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DOD SPACE TRANSPORTATION SYSTEM (STS) COMMAND AND CONTROL DATA SYSTEM STUDY. VOLUME II. SYSTEM REQUIREMENTS ANALYSIS DEFINITION

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Philco-Ford Corporation

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DOD SPACE TRANSPORTATION SYSTEM COMMAND AND CONTROL DATA SYSTEM STUDY FINAL REPORT

Volume II - System Requirements Analysis Definition

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30 October 1974
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FOREWORD

This study was performed for the United States Air Force Space and Missile Systems Organization (SAMSO) in accordance with the statement of work for the DOD Space Transportation System CCDS Study. It was performed during the period of 1 February to 30 October 1974 under contract F04701-74-C-0260.

The complete set of volumes comprising this report includes:

- Volume I - Study Summary
- Volume II - System Requirements Analysis Definition
- Volume III - Command and Control Data System Concept Development
- Volume IV - AFSCF/Shuttle Mission Control Center Requirements Analysis
- Volume V - DOD Shuttle Mission Simulator Requirements Analysis and Resource Acquisition Schedules
- Volume VI - Secure Data and Equipment Handling

This study was performed under the direction of DOD/SAMSO. Aerospace Corporation provided assistance to SAMSO. This study was performed by Philco-Ford's Western Development Laboratories Division, Philco Houston Operation with key participation of personnel from Philco-Ford's Satellite Control Facility Operation at Palo Alto.

Donald K Dorman

D. K. Dorman, USAF Study Manager
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This final report has been reviewed and is approved. Readers are cautioned that the material presented herein represents the findings and conclusions of the Philco-Ford Study Group and does not necessarily define a DOD/SAMSO position, policy, or decision.

Robert W. Lindemuth

Maj. R. Lindemuth, USAF Study Monitor

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This six volume report presents a Command and Control Data System (CCDS) concept for support of DOD Space Transportation System (STS) missions launched from VAFB or KSC. It describes the CCDS concept in terms of its functional control elements (e.g., Mission Control, Launch Control, etc.), their interfaces, and functional requirements for personnel, data processing, display, command/control, and communications. Candidate operating positions required in the Shuttle Mission Control Center to support STS missions are described and a sample annex to an Orbital Requirements Document (ORD) for the interim upper stage is

presented. The joint use of the JSC Shuttle Mission Simulator (SMS) was investigated and the DOD SMS capability requirement determined. Budgetary cost and schedule estimates for a DOD SMS were provided based on NASA budgetary figures.

The complete set of volumes comprising this report includes: Volume I - Study Summary; Volume II - System Requirements Analysis Definition; Volume III - Command and Control Data System Concept Development; Volume IV-AFSCF/Shuttle Mission Control Center Requirements Analysis; Volume V - DOD Shuttle Mission Simulator Requirements Analysis and Resource Acquisition Schedules; Volumes VI - Secure Data and Equipment Handling.

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SECTION 1

INTRODUCTION

1.1 GENERAL

This study addressed the DOD Command and Control Data System (CCDS) required to support DOD operations of the Space Transportation System (STS). CCDS is a collective term since it comprises the ground-based data systems and their inter and intra-system communications required for support of the DOD STS. It is defined as that system of communications, data transfer techniques, information display devices, data processing equipment and algorithms, and the personnel required for direct or near-real-time control of ths STS and its mission. In terms of functional elements, the CCDS consists of a mission, landing, turnaround, launch, range, recovery, and payload checkout functional control elements.

The CCDS is neither a single nor a totally new system. Much of the CCDS currently exists in the USAF Satellite Control Facility (SCF) and the Vandenberg Air Force Base (VAFB) data and communications systems. NASA-operated systems and facilities are to be utilized where possible to avoid expensive duplications (e.g., mission planning systems or optional use of TDRS for contingency reaction). NASA systems, for this study, were considered external to the DOD CCDS. In applications requiring new equipment, it is expected that NASA-developed systems will be installed in DOD facilities to the maximum extent possible (e.g., launch processing system). The DOD CCDS was considered a functional entity for purposes of this study to ensure the compatibility of its several elements by developing its functional requirements as an integrated system. This will permit subsequent integration of its elements to be accomplished efficiently and effectively, and will ensure completeness of the total STS ground support system concept.

Considered as a collective system, and consistent with its definition above, the CCDS objectives are as follows:

A. Monitor mission operations sufficiently to permit ground decisions on mission management in real or near-real-time.

B. Provide support to the Orbiter vehicle and crew in responding/reacting to contingencies.

C. Support the 160-hour ground turnaround requirement of the STS.

1.1 GENERAL (CONT'D)

D. Provide the capability for, or support to, mission planning and flight and ground crew simulations.

E. Provide the integrated information management, storage, and retrieval for the STS missions and vehicles.

F. Provide the necessary range and air space clearances for STS launches and landings.

G. Provide efficient handover of satellite control to the user at satellite deployment, and efficient acceptance of satellite control from the user at retrieval for satellite return missions.

This study developed a preferred CCDS concept; a set of functional requirements for each of its functional control elements (e.g., mission control, launch control, turnaround control, etc.); a further definition of a Shuttle Mission Control Center (SMCC) and the DOD Shuttle Mission Simulator (SMS) requirements; and an Orbital Requirements Document (ORD) for the STS.

This volume documents the results of Task II, System Requirements Analysis Definition, which determined the functions required to be performed by the CCDS. Figure 1-1 illustrates the relationship of this volume to the other volumes of the DOD STS CCDS Study Final Report and indicates the realationship of each of the tasks.

1.2 TASK II OBJECTIVE

The objective of Task II was to determine the functions for the CCDS required by DOD to support the vehicle mission operations and launches from VAFB and Kennedy Space Center (KSC). CCDS functions were to be determined for all phases of the STS mission, including on-pad and flight operations of the Orbit-to-Orbit Shuttle (OOS)*. Both nominal and contingency operations were considered.

Task II determined those functions which must be performed by the CCDS in support of STS operations. They are definable and factual and, except in the area of payload support, each can be

*In this volume, the upper stage is referred to as the OOS; in all others, the upper stage is the interim upper stage (IUS).

