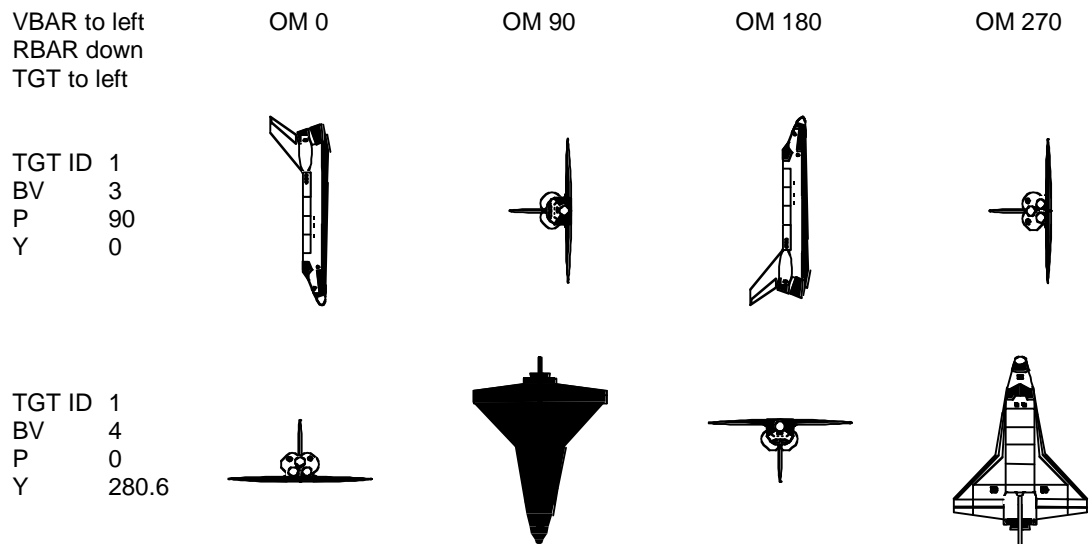


Figure 3.3-1 Universal Pointing Examples for Target Track from Behind

VBAR to left
RBAR down
TGT to right

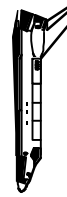
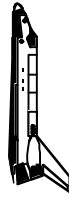
OM 0

OM 90

OM 180

OM 270

TGT ID 1
BV 3
P 90
Y 0



TGT ID 1
BV 4
P 0
Y 280.6

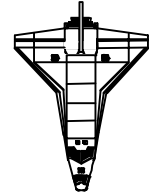
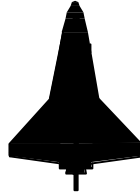


Figure 3.3-2 Universal Pointing Examples for Target Track from in Front

Earth Track

The following illustrates the orientation of the Orbiter when tracking the center of the Earth for 6 body pointing vectors (+/-X, +/-Z, +/-Y) and 4 values of omicron (0, 90, 180, 270).

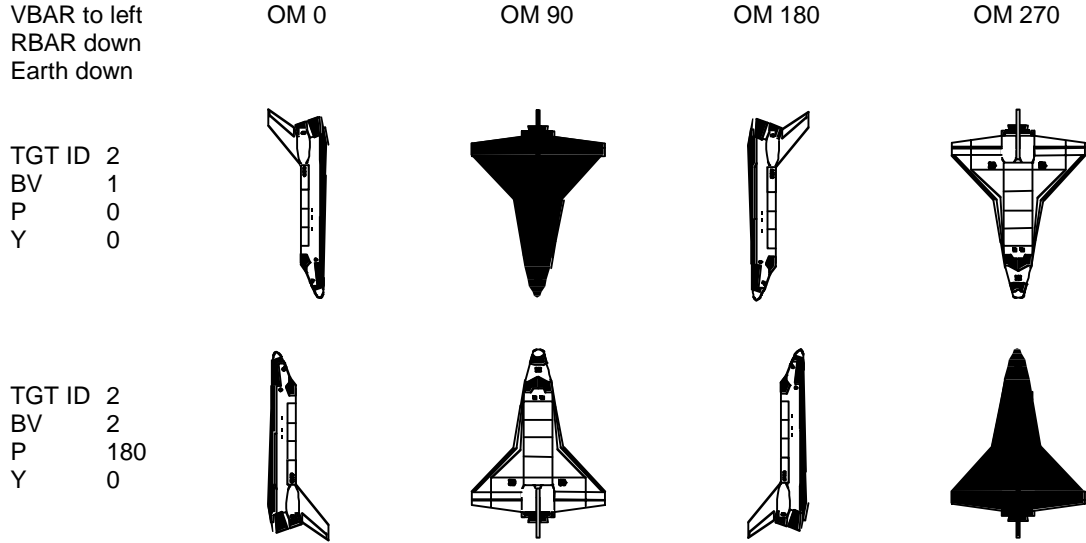


Figure 3.3-3 Universal Pointing Examples for Earth Track with ±X Axis

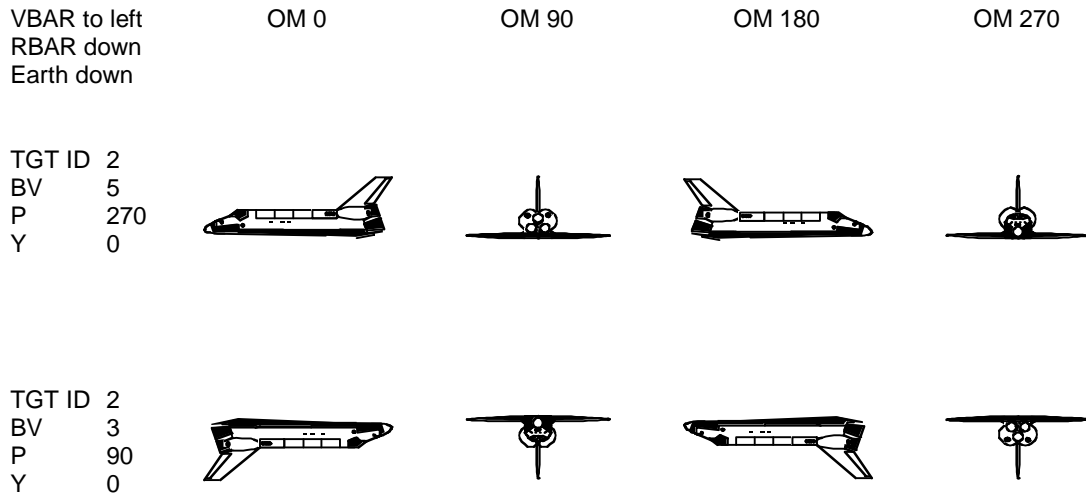


Figure 3.3-4 Universal Pointing Examples for Earth Track with ±Z Axis

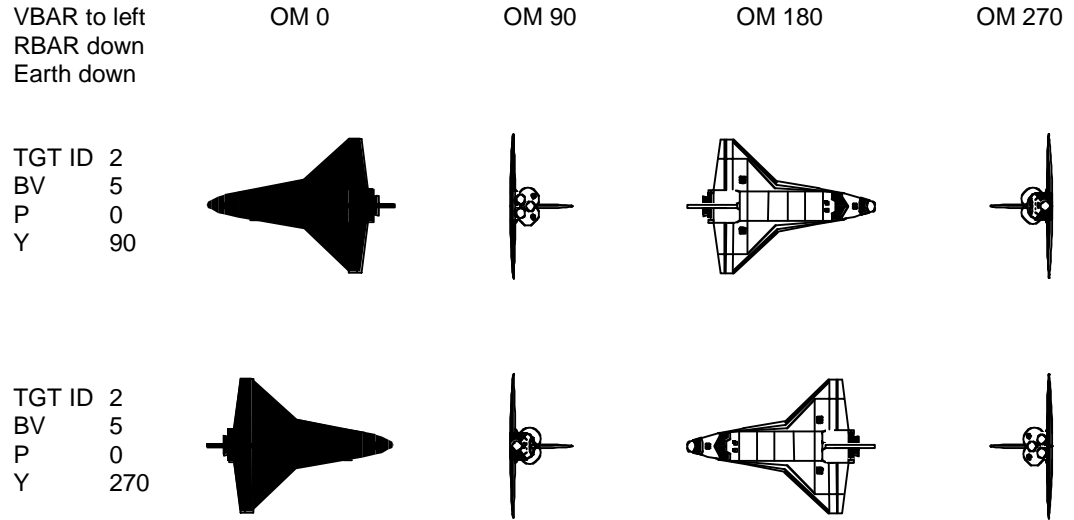


Figure 3.3-5 Universal Pointing Examples for Earth Track with $\pm Y$ Axis

BACKGROUND

The Orbiter body pointing vector (BPV) is specified in terms of a vector starting coincident with the Orbiter +X body axis. The vector is rotated in a pitch/yaw Euler sequence from this point. (A convenient mechanism for determining the BPV is to use a "ghost Orbiter" starting coincident with the Orbiter and applying the pitch/yaw Euler sequence.) Omicron is defined as the angle between the plane containing the negative angular momentum (+YLV) vector and the BPV and the plane containing the BPV and the Orbiter body +Y axis. In cases where the BPV is along the Orbiter body +Y-axis, the Orbiter body +Y-axis is replaced with the -Z-axis. If the BPV is along the +YLV vector, the negative angular momentum vector is replaced with the -ZLV vector. A less precise but perhaps more easily implemented procedure to determine the desired omicron is:

- Point the BPV at the target (center of earth, orb vehicle, sun etc.).
- Find omicron = 0 by rotating the Orbiter about the BPV until the starboard (right) wing (+Y body) is pointed down the +Y LVLH axis. (Depending on the BPV and the target, this is not always possible. In these cases rotate the Orbiter about the BPV until the starboard wing is as close to the +Y LVLH as you can get)
- Using the right hand rule rotate about the BPV to define the attitude associated with any other omicron.

Several references exist for discussing BPV and omicron in detail, including the I/O/D G&C 2102 manual.

3.4 OMS

PURPOSE

To give an overview of the OMS systems monitored by PROP.

PROCEDURE

OMS System

Pre-burn

- Review the MDM, Control Bus, OMS FAILURES Cue Card, and OMS Plumbing charts along with the current stringing to determine if any single GPC, MDM, or bus failure will result in ignition problems, early shut down, or TVC problems.
- Work with FDO and PROP to predetermine the appropriate response to the above.

No Ignition

- Switch to other OMS engine (ITEM 2 or 3 as required).
- Retarget (if LAMBERT-guided burn - SPEC 34)
- LOAD (ITEM 22) and start TIMER (ITEM 23)
- Maneuver to new attitude (ITEM 27)

Note: should take about 2 minutes once call is made to the crew.

Early Shutdown

- If GPC problem, restring and complete/start the burn.
- Otherwise, downmode to +X RCS.

Overburn

- ARM/PRESS switch to OFF.
- Trim residuals (may be large) with RCS.

Gimbal Failure

- Trim residuals with RCS ASAP.
- Work gimbal failure procedures after VGOs trimmed.

OMS System Description

Each OMS engine has two main control valves aligned in series, each with two coils. Either coil can operate the valve but both valves must be open for the engine to burn. Each valve will spring close unless at least one of the coils is holding it open. A coil will hold the valve open only if it receives the following

- An OPEN signal from a GPC via one of the Aft MDMs; and
- Power via the main bus.

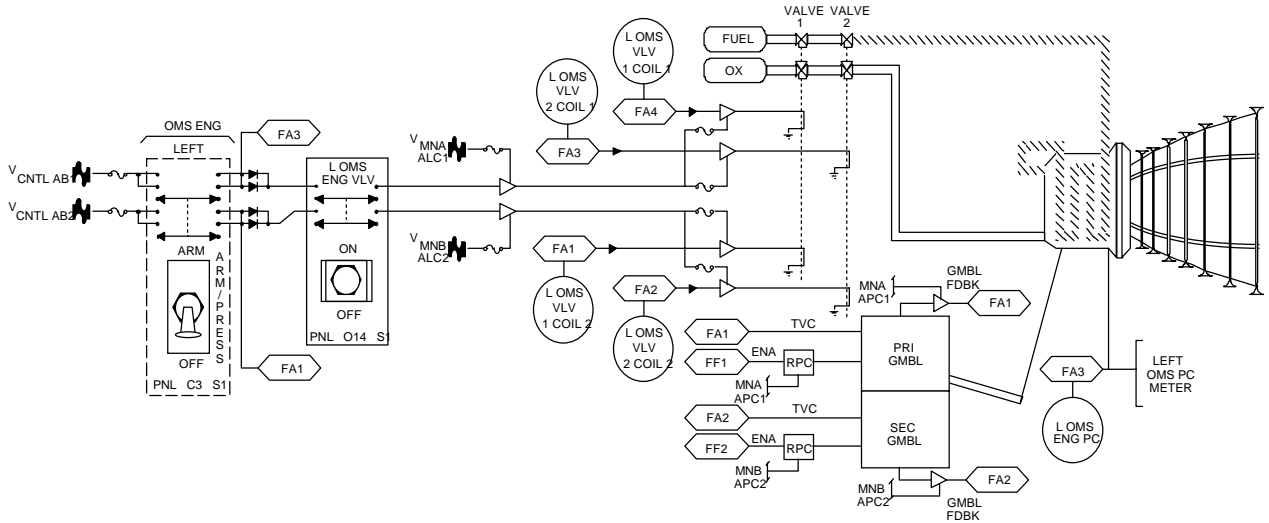


Figure 3.4-1 Left OMS Plumbing with DPS Interfaces

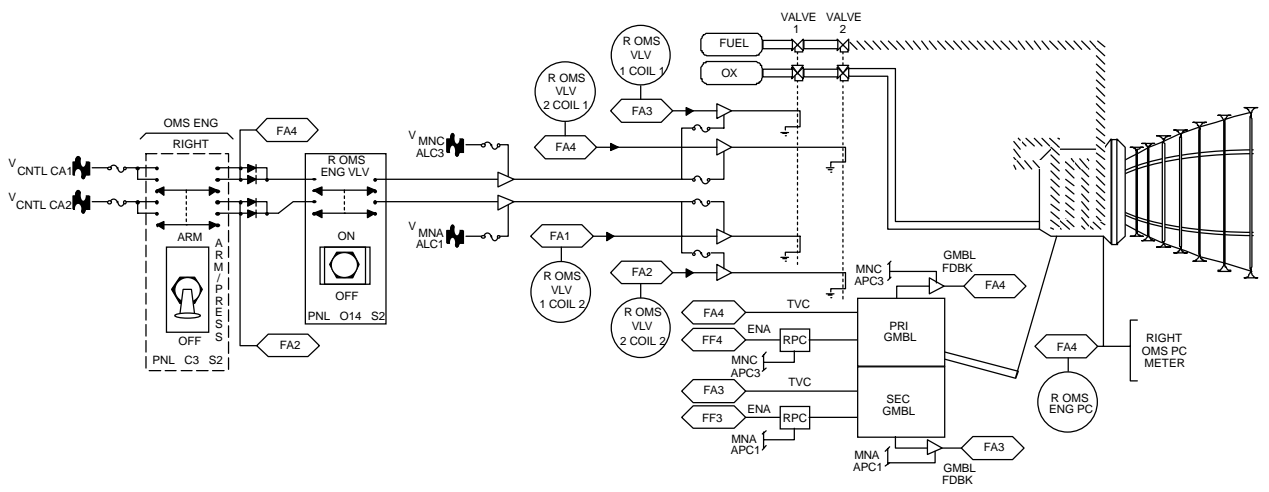


Figure 3.4-2 Right OMS Plumbing with DPS Interfaces

To receive power, the main power bus element (ALC1, ALC2, or ALC3) must be working along with the corresponding control bus element for each coil (CNTLCA1, CA2, AB1, or AB2). Also, if a GPC or MDM fails during a burn, it is possible for the MDM to "hang-up" in

the ON mode. In this case the coil will continue to hold that valve open until the power is removed from the coil. If this happens to both valves, the burn must be shut down manually via the ARM/PRESS switch (to OFF). Refer to the OMS Plumbing figures.

For OMS ignition, both valves must open. Since either coil can open each valve, it takes two failed coils on the same valve to prevent the OMS from burning. The PROP Officer will normally try to set the stringing such that the same GPC does not command both coils on either valve. This is not always possible. The OMS FAILURES Cue Card presents a quick summary of this failure. Details are available in the OMS Plumbing figures later.

For OMS shut down, the burn is terminated if either valve closes. GPC or MDM failures can cause stuck "ON" commands from the MDM. If this happens to both valves, the burn must be manually terminate via the ARM/PRESS switch. The PROP Officer will try to establish a stringing such that the same GPC does not command coils on both valves. For dual G2 operations this stringing is in direct conflict with the desirable stringing for OMS ignition. Something has to give. The OMS FAILURES Cue Card covers this case in the table "If two FA MDMs lost".

Propellant Costs

Refer to the OMS/RCS Estimated Performance tables below for detailed propellant usages for various maneuvers.

Table 3.4-1 OMS Propellant Approximate Quantities Quick Reference

Quantity	Amount of Propellant
L OMS Fuel	4711.5 lbs
L OMS Oxidizer	7743.5 lbs
R OMS Fuel	4711.5 lbs
R OMS Oxidizer	7743.5 lbs
Total OMS Load	25064 lbs*
* includes prop trapped in lines, budgeted for dispersions, and gauging errors.	

3.5 RCS

PURPOSE

To give an overview of the RCS systems monitored by PROP.

PROCEDURE

Overview

The Reaction Control System (RCS) consists of 38 primary jets and 6 vernier jets. The primary jets are rated at 870 lbs of thrust each, the vernier jets at 24 lbs each. The primary RCS system is multiply redundant in each of the 6 thrust directions with each jet being assigned a priority via SPEC 23. The vernier RCS system is zero-fault tolerant to the loss of any single vernier jet.

RCS System

Refer to the DPS Stringing, MDM, Control Bus, RCS Plumbing, RCS Jet Configuration, and the Primary RCS Jet Selections and Priorities charts to uncover losses or vulnerabilities in translational and/or rotational capabilities. Note that +Z translations MUST be single-fault tolerant to enter within 200 feet of a target (see FR 2-61); LOW Z counts as a level of redundancy to NORM Z +Z translations.

Table 3.5-1 Primary RCS Commanded Jet and Jet Group Selection

Rotation	Fwd	Left Aft	Right Aft
+Pitch	F3D, F4D (5,6)	L1U (11)	R1U (12)
-Pitch	F3U (4)	L3D (13)	R3D (14)
+Roll	---	L3D (13)	R1U (12)
-Roll	---	L1U (11)	R3D (14)
+Yaw	F3L (2)	---	R3R (10)
-Yaw	F4R (3)	L1L (9)	---
Low Z	Fwd	Left Aft	Right Aft
+Pitch	F3D, F4D (5,6)	---	---
-Pitch	---	L3D (13)	R3D (14)
+Roll	---	L3D (13)	---
-Roll	---	---	R3D (14)
+Z	F1F, F2F (1)	L3A (8)	R3A (7)
Translation	Fwd	Left Aft	Right Aft
+X	---	L3A (8)	R3A (7)
-X	F1F, F2F (1)	---	---
+Y	F3L (2)	L1L (9)	---
-Y	F4R (3)	---	R3R (10)
+Z	F3U (4)	L1U (11)	R1U (12)
-Z	F3D, F4D (5, 6)	L2D, L3D (13)	R2D, R3D (14)
Hi Z	Fwd	Left Aft	Right Aft
+Z	F1U, F2U, F3U (4)	L1U, L2U, L4U (11)	R1U, R2U, R4U (12)

The highest priority jet(s) shown from the jet group indicated in parentheses.

Table 3.5-2 Primary RCS Nominal Jet Priority by Jet Group

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	-X	+Y	-Y	+Z	-Z	-Z	+X	+X	+Y	-Y	+Z	+Z	-Z	-Z
1	F1F	F3L	F4R	F3U	F4D	F3D	R3A	L3A	L1L	R3R	L1U	R1U	L3D	R3D
2	F2F	F1L	F2R	F1U	F2D	F1D	R1A	L1A	L3L	R1R	L4U	R4U	L2D	R2D
3	F3F		F2U						L4L	R2R	L2U	R2U	L4D	R4D
4									L2L	R4R				

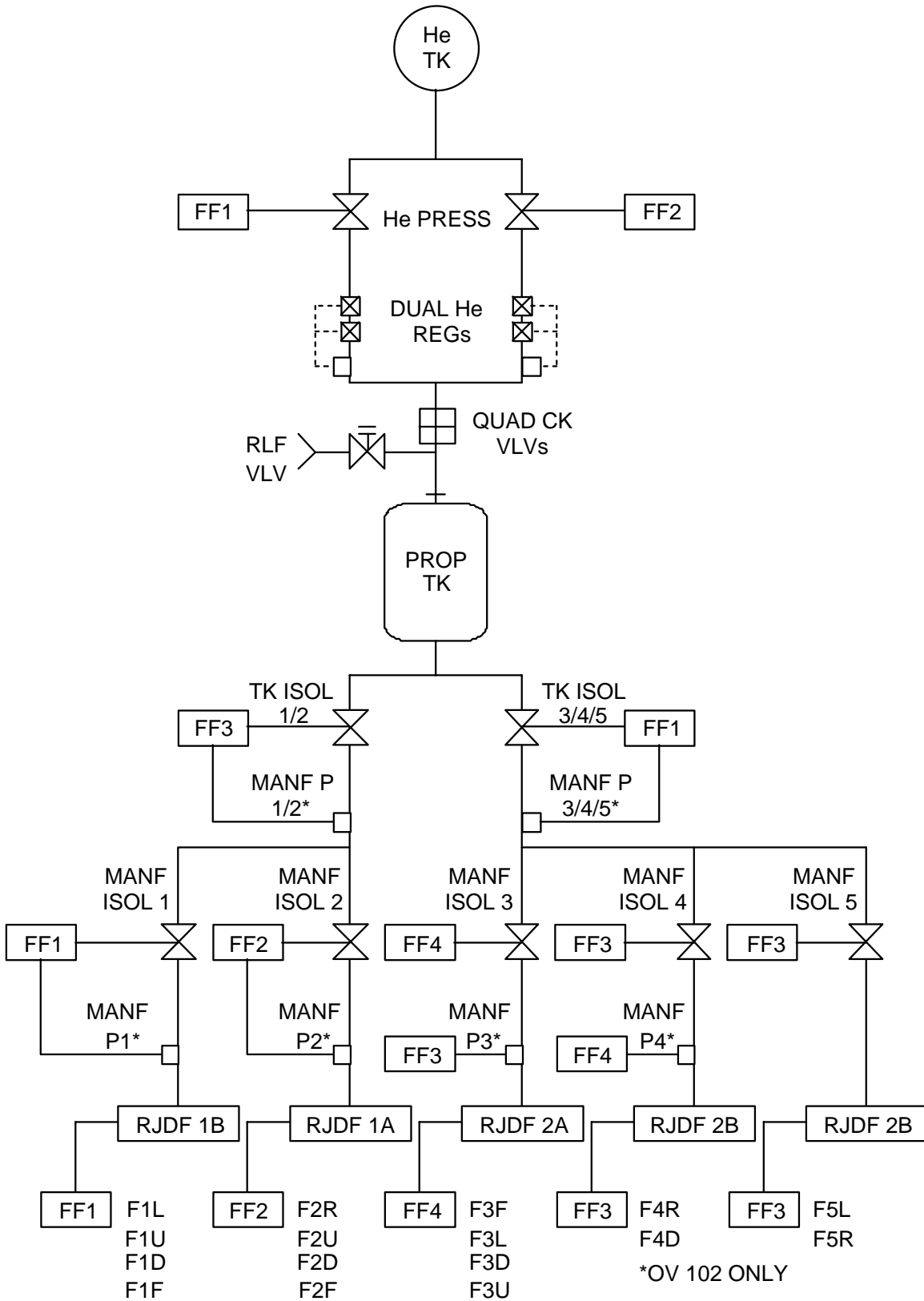


Figure 3.5-1 Forward RCS Plumbing with DPS Interfaces

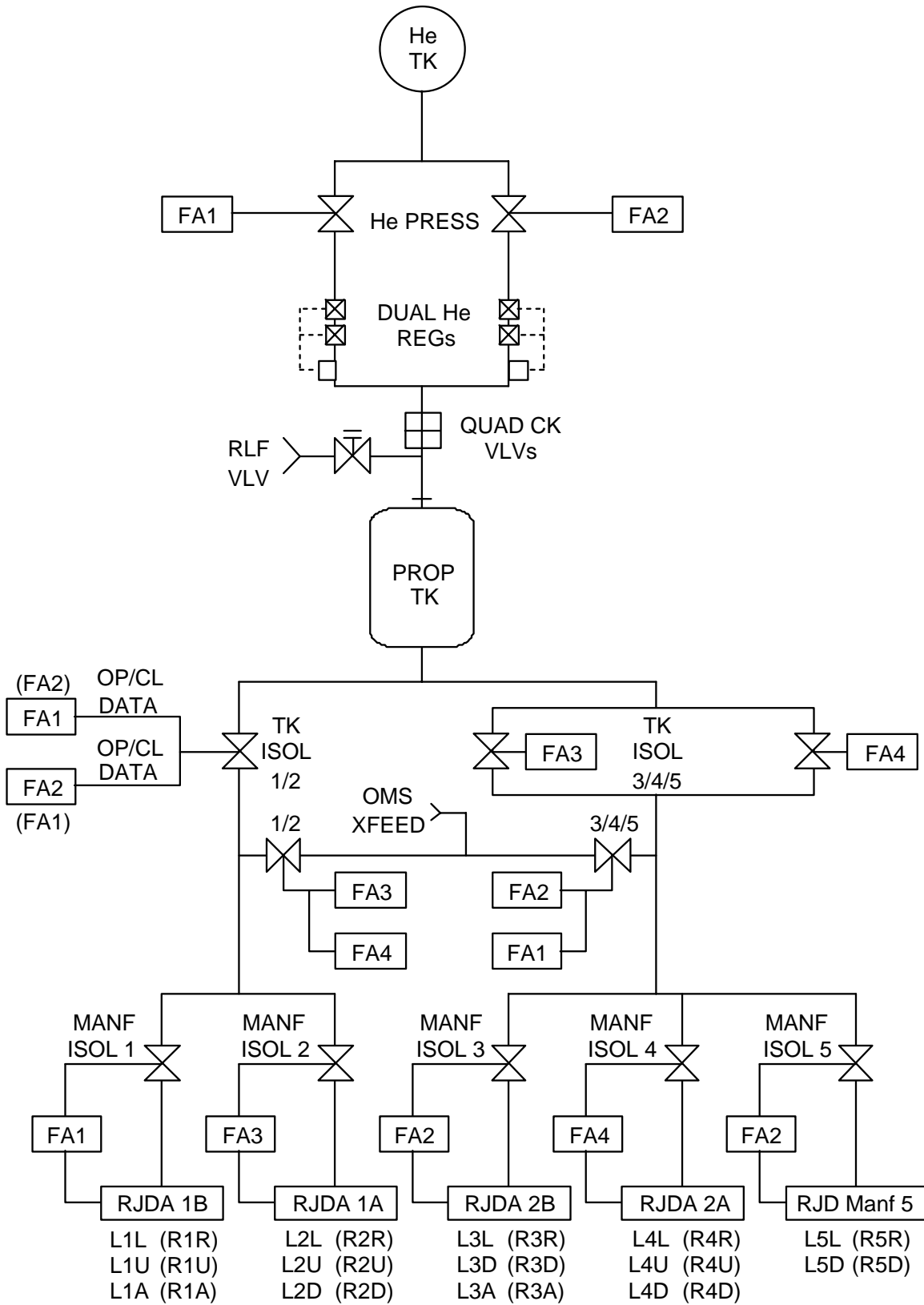


Figure 3.5-2 Left (Right) Aft RCS Plumbing with DPS Interfaces

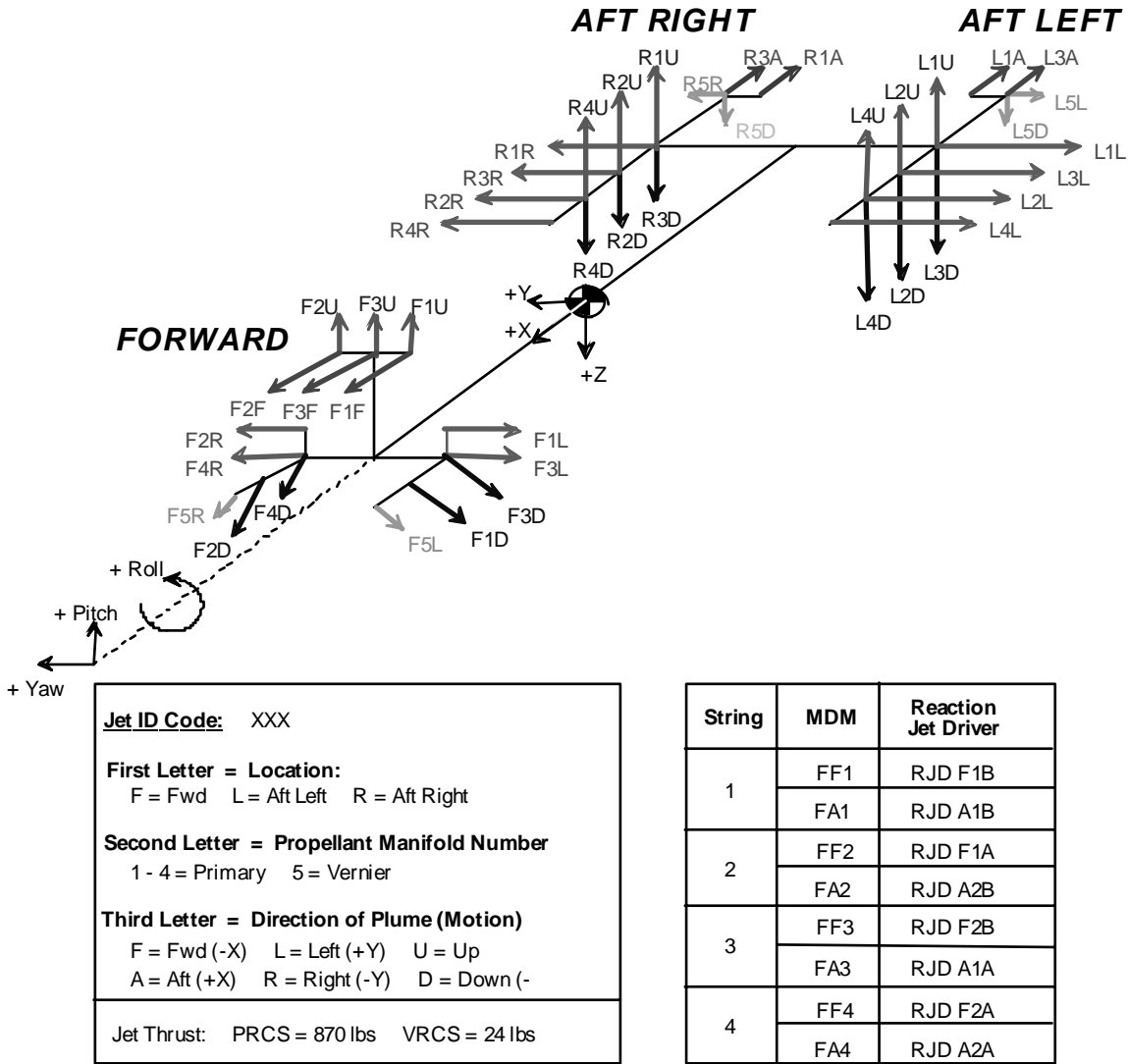


Figure 3.5-3 RCS Jet Configuration

Propellant Costs

Refer to the OMS/RCS Estimated Performance tables below for detailed propellant usages for various maneuvers.

Table 3.5-3 RCS Propellant Approximate Quantities Quick Reference

Quantity	Amount of Propellant
Fwd RCS Fuel	805 lbs
Fwd RCS Oxidizer	1275 lbs
Total F RCS	2446 lbs*
L or R RCS Fuel	856 lbs
L or R RCS Oxidizer	1356 lbs
Total Aft RCS	4970 lbs*

* includes prop trapped in lines, budgeted for dispersions, and gauging errors.

Table 3.5-4 Primary RCS Thrusters Propellant Usage (lbs/hr, 3.5 deg deadbands)

Orientation	100 nmi		120 nmi		150 nmi		200 nmi		300 nmi	
	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
X-pop inertial	10.5	20.2	10.2	19.8	9.8	19.3	9.3	18.6	8.8	18.0
Y-pop inertial	11.0	24.0	10.2	19.9	9.4	17.7	8.4	15.7	7.6	14.6
Z-pop inertial	8.6	21.0	8.6	20.2	8.6	19.3	8.6	18.5	8.6	18.0
X-pop -ZLV	9.8	21.2	9.3	20.8	8.4	20.4	7.3	19.8	6.0	19.0
Y-pop -ZLV	10.3	18.0	10.1	17.8	9.8	17.5	9.5	17.1	9.1	16.5
-X sol inertial	10.4	20.8	10.4	20.4	10.4	19.9	10.4	19.4	10.4	19.0
-Z sol inertial	10.0	19.9	10.0	19.9	10.0	19.9	10.0	19.9	10.0	19.9
X-psl PTC	9.3	19.0	9.3	19.0	9.3	19.0	9.3	19.0	9.3	19.0

Table 3.5-5 Vernier RCS Thrusters Propellant Usage (lbs/hr, 1.0 deg deadbands)

Orientation	100 nmi		120 nmi		150 nmi		200 nmi		300 nmi	
	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
X-pop inertial	3.0	11.6	1.5	5.7	0.9	3.8	0.7	3.0	0.6	2.8
Y-pop inertial	1.9	6.3	1.6	4.7	1.5	4.5	1.4	4.3	1.3	3.9
Z-pop inertial	2.9	11.5	2.0	8.1	1.6	6.8	1.5	6.5	1.4	5.9
X-pop -ZLV	4.1	13.3	1.6	5.1	0.7	1.3	0.4	0.6	0.4	0.4
Y-pop -ZLV	0.5	1.0	0.5	0.8	0.5	0.7	0.5	0.6	0.5	0.5
-X sol inertial	2.9	10.6	2.2	7.7	1.8	6.7	1.8	6.5	1.8	6.1
-Z sol inertial	3.6	8.8	2.6	5.5	2.3	4.8	2.2	4.7	2.2	4.5
X-psl PTC	5.6	10.9	4.8	7.2	4.2	4.9	3.8	3.4	4.3	3.6

Table 3.5-6 Propellant Usage to Start, Maintain, and Stop a 115-deg Rotation (lbs)

Jets	Rot Rt (deg/s)	Roll		Pitch		Yaw		3-axis	
		Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
VRCS	0.2	1.4	5.7	2.0	6.5	1.6	8.3	2.0	9.6
PRCS	0.2	10.3	23.9	13.1	28.3	9.0	20.3	8.8	20.2
PRCS	0.5	8.2	20.7	10.0	19.4	10.2	21.0	10.6	18.2
PRCS	1.0	6.8	23.7	12.9	22.4	13.2	24.1	16.5	26.9
PRCS	2.0	6.4	34.2	22.0	32.7	21.0	36.6	30.2	45.5

Table 3.5-7 RCS Propellant Usage for Translation Maneuvers (lbs/fps)

Orb Wt (klbs)	+X		-X		+/-Y		+Z		LO +Z		-Z		OM S
	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	
180	0.5	20.8	19.6	4.1	8.5	25.2	7.5	12.5	140	117	10.5	18.9	17.9
200	0.5	23.1	21.8	5.1	9.3	27.4	8.1	14.1	159	132	11.3	21.2	19.8
220	0.5	25.4	24.0	6.1	10.0	29.6	8.7	15.7	178	147	12.1	23.5	21.8
240	0.5	27.7	26.2	7.1	10.7	31.8	9.3	17.3	197	162	12.9	25.8	23.8
260	0.5	30.0	28.4	8.1	11.4	34.0	9.9	18.9	216	177	13.7	28.1	25.8

Multiple Jet Failures

On STS-110, the failure of two jets increased the risk of a loss of full control capability. Specifically, L1A and F1D were down. The additional loss of L3A would have left the Orbiter with a degraded +X capability (see SCP 7.5). The additional loss of F3D would have prohibited $\pm Y$ translation. The following notes were generated during STS-110 real-time operations.

If L1A and L3A are down:

- Impacts to flight control:
 - Degraded +X translation.
 - +Ydot will result from roll and yaw axis cross-coupling induced during +X translations.
 - All +X inputs need to be doubled to achieve the desired +X translation.
 - While LOW Z is selected, the DAP will fire down-firing jets to counter yaw moment, resulting in a closing rate and prop consumption.
 - Degraded LOW Z braking capability.
 - -X translation will occur during LOW Z braking pulses, which may require additional +X translation commands (see +X translations concerns above).
 - No additional impact for loss of verns.
- If L3A fails, full LOW Z capability is lost. Go to Vbar or Shuttle Nose In-Plane Breakouts as appropriate with the following notes:
 - Vbar Breakout is OK at any time outside of 150 ft. Preferred initial +X burn range is 150 ft due to recontact concerns brought on by expected increase in closure rate. Since this breakout is performed in LOW Z attitude control, unbalanced +X inputs that induce a yaw moment will force the DAP to fire down-firing LOW Z jets to control attitude. This induces moderate closure that should be acceptable for all applicable ranges of the Vbar Breakout. Ignore the temporary closure rate and avoid pluming ISS with braking pulses.
 - Do not attempt to null Ydot in either breakout because the out-of-plane translation gives us even safer relative motion.

If F1D and F3D are down:

- Impacts to flight control:
 - No $\pm Y$ translations will be honored due to DAP software logic inhibit.
 - Degraded $-Z$ translation available.
 - A $-$ roll and $-$ yaw rate will be induced during $-Z$ translation commands. The DAP will fire $+$ roll and $+$ yaw VRCS jets as necessary to correct any attitude excursions exceeding control deadbands.
- Stay in Vernier attitude control and go LOW Z at 75 ft per nominal procedures.
 - If cockpit resources are available, monitor deadbands and avoid making translational firings near pitch, yaw or roll firings.

- We recommend DAP B only for +Z translation, because the pulse duration used for DAP B pulses limits the hot sticking phenomena, which is of concern here. The use of DAP A in this case could potentially stall the opening rate because of a degraded +Pitch condition. DAP A firings are OK in all other axes.
- If F3D fails, $\pm Y$ translation capability is lost, perform the breakout listed below:
 - If Range < 150 ft, continue corridor sep to 150 ft and then perform the VBAR CORRIDOR BREAKOUT, page 5-14.
 - If a $\pm Y$ input is required to prevent a corridor violation, reselect F1D
 - After the breakout has been initiated, do not attempt to null Ydot. Deselect F1D.
 - If on the Vbar and Range > 150 ft, perform VBAR CORRIDOR BREAKOUT, page 5-14.
 - Do not attempt to null Ydot in either breakout because the out-of-plane translation gives us even safer relative motion.
 - The Vbar Breakout is OK at any time outside of 75 ft, but we would prefer to do it at 150 ft due to reduce loads and give you safer relative motion. Ignore any temporary closure rate and do not plume ISS with braking pulses. Same applies if NORM Z due to loss of VRCS (see VRCS failed concerns below). Rdot will open up as the Orbiter passes over ISS.
 - If flyaround is in progress, perform SHUTTLE NOSE IN-PLANE BREAKOUT, page 5-16.
- If F3D and Vernier attitude control fails:
 - If in LOW Z mode, go to NORM Z/ PRI immediately. reselect F3D, select LOW Z, if on Vbar, establish an opening rate, and execute the breakout listed below.
 - If Range < 150 ft, continue corridor sep to 150 ft and then perform the VBAR CORRIDOR BREAKOUT, page 5-14.
 - If a $\pm Y$ input is required to prevent a corridor violation, reselect F1D
 - After the breakout has been initiated, do not attempt to null Ydot. Deselect F1D.
 - If on the Vbar and Range > 150 ft, perform VBAR CORRIDOR BREAKOUT, page 5-14.
 - Do not attempt to null Ydot in either breakout because the out-of-plane translation gives us even safer relative motion.
 - The Vbar Breakout is OK at any time outside of 75 ft, but we would prefer to do it at 150 ft due to reduce loads and give you safer relative motion. Ignore any temporary closure rate and do not plume ISS with braking pulses. The same applies if NORM Z due to loss of VRCS (see VRCS failed concerns below). Rdot will open up as the Orbiter passes over ISS.
 - If flyaround is in progress, perform SHUTTLE NOSE IN-PLANE BREAKOUT, page 5-16.
 - Note: If F1D, F3D and VERNIS have failed and the LOW Z is selected, a large closing rate can quickly develop. If the Orbiter reaches a -Pitch deadband, the

DAP will try to fire unbalanced down-firing nose jets and will get roll, pitch and yaw. In LOW Z, while the yaw error is controllable with aft yaw jets, the DAP attempts to control the roll error with an uncoupled (due to failure of forward jets) down-firing tail jet, which leads to more –Pitch. This cycle continues, leading to dramatically increased closure rates (approximately 0.3 fps) and prop usage. +Z translation commands to counter this closure will not compensate for the closure rate seen. Securing from LOW Z ensures adequate control in this scenario.

- In the Vbar Breakout procedures under step 3, load DAP A9/B9 instead of A7/B7. This ensures the Orbiter configures for tail-only control.

3.6 Star Tracker

PURPOSE

To describe the Star Tracker system.

PROCEDURE

Refer to SCP 4.5 STAR TRACKER NAVIGATION for details on the use of the star trackers for onboard navigation.

Refer to the Stringing tables in SCP 3.1 DPS for impacts to star trackers due to MDM and/or bus losses.

Star Tracker System Characteristics

The -Z Star Tracker boresight is tilted by 3 degrees in a plane rotated by 41 degrees from the Orbiter +X Body axis. The Horizontal direction is approximately in the Orbiter X and the Vertical in the Orbiter Y. The Universal Pointing Body Vector used with the -Z Star Tracker is body vector 3, which points along the Orbiter -Z axis and not the star tracker boresight. The -Y Star Tracker boresight is rotated by about 10.5 degrees from the Orbiter -Y Body axis. The horizontal direction is approximately in the Orbiter Z axis and the Vertical in the Orbiter X axis. The Universal Pointing Body Vector used with the -Y Star Tracker is body vector 4, which points along the -Y star tracker boresight. See Figure 3.6-1 for an illustration of the star tracker coordinate system.

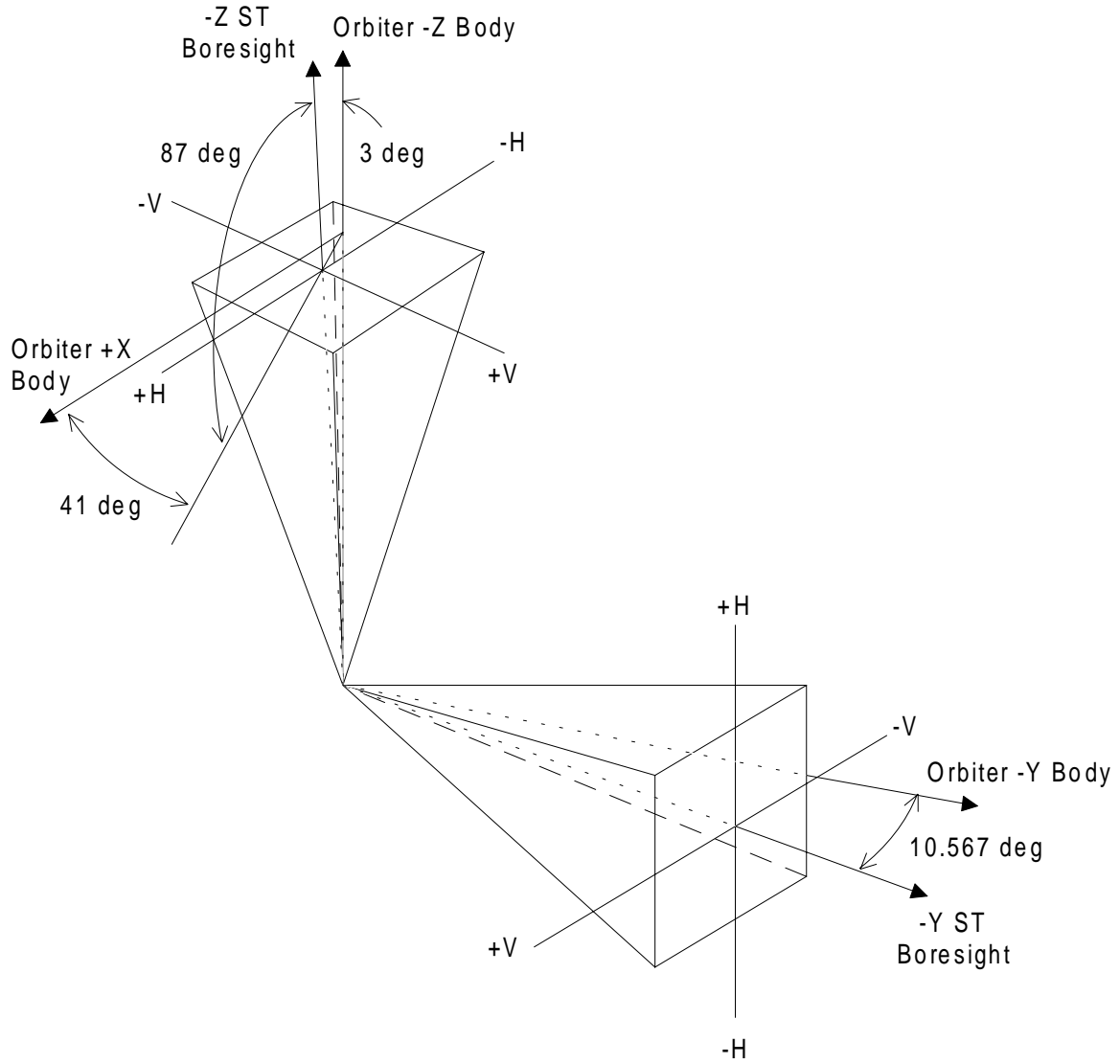


Figure 3.6-1 Star Tracker Coordinate System

The following table lists the values at which the star tracker shutters will open and close due to the detection of a bright object.

Table 3.6-1 Star Tracker Bright Object Sensor Limits

Object	Shutter Close	Shutter Open
Sun Limb	23 deg	29 deg
Earth Limb	16 deg	19 deg
Target (Magnitude < -12)	9 deg	9 deg

The next table lists the possible star tracker status words.

Table 3.6-2 Star Tracker Status Words

Value	Meaning
0	Blank
1	ST Fail Self Test
2	ST Pass Self Test
3	False Track
4	Out of FOV
5	High Rate
6	No Target

Solid State Star Tracker (SSST) Ground Testing performed by Engineering personnel in the Electro-Optics Laboratory showed a tendency for 'ghost' images to appear in the tracker's field-of-view if the target was too large and bright (like the ISS). These 'ghost' images are produced by reflections in the tracker's casing, between the tracker lens and the Protective Window Assembly (PWA). These reflective images can be bright enough for the tracker to lock on to, which could occur if the tracker were to initiate a full-field scan. The ground testing also showed that the tracker was less likely to track the same ghost image if the threshold level was set to a lower sensitivity (because the ghost image would then not be bright enough to track). So in an attempt to avoid finding ghost images in a full-field scan, the tracker's threshold setting is set to it's lowest sensitivity (3) at the beginning of rendezvous star tracker operations.

For both the SSST and Image-Dissecting Tube (IDT) star trackers, the threshold settings are as follows (on SPEC 22):

- Item 14+0 = Sensitivity threshold equivalent to 3.0 magnitude (highest sensitivity)
- Item 14+1 = Sensitivity threshold equivalent to 2.4 magnitude
- Item 14+2 = Sensitivity threshold equivalent to 2.0 magnitude
- Item 14+3 = Sensitivity threshold equivalent to 1.0 magnitude (lowest sensitivity)

3.7 Ku Radar

PURPOSE

To describe the Ku Radar system hardware. Also see SCP 4.4 RENDEZVOUS RADAR NAVIGATION.

SYSTEM CHARACTERISTICS

1. Coordinate System

The native coordinate system for the KU radar is α and β gimbal angles (also called shaft and trunnion). The KU electronics convert these gimbals to an azimuth and elevation (also called roll and pitch) that are in the Orbiter body sense. To compute the LOS of the radar given azimuth and elevation, first rotate in azimuth (positive about the Orbiter -X body axis), then in elevation (positive about the Orbiter -Y body axis) as in an azimuth/elevation Euler sequence. Note that the Rendezvous Navigation software converts the KU angle measurements back to shaft and trunnion to do its angle processing, for it is in this frame that angle biases must be solved for and applied.

To compute α and β (shaft and trunnion) from azimuth (ϕ) and elevation (θ), the following equations can be used:

$$\beta = \arcsin[-\cos K \sin \theta + \sin K \sin \phi \cos \theta] \quad \text{Equation 3.7-1}$$

$$\alpha = \arctan\left[\frac{-\sin K \sin \theta - \cos K \sin \phi \cos \theta}{\cos \phi \cos \theta}\right] \quad \text{Equation 3.7-2}$$

where $K = 67 \text{ deg} = 1.17 \text{ rad}$ (the "deployed" angle of the KU system relative to Orbiter +X).

CAUTION:

There is an operational constraint to not allow RR angle searches when the magnitude of the β gimbal exceeds 38 deg. Above this value, the high-speed angle search can result in hitting gimbal hard stops that could cause damage to the mechanism. When the β gimbal exceeds 38 deg, the GPC should be moded to AUTO TRK and GPC mode should be avoided to prevent automatic searches after a break lock.

2. Radar Data Parameter Measurement Limits

Table 3.7-1 Radar Operational Limits

Parameter	Passive Mode Characteristic
LOS range	100 ft to 10 n.mi.
Effective range	135 kft (22 n.mi.)
Maximum unambiguous range	147 kft (24 n.mi)
LOS range rate	148 fps closing 75 fps opening
LOS pitch angle	Plus or minus 30 degrees
LOS roll angle	Plus or minus 30 degrees
Pitch inertial angle rate	Plus or minus 20 mrad/sec
Roll inertial angle rate	Plus or minus 20 mrad/sec

3. Radar Error Characteristics

Table 3.7-2 Radar Error Characteristics

Parameter	Random Error (1 σ)	Bias Error (1 σ)
Range	27 ft out to 8 kft 0.0033*Range from 8 to 30 kft 100 ft when > 30 kft	27 ft out to 8nm 0.00053*Range when > 8 nm
Range rate	0.33 ft/sec or 0.33% of range rate, whichever is greater	0.33 ft/sec
Angle	0.153 deg	1.0 deg
Angle rate	0.0027 deg/sec	0.0027 deg/sec

4. Radar Data Path

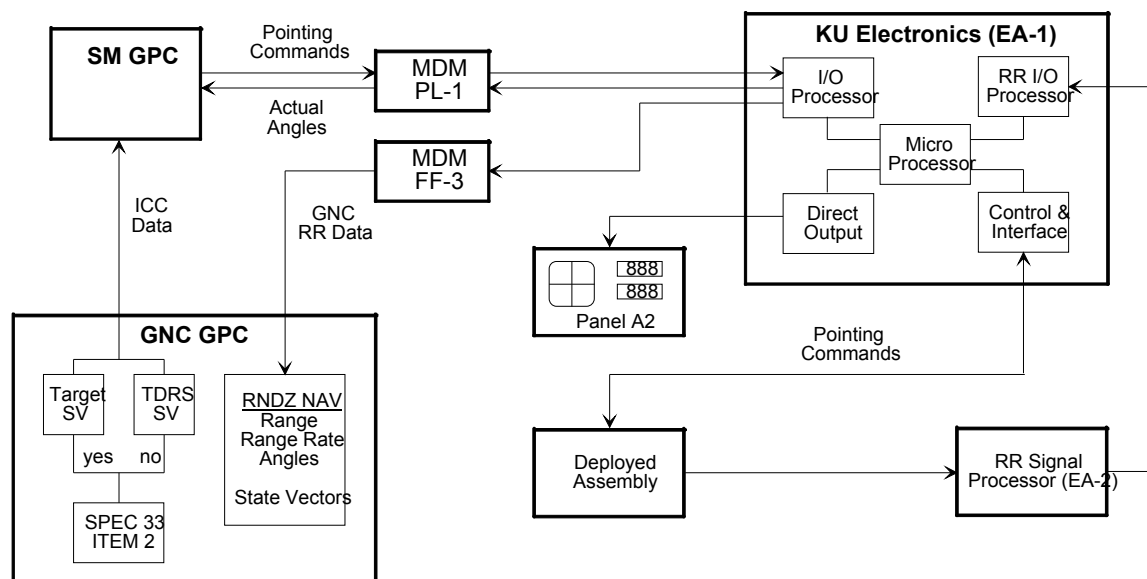


Figure 3.7-1 Radar Data Path

5. Radar Steering Modes

GPC

This is a fully automatic mode. If no signal is detected when GPC mode is selected, the antenna will automatically be commanded to search around the GPC commanded point in a spiral pattern up to 30 deg, the size depending on range. The antenna is inertially stabilized during the search operation. Once the antenna is tracking in GPC mode and it loses lock, an SM alert (G33 RNDZ RADAR) will be issued, the system will wait 20 sec, then a search will be started. Manual control is inhibited in this mode.

AUTO TRACK

In this mode, the antenna must be manually pointed for initial acquisition. Searches must be manually initiated using the KU SEARCH switch. The SLEW RATE must be in SLOW in order for the antenna to lock onto the target while it is being slewed. When tracking in this mode, manual control is inhibited. To force the system to break lock, the mode must be switched to MAN SLEW and the antenna slewed away from the target. This mode also uses a 30 deg spiral search pattern that is inertially stabilized.

GPC DESIGNATE

In this mode, the antenna is commanded to point to the location indicated by SPEC 33 ITEM 2 - uses the TGT SV if (*), uses TDRS SV if no (*). No closed-loop angle tracking is performed in this mode. Range and range rate data goods will be set when tracking.

MAN SLEW

Angle search and angle tracking are not available in this mode. The antenna is body stabilized when not being manually slewed. Since no angle tracking is available in this mode, angle data goods will never be set. Range and range-rate data goods will be set when tracking, however, and this data could conceivably be taken into nav if the switch were stuck in this mode for some reason.

Table 3.7-3 Summary of Ku-band Steering Modes

Steering Mode	Computer Steering	Manual Steering	Angle Tracking	Signal Tracking	Search	Stabilize
GPC	X		X	X	Computer	Inertial
Designate	X			X	NA	Both
Auto		X	X	X	Manual	Inertial
Manual		X		X	NA	Body

6. Radar Tracking Criteria

When the radar system gets a "DETECT" on a target, it starts a timer and will not declare data good for the various radar measurements until a certain amount of time has elapsed, based on the following table (times in seconds):

Table 3.7-4 Radar Tracking Criteria

Parameter	Range < 23040 ft	23040 ft < Range < 49920 ft	Range > 49920 ft
Range	8 sec	8 sec	28 sec
Range Rate	5 sec	5 sec	30 sec
Angle	7 sec	7 sec	7 sec
Angle Rate	10 sec	30 sec	30 sec

In GPC DESIG and MAN SLEW, a "TRACK" indication results when the range data good is set. In GPC and AUTO TRACK, angle and angle-rate data goods are required in addition to range data good to get a "TRACK" indication. Note that range rate data goods are not required to get a "TRACK" indication in any mode. Once true, the angle data good flags will only go false after a break track or if the steering mode is switched to a non-angle tracking mode (GPC DESIG or MAN SLEW).

One idiosyncrasy has been observed concerning the Antenna Steering Mode Select switch. When this switch is turned from AUTO TRACK to GPC or vice-versa, it passes through GPC DESIG. If the radar SOP, running at 6 HZ, happens to sample the switch at the time the switch is in GPC DESIG, it will set the angle data good flags to false. The radar will then break track when the SOP finally sees the switch in GPC mode (say the next cycle). Depending on the range from the target, it will take from 10 to 30 sec (see the table above) to get a "TRACK" indication again. To circumvent this problem, the KU CONTROL switch can be temporarily turned to CMD while the steering mode is switched, then returned to PNL to read the switch.

7. Radar Mainscan

The mainscan is the initial pattern used to search for a target. It is commanded automatically by GPC and via the SEARCH switch in AUTO. The pattern is a spiral with a maximum radius (pmax) up to 30 degrees, depending on the steering mode and/or the range designate. When the scan radius (p) is less than 9 degrees ("zone 1"), the scan radius has a constant rate change (pdot = constant); for a scan radius greater than 9 degrees ("zone 2"), the scan has a constant dwell. The scan is terminated by target detection or 60 seconds, whichever comes first. Unfortunately, one cannot follow the progress of the scan via telemetry since during the search the angle data is not updated during the scan.

Table 3.7-5 Radar Mainscan Characteristics

Mode	Designate (nmi)	T1 (sec)	p1 (deg)	Q1 (deg/s)	Q2 (deg/s)	Tmax (sec)	pmax (deg)
AUTO	--	10.1	9	290	45	60	30
GPC	0 to 8	10.1	9	290	45	60	30
	8 to 9.2	10.1	9	290	45	60	27.7
	9.2 to 10.3	10.1	9	290	45	60	24.4
	10.3 to 11.8	10.1	9	290	45	60	21.7
	11.8 to 15	10.5	9	275	43	60	19.6
	15 to 25	13.8	9	230	33	60	16.5

Notes: **T1** is the time to the switchover point between zones 1 and 2;
p1 is the scan radius at the switchover point between zones 1 and 2;
Q1 is the angular rate of change of the spiral scan in zone 1; (continued)
Q2 is the angular rate of change of the spiral scan in zone 2;
Tmax is the timeout point; and
pmax is the scan radius at the timeout point.

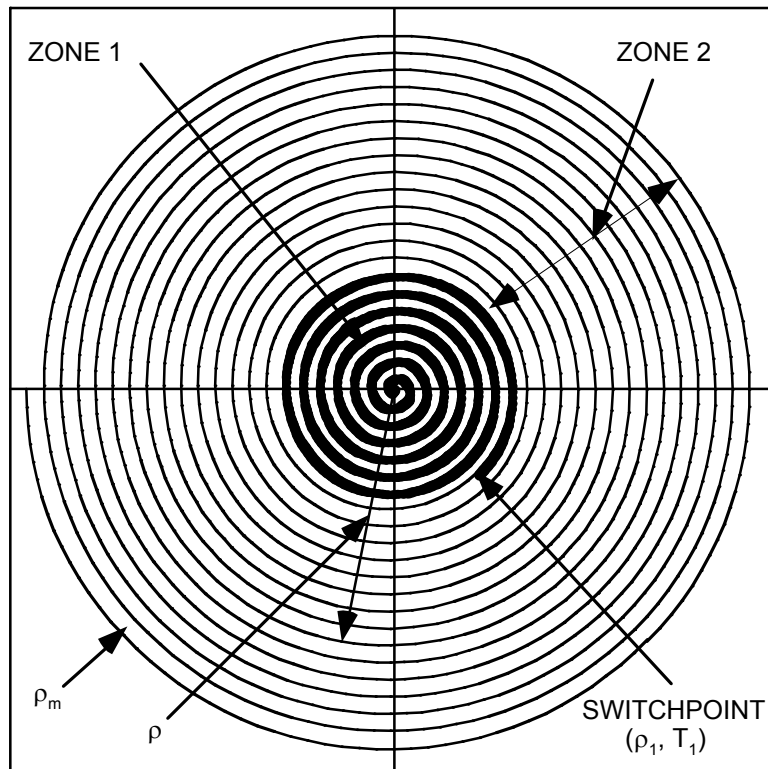


Figure 3.7-2 Radar Mainscan Pattern

8. Radar Velocity Ambiguity

When the radar is tracking a target at a range greater than 7.2 nmi, the Ku-band radar operates in a PRF mode of 3 kHz (per table, above). This region is a velocity ambiguous region.