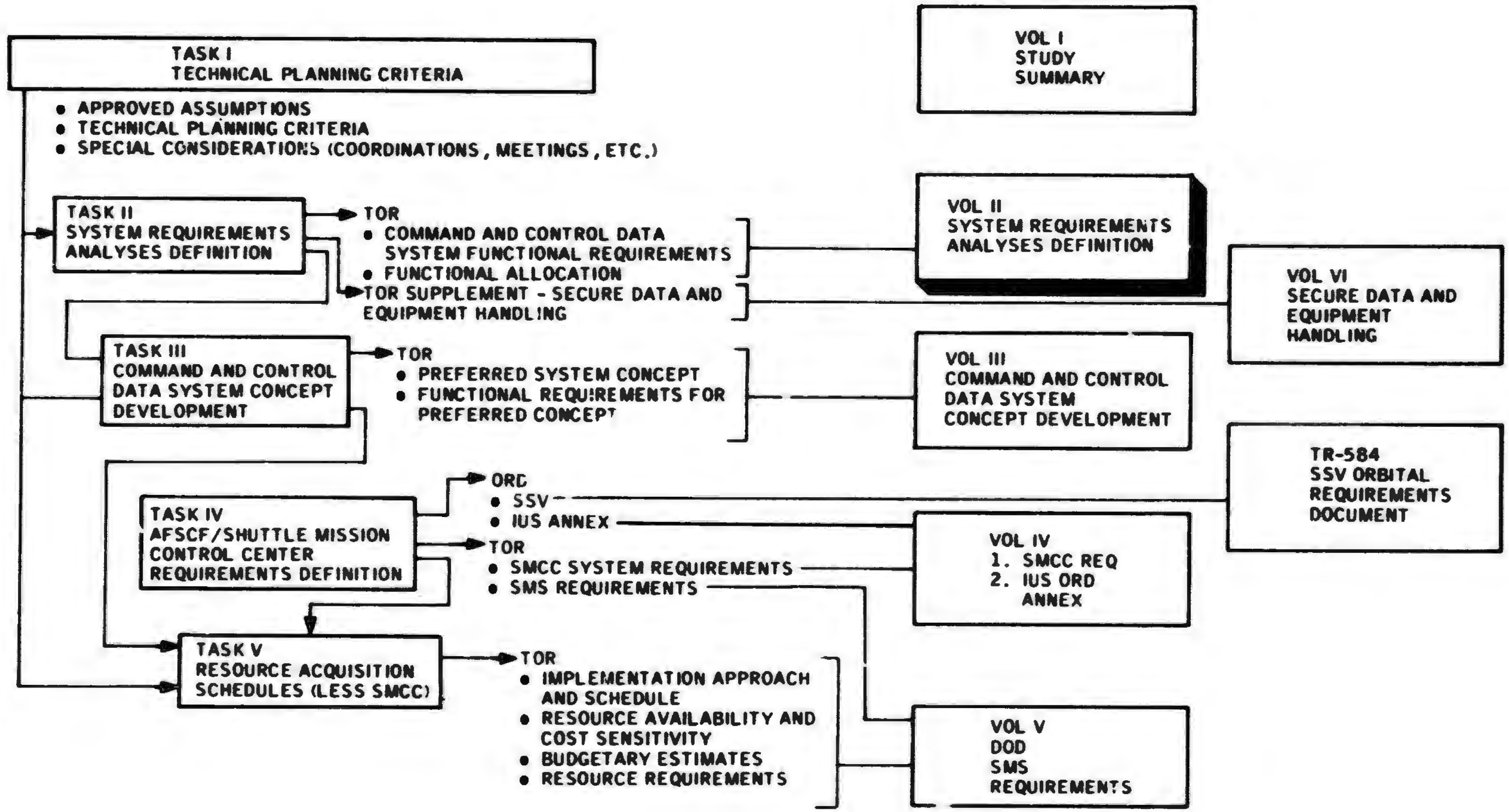

Figure 1-1 Tasks and Reports

1.2 TASK II OBJECTIVE (CONT'D)

traced to a NASA/DOD Level II requirement. No attempt was made in Task II to allocate the functions to a control element or to define the functions to a level that they could be allocated to data processing hardware, software, or personnel. These activities occurred in Task III, and the results are documented in Volume III.

1.3 METHOD

In the derivation of the CCDS functions, input documentation (referenced in Appendix C) was reviewed and informal discussions with NASA and DOD personnel were held. From this review and discussions, general guidelines and assumptions required for the conduct of the study were made. The flight vehicle capabilities were baselined (Appendix B) from stated requirements and the preliminary design review of the Orbiter avionics systems*. Based on the study guidelines and CCDS objectives, criteria were developed for allocating STS functions to the Orbiter, OOS, payload and/or CCDS (paragraph 1.4). Functions not meeting the criteria for allocation to one of these elements were not considered further. These functions were generally those that were purely manual or involved GSE or AGE. Required functions for the STS were determined primarily from SD73-SH-0023, *Space Shuttle System Functional Flow Diagrams*, Rockwell International; SD73-SH-0114, *DOD Space Transportation System Ground Operations Study*, Rockwell International; and SAMSO-TR-73-299, *DOD STS Mission Planning and Software Requirements Study*, TRW Systems Group. Functions described in these documents were analyzed, subdivided, and/or supplemented with derived functions as required in order to compare the function with the criteria developed in Task I and make a determination of its allocation. Appendix A contains a listing of these functions, their allocation, and their traceability to a Level II requirement.

1.4 CRITERIA SELECTED

The criteria used for selecting functions to be performed or directly supported by the CCDS and/or STS flight elements are listed in the following paragraphs.

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*Baseline was established as of 1 March 1974. Changes occurring subsequent to that date are not included.

1.4 CRITERIA SELECTED (CONT'D)

The CCDS was allocated all functions that involve the following:

- Overall management of flight and ground operations
- Management of STS mission and ground elements data
- Command and/or control which cannot be exercised by the flight vehicle elements due to a lack of capability or constrained time availability.
- Telecommunications/teleprocessing between the STS flight and ground elements and their external interfaces.
- Mission decisions
- Mission design, scheduling, trajectory design, flight activity plans, and abort or alternate mission procedures development.
- Simulations for preflight readiness, malfunction analysis, and mission support.
- Training of flight crew and ground-based mission support personnel in the operation of elements of the CCDS.
- Contingency reaction/support
- Enhancement of crew safety and/or mission success probabilities.
- Control and monitor of the STS onboard computational capabilities during ground checkout of the STS vehicles.
- Remote control and monitoring functions for GSE/SE and facilities.

The Orbiter/flight crew was allocated primary responsibility for all functions that:

- Can be performed onboard (source: SOW)

1.4 CRITERIA SELECTED (CONT'D)

- Involve vehicle management or decisions while the crew is onboard (source: DOD operation concept)
- Involve Orbiter vehicle abort decisions (source: JSC 07700, Vol. X)
- Involve the primary payload command and control functions for attached payloads during flight phases.

All functions which can be performed by the OOS systems were allocated to the OOS (based on OOS capabilities stated in the baseline functional description or assumed capabilities approved by the Air Force).

1.5 GUIDELINES AND ASSUMPTIONS

In the performance of this task, general study guidelines were given or established and, where required, certain assumptions were made. Those that have application to a limited aspect of the study are contained in the paragraph to which they apply. This paragraph lists those that bound or establish limits on the CCDS Study. Each of the guidelines or assumptions listed below has been submitted to USAF SAMSO, and either explicit or tacit approval of each was obtained.

A. Orbiter vehicle autonomy for flight operations is a DOD STS design requirement.

B. Ground operational support functions defined will be limited to those applicable to the CCDS.

C. It is assumed that a checked out payload will be delivered to the launch site for integration into the Orbiter. Payloads will be analyzed in this study to the extent they affect the CCDS requirements subsequent to delivery to the launch site and until control is transferred to the payload user.

D. Detailed test and checkout requirements/procedures for the STS flight elements will not be developed as a result of this study effort.

1.5 GUIDELINES AND ASSUMPTIONS (CONT'D)

E. DOD may use the Spacecraft Tracking and Data Network (STDN) and Tracking Data Relay Satellite (TDRS), but only as an option in responding to contingencies.

F. Ferry flights will employ the "piggyback" configuration.

G. All functions which can be performed onboard the Orbiter (based on current Orbiter systems baseline) shall be allocated to the Orbiter.

1.6 DEFINITION

In subsequent sections of this volume and throughout the final report, the term payload is used in the singular context as opposed to the plural context; i.e., the Orbiter will carry *a* payload and not payloads. For study purposes, a payload may consist of several payload elements. The elements include the OOS, satellite(s), and OOS/satellite(s) combination. The principal impact of several payload elements is not upon the number of generic functions performed (except for the OOS/satellite interface), but upon the fact that the same generic functions must be performed several times (once for each payload element) entailing a greater control problem and/or increasing the time required to perform all the functions.

SECTION 2

RESULTS, CONCLUSIONS, AND OBSERVATIONS

2.1 GENERAL

This section summarizes the results of the performance of the System Requirements Analyses Definition Task; it presents the conclusions reached; and it lists any observations, with appropriate recommendations, noted during the performance period.

2.2 RESULTS

Task II resulted in the following accomplishments:

A. Functional Allocation. Performed a review of the Space Transportation System (STS) functions contained in the functional flow diagrams (FFD's) or other completed studies. Supplemented these documented functions by independent analysis as required to permit allocating the function to the Command and Control Data Center (CCDS) or STS flight element as determined by the allocation criteria or allocating it to an "other" category that will not be of concern to subsequent efforts of this study. This category includes purely manual functions, facility functions, ground support equipment (GSE) functions, or similar areas not within the scope of this study.

B. CCDS Functions. Allocated functions to the CCDS in A above, and, additionally, determined functions it had to perform in support of a function allocated to another element, i.e., remote control of GSE.

C. CCDS Contingency Functions. Postulated contingency situations and determined the CCDS functions required to provide support in the event of these contingencies.

D. Multiple Vehicle Support. Investigated the introduction of a second STS vehicle into the turnaround processing or into orbital operations and defined the preliminary deltas to the CCDS functions caused by multiple vehicle support.

2.2 RESULTS (CONT'D)

E. Kennedy Space Center (KSC) Launches. Examined the launch of a Space Shuttle Vehicle (SSV) from KSC on a Department of Defense (DOD) mission and determined the DOD-unique functions for KSC processing and launch.

F. Security. Investigated STS operations and established the requirements involved with security, communications security, and cryptographic equipment handling.

G. Mission Planning, Training, and Simulation. Although beyond the scope of this task, it was recognized that premission planning, training, and simulations are an integral part of STS operations. We therefore identified top-level functions to be supported by the CCDS that are associated with these topics.

H. External Interfaces. Established the CCDS requirements to interface with systems or agencies external to it and defined the type of information to be exchanged among them.

I. System Baselines. Based on Level II requirements, the Preliminary Design Review (PDR) design, the DOD-provided orbit-to-orbit Shuttle (OOS) description, and informal discussions with cognizant NASA and DOD personnel and other applicable documents, determined the Orbiter avionics (as of 1 March 1974), the OOS, and the Satellite Control Facility (SCF) baselines to be used and developed a baseline satellite description. Each is documented in summary format as appendix B of this Technical Operating Report (TOR).

2.3 CONCLUSIONS

2.3.1 Operations Management Support. A major CCDS function in support of ground turnaround, assembly, and launch operations is that of Operations Management Support. It is defined to include: work scheduling, logistics support, configuration control, technical documentation support (electronic), anomaly reporting, and communications configuration control.

2.3.2 Payload On-Pad Operations. Because of the relatively short timeframe for on-pad activities, the primary launch pad payload operations should be restricted to the installation and integration of the payload into the STS system and the verification and maintenance of operational integrity of the payload once installed.

2.3.3 On-Orbit Support. The capability of the Shuttle to perform the on-orbit phases of the DOD missions, independent of any external support except for use of the AFSCF for support in the event of an emergency (*DOD Shuttle System Requirements*, paragraph 3.2.1), obviates the need for ground support to a nominal mission. However, for the ground systems to respond or react to on-orbit contingencies requires ground monitoring and analysis of orbital trajectories, orbiter systems, and mission events and status. The capability to monitor in preparation for contingency response then becomes a normal function of the CCDS during the nominal mission. This function, however, places no ground support constraints on the conduct of a nominal mission such as station contact prior to, during, or subsequent to every flight event or activity.

2.3.4 Launch Abort Operations. Modes I and II aborts will occur in view of the launch/landing site. Modes III through VI aborts may occur after launch site loss-of-signal following normal CCDS launch support. A non-nominal acquisition or no acquisition at the first remote tracking site (RTS) may indicate any of abort cases III through VI. Thus, the landing site will have to be on alert until contact is made with either the first RTS or the landing site. At this station contact, the landing site will be notified of mission status. The landing site will be released from alert status or advised of the abort condition.

2.3.5 OOS Orbital Transfer. Possible problems have been identified in support of the OOS orbital transfer, as follows:

- Maintenance of a communication link to the OOS and mated satellite(s) for all altitudes of the OOS
- Time constraints on the availability of an RTS
- Possible need for a midcourse correction
- RTS equipment limitation which may preclude monitoring both the OOS and a satellite simultaneously.

2.3.6 Satellite Deployment. In support of satellite deployment a possible requirement exists for simultaneous Space Ground Link Subsystem (SGLS)-compatible communication between Orbiter, OOS and the ground and between the satellite(s) and the ground. Single SGLS ground stations currently can communicate on only one link at a time; channel selection and changeover is a lengthy process.

2.3.7 Communication Limitations. Ground support will be possible only as appropriate communication links are available. It is assumed that communication of adequate capability will be available between the Shuttle Mission Control Center (SMCC) and the various tracking stations to handle any postulated anomaly. However, communications between the Orbiter and the ground will be limited to station contact. The Orbiter will be equipped with unified S-band communications equipment and a Tracking Data Relay Satellite (TDRS) communication package. The concept for use of these systems in support of DOD contingencies has not been determined. Problem areas include: interfaces between NASA and DOD, security, communications compatibility, and TDRS implementation schedules.

2.3.8 Dual Mission Support. The basic additional requirements on the CCDS as a result of dual mission support are the capabilities of the CCDS to identify, accept, and display data from each mission, and scheduling of CCDS resources in support of both missions. Previous conclusions relating to SGLS communications capability are also applicable for dual mission support.

2.3.9 DOD Operations from KSC. DOD launch site operations from KSC are essentially identical to the NASA operations. The exceptions result from DOD requirements concerning physical security and secure data handling. Payload installation on the pad is a DOD requirement, but NASA's requirement for on-pad changeout capability removes the uniqueness of the DOD requirement except for the associated security functions.

2.3.10 Red-Black Considerations. All STS interfaces having Red or Black implications must either 1) maintain the same environment (Red or Black) on both sides of the interface, or 2) provide an appropriate isolation device. This is a problem in the case of

2.3.10 Red-Black Considerations (Cont'd)

the data interface between the front end processor (FEP) in the DOD vault at the Launch Control Center (LCC) and the Launch Processing System (LPS) common data buffer (CDBFR).

2.3.11 Secure Voice. The requirement for secure voice from the Orbiter creates a unique environment during ground operations. In the Orbiter Maintenance Facility (OMF) and Integration and Mating Facility (I/MF) checkout areas, the voice link from the Orbiter is encrypted and a vault is required for the decryption.

2.3.12 Data Purging. Mission data storage contained in the non-volatile computer memories of the Orbiter and upper stage must be purged. A software program to provide destructive readout of those portions of a memory containing the data of interest and a verification that it has purged those locations must be provided.

2.4 OBSERVATIONS

During the performance of this study phase, two observations were made that, in one instance, qualify many of the functional allocations, and in the second, identify an area (simulations) that requires subsequent investigations. These are discussed below.

2.4.1 Functional Allocations. In accordance with direction furnished by DOD, all functions that were within the capabilities of the Orbiter were allocated to the Orbiter. Orbiter capabilities based on the Level II requirements and the Orbiter PDR that satisfied those requirements were accepted. As Orbiter and ground support system design continues, analyses will almost certainly be conducted that investigate topics such as autonomy versus onboard software sizing and complexity, CCDS/GSE versus onboard checkout during turnaround activities and launch pad operations, and the degree of parallel performance of tasks (time and motion studies). Each of these may influence the onboard/ground allocations, and this influence will continue to optimize these allocations throughout the design, development, test, and evaluation (DDT&E) phase of the Space Shuttle Program.

2.4.2 Simulations. Mission planning, training, and simulation are integral functions of the STS operations. But since they were not included in the phases of operations specified for this study, CCDS support of these functions was not investigated to any depth. It is recognized that current DOD efforts are underway to investigate mission planning and flight software development, but no comparable effort is known for training and simulations. In particular, simulations are important and essential functions of the CCDS from the standpoint of:

- Crew training
- Mission support personnel training
- Specific mission rehearsals
- Integrated flight crew - ground support personnel training
- Readiness testing
- Real-time malfunction and corrective action analyses
- Procedures development.

Concomitant with these simulation functions are the questions of what are the specific simulation and training requirements; which functions should be done in NASA facilities and which in DOD; what interfaces and communications are required to support simulations; to what degree are joint NASA/DOD simulations required.

Subsequent CCDS study efforts should be expanded to include a more thorough examination of the simulation functions and their resultant influence on the CCDS concept.

SECTION 3

DOD STS GROUND OPERATIONS

3.1 INTRODUCTION

Command and Control Data System (CCDS) functions are defined for this task as those functions required to support the receipt, processing, integration, checkout, and servicing of the Space Shuttle vehicle elements, upper stage, and payload(s) in preparation for launch. In addition, they will include those activities not directly related to vehicle systems, such as performing support equipment/facility maintenance and recycling launch facilities. The vehicle-related activities will, by definition, commence upon receipt of the vehicle elements at the launch site, including Orbiter receipt at end of rollout on the airfield, and terminate at liftoff from the launch pad. The support equipment/facilities recycling and maintenance activities are assumed to logically occur during vehicle on-orbit periods to ensure minimum impact on actual vehicle ground turnaround cycles. Figure 3-1 is a top level functional flow of these activities.

Ferry operations, a third major area subjected to analysis under the ground operations category, occur outside the previously defined time periods in that they commence at rollout at the alternate landing site and terminate at rollout on return to the host launch site. This latter rollout initiates the nominal vehicle-related ground operations cycle defined in the previous paragraph. A summary activity sequence for these ground operations is illustrated in figure 3-2.

The presentation in this section (section 3) emphasizes turnaround and assembly/prelaunch activities, with the specific presentation format being the following:

- OFF-PAD: Landing and securing, deservicing, hangar operations, SRB, external tank (ET) preparation, hypergolic operations, and off-pad vehicle assembly

- ON-PAD: Pad installation, on-pad assembly, flight readiness verification, standby phase, and launch operations

- PAYLOAD ACTIVITIES: Installation, verification, readiness, and standby activities