The spec values for the radar are 75 fps max closing and 150 fps max opening. These values relate to the frequencies of -2100 Hz and 4144 Hz, respectively. When in the 7 kHz PRF mode, there are enough filters (or bins) to cover the entire opening and closing velocities expected. When in the 3 kHz mode, the PRF of 2987 Hz is insufficient to cover

the 4144 Hz associated with the 150 fps of a maximum closing target. These velocities are aliased into lower frequencies. Unfortunately, there is a corresponding overlap from opening target returns. In the 3 kHz PRF mode, there is a region of frequency “bins” occurring from 887 Hz to 1157 Hz where this aliasing overlap occurs. If a target returns a Doppler frequency in this region, it could be either opening or closing. To resolve what a target is actually doing, the velocity processor uses the coarse estimate of the range rate computed by the range processor by differencing the last two range measurements.

For a target providing a weak signal return, two or more successive range measurements could be confused. In the overlap region and at the same aliased frequencies, two successive returns could be confused as a target varying in velocity by approximately 106 fps. If two successive returns measure a target with a 106 fps error, then the displayed velocity will be in error by 106 fps. If one measured return is in error by 106 fps and the next is correct, then the displayed velocity will be in error by 53 fps.

RADAR SEARCH GATES

Table 3.7-6 Radar Search Gates

Designation		Search	
Range, nmi.	Range, ft.	Range Gate Setting	PRF mode*, kHz
0.0 - 0.42	100 - 2550	**	7
0.42† - 0.63	2560 - 3830	3840 ft	7
0.63 - 0.95	3840 - 5750	at designate	7
0.95 - 1.1	5760 - 6390	6400 ft	7
1.1 - 1.9	6400 - 11510	at designate	7
1.9 - 2.2	11520 - 13430	13440 ft	7
2.2 - 3.8	13440 - 23030	at designate	7
3.8 - 4.2	23040 - 25590	25600 ft	7
4.2 - 7.2	25600 - 43510	at designate	7
7.2‡ - 8.2	43520 - 49910	49920 ft	3
8.2 -	49920 -	at designate	3

Notes: *Cycled between TWT bypass, TWT-24 dB, and TWT-12 dB
 **60-foot intervals from 120 ft to 4260 ft
 †2560 ft for closing targets, 3200 ft for opening targets
 ‡43520 ft for closing targets, 49920 ft for opening targets

9. SM ANTENNA Display Functions

RDR RNG AUTO

An ITEM 16 on the SM ANTENNA Display enables the GPC pointing angles and range designate to be based on the onboard NAV relative state. The KU SEL switch must be in GPC for this setting to have any effect.

RDR RNG MIN

An ITEM 17 on the SM ANTENNA Display forces the GPC pointing angles to an AZ/EL of 0/0 (the Orbiter -Z axis) and a range search between 100 and 2500 ft. This mode is used during deploys when the onboard NAV state may not be accurate enough to provide proper pointing. The KU SEL switch must be in GPC for this setting to have any effect. Care must

be taken to deselect this RNG MIN mode if the target is known to be considerably off the Orbiter -Z axis and the steering mode is GPC.

SELF TEST

A self-test performs a series of tests to demonstrate that the EA1, EA2, and DA units are operational. The self-test can only be performed in the radar mode. Also the KU RADAR OUTPUT must be in HI to prevent the system from failing the self-test. The self-test is started with an ITEM 7 on the SM ANTENNA display and runs 3 min, 20 sec. It must be terminated with a second ITEM 7. If the self-test is not terminated it will continue to repeat. If the KU is switched to COMM mode while the self-test is in progress, the self-test will stop but will resume again when returned to radar mode. As a note of interest, INCO can command the initiation and termination of the self-test from the ground if the KU is in radar mode.

10. Radar Self Test Data

Table 3.7-7 Radar Self Test Steps

Task	Description
1	(not implemented)
2	PROM check of EA-1
3	EA-2 Operate Status
4	Initialize Antenna
5	Servo test: P = 30, R = 0; P = 30, R = -30; P = 0, R = 0
6	XMIT Power Level
7	Range, Range Rate
8	Angle Track
9	Receiver Sensitivity
10	Compile Test Results

This is a brief summary of what indications to look for during the Radar Self Test:

Task 2 (at elapsed time = 0 seconds):

- Range at 2621439
- Range Rate at +1638.3

Task 4 (at elapsed time = 25 seconds):

- Antenna Pointing Mode in GPC DESIG

Task 5.1 (at elapsed time = 40 seconds):

- Elevation Angle counting up to 30.0

Task 5.2 (at elapsed time = 55 seconds):

- Azimuth Angle counting down to -30.0

Task 5.3 (at elapsed time = 70 seconds):

- Elevation Angle counting down from 30.0 to 0.0
- Azimuth Angle counting up from -30.0 to 0.0

Task 7.1 (at elapsed time = 100 seconds):

- Antenna Pointing Mode in MAN SLEW

- TRACK indication
- Range at 5320 (expected value -- noise will deviate this value)
- Range Rate at 0.0
- RANGE DATA GOOD indication
- RANGE RATE DATA GOOD indication

Task 7.2 (at elapsed time = 110 seconds):

- No TRACK indication
- Range at 0.0
- No DATA GOOD indications

Task 7.3 (at elapsed time = 120 seconds):

- TRACK indication
- Range at 10240 (expected value -- noise will deviate this value)
- RANGE DATA GOOD indication
- RANGE RATE DATA GOOD indication

Task 8.1 (at elapsed time = 130 seconds):

- Antenna Pointing Mode in AUTO TRACK
- No TRACK indication
- All DATA GOOD indications

Task 8.2 (at elapsed time = 140 seconds):

- TRACK indication

Task 9 (at elapsed time = 160 seconds):

- Antenna Pointing Mode in GPC ACQ

Task 10 (at elapsed time = 200 seconds):

- Antenna Pointing Mode in MAN SLEW
- Range at 8888.8 or 3333.3, indicating SELF TEST PASSED or FAILED, respectively
- No ANGLE DATA GOOD indication
- No ANGLE RATE DATA GOOD indication

3.8 Hand Controllers

PURPOSE

To discuss Translational Hand Controller (THC) and Rotational Hand Controller (RHC) systems.

PROCEDURE

Refer to the Stringing tables in SCP 3.1 DPS AND EPS for details concerning impacts to THC and RHC operations due to MDM and/or bus losses.

RHC / THC Power

Three internal power supplies each power one channel of the Commander (CDR), Pilot (PLT), and aft station controllers.

The three power channels in each controller are redundant and each controller can operate with only one channel powered.

Signals

Triple redundant roll pitch and yaw signals are processed from both the CDR and PLT RHC. The three redundant signals are then sent through RM and failure/dilemma conditions are presented to the crew. The crew can deselect/reselect RHC signals through the keyboards in OPS 2 & 8. Automatic deselection can also occur.

THC Operations in PULSE Mode

The SOP samples THC contacts at a rate of 6.25 Hz (160 ms). In PULSE mode, the DAP requires an ON sample and an OFF sample. Thus, the maximum effective THC input rate in PULSE mode is 3.125 Hz, or one input every 320 ms, or at most 3 deflections per second. A positive deflection followed quickly by a negative deflection can effectively cancel out each other, resulting not in one positive and one negative firing by the DAP, but instead resulting in no firing. Therefore, careful THC deflections by the operator are imperative.

Transient Signals

The THC no longer generates spurious inputs to the flight control system when the Flight Controller power is turned on, however this had been a problem in the past. Prior to the Multifunction Electronic Display System (MEDS) cockpit configuration, all hand controller channels were powered on at once. If transient signals were received on at least 2 channels by 2 or 3 level switch RM, this would command a jet firing. The workarounds were to minimize the number of times the Flight Controller power is switched on and to disable RM by a SPEC 25 ITEM 16 EXEC immediately before powering on the flight controllers. The crew would then re-enable switch RM with another SPEC 25 ITEM 16 EXEC (toggle) immediately after flight controller power was turned on. During the switch RM disable period, all cockpit switch changes were ignored by the flight software, therefore it was important that the re-enable occur before any other switch changes were made. These steps were employed in the undocking procedure, when powering on the THC, however they have since been removed.

The spurious inputs did not downmode the DAP, but they did fire jets unnecessarily. Before OI-8D, the workaround for the Orbit DAP was to set the DAP to VERNIER mode before switching the Flight Controller power on. In VERNIER mode, the DAP ignored translation commands. With the hotstick downmoding (OI-8D CR # XXXX), when in VERNIER mode, the orbit DAP will upmode to primary for the duration of THC out of detent. This would result in unnecessary primary jet firings. With the MEDS reconfiguration, hand controller channels are powered on sequentially, so that a transient input can occur in only one channel at a time. This will not result in unwanted jet firings, because 2 or 3 level switch RM must receive two channels high to command a jet firing. A spurious firing is still possible if switch RM is at the 1 level.

BACKGROUND

RHC

The RHC mechanical hard stop occurs at +24.3° in the pitch and roll axes and at +14.3° in the yaw axis. The mechanical hard stop is the maximum deflection that can be obtained in an axis. The mechanical soft stop for the RHC occurs between +19° and +20° for the roll and pitch axes and between +9.5° and +10.5° for the yaw axis. The mechanical soft stop is a built-in resistance that occurs prior to the hard stop in an axis.

See section 13.2 of SHUTTLE OPS GNC/JSC-18863, "CONTROLLERS" for redundancy management information. That document and other systems briefs are available on the GNC web site at <http://mod.jsc.nasa.gov/df/df62/sb.html>.

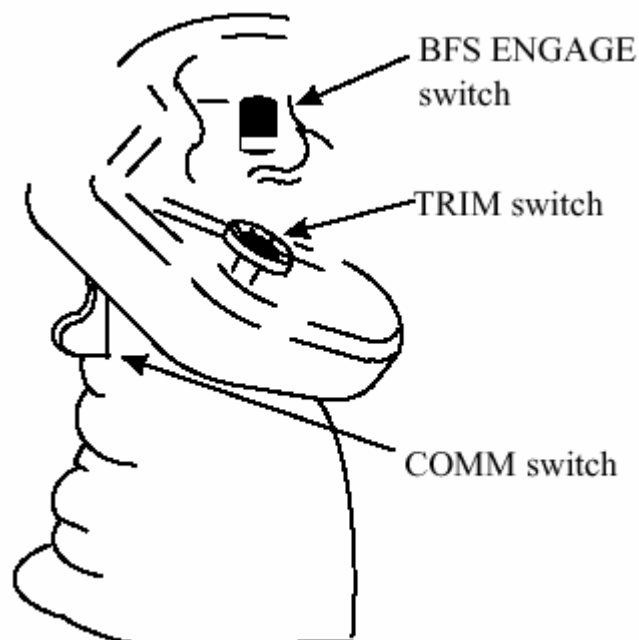


Figure 3.8-1 Rotational Hand Controller

THC

The THC is utilized to perform translation movements of the vehicle by utilizing propulsion systems associated with the movement of the controller. The THC has three-axis movement respective to itself: up-down (vertical), left-right (lateral), and in-out (longitudinal). See Figure 3.8-2 for a pictorial view of the THC. The movement of the THC in any axis is a maximum of half an inch from the center position. As previously stated, there is a THC on the commander's side forward and a THC in the aft station. The THC is the only controller that uses DC power exclusively.

See section 13.3 of SHUTTLE OPS GNC/JSC-18863, "CONTROLLERS" for redundancy management information. That document and other systems briefs are available on the GNC web site at <http://mod.jsc.nasa.gov/df/df62/sb.html>.

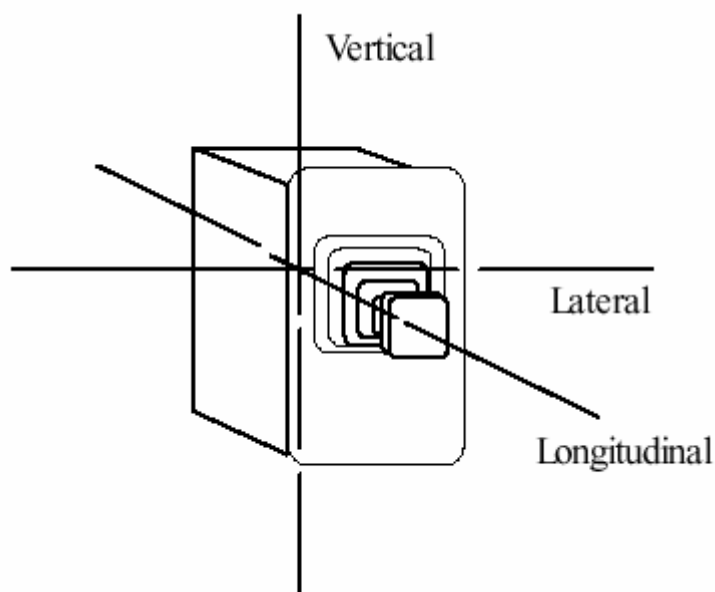


Figure 3.8-2 Translational Hand Controller

Table 3.8-1 Body transformations of Aft THC Inputs in Both Senses

Aft THC Physical Movement (wrt panel)	Display Outputs	Transformed Aft THC Outputs (body axis)	
		-X Sense	-Z Sense
+X	+X	-X	-Z
-X	-X	+X	+Z
+Y	-Z	-Y	-Y
-Y	+Z	+Y	+Y
+Z	+Y	+Z	-X
-Z	-Y	-Z	+X

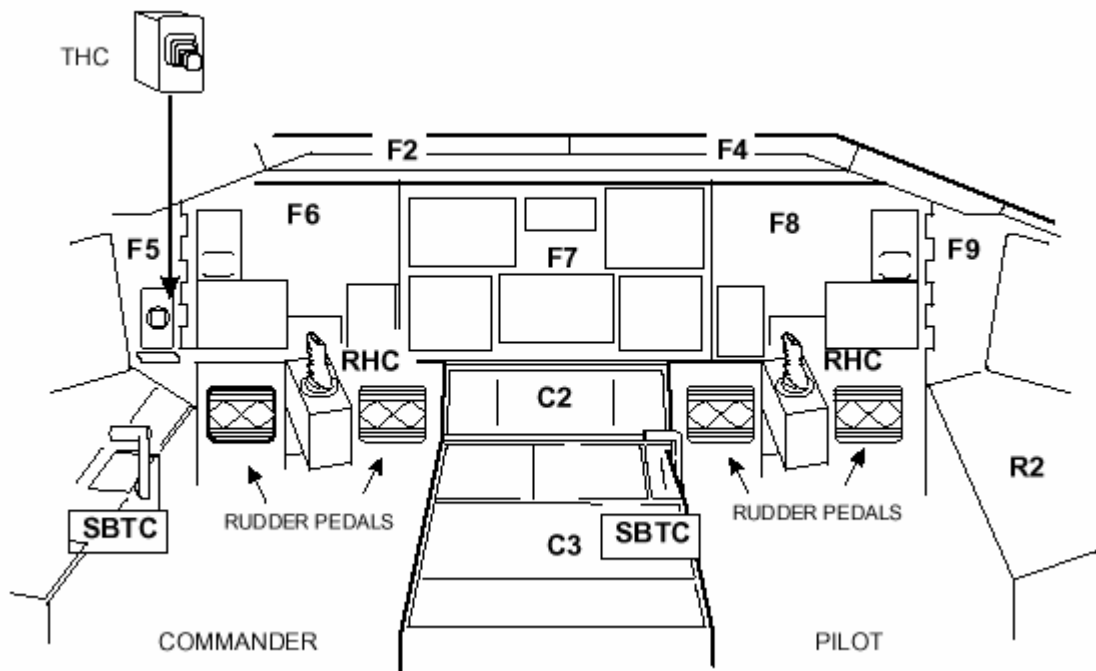


Figure 3.8-3 Forward Locations of CDR and PLT Hand Controllers

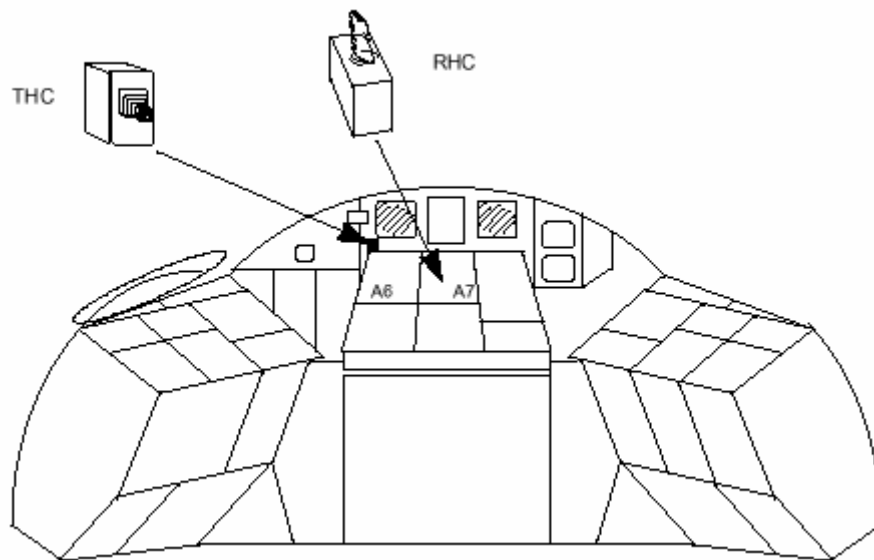


Figure 3.8-4 Aft Locations of CDR and PLT Hand Controllers

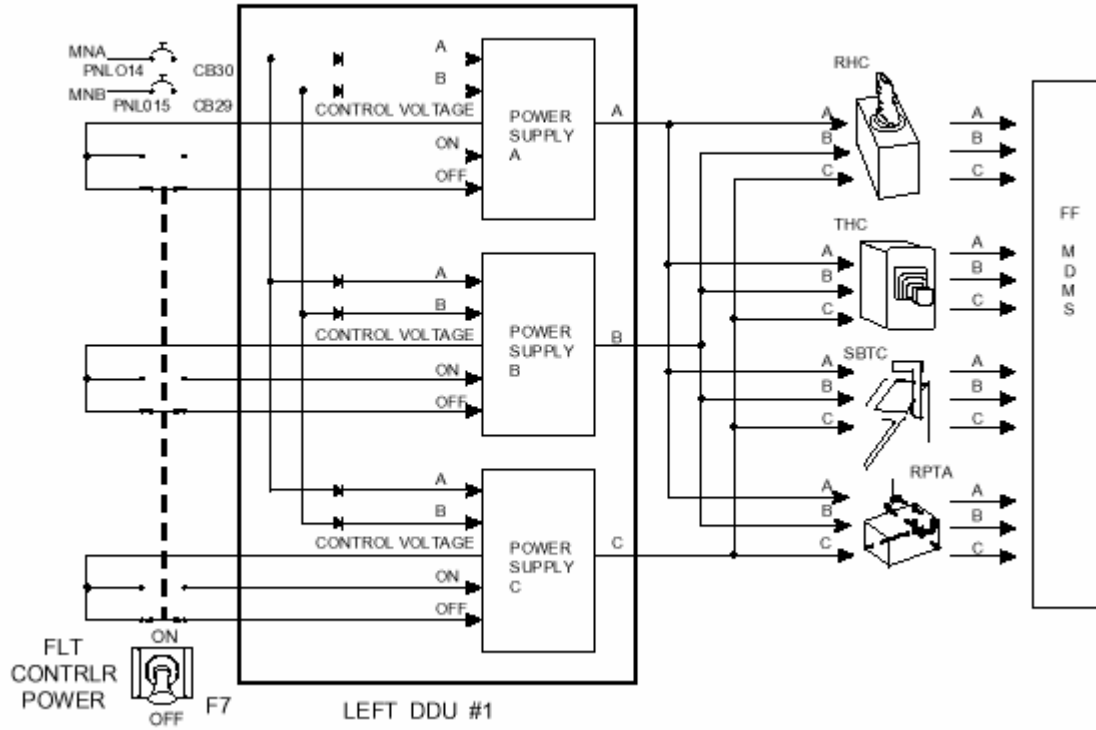


Figure 3.8-5 Power Diagram for CDR and PLT Controllers

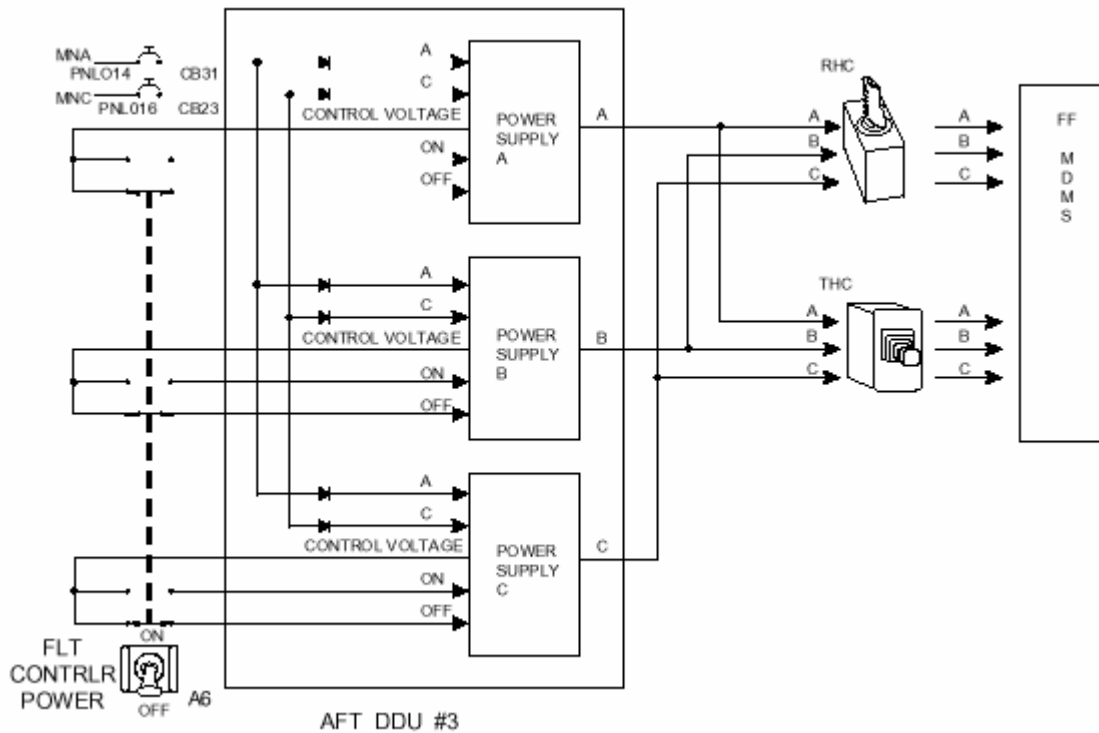


Figure 3.8-6 Power Diagram for Aft Flight Deck Controllers

3.9 Cameras

PURPOSE

To discuss various cameras used on the Orbiter during rendezvous.

PROCEDURE

The procedures in the Rendezvous Checklist and Photo/TV 19 should be used for camera operations during rendezvous and proximity operations.

BACKGROUND

Portions of the following information are taken from the Rendezvous & Prox Ops Design Reference (RPODR) for the International Space Station. See sections 70 through 74 of the Systems Brief on the Instrumentation and Communications Officer (INCO) web site at <http://mod.jsc.nasa.gov/df/df24/index.htm> for more detailed information.

Closed Circuit Television Cameras

The Orbiter is equipped with several television cameras and camera mounts in the payload bay (PLB). These cameras are used heavily during proximity operations. Table 3-9.1 identifies the cameras used during various phases of rendezvous and undocking operations, while the exact locations of Orbiter cameras are shown in Figure 3.9-1.

The Orbiter Closed Circuit Television (CCTV) system is comprised of several types of cameras. The Intensified Television Cameras (ITVC) are black and white cameras with the capability to remotely control the lens iris, zoom and focus. The ITVC uses an illuminator ring, which makes the camera more effective during nighttime payload bay operations than the color television camera. The solid-state color television camera (CTVC) system consists of a color-separating prism that provides a balanced composite color video output signal that is compatible with the CCTV system. The CTVC does not have an image intensifier and is not used in very low light conditions, such as the viewing of stars.

The flight requirements document can be checked to determine flight-specific camera assignments.

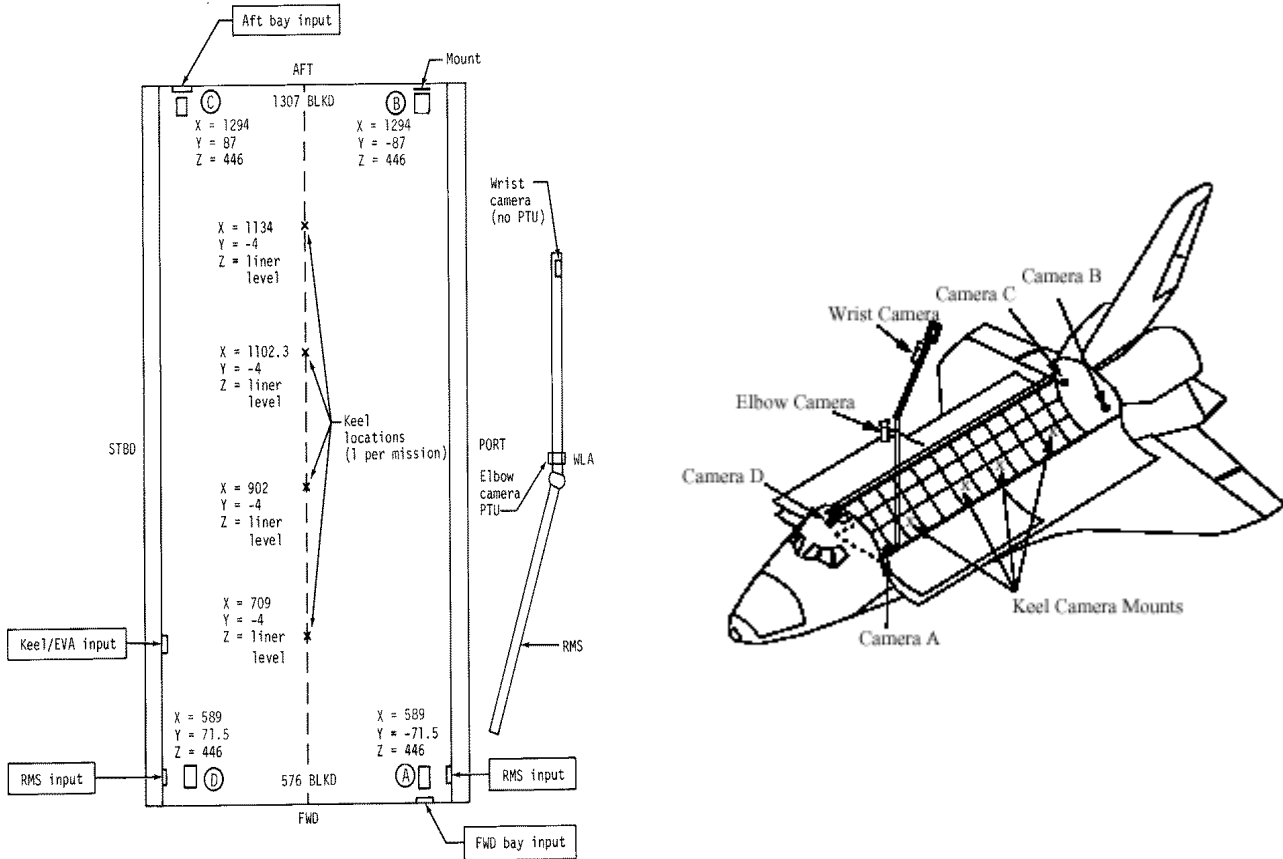


Figure 3.9-1 CCTV Camera Locations

Table 3.9-1 CCTVs Used During Rendezvous

Operation	Cameras Required	Usage	Functions Required
Flyaround	ODS Centerline	Line-of-Sight	Zoom
	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom
Rbar Approach	ODS Centerline	Corridor	Zoom
	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom
Vbar Approach	ODS Centerline	Corridor	Zoom
	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom
Stationkeeping	ODS Centerline	Corridor	Zoom
	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom
Angular Misalignment Flyout	ODS Centerline	Corridor, Angular Misalignment	Zoom
	ODS Centerline	Corridor	Zoom
Docking (30 to 0 ft)	A/D	Range/Range-Rate	Pan, Tilt, Zoom
	ODS Centerline	Corridor	Zoom
Separation	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom
	ODS Centerline	Corridor	Zoom
Backout	ODS Centerline	Corridor	Zoom
	A/D, B/C	Backup Range/Range-Rate	Pan, Tilt, Zoom

The Orbiter will use both types of cameras in the PLB during approaches to the ISS. Cameras A, B, C, D, and the RMS elbow will be mounted in a Pan/Tilt unit which provides 170° in pan and tilt

moving at 12°/s or 1.2°/s. All cameras have zoom capability listed in Table 3.9-2. For approach and separation, the ISS flights will primarily use the centerline camera, which should always be a CTVC, as shown in Figure 3.9-1. For non-ISS payloads such as HST, the keel camera will be used for approach and separation (ODS/centerline camera is not installed).

Table 3.9-2 CCTV FOVs

Camera	Full Zoom (HFOV x VFOV) (deg)	Corridor Zoom (HFOV x VFOV) (deg)	No Zoom (HFOV x VFOV) (deg)
CTVC	10.1 x 7.6	40.0 x 30.816	74.4 x 59.9
ITVC	6.95 x 4.4	N/A	56.13 x 42.1

Onboard Camera Selection

The CCTV system is operated onboard from the switches on panel A7, and switches on the cameras themselves.

Automatic Light Control (ALC)

The CTVCs and ITVCs are normally operated in an ALC mode. ALC circuits provide automatic feedback to limit the amount of light penetrating the lens and exciting the Charge-Coupled Devices (CCDs) that convert the light energy into an electric signal. Each camera type has the common settings of peak, normal, and average. What differentiates each setting is the area of the video picture in which the amplitude of the video signal from adjacent picture elements (pixels) must exceed a defined limit before the ALC circuit senses a video signal amplitude violation. The purpose of an ALC circuit is to maintain consistent illumination for maintaining picture quality.

Gain and Iris Settings

Both the CTVC and ITVC provide manual gain and iris settings in case the automatic settings do not provide the desired output. Both types of cameras can provide manually selected gain settings of 0db, +12db, and +24dB gain settings. Whenever a manual gain setting is selected, the ALC circuit is bypassed, enabling the users to fully control the amount of light entering the camera by commanding the iris themselves. The ITVCs also provide an additional gain option that can be used with either manual or ALC mode. The NITE setting provides approximately 16dB more gain at low light levels than the DAY setting, but does this at the expense of Signal/Noise Ratio (SNR). The SNR for DAY at higher light levels is around 56dB, whereas the SNR for NITE mode is, at best, 40dB. NITE setting also amplifies the fixed-pattern noise (inherent to the image intensifier) in addition to the random white noise in the video signal. Generally speaking, reducing the gain in the ITVC provides a less noisy picture.

Pan/Tilt Unit (PTU)

The PTU is a remotely controlled azimuth/elevation mount for CCTV cameras located on the forward and aft bulkheads and on the Remote Manipulator System (RMS) elbow of the orbiter. The power supply cable routing is from bulkhead to PTU and from PTU to TVC. Pan and tilt motions are provided upon TVC command at 1.2° per second (slow command) or 12° per second (fast command) over a total range of 340° (+170° from nominal zero position).

Note that the pan/tilt readouts on each camera display are not true pan/tilt unit telemetry. They are maintained by the camera and indicate where the camera “thinks” that it is pointed. If the PTU hangs up, fails, or is nonexistent, the camera does not know and indicates pan/tilt angles as if it were really panning or tilting. The pan/tilt counter is 11 bits; so the angles could go as high as 409.4°, then reset to zero and continue.

Camera Selection from the Ground

Ground commanding is accomplished via a 14-bit parallel word set on MDM PF2 (sometimes known as MDM PL2).

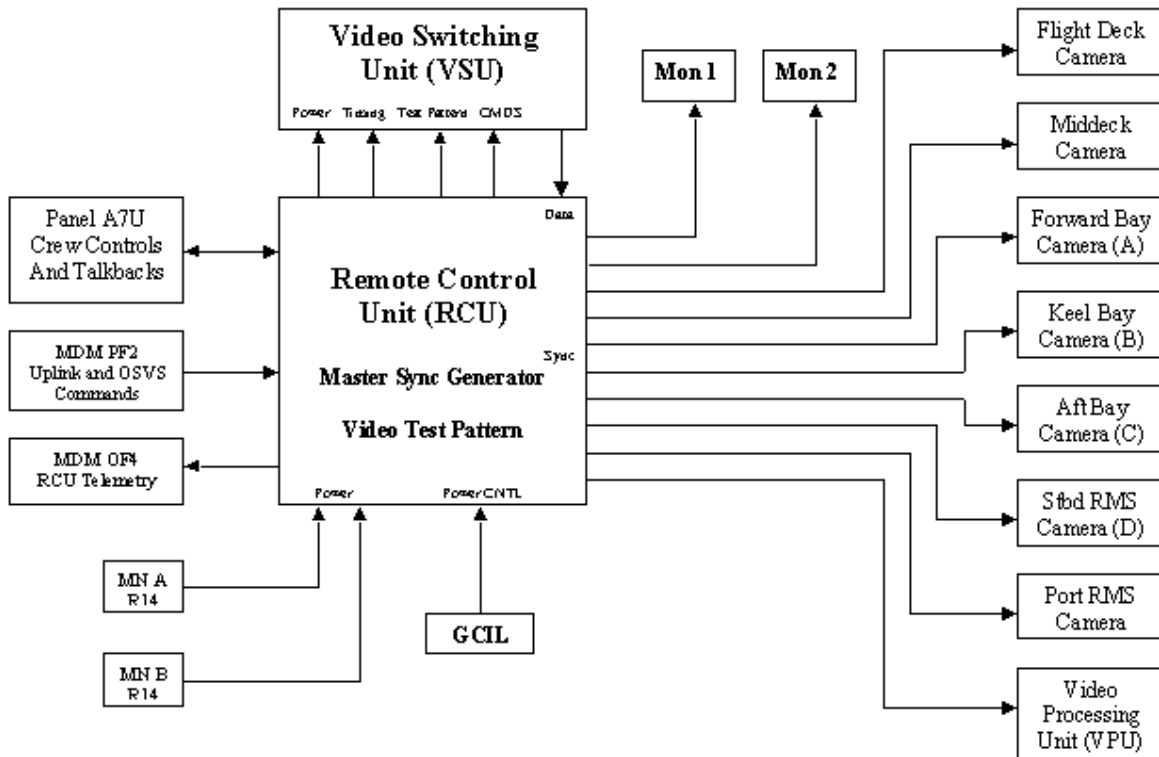


Figure 3.9-2 CCTV Hardware Diagram

Centerline Camera

The ODS centerline camera is mounted in a way that provides a 12.8° unobstructed field of view. The camera has a capability for on-orbit alignment prior to rendezvous. Since the centerline view is required for docking, a spare camera is carried in case the prime camera fails. There is no non-axial camera like there was for Shuttle/Mir dockings, so a failed centerline camera will require a halt in the approach until the centerline camera is replaced and aligned.

The centerline camera is installed and aligned in PHOTO/TV 19 – SETUP C/L CAM INSTALL. This usually takes place on the day before rendezvous. Crew members are required to install the camera itself into the camera bridge, which is flown in place. Using the green crosshairs on a flight deck monitor, the crew ensures that the center of the crosshairs (representing the center of the camera field of view) are within the **inner diameter** of the ODS washer, which can also be seen on the monitor. The procedures also call for the crew to check the alignment of the camera using the crosshairs and the vertical and horizontal tick marks on the sides of the screen. These operations are represented in Figure 3.9-3.

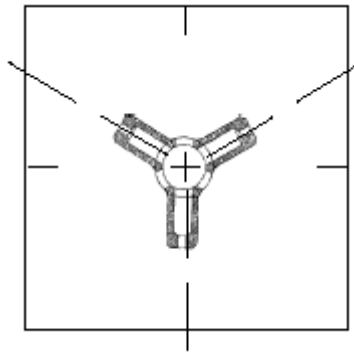


Figure 3.9-3 A Well-Aligned C/L Camera View

Side and top views of the ODS with the centerline camera installed are shown in Figures 3.9-4 and 3.9-5.

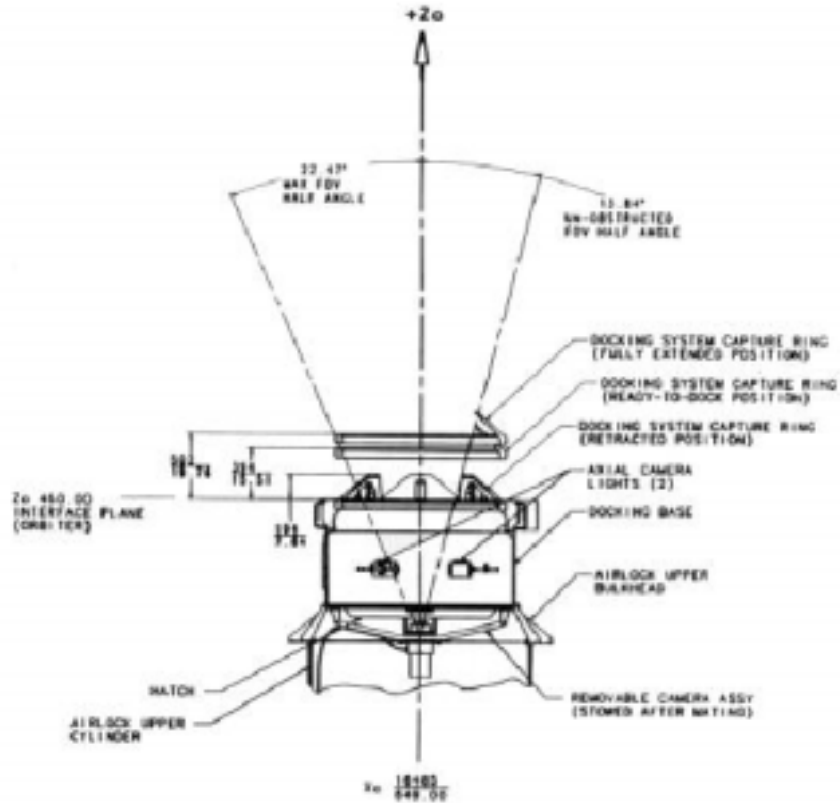


Figure 3.9-4 Side View of ODS with C/L Camera Installed

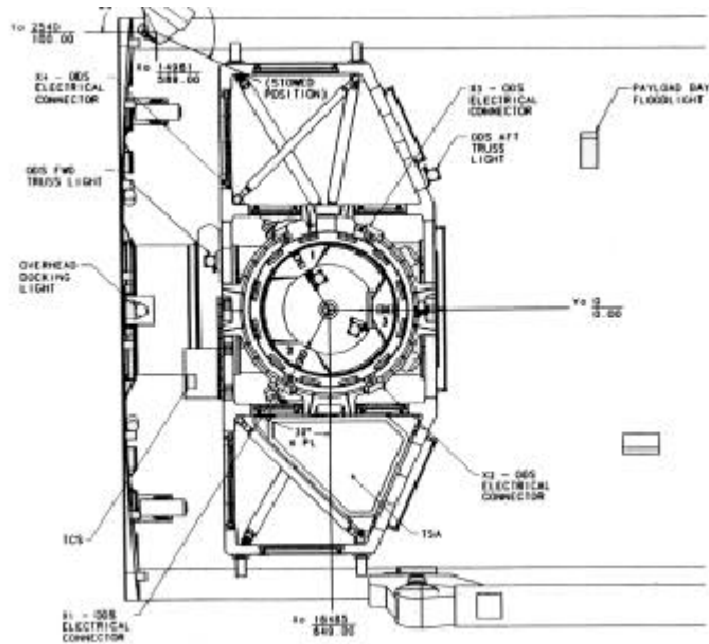


Figure 3.9-5 Top View of ODS with C/L Camera Installed

Centerline Video Troubleshooting

Because the centerline video is critical to a successful docking, it is important to have a rudimentary understanding of the potential system failures (and their possible workarounds), so that the Rendezvous team may be able to effectively coordinate troubleshooting efforts with INCO/IFM. Nominally, the centerline camera video output is connected to ODS TV port 1, and then travels through the VPU (video processing unit), PL2, VSU (video switching unit) and then to the monitors. Each of these paths has the potential to fail, and if they do, some workarounds exist in the photo TV flight supplement checklist. For example, if the video switching unit fails, it can be replaced with a rudimentary switching unit called the TVCU in about 25 minutes (5 minutes to unstow and 20 minutes to configure). Figure 3.9-6, which is from the photo TV flight supplement checklist, shows the cabling configuration for a VSU failure (where the TVCU replaces the VSU). Besides the VSU failure, two other 0 fault tolerant video components exist in the centerline video path and they are PL2 and the VPU. Although the workarounds for these failures are not currently documented in the flight procedures, failure of PL2 can be worked around by using the stowed TVCU cable (SED33105876-301) connected between the VPU and the PIGMY cable (see lower right hand corner of figure 3.9-6) that leads to the flight deck TV port (O19). The flight deck TV port connects directly to the VSU, thereby eliminating the failed PL2 video bus from the video path. To work around a VPU failure (and a PL2 failure if desired) an option is to connect a video cable directly from the centerline camera to the middeck TV port. Unfortunately, the drawback of this option is that the inner hatch must be left open during docking to allow the cable run.

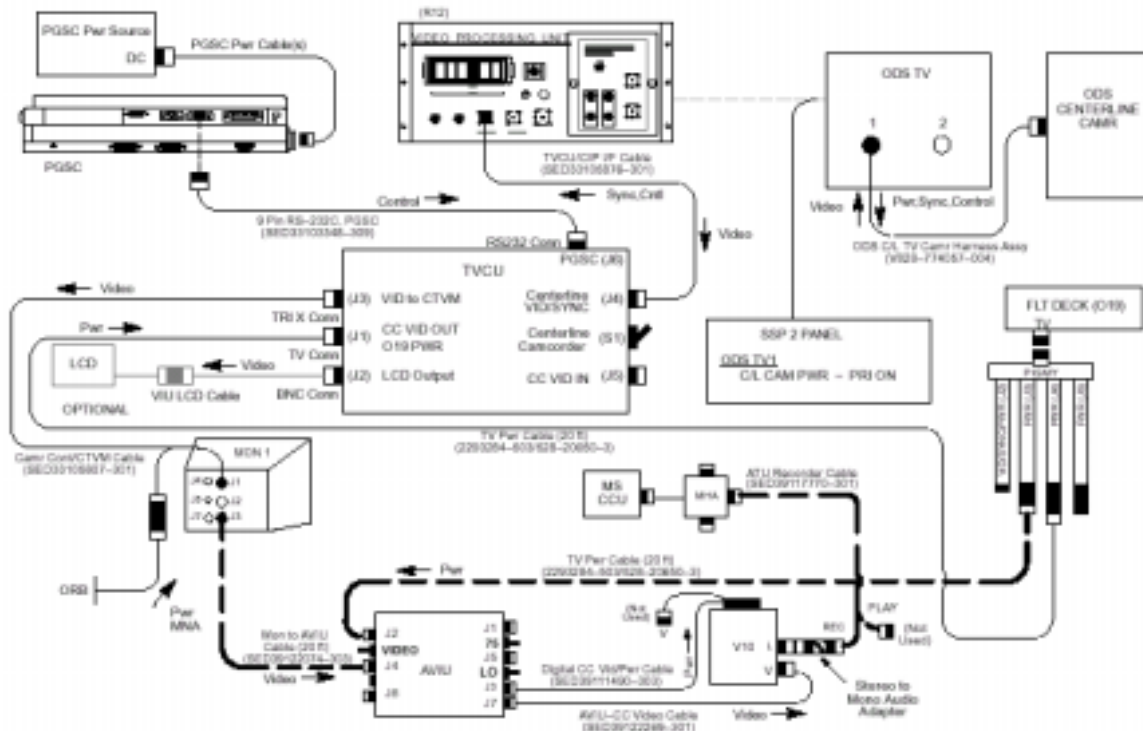


Figure 3.9-6 VSU Failure Workaround Cabling Diagram

4.1 State Vector Management

PURPOSE

To provide a description of the onboard navigation system and management of the PROP and FILT state vectors.

PROCEDURES

1. Onboard State Vector Overview:

Prior to the initialization of relative navigation, FDO generates and uplinks a fresh Orbiter and Target state vector using the latest ground tracking available. A drag K-factor for each vehicle is also uplinked. When rel nav is enabled the PROP vector is created and is equal to the FILT vector.

The onboard state vectors are propagated using sensed velocity changes from the three functionally independent Inertial Measurement Units (IMUs) and math models that account for Earth gravity and atmospheric drag.

Once the orbiter is within sensor range of the target, sensor data is fed to the onboard Kalman filter and the FILT vector is updated accordingly.

The external sensors used during the orbit RNDZ phase are: Ku-band RNDZ Radar (RR), Star Tracker (STRK), and Crew Optical Alignment Sight (COAS).

2. Onboard State Vector Maintenance

Tables 4.1-1 and 4.1-2 define the environmental models, IMU thresholds and algorithms used in onboard vector propagation.

Note:

SPEC 33 ITEM 5 AVG G - OFF disables incorporation of IMU-sensed accelerations (despite the label, it does not turn on or off AVG G).

SPEC 21 ITEM 18 is in units of $\mu\text{g}\cdot\text{sec}$, meaning that it is the number of microgees accumulated in one nav cycle of 3.84 sec (therefore, 1000 μg will use a value of 3840 in SPEC 21 ITEM 18).

Table 4.1-1 On-Orbit Vector Propagation

Thrust Status	Threshold	Models Used
OFF	Acceleration > 1000 μg (SPEC 21 ITEM 18) accumulated velocity > 0.12 fps/NAV cycle	J4 Gravity, Atmospheric Drag
ON	Accumulated velocity > 0.06 fps/NAV cycle (ILOADed value)	J2 Gravity

Table 4.1-2 Vectors Updated by Rendezvous Navigation Vector Propagation

Vector	Update Rate	Propagated By	Updated With
Orbiter FLTR	3.84 sec	Super G	Vents, drag, IMU ΔVs, NAV sensor data
Orbiter PROP	3.84 sec	Super G	Vents, drag, IMU ΔVs
UPP	0.96 sec	Average G	IMU ΔVs
	3.84 sec	SV SEL overwrite	---
TGT	3.84 sec	Super G	Drag

3. Ground Vectors

- The **TLM-10** vector contains either the FLTR or UPP downlisted Orbiter vector elected by FDO.
- The **TLM-11** vector contains the downlisted Target vector.
- Usually, **Ephemeris-1** contains FDO's best Orbiter vector and **Ephemeris-3** the best Target vector. Check with FDO to confirm this.
- The **EPH-1, EPH-3, TLM-10, and TLM-11** vectors are used in the STATE VECTOR section at the top left part of the Rendezvous ONAV Status, window title, "RNDZ_STAT:(RNDZ_STAT): ONAV ORBITAL STATUS. This display is accessed from the DNAV menu under Console Apps> ONAV Orbital Status.
 - $GND-PFS = EPH-1 \text{ minus } TLM-10.$
 - $GND-TGT = EPH-3 \text{ minus } TLM-11.$
 - $ONBD_REL = TLM-11 \text{ minus } TLM-10.$

4. FILT vs PROP Management

Overview

Either FLTR or PROP can be selected as the NAV source for other guidance and navigation functions. Also, either vector can be transferred to replace the other. As NAV sensor measurement data is incorporated into the FLTR, the difference between the vectors is monitored in terms of delta position and energy. At various points during the rendezvous, the FLTR vector will be transferred to the PROP after the FLTR has been determined to be the best vector.

Rendezvous NAV Initialization

When RNDZ NAV is enabled, the PROP vector is created and set equal to the FLTR. The SV SELECT option is initialized to PROP. The SV Select is changed to FILT after the required number of sensor marks have been incorporated into the FILT state and the SV update is less than as specified tolerance. See SCP 4.4 Rendezvous Radar Navigation and SCP 4.5 Star Tracker Navigation.

FLTR-TO-PROP

FLTR-TO-PROP vector transfers will usually be done for the following:

- Second star tracker pass: After STRK acquisition but prior to incorporating data into the Filter. This is to save the current best SV before incorporating STRK data into it, on the chance that the STRK data may subsequently degrade rather than improve the FLTR vector.

- Radar. After RR acquisition but prior to incorporating data into the Filter. Criteria are radar data good and ratios less than 1.0 for four NAV cycles (about 31 sec).
- Post-Ti. After sensor acquisition but prior to incorporating data into the Filter.
- Final MC2 Targeting. The vector used to target and execute MC2 and MC3 is saved for possible use in the failed radar procedures
- Late Radar Nav. Another FLTR → PROP is included to ensure the Orbiter continues to point based on the vector used to target and execute MC2.
- Note: A FLTR-TO-PROP vector transfer is generally not performed in the middle of a sensor pass because there is no positive test to determine if the FLTR is really better than the PROP.

PROP-TO-FLTR

The PROP vector is maintained to provide recovery capability should the Filter solution be polluted as the result of processing erroneous sensor measurement data.

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4.2 Rendezvous Nav Safing & Impacts

PURPOSE

To describe Rendezvous Nav safing steps and the possible impacts on Rendezvous Nav from DPS operations.

PROCEDURES

1. Preparation for Rendezvous Nav Disable:

CANCEL target track on UNIV PTG 201 (ITEM 21) and reconfigure DAP as desired.

- Targeting: protected simply by not executing Lambert targeting when Rendezvous Nav is not active.
- Pointing: protected by canceling target track on the DAP or moding to INRTL, LVLH or FREE. If UP tries to track the target after Rendezvous Nav disable, internal GPC errors and excessive jet firing may be seen due to the static TGT vector.
- TGT Vector: Becomes static (not propagated) and may require new uplink from ground if Rendezvous Nav is disabled for a long time period.
- Orbiter Vector: May be lost with OPS 0 transition (see table below).

2. REL NAV Display Status Impacts

Table 4.2-1 Rendezvous Nav Status Impacts

	RNDZ NAV Enable	Restrिंग	Add/Delete GPC to/from RS	OPS Transition
RNDZ NAV Enable	---	OK	Lost	Lost
Angle Source	Last Value	OK	OK	STRK
AUTO/INHIBIT/FORCE	Last Value	OK	Last Value	INHIBIT
COAS Calibration	---	OK	OK	OK
DV_DISP Counters	OK	OK	0	0
FLTR minus PROP	0	OK	PROP=FLTR	PROP=FLTR
IMU Deselect	---	OK	OK	OK
KU Antenna Enable	Last Value	OK	OK	Lost
Mark Counters	0	OK	0	0
Orbiter State Vector and drag K-factor	OK	OK	OK*	OK*
Star Tracker Mode	---	OK	TERM IDLE	TERM IDLE
State Vector Select	PROP	OK	PROP	PROP
Target State Vector and drag K-factor	OK	OK	OK	Lost
2-Level IMU Reference	---	OK	Lowest IMU	Lowest IMU
U/L Covariance Matrix	Initialized	OK	Reinitialized	Lost
UNIV PTG Options	---	OK	OK	Same

* Orbiter state vector is lost if more than 10 minutes is spent in OPS 0.

Notes:

- Adding or deleting a GPC in the GNC GPC redundant set causes the GPC(s) to enter OPS 0 momentarily.
- After 10 minutes in OPS 0, the Orbiter state vector will be replaced by an I-Loaded default orbital state vector in an equatorial orbit and a new, valid Orbiter state vector must be uplinked.
- The Target state vector must be within ± 15 hours of current time to enable Rendezvous Nav.

4.3 Navigation Anomalies

PURPOSE

To provide procedural guidance for cases where REL NAV ratios > 1.0 on SPEC 33 (REL NAV) and thus to respond to the specified "Call MCC" note in the Rendezvous Checklist.

PROCEDURE

Take actions in an order that will cause the smallest perturbation to the onboard relative state vector. More aggressive actions can always follow in an attempt to correct a bad NAV situation.

Manage the onboard state vectors (SV) as described in SCP 4.1 STATE VECTOR MANAGEMENT. In the event one of the two state vectors (Orbiter or Target) must be uplinked, procedures are in place to build the other vector from the existing good relative state so as to minimize the effect on the onboard relative state.

Uplink of New Orbiter SV

- Verify current Onboard relative state and Inhibit data to the FLTR
- Coordinate with FDO to select a new Orbiter state vector (choose an ephemeris vector or a previously saved onboard vector)
- Coordinate with FDO to build a new Target vector based on the new Orbiter vector and current onboard relative state

When both vectors are ready:

- Request FREE Drift on the DAP
- Uplink both state vectors and verify them
- Return to AUTO DAP
- Perform a FLTR TO PROP vector transfer (Orbiter vector uplinks always go into the FLTR vector)

Note: AUTO DAP **cannot** be used while uplinking the new vectors. There will be some short amount of time when only one new vector is onboard and the onboard relative state will be bad. Furthermore, should a bad state vector be uplinked for either the Orbiter or Target, an attitude maneuver would be initiated in AUTO. Previously, LVLH was to be selected but this would also be vulnerable to an erroneous Orbiter state vector uplink.

Uplink of New Target SV

- Coordinate with FDO to uplink the new Target vector
- Verify the new vector
- Resume incorporation of sensor data

Note: With this method, NAV will behave as if this were the first sensor acquisition using a bad vector.

BACKGROUND

There are several points in the RENDEZVOUS C/L where a sequence of anomalous conditions requires the crew to "call MCC". The key symptom is that ratios computed by onboard NAV and displayed on SPEC 33 (REL NAV) are greater than 1.

Most NAV problems can be characterized as follows:

Bad State Vector

A bad Orbiter or Target state vector uplink will be seen either at uplink (Orbiter/Target) or upon enabling RNDZ NAV (Target). A "bad" state vector uplink can be characterized in one of two ways:

- Invalid time-tag. The vector's time-tag is beyond the 15 hour limit for onboard NAV propagation. Symptom is a fail indication on MSK 549 in the TIME TAGS section - "O F" or "T F" indicated for Orbiter or Target state prediction failures, respectively. In this event, the uplinked vector will be rejected and the current state vector will be retained
- Bad state vector. Symptoms are large GND-PFS or GND-TGT vector comparisons and apparent attitude control or DAP problems. During day of Rendezvous navigation, a bad state vector could also be detected as a larger than expected FLTR - PROP or change in the relative nav range that does not match predictions.

IMU Problems

A bad IMU may be due to bad attitude (gyro) data, bad accelerometer data, or both.

- Bad attitude data. A drifting or biased IMU gyro platform will affect NAV only while incorporating NAV sensor data and thus will affect the FLTR vector only. The bad attitude data will be fed into the Filter via the sensor Angle updates and it may at first appear to be NAV sensor problem. STRK data will be affected much more than RR data.
- Bad accelerometer data. IMU accelerometer data is always incorporated into both the FLTR and PROP state vectors. At the 3-IMU level RM will protect NAV, but at the 2-IMU level (during a STRK pass) accelerometer data is averaged. This means that both FLTR and PROP vectors will be affected. The FLTR may be better than the PROP depending on the quality of sensor data but it is best in this case to uplink a whole new Orbiter state - preferably the last onboard state that was saved. See the state vector uplink procedures below.

Note: The possibility for an IMU accelerometer spike short enough to avoid RM action is small but real.

NAV Errors

NAV Sensor errors are almost guaranteed in some form or another. That is why Navigation uses the Kalman Filter. The Filter is designed to account for limited amounts of sensor bias, noise, and drift against predetermined estimates of NAV state error. The NAV Filter I-Loads define the expected sigma error for each sensor. The Filter has the capability of solving for constant bias errors if provided enough information and time.

- Star Tracker. STRK data is the most accurate sensor and has very small sigma error values. The health of the STRKs will be known (based on current flight data and IMU align history), and a bad STRK will not be used. In general any NAV error introduced during a STRK pass will be due to IMU misalignment or drift. The possibility of acquiring a star is quite real, either at the beginning of a STRK pass or during the pass if the star is close to the LOS to the Target.

- Rendezvous Radar. Radar is currently the only sensor to provide both range and bearing data to NAV. RR angle data is expected to be quite noisy and range and range rate error will vary as a function of range. Faulty radar may or may not be detected by INCO during the self-test. The probability of failing self-test and still having good RR data is high and the possibility of losing RR lock is quite real.

Note: It can be assumed that no other orbiting body is close enough to the target to confuse the radar.

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4.4 Rendezvous Radar Navigation

PURPOSE

To give information concerning the rendezvous radar data and its use by onboard nav. For characteristics of the Ku-band radar system, see SCP 3.7 KU RADAR.

PROCEDURE

Refer to the BACKGROUND section on information regarding the rendezvous radar data:

- Radar Data Parameter Measurement Limits
- Radar Data Error Characteristics
- Radar Data Angle Definitions, Calculations, and Constraints
- Radar Data Path

BACKGROUND

Radar Data Parameter Measurement Limits

Table 4.4-1 Radar Parameter Measurement Limits

Parameter	Passive Mode Characteristic
LOS range	100 ft to 10 n.mi.
Effective range	135 kft (22 n.mi.)
Maximum unambiguous range	147 kft (24 n.mi)
LOS range rate	148 fps closing 75 fps opening
LOS pitch angle	Plus or minus 30 degrees
LOS roll angle	Plus or minus 30 degrees
Pitch inertial angle rate	Plus or minus 20 mrad/sec
Roll inertial angle rate	Plus or minus 20 mrad/sec

Radar Data Error Characteristics

Table 4.4-2 Radar Error Characteristics

Parameter	Random Error (1σ)	Bias Error (1σ)
Range	27 ft out to 8 kft 0.0033*Range from 8 to 30 kft 100 ft when > 30 kft	27 ft out to 8nm 0.00053*Range when > 8 nm
Range rate	0.33 ft/sec or 0.33% of range rate, whichever is greater	0.33 ft/sec
Angle	0.153 deg	1.0 deg
Angle rate	0.0027 deg/sec	0.0027 deg/sec

Radar Angle Definitions, Calculations and Constraints

The native coordinate system for the KU radar is α and β gimbal angles (also called shaft and trunnion). The KU electronics convert these gimbals to azimuth and elevation (also called roll and pitch) that are in the Orbiter body sense. To compute the LOS of the radar given azimuth and elevation, first rotate in azimuth (positive about the Orbiter -X body axis), then in elevation (positive about the Orbiter -Y body axis) as in an azimuth/elevation Euler sequence. Note that the Rendezvous Navigation software converts the Ku angle measurements back to shaft and trunnion to do its angle processing, for it is in this frame that angle biases must be solved for and applied.

To compute α and β (shaft and trunnion) from azimuth(Φ) and elevation(θ), the following equations can be used:

$$\beta = \arcsin[-\cos K \sin \theta + \sin K \sin \varphi \cos \theta] \quad \text{Equation 4.4-1}$$

$$\alpha = \arctan\left[\frac{-\sin K \sin \theta - \cos K \sin \varphi \cos \theta}{\cos \varphi \cos \theta}\right] \quad \text{Equation 4.4-2}$$

where $K = 67 \text{ deg} = 1.17 \text{ rad}$ (the “deployed” angle of the KU system relative to Orbiter +X).