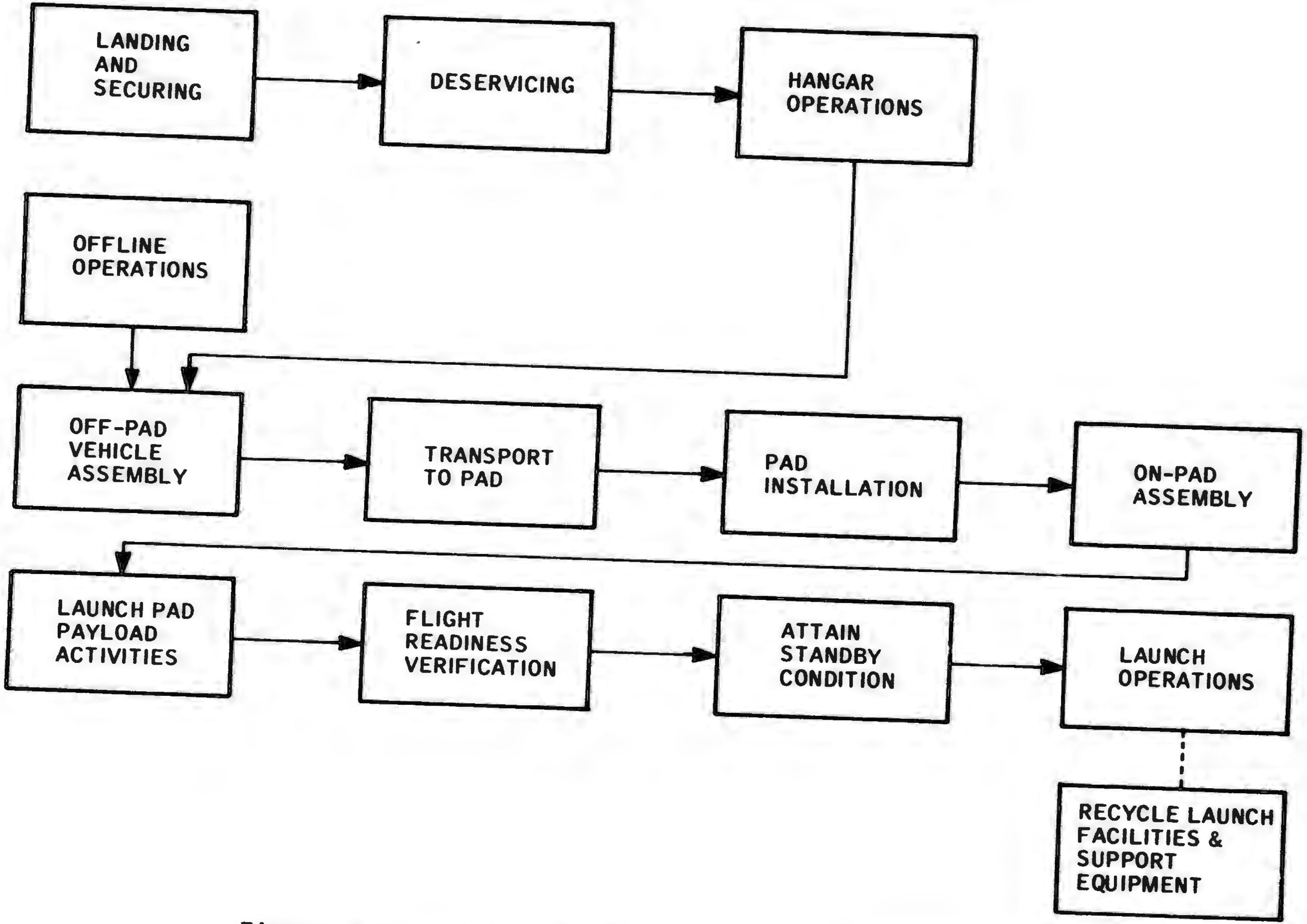

Figure 3-1 Top-Level Ground Operations Functional Flow

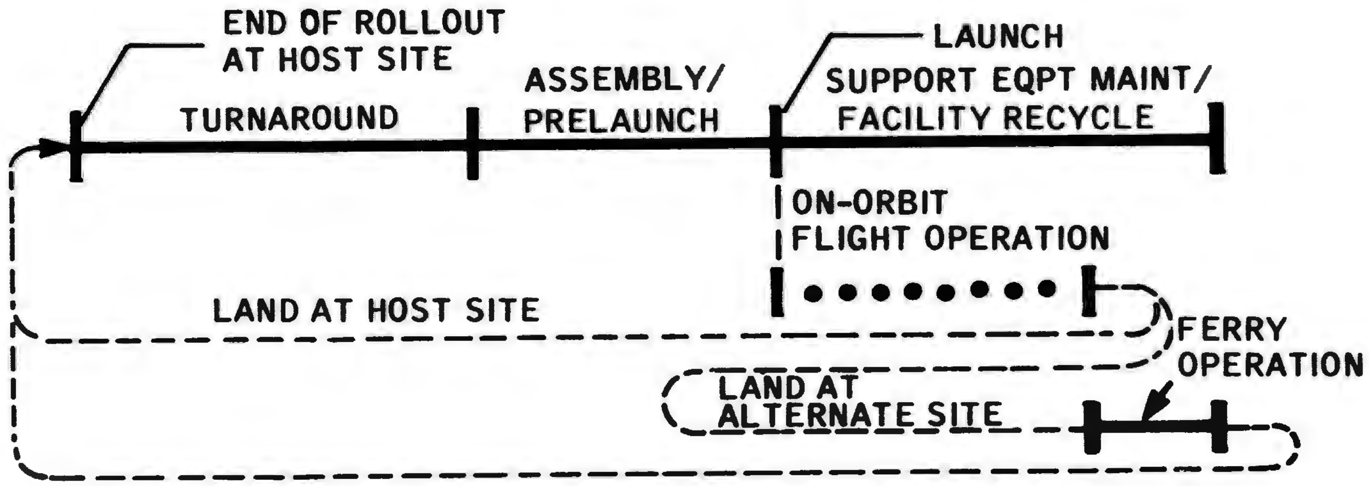

Figure 3-2 Ground Operation Sequences (Solid Black Lines)

3.1 INTRODUCTION (CONT'D)

- SRB RECOVERY
- CONTINGENCY SUPPORT: Satellite Orbit-to-Orbit Shuttle (OOS) changeout operations, retargeting and on-pad contingencies
- MULTIPLE VEHICLE PROCESSING: Second Orbiter in turnaround/on-pad or DOD Orbiter in turnaround/on-pad at Kennedy Space Center (KSC)
- NASA LAUNCH AT VANDENBERG AIR FORCE BASE (VAFB)
- FERRY OPERATIONS: Preparation for flight, take-off, preparations for landing, landing and ferry-to-Orbiter configuration activities
- SUPPORT EQUIPMENT AND FACILITIES: Recycling launch facilities and maintaining support equipment.

Where applicable, allocation matrices are presented in appendix A, modules A.2.1 thru A.2.34 corresponding to each of the operations listed above (e.g., landing and securing). The large majority of functions listed in these appendices was extracted from Support Requirement Analyses (SRA's), the Shuttle CEI specification, two volumes (X and XVIII) of NASA document JSC 07700 and the *DOD STS Ground Operations Study*, Vol. II, dated July 1973. Other supporting documents include those referenced in appendix C.

3.1.1 Allocation Methods and Rationale. For each function listed in the appendices under a given operation, allocation was made to one or more of five categories (Orbiter, OOS, payload, CCDS or "other", with "other" being manually accomplished functions or provided by ground support equipment (GSE). The primary rationale for these allocations was adherence to a general guideline allocating functions to the Orbiter systems to the maximum extent possible. It was recognized, however, that many of the allocations will be subject to results of parallel studies and future Orbiter System development. In the latter case, the activities of the Software Development Laboratory (SDL) and subsequent design of Orbiter processing capabilities will be of particular significance. These

3.1.1 Allocation Methods and Rationale (Cont'd)

and similar activities will ultimately determine the true capacity of the Orbiter System.

A nominal example (from many encountered in this study) that illustrates possible future reallocation of certain functions is presented in figure 3-3. Selected from the hangar operations phase, and reflecting timelines extracted from KSC Launch Processing System (LPS) station set definitions, the particular example illustrates apparent extensive parallel processing loads (up to 5 hours duration) levied upon the Orbiter by allocations in this study. These loads may or may not prove to be within the Orbiter Flight Computer Operating System (FCOS) capabilities. Based on present SDL FCOS and applications software development schedules, this determination will not occur within the duration of this study. In lieu of this determination, Task III of this study (CCDS concept definition) will also consider other ground vs. onboard function partitioning, wherein such heavy parallel processing activities (determined from available timelines) are allocated primarily to the CCDS, thus ensuring an option which can accommodate such functions if determined necessary.

3.1.1.1 Operations Management Support. A major CCDS function is the operations management support function required of the ground based data systems. It is referenced throughout the ground operations discussions, and is defined to include the following capabilities:

A. Work Scheduling. Consists of scheduling all tasks to be performed, designating resources affected, evaluating manpower requirements, and designating task start times, duration of task, and task completion time.

B. Logistics Support. Consists of maintaining spares availability status, providing automated and/or real-time request capability (items from base supplies) for ground turnaround support, and requesting/verifying propellent availability for prescribed mission schedules. A primary capability within this support function will be to evaluate parts failure trend analysis and update or augment spares accordingly.

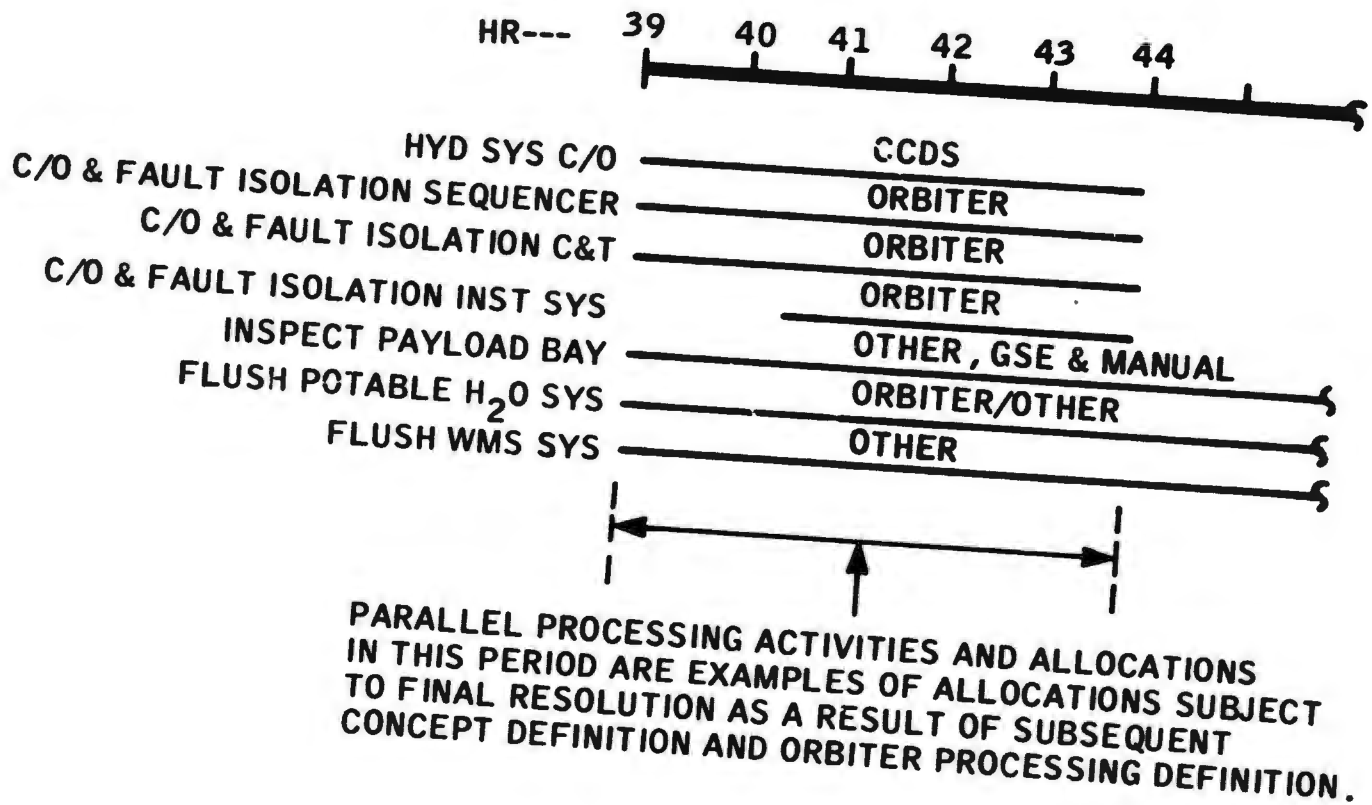

Figure 3-3 Hangar Operations

3.2 OFF-PAD OPERATIONS

This paragraph documents the results of the analysis of STS operations from landing until the integrated vehicle is transported to the launch pad.

3.2.1 Landing and Securing Operations. (Refer to appendix A, module A.2.1.) Landing and securing operations begin at the end of rollout and end with towing the Orbiter to the deservicing area. These operations will include securing of the Orbiter, connection of the GSE, flight dump data, flight crew egress, ground crew ingress, preparation for towing, and towing.

The majority of these operations are allocated to the Orbiter and Other*. The CCDS operations management support provided during this phase will consist primarily of maintaining voice communications configurations for status monitoring and task coordination. It will receive, record, and accomplish data reduction of all Orbiter flight data received from the ground data dump. This function will require capability to receive, record, reduce, analyze, and display the data, including flagging any anomalies. The payload data received during the dump (16 kb/s health and status data) will be stripped, formatted, and passed to the mission control center for dissemination to the user. Due to the fact that classified data is involved, all security requirements will be supported by CCDS secure communications capabilities (see section 6 of this report).

One operation subject to further consideration is the method of accomplishing the data dump. Earlier studies indicate a hardwire dump onto recorders located on the Orbiter towing vehicle, transporting the data to the hangar area, and then dumping the data into a centralized data processing system for reduction, analyses, and presentation in an unspecified medium (tape, printout, etc.). This method would entail two data transfers plus a delay in getting the data processed. It also increases the possibility of data loss due to the multiple data transfers. A suggested alternative would be to accomplish the data dump by direct RF transmission into the processing center, requiring only one data transfer, reducing error vulnerability and decreasing processing turnaround.

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*Other is defined as Manual, GSE, SE or Facilities.

3.2.2 Deservicing Operations. (Refer to appendix A, module A.2.2.) Deservicing operations begin when the Orbiter arrives at a deservicing area and end with towing the Orbiter to the hangar area. The deservicing operations include safing of the Orbiter, deservicing the hypergol systems, removal of the hypergol modules (optional), payload deservicing, payload removal, connection of facility services, and preparation and towing of the Orbiter to the hangar area.

The CCDS will provide remoted command, control, and monitoring of those functions which involve hazardous operations, per Level II requirements. Support by CCDS will include generating commands to operate selected systems and components, providing stimuli to sensors, providing control of those systems and components, and providing both continuous and exception monitoring of systems status and outputs. The CCDS will provide the necessary displays to ensure proper and safe operations during this phase. Additionally, the CCDS will record, reduce, and analyze the test data, noting any anomalies which occur during this phase. The CCDS will also provide operations management support during this phase.

The baseline calls for removal of the hypergol modules from the Orbiter during this phase. However, an alternate approach exists stipulating that the modules would be removed only if a problem exists with the hypergol systems. If this approach becomes baseline, a majority of the deservicing operations would be unnecessary, thus reducing the duration of this phase.

3.2.3 Hangar Operations. (Refer to appendix A, module A.2.3.) Hangar operations begin with the arrival of the Orbiter at the hangar and end with the towing of the Orbiter to the assembly area. Hangar operations will include Orbiter maintenance and field modification, Thermal Protection System (TPS) refurbishment, hypergol module installation, and checkout of the Orbiter systems for flight.

The CCDS will provide support for all system checkout accomplished by the Orbiter onboard systems. It will provide either continuous or exception monitoring of all checkout. The CCDS will provide command, control, and monitoring of those functions which, due to the lack of capability of time constraints, cannot be assigned to the onboard systems. The CCDS will provide the support required to accomplish fault isolation and line replacement unit (LRU) checkout, a function consisting primarily of loading all

3.2.3 Hangar Operations (Cont'd)

checkout software onto the onboard systems and initializing of testing. The CCDS will provide the equipment to receive and record resultant test data, accomplish data reduction, perform trend analysis, perform anomaly analysis, and generate displays required to accomplish checkout of the Orbiter and associated systems. Operations management support will be a major support activity during this phase.

The present baseline includes installation of the hypergol modules during this phase. However, as stated in appendix A, module A.2.2, the modules may not be removed unless anomalies occur. If this concept becomes baseline, the duration of this phase will be significantly reduced.

In adherence to the basic onboard vs. ground allocation criteria, all functions have been allocated to the Orbiter if the capability has been specified for onboard. However, several areas subject to further evaluation relative to onboard checkout were noted that will impact the CCDS. These include the following.

- To what level will the onboard system have the capability to accomplish fault isolation and the time to accomplish this function with onboard resources?

- Will the onboard system be able to accomplish simultaneous systems checkout and, if so, how many? Based on present information, there may be as many as four system checkouts occurring simultaneously due to time constraints.

- To what extent will the onboard systems have capability to rapidly isolate to the LRU level, especially for multi-subsystem failures

- Isolation of malfunctions occurring in the onboard checkout systems.

Resolution of these concerns will, of course, depend on results of presently developing analyses and analytical systems such as the SDL, as noted in the introduction.

3.2.4 Off-Line Operations. (Refer to appendix A, module A.2.4.) Off-line operations are those operations involving STS elements being processed outside the Orbiter flow. (The Orbiter process flow is

3.2.4 Off-Line Operations (Cont'd)

considered as the on-line element of the STS.) These elements are the SRB's, the ET, and the hypergol modules (which are a part of the Orbiter but are processed separately). The processing of each of these elements is considered separately.

3.2.4.1 SRB Preparation. (Refer to appendix A, module A.2.4.) SRB preparation includes the receipt, inspection, subassembly, and subsystem checkout. A majority of the functions accomplished during this phase are manual in nature and have been assigned to "Other" category.

The CCDS will provide operations management support during this phase, with specific support including provision of command, control, and monitoring for all checkout functions. This support will require data receipt and recording, data reduction and analysis, and data display capabilities.

3.2.4.2 ET Preparation. (Refer to appendix A, module A.2.4.) The CCDS support requirements are the same as in SRB preparation.