Note that there is an operational constraint to not allow RR angle searches when the magnitude of the β gimbal exceeds 38 deg. Above this value, the high-speed angle search can result in hitting gimbal hard stops that could cause damage to the mechanism. When the β gimbal exceeds 38 deg, GPC mode should be avoided (AUTO TRACK preferred) to prevent automatic searches after a break lock.

Radar Data Path

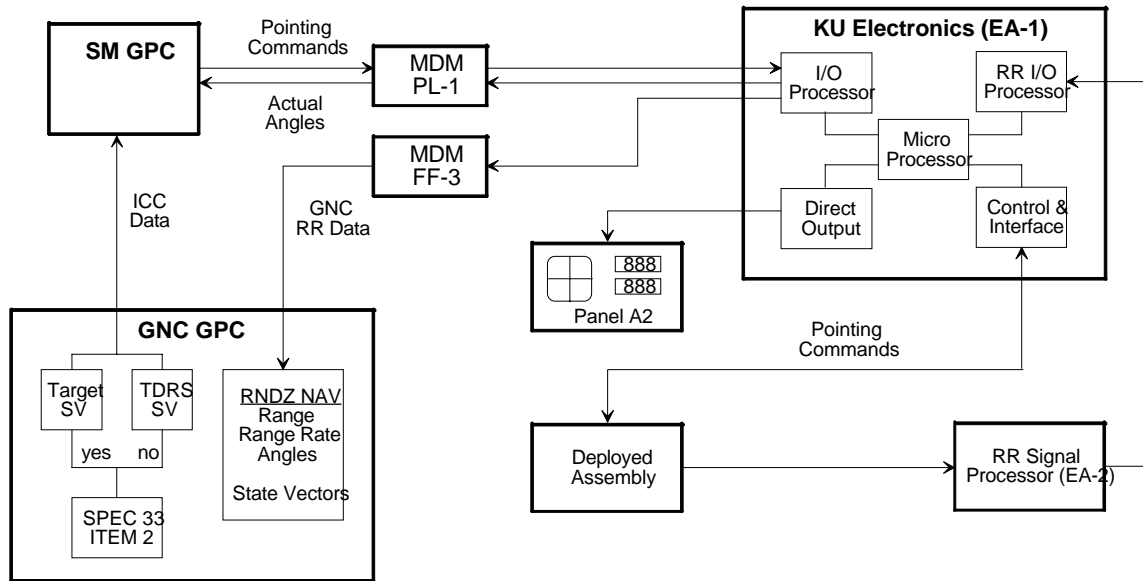


Figure 4.4-1 Radar Data Path

4.5 Star Tracker Navigation

PURPOSE

To give information concerning the incorporation of star tracker measurements into onboard navigation. See SCP 3.6 Star Tracker for details on the star tracker hardware systems.

PROCEDURES

1. Star Tracker Pass Overview

After sensor data is accepted into the NAV Filter, the Filter position update behavior is monitored for indication of Filter convergence. For each measurement processed, the SV correction is weighted as a function of the estimated knowledge of the state error (i.e., covariance matrix) before the correction is applied to the state vector. Thus, the decrease in size of successive SV updates should be fast initially, then more gradual as the number of data marks incorporated increases. After the SV update values stabilize below a specified value, the Filter is considered converged on the relative state. For STRK NAV, SV updates are expected to increase in the middle of the STRK pass (80 to 100 marks) as the Filter gains enough knowledge to distinguish downtrack position error from radial position error and begins to apply the appropriate position updates.

In addition to SV position updates, the individual measurement residuals (Estimated minus Measured) are observed. As the Filter converges, these values should also stabilize below a predefined value but will do so very quickly and then remain there. Other parameters monitored for general Filter status and data quality assessment include covariance matrix position RSS, number of sensor marks accepted/rejected, and sensor biases as determined by the Filter. Ground minus Onboard vector differences for both Orbiter and Target are monitored as an overall evaluation of the onboard state.

2. Assessing a Star Tracker Pass

Procedures call for a SV SELECT switch to FLTR when 9 or more marks have been accepted by the filter and when SV UPDATE POSITION is less 1000 ft for STRK and 300 ft for radar:

- Verify that ST is selected as the angle source (SPEC 33 ITEM 12)
- Compare initial residual versus range per tables in the BACKGROUND section

If FLTR minus PROP exceeds 8* kft (profile dependent) in a single STRK data pass the data should be discarded by performing the following:

- ◇ Inhibit sensor data to NAV
- ◇ Perform a PROP-to-FLTR
- ◇ Break track with the star tracker

NOTE: The 8 kft value applies assuming a post-NC star tracker pass in a rendezvous from behind with NC at approximately -40 nmi, single-rev transfer to Ti. Another value is 12 kft for a rendezvous from in front with NC at approximately +30 nmi, two-rev transfer to Ti.

BACKGROUND

The relationship between a residual and an offset distance at a particular range is

$$\delta = \left(\frac{180}{\pi}\right) * \left(\frac{d}{R}\right)$$

Equation 4.5-1

hence,

$$d = \left(\frac{\pi}{180}\right) \delta R$$

Equation 4.5-2

where d = offset distance,
 δ = residual from SPEC 33
 R = range to target

The correspondence between residual value and offset distance for typical star tracker passes:

Table 4.5-1 Star Tracker Offsets Versus Residuals

Star Tracker Pass #1		Star Tracker Pass #2		Post-Ti Star Tracker Pass	
Range = 245,000 ft		Range = 148,000 ft		Range = 50,000 ft	
Resid	Offset (ft)	Resid	Offset (ft)	Resid	Offset (ft)
0.01	43	0.01	26	0.01	9
0.05	214	0.05	129	0.05	44
0.10	428	0.10	258	0.10	87
0.50	2138	0.50	1291	0.50	436
1.00	4276	1.00	2583	1.00	873

The offset direction is dependent upon the star tracker component (H, V) and the value of omicron.

For the -Z Star Tracker in the nominal -Z Target Track attitude (BV=3, OM=0):

- **H** residual corresponds to a **radial** offset;
- **V** residual corresponds to an **out-of-plane** offset;

For the -Y Star Tracker in the nominal -Y Target Track attitude (BV=4, OM=90):

- **H** residual corresponds to an **out-of-plane** offset;
- **V** residual corresponds to a **radial** offset;

As it turns out (due to the definition of H and V for each star tracker) the offset direction for a given value of omicron is completely independent of which star tracker took the measurement. For example, for OM=0, H always corresponds to a radial offset, regardless of whether it is measured by the -Z or -Y star tracker. Refer to the table, below, for offset directions versus orthogonal values of omicron.

Table 4.5-2 Star Tracker Residuals Versus Offset Direction

Component	OM 0	OM 90	OM 180	OM 270
H	radial	out-of-plane	radial	out-of-plane
V	out-of-plane	radial	out-of-plane	radial

See SCP 3.3 POINTING for illustrations of the above UNIV PTG attitudes. Obviously, if omicron is non-orthogonal, then H and V do not map directly into radial and out-of-plane.

4.6 COAS Navigation

PURPOSE

To provide information about the Crew Optical Alignment Sight (COAS).

PROCEDURE

For nominal operations, the COAS is used from post-MC4 until docking in the following manner:

- Line-of-sight manual trajectory control to set up for Rbar arrival, in conjunction with the centerline camera. See SCP 3.9 CAMERAS.
- Secondary cue to backup the centerline camera for TORVA start and control, Vbar acquisition, and corridor maintenance.

In a radar failed case, in addition to the functions listed above, the COAS is used for the following:

- Determination of the magnitude of the radar failed correction burn. For every degree the target is high in the COAS, the crew performs two +X (“up”) pulses. For every degree the target is low, the crew performs one –X (“down”) pulse. These procedures are in 20D in the Rendezvous Checklist.

BACKGROUND

The COAS has two principal functions. First, it provides optical alignment capability for rendezvous and docking (see below).

Second, the COAS provides redundancy to the two star trackers for aligning the inertial measurement units (IMUs). The star tracker software will not accept stars for IMU alignments if the stars are more than 1.4° from where the general purpose computer (GPC) thinks it should be. Should the IMUs become misaligned by more than this limit, the COAS serves as the alternate method of star tracking. Like the trackers, the COAS is used to establish a line-of-sight (LOS) vector to a star, thus enabling determination of the IMU orientation with respect to the stars. It can be used as the method of approximate alignment, with the star trackers completing the job with a fine alignment, or it can be used stand alone in the case of a failure of both star trackers. An orbit calibration is required before the device can be relied upon as a backup to the trackers.

The COAS is a cylindrically shaped device about 8 inches long, with a combining glass at one end, a box-like attachment at the other end containing a rheostat for light intensity control, and a mounting plate attached to the central portion of the cylinder.

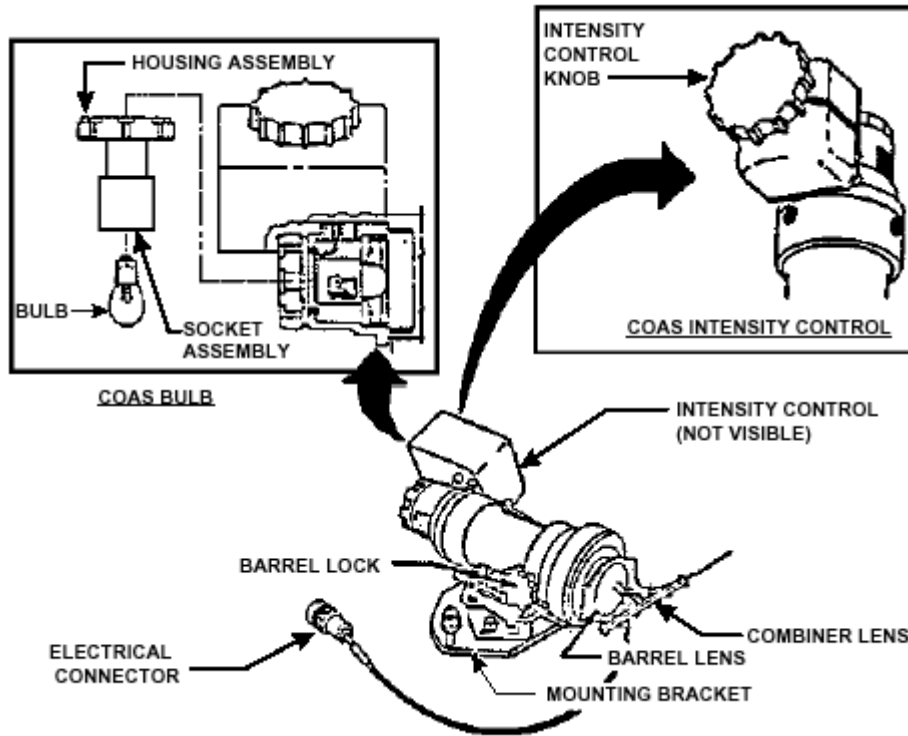


Figure 4.6-1 COAS Hardware

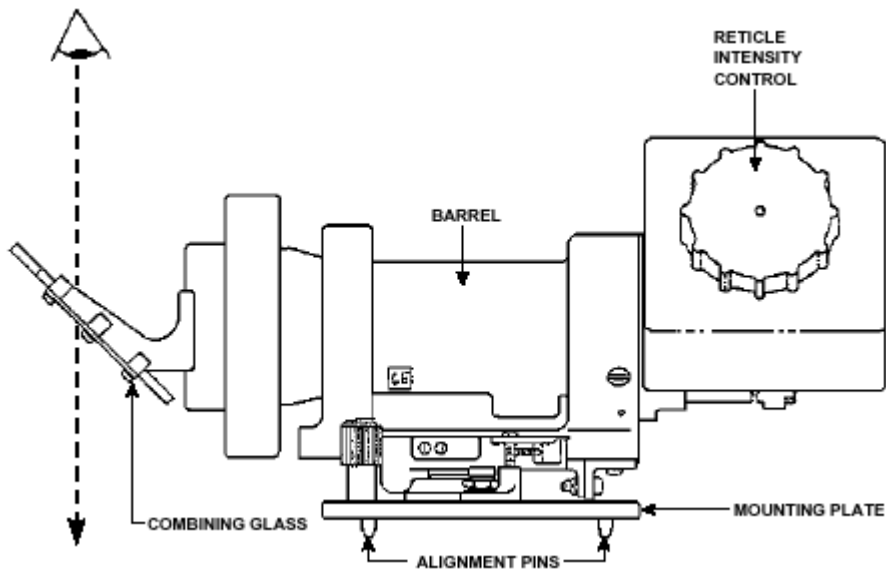


Figure 4.6-2 COAS Hardware Side View

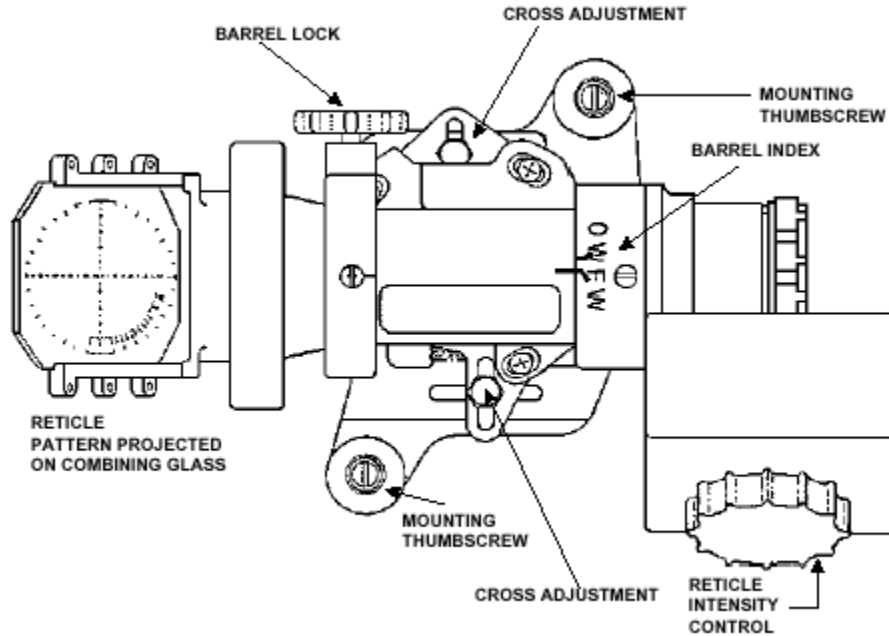


Figure 4.6-3 COAS Hardware Bottom View

For rendezvous and proximity operations, the COAS is mounted in the aft overhead window looking along the Orbiter -Z axis. Measurements within the 5° reticle are the most accurate; however, less accurate measurements can be estimated up to about 15°.

The COAS has two mounting positions: one above the commander (CDR) +X FW window (W3) and one in front of the starboard OW (W7) above the aft flight station. The +X mount is boresighted parallel to the +X axis and the -Z mount parallel to the -Z axis of the Shuttle.

Attention must be given to the forward/overhead (FW/OW) switch. This switch allows the crew to rotate the COAS when installed for forward or aft/overhead view. If used in wrong position, the Station could see approximately 10° of error displacement in the -y direction, like on STS-101.

With the COAS mounted on panel 01, power to illuminate the reticle is provided from the COAS POWER switch on panel 01. COAS power at the aft mount is controlled by the COAS POWER switch on panel 019.

The COAS, because it is aligned with a high degree of accuracy along the Orbiter -Z axis, is used by the pilot as a tool for flying the “manual phase” of rendezvous, in which course deviations normal to the LOS must be corrected by manual inputs to the THC. This phase runs from shortly after MC4, at about 2000 ft, to the final docking or RMS berthing. The COAS may be used as early as ~5000 ft for the radar fail case manual correction burn.

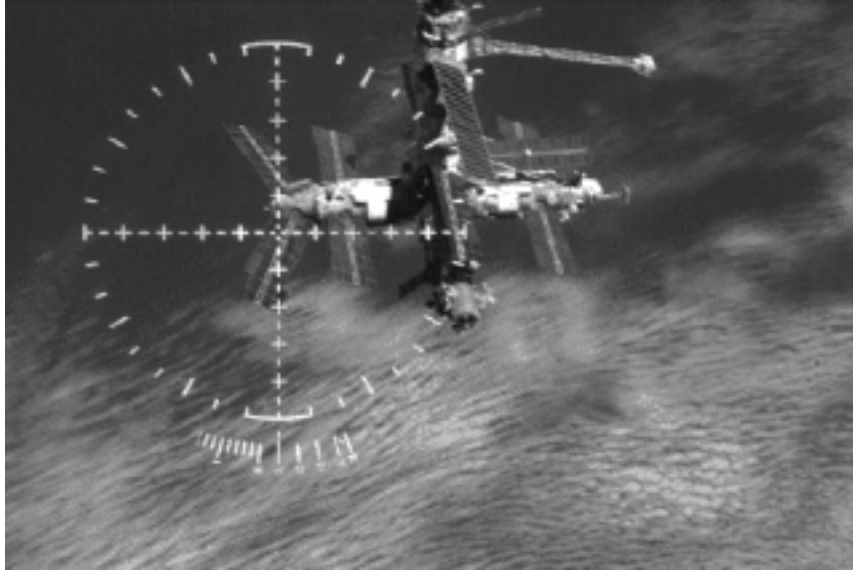


Figure 4.6-4 Mir Through the COAS

Currently, the COAS is not used for close range angular alignment, although working groups have studied it. Due to the large offset in distance between the COAS and the ODS, a COAS target would not be accurate enough for lateral alignment. Current docking mechanism requirements specify a maximum 4.2 inches of lateral misalignment. Accounting for all quantifiable error sources, this would require the COAS target to be within 4.4 inches of the docking mechanism centerline. The COAS can be used as a backup navigation sensor during rendezvous, as long as the pilot can see the target vehicle.

Line-of-sight angles can be measured by having the pilot manually rotate the Orbiter with the rotational hand controllers (RHC) until the target vehicle passes across the center of the reticule pattern. At that point, the pilot takes a mark by depressing the ATT REF push button. If the pilot feels the mark was a good one, he then enters it into onboard navigation with a keyboard item entry on SPEC 33.

4.7 Covariance Matrix Management

PURPOSE

To provide a description of the covariance matrices used by the onboard navigation system during rendezvous and proximity operations, and how they are manipulated.

PROCEDURE

Covariance Matrix Uplink

Covariance Matrix Uplink Requirements

- Deploy - If Rendezvous Nav will be used following Deploy the Prox Ops covariance matrix should be uplinked.
- Deploy/Rendezvous - If the Prox Ops covariance was uplinked to support Deploy and Sep, the Rendezvous covariance must then be uplinked before the start of rendezvous operations.
- Ground-Up Rendezvous - No uplink is required, the I-Loaded Rendezvous covariance matrix will be used.
- Rendezvous Post-Ti - The Prox Ops covariance matrix will be uplinked post-Ti if radar data has been incorporated. The COAS Nav covariance matrix will be uplinked if COAS navigation will be performed post-Ti.

Covariance Matrix Uplink Procedures

See SCP 9.1 RENDEZVOUS GPO COMMAND LOADS.

Covariance Matrix Reinitialization

Reinitializing the Covariance Matrix will reset Mark Accept/Reject counters to zero and NAV Sensor Bias Estimates to zero.

Automatic Reinitialization

The following events will reinitialize the covariance matrix to the I-Loaded (or Uplinked) value:

- Enable Rendezvous Nav
- Orbiter or Target state vector uplink
- Any of the following state vector transfers:
 - PROP TO FLTR
 - TGT TO ORB
 - ORB TO TGT

Manual Reinitialization

The crew can reinitialize the covariance matrix to the I-Loaded (or Uplinked) value via SPEC 33 ITEM 16 (COVAR REINIT).

Covariance Matrix Reset

The covariance matrix will automatically be reset to the I-Loaded (i.e., RNDZ) covariance by either an OPS 2-8-2 Transition or an OPS 2-3-2 Transition.

If the PROX OPS covariance had been uplinked it must be re-uplinked before resuming rendezvous operations. It is preferable to uplink it before re-enabling RNDZ NAV, otherwise the crew must perform a manual COVAR REINIT to read in the uplinked values.

BACKGROUND

(Parts of the following are from FDD-NAV-630-90-53 by T. Miller.)

The onboard RNDZ navigation covariance matrix was originally developed for the Solar Max rendezvous mission and has been used for rendezvous ever since. It represents the expected relative state covariance matrix at the time of RNDZ NAV initialization, which takes into account Orbiter and Target state vector uncertainties, Orbiter energy growth, and both Orbiter and Target propagation errors.

The current I-loaded RNDZ state covariance matrix sigma values are

2000,20000,2000,21,2,6 (U,V,W ft, and VU,VV,VW ft/sec).

The important item to remember is that this covariance matrix assumes small sensor errors and large state vector errors at NAV sensor acquisition in order to protect for large state errors. This tends to drive the sensor RATIO artificially low even for very large sensor errors. This is especially true for star tracker data.

The current PROX OPS state covariance matrix sigma values are

1000,1000,1000,1,1,1 (U,V,W ft, and VU,VV,VW ft/sec).

The sigma values for the PROX OPS matrix were arbitrarily chosen to be small (to represent state errors after radar data incorporation) but large enough to prevent excessive editing of NAV sensor data.

The COAS NAV state covariance matrix sigma values are

500,5000,100,5,1,1 (U,V,W ft, and VU,VV,VW ft/sec).

This covariance matrix was tailored specifically to COAS navigating with large objects and was first designed for the STS-63 mission for the first rendezvous with Mir.

The covariance matrix used by NAV exists in the NAV software. These values are loaded from a "Covariance Matrix Buffer" by a Covariance Reinitialization event (automatic or manual). The contents of the Buffer is loaded from the I-Load values by an OPS Transition or the uplinked values by an Uplink event.

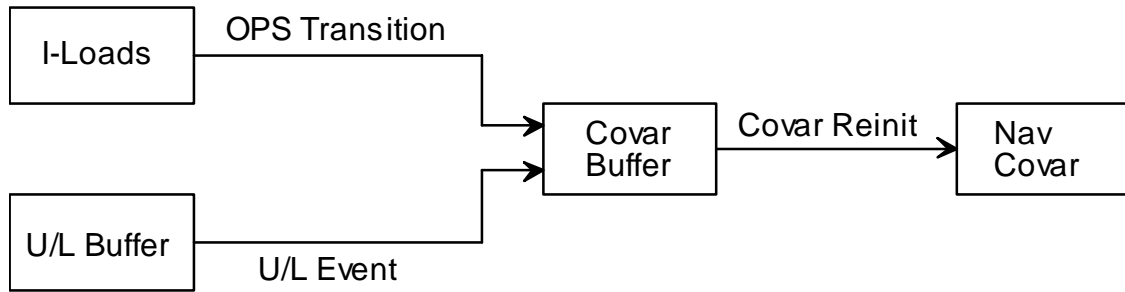


Figure 4.7-1 Covariance Matrix Paths

Note: Care should be taken when reinitializing the covariance matrix. Reinitialization may have the effect of actually making NAV worse for a short time because whatever certainty had been acquired in the state vector will be lost. Depending on what sensors are available it may take some time for NAV to reconverge to the degree seen before.

5.1 Orbit Targeting SPEC 34 Overview

PURPOSE

Provide an overview of the Orbit Targeting software to be used by the RNDZ GPO as a quick reference.

PROCEDURE

SPEC 34 Inputs

Table 5.1-1 Description of SPEC 34 Inputs

ITEM #	Variable	Description
1	TGT NO	Target set #. Recalling the TGT Set initiates several actions that are discussed later.
2-5	T1 TIG	= BASE TIME + "T1 rel to BASE TIME"
6	EL	Elevation angle.
7-12	$\Delta x, y, z; \Delta x, y, z \text{ dot}$	Position and velocity at T1.
13-16	T2 TIG	= T1 TIG + ΔT
17	ΔT	Transfer time. Used to calculate T2.
18	ΔX	X offset at T2.
19	ΔY	Y offset at T2.
20	ΔZ	Z offset at T2.
21-24	BASE TIME	Used to calculate T1 each time TGT Set is recalled.
26	LOAD	Loads Display buffer variables into the Compute and Load buffers.
28	COMPUTE T1	Computes the velocity required at T1TIG to reach the offset position in the specified transfer time.

Targeting based on time or elevation?

- Targeting is based on TIME if EL = 0 or T1 TIG is in the past.
- Targeting is based on ELEVATION if EL \neq 0 and T1 TIG is in the future.

Targeting based on time (T1 TIG in the future)

- If EL = 0 and T1 TIG is in the future, targeting is based on time.
- No Compute Buffer variables are changed when compute (ITEM 28) is executed. (Exception: If T1 position and velocity (ITEMs 7-12) are zero, the software will compute T1 state vector based on the onboard state.)
- Neither BASE TIME nor "T1 rel to BASE TIME" are altered after a solution is found.

Targeting based on elevation

- If $EL \neq 0$ and T1 TIG is in the future, targeting is based on elevation angle.
- Targeting s/w makes the following adjustments to the Compute Buffer variables when compute is executed:
T1 TIG is determined from EL angle search. $T1\ TIG = \text{Function}(EL)$. "Seed" T1 TIG is used as the first guess for the elevation search.
 $T2\ TIG = \text{new } T1\ TIG + \Delta T$.
- After the solution is found:
BASE TIME is set to T1 TIG (I-Load & Display Buffer)
"T1 rel to BASE TIME" is set to 0/00:00:00 (I-Load Buffer)

Targeting based on time (T1 TIG in the past)

- If **T1 is in the past**, targeting is **based on time**. (Value of Elevation Variable (EL) is not significant)
- Targeting s/w makes the **following adjustments** to the Compute Buffer variables when compute is executed:
 - T1 TIG is set to current time + 1 minute.
 - $\square T$ (Compute and Display Buffer) is adjusted so that T2 TIG does not change.
- After the solution is found:
 - No I-Load Buffer variables are changed unless LOAD (ITEM 26) is executed.
 - Display Buffer variables "T1 TIG", "T2 TIG" and " ΔT " are updated automatically.

Buffers

- **Display Buffer** - memory location for values displayed on MCDS. Values displayed on the MCDS always equal buffer values.
- **Compute Buffer** - memory locations for values actually used as targeting constraints.
- **I-Load Buffer** - memory location for target set information and BASE TIME.

Actions initiated by EXECution of ITEM entries

TGT NO (ITEM 1 +## EXEC) transfers data from the I-Load Buffer (IB) to the Display Buffer (DB) and Compute Buffer (CB) and sets items 7-16 equal to zero. ΔT , ΔX , ΔY , ΔZ and BASE TIME are transferred directly. T1 TIG is calculated as follows:

- Set T1 TIG (DB & CB) = BASE TIME (IB) + "T1 rel to BASE TIME" (IB).
- Set Position @ T1 TIG (ITEMs 7-9 in DB & CB) = 0.0
- Set Velocity @ T1 TIG (ITEMs 10-12 in DB & CB) = 0.0
- Set T2 TIG (DB & CB) = 0.0
- Set ΔT , Δx , Δy , Δz (DB & CB) = ΔT , Δx , Δy , Δz (IB)

LOAD (ITEM 26 EXEC) transfers data from the Display Buffer (DB) to the Compute Buffer (CB) and the I-load Buffer (IB). If the crew changes ITEMs 2-24 via manual input, LOAD will flash. The values are transferred to the IB and CB when an ITEM 26 (LOAD) is

executed. All variables are transferred directly from the DB to the CB and/or the IB expect for "T1 rel to BASE TIME" which is set equal to T1 TIG (DB) - BASE TIME (DB).

COMPUTE (ITEM 28 EXEC) performs checks on the Compute Buffer (CB) variables:

- Is T1 in the future? (See earlier discussion.)
- Is Elevation = 0? (See earlier discussion.)
- Is T1 position and velocity = 0? (If YES, calculate a new T1 state vector based on onboard nav; if NO, use current state that was manually input by the crew.)

After the checks are performed, the targeting s/w is executed in an attempt to solve for the ΔV that must be burned at T1 to arrive at T2.

Changing the I-Load buffer

The **I-Load buffer** can be **altered** in only 3 ways:

- Ops Transition: I-Loaded values are read from the MMU.
- LOAD - ITEM 26 EXEC: Display values over-write old values.
- COMPUTE - ITEM 28 EXEC: If and only if $EL \neq 0$ and T1 TIG is in the future, the s/w automatically changes BASE TIME and "T1 rel to BASE TIME"

To change any variable except "T1 rel to BASE TIME":

- Change the value in the Display Buffer (crew MCDS entries)
- LOAD - ITEM 26 EXEC

To change "T1 rel to BASE TIME":

- Recall the TGT SET (ITEM 1 + ## EXEC). {Not required if TGT Set already displayed}
- Set the BASE TIME as desired (ITEM 21 + # +## +## +## EXEC).
- Set T1 TIG so that T1 TIG = BASE TIME + desired "T1 rel to BASE TIME" (ITEM 2 + #... EXEC).
- LOAD - (ITEM 26 EXEC).
- Recall target set and confirm T1 TIG and BASE TIME. (ITEM 1 +## EXEC).

5.2 Targeting Anomalies

PURPOSE

To identify possible anomalies associated with Orbit Targeting and to define the proper MCC/crew responses to them. The following are addressed:

- Quick lookup tables for targeting alarms.
- MC2 TIG slip.
- Half-rev transfers for late NCC and MC1 burns.
- Targeting alarms during re-maneuver orbit targeting in Major Mode 201.
- Alarms During ORBIT MNVR EXEC Target LOAD (Major Mode 202).
- Alarms During ORBIT MNVR EXEC burn execution with Lambert Cyclical Guidance.
- Second rendezvous attempt.
- Unreasonable ΔV s with no targeting alarms.
- Checking PRED MATCH, solution ΔV s, and target set I-loads.

PROCEDURE

Quick Lookup Reference for Lambert Targeting Alarms

Table 5.2-1 Lambert Targeting Alarms

Alarm	PRED MATCH	Quick Cause
TGT DT	---	ITEM 28 requested with DT and T2 TIG=0
TGT DT	999999	Transfer angle = 0 or 360 deg or transfer requires parabolic trajectory
TGT DT	999999	Orthogonal braking fails to solve for transfer time
TGT ITER	999999	Max Newton-Raphson iterations
TGT ITER	---	Max iterations to reduce miss distance
TGT EL ANG	---	Elevation angle search error

MC2 TIG Slip

For TIG slips at the limit direct crew to "BURN MC2 USING TGT SET 19" in the RENDEZVOUS C/L. The following steps describe this direction.

If MC2 TIG slip < - 3 minutes

- Set BASE TIME to Nominal MC2 TIG - 3 minutes.
- LOAD changes with ITEM 26.
- Use Target Set 19 and retarget.

If MC2 TIG slip > +7 minutes

- Set BASE TIME to Nominal MC2 TIG + 7 minutes.
- LOAD changes with ITEM 26.
- Use Target Set 19 and retarget.

Half Rev Transfers for late NCC and MC1 Burns

If NCC burn TIG is delayed to PET -00:48 (i.e., a 7 to 10 minute delay)

- LOAD final targeting solution.
- Downmode to EXDV and burn VGOs.

If MC1 burn TIG is delayed to PET +00:30 (i.e., a 7 to 10 minute delay)

- LOAD final targeting solution.
- Downmode to EXDV and burn VGOs.

Targeting Alarms During Pre-Maneuver Orbit Targeting in Major Mode 201

If TGT ΔT Alarm

- Check TRANSFER TIME - ITEM 17 - to see if it is near zero or a FULL REV-- if so,
 - Check inputs for errors and correct.
 - LOAD - ITEM 26.
- If using orthogonal braking
 - Recall Target Set.
 - Abort orthogonal braking by removing minus sign from ITEM 17.
 - LOAD - ITEM 26.
- If TRANSFER TIME is acceptable and not using orthogonal braking, proceed with TGT ITER Alarm Procedure, below

If TGT ITER Alarm

- Check Target Set Data.
- Get crew report on PRED MATCH and solution ΔV s.

- Recall Target Set and repeat targeting.
- If alarm repeats,
 - If good agreement between onboard and ground and PRED MATCH small, retype and reload onboard PEG 7s and burn as External Δ Vs (EXDV).
 - If NOT good agreement between onboard and ground or PRED MATCH large, load ground solution into PEG 7s and burn as External Δ Vs (EXDV).

If MC2 EL ANG Alarm

- Check TGT Set Data
- If trajectory is short (trajectory never hits the angle) AND TIG slip is within limits (7 minutes late and 3 minutes early), burn the solution.
- If trajectory is short AND TIG slip is NOT within limits, use target set 19 and use the early or late limit.
- If T1 TIG and EL are approximately nominal values, recall target Set and recompute T1.
- If T1 TIG and EL are NOT approximately Nominal Values:
 - Check NAV state and trajectory with FDO.
 - If NAV State questionable and using FILT, repeat targeting with PROP.
 - If NAV State OK and FDO confirms trajectory is short or if using PROP, use Target Set 19 and target using nominal + 7 min MC2 TIG.

Alarms During ORBIT MNVR EXEC Target LOAD (Major Mode 202)

If TGT Δ T Alarm

- Check TRANSFER TIME - ITEM 17 - to see if it is near zero or a FULL REV. If so:
 - Check inputs for errors and correct.
 - LOAD - ITEM 26.
- If TRANSFER TIME is acceptable, use TGT ITER Alarm procedure, below.

If TGT ITER Alarm

- Check TGT Set Data.
- Get crew report on PRED MATCH and solution Δ Vs.
- Have FDO grab onboards and run ground solution.
- If good agreement between onboard and ground and PRED MATCH small, downmode from LAMBERT to EXDV and burn onboard PEG 7 solution.
- If NOT good agreement between onboard and ground or PRED MATCH large, load ground solution into PEG 7s and burn EXDV.

Alarms During ORBIT MNVR EXEC Burn Execution with LAMBERT Cyclical Guidance

For any alarm (TGT DELTA T or TGT ITER), complete the burn.

Second Rendezvous Attempt

Prior to having the crew load BASE TIME at the start of the rendezvous day,

- Check TGT Set Data in each target set, ESPECIALLY TGT Set 12 (MC2 on EL ANG)
- Correct as necessary.
- LOAD - ITEM 26.
- Proceed with LOAD BASE TIME.

Unreasonable Δ Vs with No TARGETING ALARM

If "unreasonable" Δ Vs appear during preliminary targeting.

- Check target set data for errors.
- Correct as necessary.
- LOAD - ITEM 26.
- COMPUTE T1 - ITEM 28.
- If unreasonable Δ Vs reappear or no errors noted, perform one of the following:
 - Ti - Ti Delay.
 - MC2 - Use Target Set 19 and target using nominal MC2 TIG.
 - Other - Load ground solution into PEG 7s and burn EXDV.

If "unreasonable" Δ Vs appear preburn during LCG (TIG-15 sec)

- Do nothing -- no action required.

If "unreasonable" Δ Vs appear during LCG while burning

- Downmode to EXDV and burn VGOs.

Checking PRED MATCH, Solution Δ Vs, and TGT Set ILOADs

Have crew read down PRED MATCH and solution Δ Vs

- PRED MATCH
- Δ VX
- Δ VY
- Δ VZ

Have crew recall TGT Set and read the following:

- T1 TIG (ITEM 2-5)
- El Angle (ITEM 6)
- T2 TIG (ITEM 13-16)
- Transfer Time (Δ T) (ITEM 17)
- X Offset at T2 (Δ X) (ITEM 18)
- Y Offset at T2 (Δ Y) (ITEM 19)

- Z Offset at T2 (ΔZ) (ITEM 20)
- BASE TIME (ITEM 21-24)
Compute T1 Rel To BASE TIME:
- T1 TIG BASE TIME = _____
Compare vs. expected values on page 6-3 of RENDEZVOUS C/L

BACKGROUND

MC2 TIG

The MC2 TIG can vary in time since this burn is tied uniquely to elevation angle. The amount of the slip is computed onboard and is double-checked by the ground. The 3 min early limit is to ensure that manual takeover at MC4 +2 min will occur in sunlight. The 7 min late limit is to ensure that the Orbiter will reach 200 ft prior to sunset. MC2 TIG slips can occur with non-nominal trajectories, if T_i is burned such that the resulting trajectory is "short" or "long." Target Set 19 removes the elevation angle constraint and targets MC2 on time.

Half Rev Transfers

Late execution of NCC or MC1 can result in a burn targeted with a near half rev transfer. Special caution is required when this scenario occurs. The problem stems from the fact that as the transfer angle approaches 180 deg, the transfer orbit becomes undefined. Orbit Targeting handles this case by forcing the transfer orbit to be in the chaser's orbit plane. Orbit Targeting recognizes this condition whenever the transfer angle is within 9.7 deg of a half rev (the "180 deg transfer cone"), and sets a flag to alert LCG of this condition. If this burn is targeted just outside the cone, however, LCG will be unaware of this condition. As the burn progresses, the transfer angle will slip into "the cone" and divergent VGOs can result, initially in the Y component. Since only LCG is susceptible to this problem, it can be avoided by downmoding to EXDV prior to loading a Lambert burn whenever the burn is likely to be executed within ~3 min of a half rev transfer.

Typical Targeting Alarm Responses

The response to a targeting alarm can be categorized roughly by the type of alarm, the value of PRED MATCH, and the event leading to the alarm (targeting in SPEC 34, during LOAD, or during Lambert Guidance). In general, if the value of PRED MATCH is small and Orbit Targeting yields a solution, loading the solution and downmoding to EXDV is usually fine. If PRED MATCH is large, burning the ground solution is the obvious choice. If the alarm occurs during LCG, the algorithm automatically zeroes out the VGO_CORR term calculated by Lambert, essentially leaving the situation in an EXDV scenario. That is why simply completing the burn is satisfactory in this case.

TGT ITER

A TGT ITER alarm indicates that the Orbit Targeting software executed 10 iterations without converging on a solution. In general, this is an indication of a FSW problem or a problem with some of the supporting I-loads used by Orbit Targeting.

Lambert's algorithm results in a velocity required to get from one inertial position to another over a given transfer time. It is an iterative routine that, in the Shuttle Flight Software, uses a Newton-Raphson iteration scheme. Normally, the algorithm should converge quickly, but if a maximum number of iterations is reached (currently 10), the iteration will be terminated and a TGT ITER will result. A PRED MATCH of 999999 on SPEC 34 during targeting is the key indicator that max iterations were reached in the LAMBERT routine. Since a valid ΔV could not be determined, ΔV s will not be calculated and transferred to PEG 7 guidance. Additionally, since the LAMBERT module is called during both Lambert targeting and Lambert guidance, TGT ITER can be scene during both burn targeting and execution. If a TGT ITER is experienced during burn execution, the Flight Software will not update the VGOs based on Lambert updates and the burn will behave as an EXDV type burn.

Table 5.2-2 TGT ITER Alarm Details

Alarm (PRED MATCH)	Targeting	Cause	FSSR Task	Related FSSR Parameters
TGT ITER (---)	Lambert	Difference between predicted position at T2 (RS_TERMINAL) and desired position (RS_T2TIG) could not be reduced to or below R_TOL in under 10 iterations	Precision Velocity Task (PREVR)	ALARM_A N_MAX_ITER (V96U7790C) R_TOL (V96U7789C)
TGT ITER (999999)	Lambert	Either of the following did not occur in under N_MAX_ITER iterations: 1. $ T_TILDA_ERROR < T_TILDA_DESIRED (EPS_U)$ 2. $ U_STEP \leq EPS_U$	LAMBERT	ALARM_A ALARM_KILL EPS_U (V96U7515C) N_MAX_ITER (V96U7790C)
TGT ITER (---)	CW	Difference between desired and predicted relative positions at T2 has increased 2 iterations in a row	PROX_TGT_SUP	ALARM_C ERR D_MISS1 D_MISS2
TGT ITER (---)	CW	A solution could not be found in under N_MAX_ITER iterations for which the miss distance is less than a computed tolerance -or- the solution for any three successive iterations out of N_MAX_ITER was not less than 0.05 ft/sec	PROX_TGT_SUP	ALARM_C I_LOW N_MAX_ITER (V96U7790C) R_MAX

Assuming the LAMBERT module computes a velocity required successfully (without reaching max iterations), this solution is passed up to the Precision Velocity Required task (PREVR). Since the Lambert solution is a conic solution (spherical earth, no drag, etc.), it is the job of PREVR to "fly out" the Lambert solution using a high accuracy integrator with an oblate earth and atmosphere model. One this solution is flown out, a miss distance from the desired aim point is determined and the aim point is adjusted to compensate for this miss distance. The LAMBERT module is called with the "tweaked" aim point to get a new solution. As before, this new solution is flown out and a new miss distance is

computed. This process continues until the miss distance is less than an I-loaded tolerance (RTOL), which is currently set to 250 ft. If the miss distance does not converge to less than the tolerance within 10 iterations, a TGT ITER will be annunciated. In this case, the last computed ΔV will be displayed and passed on to PEG 7 guidance for execution and the PRED MATCH will reflect the magnitude of the last computed miss distance. If the PRED MATCH is a reasonably small value, the computed solution can be burned. Note that this type of TGT ITER can only be seen during burn targeting since the PREVR routine is not called during Lambert guidance.

Additional notes: There is a bug in the LAMBERT module in the Flight Software that has previously resulted in slightly erroneous ΔV s being computed. These ΔV s were in error enough to cause the PREVR iteration to not converge, and a TGT ITER resulted with a PRED MATCH of approximately 350 ft. This problem was "patched" with an I-load change that significantly reduces the probability of the TGT ITER, but can result in a slightly less accurate solution:

Old Iloads: $EPS_U = 1e-6$ RTOL = 10

New Iloads: $EPS_U = 1e-7$ RTOL = 250

The Flight Software bug will be fixed in OI-26A, slated for STS-85. There are currently no plans to go back to the old I-loads with the tighter convergence requirements.

TGT ΔT

A TGT ΔT alarm occurs when the onboard software tries to compute a solution with a ΔT resulting in either a transfer angle near 0 deg or 360 deg (the term "near" is defined by an I-loaded value with a present value of ~ 2 min or ~ 8 deg), a parabolic transfer, a value near a multi-REV transfer time singularity, or an iteration failure in the orthogonal braking logic. This alarm is usually an indirect indication of a target set I-load problem.

Table 5.2-3 TGT DT Alarm Details

Alarm (<i>PRED MATCH</i>)	Targeting	Cause	FSSR Task	Related FSSR Parameters
TGT DT (---)	Lambert	Lambert targeting was requested (ITEM 28) but the transfer time (ITEM 17) and T2 TIG (ITEMs 13-16) are zero.	PROX_EXEC	ALARM_D COMP_PROX_DT T2_TIG
TGT DT (999999)	Lambert	Pre-iteration normalized transfer time (T_TILDA_DESIRE) is negative or less than or equal to the parabolic transfer time (T_MIN)	LAMBERT	ALARM_D ALARM_KILL
TGT DT (999999)	Lambert	Transfer Angle is close to 0 or 360 degrees	LAMBERT	ALARM_D ALARM_KILL EP_TRANSFER (V96U7517C)
TGT DT (999999)	Lambert or CW	Transfer time for orthogonal braking could not be found in under 10 iterations	OMEGA_DT_ COMP	ALARM_D ALARM_KILL IC_MAX (V96U7517C)
TGT DT (999999)	CW	Transfer angle = integral rev, also denoted as $1/K < EP_TRANSFER$	OFFSET_TGT	ALARM_D ALARM_KILL EP_TRANSFER (V96U7514C)

MC2 EL ANG

An MC2 EL ANG alarm appears during Lambert targeting when the software exceeds the maximum number of iterations in planning a burn based upon elevation angle, or when the desired elevation angle is not achievable. Targeting will indicate in ITEM 6 at what angle the iteration stopped. The ΔV s displayed by ORBIT TGT pertain to the displayed angle. A possible scenario for giving rise to this alarm would be that the current trajectory will be short at intercept and will not cross the desired elevation angle. In the case where the trajectory never achieves the subtended angle, the last time iteration is transferred to PREVR and a valid solution is returned. The solution is transferred correctly to guidance. Standard TIG slip logic should be applied.

Table 5.2-4 TGT EL ANG Alarm Details

Alarm (PRED MATCH)	Targeting	Cause	FSSR Task	Related FSSR Parameters
TGT EL ANG ---	Lambert	Time could not be found in less than 10 iterations when target position is on the same side (above/below) of Orbiter local horizontal as desired target position specified by I-loaded elevation angle	Elevation Angle Search Task (TELEV)	ALARM_B DELTA_H EL_ANG IC_MAX (V96U7517C)
TGT EL ANG ---	Lambert	Time could not be found in less than 10 iterations when the elevation angle was within EL_TOL of the I-loaded elevation angle.	Elevation Angle Iteration Task (ELITER)	ALARM_B EL_ERR EL_TOL (V96U7787C) IC_MAX (V96U7517C)

ILOADs

On second and subsequent rendezvous attempts, the ILOADs used by Orbit Targeting will be different than those stored on the MMUs unless an OPS TRANSITION (mode from OPS 2 to OPS 3 or 8, and back) is performed after the first rendezvous attempt. This is so because of the structure of the buffers used by Orbit Targeting. The contents of the ILOAD buffer can be changed by an OPS TRANSITION (loads original ILOADs from MMU), a LOAD via ITEM 26 on SPEC 34 (loads contents of DISPLAY buffer into ILOAD buffer), or through a successful EL angle search for BURN on EL ANGLE sets (because the results of the computation overwrite EL and BASE TIME). The safest and surest bet is to perform an OPS TRANSITION if time permits.

Unreasonable ΔVs

Unreasonable ΔVs during preliminary targeting may arise (in order of likelihood) through inadvertent crew keystrokes missed by the ground, through improper ILOADs due to previous rendezvous attempts, or through MMU and/or GPC problems. The first response is to check the TGT Set data for indications of incorrect entries in SPEC 34. If these can be corrected, press. If not, MMU and/or GPC problems may be the cause.

Note that large ΔVs may be observed during the first few seconds of LCG, starting at TIG-15 seconds. This is a known anomaly that was not fixed by crew request; it serves as an indication to them that LCG is active.

5.3 [Reserved]

This section formerly dealt with Target Set I-loads for Late Rendezvous. OI-29 fixes this problem, since base times up to 365 days can be entered on SPEC34. This section is left in the CHB to preserve page numbering.

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5.4 Maneuver Monitor

PURPOSE

To specify steps to be taken during every the execution of every rendezvous maneuver.

PROCEDURE

During Preliminary/Intermediate Targeting

- Coordinate appropriate TV Roll with FDO to minimize attitude maneuvers both before and after burn.
- Review FLIGHT PLAN and Predicted Site Acquisition Table (PSAT) for comm coverage during burn. If no comm is expected, prepare Playback request.
- Monitor the MNVR pad as it is read up/down.
- Monitor the crew inputs in MM 202 (Engine Select, TV Roll, Trim Load, WT, TIG, Δ Vs)
- Monitor targeting solutions and record in console log and RENDEZVOUS C/L.

After Final Solution

- If RSS of PEG7 components < 0.2 fps, execution of RCS Burn Cue Card is not required. If crew has already transitioned to MM202, no action is required.
- Verify Engine Select (FR 2-56).
- Select appropriate procedure to monitor (RNDZ OMS BURN plus OMS 2/ORB OMS Cue Card or RCS BURN Cue Card)

If Maneuver to Burn Attitude is Required

- Verify TV Roll.
- Determine latest PET at which to begin maneuver and achieve attitude prior to TIG using 0.2 deg/s and 0.5 deg/s maneuver rates.
- Monitor attitude maneuver and compute time remaining to achieve burn attitude.
- At TIG - 00:30: Confirm proper DAP selection (If RCS is selected, ensure DAP is NOT in AUTO).
- Watch crew trim out residuals (< 0.2 fps).

To Return to Lambert Guidance after Downmode to EXDV

- Recall SPEC 34 ORBIT TGT SPEC 34 PRO
- Recall the target set ITEM 1 + XX
- Recompute the ΔV s ITEM 28 EXEC
- Resume to MNVR EXEC RESUME
- LOAD the ΔV s ITEM 22 EXEC, ITEM 23 EXEC

Note: Burn TIG is automatically set to 1 minute in the future.

BACKGROUND

RNDZ GPO is responsible for determining the burn/no-burn status of onboard-targeted burns with total delta Vs near the no-burn threshold.

RPS is responsible for assuring that the proper procedures are followed during a maneuver. TARGET and ONAV are responsible for verifying the ΔV attained from the maneuvers.

Burn/No-burn status for small NCC and midcourse burns

For small onboard-targeted corrective burns (typically NCC, MC1-3) whose total PEG-7 ΔV falls below the 0.2 fps level, it is preferable to avoid the RCS burn procedure completely and remain in MM201 through the burn TIG, so that sensor data into nav is not interrupted. Going to MM202 and working the burn cue card is not bad, however. If a PEG-7 ΔV is borderline, it is recommended that the crew go to MM202 to check each body VGO.

In the past, the standard procedure for no-burns had been to stay in MM201 if at all possible, to avoid having the crew mode the DAP to LVLH. In working the old pre-OI29 cue card, very small trajectory perturbations are introduced by the act of selecting LVLH/PRI at TIG-30 seconds and subsequently returning to AUTO/VERN after the burn. These small perturbations could have incurred a relatively large cost for subsequent burns. Now, with OI-29, multi-axis burns are performed in target track, so it is OK to have the crew go to MM202 and check individual body VGOs while eliminating trajectory perturbations. Time spent in MM202, however, detracts from time incorporating data into nav, therefore it is probably best to stay in MM201.

When RNDZ sees a final targeting solution with an RSS of the PEG7 ΔV s that is less than 0.2 fps, a call will be made to Flight stating that the maneuver is a no-burn and that the RCS Burn Card actions are not required. In response, the crew should remain in MM201 with the current REL NAV AUTO/INH options in place. In the event that the crew has already transitioned to MM202 (either final NCC targeting or just a quick transition after final MC targeting), the call to Flight will indicate that the crew may return to MM201. RNDZ should strive to make the no-burn call prior to TIG - 2 minutes, although the transition back to MM201 can be made without impact at any time while on the cue card.

Engine Select Criteria

If forward prop is critical, a maneuver to attitude should be performed if more than 2 fps will be used out of the forward prop. The FDO will assess the body VGOs to make this determination and coordinate engine selection with PROP. The general rule for the crew in the event of no comm is:

- $\Delta V < 4$ fps - RCS multiaxis
- $4 < \Delta V < 6$ - RCS +X
- $\Delta V > 6$ fps - 1 OMS

TV Roll selection

Commonly used values are 0 and 180 (heads up and heads down). For off nominal burns at Ti, a TV Roll should be selected to maintain radar lock if possible. The value of TV Roll is determined by the right-hand rule about the thrust vector with 0 being heads up (-RBAR). For burns nearly parallel to the RBAR (within 3 degrees), the value of TV Roll is defined by the right-hand rule about the \pm RBAR (which ever is nearly aligned with the Orbiter +X axis), with 0 being along the +VBAR. FDO makes the TV Roll determination usually upon the choice that minimizes maneuvers to and from burn attitude.

Guidance

Any entries to the left side of MNVR EXEC will cause an automatic downmode from Lambert to External ΔV guidance mode. Recovery is to retarget and reload solution. Burn TIG is automatically advanced to 1 minute in the future.

Lambert guidance will begin cycling at ~15 seconds prior to TIG causing VGOs to update and will continue to compute VGOs every 3.84 seconds during the burn.

When in OPS 202, ORBIT MNVR EXEC, if the DAP is in AUTO a maneuver to burn attitude will be commanded at TIG regardless of whether or not an ITEM 27 MNVR was performed.

For any burn performed in OPS 202, attitude guidance will compute a burn attitude. Attitude guidance will activate at TIG and will continually update the burn attitude based upon VGO remaining and the desired thrust vector. When TGO=6 seconds, guidance will freeze the burn attitude to avoid the possibility of large attitude deviations at the end of the burn due to off-axis residuals.

If RCS is selected (ITEM 4 on ORBIT MNVR EXEC), there is a 'gotcha' in the software that checks for TGO<6 **AND** THC out of detente. This means that the guidance will perform as expected during the burn when the CDR is pushing on the THC; however, as soon as the CDR releases the THC (say, at the end of a burn or when DAP TRANS is set to PULSE), attitude guidance will update the burn attitude regardless of the TGO. This means that if the DAP is configured to AUTO, attitude maneuvers will be initiated as the burn attitude is updated with each pulse.

If OMS is selected, the only check is for TGO<6, so even though the CDR may trim residuals at the end of a burn, the burn attitude will not update and therefore no attitude maneuver will take place.

Attitude Verification

The ROSS application Timers displays the time to reach attitude.

If any ATTITUDE ERROR > 5° at TIG, the burn is NO-GO per GNC's call.

For EXDV burns, delay until in burn attitude, then proceed with the burn if still within TIG slip limits.

For LAMBERT burns, delay until in burn attitude, retarget, reload, re-maneuver, then proceed with the burn if still within TIG slip limits.

With OI-28 and subs, the 202 Burn Attitude will display yaw = 90 or 270 and blank the roll and pitch values if yaw value = ±90. Prior, all three values were blanked.

Other OMS Burn Considerations

For an OMS burn, the PRCS attitude deadband is 5°.

5.5 TIG Slips

PURPOSE

To clarify the effects of TIG slips.

PROCEDURE

Slips in EXDV Burns

- Check with FDO for specific TIG slip capability for upcoming burn
- Configure DAP as required to avoid unnecessary attitude maneuvers
 - Use DAP: LVLH for NC burns
 - Use DAP: INRTL for NH burns
- Coordinate slip capability with MCC and crew prior to critical burns
- Update TIG, if required (check with FDO)

Slips in Lambert Guided Burns

- Check with FDO for specific ground-targeted TIG slip capability for upcoming burn
- Coordinate slip capability with MCC and crew prior to critical burns
- Retarget with Lambert to update TIG and ΔV if burn start has been delayed such that the burn will not be completed by 90 seconds after original TIG

BACKGROUND

EXDV Burns

Slips in EXDV burns are driven primarily by the increase in prop and ΔV with increasing time. In some circumstances, there is a point in time where it is cheaper to waive-off a burn in favor of modifying a subsequent burn later or a rendezvous the next day. FDO is responsible for computing this trade-off point.

For EXDV maneuvers, it is typically required to update the burn TIG to a future time. When this occurs, the DAP should be placed in LVLH to maintain the LVLH burn attitude and avoid maneuvering to the new inertial attitude of the future burn TIG. When the TIG is updated to a future time, the new burn attitude will be close to the old burn attitude in an LVLH sense and therefore LVLH hold is the desired DAP configuration. (NC is typically in this category.) In some instances, however, if there is no need to update the TIG, inertial hold is desired to maintain the inertial attitude of the old TIG. (NH is typically in this category.)

Lambert Guided Burns

Slips in Lambert Guided burns are driven primarily by algorithmic shortcomings and secondarily by the same considerations as EXDV burns (prop and ΔV). Due to algorithmic shortcuts, the onboard Lambert Cyclical Guidance (LCG) function ΔV solution starts to degrade around 2 minutes after TIG. The errors are a function of the non-conic acceleration experienced by the Orbiter with the J2 acceleration being the primary perturbing factor. The change is strongly driven by the orientation of the J2 vector. To protect from unwanted divergence in solution ΔV s, the time limit for LCG solutions is 90 seconds, after which the burn should be retargeted with Lambert Targeting. Lambert Targeting resets the TIG to one minute in the future and also does not suffer from the algorithmic shortcuts taken in LCG.

5.6 Degraded +X RCS Translations

PURPOSE

To document the procedures for performing +X burns with combinations of jet failures resulting in the loss of one of the aft pods.

PROCEDURE

In the context of degraded +X burns, the following terminology is used:

- Loss of LEFT POD results from loss of RCS jets L1A and L3A;
- Loss of RIGHT POD results from loss of RCS jets R1A and R3A.

Degraded +X RCS Rendezvous Burns

Use OMS if possible (burn large enough, jet losses known in advance, etc.). However, if this is not an option (if loss occurs during a +X RCS burn, for instance), then

- Stop burn
- Loss of LEFT POD: Manually yaw right 19 degrees
- Loss of RIGHT POD: Manually yaw left 19 degrees
- Resume burn
- Burn VGO X in NORM until VGO X < 0.5 fps (vice 1.0).
- When burn complete, remain in DAP: PRI until DAP errors and rates are within deadbands.

BACKGROUND

The following information was compiled during the STS-66 mission after L3A was lost during ET SEP and the potential impacts of an L1A failure were investigated

Rendezvous Impacts

For a degraded +X burn, only one jet will fire instead of two (a normal +X translation uses one jet from each pod). Acceleration is cut in half, so all +X burns will require twice as much time to complete. The DAP does not provide any compensation for degraded +X translations, so each +X pulse will result in only one-half the loaded TRANS PLS size. Degraded +X burns will induce minus yaw and plus roll (loss of LEFT POD) or plus yaw and minus roll (loss of RIGHT POD). Attitude jets will fire to maintain the attitude, resulting in Y translations due to cross-coupling. The amount and direction of cross-coupling is highly dependent on the attitude hold DAP mode. Degraded +X burns also increase prop usage.

Proximity Operations Impacts

In vernier attitude control, a +X burn will cross-couple into a small amount of minus Y (loss of LEFT POD) or plus Y (loss of RIGHT POD) translation. In PRCS NOSE/TAIL attitude control, there is very little cross-coupling of X into Y. Once stable on the approach axis, VRCS is an acceptable mode since the quantity and frequency of +X inputs are reduced (in other words, it is easier to accommodate the degraded mode). Since LOW Z requires one jet in each pod, LOW Z is not available with the loss of either pod.

6.1 Trajectory Rules of Thumb

PURPOSE

To provide the Rendezvous Team with general trajectory information for quick "back of the envelope" calculations.

PROCEDURE

Orbital Parameters, 160 nmi Orbit

Table 6.1-1 Orbital Parameters for a 160 nmi Orbit

Parameter	Value
Period:	90.44 min, 5426.71 sec
Orb rate:	0.06634 deg/sec, 3.98 deg/min, 1.158 mrad/sec
Velocity:	25353 fps, 4.173 nmi/sec
Phase:	62.9 nmi/deg
Sunlight/Darkness:	55/35 min (for Beta = 0°)
Depression Angle:	17.1°

Delta Velocity Effects, 160 nmi Orbit

Table 6.1-2 ΔV Requirements for a 160 nmi Orbit

Parameter	Value
Plane change:	442 fps/deg
Node change:	220 fps/deg (28.5° incl.)
Altitude change:	1.76 fps/nmi (one side of orbit)

Table 6.1-3 Trajectory for a 1 fps Burn in a 160 nmi Orbit

	Downrange in 1 rev	Radial in $1/2$ rev (Altitude change)
1 fps Posigrade	16280 ft 2.7 nmi 5.0 km	3455 ft 0.57 nmi 1.0 km
	Downrange in $1/2$ rev	Radial in $1/4$ rev (Altitude change)
1 fps Radial	3455 ft 0.57 nmi 1.0 km	864 ft 0.14 nmi 0.26 km
	OOP in $1/4$ rev	
1 fps Out of Plane	864 ft 0.14 nmi 0.26 km	

Delta Height Effects, 160 nmi Orbit

Table 6.1-4 Constant Height Offset Relationships Based on a 160 nmi Coelliptic Orbit

Quantity	Relationship vs ΔH	Rule of Thumb
Downrange Displacement (xx/rev):	$3\pi * \Delta H$ (xx)	$10 * \Delta H$ (xx)
Coelliptic Velocity (xx/sec):	$3/2 * \omega$ (rad/sec) * ΔH (xx)	ΔH (xx) / 600

Table 6.1-5 Cusp Trajectory Relationships Based on a 160 nmi Coelliptic Orbit

Quantity	Relationship vs ΔH
Downrange Displacement (xx/rev):	$12\pi * \Delta H$ (xx)
Δ Period:	2.26 (sec/rev) * ΔH (nmi)

Phasing Rates, 160 nmi Orbit

Table 6.1-6 Phasing Rate Relationships Based on a 160 nmi Orbit

Parameter	Value
$\Delta\theta$ (nmi/rev):	$2.68 * \Delta V$ (fps) (same initial orbit)
$\Delta\theta$ (xx/rev):	$4.7 * \Delta H$ (xx) (coapsidal orbits)
$\Delta\theta$ (°/hr):	ΔH (nmi) / 10 (coelliptic orbits)
$\Delta\theta$ (°/rev):	$0.15 * \Delta H$ (nmi) (coelliptic orbits)
$\Delta\theta$ (nmi/rev):	$9.45 * \Delta H$ (nmi) (coelliptic orbits; $1^\circ = 63$ nmi @ 160 alt)

Altitude Effects

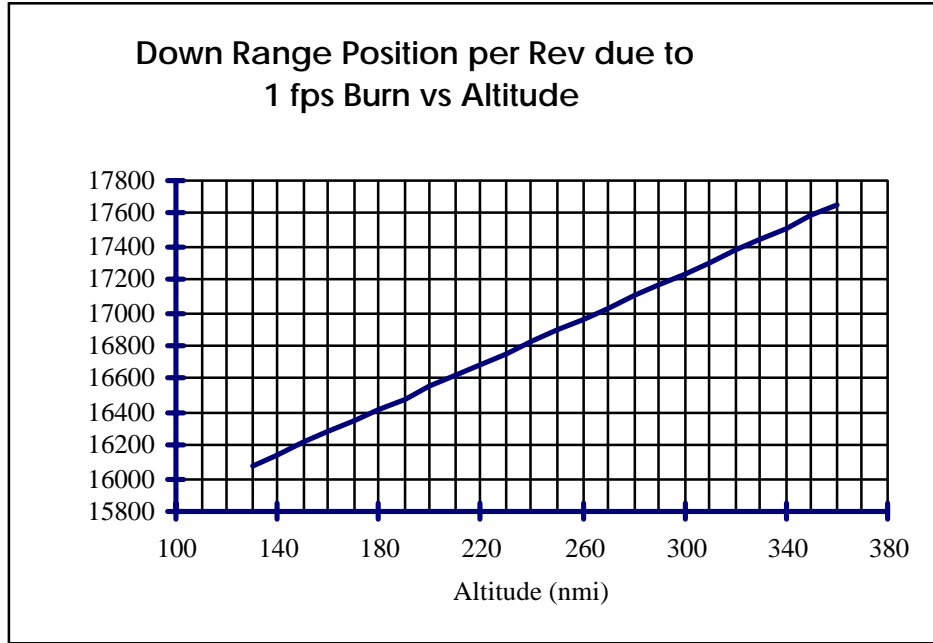


Figure 6.1-1 Downrange Displacement vs Altitude

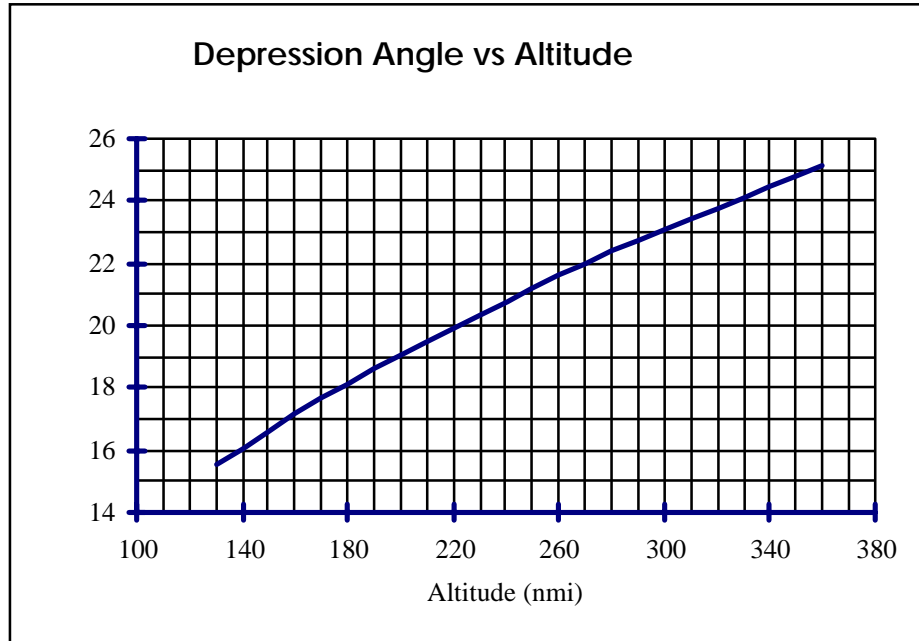


Figure 6.1-2 Depression Angle vs Altitude

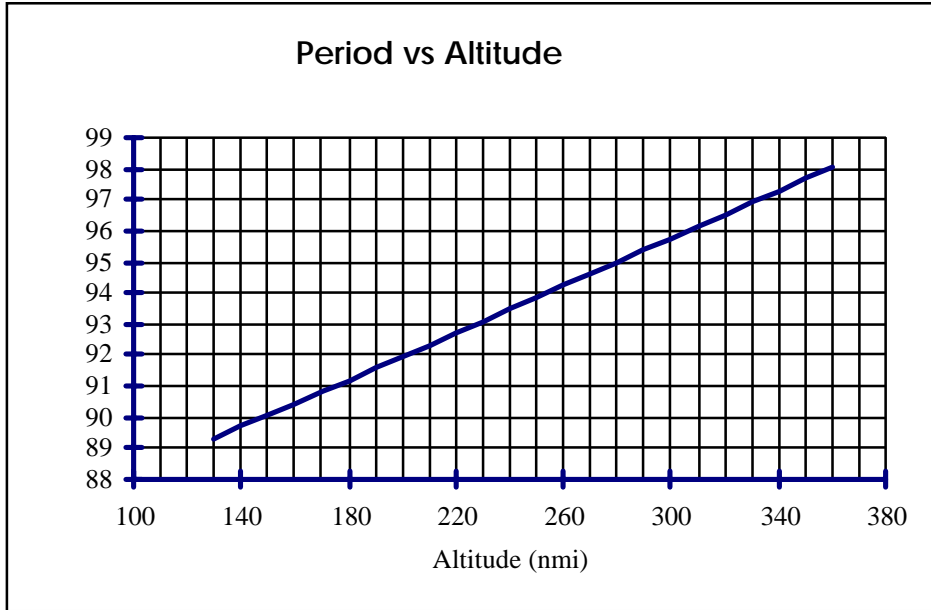


Figure 6.1-3 Orbital Period vs Altitude

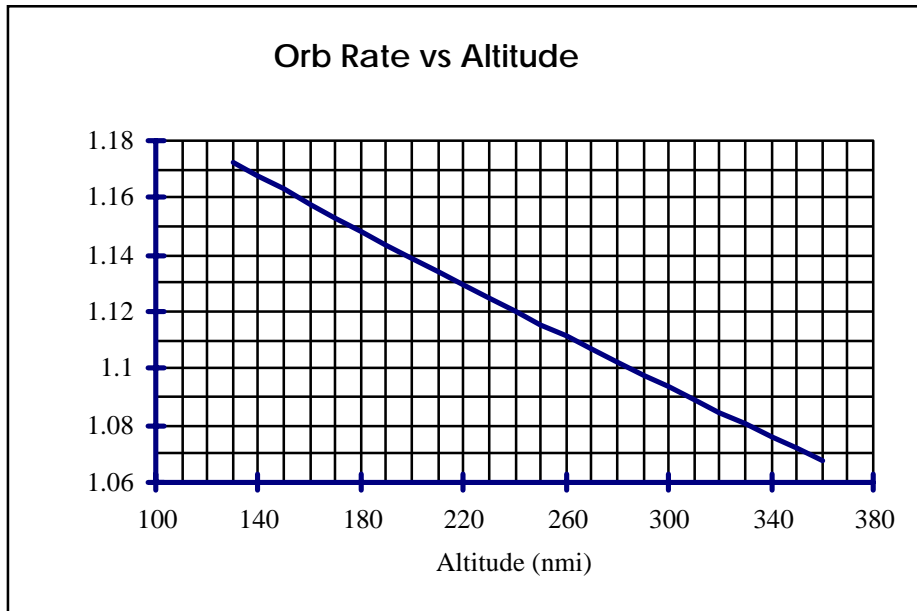


Figure 6.1-4 Orbital Rate vs Altitude

6.2 Relative Motion

PURPOSE

To provide the Rendezvous Team with relative motion time histories for quick "back of the envelope" calculations.

PROCEDURE

Optimal Manual Phase Approach

The Optimal Manual Phase Approaches contained below were developed using a Clohessy-Wiltshire (CW) formulation with no atmospheric drag at an orbital altitude of 210 nmi. Three approaches are addressed:

- Standard RBAR trajectory from MC4 to 250 feet CG-to-CG separation
- ORBT RBAR trajectory from MC4 to 250 feet CG-to-CG separation
- ORBT RBAR with TORVA trajectory from MC4 to VBAR arrival

The Standard RBAR trajectory is that based upon the existing Stable Orbit Rendezvous (SOR) profile with T_i located at 1200 feet above the VBAR, 48600 feet trailing, and with a designed RBAR state at 600 feet below the target traveling at 0.8 fps closing. Manual phase is constrained by not allowing the target to drop below 15 degrees, performing an ideal +X burn to stop motion at subsequent RBAR crossing, and pumping Z_{dot} per the standard RBAR braking gates.

The ORBT RBAR trajectory is that based upon an Optimized RBAR Targeting (ORBT) profile with T_i below the VBAR and with T_i and midcourse corrections designed to achieve an RBAR state of 600 feet below the target traveling at 0.8 fps closing. The ORBT design itself highly optimizes manual phase with little or no burns required between the last midcourse correction burn and RBAR arrival.

The ORBT RBAR with TORVA trajectory is that based upon the above with an initiation of a Twice Orbit rate RBAR to VBAR transition (TORVA) at 500 feet on the RBAR and ending upon VBAR arrival around 300 feet leading the target. No R_{dot} logic is invoked during the TORVA itself by design.

Table 6.2-1 Standard RBAR Approach to 250 ft CG-CG (170 IF-IF), 210 nmi Orbit

MC2 time (min)	Delta Xdot (fps)	Delta Zdot (fps)	X(t) (ft)	Z(t) (ft)	Xdot (fps)	Zdot (fps)	Range (ft)	Rdot (fps)	Θ (rad)	Θ dot (rad/s)
20.0	0.00	0.00	-1378	4438	7.14	-6.84	4647	-8.64	1.87	-1.030
21.0	0.00	0.00	-978	4030	6.21	-6.76	4147	-8.04	1.81	-1.071
22.0	0.00	0.00	-633	3627	5.30	-6.66	3682	-7.47	1.74	-1.106
23.0	0.00	0.00	-342	3231	4.40	-6.53	3250	-6.95	1.68	-1.135
24.0	0.00	0.00	-105	2845	3.52	-6.36	2847	-6.49	1.61	-1.154
25.0	0.00	0.00	81	2469	2.67	-6.17	2470	-6.08	1.54	-1.161
26.0	0.00	0.00	216	2105	1.84	-5.94	2116	-5.73	1.47	-1.154
27.0	0.21	1.61	313	1816	1.39	-4.11	1843	-3.81	1.40	-1.125
28.0	-0.70	0.00	342	1579	0.16	-3.78	1616	-3.66	1.36	-0.590
29.0	0.24	1.00	344	1390	-0.04	-2.44	1432	-2.37	1.33	-0.385
30.0	0.00	0.00	332	1254	-0.34	-2.11	1297	-2.12	1.31	-0.159
31.0	0.00	0.00	303	1138	-0.61	-1.76	1178	-1.86	1.31	0.113
32.0	0.00	0.00	260	1042	-0.82	-1.41	1074	-1.57	1.33	0.425
33.0	0.00	0.00	205	968	-0.99	-1.06	990	-1.24	1.36	0.759
34.0	0.00	0.00	142	916	-1.11	-0.70	927	-0.86	1.42	1.070
35.0	0.00	-0.35	73	877	-1.20	-0.68	880	-0.78	1.49	1.295
36.0	1.29	-0.47	1	833	-0.01	-0.79	833	-0.79	1.57	0.007
37.0	0.11	-0.19	1	786	-0.01	-0.79	786	-0.79	1.57	0.007
38.0	0.11	-0.18	0	739	0.00	-0.79	739	-0.79	1.57	0.006
39.0	0.11	-0.17	0	691	0.00	-0.79	691	-0.79	1.57	0.006
40.0	0.11	-0.16	-1	644	0.00	-0.79	644	-0.79	1.57	0.006
41.0	0.11	-0.13	-1	597	0.00	-0.78	597	-0.78	1.57	0.005
42.0	0.10	0.00	-1	554	0.00	-0.65	554	-0.65	1.57	0.003
43.0	0.08	0.00	-1	519	0.00	-0.52	519	-0.52	1.57	0.001
44.0	0.07	-0.08	-1	489	0.00	-0.49	489	-0.49	1.57	0.001
45.0	0.06	-0.08	-1	460	0.00	-0.46	460	-0.46	1.57	0.000
46.0	0.06	-0.08	-1	434	0.00	-0.43	434	-0.43	1.57	-0.001
47.0	0.06	-0.07	-1	409	0.00	-0.41	409	-0.41	1.57	-0.001
48.0	0.05	-0.07	-1	385	0.00	-0.38	385	-0.38	1.57	-0.002
49.0	0.05	-0.06	-1	363	0.00	-0.36	363	-0.36	1.57	-0.003
50.0	0.05	-0.06	-1	342	0.00	-0.34	342	-0.34	1.57	-0.003
51.0	0.04	-0.06	-1	322	0.00	-0.32	322	-0.32	1.57	-0.004
52.0	0.04	-0.05	-1	304	0.00	-0.30	304	-0.30	1.57	-0.004
53.0	0.04	-0.04	-1	286	0.00	-0.27	286	-0.27	1.57	-0.004
54.0	0.03	0.00	-1	272	0.00	-0.21	272	-0.21	1.57	-0.005
55.0	0.02	0.00	-1	261	0.00	-0.15	261	-0.15	1.57	-0.006
56.0	0.02	0.00	-1	254	0.00	-0.09	254	-0.09	1.57	-0.006
57.0	0.01	0.00	0	251	0.00	-0.03	251	-0.03	1.57	-0.006
Total	3.87	5.37								

 = RBAR +/-X logic
 = braking gates
 = RBAR -Z logic

Note: Table starts with post-MC4 burnout vector at MC2 + 20 min and ends at the beginning of the 250-ft CG-CG (170-ft IF-IF) stationkeeping point.

Table 6.2-2 ORBT RBAR Approach to 250 ft CG-CG (170 IF-IF), 210 nmi Orbit

MC2 time (min)	Delta Xdot (fps)	Delta Zdot (fps)	X(t) (ft)	Z(t) (ft)	Xdot (fps)	Zdot (fps)	Range (ft)	Rdot (fps)	Θ (rad)	Θ dot (rad/s)
27.0	0.00	0.00	-900	1800	2.69	-2.07	2012	-3.05	2.03	-0.736
28.0	0.00	0.00	-747	1677	2.41	-2.01	1836	-2.82	1.99	-0.754
29.0	0.00	0.00	-610	1558	2.14	-1.95	1674	-2.60	1.94	-0.767
30.0	0.00	0.00	-490	1444	1.88	-1.88	1524	-2.38	1.90	-0.773
31.0	0.00	0.00	-384	1333	1.63	-1.79	1388	-2.18	1.85	-0.772
32.0	0.00	0.00	-294	1229	1.39	-1.70	1263	-1.98	1.81	-0.760
33.0	0.00	0.00	-217	1129	1.17	-1.60	1150	-1.80	1.76	-0.735
34.0	0.00	0.00	-153	1036	0.96	-1.50	1047	-1.62	1.72	-0.695
35.0	0.00	0.00	-102	950	0.76	-1.39	955	-1.46	1.68	-0.638
36.0	0.00	0.00	-62	870	0.58	-1.27	872	-1.30	1.64	-0.562
37.0	0.00	0.00	-32	798	0.42	-1.14	798	-1.16	1.61	-0.465
38.0	0.00	0.00	-11	733	0.27	-1.01	733	-1.01	1.59	-0.348
39.0	0.00	0.00	1	677	0.14	-0.87	677	-0.87	1.57	-0.212
40.0	0.00	-0.06	6	628	0.03	-0.79	628	-0.79	1.56	-0.062
41.0	0.05	-0.08	6	581	-0.02	-0.73	581	-0.73	1.56	0.024
42.0	0.09	0.00	4	541	-0.02	-0.60	541	-0.60	1.56	0.021
43.0	0.08	-0.03	3	509	-0.01	-0.51	509	-0.51	1.56	0.019
44.0	0.07	-0.09	3	480	-0.01	-0.48	480	-0.48	1.57	0.017
45.0	0.06	-0.08	2	452	-0.01	-0.45	452	-0.45	1.57	0.015
46.0	0.06	-0.08	1	426	-0.01	-0.42	426	-0.42	1.57	0.013
47.0	0.06	-0.07	1	401	-0.01	-0.40	401	-0.40	1.57	0.012
48.0	0.05	-0.07	1	378	0.00	-0.38	378	-0.38	1.57	0.010
49.0	0.05	-0.06	0	357	0.00	-0.35	357	-0.35	1.57	0.008
50.0	0.05	-0.06	0	336	0.00	-0.33	336	-0.33	1.57	0.006
51.0	0.04	-0.06	0	317	0.00	-0.31	317	-0.31	1.57	0.005
52.0	0.04	-0.05	0	298	0.00	-0.30	298	-0.30	1.57	0.003
53.0	0.04	-0.03	0	282	0.00	-0.25	282	-0.25	1.57	0.002
54.0	0.03	0.00	0	268	0.00	-0.19	268	-0.19	1.57	0.000
55.0	0.02	0.00	0	259	0.00	-0.13	259	-0.13	1.57	-0.002
56.0	0.01	0.00	0	253	0.00	-0.07	253	-0.07	1.57	-0.003
57.0	0.01	0.00	0	250	0.00	-0.01	250	-0.01	1.57	-0.004
Total	0.98	1.13								

 = RBAR +/-X logic = braking gates
 = RBAR -Z logic

Note: Table starts with post-MC4 burnout vector at MC2 + 27 min and ends at the beginning of the 250-ft CG-CG (170-ft IF-IF) stationkeeping point.

Table 6.2-3 ORBT TORVA Approach to VBAR Arrival, 210 nmi Orbit

MC2 time (min)	Delta Xdot (fps)	Delta Zdot (fps)	X(t) (ft)	Z(t) (ft)	Xdot (fps)	Zdot (fps)	Range (ft)	Rdot (fps)	Θ (rad)	Θ dot (rad/s)
27.0	0.00	0.00	-900	1800	2.69	-2.07	2012	-3.05	2.03	-0.736
28.0	0.00	0.00	-747	1677	2.41	-2.01	1836	-2.82	1.99	-0.754
29.0	0.00	0.00	-610	1558	2.14	-1.95	1674	-2.60	1.94	-0.767
30.0	0.00	0.00	-490	1444	1.88	-1.88	1524	-2.38	1.90	-0.773
31.0	0.00	0.00	-384	1333	1.63	-1.79	1388	-2.18	1.85	-0.772
32.0	0.00	0.00	-294	1229	1.39	-1.70	1263	-1.98	1.81	-0.760
33.0	0.00	0.00	-217	1129	1.17	-1.60	1150	-1.80	1.76	-0.735
34.0	0.00	0.00	-153	1036	0.96	-1.50	1047	-1.62	1.72	-0.695
35.0	0.00	0.00	-102	950	0.76	-1.39	955	-1.46	1.68	-0.638
36.0	0.00	0.00	-62	870	0.58	-1.27	872	-1.30	1.64	-0.562
37.0	0.00	0.00	-32	798	0.42	-1.14	798	-1.16	1.61	-0.465
38.0	0.00	0.00	-11	733	0.27	-1.01	733	-1.01	1.59	-0.348
39.0	0.00	0.00	1	677	0.14	-0.87	677	-0.87	1.57	-0.212
40.0	0.00	-0.06	6	628	0.03	-0.79	628	-0.79	1.56	-0.062
41.0	0.05	-0.08	6	581	-0.02	-0.73	581	-0.73	1.56	0.024
42.0	0.10	-0.10	4	539	-0.02	-0.69	539	-0.69	1.56	0.022
43.0	1.24	-0.12	3	498	1.12	-0.69	498	-0.69	1.56	-2.268
44.0	-0.07	0.01	66	455	0.95	-0.72	460	-0.58	1.43	-2.274
45.0	-0.05	0.01	118	412	0.80	-0.73	428	-0.48	1.29	-2.272
46.0	-0.03	0.01	163	368	0.68	-0.73	402	-0.39	1.15	-2.270
47.0	-0.01	0.01	200	324	0.57	-0.73	381	-0.32	1.02	-2.269
48.0	0.00	0.00	231	281	0.47	-0.73	364	-0.26	0.88	-2.268
49.0	0.01	-0.01	256	237	0.38	-0.73	349	-0.22	0.75	-2.267
50.0	0.01	-0.01	276	193	0.28	-0.73	337	-0.19	0.61	-2.267
51.0	0.01	-0.01	290	149	0.19	-0.74	326	-0.17	0.47	-2.267
52.0	0.00	0.00	299	105	0.09	-0.73	317	-0.16	0.34	-2.268
53.0	0.00	0.00	301	62	-0.01	-0.71	307	-0.15	0.20	-2.269
54.0	0.00	0.01	298	20	-0.11	-0.69	298	-0.15	0.07	-2.270
55.0	0.00	0.67	289	-1	-0.15	0.00	289	-0.15	0.00	0.003
Total	1.58	1.11								

1.24 = start/stop TORVA 0.67 = braking gates
0.67 = TORVA maintenance logic

Note: Table starts with post-MC4 burnout vector at MC2 + 27 min and ends after stabilizing on the VBAR.

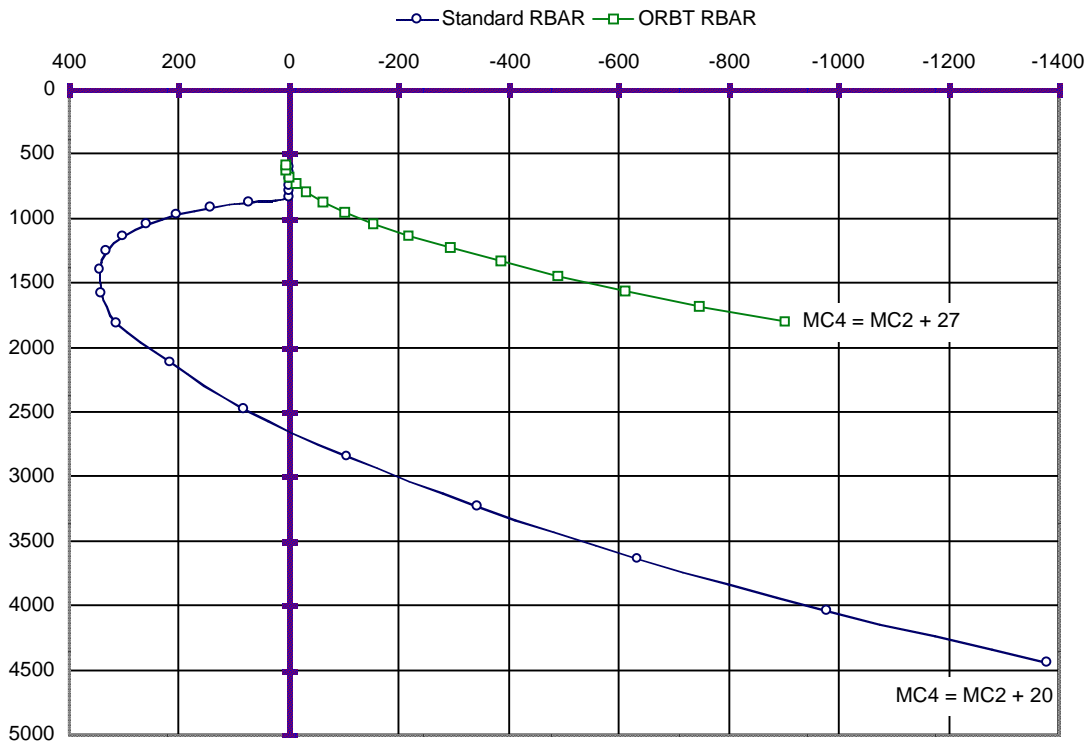


Figure 6.2-1 Relative Motion Plot of Optimal Manual Phase Approaches to 600 feet

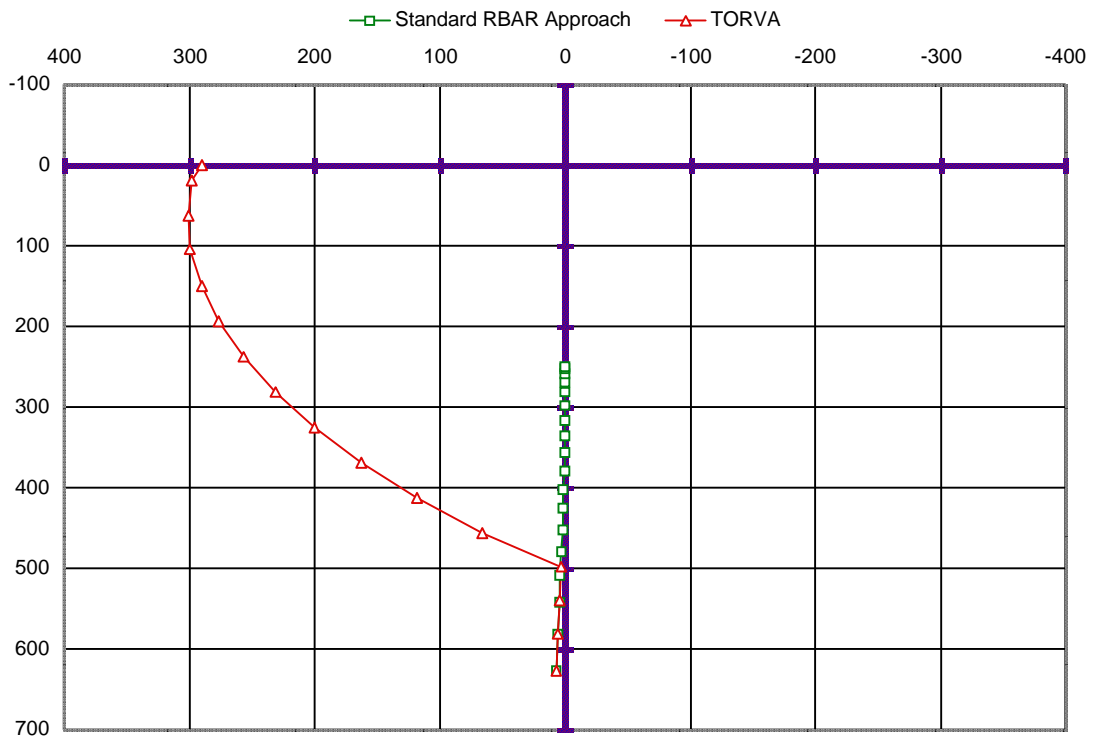


Figure 6.2-2 Relative Motion Plot of TORVA and RBAR Approaches from 600 feet

Effects of a 1 fps Burn

The following chart details the relative motion achieved by a 1 fps posigrade burn.

Time (min)	X(t) (ft)	Z(t) (ft)	Range (ft)	Xdot (fps)	Zdot (fps)	Rdot (fps)
0	0	0	0	1.00	0.00	1.00
1	60	-4	60	0.99	-0.14	1.00
2	119	-16	120	0.96	-0.27	0.99
3	175	-37	179	0.92	-0.41	0.98
4	228	-65	237	0.85	-0.54	0.97
5	277	-101	295	0.77	-0.67	0.95
6	320	-145	352	0.67	-0.79	0.94
7	357	-196	408	0.55	-0.92	0.93
8	387	-255	463	0.42	-1.04	0.92
9	407	-321	518	0.27	-1.15	0.93
10	419	-393	574	0.11	-1.26	0.94
11	420	-471	632	-0.07	-1.36	0.97
12	410	-556	691	-0.26	-1.46	1.02
13	389	-646	754	-0.47	-1.55	1.09
14	354	-742	822	-0.68	-1.63	1.18
15	307	-842	896	-0.91	-1.70	1.29
16	245	-946	977	-1.15	-1.77	1.43
17	169	-1054	1068	-1.39	-1.83	1.59
18	78	-1166	1168	-1.64	-1.88	1.77
19	-28	-1280	1280	-1.90	-1.92	1.97
20	-150	-1396	1404	-2.17	-1.96	2.18
25	-1003	-1993	2231	-3.52	-1.98	3.35
30	-2257	-2563	3415	-4.81	-1.78	4.52
35	-3871	-3042	4923	-5.90	-1.38	5.49
40	-5763	-3374	6678	-6.65	-0.81	6.15
45	-7820	-3521	8576	-6.99	-0.16	6.44
50	-9910	-3467	10499	-6.86	0.52	6.31
55	-11895	-3218	12322	-6.30	1.13	5.78
60	-13651	-2802	13935	-5.35	1.62	4.92
65	-15080	-2266	15250	-4.14	1.92	3.81
70	-16122	-1674	16209	-2.80	2.00	2.57
75	-16760	-1091	16796	-1.47	1.85	1.35
80	-17025	-585	17035	-0.33	1.49	0.28
85	-16988	-215	16989	0.51	0.96	-0.52
90	-16758	-22	16758	0.95	0.32	-0.95

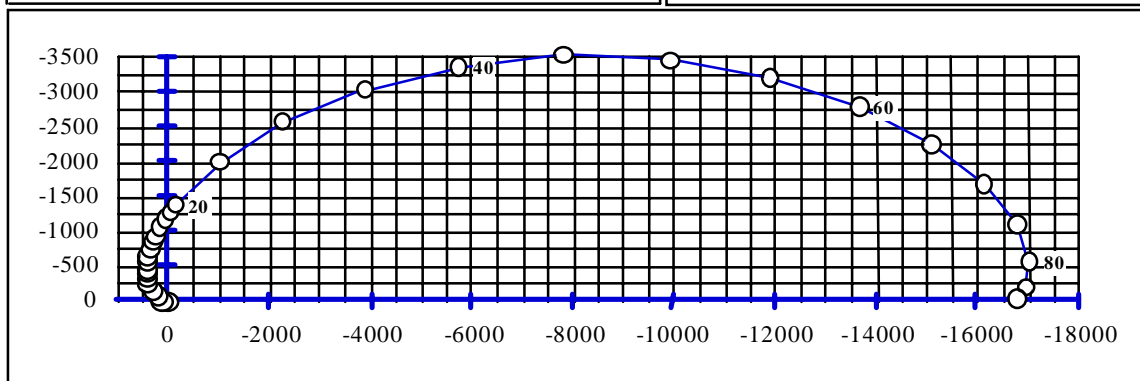
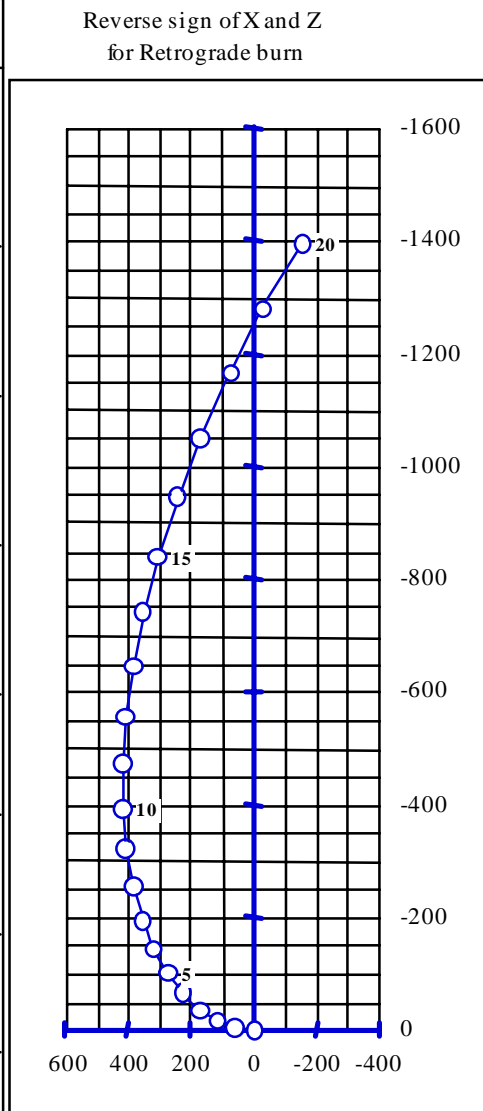


Figure 6.2-3 Relative Motion Effects of a 1 fps Posigrade Burn, 210 nmi Orbit

The following chart details the relative motion achieved by a 1 fps radial burn.

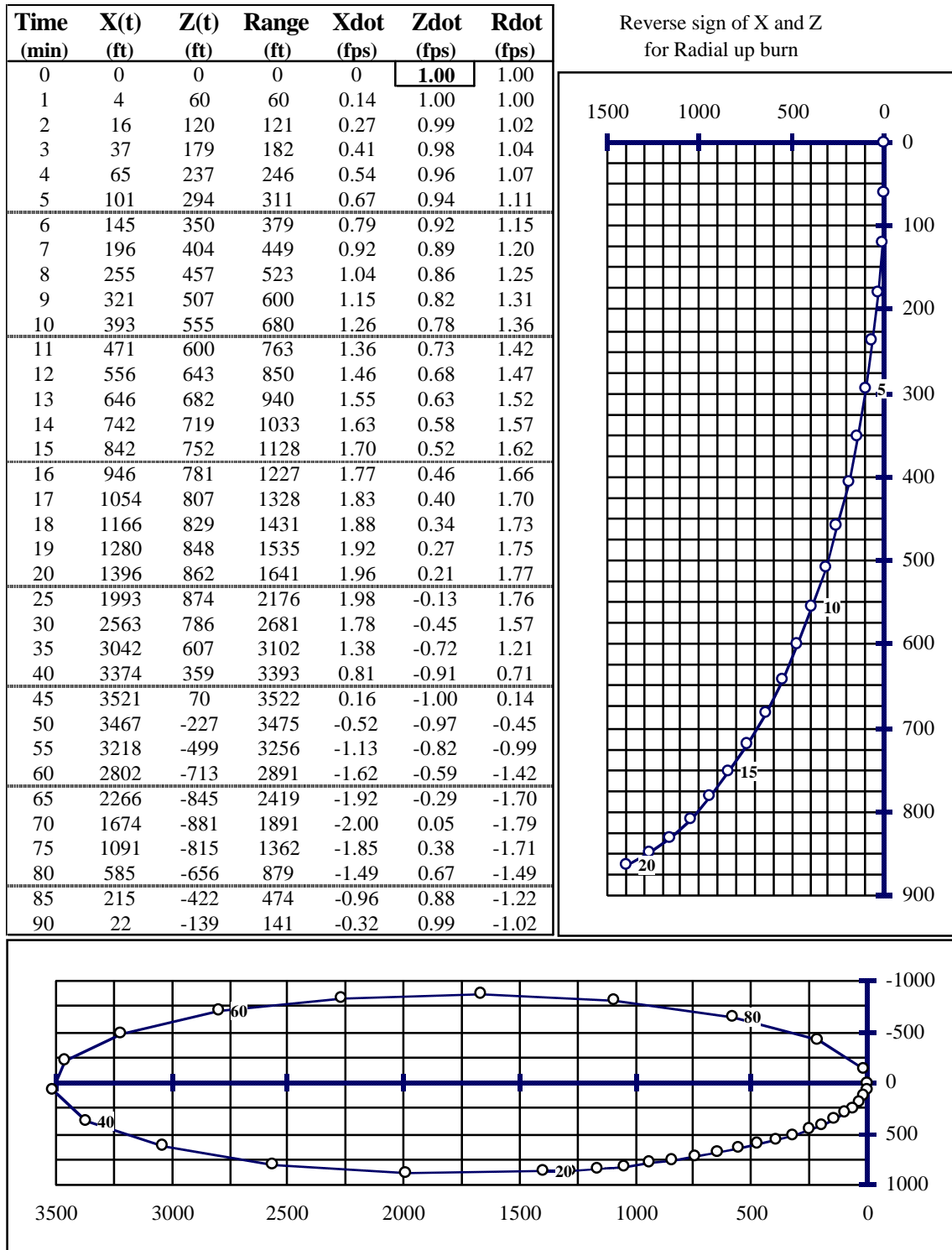


Figure 6.2-4 Relative Motion Effects for a 1 fps Radial Burn, 210 nmi Orbit

The following chart details the near-field relative motion achieved by a 1 fps burn at various angles relative to the VBAR. All of these have some degree of posigrade component, so reverse the signs for retrograde motion.

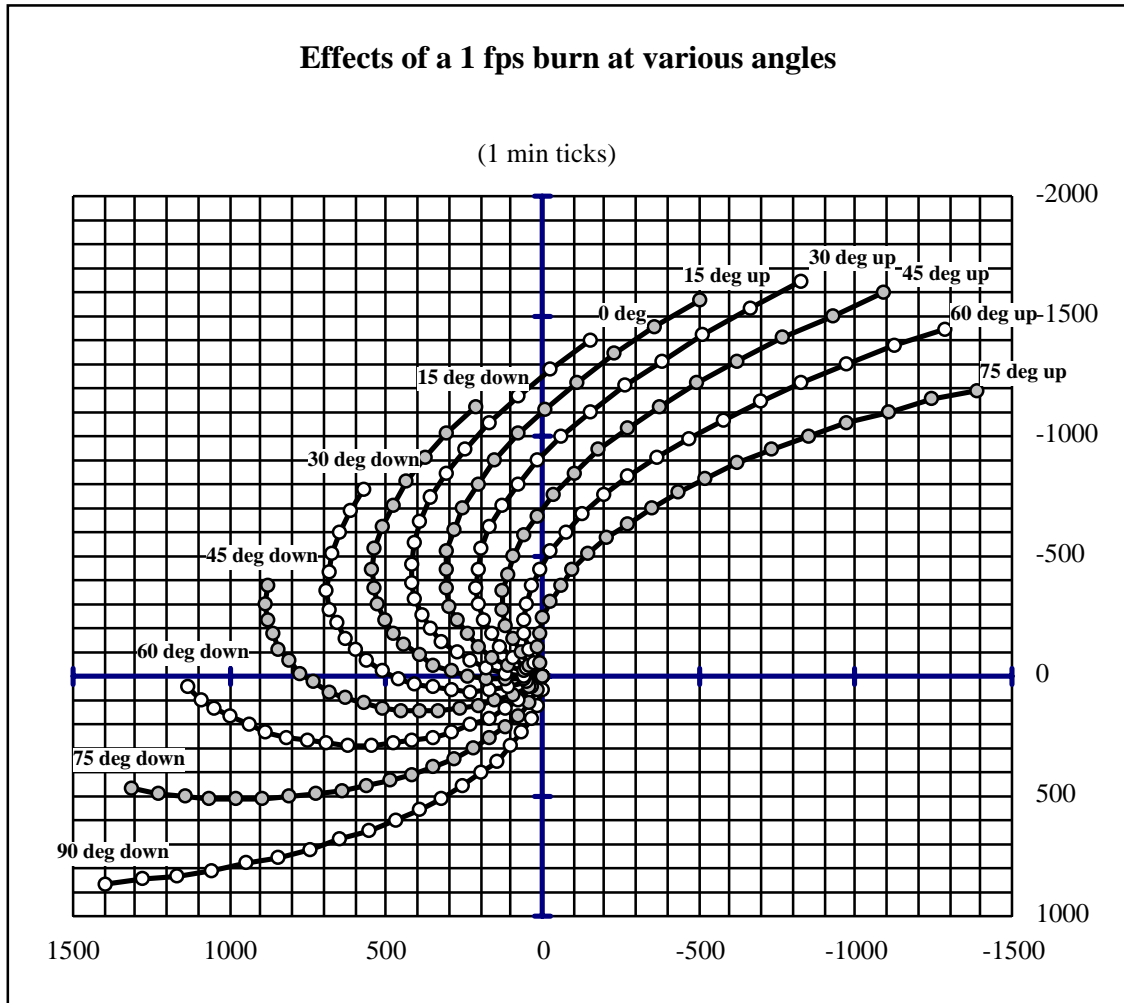


Figure 6.2-5 Relative Motion Effects for 1 fps Burns at Various Angles, 210 nmi Orbit

6.3 Rendezvous Delay

PURPOSE

To specify the procedures to follow in the event that a rendezvous delay is required.

PROCEDURE

Prop Assessment

Assess prop available and time required for delay and recommend where to delay, at Ti versus prox ops.

- Ti delay cost \approx 6 fps, 150 - 200 lbs.
- Prox ops stationkeeping costs \approx 175 lbs/rev.

General rules of thumb:

- If delay time required is greater than 1 hour, perform Ti delay.
- If delay time required is less than 1 hour, delay can be accommodated with prox ops stationkeeping.
- If delay time required is uncertain, a Ti delay is preferred to preserve options and save prop in the event a breakout and second rendezvous attempt may be needed.
- Make decision to delay as early as possible and stick to that decision; make it no later than Ti TIG -10 minutes.

Note: For a loss of communication case, the LOSS OF COMM procedure in the Rendezvous Checklist instructs the crew to perform a Ti Delay if a "go for Ti" is not received from the MCC by Ti TIG - 5 minutes.

Note: Check flight-specific FLIGHT RULES ANNEX for specific rules governing Ti Delay versus prox ops stationkeeping.

Pre-Burn Actions

- Ensure entire FCR is aware of choice of Ti burn.
- Verify burn pad with FDO.
 - RNDZ from behind: $Ti\ Delay\ \Delta V \approx Ti\ \Delta V + 3\ fps\ \Delta Vx$.
 - RNDZ from in front: $Ti\ Delay\ \Delta V \approx Ti\ \Delta V - 3\ fps\ \Delta Vx$.
- Send crew to Ti Delay procedure on page 5-25 of the RENDEZVOUS C/L.
- Perform SCP 5.4 MANEUVER MONITOR.

Post-Burn Actions

- Maneuver to target track attitude.
- Establish/maintain navigation.
- Get new BASE TIME to crew.
- Assess Post-Ti NAV - star tracker or radar?
- Assess need for a second NCC.
- Reset MCC PET timer counting to Ti TIG.

Prox Ops Stationkeeping

Ensure entire team is aware of choice of stationkeeping and provide FD and PROP with estimates of prop usage. See SCP 7.2 STATIONKEEPING for more information.

- VBAR in LOW Z \approx 175 lbs/rev
- VBAR in NORM Z \approx 101 lbs/rev
- RBAR \approx 110 lbs/rev + Δ height (ft) * 0.5 (lbs/rev)
- Inertial \approx 110 lbs/rev + Range (ft) * 0.5 (lbs/rev) * 0.7

BACKGROUND

Orbiter and/or payload system anomalies may induce a significant delay into the planned rendezvous. Such delays can be accommodated prior to entering onto the rendezvous, at Ti via a Ti delay, or post-Ti via prox ops stationkeeping.

Delay prior to day of rendezvous

The most convenient way to delay a rendezvous is to slow the catch-up rate such that the Orbiter makes a rendezvous with the target at the desired time. This can be done at any planned phasing MNVR (NC), typically with no propellant penalty, or an additional maneuver can be inserted into the rendezvous profile. Mission activities and propellant budgets will determine which option to use.

Delay at Ti

If it becomes inconvenient to slow the phasing prior to Ti, continue the nominal rendezvous profile and delay at Ti. Ti is the last point at which the RNDZ can be delayed prior to entering into prox ops.

Should a situation arise prior to execution of the Ti burn that requires a delay in the completion of the rendezvous, performing the Ti Delay burn places the Orbiter in a safe trajectory relative to the target. This allows the crew and ground to assess the status of the problem and decide whether or not to continue with the rendezvous.

Short term delay at Ti point

For short delays (one or two revs), the ground will compute a phasing maneuver to return to the Ti position (football) based on the most current onboard relative state and will voice the MNVR target sets to the crew during the RNDZ sequence. Desirable lighting conditions will be maintained as long as there is an integral number of revs between the original and new Ti MNVR. The crew has expressed an interest in remaining at least 6 nmi. from the target when Ti is positioned at 8 nmi.; the ground can easily accommodate this desire.

Unfortunately, there is a propellant penalty for executing a Ti delay when rendezvousing from behind. The magnitude of this penalty, due only to the extra ΔV required, is ~ 6 ft/sec (an extra ~ 3 fps to initiate the delay plus ~ 3 fps to start again). There is no penalty when rendezvousing from in front.

Long Delay at Ti Point

A long delay (greater than two revs) requires an opening rate to eliminate the need for the crew to continuously monitor the target. Long delays usually involve at least one crew sleep cycle. Typically, if propellant is available, the delay MNVR would be targeted to the point where the last phasing MNVR was executed (~ 40 nmi. trailing).

Post Ti-Delay-Burn Activities

If Ti delay has been performed, a number of activities will occupy the extra 90 minutes.

First, the cause of the Ti delay may impact the timing and order of the RNDZ activities to perform post-Ti. For instance, if the delay requires an OPS 2-8-2 transition, performing the BASE TIME load prior to the transition is a wasted effort; it will have to be repeated after the transition. Therefore, the RNDZ team must be aware of the immediate activities and respond flexibly and accordingly.

Second, retargeting Ti with the new base time received from the MCC will restart the GNC counter. As a first approximation, add 90 minutes to the old base time. Set the systems management (SM) timer to the next burn.

If there has not been good radar tracking pre Ti, the MCC will advise the crew to perform a STRK pass post Ti. Note that the Ti DELAY procedure states where the RENDEZVOUS C/L should be reentered after the Ti Delay burn.

Two Revs to Ti Transfers

Given sufficient notice of an impending delay, FDO and RGPO may decide to recommend modification of the rendezvous profile such that two revs rather than one occur between NC4 and Ti. This technique has various pros, such as the addition of an extra star tracker pass and reduced prop cost for the day. However, two negative aspects are that a two rev to Ti transfer changes the rendezvous profile in ways the crew may not have seen in their training, and the RGPO team will have to uplink numerous changes to the rendezvous timeline. In addition, the flight control team would have to ensure the NCC burn was not attempted on the first rev, since the transfer time expected by Lambert targeting would be wrong.

These pros and cons should be considered carefully when making the decision real-time. In general, the most benign and accepted means by which to delay a rendezvous is via a Ti Delay, since the crew can go hands off during that time to work systems malfunctions, etc.

Prox Ops Delay (via Stationkeeping)

See SCP 7.2 STATIONKEEPING.

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6.4 Breakout

PURPOSE

To specify the procedures to follow in the event that a breakout is required.

PROCEDURE

- Coordinate with FDO on type of breakout to be performed
- Ensure everyone is aware of decision to perform a breakout
- If in prox ops, ensure that crew keeps target along -Z axis and nulls any closing rate
- Log PET of breakout decision and type of breakout required
- Direct crew to proper breakout procedure (Rendezvous Breakout, Shuttle Nose In-Plane Breakout, a flight-specific breakout, or, if time permits, a modified Prox Ops breakout that minimizes plume effects on the payload)
- Monitor crews execution of breakout procedure
- Disable Rendezvous Nav and evaluate potential for another rendezvous attempt on subsequent flight days

BACKGROUND

Maintain awareness as to the type of breakout that may be required at all times during the rendezvous. It is a good idea for the Rendezvous team to cross-check each other at various stages of the rendezvous to determine the kind of breakout to perform if a breakout is required at that stage.

6.5 Planar Control

PURPOSE

To specify the procedures to control planar motion.

PROCEDURE

- Determine time to next planar crossing. Use one of the six available options listed in the BACKGROUND section.
 - Ross application: Time To ATT/OPP
 - SPEC 33 Display
 - Exact Equations
 - Rough Equations when Closing on a Node
 - Full-Range "Spider" Chart
 - Final 10 Minutes Chart
- Null Ydot when Y = 0 (Y firings cost ~35 lbs/fps).

Next Planar Crossing

Reference one of the following six means to obtain the time to the next planar crossing.

Option 1: ROSS application Time To ATT/OPP

The ROSS application "Time to ATT/OPP" displays the time to node, out of plane (OPP) velocity at node, current OPP velocity, current OPP position and maximum OPP position:

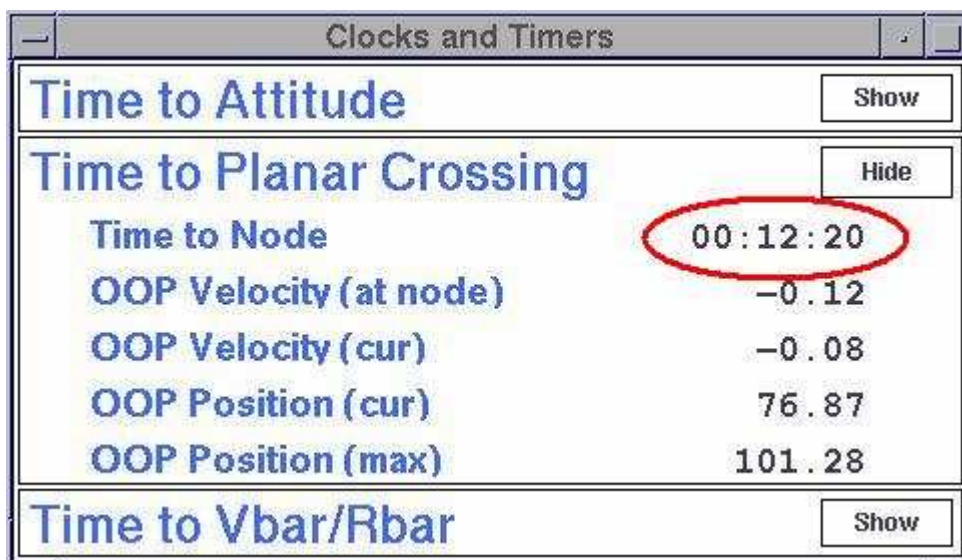


Figure 6.5-1 ROSS Time To ATT/OOP display

Option 2: SPEC 33 Display

Starting with OI-30 the time to nodal crossing is displayed on SPEC 33 (downlinked parameter).

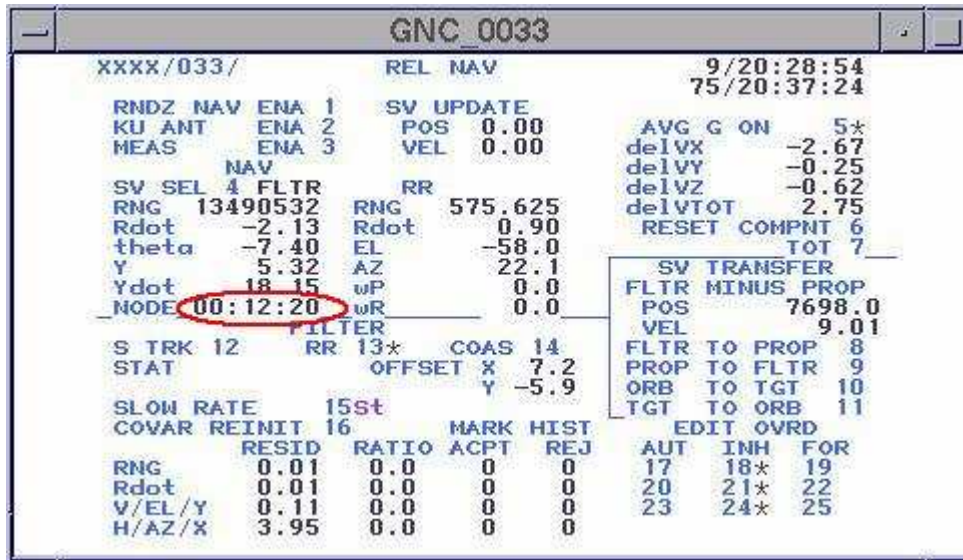


Figure 6.5-2 SPEC 33 Time to Nodal Crossing

Option 3: Exact Equations

For Y and Ydot having opposite signs (i.e., approaching a nodal crossing), the time in **minutes** to the next nodal crossing is given by the following equations:

RAD mode	DEG mode	
$t = \frac{1}{60\omega} \arctan\left(\frac{-\omega y}{\dot{y}}\right)$	$t = \frac{T}{360} \arctan\left(\frac{-\pi y}{30T \dot{y}}\right)$	Equation 6.5-1

where Y is in ft, Ydot is in ft/s (any consistent unit can be used in place of ft in both), ω (orb rate) is in rad/s, and T (orb period) is in minutes.

For Y and Ydot having the same sign (i.e., departing from a nodal crossing):

RAD mode	DEG mode	
$t = \frac{1}{60\omega} \left\{ \pi - \arctan\left(\frac{\omega y}{\dot{y}}\right) \right\}$	$t = \frac{T}{360} \left\{ 180 - \arctan\left(\frac{\pi y}{30T \dot{y}}\right) \right\}$	Equation 6.5-2

Option 4: Rough Equation, Closing on Node

For Y and Ydot having opposite signs (i.e., approaching a nodal crossing), the approximate time in minutes to the upcoming nodal crossing is given by the following equation:

RAD mode	DEG mode	
$t = 15 \cdot \arctan\left(\frac{-y}{1000\dot{y}}\right)$	$t = \frac{1}{4} \cdot \arctan\left(\frac{-y}{1000\dot{y}}\right)$	Equation 6.5-3

where Y is in ft and Ydot is in ft/s (any consistent distance unit can be used in place of ft in both)

Option 5: Full Range "Spider" Chart

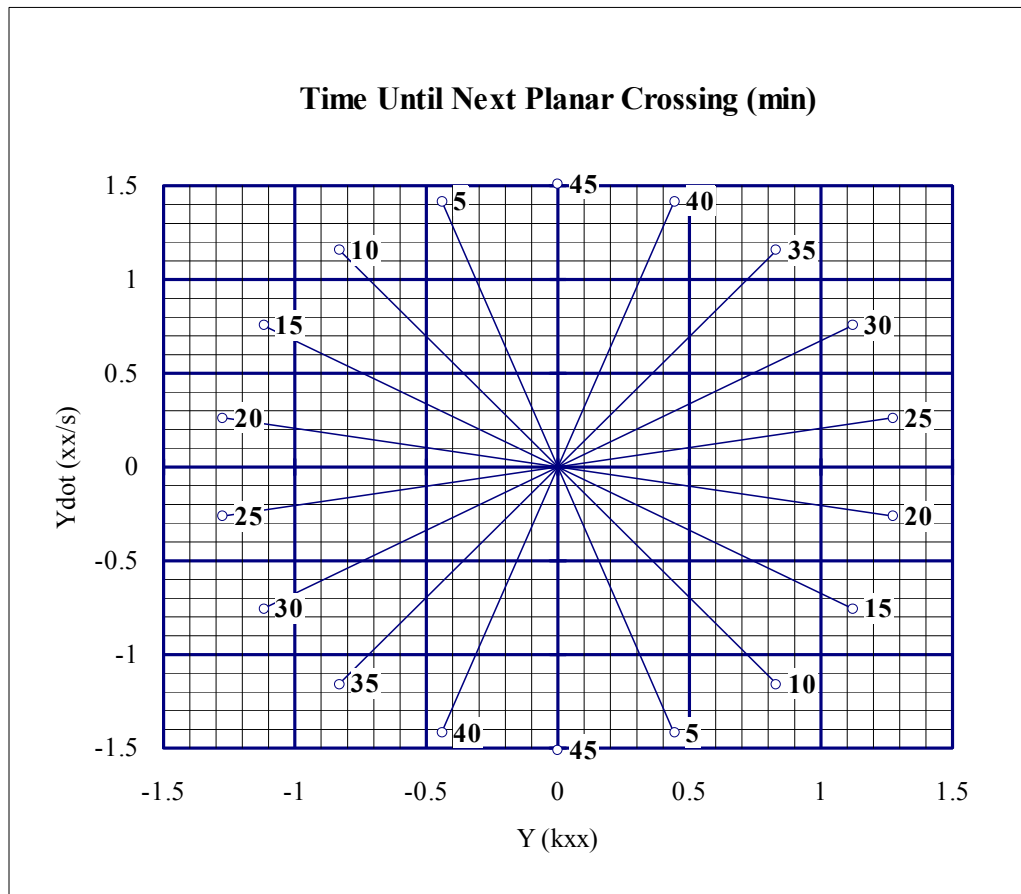


Figure 6.5-3 Time Until Next Planar Crossing, Full Range

How to use:

- Locate current value of Y in kft (km) along the horizontal axis;
- Locate current value if Ydot in ft/s (m/s) along the vertical axis;
- Determine intersection of Y and Ydot and read (or interpolate) the value of t in minutes.

Option 6: Final 10 Minutes Chart

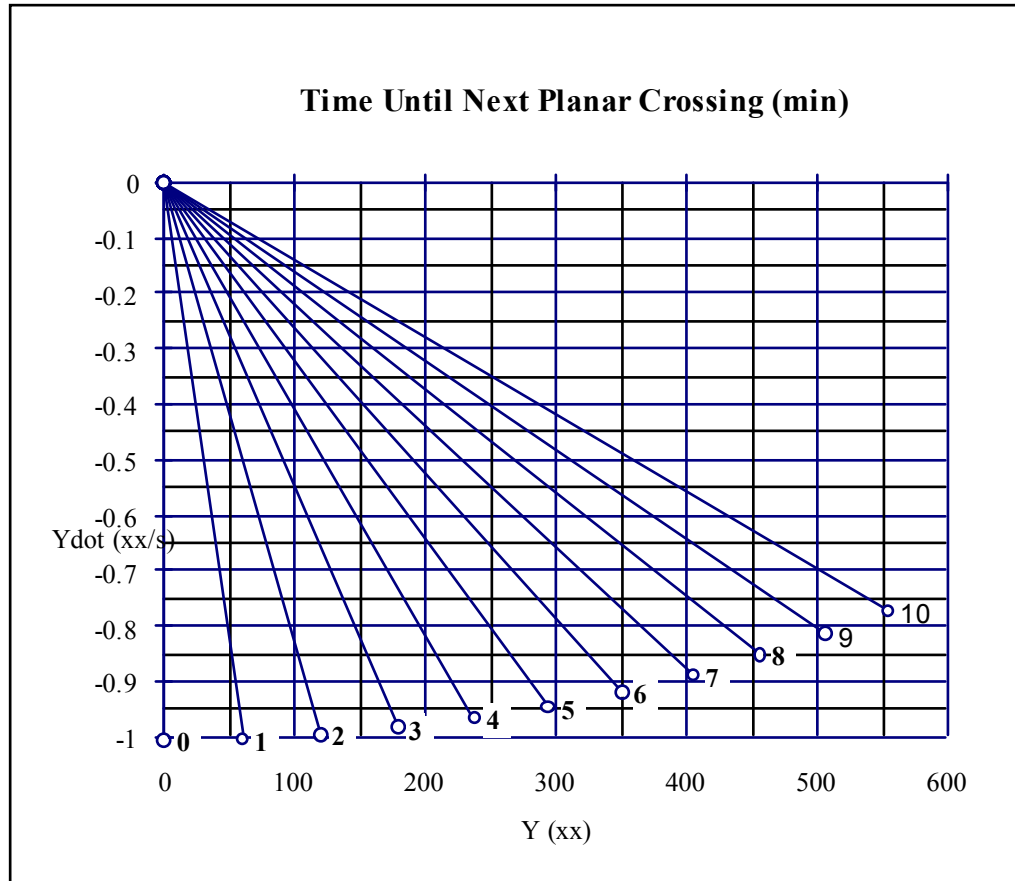


Figure 6.5-4 Time Until Next Planar Crossing, Final 10 Minutes

Use this chart when Y and Ydot have opposite signs. For the purposes of this chart, negate both Y and Ydot if Y is negative and Ydot is positive. Use a consistent distance unit in both Y and Ydot.