3.2.4.3 Hypergol Operations. (Refer to appendix A, module A.2.4.) Hypergol operations consist of deservicing, maintenance, checkout, and servicing of the hypergol modules and pods. Due to the hazards involved, all systems operations and checkout will be accomplished remotely (Level II requirement).

The CCDS will provide command, control, and monitoring of all system operations and checkout during this phase. It will receive, record, reduce (as required), and display data during system operations and checkout. The majority of these functions are provided by the CCDS operations management capability during this phase.

The eventual level of CCDS support required in this area is subject to determination of whether the hypergol modules are removed after each flight or removed only when an anomaly exists.

3.2.5 Off-Pad Vehicle Assembly. (Refer to appendix A, module A.2.5.) Off-pad vehicle assembly begins with preparing the mobile launch platform (MLP) for stacking of the SRB's and ends with preparing the

3.2.5 Off-Pad Vehicle Assembly (Cont'd)

STS/MLP for transfer to the launch pad. This phase will include stacking the SRB's, mating the ET to the SRB's, mating the Orbiter to the ET, accomplishing interface checkout, integrated checkout of the STS flight systems, ordnance installation and hookup, and preparation for rollout to the launch pad.

Due to the nature of the functions to be accomplished during this phase, the majority of the functions have been allocated to "Other." The CCDS will provide support for those functions which have been allocated to the Orbiter. The CCDS will provide either continuous or exception monitoring of all system checkout and will receive, record, reduce, and display data during this phase. When required, the CCDS will provide command initiation and control of functions being accomplished. These functions are provided within the operations management capability.

The only problems foreseen in this area are those related to the onboard system capabilities that were discussed in appendix A, module A.2.3, "Hangar Operations."

3.2.6 Transport to Pad. (Refer to appendix A, module A.2.6.) Transport to pad consists of transporting the assembled vehicle to the pad. Support required from the CCDS includes the monitoring and voice conferencing support provided by operations management.

3.3 ON-PAD OPERATIONS

The activities associated with the STS operations while on the launch pad are discussed in this paragraph and the CCDS functions identified. It is assumed the SSV will be integrated off-pad; however, the option of on-pad installation is discussed in terms of its CCDS implications. Paragraph 3.3 is concerned primarily with the Orbiter, ET, and SRB's. A separate, more detailed discussion is presented in the next paragraph concerning the activities and CCDS functions associated with payloads while on the pad.

3.3.1 Pad Installation. (Refer to appendix A, module A.2.7.) Pad installation activities commence upon arrival of the MLP/vehicle on the crawler/transporter (C/T) at the pad and end with completion of

3.3.1 Pad Installation (Cont'd)

the mating of the MLP/vehicle to the pad and verifying their interfaces. Major installation activities, as noted in appendix A, module A.2.7, are primarily those involving connection and activation of mechanical GSE for simple electrical continuity tests and leak checks.

CCDS functions will consist of operations management support as defined in the introduction, with support function initiation and facilities services control being provided from a launch area terminal which will be an extension of the CCDS processing system.

Major CCDS requirements, in addition to activating pad/MLP systems and generating interface verification stimuli, will include:

A. Work Scheduling/Data Management. The CCDS will support the pad installation phase by generating and displaying, on local area terminal(s), job completion updates, changes in schedules, and work authorizations as requested from the local area terminal.

B. Configuration Control. The CCDS will track, via an automated configuration control function, the installation and removal of non-flight hardware and test equipment during the pad installation phase, and provide real-time reconfiguration status displays of vehicle and GSE for resolution of anomalies, etc.

C. Problem Reporting and Investigation. The CCDS will provide tracking of problem reporting, investigation, resolution and closeout during pad installation, utilizing an interactive communications technique between its processing systems and the local area terminal. This will include maintenance of and access to failure history and trend analyses data bases applicable to installation-related activities, and display generation/presentation at the terminal.

Installation of the payload (discussed in paragraph 3.4) is also accomplished during this period.

3.3.2 On-Pad Assembly. On-pad assembly consists of assembling the elements on the pad, interface checkout, checkout of vehicle flight systems, and installation of ordnance.

3.3.2 <u>On-Pad Assembly</u> (Cont'd)

The requirements for CCDS support for the on-pad assembly concept are basically the same as those for off-pad assembly. The major difference would be that the interface checks (Orbiter/ET/SRB) would be accomplished on the pad and would include the MLP/STS interface tests. In addition, any of the system end-to-end checks which are accomplished twice (at IMF and pad) would only be accomplished once (at the pad).

3.3.3 <u>Flight Readiness Verification</u>. (Refer to appendix A, module A.2.8). Flight readiness verification consists of checkout of flight systems, loading software, and preparing the propellent systems for servicing.

The CCDS will provide operations management support during this phase, consisting of work scheduling, technical documentation, maintenance scheduling/planning, logistic support, configuration control, and anomaly reporting.

The CCDS will monitor all systems checks. In addition, it will provide command, control, and monitoring of those functions which, due to the lack of capability or time constraints, cannot be assigned to the Orbiter. The CCDS will load all checkout software into the onboard computers, provide the necessary support to accomplish fault isolation and/or LRU checkout, and provide the displays required to support checkout and control recording of all test data results. The CCDS will load all mission software into onboard computers. This operation will meet COMSEC/TEMPEST requirements. The CCDS will command, control, and monitor all facility services provided to the vehicle.

It is assumed that the potential for an extensive prelaunch checkout system is automatically provided with every orbiter, within the onboard processing configuration of five general-purpose computers and their two associated magnetic tapes, built-in sensors, and stimulators throughout the Shuttle. With special prelaunch checkout software developed for this system, a large percentage of the functional path verification and LRU-level fault isolation could be performed from the crew stations. Only those subsystems that cannot be checked out from the GN&C/PM computers would be

3.3.3 <u>Flight Readiness Verification</u> (Cont'd)

supported by GSE. Within the limitations of onboard memory and storage (both physical and operating system utilization limitations), the same level of checkout should be available onboard as with the ground system. Special software in the onboard computer system during the prelaunch phase could replace a large portion of the checkout system. Tables 3-1 and 3-2 present the prelaunch ground monitoring and control functions (typical) required and allocated to the CCDS or Orbiter. A driver for prelaunch checkout is the time available. Performing integrated checkout of a vehicle as complex as the STS requires the capability to 1) monitor a large number of parameters, 2) send commands to the vehicle (to open and close valves, turn switches on and off, etc.), and 3) send simulated data to the vehicle computer subsystems (gimbal angle and accelerometer readings, propellent level sensor readings, discrete signals, etc.). Hence, it appears mandatory that a highly automated, ground/Orbiter *integrated checkout* philosophy be developed that will enable a high degree of parallel checkout to be accomplished. As the performance monitoring systems and operations are definitized, a more optimal sequence of tests may be indicated; however, the requirement of a fast, automated checkout system will still be valid.

A second consideration for on-pad checkout is one of scope. To optimally define the integrated checkout system, the level of checkout performed prior to vehicle mating must be understood. The more extensive premate checkout is, the less extensive integrated checkout has to be.

Another area that must be given early attention is the interaction between the onboard checkout crew and the ground support crew. This must be established to prevent unnecessary duplication of effort or inefficiency which could seriously impair checkout operations.

A well planned, integrated checkout system involves both the CCDS and the onboard computer system. Each will have monitor and control functions. A parallel checkout scheme must be employed to meet time constraints.

TABLE 3-1

PRELAUNCH MONITORING FUNCTIONS (TYPICAL)

DATA CENTER	FUNCTIONS
ORBITER	• ALL VEHICLE SUBSYSTEM HEALTH DATA • VEHICLE SUBSYSTEM AND PAYLOAD RESPONSES TO STIMULI • PROPER CONFIGURATIONS • GN&C COMPUTER CALCULATED OUTPUTS
CCDS	• ALL VEHICLE SUBSYSTEM HEALTH DATA • VEHICLE SUBSYSTEM RESPONSES TO STIMULI • PROPER CONFIGURATIONS • GN&C COMPUTER CONFIGURATIONS • TREND PREDICTIONS FROM PM • GSE HEALTH AND OPERATION • COMPUTER MEMORY SUM CHECKS • COMPUTER DISCRETE OUTPUTS (RESPONSE TIME AND VALUES) • HAZARDOUS GAS DETECTION SYSTEM

TABLE 3-2

PRELAUNCH CONTROL FUNCTIONS (TYPICAL)

DATA CENTER	FUNCTIONS
ORBITER	• VEHICLE CONFIGURATION COMMANDS • VEHICLE CHECKOUT COMMANDS
CCDS	• ACTIVATION OF COMPUTER DATA DUMPS • LOADING OF FLIGHT COMPUTERS • UPDATING OF FLIGHT COMPUTERS • VEHICLE CONFIGURATION COMMANDS • GO/NO-GO DECISIONS • VEHICLE CHECKOUT COMMANDS (POSSIBLE) • ECS FLOW TEST (REFER TO APP A, MOD A.1.1.2) • PROVIDE ELECTRICAL POWER TO VEHICLE • LO_2 AND LH_2 TEST (REFER TO APP A, MOD A.1.1.4) • PROPELLENT CONDITIONING, LOADING, AND DRAINING • PLATFORM TURN-ON • PLATFORM POSITIONING

3.3.4 Attainment of Standby Condition. (Refer to appendix A, module A.2.9.) The standby condition consists of configuring the vehicle for standby status and monitoring vehicle systems while in standby.

The CCDS will provide operations management support during this phase, consisting primarily of work scheduling, configuration control, vehicle status monitoring and anomaly reporting.

The CCDS will also command, control, and monitor all facility services provided to the vehicle.

3.3.5 Launch Operations. (Refer to appendix A, module A.2.10.) Launch operations commence at T-2 hours and end at liftoff; they will include propellent loading, crew ingress, systems verification for launch, automatic countdown, and terminal countdown.

Ground support is required during launch operations for the following:

- Control and monitor of propellent loading, fuel cell reactant loading, pressurization, and start-up.
- Monitor crew activation of vehicle systems and crew preflight checks
- Provide range safety clearance and control pad access
- Provide mission clearance
- Monitor for unsafe conditions - leaks, excessive temperatures and pressures
- Control and monitor all GSE
- Provide for sequencing critical launch functions

3.3.5 <u>Launch Operations</u> (Cont'd)

Ground support includes the control and monitoring of propellent loading and other GSE functions. Propellent loading, being a hazardous operation, is performed prior to crew boarding and with the pad area clear of personnel. Extensive leak, pressure, and temperature monitoring, external and internal to the vehicle, is performed to detect and safe ground and vehicle elements in the event of a hazardous failure.

Ground support also provides for transportation of crew and boarding assistance and monitoring and assisting in vehicle systems activation and preflight checks during this high-activity terminal count period.

Ground support provides for mission planning and range safety clearance to assure that all factors external to the vehicle are compatible with a go for launch. Sequencing of critical GSE launch functions, such as service mast retraction and tip lock release, are handled by ground support.

The CCDS will provide operations management support during this phase, consisting primarily of work scheduling, configuration control, and anomaly reporting and resolution. Specifically, these activities will include monitoring, task initiation and control, vehicle propellent loading control; terminal countdown control, recording of data and provision of the necessary displays to assure safe and proper operations during this phase.

CCDS functions of launch operations include the update of mission software and verification of GN&C alignment. This paragraph looks at those activities associated with the GN&C support required of the CCDS.

Ground participation is required in activation of GN&C System.

- Initialize and load onboard computers
- Monitor and verify checkout of GN&C hardware units
- Monitor calibration and reference alignment of navigation aid sensors

3.3.5 Launch Operations (Cont'd)

- Perform calibration and reference alignment of IMU
- Load targeting data for given mission
- Load target state vector for rendezvous mission

During the prelaunch phase, activation and checkout of the GN&C System will be performed. CCDS will initialize and load software to the onboard computers. The software includes targeting data for a given mission, target ephemeris data for a rendezvous mission, and vehicle dependent parameters. CCDS will monitor onboard status of GN&C and the calibration and reference alignment of the IMU. If a launch delay should occur, resulting in a change in launch azimuth, computations to effect this change would be performed onboard.

3.4 PAYLOAD PRELAUNCH OPERATIONS

3.4.1 Launch Pad Payload Activities. The purpose of this section is to present the results of the launch pad payload activity functional analysis. Particular emphasis was placed on defining the CCDS functions associated with 1) receiving at the launch pad, installing, and integrating the payload into the STS system, 2) maintaining the payload integrity, and 3) completing payload preparations for launch. The functions are developed chronologically from the point of payload arrival at the launch pad through liftoff.

3.4.1.1 Background. A key element in the STS philosophy is rapid turnaround of the Orbiter from landing to liftoff. Within the current turnaround baseline of approximately 14 days, less than 1 day of launch-pad activity is scheduled. This short time-frame precludes performing lengthy testing and checkout of payloads at the launch pad; therefore, all payloads must undergo complete and rigorous testing and checkout prior to pad delivery. The primary launch pad payload operations should be restricted to installing and integrating the payload into the STS system, and to verifying and maintaining the operational integrity of the payload, once installed.

3.4.1.2 Scope of Launch Pad Payload Activites. The on-pad payload prelaunch operation begins with the payload installation into the Orbiter and terminates at liftoff. There are four distinct phases to this operation; payload installation, readiness verification, standby, and countdown (see figure 3-4). Payload installation includes the physical installation of the payload into the Orbiter. Payload launch readiness verifies the operability of the payload, payload/Orbiter interfaces, and payload/ground interfaces. Upon completion of payload launch readiness verification, the payload has achieved flight status and the standby mode commences. The CCDS support in standby is to maintain the payload in a state of readiness by monitoring the various subsystems' status and controlling the payload bay environment. Standby terminates upon initiation of countdown operations. During countdown, the payload flight status is maintained; loading of payload fluids and gases is completed; payload software is loaded, updated, and validated; payload facility support switched to the Orbiter; all communications between the payload and ground are routed through the Orbiter communication subsystem; and the flight crew assumes control of the payload. The on-pad payload prelaunch function analysis is addressed in the following paragraphs based upon the above considerations.

3.4.1.3 Payload Installation. (Refer to appendix A, module A.2.11.) For the purpose of this analysis, the payload installation operations (satellite, OOS, or OOS/satellite) are considered to begin with verification that the launch pad payload installation and support facilities and the Orbiter are ready and activated, and to terminate upon completion of physical and visual verification that all electrical, hydraulic, and mechanical connections among the payload, Orbiter, and payload-related ground support equipment have been properly established. (Verification of interfaces via remotely initiated stimulus is performed later and described in the section on launch readiness tests.)

Payload installation facilities are conditioned and activated preparatory to receiving the payload subsequent to installation of the SSV on the launch pad. The payload installation facilities include receiving dock, service elevator, enclosed installation area, and supporting services (e.g., electrical and hydraulic power, water, environmental control, etc.).

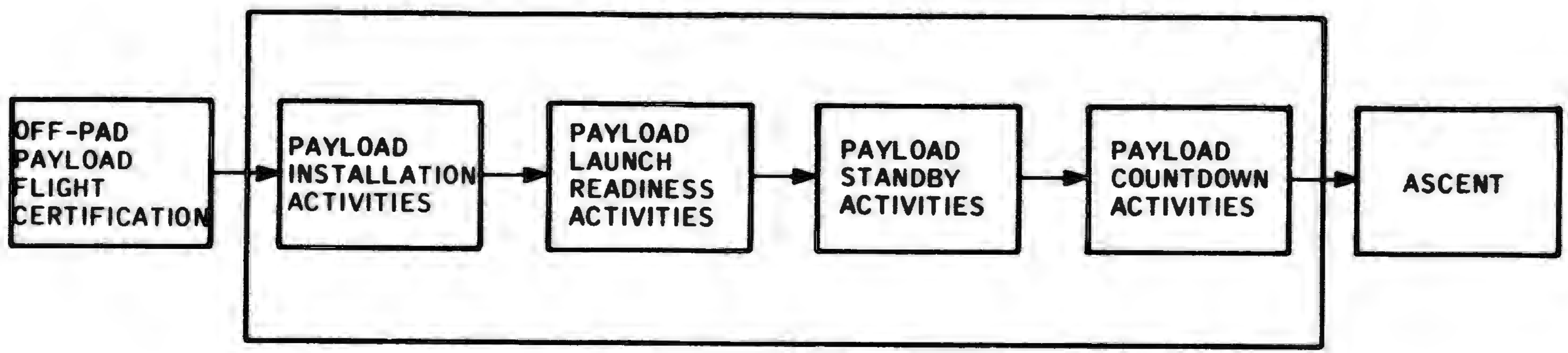


Figure 3-4 Launch Pad Payload Prelaunch Operations

3.4.1.3 Payload Installation (Cont'd)

Upon transfer of the payload to the environmentally controlled installation area, the installation handling equipment is attached, and interfaces on the payload, Orbiter, and payload GSE are conditioned and configured for mating. Subsequently, the interface connections are established, the payload is placed in the Orbiter payload bay, and all interface connections are physically and visually verified.

The functions associated with installation operations have been grouped as follows.

- Establish, verify, and maintain launch pad payload installation support facilities
- Receive payload at launch pad
- Payload handling and mating with Orbiter and GSE
- Interface verification
- Payload installation and verification support operations.

The criteria governing the allocation of the specific functions include the following.

- Physical handling and mating operations will be performed by payload installation personnel
- Supporting services such as electrical and hydraulic power, water, air conditioning, etc., are GSE
- Event sequence control and event monitoring must be centrally controlled as much as possible to assure personnel and flight safety, and to assure adherence to operations schedules
- Functional control will be allocated to the local area whenever impact upon other operations is minimal or cannot be practically allocated otherwise, to assure quick, effective, and safe performance
- Payload COMSEC equipment has been operationally configured prior to delivery to launch pad. Therefore, no physical access to payload crypto units is required during payload installation.