- Locate appropriate value of Y in ft (m) along the horizontal axis;
- Locate appropriate value of Ydot in ft/s (m/s) along the vertical axis;
- Determine intersection of Y and Ydot and read (or interpolate) the value of t in minutes.

6.6 Vents and Dumps

PURPOSE

To specify the effects of Orbiter vents and dumps on the relative trajectory and actions to be taken by the Rendezvous team.

PROCEDURE

Venting an Auxiliary Power Unit (APU)

- Pre-Ti: vent out-of-plane
- Post-Ti: vent in-plane

Water Dumps

- Flash Evaporator System (FES): anytime from a trajectory standpoint (may be payload constraints, however)
- Waste/Supply Water Dump: never during a rendezvous

Unknown Vent

If the relative trajectories of the Orbiter and target have unexplained motions, check the following:

- FDO: Is the target drag correct?
- PAYLOADS: Is the target venting anything?
- PROP: Are there any prop leaks?

BACKGROUND

APU

To avoid trajectory impacts, APU burns should be performed out of plane to negate possible down-range errors. However, post-Ti, this cannot be done without impacting sensors, so the ΔV hit must be taken in plane and then corrected with the MC burns.

The thrust of an APU burn oscillates between ~4 and ~12 lbs in the +Z direction can introduce a significant ΔV of several ft/s over an hour period. Specifically, the APUs vent 4 lbf in OPS 2 and 21 lbf in OPS 8. Also note that the Water Spray Boilers kick on after the first ten minutes when the APUs are driving aerosurfaces. That adds 2 lbf and 3 lbf, respectively. These numbers translate into roughly 2 fps per hour in OPS 2 and 12 fps per hour in OPS 8.

The APU houses two chemical reactions that produce hydrogen and nitrogen. Contamination of the target vehicle with this exhaust should be looked at real-time. Also

note that ammonia may also be vented if the second chemical reaction is not working properly.

Note that it is unlikely that an APU will be burned during a RNDZ because, if the leak is tiny, burning the APU can be delayed, and if the leak is large, it can be expected that the RNDZ will be terminated with the appropriate breakout, followed by APU burn and deorbit prep.

See MALFUNCTION, APU/HYD SSR-5 and ORB OPS, DPS G2-G8 and G8-G2 for applicable procedures.

Water Dumps

The FES releases water at very slow rates with little or no perturbing effects on the Orbiter. Also, the water released does not interfere with rendezvous sensors.

Waste and/or supply water dumps, on the other hand, require a large amount of time, greatly perturb the Orbiter in the +Y body axis direction, and can interfere with optical tracking, especially with the -Y star tracker. Therefore, waste/supply water dumps are ruled out of the rendezvous timeframe.

7.1 Prox Ops Overview

PURPOSE

To specify procedures to follow during proximity operations.

PROCEDURE

- Maintain awareness of Orbiter DAP configuration at all times, especially LO Z.
- Keep track of Orbiter and payload attitudes and relative position. If you are unsure of the Orbiter/payload relative position, do not hesitate to ask the crew.
- If a backout is needed, send crew to VBAR CORRIDOR BACKOUT in the Contingency section of the RENDEZVOUS C/L.
- Maintain awareness of propellant consumption and prop bingos.

7.2 Stationkeeping

PURPOSE

To specify considerations needed while stationkeeping.

PROCEDURE

- Ensure entire team is aware of choice of stationkeeping.
- Provide FD and PROP with estimates of prop usage.
 - Vbar (in LOW Z) ~ 175 (lbs/rev)
 - Vbar (in NORM Z) ~ 101 (lbs/rev)
 - Rbar ~ 110 (lbs/rev) + Δ height (ft) * 0.5 (lbs/rev)
 - Inertial Stationkeep ~ 110 (lbs/rev) + Range (ft) * 0.35 (lbs/rev)

BACKGROUND

Due to a requirement to suspend the rendezvous post-Ti, or to backout from the target post-rendezvous prior to a second approach, it may be necessary to stationkeep on the Vbar for up to several hours.

Vbar Stationkeeping

Vbar stationkeeping, which is typically performed inside 400 ft and outside 170 feet, costs roughly 1.9 lbs per minute (175 lbs/rev) in LOW Z with Vernier control. Vbar stationkeeping should be performed outside 400 ft CG-to-CG for ISS attitude control or US array feathering problems, outside 250 ft for Orbiter problems, and outside 170 ft for Russian array problems. Therefore, all Vbar stationkeeping should be done in LOW Z. In the event of a loss of LOW Z capability, stationkeeping in NORM Z is acceptable as long as no +Z (out) pulses are input between 1000 and 75 ft. In this case, prop usage is approximately 1.1 lbs per minute (101 lbs/rev).

There are time constraints for stationkeeping based on Orbiter range. For instance, stationkeeping at 30 ft is only allowed for 15 minutes before the Orbiter must back out to a greater range. These time constraints decrease linearly until 170 ft, where no time constraints exist.

Rbar Stationkeeping

Rbar stationkeeping above or below the target requires the same propellant allotment as for Vbar with NORM Z plus additional prop to counteract the Δ height effects (~ 0.022 fps per rev per foot of separation, or ~ 0.5 lb per rev per foot of separation). There is no additional penalty for Rbar stationkeeping with LOW Z.

For example, a 200 foot Rbar stationkeep would require approximately 110 lbs + 100 lbs, or 210 lbs/rev ($\sim 9.5\%$ RCS).

Inertial Stationkeeping

Inertial Stationkeeping cost is essentially the cost of Vbar stationkeeping plus and additional cost due to the range offset rotating above and below the Vbar. This cost can be approximated by $0.707 * \text{the max } \Delta\text{height} * 0.5 \text{ lbs per rev}$ which equates to $0.35 * \text{range}$.

For example, a 200 foot Inertial Stationkeep would require approximately 110 lbs + 70 lbs, or 180 lbs/rev (~8% RCS).

7.3 Plumes

PURPOSE

To provide dynamic pressure contours from RCS jet firings for prox ops considerations. Focus is on translations and rotations with upward-firing jets.

PROCEDURE

Refer to appropriate charts as listed below (value in parentheses denotes maximum dynamic pressure in lb/in² shown on that chart).

Translation

Plume contours are show for the following translation maneuvers at the values denoted:

- NORM Z +Z Translation (10-1)
- NORM Z +Z Translation (10-3)
- LOW Z +Z Translation (10-1)
- LOW Z +Z Translation (10-3)
- +X Translation (10-3)
- +X Translation (10-3)

Rotation

Plume contours are shown for the following rotation maneuvers:

- NORM Z +Pitch Rotation (10-1)
- NORM Z -Pitch Rotation (10-1)
- NORM Z ±Roll Rotation (10-1)

BACKGROUND

The following charts illustrate plume contours for various key maneuvers obtained from simulation modeling.

NORM Z +Z Translation (10⁻¹)

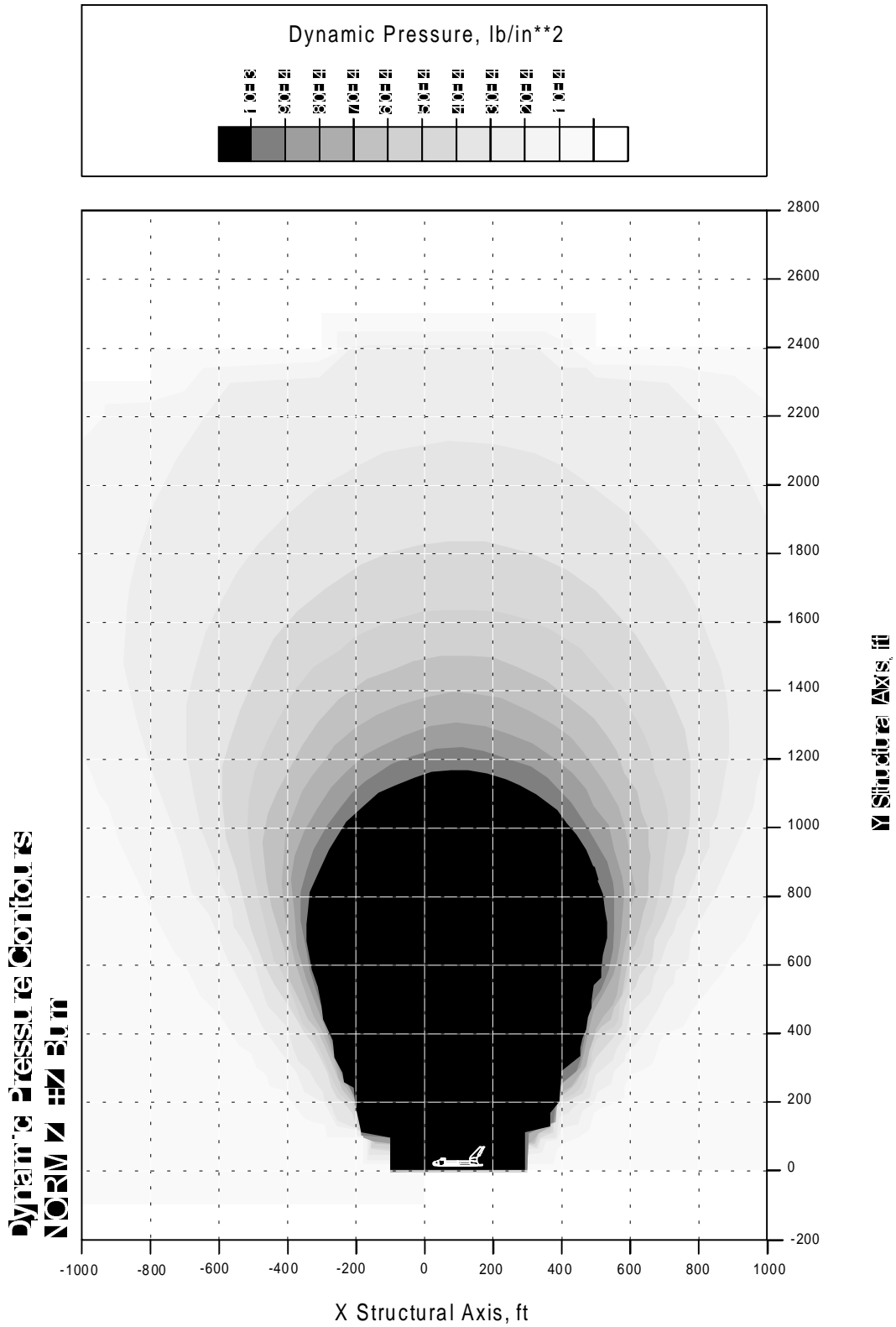


Figure 7.3-1 NORM Z +Z Translation (10⁻¹)

NORM Z +Z Translation (10⁻³)

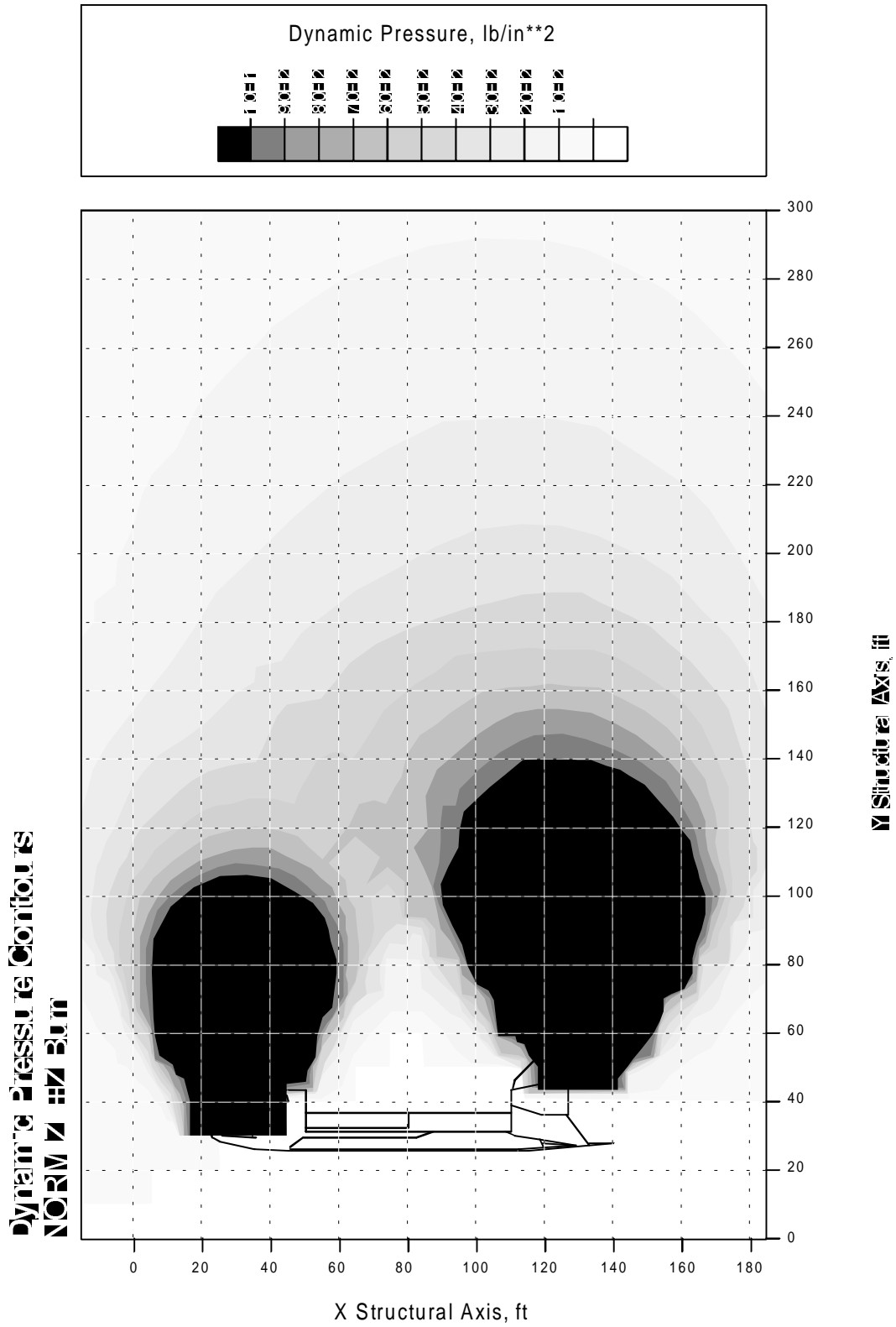


Figure 7.3-2 NORM Z +Z Translation (10⁻³)

LOW Z +Z Translation (10^{-1})

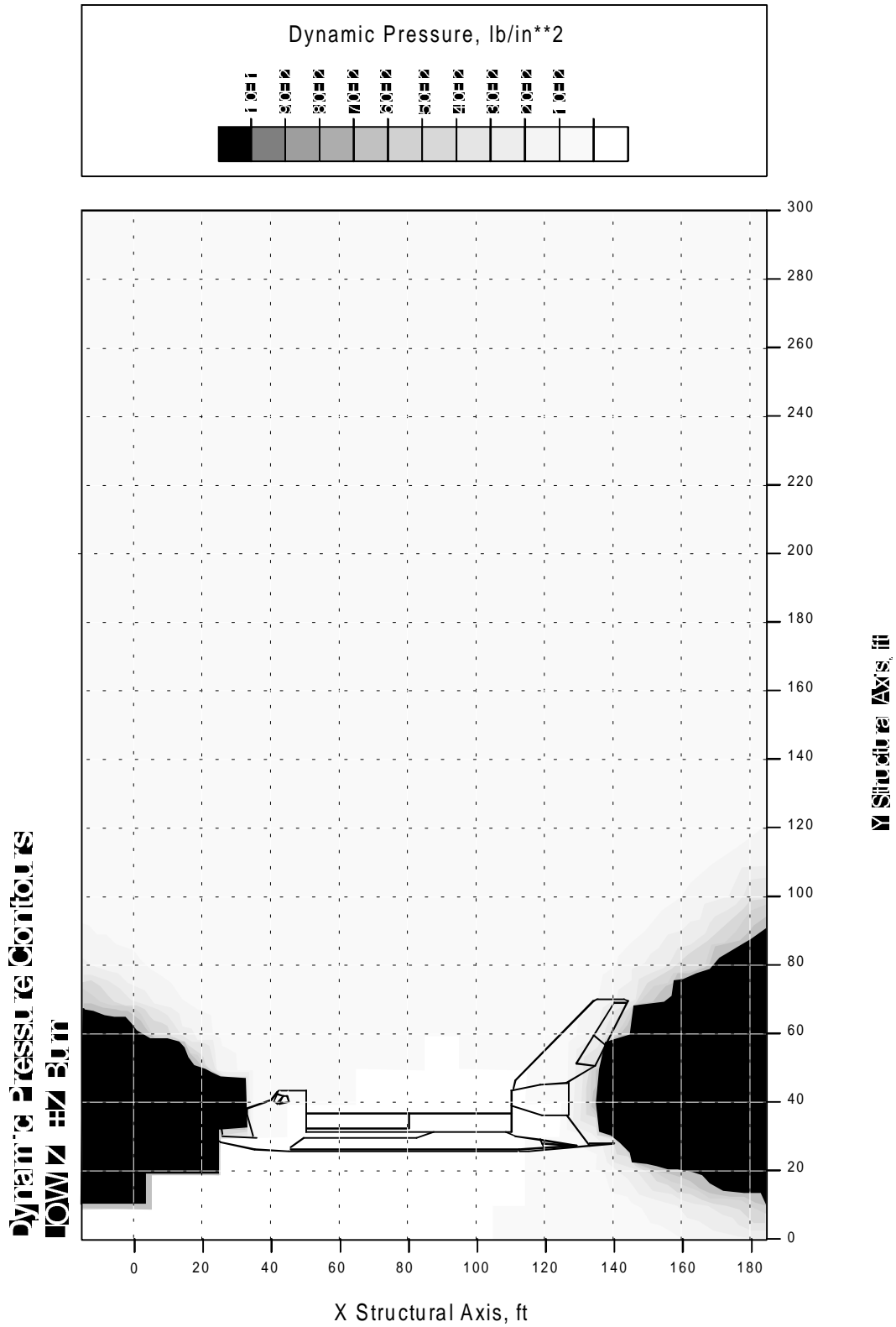


Figure 7.3-3 LOW Z +Z Translation (10^{-1})

LOW Z +Z Translation (10⁻³)

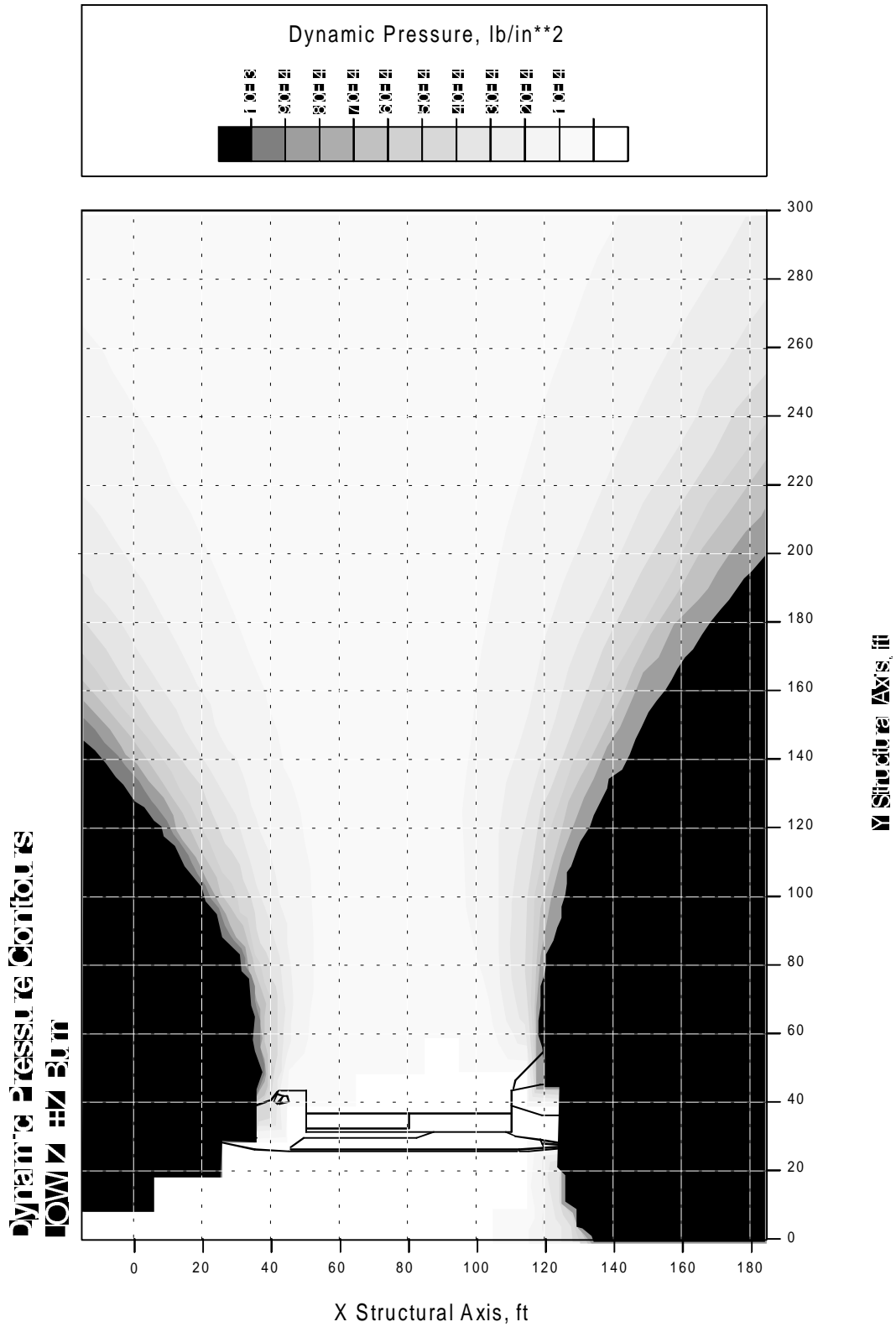


Figure 7.3-4 LOW Z +Z Translation (10⁻³)

+X Translation (10⁻³)

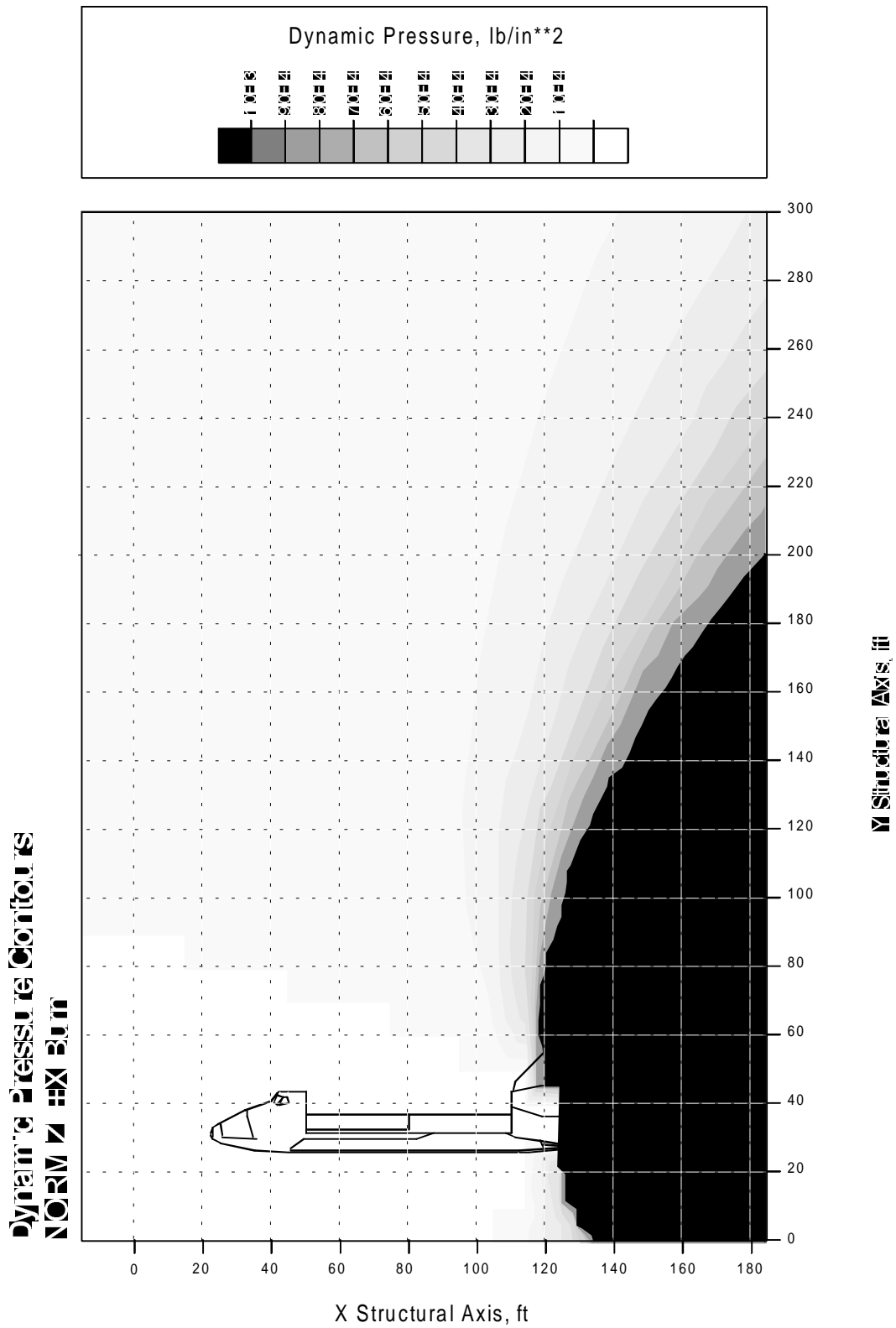


Figure 7.3-5 +X Translation (10⁻³)

-X Translation (10⁻³)

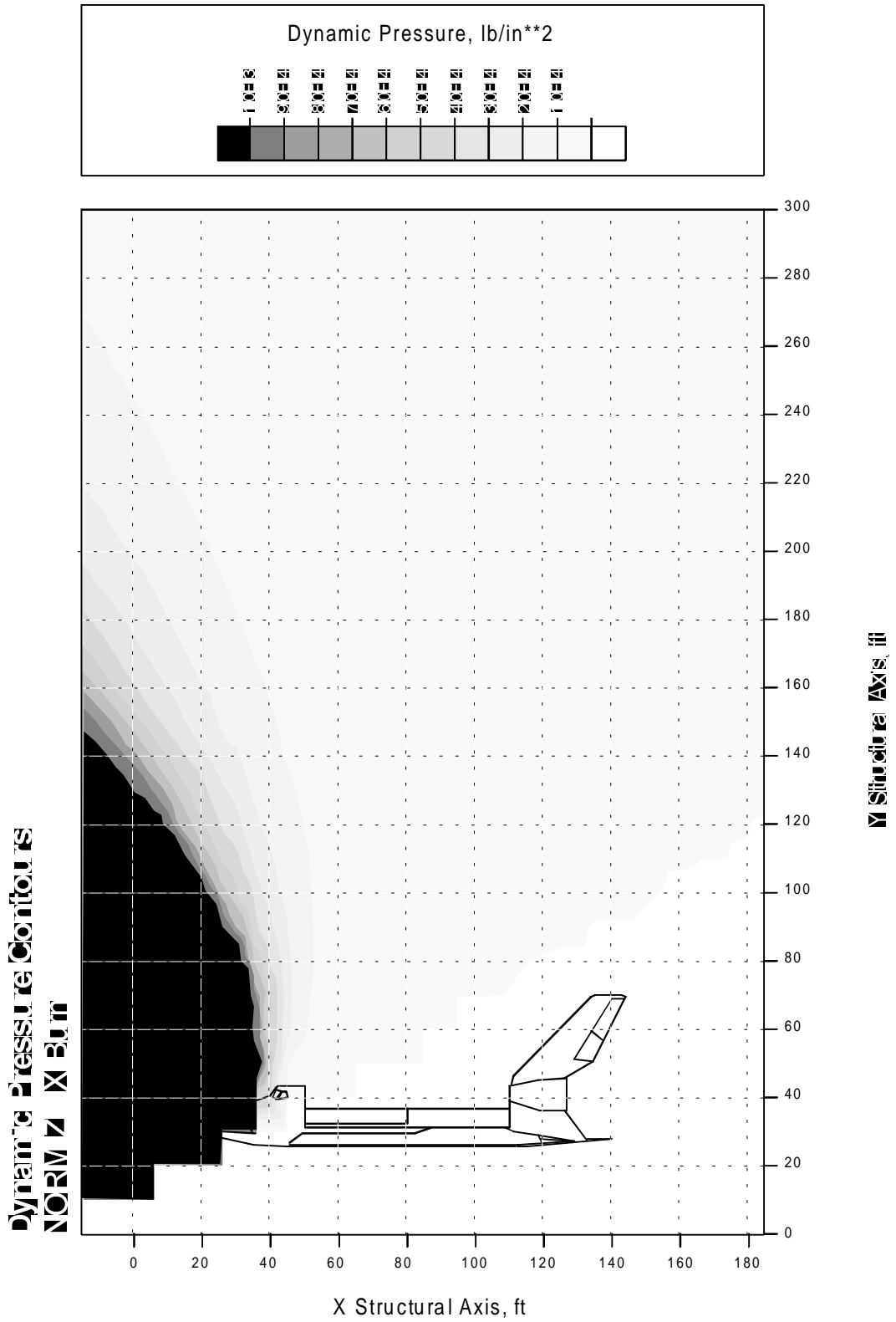


Figure 7.3-6 -X Translation (10⁻³)

NORM Z +Pitch Rotation (10⁻¹)

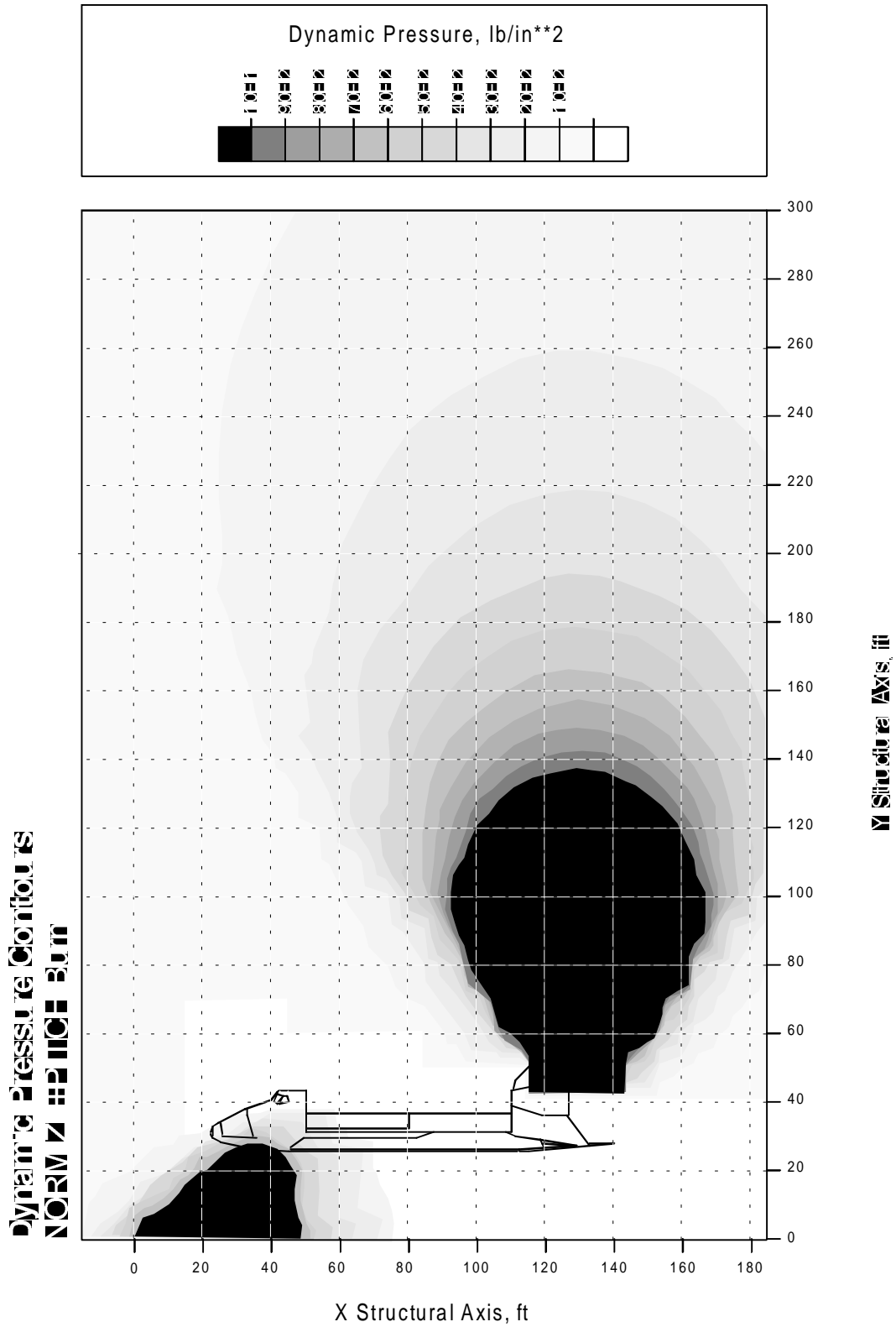


Figure 7.3-7 NORM Z +Pitch Rotation (10⁻¹)

NORM Z -Pitch Rotation (10^{-1})

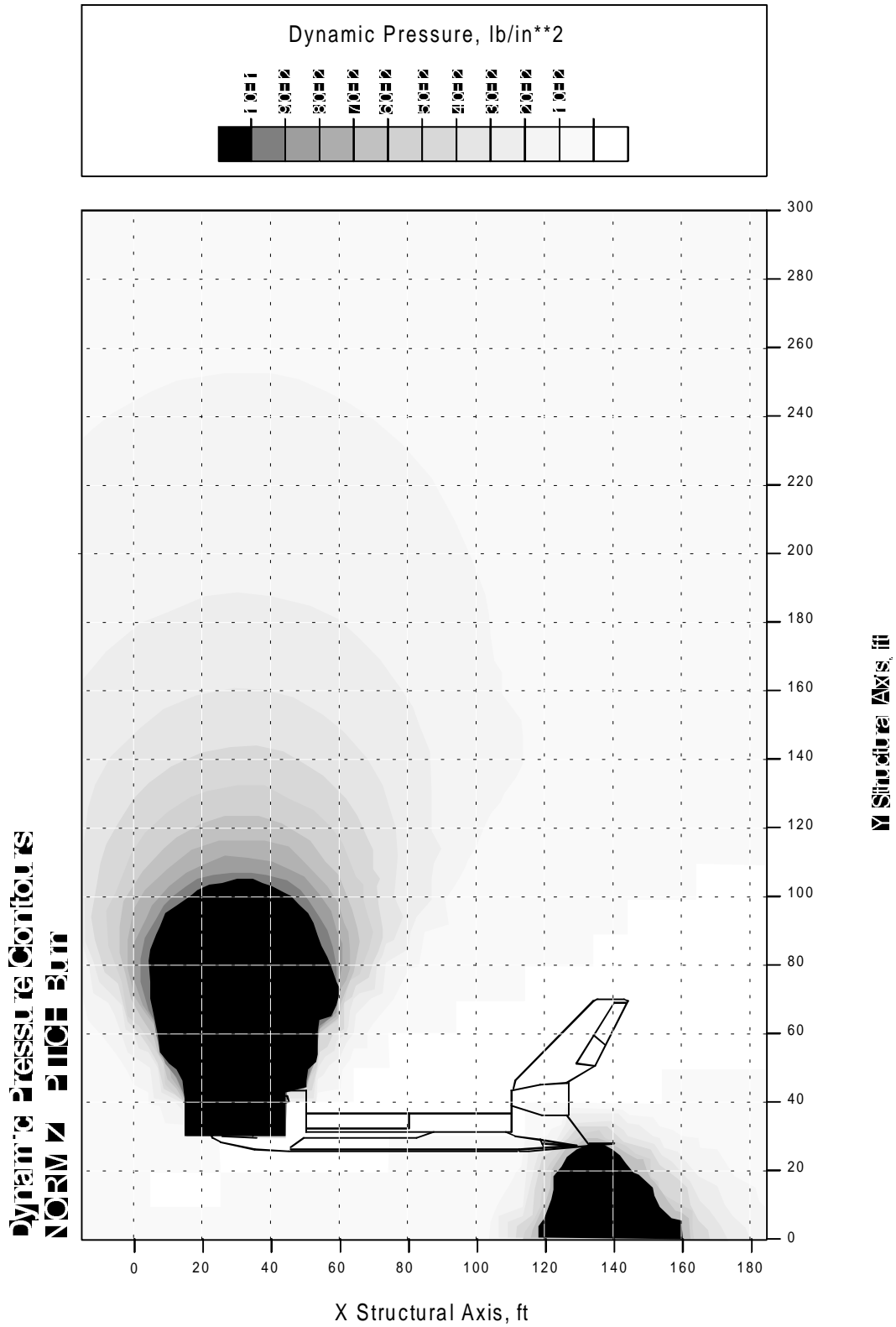


Figure 7.3-8 NORM Z -Pitch Rotation (10^{-1})

NORM Z \pm Roll Rotation (10^{-1})

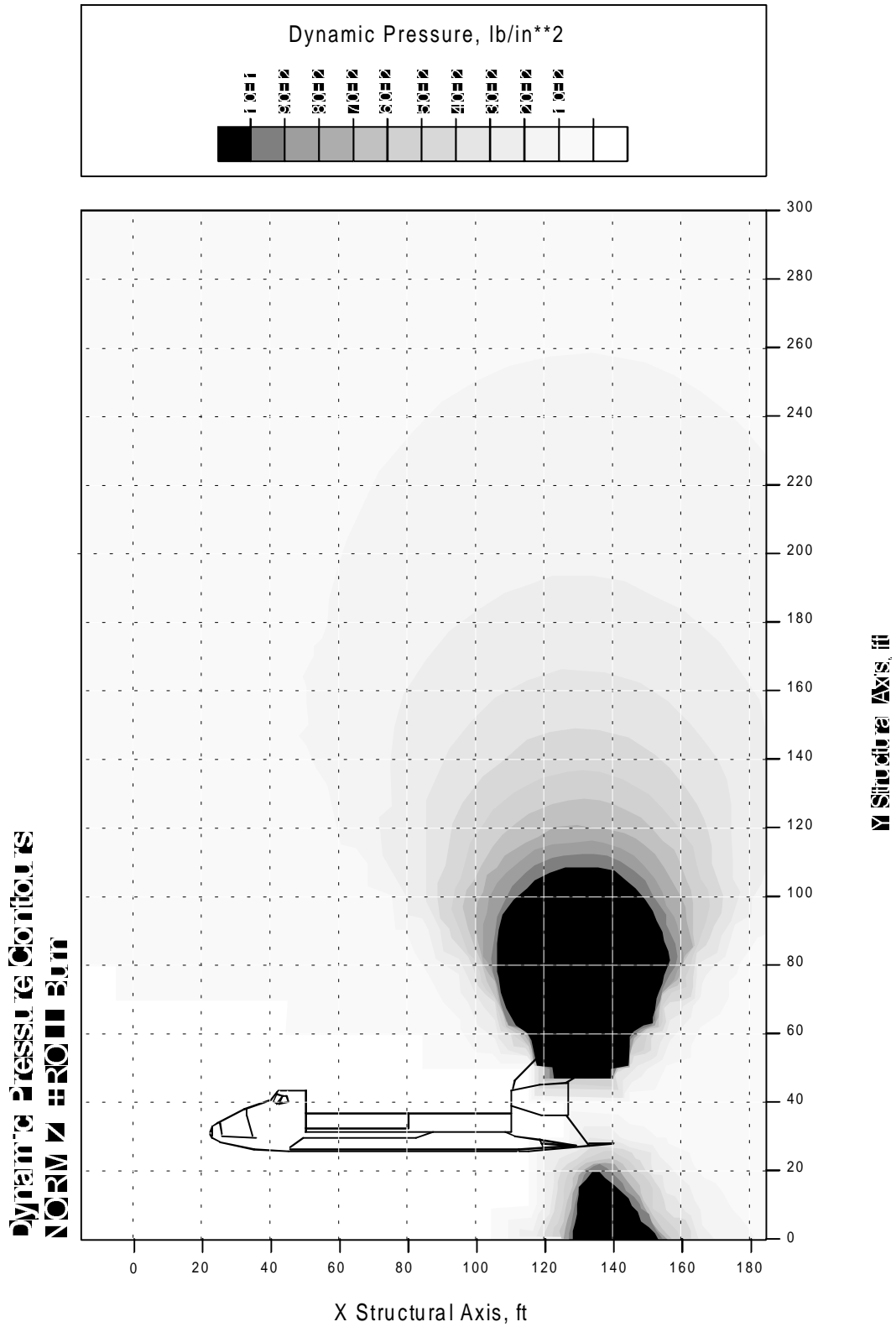


Figure 7.3-9 NORM Z \pm Roll Rotation (10^{-1})

7.4 Jettison

PURPOSE

To specify the actions of the Rendezvous GPO team during a contingency jettison.

PROCEDURE

Assessment

Assess planned jettison time to ensure:

- Sufficient time to reach attitude
- Jettison will occur during sunlight
- In AOS, if possible

Attitude

Ensure Orbiter is in proper jettison attitude (+Z VV, -X LV):

TGT ID	+2
BODY VECT	+2
OM	+0

BACKGROUND

Jettison procedures exist for the RMS (PDRS/ALL p6-50), the Ku-band antenna (ORBIT OPS/ALL p2-18), and the IPS (Instrument Pointing System, a GNC book), and, although systems functions are the responsibility of respective systems FCs, the dynamics of vehicle flying are the responsibility of the Rendezvous GPO (if on console) or the FDO (if not RNDZ phase).

7.5 Degraded +X RCS Prox Ops

PURPOSE

To document the procedures for performing Prox Ops with combinations of jet failures resulting in the loss of both +X jets in one of the aft pods.

PROCEDURE

In the context of degraded +X burns, the following terminology is used:

- Loss of LEFT POD results from loss of RCS jets L1A and L3A;
- Loss of RIGHT POD results from loss of RCS jets R1A and R3A.

Loss of Right Pod (Group 7) or Left Pod (Group 8) +X Jets

If LEFT or RIGHT POD +X jets are down:

- Impacts to flight control:
 - Degraded +X translation.
 - All +X inputs need to be doubled to achieve the desired +X translation.
 - Ydot will result from roll and yaw axis cross-coupling induced during +X translations. -Ydot (body sense) will occur from loss of the left pod and +Ydot will occur for loss of the right pod. The magnitude of Ydot is similar for NORMZ vs. LOWZ and for PRI vs. VERN, but is much more pronounced in TAIL-ONLY than in NOSE+TAIL control. For example, there is a 5-10% coupling of X into Y for NOSE+TAIL, but a 30-35% coupling of X into Y for TAIL-ONLY. The largest single step that can be taken to reduce the Ydot effect is to transition to NOSE+TAIL control. This is true even if VERN is selected since the PRCS jets can fire while the THC is deflected.
 - Control of the induced Ydot while in LOW Z will lead to a closing rate.
 - The asymmetric jet configuration will lead to increased deadbanding and associated perceived lateral rates in the COAS or centerline camera. The deadband motion should be checked before making manual inputs based on these visual cues.
 - There is little difference between PRI and VERN, although larger burns should be performed in PRI as usual.

- Degraded LOW Z braking capability.
 - -X translation will occur during LOW Z +Z braking pulses, which will require additional +X translation commands to offset the motion. For example, as many as 10 +X pulses would be required to balance out the -X motion from a 0.05 ft/sec translation. As with degraded +X translations, some Ydot will develop from the +X translations. Control of this Ydot will completely nullify LOWZ braking while in TAIL-only, and will severely degrade the capability while in NOSE+TAIL control (maybe 20% effective).
- Impacts to TORVA and Vbar Approach
 - Modify DAP A9/B9 to NOSE+TAIL control prior to TORVA start. Maintain NOSE+TAIL control until A10/B10 is selected at 75 ft.
 - The TORVA initiation should be performed in PRI as usual, but the number of +X pulses must be doubled. Expect to have about 0.1 fps Ydot to control immediately after the TORVA start. Control of the Ydot could increase Rdot slightly, so consider being conservative on Rdot management.
 - Management of Rdot during the Vbar approach should be conservative (similar to a VERN-fail case).
 - NORMZ corridor operations and achieving docking contact conditions are not difficult with degraded +X jets.
- Impacts to Vbar Breakout and Shuttle Nose-In-Plane Breakout
 - The A9/B9 DAP should be modified to PRI NOSE+TAIL control to minimize Y-axis coupling from +X burns.
 - The THC deflection time must be doubled to achieve the specified +X breakout burn delta V.
 - Do not attempt to null Ydot in either breakout because the out-of-plane translation gives even safer relative motion.

BACKGROUND

If a single +X jet is failed, there are many single additional failures that can result in loss of the other +X jet in that pod. The Rndz team should provide a plan of action for the next worst failure.

7.6 Grappling a Rotating Payload

PURPOSE

To specify procedures, guidelines, and techniques for grappling a rotating payload.

PROCEDURE

Track-and-Capture Grapple from a Non-rotating Orbiter

- Configure Aft Station for proximity operations.
- Assess rates and stability of payload rotation.
- Discuss options with MCC (grapple now vs. future EVA capture vs. other options).
- If required, flyaround to an attitude that supports grapple (NOTE: Limit Orbiter rotation rate during flyaround to 0.5 deg/sec maximum in a single axis).
- Return to LVLH or INRTL hold and null translational motion.
- Attempt track-and-capture grapple with RMS.

Note: Rate matching is not recommended as a primary technique. See comments in the BACKGROUND section, below.

Track-and-Capture Technique Guidelines

If the attitude of the payload **CAN** be predicted accurately 3 to 10 minutes in the future (i.e., the rotation is small and stable about 1 or 2 axes), discuss above procedures with the crew and MCC, and above all else, do not hurry. Estimated Prop use: < 100 lbs of propellant (50 fwd and 50 aft). (Because the attitude can be accurately predicted, the Orbiter should be able get to the proper attitude by performing no more than two 90-degree attitude maneuvers.)

If the attitude of the payload **CANNOT** be predicted accurately 3 to 10 minutes in the future, the best technique may be to keep it stable and wait for the grapple fixture to rotate into the grapple envelope. Since by definition it is hard to predict the attitude in this case, it is important to minimize the time between beginning an attitude maneuver and going in for grapple. To accomplish this the pilot should be aggressive in performing the rotation and translation required to set up the grapple. Estimated propellant usage can be excessive and very hard to predict, and could range from 100 to 500 lbs **plus**. (Over 1200 lbs of prop was used attempting to match rates on STS-87.)

BACKGROUND

Why use the track-and-capture technique instead of match rates?

1. Rotating the Orbiter to match rates makes the grapple task harder--in many cases much harder.
 - Rotating the Orbiter to match the payload rotation creates relative translation. If the rates are matched, the relative attitude will stay in an acceptable envelope for grapple for a longer period of time, but the relative position will quickly move out of an acceptable range. The faster the rotation the quicker this will happen.
 - Performing a track-and-capture from a non-rotating Orbiter allows translation rates to be nulled, but by definition, creates relative rotation. The position will stay in the acceptable grapple envelope for a long period of time, but the payload will quickly rotate out of the grapple envelope.
 - SES runs with MOD and CB personnel have shown that grapple is more easily accomplished by nulling translation and accepting the corresponding high rotation rates.
2. Matching rates is typically much more propellant expensive than track-and-capture.
3. Matching rates increases the risk of losing the payload out of the stationkeeping box and potentially pluming the payload or creating relative motion problems, because translation is more dynamic.

Should a Matched-Rates Flyaround technique ever be considered?

The only cases the team has identified that an Orbiter matched-rates flyaround of a rotating payload may be required are:

- if the payload is so big that rotation is required to reduce contact concerns, or
- to reduce RMS loads during capture by rotating to reduce relative rates.

In these cases rotating will probably make it harder to grapple, but may be necessary.

If a matched-rates rotation is required, the team strongly recommends rotating about Orbiter body yaw. The team also recommends that the RMS be moved as far aft as possible to reduce the cross-coupling of rotation into translation. However, other factors such proximity to RMS reach limits and position of keel cameras must also be taken into account when deciding on the final RMS position.

Why limit the Orbiter rotation rate during a flyaround to 0.5 deg/sec in a single axis?

If an Orbiter flyaround of a rotating payload is required, limit rotation rates to no more than 0.5 deg/sec and 1 axis at a time. This applies equally to flyarounds from one LVLH/INRTL attitude to another and to matched-rates flyarounds. Rotating above 0.5 can lead to safety problems. The main concerns are:

1. re-contact with the RMS upon termination of body minus roll and body minus yaw flyarounds, and

2. body minus pitch flyarounds getting out of control during the flyaround due to the very strong cross-coupling of body minus pitch rotation and minus X translation.

If attitude CAN be accurately predicted 3 to 10 minutes into the future...

At rotation rates up to 1.0 deg/sec the grapple can be successfully completed 90+% of the time. At rates up to 2.0 deg/sec the grapple can be successfully completed 25% - 50% of the time. Above 2.0 deg/sec the success rate goes down very rapidly.

No safety limits have been identified such that grapple should not be attempted if payload rates exceed x deg/sec. It is possible to damage the RMS by exceeding load limits during capture; however, RMS analysis has shown that load limits are not exceeded when attempting to grapple a Spartan type payload at rates well above 2.0 deg/sec.

If attitude CANNOT be accurately predicted 3 to 10 minutes into the future...

Typically this means the payload is in an unstable rotation.

Rotation rates as low as 0.3 to 0.4 deg/sec can be very difficult to grapple.

No safety limits have been identified such that grapple should not be attempted if payload rates exceed x deg/sec. It is possible to damage the RMS by exceeding load limits during capture; however, RMS analysis has shown that load limits are not exceeded when attempting to grapple a Spartan type payload at rates well above 2.0 deg/sec.

Miscellaneous Lessons Learned from STS-87

RMS/Stationkeeping position should be selected to optimize stationkeeping cues (such as keel cameras), grapple cues (grapple pin 90 degrees to RMS operators line of sight) and minimize reach limits and plume concerns.

RMS operator should ask the CDR to bias the payload stationkeeping position to help use the entire grapple window. After the CDR gives goes to free drift the RMS operator can pre-condition the RMS attitude to use entire grapple window.

7.7 Twice Orbital Rate Vbar Approach

PURPOSE

To describe the operation and dynamics involved with the Twice Orbital Rate Vbar Approach (TORVA).

PROCEDURE

The procedures on the VBAR APPROACH cue card in the Rendezvous Checklist should be followed closely. Being a large tabular cue card, the crew should follow the steps in each row from left to right. That typically results in DAP changes being made before jet firings or Universal Pointing Inputs.

The TORVA is started on the 600 ft line of the VBAR APPROACH cue card. The procedure calls for the crew to:

- Select DAP A9/B9 at 600 ft and a closing rate of -0.8 fps.
- Change the Universal Pointing pitch setting to 179° , which corresponds to the Vbar attitude, taking into account the 1° ODS pressurization bias when no extended tunnel is in place.
- Enter an ITEM 19 to actually kick off the maneuver.
- Input approximately 22 +X pulses ("ups") to null target motion in the centerline camera.
- Maintain the target in the centerline camera until Vbar arrival.
- End the TORVA with several -X pulses ("downs") at the appropriate time on or near the Vbar.

In failed VERN cases:

With VERNs down, the crew will probably want to bias their TORVA to end up farther away than normal on the Vbar, to protect for increased closure rate induced by attitude control on the PRI jets. The crew would bias their TORVA in this manner by performing fewer +X pulses and by possibly initiating the TORVA at a slightly slower closing rate.

In the event of GPC failures during the TORVA:

Regaining attitude control and maneuvering to the Vbar attitude is first priority. Don't waste time talking around the room about which stringing to load. Simply restring to all one GPC and continue to the Vbar where stationkeeping should be started. The restringing can be done while stable on the Vbar, where no time constraints are on the crew. This also gives the flight control team time to ensure all systems are "go" for approach.

BACKGROUND

For ISS flights 5A.1 and subsequent, the Orbiter has been using a TORVA approach as shown in Figure 7.7-1. At the end of the terminal phase, the Orbiter is at 600 ft with a closing rate of 0.8 ft/s. After the pilot nulls the target motion in the COAS, the TORVA is initiated by an AUTO maneuver to an LVLH attitude of $\text{PYR} = 90, 0, 0$ and by performing approximately twenty-two 0.05 ft/s pulses to null target motion in centerline camera. Few Orbiter $\pm X$ burns should be required to maintain the ISS within the COAS as the Orbiter begins a coasting trajectory toward the +Vbar. Due to the outward acceleration from the twice orbital rate flyaround mechanics, the range rate will slow down quickly but should not be allowed to begin opening. The maneuver will be completed as the Orbiter reaches the +Vbar and begins to hold LVLH attitude. The pilot will have to perform a number of Orbiter -X burns to null the apparent motion of the ISS in the COAS that will result. The Orbiter should reach the +Vbar at an interface-to-interface range of 310 ft in the nominal case. The pilot then initiates a closing rate of 0.2 ft/s. The requirement for the pilot to maintain an 8° corridor from 250 ft to 30 ft also applies to the +Vbar final approach.

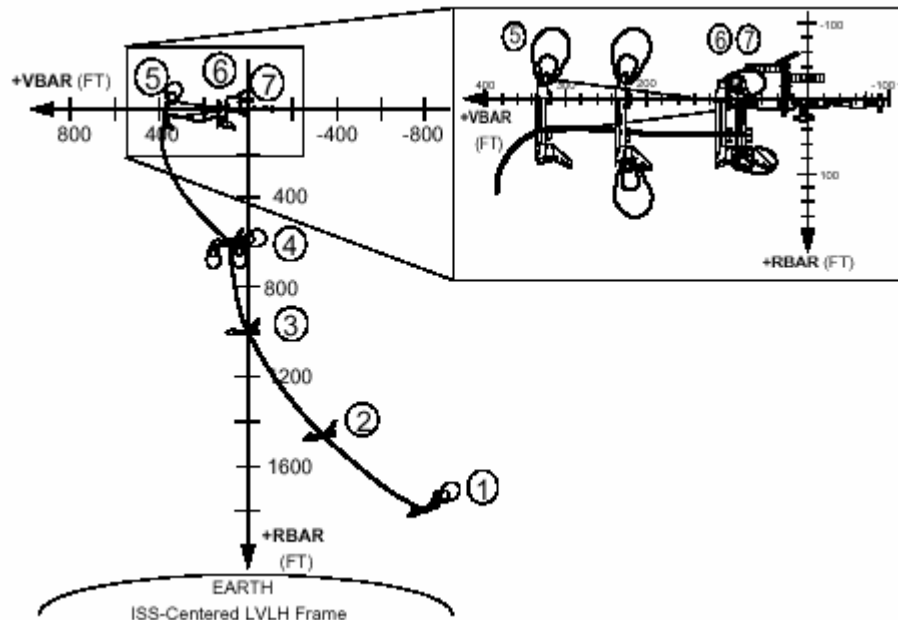


Figure 7.7-1 TORVA and Vbar Approach Trajectory

At 100 ft, the pilot will reduce the closing rate to 0.15 ft/s. At 75 ft, the pilot will mode the DAP to NORM Z, switch to A10/B10, and configure the approach for single -X jet (deselect F1F and F2F) to reduce loads on the radiator that is extended out over the Orbiter nose. Jet F2F was originally selected because the relative geometry between the Orbiter and ISS placed it the furthest jet away from the ISS, but an agreement was made to use F3F to reduce cross-coupling.

At 30 ± 5 ft, the pilot will brake to null the closing rate and will stationkeep to perform an angular alignment maneuver if necessary. From 25 ft to docking, the procedure is identical to the +Rbar final approach. Since the +Vbar does not offer the deceleration effect experienced on the $\pm Rbar$, the approach dynamics will differ. During the +Rbar final approach, very little or no braking is required. During the +Vbar approach, however, braking burns will be required to slow the closing rate. Thus, the +Vbar approach will use more propellant due to the LOW Z braking burns required, and will result in more plume impingement from the NORM Z braking burns inside 75 ft.

7.8 Twice Orbit Rate Flyaround

PURPOSE

To specify procedures and techniques for performing a twice orbit rate flyaround (TORF).

PROCEDURE

Earth Track Method

This method uses the UNIV PTG TRACK option and a specific value of the ROT RATE to achieve the maneuver. The Orbiter Body Vector is changed prior to maneuver completion to keep the flyaround in progress.

- Set DAP PRI ROT RATE and VERN ROT RATE to 0.13 deg/s.
- Change UNIV PTG Body Vector once every quarter of the flyaround, anytime UNIV PTG ERROR is less than 180 degrees and greater than the ATT DB limit.
- Select DAP: AUTO and translate to keep target in field-of-view.
- Manage range rate near zero.

UNIV PTG ROT Method

This method uses the UNIV PTG ROT option to spin the Orbiter about an inertially fixed vector. The ROT rate in combination with LVLH-to-inertial rate yields an effective rate of twice orbit rate with respect to LVLH during the flyaround.

- Set DAP PRI ROT RATE and VERN ROT RATE to +0.065 deg/s.
- Change UNIV PTG Body Vector to the appropriate rotation axis (+Y for Nose Forward, -Y for Tail Forward).
- Select the ROT option on UNIV PTG.
- Select DAP: AUTO and translate to keep target in field-of-view.
- Manage range rate near zero.

THC Strategy

One can optimize the THC inputs needed to maintain a TORF by using the following rule-of-thumb strategy. Actual inputs should be made on the basis of observed values (field-of-view lateral position, range rate), but can be optimized using the following information.

- $-Z$ (in) burns reach a maximum near $\pm R_{bar}$ and decrease towards $\pm V_{bar}$.
- No $-Z$ (in) burns are required near $\pm V_{bar}$, and are in fact discouraged.
- $\pm X$ burns reach a maximum at the halfway points between the bar crossings.
- No $\pm X$ burns are required near any of the bar crossings.

- “Speed up” burns are required in the +Rbar to +Vbar (“lower left”) quadrant and the –Rbar to –Vbar (“upper right”) quadrant.
- “Slow down” burns are required in the other two quadrants (“upper left” and “lower right”).

BACKGROUND

Idealized TORF in LVLH coordinates

Motion constrained to the same area of the XZ LVLH plane exhibits a “football”-shaped trajectory in the absence of any course corrections. Part of this trajectory is a natural tendency of the transverse velocity to vary with distance. Assuming a constant rotation rate, by making inputs to keep the transverse velocity a constant, the range must remain constant. The trick is to decide how best to make the delta-velocity inputs. The optimal inputs for a TORF follow from examination of the Clohessy-Wiltshire (CW) equations for relative motion:

$$a_x(t) = \ddot{X} - 2\omega \dot{X} \quad \text{Equation 7.8-1}$$

$$a_z(t) = \ddot{Z} + 2\omega \dot{X} - 3\omega^2 z \quad \text{Equation 7.8-2}$$

By constraining the motion to a circle with constant range and constant twice orbit rate transverse velocity,

$$\dot{X} = +2\omega z \quad \text{Equation 7.8-3}$$

$$\dot{Z} = -2\omega x \quad \text{Equation 7.8-4}$$

and thus the ΔV inputs required to meet these constraints are:

$$a_x(t) = 0 \quad \text{Equation 7.8-5}$$

$$a_z(t) = -3\omega^2 z \quad \text{Equation 7.8-6}$$

The interpretation of these results is shown below.

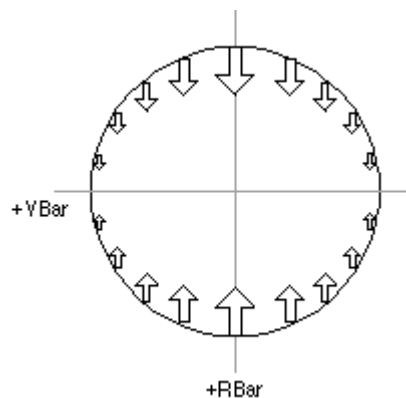


Figure 7.8.1 Idealized TORF in LVLH Coordinates

- All corrections are made in the Z-LVLH direction, pushing towards the Vbar (i.e., DVz is negative if Z is positive, and vice-versa).
- Instantaneous Z-LVLH burn magnitude is proportional to distance from the Vbar.

- No corrections are required in the X-LVLH direction.

Note: In the absence of any additional inputs, the resulting motion is “football-shaped,” with the size and location of the football dependent on the point at which inputs are discontinued.

Idealized TORF in Body Coordinates

Since the Orbiter performs a TORF by pointing the $-Z$ Body axis towards the center, the above LVLH-based inputs could be transformed to body coordinates to determine body VGOs. Alternatively, one can examine this scenario by using the polar-cylindrical form of the CW equations,

$$a_{\rho}(t) = \ddot{\rho} - \rho \dot{\theta}^2 - 2\omega\rho\dot{\theta} - 3\omega^2\rho \sin^2 \theta \quad \text{Equation 7.8-7}$$

$$a_{\theta}(t) = \rho \ddot{\theta} + 2\dot{\rho}\dot{\theta} + 2\omega\dot{\rho} - 3\omega^2\rho \cos\theta \sin\theta \quad \text{Equation 7.8-8}$$

subject to the same constant range and constant transverse velocity constraints as before, only expressed in polar form:

$$\rho = R \quad \text{Equation 7.8-9}$$

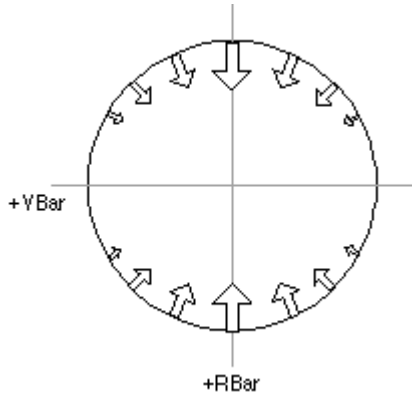
$$\dot{\theta} = -2\omega \quad \text{Equation 7.8-10}$$

This results in the following required Δ velocity inputs:

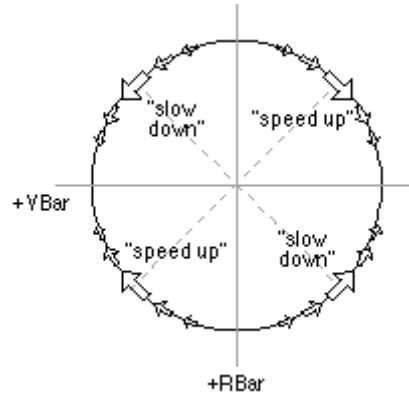
$$a_{\rho}(t) = -3\omega^2 R \sin^2 \theta \quad \text{Equation 7.8-11}$$

$$a_{\theta}(t) = -3\omega^2 R \cos\theta \sin\theta \quad \text{Equation 7.8-12}$$

If we assume the Orbiter performs the flyaround with the $-Z$ Body axis directed towards the center, we can assign the Orbiter Z Body axis to the radial direction and the Orbiter X Body axis to the tangential direction. From this, one can conclude the following (ignoring Orbiter translational cross-coupling):



All VGO Z inputs are made in the $-Z$ Body direction, pushing towards the center.
No $+Z$ Body inputs are required.
Maximum $-Z$ inputs occur at $\pm Rbar$ crossings.
No $-Z$ inputs are required near $\pm Vbar$ crossings.
The total VGO Z required is twice the total VGO X required.



Maximum VGO X inputs occur at the 4 quadrature points of the flyaround.
No VGO X inputs are required at the 4 $Vbar/Rbar$ crossings.
Speed-up ($+X$ Body for Nose Forward) inputs are required in the lower left and upper right quadrants.
Slow-down ($-X$ Body for Nose Forward) inputs are required in the upper left and lower right quadrants.
The total VGO X required is one-half the total VGO Z required.

Figure 7.8.2 Idealized TORF in Body Coordinates, VGO Z and VGO X, Respectively

From the original radial equation (Eq. 7.8-7), note the following interesting fact about the flyaround rate. If one considers a general flyaround rate of n times orbit rate,

$$a_{\rho}(t) = (-n^2 + 2n)\omega^2 R - 3\omega^2 R \sin^2 \theta \quad \text{Equation 7.8-13}$$

the leading term cancels out only when $n = 2$. If the flyaround rate is slower than twice orbit rate (i.e., $n < 2$ in the above equation), the leading term is positive. Thus, it follows that braking is required whenever the first term exceeds the second term in magnitude. This occurs at the points of the flyaround close to the $\pm Vbar$ (i.e., when θ is approximately equal to 0 or 180). If the flyaround rate is faster than twice orbit rate (i.e., $n > 2$), the leading term is negative. This implies that a constant inward thrust during all points of the flyaround is required. Although this flyaround is quicker and avoids braking inputs, it requires more propellant to execute than the twice orbit rate flyaround.

7.9 Low β Angle TORVA Lighting

PURPOSE

Provide direction for alleviating lighting problems on TORVA flights with a low beta angle. When executing a rendezvous and TORVA on a flight with a low Beta angle ($\sim < 15$ deg), the standard Ti TIG at Sunset – 28 typically puts TORVA init near noon. This places the sun directly behind the target, making visual confirmation of TORVA initial conditions difficult to impossible.

PROCEDURE

Note:

This procedure is only valid for targets with active light sources (like ISS) because it will likely result in the radar failed correction being executed in darkness.

1. Move Ti TIG earlier to Sunset – 38.5 minutes. FDO should be notified pre-launch.
2. In case the radar fails and post-Ti day star tracker is not available:

- o Delay the intermediate MC2 targeting (usually at 35 min PET):

PLT When NAV converged (SV UPDATES small and stable):
 TARGET MC 2 BURN [18A] (Intermediate)

To 44 min PET (this is nominal MC2 TIG – 6 minutes, but keep it fixed on PET):

PLT TARGET MC 2 BURN [18A] (Intermediate)

- o Closely monitor MC2 TIG slip as night star tracker is incorporated into Nav.
- o Delete the END STAR TRACKER NAV callout at MC2 - 6 min
- o Modify the Post MC2 starred blocks to look like this:

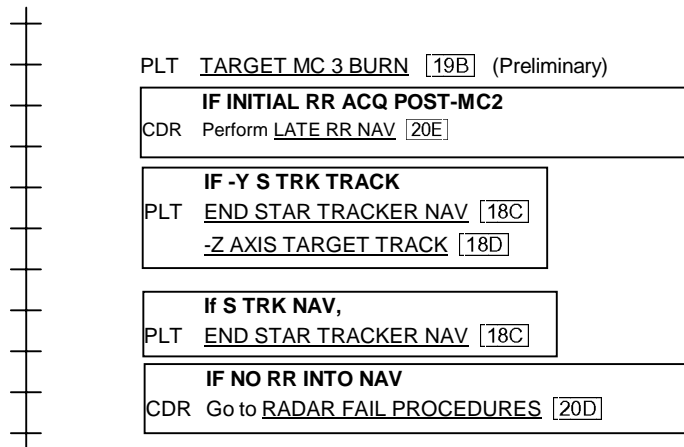


Figure 7.9-1 Low β Angle Timeline Changes

BACKGROUND

Moving Ti TIG to sunset – 38.5 should allow up to 7 minute MC2 TIG slip, and TORVA initiation as close as 525 ft while maintaining the sun >15 deg from camera centerline. One thing that is not protected is being slower than the braking gates from 2000 ft to TORVA init. The sun will cross through the centerline camera field of view on the Vbar between 200 and 150 ft.

Impacts to Radar Failed Procedures

Radar Failed Manual correction at MC2+19 will be dark unless MC2 slips more than +5 min late (see Note above). Since the shuttle crew executes the RF correction based on visual elevation, they need to see the target. If the ISS is in LVLH 0, 0, 0 attitude, the SM tracking light will be visible to the shuttle crew. If the ISS is not in that attitude, one of the SM solar array tip lights will be visible. It is also likely that TCS will have acquired. It is recommended that the HHL with the night scope be used.

Latest breakout time at MC2+24 will be dark unless MC2 slips more than 1 min late. If the shuttle crew has not yet acquired the target visually or with a range sensor, the breakout should be executed. Again, if the ISS is in LVLH 0, 0, 0 attitude, the SM tracking light will be visible to the shuttle crew. If the ISS is not in that attitude, one of the SM solar array tip lights will be visible. It is also likely that TCS will have acquired. It is recommended that the HHL with the night scope be used.

Will get less than 8 min darkness pre MC2 for night star tracker if MC2 slips more than 1 min early. If daytime star tracker is available post-Ti, this is no impact. But since day star tracker is not guaranteed (it would not have been available on STS-98), this is a concern. Allowing for 1 min of initial data evaluation and going to OPS 202 at 3 minutes before a 3 minute early MC2, that leaves 4 minutes of data, which should yield 30 marks. Not quite the historical 40 mark requirement, but given that state vector errors will have been propagating for an orbit (the previous sunset), you should see a pretty good elevation residual and pick up lots of downtrack quickly. Delaying the end of the post-Ti night star tracker pass until about 1 hour PET (post MC2) will help finish cleaning up the nav state and support MC3 targeting.

Final MC2 TIG could move significantly early and surprise people. If radar is failed and no post-Ti day star tracker is available, the preliminary and intermediate MC2 TIGs would be based on the pre-Ti star tracker pass and sensed accelerations through NCC, Ti, and MC1. There is enough error that, the preliminary solution could show an MC2 TIG near the 7 min late limit, and then large updates from nighttime star tracker could move the final MC2 TIG to the early limit and catch the crew and MCC by surprise. Moving the intermediate MC2 targeting to nominal MC2 TIG – 6 minutes puts it late enough to be based on some night star tracker data, while allowing MC2 to slip to the 3 min early limit and still have 3 minutes to get ready to execute the burn. In order to closely monitor the MC2 TIG slip as night star tracker data is incorporated, have NavCon running and configured to target of the FLTR, and call up the DAP_ORB_TGT ROSS Alarm on the same workstation. NavCon calculates its own MC2 TIG and compares it to the latest onboard TIG. The **difference** in TIGs is displayed in upper right hand cell of the DAP_ORB_TGT ROSS Alarm (see appendix B).

7.10 Standardized Approach Calls

PURPOSE

Provide direction for making standardized callouts to the flight control team at the initiation of final approach, 20, 10, and 5 feet.

PROCEDURE

As shown in the examples below, the Rendezvous Officer will make the following calls to the Flight Director at the initiation of final approach (near 30 feet), 20, 10 and 5 feet:

- A reading of the range at the time of the call.
- An evaluation of the range rate. If the rate is within acceptable values (as reflected in the crew procedure), "good rate." If the rate is faster or slower than acceptable values, the delta between the current rate and the acceptable rate will be called to Flight.

Table 7.10-1 Examples of Standardized Approach Calls

Range	"Good" Rdot Values	Actual Range Rate	Call to Flight Director
Initiation of final approach	-0.05 to -0.09	-0.09	"28 feet, good rate."
20 feet	-0.05 to -0.13	-0.14	"20 feet, a hundredth fast."
10 feet	-0.07 to -0.13	-0.06	"10 feet, a hundredth slow."
5 feet	-0.07 to -0.13	-0.13	"5 feet, good rate."

These calls will be made quickly and concisely to avoid distracting the flight control team from docking activities. As always, discussion about failures or anomalous rates can override these calls.

BACKGROUND

In response to high contact rate experienced on STS-112, the Rendezvous community suggested, among other things, the standardization of status calls to the Flight Director at regular intervals inside of 30 feet, to increase situational awareness. It would then be up to the individual Flight Director and flight crew to decide whether they'd like to have those calls read up during real-time docking operations. The Orbit Flight Techniques Panel accepted this proposal on April 25, 2003.

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8.1 RPOP Operations

PURPOSE

To provide details for using non-standard options within the Rendezvous and Proximity Operations Program (RPOP) covering:

- Radar Bias Inputs
- CCTV Tilt Bias Inputs

and to provide constraints for selecting the COM port configuration within RPOP.

PROCEDURE

Radar Bias Inputs

- Exit RPOP (SHIFT-F10)
- Use Notepad to edit the appropriate RPOP I-load file, (for example `tailfwd.ild`). To determine the directory in which the `.ild` file resides, right click `Properties>Shortcut` for the appropriate Win95 RPOP shortcut and look for the `start in` directory.
- Use the arrow keys to scroll through the file. Look for the radar range bias lines:

```
:= Rendezvous Radar Range Bias (ft)
;=====
Bias=0
```

- Enter the radar range bias in feet by replacing the zero on the second line. The sign convention is such that

$$\text{true range} + \text{radar range bias} = \text{measured radar range}$$

- Example 1: Radar reads 1000 ft. The true range is 750 feet. Therefore, the bias to enter is 250.
- Example 2: Radar reads 1000 ft. The true range is 1250 feet. Therefore, the bias to enter is -250.
- Save the change and exit Notepad.
- Verify that the Iload change has been made on all RPOP PGSCs.
- Run RPOP and confirm the radar range bias under `File>Flight` data.

CCTV Tilt Bias Inputs

NOTE: Since CCTV tilt biases are known to change any time the unit is tilted to a different position, the RPOP tilt bias function is not very useful in compensating for errors. Use of the bias to compensate for readout errors is not recommended unless the CCTV will not be moved.

The tilt bias can be used for creative workarounds to unique problems if the following convention is understood. The Tilt bias is entered as the CCTV tilt digital readout when the CCTV has been verified to be pointing along the -Z axis. One method of verifying a true 90 degree tilt would be to point the -Z axis at some celestial object and tweak the tilt until centered (remember that any subsequent adjustments could change the bias).

Use the following steps to change the bias in the RPOP I-load file.

- Use Notepad to edit the appropriate RPOP I-load file (for example tailfwd.ild). To determine the directory in which the .ild file resides, right click Properties>Shortcut for the appropriate Win95 RPOP shortcut and look for the "Start in" directory.
- Use the arrow keys to scroll through the file. Look for the CCTV tilt bias lines:

```
=====
;= Forward CCTV tilt readout when true tilt is 90 degrees
;=====
Forward Scale=90

;=====
;= Aft CCTV tilt readout when true tilt is 90 degrees
;=====
Aft Scale=90
```

- Enter the biased tilt value for the appropriate camera.
- Save the change and exit Notepad.
- Verify that the Iload change has been made on all RPOP PGSCs.
- Run RPOP and confirm the CCTV tilt biases under **File>Flight** data.

RPOP and TCS COMM Port Configuration

The PGSC comm ports and dynamic link library (DLL) must be configured properly to read HHL, PCMMU (PCDecom), and TCS data. Both RPOP and TCS CAD are I-loaded with the nominal port config. The following rules apply for any nominal or off-nominal cable or port config:

- TCS CAD software "controls" the comm port connected to the TCS PDIP data cable
- RPOP software "controls" the comm port connected to the PCDecom data cable
- RPOP software "controls" the comm port connected to the HHL data cable
- RPOP and TCS CAD share data internally via the DLL

- COM4 is occupied by the PCDecom Bit-sync card and is always connected directly to the PCMMU
- COM4 and the port connected to TCS are always selected as NONE in the RPOP comm port config window

An example for the standard Rndz Tools cable config (COM1=HHL, COM2=TCS, COM3=PCMMU) is as follows:

- In TCS CAD, Select COM2 under Config>Com Port...
- In RPOP, Select Config[cntrl-F10]>Comm Ports... to bring up the comm port config window. Select the following:

COM1 - HHL
COM2 - None
COM3 - PCMMU
COM4 - None
DLL - TCS

The RGPO should be aware that the comm port and software configs for the ICDS lab, SES, MPSR, and sometimes SMS are not necessarily as stated above. For example, ICDS sends TCS data directly to RPOP via a comm port without passing through TCS CAD. It is possible that a crew may have trained on the ground at some point with software or hardware that did not follow all the rules listed above.

BACKGROUND

RPOP is a Payload and General Support Computer (PGSC) application used on-orbit for situational awareness and navigation during rendezvous and proximity operations. Certain capabilities not documented in the FDF exist within the software for contingency scenarios, specifically that RPOP has the ability to use a radar range bias and CCTV tilt biases to automatically compute and display the "true" relative range between the Orbiter and target when inputting marks.

8.2 Hand-Held Lidar Operations

PURPOSE

To provide operations information and specifications on the LTI hand-held lidar (HHL). Lidar stands for light detection and ranging.

PROCEDURE

The HHL is used by the crew to provide estimates of range and range rate to a target.

HHL Overview

The HHL is referred to as NSRV1-OH by the manufacturer (LTI - Laser Technology Inc.)

The HHL uses an infrared semiconductor laser diode and is a pulse laser.

The HHL uses a least squares analysis to find the best-fit line of the range measurements and takes the slope of this line to determine the average velocity of the target during the measurement period.

The HHL is not affected by diffraction and re-radiation; therefore, it does not bend around corners or experience strong returns due to secondary reflections off unwanted targets

The HHL is immune to interference or errors caused by rotating or moving objects.

Normal System Operation

The HHL enters a self-test mode upon powering on (issues three mid-frequency beeps followed by the display going from "8.8.8.8" to "- - -", followed by a high tone). An error message will be displayed if the HHL fails its self test.

The HHL defaults to measurement mode with the distance displayed in whole feet.

The trigger on the HHL can be held continuously while attempting to acquire a target. A low tone is issued during this period. When the HHL locks onto a target, the low tone stops -- this signifies that a measurement has begun. The measurement period is variable -- between 0.5 and 5.0 seconds -- depending upon the length of time the trigger is held. A short tone will sound at the completion of the measurement.

Velocity and range are calculated with every measurement and represent the average position and velocity of the target during the measurement period.

In tenths mode, the maximum displayable number is 999.9; in whole units mode, the maximum displayable number is 9999. Numbers greater than either will result in the message "doF" (display overflow).

The Velocity button toggles the display between tenths and hundredths of fps with leading zeros blanked and the leftmost digit showing the sign of the speed.

If the range is increasing during the measurement, the velocity is positive and the leftmost digit is blanked. If the range is decreasing the velocity is negative and the minus sign is displayed.

Test Mode

If the Test Mode button is pressed and immediately released, the HHL will enter test tone mode and "tt" will be displayed. The HHL will emit an audible tone when the trigger is depressed. The pitch of the tone will change when the HHL acquires a target. This mode is handy for verifying scope alignment.

If the Test Mode button is held for approximately half a second, the power-up display test is initiated. All LED display segments will be lighted. If any segment of the display is not functioning properly, a flaw will be evident in one of the fields.

If the Test Mode button is held for approximately 5 seconds, a software verification code will be displayed.

To exit the test mode, press either the Range or Velocity button.

Trapping of Erroneous Readings/Error Messages

The data from each individual laser pulse must pass certain tests to ensure its quality before it is included in the aggregate data set.

Of the total number of pulses used for a given measurement, a certain percentage must pass these initial raw data integrity tests before any other calculations are performed.

In addition to the overall performance test, a limit has been placed on the maximum number of consecutive "bad" pulses.

Table 8.2-1 HHL System Error Codes

E50	Internal self-calibration error 1
E51	Internal self-calibration error 2
E52	Instrument temperature too low
E53	Instrument temperature too high
E60	Program checksum mismatch. Unauthorized changing of instrument program IC.
E61	External EEPROM checksum mismatch error 1
E62	External EEPROM checksum mismatch error 2
E63	External RAM test failure

Table 8.2-2 HHL Measurement Error Codes

E01	Never acquired a target because the target was out of range or the target was too close
E02	An excessive percentage of the total laser pulses in the measurement sample was unsatisfactory
E03	An excessive number of consecutive laser pulses in the measurement sample was unsatisfactory

Scope Alignment

Scope alignment is set at the factory. The only reason the scope might ever go out of alignment would be from a heavy blow.

Scope Filter

The scope filter is a ring located at the end of the scope. By turning the filter clockwise the brightness and contrast can be adjusted for changes in lighting conditions.

The laser should never be aimed directly into the sun. Direct sun exposure in excess of 1 second may damage the laser diode.

Fixed Distance Tests

Range measurements are referenced to the approximate center of the HHL.

Standard Maintenance

There are no moving parts or radio frequencies to go out of alignment. The design of the HHL is capable of withstanding rough treatment and extreme environments (i.e., almost astronaut-proof).

Serial Port Operation

The serial bit stream is configured to the following format: 9600 baud, 1 start bit, 8 data bits, 1 stop bit, no parity.

There is no data output in the event of a measurement error.

The range and velocity data will be output correctly even if the display shows "doF".

Laser Technology, Inc. (LTI) Specification Sheet

Table 8.2-3 General HHL Specifications

Wavelength	775 nm \pm 10 nm
PRF	150 Hz
Average power	26 μ W \pm 10% at 25 deg C (measured at full aperture - 48.5 mm)

Table 8.2-4 HHL Range Specifications

Minimum	\leq 12 ft
Maximum*	\geq 1500 ft (30% diffuse target) \geq 5000 ft (2.5-inch diameter retroreflector)
Accuracy	\pm 0.5 ft
Display Resolution	0.1 ft

*This is an approximation of the maximum range a target can be detected assuming 60% attenuation through the Orbiter overhead window, round trip.

Table 8.2-5 HHL Range Rate Specifications

Minimum	0 ft/s
Maximum	≥ 10 ft/s
Accuracy	0.5 second average 0.2 ft/s at 1σ 1.0 second average 0.1 ft/s at 1σ 2.0 second average 0.05 ft/s at 1σ 5.0 second average 0.02 ft/s at 1σ
Display Resolution	0.01 ft/s

Table 8.2-6 HHL Power Specifications

Voltage	10.5 Vdc (seven alkaline batteries size "C")
---------	--

Table 8.2-7 HHL Physical Specifications

Size, inches	12.2 high, 8.2 long, 3.5 wide (including handle and sighting scope); 5.1 wide with battery housing
Weight	6.5 lb.

Table 8.2-8 HHL-PGSC Interface Specifications

Connection	Modified RS-232 cable, default to 9600 baud, 8 data bits, no parity, and 1 stop bit.
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8.3 Trajectory Control Sensor (TCS)

OVERVIEW

For detailed specifications, see the TCS systems brief on the GNC web site at <http://mod.jsc.nasa.gov/df/df62/www/files/sb/tcs.pdf>. The TCS Project home page is located at <http://www4.jsc.nasa.gov/eaprojects/ea-projects/flightgfe/tcs/html/tcs.htm>. For additional detail and locations of ISS reflectors, reference the JSC-27240, Rendezvous and Proximity Operations Design Reference (RPODR) for the International Space Station.

The TCS is an Orbiter payload bay mounted laser that provides the crew with relative range, range-rate, bearing and bearing rate data. It is a scan and track device that can operate in either a pulse or a continuous wave mode with a square 20° scan/track field of view.

The TCS is mounted on the side of the Orbiter Docking System (ODS) and its center line is aligned with the orbiter -Z axis. TCS units are mounted to an accuracy of 0.24 inches.

TCS units require passive reflectors on the target vehicle thus the TCS must be positioned so they can adequately see and track these reflectors during proximity operations. The existing reflectors on the ISS PMA were located to accommodate TCS data all the way to docking based on the ODS mounted position of the TCS units.

During orbit operations, the TCS is controlled from a PGSC located in the crew cabin. The raw TCS data is sent to the RPOP PGSC running via the CAD program where it is filtered and displayed as part of the RPOP data.

Generally one TCS unit is carried, however, secondary TCS units can be mounted in off-nominal positions in the cargo bay.

SPECIFICATIONS

Laser Ranges

Both Lasers Operational

Range (ft)	Controlling Laser / Rationale
< 5	No tracking. Continuous Wave (CW) receiver becomes saturated by return signal.
5 to 328	CW laser.
328 to 1312	Both lasers.
1312 to 5000	Pulsed laser. Maximum tested range on the ground was 5825 ft.

CW Laser Only (Pulsed Laser Failed)

Range (ft)	Controlling Laser / Rationale
< 5	No tracking. CW receiver becomes saturated by return signal.
5 to 1312	CW laser. Maximum range tracked in flight was 1232 ft.

Pulsed Laser Only (CW Laser Failed)

Range (ft)	Controlling Laser / Rationale
< 66	No tracking. Pulsed laser is electronically blanked.
66 to 5000	Pulse laser. Maximum tested range on the ground was 5825 ft.

Pulsed Laser To CW Laser Handoff (During Approach)

The normal operational mode for the TCS unit is to acquire the target near a minimum distance of 5000 ft with the pulsed laser. The system will continue to track the retroreflectors exclusively with the pulsed laser until the range is less than 1312 ft. At this distance, the TCS software will begin the process of handing off operational control to the CW laser. This action is preferred due to the better accuracy of the CW laser. The handoff occurs in the background with no intervention by - or indication to - the user. Completion of the handoff must follow a series of tracking performance trials to ensure the CW system can continue to track the retroreflectors without a loss of tracking. This feature is assured by the number of trials that must be successfully completed. The number of trials is a function of the current range. The greater the range the greater the number of successful CW updates that are required. The tracking trials are grouped into sets of two update tests per trial. The following general requirement must be met for a successful handoff:

Range (ft)	Updates Required for CW-to-Pulsed Laser Handoff
1312 to 997	3 sets of 2 updates
997 to 499	2 sets of 2 updates
499 to 66	1 set of 2 updates
< 66	0 sets of 2 updates (immediate handoff)

A counter counts the number of successful trials completed. If a failure occurs, the counter is decremented to a minimum of zero. If a success occurs, it is incremented. When the required number of successes has accrued, the CW ranger begins tracking on the next update, completing the handoff process. If a loss of tracking with the CW laser occurs and the range is less than 328 ft, the TCS system will attempt to reacquire the retroreflector exclusively with the CW laser. If a loss of tracking with the CW laser occurs and the range is greater than 328 ft and less than 1312 ft, the TCS system will attempt to reacquire the retroreflector with the CW laser. If these attempts are unsuccessful, the unit will promote to the pulsed laser. Following a successful acquisition with the pulsed laser, the unit will again attempt to handoff to the CW laser using the handoff criteria defined earlier in this section.

CW Laser to Pulsed Laser Handoff (Undocking)

The CW to Pulsed laser handoff will be slightly modified from the more structured Pulsed to CW handoff. The nominal method will be to continue tracking the retroreflectors with the CW laser until a loss of tracking occurs. The unit will attempt to reacquire the target with the CW laser. If an immediate reacquisition is not successfully completed, the TCS will begin a full scan in an attempt to resume tracking. If the last range was less than 100m(328ft), the CW laser will be used for the full scan. If the last range was greater than 100m(328ft) the TCS system may begin the full scan with the pulsed laser. After the acquisition is successful with the pulsed laser and if the range is less than 400m(1312ft), the TCS system will again attempt to handoff to the CW laser, according to the criteria defined in the previous section. If the range is greater than 400m(1312ft), the unit will continue to use the pulsed laser exclusively.

Table 8.3-1: TCS Accuracies

Parameter	Spec	Particulars
Range Accuracy	400 to 10': $\pm 0.01 \cdot \text{range}$ 10' to Dock: $\pm 0.1'$	All accuracies are RSS of 1σ noise and bias
Range Rate Limits	$\pm 1 \text{ fps}$	
Range Rate Accuracy	400 to 262': $\pm 0.1 \text{ fps}$ 262' to dock: $\pm 0.01 \text{ fps}$	
Bearing Limits	$\pm 20^\circ$	
Bearing Accuracy	$\pm 0.5^\circ$	
Bearing Rate Limits	$\pm 1^\circ / \text{s}$	
Bearing Rate Accuracy	$\pm 0.5^\circ / \text{s}$	

9.1 Rendezvous GPO Command Loads

PURPOSE

To document all commands issued by the Rendezvous GPO in the course of performing his or her normal duties. Formal Command Procedures are contained in the Flight Dynamics Command Procedures document. Refer to section 4.7 COVARIANCE MATRIX MANAGEMENT for procedures using the Command Server. The procedure below is a summary of that contained in the formal documentation, assuming use of the Command Server.

PROCEDURE

Set-Up

To set-up your workstation for monitoring and/or building a command load, perform the following steps:

- On Master DNAV select: Global Apps > Command Server > Start Command Manager.
- Wait for Command Manager window to appear and indicate that it is running.
- On Rendezvous DNAV select: Console Apps > Command > Covariance.
- Wait for Covariance display to appear after a few seconds.

Build

To build a covariance matrix, perform the following steps. If ONAV builds the covariance matrix (typical operation), proceed to Verify. Available covariance matrices are defined in the BACKGROUND section.

- Select the appropriate covariance from the Covariance display menu bar.
 - File > Open RENDZ (Rendezvous Covariance, 42101)
 - File > Open PROX OPS (Prox Ops Covariance, 42102)
 - File > Open COAS (COAS Nav Covariance, 42103)
- Verify that the selected covariance populates the blanks in the Build section of the display.
- Verify that the Build Sequence Counter and the Verification Sequence Counter match the last digit of the command load number (i.e., "2" for command load 42102).
- Click on GEN button in the Build Command section (it should turn green) to "arm" the command load.
- Select CONFIRM button (it should turn green) to "fire" the command load.
- Note appearance of command in Load Inventory.
- Toggle NO COMPARE to COMPARE in Verification Sequence portion of display and inspect the populated fields in the Build portion as compared to the Ground Verification portion. Note any discrepancies (matches highlight in green, mismatches highlight in red).

Verify

To verify a covariance matrix built by someone else, perform the following steps.

- Select the appropriate covariance from the Covariance display menu bar.
 - File > Open RENDZ (Rendezvous Covariance, 42101)
 - File > Open PROX OPS (Prox Ops Covariance, 42102)
 - File > Open COAS (COAS Nav Covariance, 42103)
- Verify that the selected covariance populates the blanks in the Build section of the display.
- Verify that the Build Sequence Counter and the Verification Sequence Counter match the last digit of the command load number (i.e., "2" for command load 42102).
- Toggle NO COMPARE to COMPARE in Verification Sequence portion of display and inspect the populated fields in the Build portion as compared to the Ground Verification portion. Note any discrepancies (matches highlight in green, mismatches highlight in red).

Uplink

The protocol for performing an uplink is summarized below:

- Contact FLIGHT for permission to uplink the command.
 - Example: "FLIGHT, I would like to uplink a Rendezvous Covariance Matrix."
- Upon a GO from FLIGHT, contact INCO and state that you wish to uplink command load <xxx> to the <GN/SM>.
 - Example: "INCO, I would like to uplink command load 42101 Rendezvous Covariance Matrix to the GN, with a GO from FLIGHT."
- INCO will repeat your words back to you. Remain on the INCO loop to receive his verbal verification of the command load uplink.
- Also, watch for command to be uplinked under the Command Tracking section of the display; perform a horizontal scroll to see COMP, indicating success.

Flush

Perform the following steps to flush a command load. If ONAV performed the build, ask ONAV to perform the flush; proceed to Clean-Up.

- Set sequence number in the Build Sequence part of display to the load number to be deleted.
- Select DEL button.
- Select CONFIRM button.
- Verify that the load disappears from the Load Inventory window.

Clean-Up

To free workstation resources, drop the Command manager and Covariance display:

- On Master DNAV select: Global Apps > Command Server > Stop Command Manager
- In the Covariance display menu bar, select File > Exit.

BACKGROUND

Details on Covariance matrices can be found in SCP 4.7 COVARIANCE MATRIX MANAGEMENT.

Command Load 42101 to GNC - Rendezvous Covariance Matrix

The Rendezvous Covariance matrix uplink is used to provide a pristine covariance matrix for Rendezvous Navigation during the **pre-Ti** timeframe in the event a COVAR REINIT (SPEC 33 ITEM 16) is issued or RNDZ NAV is enabled or reinitialized (SPEC 33 ITEM 1). The uplink of the matrix does NOT change the current covariance matrix.

UP	2000	UVC	0.0
VP	20000	UUC	0.0
WP	2000	VUC	-0.9
UV	21	UVC	-0.9
VV	2	VVC	0.0
WV	6	WWC	0.0
		UVC	0.0

Figure 9.1-1 Rendezvous Covariance Matrix

Command Load 42102 to GNC - Prox Ops Covariance Matrix

The Prox Ops Covariance matrix uplink is used to provide a pristine covariance matrix for Rendezvous Navigation during the **post-Ti or deploy** timeframe in the event a COVAR REINIT (SPEC 33 ITEM 16) is issued or RNDZ NAV is enabled or reinitialized (SPEC 33 ITEM 1). The uplink of the matrix does NOT change the current covariance matrix.

UP	1000	UVC	0.0
VP	1000	UUC	0.0
WP	1000	VUC	-0.9
UV	1	UVC	-0.9
VV	1	VVC	0.0
WV	1	WWC	0.0
		UVC	0.0

Figure 9.1-2 Prox Ops Covariance Matrix

Command Load 42103 to GNC - COAS Navigation Covariance Matrix

The COAS Navigation Covariance matrix uplink is used to provide a pristine covariance matrix for Rendezvous Navigation during the timeframe where **COAS Navigation** is used. The uplink of the matrix does NOT change the current covariance matrix. The COAS Navigation procedure calls for a COVAR REINIT (SPEC 33 ITEM 16) to force NAV to use this matrix.

UP	500	UVC	0.0
VP	5000	UUC	0.0
WP	1000	VUC	-0.9
UV	5	UVC	-0.9
VV	1	VVC	0.0
WV	1	WWC	0.0
		UVC	0.0

Figure 9.1-3 COAS Navigation Covariance Matrix

9.2 CRANS

PURPOSE

To provide details on using the Configurable Real-time Analysis System (CRANS) application.

PROCEDURE

Overview

CRANS provides flight controllers with a quick method of assessing system impacts due to failures or to look ahead at the impacts of hypothetical failures. The default configuration of CRANS will automatically detect and display system failures.

General Operations:

The RGPO CRANS application consists of individual matrices that list the various Orbiter systems of interest to rendezvous operations. Each system component is displayed in a smaller unique box (or icon) within the matrices (see figure 9.2-1). Each icon conveys the status of the system using color. The color scheme for the icons in Rendezvous CRANS was designed to easily detect off-nominal conditions using the following color scheme:

- Light green, white or gray - OK
- Dark green - OK? (only partially or not automatically updated: manual configuration may be required)
- Red - Failed
- Amber - Warning or one failure away from lost capability
- Blue - User configured

Each matrix may be opened or iconified by clicking the left mouse button on either the icon body or in the small box in the upper right corner of the matrix, respectively. Matrices come up in a standard RGPO arrangement but can be rearranged as desired by the operator. To move a matrix, place the cursor in the matrix title bar, click/hold the left mouse button, and drag the matrix to the desired location. Configurations can then be saved to the operators individual file and then recalled anytime in the future

The CRANS application consists of both executable code (maintained by USA programmers) and user-specific data files (configured by the RGPOs). The data files define what components are displayed and the logic files define the dependencies.



Figure 9.2-1 CRANS Matrices and Icons

Hypothetical Operations

The operator may choose to assess the impacts of hypothetical failures by clicking on the desired system component icon. This will permanently fail that component and the effects will cascade down to those components impacted by it. A "*" character is displayed in the first column of a box if the displayed item hard failed. When manually configured like this, the component will remain failed until deselected (toggled) by clicking on it again (will override real time updates to that component). Manual configurations will not affect the real time updates of other components. Real time failure detection in CRANS will continue to automatically detect failures as long as the RT OVERRIDE icon (bottom left of figure 9.2-1) is not selected (default configuration).

DPS Stringing:

If the operator desires to analyze hypothetical GPC failures, the GPC string configuration (NBAT) requires manual configuration. Selecting the appropriate string configuration in the DPS Stringing matrix does this. Real-time CRANS doesn't automatically do this because it doesn't have the ability to decode the NBAT. Manual configuration of the strings is really only needed for the hypothetical mode. If stringing isn't assigned in CRANS, and an actual GPC failure occurs, the real-time feature of CRANS will detect and display the failure of the

FF and FA MDMs assigned to the failed GPC. Therefore, the impacts of the failed GPC will be properly indicated even though the stringing hasn't been assigned.

Sub Matrices:

Many of the components in the matrices have associated sub components (all displayed when you left click on the main icon). These sub matrices show more detail of a component than can be practically displayed on the main matrices. For example, some sub components under RNDZ RADAR are: Radar Failed, No RR to REL NAV, RR loss GPC ptg, etc. If a sub component fails it will be displayed in the main matrix. However, if several sub menu items fail only the highest priority (upper most) sub menu item will be displayed. Thus there may be other failures that are shown in the sub menu but not on the main matrix level.

System Component Failure Modes

The operator can interrogate CRANS to display the failure logic of a component by pointing to the icon with the cursor, then clicking the center mouse button. The failures that can impact that component will then be displayed in text form. To exit this mode, hold the left mouse button down and then click the right mouse button at the same time

Commonality Testing

The commonality feature in CRANS may be useful to the operator in determining what events have a common failure. This feature become available when one or more event box is "tagged" using the right mouse button as indicated by a "~" to the right of the icon. Tagging two or more event boxes, and then requesting commonality (**Commands>Commonality**) will result in a list of logic events which are common to the tagged events. If commonality exists between the components CRANS will show what will fail them: "failed by ____". If no commonality exists CRANS will display "None". To return to the main window select **Commands>Common Off**. To clear individual tags right click again on the icon. To clear all tags select **Commands>Clear Tags**.

Commands Menu

Table 9.2-1 Commands Menu Definitions

Item	Description
Commonality	See Commonality Testing section
Fail Result	Displays the downstream failure effects of tagged items in text form
Reference	Displays the items that directly reference the items that are tagged
Clear Fails	All failures and string configuration settings are reset to their startup values.
Clear Tags	All tagged items are reset (untagged). (An item is tagged using the right mouse button)
Suppress	Suppresses all failed items in the selected matrix. All this means is that the items change color. Each item must be manually un-failed to return to normal operations.
Print Data	A summary of input and resultant failed item names is output to a printer. If real time data is active then the current values of all MSIDs are output along with their status flags. If this item is selected while in help, commonality, failure result or reference mode the contents of the display window will be printed.
Save Config	The current main window size and matrix/icon state/position information is saved to the configuration file that is selected under the CONFIG pulldown.
Update Rate	If real time data is being taken by the application, the update rate can be modified (must be greater than 1 sample per second).
Send Data	This item is currently not functional.
Un / Corral	Corral – Matrices cannot be moved outside the main window. Also, when moving or closing the main window all matrices will be closed/moved. UnCorral – Matrices can be moved outside the main window. Or can be left open after closing the main window. Select uncorral then select the applicable matrix.
Locate	Locates matrices.
Exit Crans	Exits the application.

References

CRANS User Guide, MMACS Console Handbook, JSC-26101, SCP 15.6.

9.3 Station Aids to Docking and Separation (SADS)

9.3.1 RNDZTIME

PURPOSE

The RNDZTIME.xls spreadsheet is used to help in the planning of Shuttle dockings to the International Space Station (ISS). The tool integrates communication, trajectory, and lighting data into a single timeline that highlights important events between Ti and docking. The software provides output in the form of a sequential table of events or a plot of the planned events. The spreadsheet also provides a time conversion tool.

COMPONENTS OF THE SOFTWARE

The tool is composed of fourteen spreadsheets. Information regarding the components is shown in Table 9.3-1. For STS-114, there are two versions of the spreadsheet - one with the Rbar Pitch Maneuver and one without. Since the name of the SADS spreadsheet can only be rndztime.xls, these two versions must be administratively maintained in separate, clearly marked directories. Features unique to the RPM version are described below in the Notes for the Rbar Pitch Maneuver.

TYPICAL SESSION

The following is an example of the typical use of this tool.

1. Make a copy of the RNDZTIME.XLS spreadsheet in the user's personal files. Afterwards, remove the "read only" flag from the user's copy of the spreadsheet.
2. Obtain all external data needed for the spreadsheet. This includes Predicted Site Acquisition Tables (PSATs) from the FDOs, approach type from the RNDZ book, array configurations, etc.
3. Open the spreadsheet and complete all the needed data on the Control page.
4. Press the EDIT COMM & LIGHTING DATA button and enter all the lighting, communication and TV data for the three orbits. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
5. Press the EDIT MISC DATA button and enter the camera/window constraints, the desired lighting calculations, any notes for the output table, and any user defined constraints. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
6. Generally, no updates are going to be needed for the Profile page. However, if something has changed, press the EDIT PROFILE DATA button and enter the changes to the profile trajectory in the correct segment. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.

7. Press the EDIT PLAN DATA button and enter the prime & backup Ti and MC4 times, the docking times for the six possible plans and the duration of the 30 ft stationkeeping. If the previously defined constraints are not satisfactory, input data in the optional categories for the six plans. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
8. Press the CALCULATE LIGHTING DATA button to update all the lighting calculations. It would probably be a good idea to perform a SAVE after any change in the data.
9. Press either the VIEW CURRENT PLAN DOCKING PLOT button or the VIEW CURRENT PLAN TABLE button and check the results. If acceptable, print hardcopies (as needed) or distribute (as needed). If changes need to be made, repeat steps 3 through 9 as needed.
10. When the output is correct, press the GO TO RUSSIAN COMM VERIFICATION TABLE button and print a hardcopy (or make an electronic copy) and submit to RIO (as needed) for verification from the Russians.

Notes for the Rbar Pitch Maneuver:

For STS-114, a new sheet titled 'RPM' has been added to the rndztime.xls spreadsheet. The user is not required to interface directly with this sheet. The 'RPM' sheet computes the start window for the RPM using sunrise/sunset METs, Beta angle, nominal RPM pitch rate, and the geometric requirements for RPM photography (specified on the 'RPM' sheet). The user should be aware of several changes that were required in order to fit this capability within the existing spreadsheet.

1. On the 'Comm&Light' sheet, the first sunset entered must be the one that immediately follows the nominal Ti burn. The label for this time has been changed to "post-Ti sunset" to make this clear.
2. On the 'Misc Data', three lines are dedicated to the RPM start window open time, the window close time that assures a maximum period of photography (~93 seconds), and the window close time that assures 45 seconds of photography within constraints. The METs for these three events were formerly available for manual input of event times. These cells now contain formulas that pick the times off the 'RPM' sheet and must not be modified by the user. The color of these cells has been changed from light blue to clear to indicate this to the user (consistent with other areas of the spreadsheet).
3. On the 'Profiles' sheet, two lines have been added to indicate the nominal start time and completion time of the RPM. For Beta angles less than or equal to 20 degrees, the nominal RPM start time is set to 1 second after the opening of the window. (This typically will result in a period of stationkeeping between 600 ft arrival and the RPM start, although this result is not displayed explicitly). For Beta angle greater than 20 degrees, the nominal RPM start time is set to 1.9 minutes after Rbar arrival.
4. The RPM times will now respond correctly to a change to the backup Ti rev.

QA steps for the new RPM functionality:

The following items can be checked to verify the spreadsheet is producing good RPM times:

For $0 < |\text{Beta}| < 15$ degrees:

Window open and RPM start at noon+4 minutes. Window close at approximately noon+8 minutes for the full photo window and approximately noon + 16 for the 45 second photo window.

For $15 < |\text{Beta}| < 20$ degrees:

Window open and RPM start at noon + 2 minutes. Window close at approximately noon + 8 minutes for the full photo window and approximately noon + 16 for the 45 second photo window.

For $|\text{Beta}| > 20$ degrees:

RPM window opens approximately 14-16 minutes before noon and closes at approximately 14-16 minutes after noon. The nominal RPM start time should be 1.9 minutes after Rbar arrival.

Table 9.3-1 RNDZTIME Software Components

Sheet Name	Directly Accessed By User	Purpose/Function
Control	Yes	Input of mission overview data. Provides buttons to access components of the spreadsheet and control execution of the spreadsheet functions.
Time_Conv	Yes	Allows conversion between MET, GMT, DMT and Local.
Comm & Light	Yes	Allows user to input lighting, satellite communication, ground station communication and TV coverage data for the pre-docking orbit, the docking orbit, and the backup docking orbit.
Misc Data	Yes	Allows the user to input preferences for lighting calculations, camera and window field-of-view (FOV) constraints, table notes, and any event referenced to MC4, docking or MET.
Profiles	Yes	Allows for definition of all the possible approaches to ISS. The items are broken down into many segments to accommodate all possible scenarios.
Plans	Yes	Allows the user to input the prime and backup Ti, MC4, docking time and 30 ft stationkeeping duration.
Light_Comps	No	Computes all the information regarding sun in the centerline camera, sun in the overhead window, glare and sun in camera A/D.
Comps	No	Computes all trajectory data and integrates into a single data set to be displayed in the output table.
RNDZ	Yes	Allows user to view and print all Russian communication AOS/LOS times to be used for the docking time negotiation. This sheet also contains the code to generate a data set to be plotted in the output plot.
macro	No	Holds all the macro coding used in the spreadsheet.
Table	Yes	Provides the tabular output based on the input data.
Nom_Plot	Yes	Provides the plot output for the prime docking orbit.
1RL_Plot	Yes	Provides the plot output for the backup docking orbit.
VBI Control	Yes	Provides ability to compute whether or not ground communication coverage can be achieved once Orbiter has reached the Vbar.
VBI Comps	No	Performs calculations to support VBI timing comps
RPM	No	Computes the start window for the Rbar Pitch Maneuver

9.3.2. SEPTIME

PURPOSE

This tool is used to help in the planning of Shuttle undockings from the International Space Station (ISS). The tool integrates communication, trajectory, and lighting data into a single timeline that highlights important events around undocking. The software provides output in the form of a sequential table of events or a plot of the planned events. The spreadsheet also provides a time conversion tool.

COMPONENTS OF THE SOFTWARE

The tool is composed of twelve spreadsheets. Information regarding the components are shown in Table 9.3-2.

Table 9.3-2 SEPTIME Software Components

Sheet Name	Directly Accessed By User	Purpose/Function
Control	Yes	Input of mission overview data. Provides buttons to access components of the spreadsheet and control execution of the spreadsheet functions.
Time_Conv	Yes	Allows user to convert between MET, GMT, DMT and Local time.
Comm & Light	Yes	Allows user to input lighting, satellite communication, ground station communication and TV coverage data for the pre-undocking orbit, the undocking orbit, and the backup undocking orbit.
Misc Data	Yes	Allows the user to input preferences for lighting calculations, camera and window field-of-view (FOV) constraints, table notes, and any event referenced to undocking or MET.
Profile	Yes	Allows for definition of the separation and flyaround (if applicable). The sheet also helps calculate the times for a flyaround.
Light_Comps	No	Computes all the information regarding sun in the centerline camera and sun in the overhead window.
Comps	No	Computes all trajectory data and integrates into a single data set to be displayed in the output table.
SEP	Yes	Allows user to view and print all Russian communication AOS/LOS times to be used for the undocking time negotiation. This sheet also contains the code to generate a data set to be plotted in the output plot.
macro	No	Holds all the macro coding used in the spreadsheet.
Table	Yes	Provides the tabular output based on the input data.
Nom_Plot	Yes	Provides the plot output for the prime undocking orbit.
1RL_Plot	Yes	Provides the plot output for the backup undocking orbit.

TYPICAL SESSION

The following is an example of the typical use of this tool.

1. Make a copy of the SEPTIME.XLS spreadsheet in the user's personal files. Afterwards, remove the "read only" flag from the user's copy of the spreadsheet.
2. Obtain all external data needed for the spreadsheet. This includes PSATs from the FDOs, separation profile from the RNDZ book, array configurations, etc.
3. Open the spreadsheet and complete all the needed data on the Control page.
4. Press the EDIT COMM & LIGHTING DATA button and enter all the lighting, communication and TV data for the three orbits. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
5. Press the EDIT MISC DATA button and enter the camera/window constraints, the desired lighting calculations, any notes for the output table, and any user defined constraints. If needed, toggle the autocalculation off. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
6. Press the EDIT PROFILE DATA button and enter the trajectory profile for the undocking. When complete, re-enable autocalculation (if needed) and press the RETURN TO CONTROL button. It would probably be a good idea to perform a SAVE after any change in the data.
7. Press the CALCULATE LIGHTING DATA button to update all the lighting calculations. It would probably be a good idea to perform a SAVE after any change in the data.
8. Press either the VIEW CURRENT PLAN UNDOCKING PLOT button or the VIEW CURRENT PLAN TABLE button and check the results. If acceptable, print hardcopies (as needed) or distribute (as needed). If changes need to be made, repeat steps 3 through 9 as needed.
9. When the output is correct, press the GO TO RUSSIAN COMM VERIFICATION TABLE button and print a hardcopy (or make an electronic copy) and submit to RIO (as needed) for verification from the Russians.

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9.4 Flight Notes

PURPOSE

To document the procedures for generating flight notes using the PCs.

PROCEDURE

Note: These procedures assume that you have a user ID on the JSCMODM fileserver.

Calling up the Flight Note system

- Verify that the Flight Director has started the MCCPC System
- Under the Start button, select MCC Menu
- Select C – Applications
- Select EFN Current Version (There will be 2 EFN choices)

After the MCCPC initialization completes move on to the next section. If the MCCPC initialization does not complete, check network connection.

Note – The MCC PC System must be running to save and publish flight notes.

Initializing the Flightnote Template

- Check the ISS and Shuttle boxes at bottom right corner
- Select New Flt Note
- A warning prompt may appear asking about macros. Enable macros.
- A prompt will appear asking:
 - ◇ Title (e.g. Approach and Docking Timeline)
 - ◇ To – People to receive the Flight Note (usually FD, CAPCOM, FDO, PROP, FAO)
 - ◇ From – Sender of the Flight Note (default is GPO)
 - ◇ Action Required
 - ◇ Next Flight Planning Cycle
 - ◇ Not time Critical (1 – 4 hours)
 - ◇ ASAP
 - ◇ N/A – Info Only (usually used)

Creating the Flightnote

This section will discuss the common way the RGPO group uses the flight note system.

Sometimes, before a flight or sim, a Microsoft Word document has been created with the information needed for the Flightnote. The following will be an example of generating a Block 22A flight note but the same basic principles can be applied to other RGPO flight notes.

Block [22A] Approach and Docking Time Flightnote Generation (no longer applicable after ISS 5A.1)

- Alternating between the Flight Note Window and the Block [22A] saved document can be accomplished under the Window option on the task bar.
- Hit enter until the line numbers on the left side of the Flightnote reach 5 or 6.
- On the [22A] page, click on the first block (all of the approach information). This block should be grouped as one object but if this is not the case: Hold down the shift key and left click on all the blocks to be included. (An object is selected when blocks are present on the borders. Not when there are hash marks.)
- Select copy and switch to the Flightnote page. Click on line 2 or 3.
- Select Paste Special – Picture. Verify all the information appears on the Flight Note.
- Return to the [22A] page and copy the RNDZ Updates data and paste it in the Flight Note below the block [22A].
- Copy the SADS spreadsheet data using the paste special – picture option. The spreadsheets can be copied all at once but it may be easier to cut and paste one at a time.
- Save the Flightnote using one of the three options in the following section but if prompted to change your save options to an upgraded version of Word – select **NO**.

Saving the Flightnote

There are three levels of flightnotes. The three levels will appear in the middle bar on the Microsoft window template. Choose the appropriate level and use the associated save procedure below:

- **Working Note (WN Save):** A working note is saved in the GPO WORK subdirectory. Use the *WN_Save* button on the button bar to save.
- **Internal Note (FCR Inbox):** An internal note is sent “inter-console” and will go into the individual operator’s INBOX subdirectory. Use the *FCR_Inbox* button on the button bar to save.
- **Flight Note (FLT NOTE):** A flight note is intended as an official note meant to be seen by FLIGHT, CAPCOM, and FAO (i.e., intended for uplink to the crew). These four positions will have messages appear on their machines when the note is sent. Use the *FLT_NOTE* button on the button bar to save.

RPS will usually generate the working note using the *WRK_Save*. Then after verification the RGPO will publish the Flightnote using the *FLT_NOTE* option.

Note: Whenever a note is saved, a name is assigned to it with the format OODNNN.DOC, where:

- OO is the operator code of the originator. Examples are FD for Flight Director, FA for FAO, and FO for FDO.
- DD is either FN for flight note, IN for internal note, WN for working note, BP for Burn PAD.
- NNN is a number from 0 to 999 (incremented each time a note is sent or revised)

Updating the Status of a Flightnote

- Double-click on the ST of STATUS
- Choose the correct STATUS from the list (Open, Closed, App_U/L, Uplinked, Withdrawn, etc)

Revising a Flightnote

- Double-click on REVISE NOTE and acknowledge the dialog with a Yes.
- Make revisions as necessary. Note that the revision letter in the Revision Block will be updated automatically by the template.
- Follow the appropriate save procedures above.

Viewing/Stating Flightnotes

- Double-click on the MCCPC icon in the Applications submenu.
- Restrict (if desired) flightnotes based on status.
- Select VIEW THE NOTE icon to view a note.

Notes:

- The database provides the filename, title, status, and time note was saved.
- The default sort order is in reverse time order (newest at the top).

Accessing MCCPC from a Windows95 Machine

For now, MCCPC access is designed assuming Windows 3.1. For Windows95 users, such as the Pentium in the MPSR, the access is different. If you have created a shortcut icon per the following steps, simply double-click on it to access MCCPC. To create the shortcut, perform the following steps:

- With the right mouse button, single-click on the desktop.
- In the menu, select New...Shortcut.
- In the command line, type the following (exactly):
`U:\mccpc\mccpc229.exe U:\mccpc\mccpc_gl.ini`
- Click on Next>.
- In the name field, type MCCPC 2.29, then click on Finish.

To update to a newer version of MCCPC, perform the following steps on an already-created shortcut:

- With the right mouse button, single-click on the MCCPC shortcut icon.
- In the menu, select Properties.
- Select the Shortcut tab in the resulting dialog box.
- In the Target line, change the 229 in mccpc229 to the newest number, and then click on OK.

BACKGROUND

Additional information about the Flightnote Template is available below.

Point of Contact

Mary Lou Griffith x34306 Beeper (281) 891-9705

Directory Structure

As of the time of this writing, the directory structure on JSCMODM for MCCPC is below:

Table 9.4-1 MCCPC Directory Structure

Directory	Description	Read Access	Write Access
BURNPAD	Burn PADS	All	FDO
EE_CONSU		All	EECOM, EGIL
ENT_MSG		All	All FCR positions
FLT_NOTE		All	All
MCCPC		All	All
PL_CONST		All	PAYLOADS
PROP_CON		All	PROP
TIPS_UP		All	All
WX_SHEET	Weather information	All	FDO
MET_TMR		All	
PADM_UP	PADMs for uplink	All	FD, CAPCOM, FAO, MATS
PADM_DN	PADMs downlinked	All	FD, CAPCOM, FAO, MATS
MSG_RVV	Messages to be reviewed	All	FAO, MATS
INBOX\<POSITION>	Messages sent to <POSITION>	All	All
WORK\<POSITION>	Working area for <POSITION>	<POSITION>	<POSITION>

IDs and Passwords

Your user ID is the same as your JSCDM server ID. If it's been longer than 30 days since you last used your password, you may have trouble logging on. It may or may not prompt you for a new password. If you have trouble, call one of the MCCPC Point-of-Contacts listed on the machine.

9.5 ROSS Alarms

PURPOSE

The following is a reference on the certified ROSS alarms panels used by the Rendezvous team.

PROCEDURES

To certify an Alarm panel, the following actions must be performed:

- User must provide a writeup on each field in the alarm panel, containing the following information
 - ◇ Description of alarm field contents.
 - ◇ Possible value(s) displayed in alarm field.
 - ◇ MSID(s) used to arrive at possible value(s).
- User must test Alarm panel to verify correct operation
- User must provide the above writeup to the ROSS Group Administrator (GA) and request that the panel be copied to the Read-Only area
- User must provide the above writeup to RGPO CHB Book Manager for inclusion into this SCP including date built and tested

Each alarm panel above is described in the following manner:

- Name of alarm panel.
- Build date and author.
- Test date and testing engineer.
- Picture of the alarm panel.
- Field-by-field description of each alarm panel entry
 - ◇ (row, column) Alarm name as it appears in panel.
 - ◇ Description of alarm field contents.
 - ◇ Possible values displayed in alarm field.
 - ◇ MSIDs used to arrive at possible values.

BACKGROUND

DAP_CONFIG Alarm Panel

Built 08/01/95 by D.G. Hamm

Tested 08/01/95 by D.G. Hamm

PRIMARY DAP A A0	PRIMARY DAP B B0	VERN DAP A A0	VERN DAP B B0
TRANS PULSE 0.0000	TRANS PULSE 0.0000	TRANS PULSE 0.0000	TRANS PULSE 0.0000
ROT DISC 0.0000	ROT DISC 0.0000	ROT DISC 0.0000	ROT DISC 0.0000
ROT PULSE 0.0000	ROT PULSE 0.0000	ROT PULSE 0.0000	ROT PULSE 0.0000
ATTITUDE DB 0.0000	ATTITUDE DB 0.0000	ATTITUDE DB 0.0000	ATTITUDE DB 0.0000
RATE DB 0.0000	RATE DB 0.0000	RATE DB 0.0000	RATE DB 0.0000

1,1. PRIMARY DAP A

Meaning: Displays the DAP A selected per item entry in SPEC 20 ITEM 1.

Possible Values: **PRIMARY DAP A** value between 0 and 15 displayed as an integer. Zero is displayed if the crew changes one of the DAP load items (equivalent to a 'blank' on SPEC 20).

MSID(s): V93J5779C - DAP LOAD SEL A

2,1. TRANS PULSE

Meaning: Displays the translation pulse size associated with DAP A per SPEC 20 ITEM 17.

Possible Values: **TRANS PULSE** value in ft/s displayed to 4 digits after decimal point
MSID(s): LC_TPUL_PA - DAP A TRANS PULSE size acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1544C - TRANS PULSE LEVEL

3.1. ROT DISC

Meaning: Displays the PRI rotation rate (historically known as "rot discrete") associated with DAP A per SPEC 20 ITEM 10.

Possible Values: **ROT DISC** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_DIS_PA - DAP A NORM DISCRETE RATE acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1539C - NORM DISCRETE RATE

4.1. ROT PULSE

Meaning: Displays the PRI rotation velocity change (historically known as "rot pulse") associated with DAP A per SPEC 20 ITEM 13.

Possible Values: **ROT PULSE** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_ROT_PA - DAP A NORM ROT PULSE LEVEL acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1542C - NORM ROT PULSE LEVEL

5.1. ATTITUDE DB

Meaning: Displays the PRI attitude deadband associated with DAP A per SPEC 20 ITEM 11.

Possible Values: **ATTITUDE DB** value in deg displayed to 4 digits after decimal point.

MSID(s): LC_ATT_PA - DAP A NORM ATT DEADBAND acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93H1540C - NORM ATT DEADBAND

6.1. RATE DB

Meaning: Displays the PRI rate deadband associated with DAP A per SPEC 20 ITEM 12.

Possible Values: **RATE DB** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_RAT_PA - DAP A NORM RATE LIMIT acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1541C - NORM RATE LIMIT

1.2. PRIMARY DAP B

Meaning: Displays the DAP B selected per item entry in SPEC 20 ITEM 2.

Possible Values: **PRIMARY DAP B** value between 0 and 15 displayed as an integer. Zero is displayed if the crew changes one of the DAP load items (equivalent to a 'blank' on SPEC 20).

MSID(s): V93J5780C - DAP LOAD SEL B

2.2. TRANS PULSE

Meaning: Displays the translation pulse size associated with DAP B per SPEC 20 ITEM 37.

Possible Values: **TRANS PULSE** value in ft/s displayed to 4 digits after decimal point

MSID(s): LC_TPUL_PB - DAP B TRANS PULSE size acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1544C - TRANS PULSE LEVEL

3.2. ROT DISC

Meaning: Displays the PRI rotation rate (historically known as "rot discrete") associated with DAP B per SPEC 20 ITEM 30.

Possible Values: **ROT DISC** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_DIS_PB - DAP B NORM DISCRETE RATE acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1539C - NORM DISCRETE RATE

4.2. ROT PULSE

Meaning: Displays the PRI rotation velocity change (historically known as "rot pulse") associated with DAP B per SPEC 20 ITEM 33.

Possible Values: **ROT PULSE** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_ROT_PB - DAP B NORM ROT PULSE LEVEL acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1542C - NORM ROT PULSE LEVEL

5.2. ATTITUDE DB

Meaning: Displays the PRI attitude deadband associated with DAP B per SPEC 20 ITEM 31.

Possible Values: **ATTITUDE DB** value in deg displayed to 4 digits after decimal point.

MSID(s): LC_ATT_PB - DAP B NORM ATT DEADBAND acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93H1540C - NORM ATT DEADBAND

6.2. RATE DB

Meaning: Displays the PRI rate deadband associated with DAP B per SPEC 20 ITEM 32.

Possible Values: **RATE DB** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_RAT_PB - DAP B NORM RATE LIMIT acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1541C - NORM RATE LIMIT

1.3. VERN DAP A

Meaning: Displays the DAP A selected per item entry in SPEC 20 ITEM 1. (Simply a repeat of 1,1.)

Possible Values: **VERN DAP A** value between 0 and 15 displayed as an integer. Zero is displayed if the crew changes one of the DAP load items (equivalent to a 'blank' on SPEC 20).

MSID(s): V93J5779C - DAP LOAD SEL A

2.3. TRANS PULSE

Meaning: Displays the translation pulse size associated with DAP A per SPEC 20 ITEM 17. (Simply a repeat of 2,1.)

Possible Values: **TRANS PULSE** value in ft/s displayed to 4 digits after decimal point

MSID(s): LC_TPUL_PA - DAP A TRANS PULSE size acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1544C - TRANS PULSE LEVEL

3.3. ROT DISC

Meaning: Displays the VERN rotation rate (historically known as "rot discrete") associated with DAP A per SPEC 20 ITEM 23.

Possible Values: **ROT DISC** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_DIS_VA - DAP A VERN DISCRETE RATE acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1545C - VERN DISCRETE RATE

4.3. ROT PULSE

Meaning: Displays the VERN rotation velocity change (historically known as "rot pulse") associated with DAP A per SPEC 20 ITEM 26.

Possible Values: **ROT PULSE** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_ROT_VA - DAP A VERN PULSE LEVEL acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1548C - VERN PULSE LEVEL

5.3. ATTITUDE DB

Meaning: Displays the VERN attitude deadband associated with DAP A per SPEC 20 ITEM 24.

Possible Values: **ATTITUDE DB** value in deg displayed to 4 digits after decimal point.

MSID(s): LC_ATT_VA - DAP A VERN ATT DEADBAND acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1546C - VERN ATT DEADBAND

6.3. RATE DB

Meaning: Displays the VERN rate deadband associated with DAP A per SPEC 20 ITEM 25.

Possible Values: **RATE DB** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_RAT_VA - DAP A VERN RATE LIMIT acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1547C - VERN RATE LIMIT

1.4. VERN DAP B

Meaning: Displays the DAP B selected per item entry in SPEC 20 ITEM 2. (Simply a repeat of 1,2.)

Possible Values: **VERN DAP B** value between 0 and 15 displayed as an integer. Zero is displayed if the crew changes one of the DAP load items (equivalent to a 'blank' on SPEC 20).

MSID(s): V93J5780C - DAP LOAD SEL B

2.4. TRANS PULSE

Meaning: Displays the translation pulse size associated with DAP B per SPEC 20 ITEM 37. (Simply a repeat of 2,2.)

Possible Values: **TRANS PULSE** value in ft/s displayed to 4 digits after decimal point

MSID(s): LC_TPUL_PB - DAP B TRANS PULSE size acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1544C - TRANS PULSE LEVEL

3.4. ROT DISC

Meaning: Displays the VERN rotation rate (historically known as "rot discrete") associated with DAP B per SPEC 20 ITEM 43.

Possible Values: **ROT DISC** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_DIS_VB - DAP B VERN DISCRETE RATE acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1545C - VERN DISCRETE RATE

4.4. ROT PULSE

Meaning: Displays the VERN rotation velocity change (historically known as "rot pulse") associated with DAP B per SPEC 20 ITEM 46.

Possible Values: **ROT PULSE** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_ROT_VB - DAP B VERN PULSE LEVEL acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1548C - VERN PULSE LEVEL

5.4. ATTITUDE DB

Meaning: Displays the VERN attitude deadband associated with DAP B per SPEC 20 ITEM 44.

Possible Values: **ATTITUDE DB** value in deg displayed to 4 digits after decimal point.

MSID(s): LC_ATT_VB - DAP B VERN ATT DEADBAND acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1546C - VERN ATT DEADBAND

6.4. RATE DB

Meaning: Displays the VERN rate deadband associated with DAP B per SPEC 20 ITEM 45.

Possible Values: **RATE DB** value in deg/s displayed to 4 digits after decimal point.

MSID(s): LC_RAT_VB - DAP B VERN RATE LIMIT acquired by ROSS Telemetry from the cyclically-rotating DAP downlist contained in V93R1547C - VERN RATE LIMIT

DAP_ORB_TGT Alarm Panel

Built 02/03/94 by J.L. Williams

Tested 02/03/94 thru 02/07/94 by J.L. Williams

Revision A Built and Tested 04/11/96 by J.L. Williams

DAP VERN A7	MC2 TIG
TRANS PULSE 0.10	MNVR MISMATCH
ROT DISC 0.200	MNVR DIFF 21.00
ROT PULSE 0.010	O-IGN
ATTITUDE DB 1.000	Y NODE 30:58
RATE DB 0.020	Y NODE VEL -0.22

1,1. ACTIVE DAP

Meaning: Displays the active DAP. Preloaded DAP numbers range from 1-15. If the crew changes any of the DAP preloads, the DAP number is received as zero.

Possible Values: **DAP PRI A** (followed by DAP number)
DAP VERN A (followed by DAP number)
DAP ALT A (followed by DAP number)
DAP PRI B (followed by DAP number)
DAP VERN B (followed by DAP number)
DAP ALT B (followed by DAP number)
DAP UNDETERMINED - no active DAP

MSID(s): V72X2807X - FWD DAP SELECT A (LIGHT)
V72X2808X - FWD DAP SELECT B (LIGHT)
V72X2855X - FWD RCS JETS NORM (LIGHT)
V72X2856X - FWD RCS JETS VERNIER (LIGHT)
V72X2896X - FWD ALT PRCS MODE (LIGHT)

2,1. TRANS PULSE

Meaning: Displays the TRANS PLS size of the active DAP.

Possible Values: **TRANS PULSE** in ft/s displayed to 2 digits after the decimal point.

MSID(s): V90U2795C - TRANS VEL CHANGE-MAG PER PULSE

3,1. ROT DISC

Meaning: Displays the ROT DISC size of the active DAP.

Possible Values: **ROT DISC** in deg/s displayed to 3 digits after the decimal point.

MSID(s): V90U2787C - DISCRETE MANEUVER RATE-MAGNITUDE

4.1. ROT PULSE

Meaning: Displays the ROT PULSE size of the active DAP.
Possible Values: **ROT PULSE** in deg/s displayed to 3 digits after the decimal point.
MSID(s): V90U2794C - BODY ANG RATE CHG-MAG PER PULSE

5.1. ATTITUDE DB

Meaning: Displays the ATTITUDE DB size of the active DAP.
Possible Values: **ATTITUDE DB** in deg displayed to 3 digits after the decimal point.
MSID(s): V90H2785C - PHASE PLANE ATT DBD-MAG REQ(ROLL)

6.1. RATE DB

Meaning: Displays the RATE DB size of the active DAP.
Possible Values: **RATE DB** in deg/s displayed to 3 digits after the decimal point.
MSID(s): V90U2786C - PHS PLANE RATE ERR LIM-MAG REQ R

1.2. MC2 TIG

Meaning: Displays the difference between the MC2 TIG computed onboard and the nominal MC2 TIG.
Possible Values: **NON MC2 MNVR**
MC2 TIG ON TIME - displayed if difference less than 2 sec
MC2 EARLY value displayed in MM:SS
MC2 LATE value displayed in MM:SS
MC2 EARLY LIM state limit indicator set to 3 min
MC2 LATE LIM state limit indicator set to 7 min
MSID(s): V95J7466C - MNVR TGT NO COMPUTED
LC_NXTMNVR - Next maneuver number as computed by ROSS Navcon
LC_ORBTIG - Onboard TIG solution from VAR PARAM slots designated in the ROSS Telemetry Options
LC_OTTIG - I-Loaded next TIG based on the next maneuver as computed by ROSS Navcon

2.2. TIG DIFF CHK

Meaning: Displays the difference, if any, between the onboard targeted TIG and the ROSS-computed TIG.
Possible Values: **TIG DIFF OK** - displayed if difference less than 2 sec
TIG DIFF value displayed in MM:SS
MNVR MISMATCH
MSID(s): V95J7466C - MNVR TGT NO COMPUTED
LC_NXTMNVR - Next maneuver number as computed by ROSS Navcon
LC_ORBTIG - Onboard TIG solution from VAR PARAM slots designated in the ROSS Telemetry Options
LC_NXTTIG - Next maneuver TIG as computed by ROSS Navcon

3.2. MNVR VIEW

Meaning: Displays the current selected TGT Set numbers for both onboard and ROSS computations in a format XX.YY where XX=onboard and YY=ROSS

Possible Values: **MNVR IDs 9.09** - both targeting NCC
MNVR IDs 10.10 - both targeting Ti
MNVR IDs 11.11 - both targeting MC1
MNVR IDs 12.12 - both targeting MC2 on EL
MNVR IDs 19.12 - onboard targeting MC2 on TIME
MNVR IDs 13.13 - both targeting MC3
MNVR IDs 14.14 - both targeting MC4
MNVR DIFF XX.YY - displayed for anything else

MSID(s): V95J7466C - MNVR TGT NO COMPUTED
LC_NXTMNVR - Next maneuver number as computed by ROSS Navcon

4.2. O-IGN CLOCK

Meaning: Displays the time to the next maneuver based on ROSS calculations.

Possible Values: **O-IGN** value displayed in HH:MM:SS with color state limits set to 5 and 1 min
O_IGN NOW! - special color state limit set to 0 sec

MSID(s): LC_NXTTIG - Next maneuver TIG as computed by ROSS Navcon
LC_F22PET - Current PET in sec

5.2. Y NODE XING

Meaning: Displays the time until the next Y node crossing based on onboard vectors.

Possible Values: **Y NODE** time displayed in MM:SS

MSID(s): LC_YCRSTIM - Y-node crossing delta time computed by ROSS

6.2. Y NODE VEL

Meaning: Displays the anticipated velocity at the next Y node crossing based on onboard vectors.

Possible Values: **Y NODE VEL** in ft/s displayed to 2 digits after decimal point

MSID(s): LC_YNODVEL - Y-node velocity when crossing node as computed by ROSS

IMU_ST_21_22 Alarm Panel

Built 02/03/94 by J.L. Williams

Tested 02/03/94 thru 02/07/94 by J.L. Williams

Revision A Built and Tested 12/01/97 by J.L. Williams

PRIME SELECT IMU 0	DESELECT IMU 6
STRK OK	IMUs OK
STRK TGT	STRK DATA
-Y STRK NO STAR PRES	-Z STRK NO STAR PRES
-Y STRK SHUTTER OP	-Z STRK SHUTTER OP
-Y STRK LOCK	-Z STRK LOCK

1,1. IMU PRIME SELECT

Meaning: Displays the onboard prime selected IMU
Possible Values: **PRIME SELECT IMU 1**
PRIME SELECT IMU 2
PRIME SELECT IMU 3
MSID(s): V90J2560C - SELECTED IMU ID

2,1. STRK STAR LOCK

Meaning: Indicates if the star tracker, when in TGT TRK, has locked onto a star by comparing consecutive measurements. Assuming LVLH hold, a star will move through the field of view at orbit rate (0.06 deg/s). The threshold used by this alarm panel is 0.450 degrees over an 8-second cycle.
Possible Values: **STAR LOCK** - displayed if delta measurements ≥ 0.450
STRK OK - otherwise
MSID(s): V90H0214C - TAC R/OPTICS V/Y/EL MEAS RESIDUAL

3,1. STRK TGT TRACK

Meaning: Indicates if the star tracker is tracking a target. This bit is set by the star tracker logic once acquisition is confirmed.
Possible Values: **STRK GOOD TGT TRK**
STRK NOT TRACKING TGT
MSID(s): V90U4836C - SNAP STAR TRACKER MODE IND

4.1. -Y STRK STAR PRESENT

Meaning: Indicates if the -Y star tracker detects a target in its field-of-view.
Possible Values: **-Y STRK STAR PRESENT**
-Y STRK NO STAR PRES
MSID(s): V71X5526B - -Y ST STAR PRESENT

5.1. -Y STRK SHUTTER

Meaning: Indicates the status of the -Y star tracker shutter.
Possible Values: **-Y STRK SHUTTER OP**
-Y STRK SHUTTER CL
MSID(s): V71X5524B - -Y ST SHUTTER CLOSED

6.1. -Y STRK STATUS

Meaning: Indicates the -Y star tracker mode per the downlisted status word.
Possible Values: **-Y STRK LOCK**
-Y STRK STST FAIL
-Y STRK STST PASS
-Y STRK FALSE TGT
-Y STRK OUT FOV
-Y STRK HIGH RATE
-Y STRK NO TGT PRES
MSID(s): V95J4930C - -Y ST STATUS INDICATION

1.2. IMU DESELECT

Meaning: Indicates the onboard deselected IMU.
Possible Values: **DESELECT IMU 1**
DESELECT IMU 2
DESELECT IMU 3
DESELECT IMU 1 & 2
DESELECT IMU 1 & 3
DESELECT IMU 2 & 3
DESELECT ALL IMUs
3-LEVEL IMU
MSID(s): V93X6711X - IMU 1 SEL/DES CMD
V93X6712X - IMU 2 SEL/DES CMD
V93X6713X - IMU 3 SEL/DES CMD
notes: This field is unreliable if multiple IMUs are deselected.

2.2. IMU SWITCHING

Meaning: Indicates if a prime select IMU switch occurs during star tracker navigation. The switching notice will appear for approximately one second then revert to the neutral state.
Possible Values: **IMUs SWITCHING**
IMUs OK
MSID(s): V90X4868X - IND ST TO BE PROC BY FILTER
V90U4836C - SNAP STAR TRACKER MODE IND
V90J2560C - SELECTED IMU ID

3.2. STRK DATA GOOD

Meaning: Indicates whether the star tracker data good flag is ON.
Possible Values: **STRK DATA GOOD**
STRK DATA
MSID(s): V90X4835X - SNAP STAR TRACKER DATA GOOD

4.2. -Z STRK STAR PRESENT

Meaning: Indicates if the -Z star tracker detects a target in its field-of-view.
Possible Values: **-Z STRK STAR PRESENT**
-Z STRK NO STAR PRES
MSID(s): V71X5026B - -Z ST STAR PRESENT

5.2. -Z STRK SHUTTER

Meaning: Indicates the status of the -Z star tracker shutter.
Possible Values: **-Z STRK SHUTTER OP**
-Z STRK SHUTTER CL
MSID(s): V71X5024B - -Z ST SHUTTER CLOSED

6.2. -Z STRK STATUS

Meaning: Indicates the -Z star tracker mode per the downlisted status word.
Possible Values: **-Z STRK LOCK**
-Z STRK STST FAIL
-Z STRK STST PASS
-Z STRK FALSE TGT
-Z STRK OUT FOV
-Z STRK HIGH RATE
-Z STRK NO TGT PRES
MSID(s): V95J4929C - -Z ST STATUS INDICATION

MIR_DOCK_STAT Alarm Panel

Built 03/30/95 by M.M. Fletcher

Tested 03/30/95 by M.M. Fletcher

Revision A Verified 04/11/96 by J.L. Williams (removed TORF column)

Alignment OFF	PCT INHIBIT
Contact ON	Ready to Hook ON
Capture ON	Undock Cmpl't OFF
Damping ON	Latch Command ON

1,1. RING ALIGNMENT

Meaning: Indicates if the docking system ring is aligned.

Possible Values: **Alignment OFF**
Alignment ON

MSID(s): V53X0782E - RING ALIGNMENT

2,1. CONTACT

Meaning: Indicates if the docking system contact switch has been tripped. This usually occurs upon metal-to-metal contact, but it is possible to capture without tripping this contact if there is no misalignment between the docking interfaces.

Possible Values: **Contact OFF**
Contact ON

MSID(s): V53X0781E - INITIAL CONTACT

3,1. CAPTURE

Meaning: Indicates if the docking system capture latches have been tripped. This usually occurs after initial contact, but it is possible to get this indication without a CONTACT indication if there is no misalignment between the docking interfaces.

Possible Values: **Capture OFF**
Capture ON

MSID(s): V53X0757E - CAPTURE

4,1. DAMPING

Meaning: Indicates if the docking system motion dampers are active. This occurs after CAPTURE.

Possible Values: **Damping OFF**
Damping ON

MSID(s): V53X0771E - ELECTROMAG BRAKE ACTUATION

1.2. MIR DOCK DAP STATUS

Meaning: Indicates if the Post-Contact Thrust (PCT) sequence is armed.
Possible Values: **PCT ARM**
PCT INHIBIT
MSID(s): V90X0109X - DOCKING ARM

2.2. READY TO HOOK

Meaning: Indicates that the two structural rings are in close proximity and that the hooks are ready to close. This is one of the last lights the crew checks for undocking status.
Possible Values: **Ready to Hook OFF**
Ready to Hook ON
MSID(s): V53X0752E - READY TO HOOK

3.2. MIR UNDOCK

Meaning: Indicates if the undocking sequence is complete.
Possible Values: **Undock Cmplt OFF**
Undock Cmplt ON
MSID(s): V53X0751E - UNDOCK COMPLETE

4.2. CAPTURE LATCH

Meaning: Indicates if the capture latches are being latched. The capture latches provide only a temporary connection. Once hooks are closed the capture latches are released.
Possible Values: **Latch Command OFF**
Latch Command ON
MSID(s): V53X0783E - ACTUATION OF CAPTURE LATCH DRIVE

OMS_RCS_Stat Alarm Panel

Built 04/01/96 by J.L. Williams

Tested 04/11/96 by J.L. Williams

MM 201 AUTO	X
OMS OFF	Y
ENG SEL +X RCS	Z
RCS L FU.OX % 87.85	PITCH
RCS R FU.OX % 87.85	ROLL
RCS F FU.OX % 37.36	YAW

1,1. OPS/MM CONTROL

Meaning: If in OPS 2, indicates the active major mode (201, 202) and the active DAP control (AUTO, INRTL, LVLH, FREE).

Possible Values: **MM 202 AUTO**
MM 202 INRTL
MM 202 LVLH
MM 202 FREE
MM 201 AUTO
MM 201 INRTL
MM 201 LVLH
MM 201 FREE
NOT OPS 2

MSID(s): V72X2850X - FWD DAP AUTO (LIGHT)
V72X2849X - FWD DAP MAN INRTL (LIGHT)
V72X2868X - FWD MANUAL LVLH (LIGHT)
V72X2897X - FWD FREE DRIFT MODE (LIGHT)
V90Q8001C - MAJOR MODE CODE

2,1. OMS FIRING

Meaning: Indicates if either or both OMS engine(s) is firing.

Possible Values: **BOTH OMS**
LEFT OMS
RIGHT OMS
OMS OFF

MSID(s): V43K4583X - OMS-L ENG CONTROL VLV 1 COIL 1 OP
V43K5583X - OMS-R ENG CONTROL VLV 1 COIL 1 OP

3.1. ENGINE SELECT

Meaning: Indicates the engine selected per entry into ORBIT MNVR EXEC 201 ITEMS 1-4.

Possible Values: **ENG SEL BOTH OMS**
ENG SEL LEFT OMS
ENG SEL RIGHT OMS
ENG SEL +X RCS
ENG SEL UNKNOWN

MSID(s): V94J3791C - PRIME PROP SYS INDICATOR FLAG

4.1. RCS FUEL/OX LEFT

Meaning: Displays the percentage of fuel and oxidizer remaining in the left tank in a format FU.OX where FU=fuel and OX=oxidizer.

Possible Values: **RCS L FU.OX %** - fuel percentage to left of decimal, ox to right

MSID(s): V72Q1375C - RCS-L AFT FU QUANTITY
V72Q1374C - RCS-L AFT OX QUANTITY

5.1. RCS FUEL/OX RIGHT

Meaning: Displays the percentage of fuel and oxidizer remaining in the right tank in a format FU.OX where FU=fuel and OX=oxidizer.

Possible Values: **RCS R FU.OX %** - fuel percentage to left of decimal, ox to right

MSID(s): V72Q1379C - RCS-R AFT FU QUANTITY
V72Q1378C - RCS-R AFT OX QUANTITY

6.1. RCS FUEL/OX FWD

Meaning: Displays the percentage of fuel and oxidizer remaining in the fwd tank in a format FU.OX where FU=fuel and OX=oxidizer.

Possible Values: **RCS F FU.OX %** - fuel percentage to left of decimal, ox to right

MSID(s): V72Q1371C - RCS FWD FU QUANTITY
V72Q1370C - RCS FWD OX QUANTITY

1.2. TRANS X

Meaning: Indicates RCS jet activity in the +/-X direction based upon jet chamber pressures.

Possible Values: **+X FIRING**
-X FIRING

X - neutral state

MSID(s): T_POS_X - LOCI comp based on +X jet chamber pressures
T_NEG_X - LOCI comp based on -X jet chamber pressures

2.2. TRANS Y

Meaning: Indicates RCS jet activity in the +/-Y direction based upon jet chamber pressures.

Possible Values: **+Y FIRING**
-Y FIRING

Y - neutral state

MSID(s): T_POS_Y - LOCI comp based on +Y jet chamber pressures
T_NEG_Y - LOCI comp based on -Y jet chamber pressures

3.2. TRANS Z

Meaning: Indicates RCS jet activity in the +/-Z direction based upon jet chamber pressures.

Possible Values: **HI Z FIRING!**
LO Z FIRING
+Z FIRING
-Z FIRING

Z - neutral state

MSID(s): T_HI_POS_Z - LOCI comp based on HI Z jet chamber pressures
T_LOW_POS_Z - LOCI comp based on LO Z jet chamber pressures
T_POS_Z - LOCI comp based on +Z jet chamber pressures
T_NEG_Z - LOCI comp based on -Z jet chamber pressures

4.2. ROT PITCH

Meaning: Indicates RCS jet activity in the +/-pitch direction based upon jet chamber pressures.

Possible Values: **PRI +PIT FIRING**
PRI -PIT FIRING
VERN +PIT FIRING
VERN -PIT FIRING
LO Z ATT +PIT FIRING
LO Z ATT -PIT FIRING
PITCH - neutral state

MSID(s): R_POS_PITCH - LOCI comp based on +pitch pri jet chamber pressures
R_NEG_PITCH - LOCI comp based on -pitch pri jet chamber pressures
V_POS_PITCH - LOCI comp based on +pitch vernier jet chamber pressures
V_NEG_PITCH - LOCI comp based on -pitch vernier jet chamber pressures
Z_POS_PITCH - LOCI comp based on +pitch LO Z attitude pri jet chamber pressures
Z_NEG_PITCH - LOCI comp based on -pitch LO Z attitude pri jet chamber pressures

5.2. ROT ROLL

Meaning: Indicates RCS jet activity in the +/-roll direction based upon jet chamber pressures.

Possible Values: **PRI +ROLL FIRING**
PRI -ROLL FIRING
VERN +ROLL FIRING
VERN -ROLL FIRING
LO Z ATT +ROLL FIRING
LO Z ATT -ROLL FIRING
ROLL - neutral state

MSID(s): R_POS_ROLL - LOCI comp based on +roll pri jet chamber pressures
R_NEG_ROLL - LOCI comp based on -roll pri jet chamber pressures
V_POS_ROLL - LOCI comp based on +roll vernier jet chamber pressures
V_NEG_ROLL - LOCI comp based on -roll vernier jet chamber pressures
Z_POS_ROLL - LOCI comp based on +roll LO Z attitude pri jet chamber pressures
Z_NEG_ROLL - LOCI comp based on -roll LO Z attitude pri jet chamber pressures

6.2. ROT YAW

Meaning: Indicates RCS jet activity in the +/-ya direction based upon jet chamber pressures.

Possible Values: **PRI +YAW FIRING**
PRI -YAW FIRING
VERN +YAW FIRING
VERN -YAW FIRING
YAW - neutral state

MSID(s): R_POS_YAW - LOCI comp based on +yaw pri jet chamber pressures
R_NEG_YAW - LOCI comp based on -yaw pri jet chamber pressures
V_POS_YAW - LOCI comp based on +yaw vernier jet chamber pressures
V_NEG_YAW - LOCI comp based on -yaw vernier jet chamber pressures

REL_NAV_33 Alarm Panel

Built 02/03/94 by J.L. Williams

Tested 02/03/94 thru 02/07/94 by J.L. Williams

Revision A Built and Tested 04/11/96 by J.L. Williams and T.G. Miller

Revision B Built and Tested 10/31/97 by J.L. Williams

RNDZ NAV ENABLED	SV UPDATE 64	RR RNG ZERO	GPC ACQ
KU ANT NOT ENABLED	F-P 2470	RR RDOT 0.000	Ku MODE COMM
MEAS ENA OFF	COVAR STATUS	RR EL -36.56	RR OUTPUT LO
SV SEL FLTR	ONAV RNG 243804.5 FT	RR AZ -87.80	SIGNAL -91.9
COAS X -0.48	E3-1 GRNG 630385.1 FT	RR wP 0.00	RR RNG AUTO
COAS Y -0.87	E4-1 GRNG 630385.1 FT	RR wR 0.00	RR WARN
ANG SEL S TRK	DV COUNT 22	STRK ANGLES DATA GOOD	COAS ANGLES NO DG IND
RNG RESID 0.000	RNG RATIO 0.000	RNG INH 0 marks	X (DNT) F-P -2271 FT
RDOT RESID 0.000	RDOT RATIO 0.000	RDOT INH 0 marks	Y (OOP) F-P -467 FT
VEL/Y RESID -0.003	VEL/Y RATIO 0.008	ANG AUTO 101 marks	Z (RAD) F-P 879 FT
H/AZ/X RESID 0.002	H/AZ/X RATIO 0.006	RATIOS NORMAL	MARK OK
RR RANGE NO DG IND	RR RNG RATE NO DG IND	RR ANGLES NO DG IND	RR ANG RATES NO DG IND

1,1. RNDZ NAV

Meaning: Indicates whether RNDZ NAV is enabled or disabled per entry into SPEC 33 ITEM 1. Will indicate for 1 cycle if RNDZ NAV state changes from ENA to DIS. Finally, indicates if UNIV PTG has TGT TRK selected and RNDZ NAV not enabled.

Possible Values: **RNDZ NAV ENABLED**
RNDZ NAV NOT ENABLED
RNDZ NAV JUST DISABLED - displayed for 1 cycle when transition from ENABLED to DISABLED occurs, then reverts to **RNDZ NAV NOT ENABLED**
RNAV DIS & TGT ID = 1

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
V93U6810C - TGT VECTOR ID

Note: This field combines the functionality of two former fields.

2,1. KU ANT

Meaning: Indicates whether Ku antenna enable flag is set per entry in SPEC 33 ITEM 2

Possible Values: **KU ANT ENABLED**
KU ANT NOT ENABLED

MSID(s): V93X6859X - KU ANTENNA ENA/INH CMD

3,1. MEAS ENA

Meaning: Indicates whether MEAS_ENABLE flag is set per entry in SPEC 33 ITEM 3

Possible Values: **MEAS ENA ON**
MEAS ENA OFF

MSID(s): V90X1417X - NAV MEASUREMENT ENABLE IND

4,1. SV SEL

Meaning: Indicates whether the PROP or FLTR vector is selected per entry in SPEC 33 ITEM 4 and also indicates if any vector transfers are commanded per entry in SPEC 33 ITEM 8 thru ITEM 11. Selected vector transfer appears for 1-2 seconds, then reverts to the PROP/FLTR selection.

Possible Values: **SV SEL PROP** - true if PROP vector selected
SV SEL FLTR - true if FLTR vector selected
FLTR TO PROP - SPEC 33 ITEM 8 selected.
PROP TO FLTR - SPEC 33 ITEM 9 selected.
ORB TO TGT - SPEC 33 ITEM 10 selected.
TGT TO ORB - SPEC 33 ITEM 11 selected.

MSID(s): V90X4986X - POS FDBK UPP SOURCE FLAG
V90X4984X - POS FDBK FLTRD TO PROP FLAG
V90X4985X - POS FDBK PROP TO FLTRD FLAG
V90X1413X - ORBITER TO TARGET SV IND
V90X1414X - TARGET TO ORBITER SV IND

5,1. COAS X

Meaning: Displays where in the COAS X direction the TGT should be based on -Z S TRK measurements.

Possible Values: **COAS X** in deg displayed to 2 digits after decimal point
MSID(s): V95H4940C - VERTICAL OFFSET OF -Z COAS IND

6,1. COAS Y

Meaning: Displays where in the COAS Y direction the TGT should be based on -Z S TRK measurements.

Possible Values: **COAS Y** in deg displayed to 2 digits after decimal point

MSID(s): V95H4941C - HORIZ OFFSET OF -Z COAS IND

7,1. ANG SEL

Meaning: Indicates the angle source selected for incorporation into RNDZ NAV per entry in SPEC 33 ITEM 12 thru ITEM 14. Also indicates if there is a mismatch between the ANG SEL and the Ku ANT ENA state indicated per SPEC 33 ITEM 2.

Possible Values: **ANG SEL S TRK**
ANG SEL RR
ANG SEL COAS
ANG SEL RR & Ku ANT NT ENA
ANG SEL STRK & Ku ANT ENA

MSID(s): V90J1416C - ST/RR/COAS DATA SEL IND
V93X6859X - KU ANTENNA ENA/INH CMD

8,1. RNG RESID

Meaning: Displays the range residual computed by RNDZ NAV.

Possible Values: **RNG RESID** in kft displayed to 3 digits after decimal point

MSID(s): V90H0221C - BARO ALT/RR RNG MEAS RESIDUAL

9,1. RDOT RESID

Meaning: Displays the range rate residual computed by RNDZ NAV.

Possible Values: **RDOT RESID** in ft/s displayed to 3 digits after decimal point

MSID(s): V90A0711C - DRAG ALT/RR R DOT MEAS RESIDUAL

10,1. V/EL/Y RESID

Meaning: Displays the Vertical (S TRK), Trunnion (RR), or Y (COAS) angle residual computed by RNDZ NAV per the selected angle source.

Possible Values: **V/EL/Y RESID** in deg displayed to 3 digits after decimal point

MSID(s): V90H0214C - TAC R/OPTICS V/Y/EL MEAS RESIDUAL SPECIAL

11,1. H/AZ/X RESID

Meaning: Displays the Horizontal (S TRK), Shaft (RR), or X (COAS) angle residual computed by RNDZ NAV per the selected angle source.

Possible Values: **H/AZ/X RESID** in deg displayed to 3 digits after decimal point

MSID(s): LC_AZRESID - derived from V90H0212C - TAC AZ/OPTICS H/X/AZ MEAS RESIDUAL SPECIAL after converting from rad to deg

12,1. RR RANGE DATA GOOD

Meaning: Data good indicator for range data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.

Possible Values: **RR RANGE DATA GOOD**
RR RANGE LOST DGs
RR RANGE NO DG IND

MSID(s): V74X2615J - KU-A CH1 RANGE DATA GOOD (R)WD2B14

1.2. SV UPDATE

Meaning: Displays the magnitude of the last RNDZ NAV sensor position update made to the FLTR vector.

Possible Values: **SV UPDATE** in ft displayed to the nearest foot with color state limit thresholds set at 10 and 50 feet

MSID(s): V90H4999C - RSS FLTR CORRECTION POS

2.2. F-P

Meaning: Displays the RSS position difference between the FLTR and PROP state vectors.

Possible Values: **F-P** in ft displayed to the nearest foot

MSID(s): V90H4997C - RSS FLTR MINUS PROP POS

3.2. COVAR

Meaning: Displays the value of the RSS of the 1,1 2,2 and 3,3 covariance matrix elements and indicates if a COVAR REINIT has been issued per entry in SPEC 33 ITEM 16.

Possible Values: **COVAR RSS** displayed to zero digits after the decimal point
COVAR REINIT - SPEC 33 ITEM 16 issued.

MSID(s): V90U4006C - COVARIANCE MATRIX ELEMENT 1,1
V90U4027C - COVARIANCE MATRIX ELEMENT 2,2
V90U4047C - COVARIANCE MATRIX ELEMENT 3,3
V90X1415X - COVAR MATRIX REINIT IN PROG FLAG

4.2. ONAV RANGE

Meaning: If RNDZ NAV is enabled, displays the range between the chaser and target based upon onboard vectors.

Possible Values: **ONAV RNG** in ft displayed to 1 digit after decimal point

ONAV RNG N/A - if RNDZ NAV is not enabled

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
LC_LVRFY - X-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry
LC_LVRFY - Y-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry
LC_LVRFZ - Z-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry

5.2. E3-E1 GRNG

Meaning: Displays the range between the chaser and target based upon the contents of ephemerides 3 (target) and 1 (chaser).

Possible Values: **E3-1 GRNG** in ft displayed to 1 digit after decimal point

MSID(s): EPH1_M50_X - M50 X-component of ephemeris 1
EPH1_M50_Y - M50 Y-component of ephemeris 1
EPH1_M50_Z - M50 Z-component of ephemeris 1
EPH3_M50_X - M50 X-component of ephemeris 3
EPH3_M50_Y - M50 Y-component of ephemeris 3
EPH3_M50_Z - M50 Z-component of ephemeris 3

6.2. E4-E1 GRNG

Meaning: Displays the range between the chaser and target based upon the contents of ephemerides 4 (target) and 1 (chaser).

Possible Values: **E4-1 GRNG** in ft displayed to 1 digit after decimal point

MSID(s): EPH1_M50_X - M50 X-component of ephemeris 1
EPH1_M50_Y - M50 Y-component of ephemeris 1
EPH1_M50_Z - M50 Z-component of ephemeris 1
EPH4_M50_X - M50 X-component of ephemeris 4
EPH4_M50_Y - M50 Y-component of ephemeris 4
EPH4_M50_Z - M50 Z-component of ephemeris 4

7.2. DV COUNT

Meaning: Displays the current value in the delta-V counter. Displays a color state change for 1 cycle when the value increments.

Possible Values: **DV COUNT** displayed as an integer

MSID(s): V90J5184C - NO. OF ACCUM DELTA VELOCITIES

8.2. RNG RATIO

Meaning: Displays the range residual ratio as computed by RNDZ NAV.

Possible Values: **RNG RATIO** displayed to 3 digits after decimal point

RNG RATIO HI color state limit threshold set at 0.300
MSID(s): V90U0222C - BARO ALT/RR RNG RESID RATIO

9.2. RDOT RATIO

Meaning: Displays the rdot residual ratio as computed by RNDZ NAV.

Possible Values: **RDOT RATIO** displayed to 3 digits after decimal point

RDOT RATIO HI color state limit threshold set at 0.300
MSID(s): V90U0713C - DRAG ALT/RR R DOT RESID RATIO

10.2. V/EL/Y RATIO

Meaning: Displays the Vertical (S TRK), Trunnion (RR), or Y (COAS) angle ratio computed by RNDZ NAV per the selected angle source.

Possible Values: **V/EL/Y RATIO** displayed to 3 digits after decimal point

V/EL/Y RAT HI color state limit threshold set at 0.300
MSID(s): V90U0217C - TAC R/OPTICS V/Y/EL RESID RATIO

11.2. H/AZ/X RATIO

Meaning: Displays the Horizontal (S TRK), Shaft (RR), or X (COAS) angle residual ratio computed by RNDZ NAV per the selected angle source.

Possible Values: **H/AZ/X RATIO** displayed to 3 digits after decimal point

H/AZ/X RAT HI color state limit threshold set at 0.300
MSID(s): V90U0216C - TAC AZ/OPTICS H/X/AZ RESID RATIO

12.2. RR RNG RATE DATA GOOD

Meaning: Data good indicator for range rate data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.

Possible Values: **RR RNG RATE DATA GOOD**

RR RNG RATE LOST DGs
RR RNG RATE NO DG IND
MSID(s): V74X2616J - KU-A CH1 RANGE RATE GOOD (R)WD2B15

-
- 1.3. RR RNG**
Meaning: Displays the line-of-sight raw range to the target.
Possible Values: **RR RNG** in ft displayed to 1 digit after decimal point
RR RNG ZERO
RNG > 135 kft color state limit threshold set at 135,000 ft
MSID(s): V74U2623J - KU-A CH 1 RDR RANGE BITS 01-23
- 2.3. RR RDOT**
Meaning: Displays the line-of-sight raw range rate to the target.
Possible Values: **RR RDOT** in ft/s displayed to 3 digits after decimal point with color state thresholds set to indicate opening or closing rates
MSID(s): V74R2621J - KU-A CH 1 RANGE RATE BITS 01-16WD5
- 3.3. RR EL**
Meaning: Displays the elevation angle of the Ku antenna relative to its null position pointing along the -Z body axis of the Orbiter. Positive elevation is towards the nose.
Possible Values: **RR EL** in deg displayed to 2 digits after decimal point with color state limit thresholds set to 5 and 30 deg
MSID(s): V74H2619J - KU-BAND A CH1 PITCH WORD 4 WD4
- 4.3. RR AZ**
Meaning: Displays the azimuth angle of the Ku antenna relative to its null position pointing along the -Z body axis of the Orbiter. Positive azimuth is towards the port wing.
Possible Values: **RR AZ** in deg displayed to 2 digits after decimal point with color state limit thresholds set to 5 and 30 deg
MSID(s): V74H2618J - KU-BAND A CH1 ROLL WORD 3 WD3
- 5.3. RR wP**
Meaning: Displays the elevation angle rate of the Ku antenna. Positive elevation rate is towards the nose.
Possible Values: **RR wP** in mrad/s displayed to 2 digits after decimal point
MSID(s): V74R2628J - KU BAND A CH 1 PITCH RATE WD10
- 6.3. RR wR**
Meaning: Displays the azimuth angle rate of the Ku antenna. Positive azimuth rate is towards the port wing.
Possible Values: **RR wR** in mrad/s displayed to 2 digits after decimal point
MSID(s): V74R2626J - KU BAND A CH 1 ROLL RATE WD9
- 7.3. STRK ANGLES DATA GOOD**
Meaning: Data good indicator for star tracker data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.
Possible Values: **STRK ANGLES DATA GOOD**
STRK ANGLES LOST DGs
STRK ANGLES NO DG IND
MSID(s): V90X4835X - SNAP STAR TRACKER DATA GOOD
-

8.3. RNG AIF/MARK

Meaning: Indicates the value of the AUTO, INHIBIT, FORCE (AIF) flag for the incorporation of range data into RNDZ NAV per entry into SPEC 33 ITEM 17, ITEM 18, and ITEM 19, along with the number of range marks incorporated into RNDZ NAV.

Possible Values: **RNG AUTO** with number of marks displayed as an integer
RNG INH with number of marks displayed as an integer
RNG FORCE with number of marks displayed as an integer

MSID(s): V90J1362C - RNDZ NAV RR RNGE AUTO/INH/FOR FLAG
V90J1400C - RR RNG MARKS ACCEPTED

Note: This field combines the functionality of two former fields.

9.3. RDOT AIF/MARK

Meaning: Indicates the value of the AUTO, INHIBIT, FORCE (AIF) flag for the incorporation of range rate data into RNDZ NAV per entry into SPEC 33 ITEM 20, ITEM 21, and ITEM 22, along with the number of range rate marks incorporated into RNDZ NAV.

Possible Values: **RDOT AUTO** with number of marks displayed as an integer
RDOT INH with number of marks displayed as an integer
RDOT FORCE with number of marks displayed as an integer

MSID(s): V90J1368C - RNDZ NAV RANGE RATE A/I/F FLAG
V90J1401C - RR R DOT MARKS ACCEPTED

Note: This field combines the functionality of two former fields.

10.3. ANGLE AIF/MARK

Meaning: Indicates the value of the AUTO, INHIBIT, FORCE (AIF) flag for the incorporation of the selected angle source data into RNDZ NAV per entry into SPEC 33 ITEM 23, 24, and 25, along with the number of angle marks incorporated into RNDZ NAV.

Possible Values: **ANG AUTO** with number of marks displayed as an integer
ANG INH with number of marks displayed as an integer
ANG FORCE with number of marks displayed as an integer

MSID(s): V90J1361C - RNDZ NAV ANGLE AUT/INH/FOR FLAG
V90J1403C - V/Y/EL ANGULAR MARKS ACCEPTED

Note: This field combines the functionality of two former fields.

11.3. RATIO CHECK

Meaning: Indicates if a high ratio is observed in any one of the RNDZ NAV data sources.

Possible Values: **HIGH RATIO** - displayed if any ratio exceeds 0.3
RATIOS NORMAL - neutral state

MSID(s): V90U0222C - BARO ALT/RR RNG RESID RATIO
V90U0713C - DRAG ALT/RR R DOT RESID RATIO
V90U0217C - TAC R/OPTICS V/Y/EL RESID RATIO
V90U0216C - TAC AZ/OPTICS H/X/AZ RESID RATIO

Note: This field was moved to this alarm panel from RNDZ_SUMMARY

12.3. RR ANGLES DATA GOOD

Meaning: Data good indicator for angular data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.

Possible Values: **RR ANGLES DATA GOOD**
RR ANGLES LOST DGs
RR ANGLES NO DG IND

MSID(s): V74X2590J - KU-A CH1 RDR ANG DATA GD (R)WD1B07

1.4. RR POINTING

Meaning: Indicates the current Ku antenna pointing mode selected on the rotary switch S7 on panel A1U.

Possible Values: **GPC ACQ**
GPC DESIG
AUTO TRK
MAN SLEW

MSID(s): V74X2584J - KU-A CH1 ANT STRG AUTO (CR) WD1B01
V74X2585J - KU-A CH1 ANT STRG GPC DES CRWD1B02
V74X2586J - KU-A CH1 ANT STRG GPC ACQ CRWD1B03

note: all 3 MSIDs above = FALSE means MAN SLEW

2.4. KU MODE

Meaning: Indicates the current Ku antenna mode selected.

Possible Values: **Ku MODE COMM**
Ku MODE RR PASV

MSID(s): V74S2420E - KU-BAND A RADAR PASSIVE MODE

3.4. RR OUTPUT

Meaning: Indicates the setting of the Ku antenna power output control switch, reflecting the maximum output power possible.

Possible Values: **RR OUTPUT LO**
RR OUTPUT MED
RR OUTPUT HI
RR OUTPUT MED & CLOSE - if RNG < 500 ft
RR OUTPUT HI & CLOSE - IF RNG < 500 ft

MSID(s): V74S2495E - KU-BAND A RADAR OUTPUT-MED
V74S24965E - KU-BAND A RADAR OUTPUT-HIGH
V74U2623J - KU-A CH 1 RDR RANGE BITS 01-23

note: MED and HI MSIDs above both = FALSE means RR OUTPUT LO

4.4. SIGNAL

Meaning: Displays the return signal strength to the Ku antenna.

Possible Values: **SIGNAL** in dBm displayed to 1 digit after decimal point
MSID(s): V74E2508A - KU-BND A RDR/COMM RCVD SIG STR-AGC

5.4. RR RNG MODE

Meaning: Indicates the mode of the automatic range and angle search setting of the Ku antenna per entry in SM 201 ANTENNA ITEM 1 and ITEM 2; if a Ku self test is in progress, the field is overridden to indicate the status of Ku self test based on the Ku SELF TEST bit per entry in SM 201 ANTENNA ITEM 7 and the radar range.

Possible Values: **RR RNG AUTO**
RR RNG MIN
Ku SELF TEST IN PROGRESS - SM 201 ITEM 7 selected
Ku SELF TEST PASSED - all 8's in the range field
Ku SELF TEST FAILED - all 3's in the range field

MSID(s): V93X5641X - ANTENNA-RADAR RANGE ESTIMATE-MIN
V74X2592J - KU-A CH1 RDR STST IN PROG(R)WD1B09
V74U2623J - KU-A CH 1 RDR RANGE BITS 01-23

6.4. RR SEARCH

Meaning: Indicates the status of the Ku antenna search and track functions.

Possible Values: **RR TRACK** - tracking target or TDRS
RR DET - detected target or TDRS
RR SEARCH - searching for target or TDRS
RR LOST LOCK - not actively tracking or searching target in PASV mode
RR WARN - reached beta mask limit while in COMM mode
RR OK - not actively tracking or searching TDRS in COMM mode

MSID(s): V74S2420E - KU-BAND A RADAR PASSIVE MODE
V74X2601J - KU-A CH1 SEARCH (CR) WD2B00
V74X2602J - KU-A CH1 DETECT (CR) WD2B01
V74X2603J - KU-A CH1 TRACK (CR) WD2B02
V74X2614J - KU-A CH1 SCAN WARN LIMIT(CR) WD2B13

7.4. COAS ANGLES DATA GOOD

Meaning: Data good indicator for COAS data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.

Possible Values: **COAS ANGLES DATA GOOD**
COAS ANGLES LOST DGs
COAS ANGLES NO DG IND

MSID(s): V90X4849X - SNAP COAS ANGLE MEAS DATA GOOD

8.4. X (DOWNTRACK) UPDATE

Meaning: Displays the LVLH X-component difference between the FLTR and PROP vectors.

Possible Values: **X (DNT) F-P** in ft displayed as an integer

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
LC_LVRFX - LVLH X-component of TARGET minus FLTR vector computed by ROSS
LC_LVRPX - LVLH X-component of TARGET minus PROP vector computed by ROSS

9.4. Y (OUT-OF-PLANE) UPDATE

Meaning: Displays the LVLH Y-component difference between the FLTR and PROP vectors.

Possible Values: **Y (DOOPNT) F-P** in ft displayed as an integer

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
LC_LVRFY - LVLH Y-component of TARGET minus FLTR vector computed by ROSS
LC_LVRPY - LVLH Y-component of TARGET minus PROP vector computed by ROSS

10.4. Z (RADIAL) UPDATE

Meaning: Displays the LVLH Z-component difference between the FLTR and PROP vectors.

Possible Values: **Z (RAD) F-P** in ft displayed as an integer

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
LC_LVRFZ - LVLH Z-component of TARGET minus FLTR vector computed by ROSS
LC_LVRPZ - LVLH Z-component of TARGET minus PROP vector computed by ROSS

11.4. MARK REJECTED

Meaning: Indicates if any source of data is rejected by RNDZ NAV.

Possible Values: **MARK REJECTED**
MARK OK

MSID(s): V90X0223X - BARO ALT/RR RNG EDIT HIST IND
V90X0712X - DRAG ALT/RR R DOT EDIT HIST IND
V90X0215X - TAC R/OPTICS V/Y/EL EDIT HIST IND
V90X0213X - TAC AZ/OPTICS H/X/AZ EDIT HIST IND

note: If any of the above MSIDs is TRUE, the MARK REJECTED state will appear.

12.4. RR ANG RATES DATA GOOD

Meaning: Data good indicator for angular rate data. Will indicate LOST DGs for 1 cycle if state changes from GOOD to NO GOOD.

Possible Values: **RR ANG RATES DATA GOOD**
RR ANG RATES LOST DGs
RR ANG RATES NO DG IND

MSID(s): V74X2591J - KU-A CH1 RDR ANG RT DG (R) WD1B08

RNDZ_SUMMARY Alarm Panel

(Based on DEFAULT and NEW_CONFIG Alarm Panels)

Original Built 08/01/93 by C.K. Meyer and D.G. Hamm

Tested 08/01/93 by D.G. Hamm

RNDZ_Summary Built and Tested 04/11/96 by J.L. Williams

Revision A Built and Tested 10/31/97 by J.L. Williams

RNAV ENABLED	IMU OKAY	ROT MNVR IN PROGRESS	TRANS NOMINAL
TGT TRK OKAY	Range 8.05 NM	Range Rate 4.05 ft/s	TIG SLIP LIM
-Z SENSE	NAV Range 8.05 NM	MARK OK	MANEUVER MISMATCH
Y NODE 30:37	X Fit -8.05 NM	RATIOS NORMAL	MNVR DIFF 21.00
STRK TGT TRACK	Z Fit -0.08 NM	VECTOR XFER	TIG Alarm
NOM ANG RESIDS	DATA TO NAV	MM 201 AUTO	FREE DRIFT DISABLED

1.1. RNDZ NAV

Meaning: Indicates whether RNDZ NAV is enabled or disabled per entry into SPEC 33 ITEM 1.

Possible Values: **RNDZ NAV ENABLED**
RNDZ NAV DISABLED

MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG

notes: Similar to REL_NAV_33 Alarm Panel location 1,1. Does not indicate state change from ENA to DIS, nor indicates TGT TRK with RNDZ NAV not enabled.

2.1. OPS/MM CONTROL

Meaning: If in OPS 2, indicates the active major mode (201, 202) and the active DAP control mode (AUTO, INRTL, LVLH, FREE). If not in OPS 2, displays the active major mode only.

Possible Values: **MM 202 AUTO**
MM 202 INRTL
MM 202 LVLH
MM 202 FREE
MM 201 AUTO
MM 201 INRTL
MM 201 LVLH
MM 201 FREE

MSID(s): **MM** displayed as an integer if not 201 or 202
V72X2850X - FWD DAP AUTO (LIGHT)
V72X2849X - FWD DAP MAN INRTL (LIGHT)
V72X2868X - FWD MANUAL LVLH (LIGHT)
V72X2897X - FWD FREE DRIFT MODE (LIGHT)
V90Q8001C - MAJOR MODE CODE

3.1. ENGINE SELECT

Meaning: Indicates the engine selected per entry into ORBIT MNVR EXEC 202 ITEMS 1-4

Possible Values: **ENG SEL Both OMS**
ENG SEL Left OMS
ENG SEL Right OMS
ENG SEL +X RCS
ENG SEL UNKNOWN

MSID(s): V94J3791C - PRIME PROP SYS INDICATOR FLAG

4.1. OMS FIRING

Meaning: Indicates if either or both OMS engine(s) is firing.

Possible Values: **BOTH OMS Burning**
LEFT OMS Burning
RIGHT OMS Burning
OMS Engines OFF

MSID(s): V43K4583X - OMS-L ENG CONTROL VLV 1 COIL 1 OP
V43K5583X - OMS-R ENG CONTROL VLV 1 COIL 1 OP

5.1. RCS TRANS

Meaning: Indicates if an RCS translational firing is in progress.

Possible Values: **RCS Trans in progress**
RCS Trans OFF - default state

MSID(s): T_POS_X - +X translation computed by ROSS
T_NEG_X - -X translation computed by ROSS
T_POS_Y - +Y translation computed by ROSS
T_NEG_Y - -Y translation computed by ROSS
T_POS_Z - +Z translation computed by ROSS
T_NEG_Z - -Z translation computed by ROSS
T_POS_LO_Z - LOW Z +Z translation computed by ROSS
T_POS_HI_Z - HI Z +Z translation computed by ROSS

6.1. TFL

Meaning: Displays the current Telemetry Format Load (TFL) selected on the Orbiter
Possible Values: **TFL** displayed as an integer between 0-255
MSID(s): V75X4070D - ORBITER TELEMETRY FORMAT LOAD NUMBER

1.2. KU MODE

Meaning: Indicates the current Ku antenna mode selected.
Possible Values: **Ku MODE COMM**
Ku MODE RR PASV
MSID(s): V74S2420E - KU-BAND A RADAR PASSIVE MODE

2.2. RR RNG

Meaning: Displays the line-of-sight GNC range to the target.
Possible Values: **RR Range** in ft displayed to 1 digit after decimal point
RR Range Not Available - if radar is not in PASV mode
MSID(s): V74S2420E - KU-BAND A RADAR PASSIVE MODE
V90U4895C - SNAP RR RANGE MEAS
notes: Driven from GNC data. The RR Range displayed on the REL_NAV_33 Alarm Panel is driven from SM data.

3.2. ONAV RNG

Meaning: If RNDZ NAV is enabled, displays the line-of-sight navigated range to the target based upon an RSS of the vector difference between the FLTR and the TGT vectors.
Possible Values: **ONAV RNG** in ft displayed to 1 digit after decimal point
ONAV RNG Not Available - if RNDZ NAV is not enabled
MSID(s): V90X4765X - RNDZ NAV ACTIVE FLAG
LC_LVRFY - X-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry
LC_LVRFY - Y-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry
LC_LVRFZ - Z-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry

4.2. GND RANGE

Meaning: Displays the range between the chaser and target based upon the contents of ephemerides 3 (target) and 1 (chaser).
Possible Values: **GND FINAV Range** value in ft displayed to 1 digit after decimal point.
MSID(s): EPH1_M50_X - M50 X-component of ephemeris 1.
EPH1_M50_Y - M50 Y-component of ephemeris 1
EPH1_M50_Z - M50 Z-component of ephemeris 1
EPH3_M50_X - M50 X-component of ephemeris 3
EPH3_M50_Y - M50 Y-component of ephemeris 3
EPH3_M50_Z - M50 Z-component of ephemeris 3

5.2. TCS INTERFACE RANGE

Meaning: Displays the interface-to-interface range based upon data from TCS to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.
Possible Values: **TCS IF Range** value in ft displayed to 2 digits after decimal point.
MSID(s): TC_TCS2IR - Orbiter to target docking interface range using TCS 2 as computed by VPOP

6.2. OI/GNC/SM DFL

Meaning: Displays the current OI/GNC and SM Decom Format Loads (DFL) selected on the Orbiter.

Possible Values: **GNC.SM DFL** displayed as XX.YY, where XX=OI/GNC DFL, YY=SM DFL
MSID(s): V93Q0022CX - ORBITER OI/GNC DECOM FORMAT LOAD NUMBER
V93Q0022CY - ORBITER SM DECOM FORMAT LOAD NUMBER

1.3. TRANS NOMINAL

Meaning: Indicates if a FWD THC deflection occurs while in FREE DRIFT

Possible Values: **TRANS in FREE**
TRANS NOMINAL

MSID(s): V72X2897X - FWD FREE DRIFT MODE (LIGHT)
V90X7694X - SEL FWD THC NEG X OUTPUT
V90X7695X - SEL FWD THC NEG Y OUTPUT
V90X7696X - SEL FWD THC NEG Z OUTPUT
V90X7697X - SEL FWD THC POS X OUTPUT
V90X7698X - SEL FWD THC POS Y OUTPUT
V90X7699X - SEL FWD THC POS Z OUTPUT

2.3. RR RDOT

Meaning: Displays the line-of-sight GNC range rate to the target.

Possible Values: **RR Range Rate** in ft/s displayed to 3 digits after decimal point

MSID(s): V90U4896C - SNAP RR RANGE RATE MEAS
notes: Driven from GNC data. Similar to REL_NAV_33 Alarm Panel location 2,3 except that data source is GNC instead of SM.

3.3. ONBOARD NAV STATUS

Meaning: Indicates if any source of data is rejected by RNDZ NAV or if a high ratio value occurs.

Possible Values: **MARK REJECTED**
HIGH RATIO

MSID(s): **Onboard NAV OK** - neutral state
V90X0223X - BARO ALT/RR RNG EDIT HIST IND
V90X0712X - DRAG ALT/RR R DOT EDIT HIST IND
V90X0215X - TAC R/OPTICS V/Y/EL EDIT HIST IND
V90X0213X - TAC AZ/OPTICS H/X/AZ EDIT HIST IND
V90U0222C - BARO ALT/RR RNG RESID RATIO
V90U0713C - DRAG ALT/RR R DOT RESID RATIO
V90U0217C - TAC R/OPTICS V/Y/EL RESID RATIO
V90U0216C - TAC AZ/OPTICS H/X/AZ RESID RATIO

Note: This field combines the functionality of two former fields.

4.3. DATA TO NAV STATUS

Meaning: Indicates if any good data is being incorporated into RNDZ NAV. Good data is defined as the DATA GOOD flag is true and the AIF flag is set to AUTO.

Possible Values: **NO DATA TO NAV**
Radar Data to NAV
S TRK Data to NAV
COAS Data to NAV

MSID(s): V90X4835X - SNAP STAR TRACKER DATA GOOD
V90X4849X - SNAP COAS ANGLE MEAS DATA GOOD
V90X4866X - IND RR TO BE PROC BY FILTER
V90X4868X - IND ST TO BE PROC BY FILTER
V90X4880X - IND COAS TO BE PROC BY FILTER
V90X4899X - SNAP RR RANGE DATA GOOD
V90X4900X - SNAP RR RNG RATE DATA GOOD
V90X4901X - SNAP RR ANGLES DATA GOOD
V90J1361C - RNDZ NAV ANGLE AUT/INH/FOR FLAG
V90J1362C - RNDZ NAV RR RNG AUT/INH/FOR FLAG
V90J1368C - RNDZ NAV RANGE RATE A/I/F FLAG

5.3. TCS INTERFACE RANGE RATE

Meaning: Displays the interface-to-interface range rate based on data from TCS 1 to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.

Possible Values: **TCS IF Range Rate** value in ft/s displayed to 2 digits after decimal point.

MSID(s): TC_TCS2IRD - Orbiter to target docking interface rdot using TCS 2 as computed by VPOP

6.3. DAY/NIGHT INDICATOR

Meaning: Indicates whether the Orbiter is in daylight or darkness.

Possible Values: **DAY** - displayed if time to SR > SS
NIGHT - displayed if time to SS > SR

MSID(s): TC_SUNRIS - supplied by VPOP
TC_SUNSET - supplied by VPOP

1.4. ATTITUDE CONTROL STATUS

Meaning: Indicates if an Orbiter rotation maneuver is in progress (a maneuver in progress is defined as the RSS of the body rates exceeding 0.1 deg/s) or if the Orbiter is in FREE DRIFT.

Possible Values: **FREE DRIFT** elapsed time displayed in DDD/HH:MM:SS if in DAP:FREE
ROT MNVR IN PROGRESS - displayed if not in DAP:FREE and if the RSS of the body rates > 0.1 deg/s

MSID(s): **Attitude Hold OK** - neutral state
V72X2897X - FWD FREE DRIFT MODE (LIGHT)
LC_DRFTIME - Elapsed time in free drift as observed by ROSS
V95R7476C - IMU BODY RATE AROUND X-AXIS
V95R7477C - IMU BODY RATE AROUND Y-AXIS
V95R7487C - IMU BODY RATE AROUND Z-AXIS

Note: This field combines the functionality of two former fields.

2.4. SV STATUS

Meaning: Indicates whether the PROP or FLTR vector is selected per entry in SPEC 33 ITEM 4 and also indicates if any vector transfers are commanded per entry in SPEC 33 ITEM 8 thru ITEM 11. Selected vector transfer appears for 1-2 seconds, then reverts to the PROP/FLTR selection.

Possible Values: **SV SEL PROP** - true if PROP vector selected
SV SEL FLTR - true if FLTR vector selected
FLTR TO PROP - SPEC 33 ITEM 8 selected.
PROP TO FLTR - SPEC 33 ITEM 9 selected.
ORB TO TGT - SPEC 33 ITEM 10 selected.
TGT TO ORB - SPEC 33 ITEM 11 selected.

MSID(s): V90X4986X - POS FDBK UPP SOURCE FLAG
V90X4984X - POS FDBK FLTRD TO PROP FLAG
V90X4985X - POS FDBK PROP TO FLTRD FLAG
V90X1413X - ORBITER TO TARGET SV IND
V90X1414X - TARGET TO ORBITER SV IND

3.4. MNVR VIEW

Meaning: Displays the current selected onboard TGT Set number

Possible Values: **Targeting NCC** - TGT Sets 9 or 29.
Targeting Ti - TGT Sets 10 or 30.
Targeting MC1 - TGT Sets 11 or 31.
Targeting MC2 on EL - TGT Sets 12 or 32.
Targeting MC2 on TIME - TGT Set 19.
Targeting MC3 - TGT Sets 13 or 33.
Targeting MC4 - TGT Sets 14 or 34.
No Onboard Targeting - displayed if TGT set is 0.

MSID(s): **MNVR ID** value displayed as an integer for any other TGT Set
V95J7466C - MNVR TGT NO COMPUTED

4.4. GUIDANCE MODE

Meaning: Displays the current active guidance mode on the Orbiter

Possible Values: **EXT DV**
LAMBERT with next computed Lambert burn TIG displayed in DDD/HH:MM:SS MET

MSID(s): V94X4029X - GUIDANCE MODE FLAG
LC_ORBTIG - onboard-computed burn TIG PET in sec
PET_OFFSET - ROSS conversion from PET to MET

5.4. GNC TIMER

Meaning: Displays the countdown time to the next LOAded burn TIG in MM 202. If the burn was missed, displays time after nominal TIG.

Possible Values: **202 GNC TIMER** countdown/up clock displayed in MM:SS with color state limits set to 5 min before, 2 min before, at TIG, and 1 min after (for late burns).

MSID(s): V90Q8001C - MAJOR MODE CODE
V94W3790C - TIME OF IGNITION
LC_F22GMT - Current GMT in sec

6.4. GMT LIFTOFF

Meaning: Displays the GMT of liftoff.

Possible Values: **GMT Lift-off** value displayed in DDD/HH:MM:SS

MSID(s): LAUNCH_GMT - Liftoff GMT obtained by ROSS from the MOC

TCS_INFO Alarm Panel

(Based upon TCS2_NEW Alarm Panel)

Original Built and Tested 02/15/96 by D.G. Hamm

TCS_INFO Built and Tested 12/01/97 by P.T. Snow

Raw Range 0.00 (ft)	IF Range 0.00 (ft)	Raw Elevation 0.0 (deg)	IF EL 0.0 (deg)
Raw Range Rate 0.00 (ft/s)	IF Range Rate Station Keep	Raw Azimuth 0.0 (deg)	IF AZ 0.0 (deg)
PDI DECOM GMT 0/00:00:00	PDI DECOM MET 0/00:00:00	DAP A A0	DAP B B0

1.1. RAW RANGE

Meaning: Displays the raw range from TCS 2 to whichever reflector it is tracking.
Possible Values: **Raw Range** value in ft displayed to 2 digits after decimal point
MSID(s): TC_TCS2RNG - Downlisted range in feet from TCS 2 as processed by VPOP

2.1. RAW RANGE RATE

Meaning: Displays the raw range rate from TCS 2 to whichever reflector it is tracking.
Possible Values: **Raw Range Rate** value in ft/s displayed to 2 digits after decimal point
MSID(s): TC_TCS2RD - Downlisted range rate in feet per sec from TCS 2 as processed by VPOP

3.1. PDI DECOM MET

Meaning: Displays the Payload Data Interleaver (PDI) timestamp associated with the TCS measurements.
Possible Values: **PDI DECOM MET** value displayed in DDD/HH:MM:SS format.
MSID(s): P77W0002DP - PDI DECOM GMT DAY
P77W0003DP - PDI DECOM GMT HOUR
P77W0004DP - PDI DECOM GMT MINUTE
P77W0005DP - PDI DECOM GMT SECOND
LC_F22GMT - Onboard GMT in seconds as converted by ROSS Telemetry
LC_F22MET - Onboard MET in seconds as converted by ROSS Telemetry

1.2. INTERFACE RANGE

Meaning: Displays the interface-to-interface range based on data from TCS 2 to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.
Possible Values: **IF Range** value in ft displayed to 2 digits after decimal point
MSID(s): TC_TCS2IR - Orbiter to target docking interface range using TCS 2 as computed by VPOP

2.2. INTERFACE RANGE RATE

Meaning: Displays the interface-to-interface range rate based on data from TCS 2 to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.

Possible Values: **IF Range Rate** value in ft/s displayed to 2 digits after decimal point

MSID(s): TC_TCS2IRD - Orbiter to target docking interface rdot using TCS 2 as computed by VPOP

2.3. UNIT ID

Meaning: Displays the TCS number corresponding to a particular ID number.

Possible Values: **TCS 2 Unit ID value displayed as a TBD**

MSID(s): P78U0764D - DTCS UNIT ID NUMBER

1.3. RAW ELEVATION

Meaning: Displays the raw elevation angle from TCS 2 to whichever reflector it is tracking.

Possible Values: **Raw Elevation** value in deg displayed to 1 digit after decimal point.

MSID(s): TC_TCS2EL - Downlisted elevation in rad from TCS 2 as processed by VPOP

2.3. RAW AZIMUTH

Meaning: Displays the raw azimuth angle from TCS 2 to whichever reflector it is tracking.

Possible Values: **Raw Azimuth** value in deg displayed to 1 digit after decimal point.

MSID(s): TC_TCS2AZ - Downlisted azimuth in rad from TCS 2 as processed by VPOP

3.3. STATUS ID

Meaning: Displays the current status/mode of the TCS 2 laser.

Possible Values: **TCS2 Not Tracking**
TCS2 Tracking
TCS2 Reacquiring
TCS2 Standby (Not in range)
TCS2 Abort
TCS2 Autosafe
TCS2 First Acq
Unrecognized TCS2 Mode

MSID(s): P78U0151D - SW STATUS: MODE (3 BITS) WORD 15

1.4. INTERFACE ELEVATION

Meaning: Displays the interface-to-interface elevation angle based on data from TCS 2 to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.

Possible Values: **IF EL** value in deg displayed to 1 digit after decimal point.

MSID(s): TC_TCS2IEL - Orbiter to target docking interface elev using TCS 2 as computed by VPOP

2.4. RAW AZIMUTH

Meaning: Displays the interface-to-interface azimuth angle based on data from TCS 2 to whichever reflector it is tracking. Proper interface determination requires user intervention to define the reflector being tracked.

Possible Values: **IF AZ** value in deg displayed to 1 digit after decimal point.

MSID(s): TC_TCS2IAZ - Orbiter to target docking interface azi using TCS 2 as computed by VPOP

3.4. VPOP REFLECTOR

Meaning: Displays the reflector selected by the user for determining the conversion of TCS data from raw values to interface-to-interface values.

Possible Values: **VPOP Refl #1 PMA2 Planar**
VPOP Refl #2 PMA2 Hemi
VPOP Refl #3 FGB FWD Hemi
VPOP Refl #4 FGB Aft Hemi
VPOP Refl #5 PMA3 Planar
VPOP Refl #6 SM Aft
Unknown VPOP Reflector
VPOP UI NOT RUNNING

MSID(s): UI_T2TRKX - X-coordinate of the reflector selected by the user in the VPOP user interface.

Note: Currently uses the X-coordinate to determine which reflector was selected by the user. Obviously, this is valid on a flight-specific basis, and must be updated by the user for a different reflector configuration.

TGT_GNC_TIMER Alarm Panel

Built 12/15/95 by T.G. Miller

Tested 12/15/95 by T.G. Miller



1.1. GNC TIMER

Meaning: Displays the time until the next burn. If the burn was missed, displays time after nominal TIG.

Possible Values: **202 GNC Timer** countdown/up clock displayed in HH:MM:SS with color state limit thresholds set to 5 min before, 2 min before, at TIG, and 1 min after (for late burns).

MSID(s): V90Q8001C - MAJOR MODE CODE
V94W3790C - TIME OF IGNITION
LC_F22GMT - Current GMT in sec

1.2. DV TOT

Meaning: Displays the predicted RSS of the burn velocities of the targeted maneuver in Orbiter body coordinates.

Possible Values: **DV TOT** in ft/s displayed to 3 digits after decimal point

MSID(s): V94L3795C - TOTAL DELTA V REQD FOR MANEUVER

THC_RHC Alarm Panel

Built 02/03/94 by J.L. Williams

Tested 02/03/94 thru 02/07/94 by J.L. Williams

FWD THC X	AFT THC X
FWD THC Y	AFT THC Y
FWD THC Z	AFT THC Z
FLT CTL PWR OFF	AFT RHC PIT
-Z SENSE	AFT RHC ROLL
TRANS NOMINAL	AFT RHC YAW

1,1. FWD THC X

Meaning: Indicates if the FWD THC is deflected in the +/-X Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+X BODY**
-X BODY

MSID(s): **FWD THC X** - neutral state
V90X7697X - SEL FWD THC POS X OUTPUT
V90X7694X - SEL FWD THC NEG X OUTPUT

2,1. FWD THC Y

Meaning: Indicates if the FWD THC is deflected in the +/-Y Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+Y BODY**
-Y BODY

MSID(s): **FWD THC Y** - neutral state
V90X7698X - SEL FWD THC POS Y OUTPUT
V90X7695X - SEL FWD THC NEG Y OUTPUT

3,1. FWD THC Z

Meaning: Indicates if the FWD THC is deflected in the +/-Z Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+Z BODY**
-Z BODY

MSID(s): **FWD THC Z** - neutral state
V90X7699X - SEL FWD THC POS Z OUTPUT
V90X7696X - SEL FWD THC NEG Z OUTPUT

4.1. FLT CTL PWR

Meaning: Indicates the status of the FLT CTRLR PWR switch in both the FWD and AFT cockpits

Possible Values: **AFT FLT CTL PWR ON**
FWD FLT CTL PWR ON
F/A FLT CTL PWR ON
FLT CTL PWR OFF

MSID(s): V73X3001X - LH DDU PWR SPLY A GOOD
V73X3021X - AFT DDU PWR SPLY A GOOD

5.1. SENSE SWITCH

Meaning: Indicates the setting of the AFT cockpit sense switch.

Possible Values: **-X SENSE**
-Z SENSE

MSID(s): V72K5180X - SENSE SW -X CON A

6.1. TRANS NOMINAL

Meaning: Indicates if a FWD THC deflection occurs while in FREE DRIFT

Possible Values: **TRANS in FREE**
TRANS NOMINAL

MSID(s): V72X2897X - FWD FREE DRIFT MODE (LIGHT)
V90X7694X - SEL FWD THC NEG X OUTPUT
V90X7695X - SEL FWD THC NEG Y OUTPUT
V90X7696X - SEL FWD THC NEG Z OUTPUT
V90X7697X - SEL FWD THC POS X OUTPUT
V90X7698X - SEL FWD THC POS Y OUTPUT
V90X7699X - SEL FWD THC POS Z OUTPUT

1.2. AFT THC X

Meaning: Indicates if the AFT THC is deflected in the +/-X Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+X BODY**
-X BODY
AFT THC X - neutral state

MSID(s): V90X8139X - SEL AFT THC NEG Y OUTPUT
V90X8143X - SEL AFT THC POS Y OUTPUT

2.2. AFT THC Y

Meaning: Indicates if the AFT THC is deflected in the +/-Y Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+Y BODY**
-Y BODY
AFT THC Y - neutral state

MSID(s): V90X8140X - SEL AFT THC POS Z OUTPUT
V90X8141X - SEL AFT THC NEG Z OUTPUT

3.2. AFT THC Z

Meaning: Indicates if the AFT THC is deflected in the +/-Z Orbiter body direction. Direction is indicated for about 1 second, then reverts to a neutral state.

Possible Values: **+Z BODY**
-Z BODY
AFT THC Z - neutral state

MSID(s): V90X8145X - SEL AFT THC NEG X OUTPUT
V90X8136X - SEL AFT THC POS X OUTPUT

4.2. AFT RHC PIT

Meaning: Indicates if the AFT RHC is deflected in the +/-PITCH Orbiter body direction. Direction is indicated for at least 1 second, then reverts to a neutral state.

Possible Values: **+PITCH**
-PITCH
AFT RHC PIT - neutral state

MSID(s): V90H2538C - SELECTED AFT RHC PITCH CMD

5.2. AFT RHC ROLL

Meaning: Indicates if the AFT RHC is deflected in the +/-ROLL Orbiter body direction. Direction is indicated for at least 1 second, then reverts to a neutral state.

Possible Values: **+ROLL**
-ROLL
AFT RHC ROLL - neutral state

MSID(s): V90H2545C - SELECTED AFT RHC YAW CMD

Note: Original MSID is in RHC reference frame. For purposes of this field, it has been transformed to the Orbiter body reference frame.

6.2. AFT RHC YAW

Meaning: Indicates if the AFT RHC is deflected in the +/-YAW Orbiter body direction. Direction is indicated for at least 1 second, then reverts to a neutral state.

Possible Values: **+YAW**
-YAW
AFT RHC YAW - neutral state

MSID(s): V90H2542C - SELECTED AFT RHC ROLL CMD

Note: Original MSID is in RHC reference frame. For purposes of this field, it has been transformed to the Orbiter body reference frame.

TRAJECTORY_INFO Alarm Panel

Built 03/01/96 by D.G. Hamm

Tested 03/01/96 by D.G. Hamm

Revision A Built and Tested 04/11/96 by J.L. Williams

Sunrise	Noon	Sunset	Period
Altitude	Sun Pitch	Earth Pitch	HA
Beta Angle	Sun Yaw	Earth Yaw	HP
Inclination	Latitude	Longitude	Circ Velocity
Obd Rel X -8.03 nmi	Obd Rel Y 0.03 nmi	Obd Rel Z -0.09 nmi	NIGHT

1,1. SUNRISE

Meaning: Displays the time remaining until the next sunrise.

Possible Values: **Sunrise** value displayed in HMS with a color limit state set to change state at SR-10 min

MSID(s): TC_SUNRIS - supplied by VPOP

2,1. ALTITUDE

Meaning: Displays the orbital altitude.

Possible Values: **Altitude** value displayed in nmi to 2 digits after decimal point.

MSID(s): TC_ORBALT - supplied by VPOP

3,1. BETA ANGLE

Meaning: Displays the current beta angle.

Possible Values: **Beta Angle** value displayed in degrees to 2 digits after decimal point

MSID(s): TC_SBETA - supplied by VPOP

4,1. INCLINATION

Meaning: Displays the orbital inclination.

Possible Values: **Inclination** value displayed in degrees to 1 digit after decimal point.

MSID(s): TC_INCLIN - supplied by VPOP

5.1. ONBOARD RELATIVE X POSITION

Meaning: Displays the X-LVLH component of the relative vector between chaser and target.

Possible Values: **Obd Rel X** value displayed in nmi to 2 digits after decimal point.

MSID(s): LC_LVRFX - X-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry

1.2. NOON

Meaning: Displays the time remaining until the next noon.

Possible Values: **Noon** value displayed in HMS with a color state limit set to change state at N-10 min.

MSID(s): TC_ONOON - supplied by VPOP

2.2. SUN PITCH

Meaning: Displays the pointing vector pitch component of the line-of-sight vector to the sun.

Possible Values: **Sun Pitch** value displayed in degrees to 2 digits after decimal point.

MSID(s): TC_SUNPCH - supplied by VPOP

3.2. SUN YAW

Meaning: Displays the pointing vector yaw component of the line-of-sight vector to the sun.

Possible Values: **Sun Yaw** value displayed in degrees to 2 digits after decimal point.

MSID(s): TC_SUNYAW - supplied by VPOP

4.2. LATITUDE

Meaning: Displays the current latitude of the Orbiter.

Possible Values: **Latitude** value displayed in degrees to 1 digit after decimal point.

MSID(s): CUR_O_LAT - supplied by the MOC

5.2. ONBOARD RELATIVE Y POSITION

Meaning: Displays the Y-LVLH component of the relative vector between chaser and target.

Possible Values: **Obd Rel Y** value displayed in nmi to 2 digits after decimal point.

MSID(s): LC_LVRFY - Y-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry

1.3. SUNSET

Meaning: Displays the time remaining until the next sunset.

Possible Values: **Sunset** value displayed in HMS with color state limits set to change at SS-10, SS-5, and SS-2 min

MSID(s): TC_SUNSET - supplied by VPOP

2.3. EARTH PITCH

Meaning: Displays the pointing vector pitch component of the line-of-sight vector to the center of the earth.

Possible Values: **Earth Pitch** value displayed in degrees to 2 digits after decimal point

MSID(s): TC_EARPCH - supplied by VPOP

3.3. EARTH YAW

Meaning: Displays the pointing vector yaw component of the line-of-sight vector to the center of the earth.

Possible Values: **Earth Yaw** value displayed in degrees to 2 digits after decimal point

MSID(s): TC_EARYAW - supplied by VPOP

4.3. LONGITUDE

Meaning: Displays the current longitude of the Orbiter.

Possible Values: **Longitude** value displayed in degrees to 1 digit after decimal point

MSID(s): CUR_O_LON - supplied by the MOC

5.3. ONBOARD RELATIVE Z POSITION

Meaning: Displays the Z-LVLH component of the relative vector between chaser and target.

Possible Values: **Obd Rel Z** value displayed in nmi to 2 digits after decimal point

MSID(s): LC_LVRFZ - Z-LVLH component of TARGET minus FLTR vectors computed by ROSS Telemetry

1.4. PERIOD

Meaning: Displays the orbital period.

Possible Values: **Period** value displayed in HMS

MSID(s): TC_OETAU - supplied by VPOP

2.4. APOGEE

Meaning: Displays the height of apogee of the current orbit.

Possible Values: **Apogee** value displayed in nmi to 1 digit after decimal point

MSID(s): TC_HAPOGEE - supplied by VPOP

3.4. PERIGEE

Meaning: Displays the height of perigee of the current orbit.

Possible Values: **Perigee** value displayed in nmi to 1 digit after decimal point

MSID(s): TC_HPERIGE - supplied by VPOP

4.4. CIRCULAR VELOCITY

Meaning: Displays the circular velocity of the current orbit

Possible Values: **Circ Velocity** value displayed in ft/s to 1 digit after decimal point

MSID(s): CUR_O_VI - supplied by the MOC

5.4. DAY/NIGHT INDICATOR

Meaning: Indicates whether the Orbiter is in daylight or darkness.

Possible Values: **DAY** - displayed if time to SR > SS

NIGHT - displayed if time to SS > SR

MSID(s): TC_SUNRIS - supplied by VPOP

TC_SUNSET - supplied by VPOP

9.6 File Export from the MCC Workstation to the PC

PURPOSE

To document the procedures used to export files from the MCC workstation to the MCC or office PC.

PROCEDURE

Note: The user must have an IPS account.

1. The person receiving the file, usually yourself, must have a user directory in the /fads/msn/gds/gen_common/topo/pcdrop directory on the IPS system. For questions and further details see the PCDrop Users Guide on the TOPO home page at http://mod.jsc.nasa.gov/dm/dm33/TOPO_WEB/main.html.
2. To export file size must be less than 7MB.
3. See "Performing X-Window Dumps" below to create graphic files that can be translated to the PC.

Starting MCC File Transfer

- From master DNAV menu, select Tools > MCC File Transfer.

The XFTP window will appear. The widgets on the left side of the window allow the user to select the file to be exported. The widgets on the right side allow the user to select the destination path.

Note: the ASCII and Binary radio buttons in XFTPs are irrelevant to the export process. Either may be used.

Select File to be Exported and Destination Path

- Using widgets on the left side navigate to the file to be exported.
- On the right side click the Connect > Connect to Remote.
 - Enter "msn6" in the Host Name text box
 - Enter your IPS user ID in the User Name text box
- Click Connect and then enter your IPS password.
- The "file picker " widget on the right is now pointed to your IPS home directory. Use this widget to navigate to the recipient's JIN user name (usually your own) at path /fads/msn/gds/gen_common/topo/pcdrop.
- Highlight (click on) the file to be exported in the "file picker" widget on the left.

Copy the File to IPS

Click on the Copy button in the Xfer Ops box. The file will immediately be transferred to the IPS. The cron job operating on the pcdrop directories executes once every 5 minutes. When the next cron cycle is performed, the IPS resident file becomes an email attachment addressed to the recipient's JIN account. The file can then be accessed via the users standard email application.

Performing X-Window Dumps

Any window on a MCC workstation can be dumped to the PC. This is usually used to dump graphic files to the PC and especially useful for documentation purposes.

- Open a Unix window and execute PWD to print the path to your current directory.
- In the same window execute the command "xwd > filename.xwd". This creates a X-Window dump file in your present working directory. If the file is being exported to the PC environment, use the xwd extension. Files with this extension will be automatically converted to the GIF files during the export process.
- No borders option: to perform an X-Window dump without the windows border, use the nobdrs option. Example: xwd -nobdrs >myfile.wxd

9.7 MEWS Help Notes

PURPOSE

To document a few help notes for retrieving and plotting ODRC data via MEWS.

PROCEDURE

- Note:
1. These procedures are cursory and are not intended as a complete "how-to."
 2. MEWS can be very slow. Be patient.

Starting MEWS

On Master DNAV select Global Apps > MEWS/ODRC

- In the Select MEWS window, Enter 1 <Ret> (New MEWS)

Initializing MEWS

1. Initialize the Flight # & Subsys:

From the Minit menu bar, select File > Reset MEWS Configuration

Single click on the MEWS Flight button, select (highlight) your flight from the scrollable list and select OK.

If your flight is not in the scrollable list, then select Cancel twice to return to the Minit window.

From the Minit menu bar select Utilities > Create a Flight

Type your 3-digit flight number (Example: 096) and OV number (Example: 103) in the text windows and click OK.

Repeat step 1 in Initializing MEWS

If the Mew subsys is not RGPO, single click on the MEWS Subsys button, select (highlight) RGPO from the scrollable list and select OK.

- 2. Initialize the MET reference:**

From the Minit menu bar select Applications > ODRC Interface

From the ODRC Interface menu bar select Reports > Mission Events Table

An Events Table containing the GMT of ascent and entry events appears on the screen. The user can leave the window on the screen for reference, exit or print the window.

Note: The GMT of lift-off is now available to the MEWS application so that data, plot and tab requests can be made using MET.

3. Initialize MSID nomenclature access:

From the ODRC Interface menu bar select Reports > Nomenclature Report

In the Select Data Source for Nomenclature Report window toggle the button to Shuttle Data Tape and click on Apply.

If the message "Local nomenclature report already exists" is received the user can select Cancel, because the report is already available.

Note: By running the Nomenclature report a short description of each MSID is available to the user during the ODRC data request process.

At this point MEWS has been initialized to recognize your flight, access the GMT of lift-off (so MET can be used) and access MSID nomenclature files. Proceed with the next step.

Issuing a Data Request to the ODRC Host

Downlist data stored in the ODRC system can be retrieved by running the MEWS ODRC Request application. The user must specify one or more MSID(s) and define the start and stop time of the request in GMT or MET. The output is stored in "change only", binary data files that can then be accessed by the MEWS Plot (graphical) or Tab (digital) applications for viewing by the user.

If not already running, on Master DNAV select Global Apps > MEWS/ODRC

- On the Minit menu bar select Application > ODRC Request
- On the ODRC Interface menu bar select Request SSP > Operational Downlink

- *Define the MSID Items List:* Use one of the 3 methods below to add the MSIDs associated with this request to the Items List window on the Build Request Items List panel:
 1. Text Window: Type the MSID number in the Add Item text window then click on the MSID button in the Item Type list. (middle column).
 2. Scrollable MSID List: Click on the List MSID button. This will bring up a window that can be used to print all available MSIDs to the screen (along with a brief description) and then add them to the Items List
 3. Plists (files containing 1 or more MSID): Click on List Files. Click on Local Plists in the Files Types list on the right side of the window. Highlight the desired Plist(s). Click on Done. (If your Plist does not exist, see Creating Plists).

Figure 9.7-1 MEWS Menu

- Define the start, stop and rate: In the Data Request Times and Rate panel Select either GMT or MET by toggling the Time Reference button. Complete the start and stop times. Fill in the Update Rate text box (0 = max rate).
- Other stuff:
 1. Calibration toggle button: toggle to MCC calibration
 2. Product Type toggle button: toggle to COD
 3. Run Number test box: type 0 (zero) for flight data (call x3 - ODRC for help if you are requesting data from a sim)
 4. Filename text box: Either type in a file name or accept the default
- Click on Request. You can view the status of your request to confirm receipt and completion on the ODRC interface window.

Creating or Editing Plists

Plists (files of containing 1 or more MSID) can make it easy to create, store and edit lists of MSIDs that are used as input to the MEWS data requests. It is the only way to save the MSID list used in a data request.

- From the MINIT menu bar select Applications > ODRC Interface.
- To create a Plist: From the ODRC Interface menu bar select Plist > Create a Parameter List.
- To edit a Plist: From the ODRC Interface menu bar select Plist > Modify a Parameter List
- Use the Text box, Scrollable list or Plist methods to Build a Request Item List. These methods are described in the *Define the MSID Lists* section in **Issuing a Data Request to the ODRC Host**

Plotting Data Obtained from the ODRC Host

- Start the MEWS initialization program (Minit) if not already running.
- From the Minit menu bar select Applications >Plot
- From the Plot menu bar select Data > Select Data File
- All available data files for the specific flight are listed (i.e. the output file from all completed ODRC Data Requests). Highlight the file of interest and click on done.
- If a format file with the proper MSIDs and scale parameters does not exist, select Format > Create Format File(Modify Format File). For grid 1, (2 &3) define the MSID, and scale parameters for 1, 2 or 3 grids and click on save.
- From the menu bar select Format > Select Format File, highlight the desired file and click on done.
- If desired, change the time reference from GMT to MET. From the menu bar select Scale > Change Time Reference to MET.
- From the menu bar select Plot > View Plot. You'll see your plot.

Displaying/Creating Digital Output Files

MEWS can display digital data to the screen or create a tab delimited ANSI output files. Use this application if you want to transfer digital data to a PC.

- From the MINIT menu bar select Applications > Tab
- From the TAB menu bar select Data > Select Data Source. All data files for the specific flight are listed (i.e. the output file from all completed ODRC Data Requests). Highlight the file of interest and click on done.
- If a format files with the proper MSIDs and format does not exist, select Format > Create Format File (Modify Format File). Type one of MSID of interest in the text box, if desired modify the format and/or add a description in the nomenclature box then click on Add. Repeat for all MSIDs to be added to the output file. When done, click on save.
- From the menu bar select Format > Select Format File, highlight the desired file and click on done.
- If desired, change the time reference from GMT to MET by selecting Scale > Change Time Reference to MET.
- From the menu bar select Tab > Tab to Screen to view the file.
- From the menu bar select Tab > Tab to File to create a digital, tab delimited file.
- Note: Usually the user does not need to know the directory path where MEWS files are stored. However, if the user is going to transfer tab files to the IPS system (see SCP 2.16 File Export from the MCC Workstation to the PC) for transfer to the PC, the user must know the directory path. The path can be found on the Build User Items List window by clicking on Node Address. Tab files are stored in the path listed in Node Address plus `.../tab_output/"filename"`.

9.8 Acquisition Monitor (AcqMon)

PURPOSE

To describe basic usage of the FDO Acquisition Monitor (AcqMon) program for the purpose of determining sunrise/sunset, TDRS, and ground station acquisition times. In this basic mode, the RGPO will view acquisition data based on an ephemeris built by FDO. Details on advanced usage can be found in the AcqMon User's Guide (UG-ACQMON-4.0DA) or by using the HELP pulldown menu in the AcqMon application.

PROCEDURE

1. Start AcqMon

- On RNDZ DNAV, select
Console Apps > AcqMon
or
- On MASTER DNAV, select
Shuttle > FDO > Acquisition > AcqMon - Orbiter (or Target)

2. Determine the correct ephemeris

- Ask FDO which ephemeris is current for the desired vehicle (shuttle or target)

3. Configure AcqMon for the desired acquisition table

- Choose the desired ephemeris. On the AcqMon menu, select SOURCE > MOC or SOURCE > GLOBAL. Select the desired ephemeris (1 - 10). This will populate the data table area of the AcqMon window. Note: MOC nomenclature will likely change when TSU is fully implemented.
- Select the desired data table (Ground ACQ, TDRSS Acq, Sun Rise/Set) by clicking the appropriate button, located just above the data table.
- Use the CONTROLS pulldown to select MET, GMT, or DT for display in the table.
- Under the EDIT pulldown, the START TIME option can be used, if desired, to pick a start time other than the current time. After selecting EDIT > START TIME > USER START..., a GMT time can be entered. To force the table to start at the current time again, select EDIT > START TIME > CURRENT TIME.

4. Print

- The table can be printed via a window dump from the Master DNAV or from the AcqMon print menu command.

BACKGROUND

The Acquisition Monitor (AcqMon) processor provides a tool for the Space Shuttle and Space Station Flight Controllers to analyze and monitor acquisition information for an orbiting space vehicle with respect to the Tracking and Data Relay Satellites (TDRSS), Ground Station and Data Network (GSTDN), the sun, and the moon. AcqMon presents the data in a tabular graphical format. The acquisition data are generated by the TSA Predicted Satellite Acquisition Table (PSAT) processor. AcqMon reads the acquisition data associated with a user-selected ephemeris, sorts the data, and then displays the data in a scrollable table. AcqMon also connects to a timing source to monitor GMT and MET, display the next acquisition events, and checks for changes to any of the ephemeris and acquisition data files. AcqMon will automatically update the data on any file change.

AcqMon can be executed from the RNDZ DNAV menu or from the Global FDO DNAV menu.

It is important to note that the AcqMon processor computes acquisition times based on line-of-sight contact only. Acquisition times are not adjusted to reflect scheduling of TDRS or ground station services, or body blockage. The GC's TDRS SHO application should be consulted to determine the exact availability of TDRS. When checking for ground station coverage, consult the FDO to verify that the correct minimum elevation was used in computing the coverage.

User Interface

AcqMon contains a menu bar, a text area broken into two parts, 1) the General area display and 2) the data tables, and the bottom line displays error or status messages. The main window title bar will reflect the current vehicle being processed with its flight or incremental number and will reflect what time type the time tags are being displayed as; i.e., GMT, MET, or DT.

Menu Bar

The menu bar is made up of the following categories: File, Edit, Controls, Source and Help. Clicking on any of the first four items will cause a pull down menu to appear with more categories. Clicking on the Help will pop up a scrollable text area with a copy of the user's manual minus the pictures. The pulldown menus have some special symbols to denote specific functionality. A menu item with 3 periods, "...", will bring up a separate input or display menu. An asterisk, "*", will denote that a toggle selection is enabled.

File

The File category consists of the following options:

1. **Print** - This pulldown display two options for printing. The user can select which files to send to the printer or to a ASCII file.
 - a) **Printer** - The printout will be the entire contents of the acquisition file and in the current display of the table. Refer to [Figure 9.8-1 AcqMon Printer Selection Window](#).
 - b) **File** - Lets the user print any of the four tables to a file specified by the user. A window pops up display toggle buttons for each table and a text field for the directory path and name of the file. The default directory is /tmp. The default names are acqmon_ground, acqmon_moon, acqmon_sun and acqmon_tdrs. AcqMon checks to see if the user has write permissions to write to the specified directory Refer to [Figure 9.8-2 AcqMon Print ASCII File Menu](#).
2. **Quit** - This option causes a confirmation window to pop up to ensure the user really wants to exit the program.



Figure 9.8-1 AcqMon Printer Selection Window

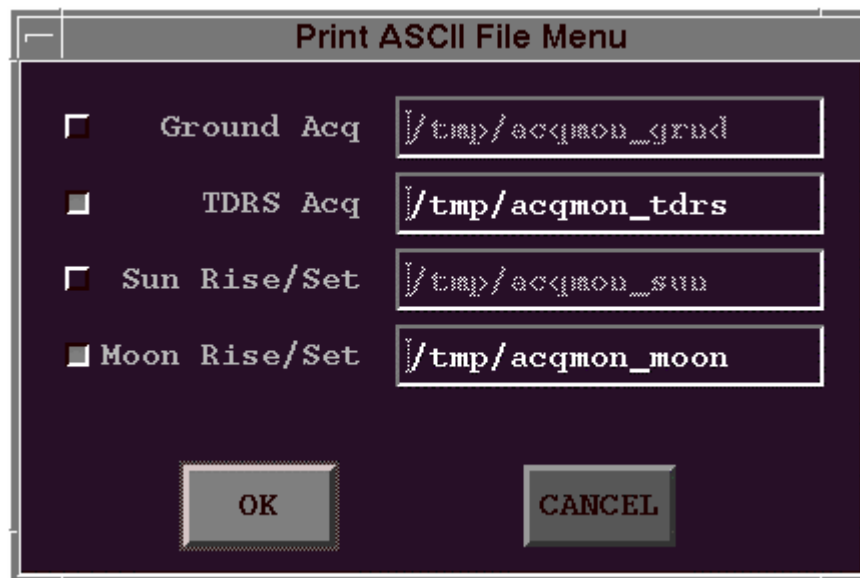


Figure 9.8-2 AcqMon Print ASCII File Menu

Edit Menu

1. **Start Time** - Allows the user to select to display Current Time (default) at the top of the table or to enter a User Start time to put at the top of the table.
 - a) Current Time - This selection causes the first record at the top of each table to be at current time - 1.5 hours. As time passes, the first record will drop off and a new bottom record will be added until at the end of the data file.

- b) User Start ... - This selection pops up a menu to allow the user to enter in GMT time, the time of the data to be displayed at the top of the tables. No data updates will be done as with the Current Time option. Refer to Figure 9.8-3 AcqMon User Start Time Menu.



Figure 9.8-3 AcqMon User Start Time Menu

Controls Menu

The Controls menu provides the following options:

1. *SHOW GMTs* - Changes the time tags in the tables to GMT format and display the GMT format options.
 - a) *SHOW DAYS* - Changes the time tags in the tables and current wall clock time to be displayed in DAY format (DDD:HH:MM:SS). This is the default for the shuttle vehicle.
 - b) *SHOW CAL* - Changes the time tags in the tables and current wall clock time to be displayed in Calendar format (MM/DD:HH:MM:SS). This is the default for the station vehicle.
2. *SHOW METs/SHOW IETs* - Changes the time tags in the table to MET or IET format and updates the title line to indicate time type. MET is displayed for shuttle and IET is displayed for station.
3. *SHOW DTs* - Changes the time tags in the table to display as a count down from the current GMT time. When an entire record has counted to zero, then that record is popped off the top of the table. The title line is updated to indicate the time type.

Source Menu

The source menu provides the following sub menu options:

1. *MOC* – The MOC submenu give a list (*Ephemeris 1-10*) from which, we can select the MOC ephemeris data and associated acquisition data to be displayed. This option is disabled for

the station vehicle. The source and status labels on the top portion of the main menu will be updated.

2. *Global* – The Global submenu give a list (*Ephemeris 1-8*) from which we can select the Global ephemeris data from the vehicle already selected and associated acquisition data to be displayed. The source and status labels on the top portion of the main menu will be updated.

Text Area

The text area of the main menu displays the acquisition data. It is broken into two parts, a General information area and the data Tables. Resizing the main menu height-wise, will resize the table portion only.

General Information

This portion of the text area displays the current GMT and MET times, the ephemeris source and status, the name of the next TDRSS and Ground acquisitions, and a countdown from current GMT of the next acquisition events. The following table describes each parameter:

Item	Format	Description
Source	String	Current Acquisition Data Source Ephemeris or Local PSAT_UDE Name
Comment	String	Comment field from PSAT File Menu
GMTR	YYYY:DDD:HH:MM:SS.SSS	Liftoff Time
GMT	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Current Greenwich Mean Time
MET	DDD/HH:MM:SS	Current Mission or Increment Elapsed Time
Status	String in color	Status of Ephemeris Source
TAOS	String	Name of next TDRSS to be acquired
GAOS	String	Name of next Ground site to be acquired
Sunrise	HH:MM:SS	Count-down from current GMT to next Sunrise event
Noon	HH:MM:SS	Count-down from current GMT to next Noon event
Sunset	HH:MM:SS	Count-down from current GMT to next Sunset event
Data Age	DDD/HH:MM:SS	DT count since last PSAT data source update
Timing	ROSS or MANUAL	Timing data source
Beta	Fff.f	Current solar beta angle in decimal degrees

Table 9.8-1 AcqMon Data Sources

Refer to the Figure 9.8.4 for a picture of the display.

Acquisition Tables

This portion of the text area displays the acquisition tables for Ground Site data (default), TDRSS data, Sun data, and Moon data. There are tabs for each table to select which table to view. If the tab is disabled, then no data for that table type is available due to error processing the file or the file was not generated by the PSAT program. The tab will be highlighted for the current table being displayed. All tables are scrollable vertically and horizontally. Resizing the main menu vertically will allow more records to be viewed.

Ground Site Data

The following table describes the parameters to be displayed on the ground site table. Refer to Figure 9.8.4 for an example of the display.

Item	Format	Description
Orbit/ Daily Orbit	int*5/int*2	Orbit Count/Daily Orbit Number for this AOS or this time depending on sort option
Site	String	Ground site name
AOS	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of acquisition of signal with specified site
LOS	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of loss of signal with specified site
Delta Time	HH:MM:SS	Total time of acquisition with specified site
Max El	Double	Maximum elevation in degrees of satellite above the specified site

Table 9.8-2 AcqMon Ground Site Data

The screenshot shows the 'Acquisition Monitor Test Data' window. It displays various acquisition parameters and a table of ground site acquisition data. The table has columns for Orbit, Site, AOS, LOS, Delta, and Max El.

Orbit	Site	AOS	LOS	Delta	Max El
64/ 2	GTSS	294/00:03:36	294/00:11:42	00:08:06	19.5
65/ 3	DKRS	294/01:01:48	294/01:04:41	00:02:53	1.0
65/ 3	TCSS	294/01:08:24	294/01:16:55	00:08:31	64.2
65/ 3	MAXS	294/01:08:38	294/01:13:12	00:04:34	20.9
65/ 3	CANS	294/01:49:12	294/01:55:22	00:06:10	64.3
66/ 4	ANTC	294/02:27:30	294/02:35:15	00:07:45	45.9
66/ 4	BDAS	294/02:31:00	294/02:37:15	00:06:15	5.9
66/ 4	TCSS	294/02:42:43	294/02:50:34	00:07:51	27.2
67/ 5	MILS	294/04:00:11	294/04:08:39	00:08:28	24.3
67/ 5	PATC	294/04:00:14	294/04:08:37	00:08:23	25.4
67/ 5	MLAC	294/04:00:37	294/04:08:34	00:07:57	24.6
67/ 5	BDAS	294/04:03:00	294/04:11:44	00:08:44	33.4
67/ 5	WLPC	294/04:03:06	294/04:11:01	00:07:55	18.2
67/ 5	ANTC	294/04:03:41	294/04:06:38	00:02:57	1.7

Figure 9.8-4 Ground Site Acquisition Table

TDRSS Data

The following table describes the parameters to be displayed on the TDRSS table. Refer to Figure 9.8.5 for an example of the display.

Item	Format	Description
Orbit/ Daily Orbit	int*5/int*2	Orbit Count/Daily Orbit Number for this AOS or this time depending on sort option
Satellite	String	Satellite name
AOS	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of acquisition of signal with specified satellite
LOS	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of loss of signal with specified satellite
Delta Time	HH:MM:SS	Total time of acquisition with specified satellite

Table 9.8-3 AcqMon TDRSS Data

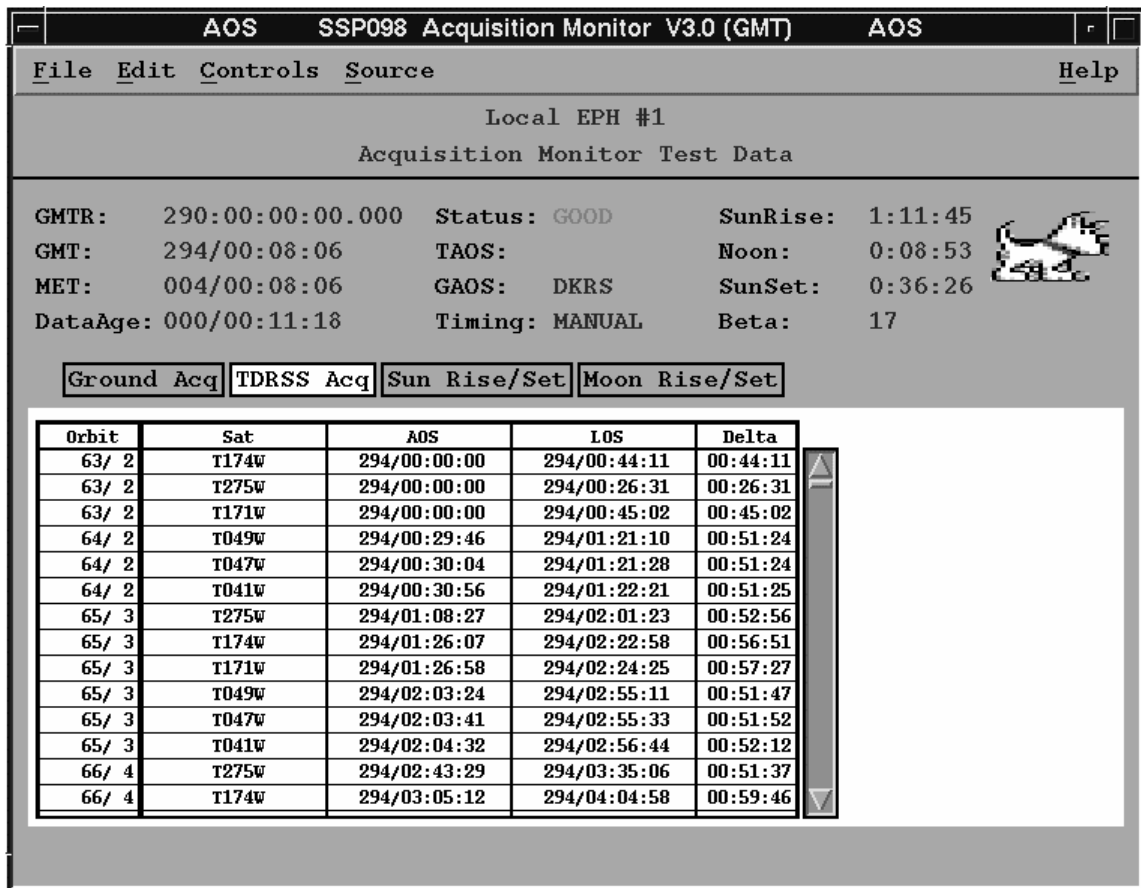


Figure 9.8-5 TDRSS Acquisition Table

Sun Data

The following table describes the parameters to be displayed on the Sun table. Refer to Figure 9.8.6 for an example of the display.

Item	Format	Description
Orbit/ Daily Orbit	int*5/int*2	Orbit Count/Daily Orbit Number for this AOS or this time depending on sort option
SunRise	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Sunrise event for specified orbit
TermRise	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Terminator Rise event for specified orbit
Noon	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Noon event for specified orbit
TermSet	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Terminator Set event for specified orbit
SunSet	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Sunset event for specified orbit
Midnite	DDD/HH:MM:SS or MM/DD:HH:MM:SS	Time of Midnight event for specified orbit
Beta	Double	Solar beta angle in degrees for specified orbit

Table 9.8-4 AcqMon Sun Data

The screenshot shows the 'Acquisition Monitor Test Data' window. At the top, it displays 'Local EPH #1' and 'Acquisition Monitor Test Data'. Below this, several status parameters are listed: GMTR: 290:00:00:00.000, Status: GOOD, SunRise: 1:10:57, GMT: 294/00:08:54, TAOS: (blank), Noon: 0:08:05, MET: 004/00:08:54, GAOS: DKRS, SunSet: 0:35:38, DataAge: 000/00:12:06, Timing: MANUAL, Beta: 17. A small dog icon is visible on the right side of the status area. Below the status area are four buttons: 'Ground Acq', 'TDRSS Acq', 'Sun Rise/Set', and 'Moon Rise/Set'. The 'Sun Rise/Set' button is selected. Below the buttons is a table with the following data:

Orbit	Rise	TRise	Noon	TSet	SunSet
66/ 4	294/02:50:15	294/02:54:52	294/03:17:51	294/03:40:49	294/03:45:22
67/ 5	294/04:20:42	294/04:25:19	294/04:48:13	294/05:11:16	294/05:15:50
68/ 6	294/05:51:06	294/05:55:43	294/06:18:38	294/06:41:40	294/06:46:15
69/ 7	294/07:21:30	294/07:26:08	294/07:49:05	294/08:12:07	294/08:16:42
70/ 8	294/08:51:56	294/08:56:35	294/09:19:34	294/09:42:32	294/09:47:07
71/ 9	294/10:22:20	294/10:26:59	294/10:49:56	294/11:12:56	294/11:17:31
72/10	294/11:52:44	294/11:57:23	294/12:20:20	294/12:43:23	294/12:47:58
73/11	294/13:23:10	294/13:27:50	294/13:50:45	294/14:13:47	294/14:18:23
74/12	294/14:53:34	294/14:58:14	294/15:21:12	294/15:44:12	294/15:48:48
75/13	294/16:24:00	294/16:28:41	294/16:51:40	294/17:14:38	294/17:19:15
76/14	294/17:54:24	294/17:59:05	294/18:22:02	294/18:45:03	294/18:49:40
77/15	294/19:24:48	294/19:29:29	294/19:52:24	294/20:15:29	294/20:20:07
78/ 1	294/20:55:14	294/20:59:56	294/21:22:52	294/21:45:53	294/21:50:31

Figure 9.8-6 Sun Acquisition Table

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A. Acronyms and Abbreviations

A/E	Ascent / Entry
ACA	Access Control and Audit
ACS	Attitude Control System (ISS)
ADI	Attitude Direction Indicator
APDS	Androgynous Peripheral Docking System (aka APAS)
APU	Auxiliary Power Unit
ATT	Attitude
Az	Azimuth
BCE	Bus Control Element
BPV	Body Pointing Vector
BV	Body Vector
C/L	Checklist
CB	Compute Buffer
CCC	Consolidated Control Center
CDE	Consolidated Development Environment
CMG	Control Moment Gyroscope
COAS	Crew Optical Alignment Sight
COTS	Commercial Off the Shelf
CPA	Closest Point of Approach
CRANS	Configurable Realtime Analysis System
CW	Clohessy-Wiltshire, Continuous Wave
DACQ	Data Acquisition (telemetry stream)
DAP	Digital Autopilot
DB	Deadband or Display Buffer
DESIG	Designate
DET	Rendezvous radar in detect mode
DEU	Display Electronics Unit
DFE	Data Flow Engineer
DFL	Data Format Load
DGEN	Data GENeration
DLL	Dynamic Link Library
DMT	Detailed Maneuver Table, Decried Moscow Time
DNAV	Display Navigation
DOF	Degrees of Freedom

doF	Display Overflow (HHL)
DPS	Data Processing System
DTO	Detailed Test Objective
DVIS	Digital Voice Intercommunications System
DVTOT	Total Delta Velocity
DYN	Dynamics
EECOM	Emergency Environmental Consumables Manager
EGIL	Electrical Generation and Illumination
EI	Elevation
EPDC	Electrical Power Distribution and Control
ET	External Tank
EXDV	External Delta Velocity
F/I/W	Failure Impact-Assessment Workaround
FADS	Flight Analysis and Design System
FADS	Flight Analysis Design System
FAO	Flight Activities Officer
FC	Flight Controllers
FCOH	Flight Controller's Operational Handbook
FCR	Flight Control Room
FCT	Flight Control Team
FD	Flight Director
FDF	Flight Data File
FEP	Front End Processor (telemetry)
FES	Flight Evaporator System
FLTR	Filter Vector
FN	Flight Note
FOM	Figure of merit
FOV	Field of View
FPA	Flight path angle
FRCS	Forward RCS
FREE	Free Drift DAP Mode
FRR	Flight Readiness Review
FSM	Facilities System Manager
FSSR	Functional subsystem software requirements
FSW	Flight Software
FTP	File Transfer Protocol
G&C	Ground Rules and Constraints, Guidance and Control
GA	Group Administrator
GC	Ground Control

GDR	Generalized data retrieval
GDSG	Ku antenna pointing and inertial stabilization are under GPC control
GMT	Greenwich Mean Time
GNC	Guidance Navigation and Control
GPC	General Purpose Computer
HDR	High Data Rate
HHL	Hand Held Lidar
HP	Height at perigee
HT	Height above the surface of the earth
I/O	Input/output
IBCS	ISS Body Coordinate System
IC	Initial Conditions
IFM	In-flight Maintenance
ILC	Integrated Load checkout
I-Load	Initial Load
IMU	Inertial measurement unit
INCO	Instrumentation and Communications
INS	Inertial navigation system
INTL	Inertial DAP Mode
IPS	Instrument Pointing System, Integrated Planning System
ISCS	ISS Structural Coordinate System
ISP	Information Sharing Protocol
I_{sp}	Specific impulse
ISPHOST	Information Sharing Protocol Host
J2K0	Julian Epoch 2000.0
JMICB	Joint Mission Integration Control Board
JOIP	Joint Operations Integration Plan
LCG	Lambert Cyclical Guidance
LDR	Low Data Rate
Lidar	Light Detection and Ranging
LOS	Line of Sight, Loss of Signal
LOWZ	Low Z DAP control mode
LRU	Line Replaceable Unit
LSO	Landing Support Officer
LVC	Local Vertical Curvilinear
LVLH	Local Vertical Local Horizontal
Man	Manual
MC	Midcourse Correction Burn

MCDS	Multifunction CRT Display System
MDM	Multiplexer / Demultiplexer
MDRF	Mission Data Request Form
MEWS	Mission Evaluation Workstation Software
MM	Major Mode
MMACS	
MMU	Mass Memory Unit
MOC	Mission Operations Computer
MOCR	Mission Operations Control Room
MOIR	Mission Operations Integration Room
MPSR	Multi Purpose Support Room
mrad	milliradians
MSID	Measurement Stimulus Identifier
MSK	Manual Select Keyboard
NBAT	Nominal Bus Assignment Table
NC	Phase Adjust Rendezvous Burn
NCC	Corrective Combination Rendezvous Burn
NH	Differential Height Adjust Rendezvous Burn
NORMZ	Norm Z DAP control mode
NPC	Rendezvous plane change
NSP	
ODRC	Orbital Data Retrieval System
ODS	Orbiter Docking System
OF	Offset field
OFD	Orbit Flight Design
OFS	Onboard Fault Summary
OM	Omicron
OMP	Orbit Maneuver Processor
OMS	Orbital Maneuvering System
OOP	Out of Plane
ORBT	Optimized R-bar Trajectory
OTBP	Orbit Targeting Bench Program
OTSF	Orbit Targeting Specialist function
PABX	Public Access phone
PAD	Pre-Advisory Data
PAO	Public Affairs Officer
PCDECOM	Payload Commutation/Decommutation
PCM	Pulse Code Modulator
PCMCIA	Personal Computer Memory Card International Association

PCMMU	Pulse Code Modulation Master Unit
PDI	Payload Data Interlever
PDRS	Payload Deployment and Retrieval System
PDSS	Payload Data Service System
PEG	Powered Explicit Guidance
PEG4	Powered Explicit Guidance 4
PEG4A	Powered Explicit Guidance 4 Ascent - Linear Terminal Velocity Constraint
PEG4D	Powered Explicit Guidance 4 Descent - Linear Terminal Velocity Constraint
PEG7	Powered Explicit Guidance 7 - External Delta V Mode on-orbit
PET	Phase Elapsed Time
PGSC	Payload and General Support Computer
PIP	Payload Integration Plan
PIT	Pitch
PL	Payload Forward
PLBAY	Payload Bay
PLS	Pulse
PRCS	Primary reaction control system
PRED MATCH	Predicted Match
PRIM	Primary DAP control mode
Prop	Propellant
PROP	Propagated
PROXOPS	Proximity Operations
PSAP	Predicted Site Acquisition Processor
PSAT	Predicted Site Acquisition Table
PSL	Perpendicular to the Sun Line
PTC	Passive Thermal Control
PTM	Payload Telemetry Message
RCT	Rendezvous Constraints Table
REF	Reference
REL NAV	Relative Navigation
RES	Residuals
RHC	Reaction Hand Controller
RIO	Russian Interface Officer
RJD	Reaction Jet Drivers
RM	Redundancy Management
RMD	Relative Motion Digitals
RMS	Remote manipulator System
ROSS	Realtime Operations Support Software
ROT	Rotation

ROTR	Rotation about a specific eigen axis
RPL	ROSS Parameter List
RPOP	Rendezvous and Proximity Operations Program
RPS	Rendezvous Procedures Support
RPT	Rendezvous Plan Table
RPY	Roll Pitch Yaw
RR	Rendezvous Radar
RSA	Russian Space Agency
RSBY	Rectilinear Shuttle Body
RSS	Root Sum Squared
RTP	Rendezvous Targeting Processor
SA	Save Area
SADS	Station Aids to Docking and Separation
SCA	Satellite Control Analyst
SCP	Specific Console Procedure
SELS	SFOC Electronic Library System
SES	Systems Engineering Simulator
SFOC	Space Flight Operations Contract
SGI	Silicon Graphics Interface
SMS	Shuttle Mission Simulator
SNIP	Shuttle Nose in Plane
SOR	Stable Orbit Rendezvous
SPADOC	Space Defense Operations Center - USSPACECOM
SPEC	Specialist Function
SPORTS	Spacecraft Proximity Operations Real-Time Simulator
SR/SS	Sunrise/Sunset
SRCH	Search
SSP	Space Shuttle Program
ST	Star Tracker
STAMPS	Spacecraft Trajectory Analysis and Mission Planning Simulation
STBY	Standby
STF	SOC Transmittal Form
STRG	String
STRK	Star Tracker
STS	Space Transportation System
SVO	Special Vehicle Operations
T1	Targeted time for the burn
T1 TIG	Time of Ignition Relative to Basetime
T1ILOAD	I-loaded time for the burn

T2 TIG	Basetime
TCA	Time of Closet Approach
TCS	Trajectory Control Sensor
TCS CAD	Trajectory Control Sensor Command and Display
TDR	True-of-date rotating
TDRE	TDRS East
TDRS	Tracking and Data Relay Satellite
TDRW	TDRS West
TDRZ	TDRS Spare
TELEV	Elevation Angle Search Task
TFF	Time for Free Fall
TFL	Telemetry Format Loads
TGO	Time to Go
TGT	Target
TGT DT	Target Delta Time
TGT EL ANG	Target Elevation Angle
TGT ITER	Target Iteration
THC	Translational Hand Controller
TI	Target Intercept
TIG	Time of Ignition
TIPS	Thermal Impulse Printer System
TOAST	Trajectory Operational Application Software Task
TOCSS	Trajectory Operations Computer Systems Support
TORF	Twice Orbital Rate Flyaround
TORRA	Twice Orbital Rate -R-Bar Approach
TORVA	Twice Orbital Rate Rbar to Vbar transition
TPI	Terminal Phase Initiation
TRAD	Tools for Rendezvous and Docking
TRAJ	Trajectory officer
TRANS DAP	Transition Digital Autopilot
TRCK	Rndz Radar Performing Close-loop Tracking
TRK	Track
trkdyn	Track/Dynamics
TSP	Trajectory Software Pane
TSS GND	Trajectory Control Sensor Ground Display User Interface Application
TSTAC	Trajectory Synchronous to Asynchronous Converter
TTA	Time to Apogee
TTC	Time to Circularize
TTP	Time to Perigee

TUP	Trajectory Update
TV	Thrust Vector
TVR	Thrust Vector Roll
U/L	Uplink
UP	Universal Pointing
UPP	User Parameter Processing
USA	United Space Alliance
USSPACECOM	United States Space Command
UVW	Quasi-inertial, right-handed Cartesian coordinate system
VAT	Vector Administration Table
Vbar	Velocity Vector Axis
VC	Vector Compare
VCR	Video Cassette Recorder (records data in this case - ROSS function)
VEL	Velocity
VERN	Vernier Attitude DAP Control Mode
VGA	Video Graphics Array
VGO	Velocity to GO
V_{horiz}	Horizontal component of Velocity
VIT	Vent initialization table
VP	Variable Parameter
VPOP	Visual Proximity Operations Processor
VRCS	Vernier Reaction Control System
VTL	Vent Timeline
VTs	Video Transfer Switch
V_{vert}	Vertical component of Velocity
WGL	Weight Gain/Loss
WN	Working Note
W_p	Weight of propellant consumption
WS	Workstation
WSS	Workstation Systems Support
W_v	Weight of vehicle at start of burn
XD	X LVLH Offset
XH	+X high RCS
XL	+X low RCS
XTDV	External delta V
XTND	Extended
YD	Y LVLH Offset
YL	+Y low RCS
YPR	Yaw Pitch Roll

ZD	Z LVLH Offset
ZFW	Orbit Fixed
ZH	+Z high RCS
ZL	+Z low RCS
ZM	-Z high RCS