3.4.1.3 <u>Payload Installation</u> (Cont'd)

Throughout the payload installation phase (and subsequent preflight phases), there are associated overall executive and managerial functions to be performed. These functions have been primarily allocated to the CCDS. The criteria for this allocation are as follows.

- A single point of responsibility is highly desirable for reasons of safety and progress control
- The CCDS is the functional hub of operations
- The CCDS will have interfaces with all operational segments

The overall CCDS executive and managerial responsibilities associated with each payload preflight phase are addressed separately in subsequent topical paragraphs. The above criteria are applicable in all cases.

A. <u>Establishment, Verification, and Maintenance of Launch Support Facilities</u>. This function is used to "ready" the launch activities. The CCDS primary function is to provide executive and administrative direction.

B. <u>Receiving, Handling, and Mating of Payload to Orbiter</u>. This function includes those activities involved in physically moving the payload into and mating with the Orbiter. The primary CCDS functions are to provide overall executive control.

C. <u>Interface Verification</u>. (Refer to appendix A, module A.2.12.) Interface verification consists of a physical and visual inspection of all required electrical, hydraulic, and mechanical interfaces between the Orbiter, payload, and payload related GSE and AGE. Physical and visual verification is performed preparatory to stimulus verification. The principal interfaces are between the following:

- Orbiter and payload
- Payload and payload-related GSE
- Orbiter and payload-related GSE.

3.4.1.3 Payload Installation (Cont'd)

The major interfaces to be verified between the Orbiter and payload are 1) the mechanical retention and deployment devices by which the payload is secured within the bay; 2) the mechanical retention devices for securing interface cabling and plumbing within the payload bay; 3) electrical power, communication and control cables; 4) liquid and gas loading, unloading, purging, and venting plumbing; and 5) payload antenna hat.

Payload and payload-related GSE interfaces to be verified include 1) electrical power, communication, and control cabling, and 2) liquid and gas loading, unloading, and venting plumbing.

Orbiter and payload-related GSE interfaces to be verified (via the Orbiter's external payload service panels) include 1) electrical power, communications, and control cabling, and 2) liquid and gas loading, unloading, and venting plumbing.

The visual and physical verification functions have all been allocated to the payload installation personnel.

D. Payload Installation CCDS Executive and Management Functions. (Refer to appendix A, module A.2.13.) Payload installation personnel will perform the actual functions of installing the payload within the Orbiter payload bay. The principal support functions of the CCDS during this phase will be to direct the sequence of events; monitor events; assure non-interference of operations; assure adherence to all safety procedures; coordinate all flight vehicle, payloads, and ground activities associated with payload installation; reschedule/modify preflight operations as required; and provide payload installation status information to all cognizant elements.

3.4.1.4 Payload Launch Readiness. Prior to delivery to the launch pad area, the payload undergoes thorough checkout and testing to certify that it is capable of performing its intended functions. The purposes of the payload launch readiness phase are 1) to assure that the payload performance capability has not degraded and is maintained; 2) to verify that the payload has been properly installed and integrated into the STS system; and 3) to conduct final payload preparation for launch (excluding loading of cryogenics).

3.4.1.4 <u>Payload Launch Readiness</u> (Cont'd)

The completion of the payload launch readiness phase marks the point at which the payload may be certified as flight ready except for final fueling, updating of mission parameters, and switching to the Orbiter for facilities support and control. This also marks the point at which the payload enters the standby phase or progresses directly into the countdown phase.

Figure 3-5 presents the higher level functions performed during payload launch readiness. This phase commences with preparatory activities such as 1) establishing the hardwire and radio frequency communication links between the payload and ground (direct and via the Orbiter), 2) checkout and activation of test equipment and facilities, 3) loading and validating test software, and 4) establishing the necessary ground/ground communications links. Following these activities, tests are run to verify the operational integrity of the payload and the payload/Orbiter, payload/GSE, payload/ground, and Orbiter/payload related GSE interfaces.

During this period, mission data may be loaded and validated. Following payload bay door closure, payload hypergolics may be loaded and payload cryogenic tank conditioning initiated.

The higher level functions delineated in figure 3-5 are addressed in more detail in the following paragraphs.

A. <u>Payload/STS Readiness Testing</u>. (Refer to appendix A, module A.2.14.) The purpose of the payload launch readiness activities is to establish, verify, demonstrate, and maintain the integrity of the payload and the operational compatibility between the payload and the rest of the STS.

   Current concepts dictate that detailed acceptance testing of each payload be performed prior to installation in the Orbiter. The purpose of on-pad payload test and checkout is not to repeat the detailed testing, but to maintain the payload integrity by performing top level, end-to-end STS system and integration test and checkout. (Detailed test and checkout is not precluded; however, this would probably entail extending on-pad operations beyond the STS program turnaround time goal.)

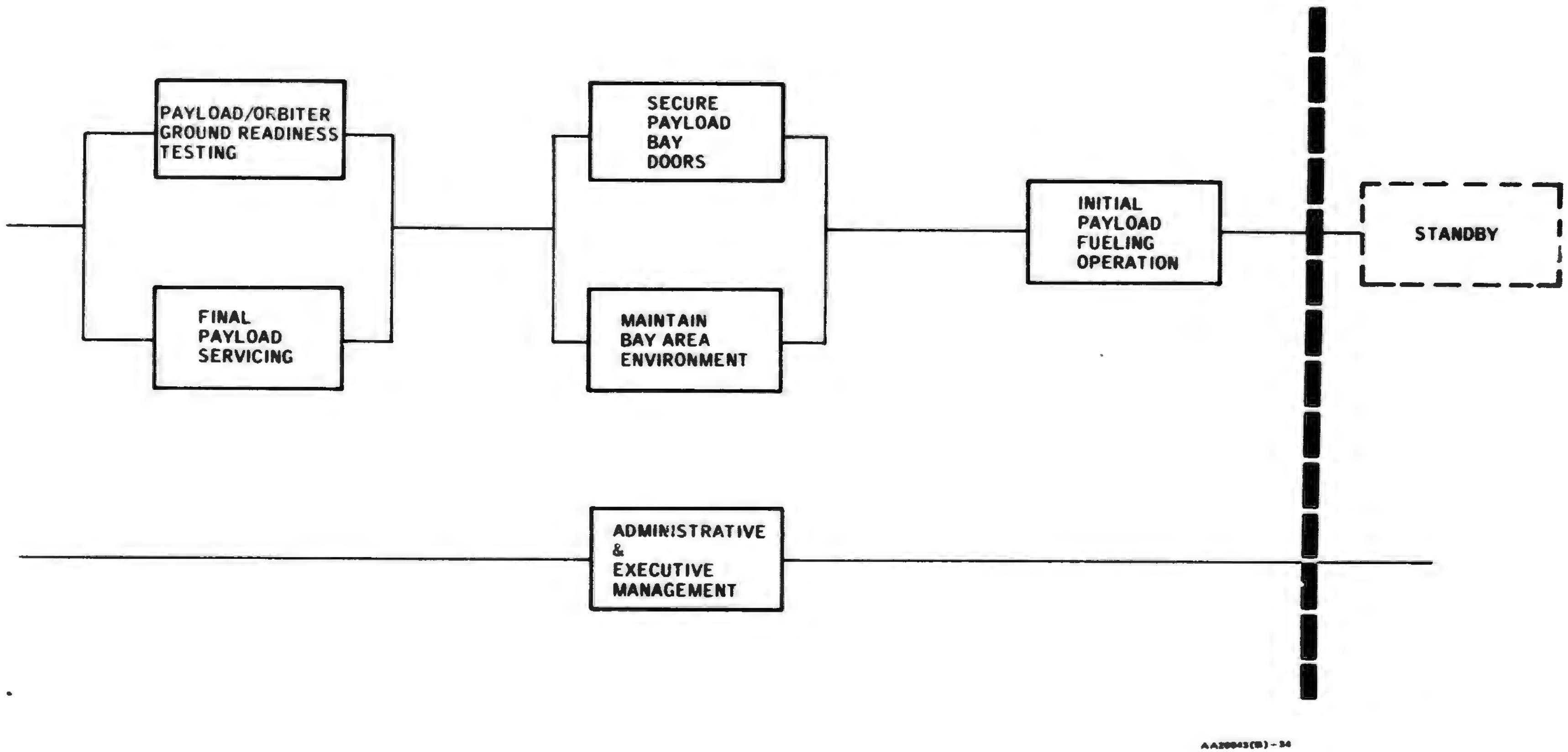


Figure 3-3 Payload Launch Readiness Operation

3.4.1.4 Payload Launch Readiness (Cont'd)

The test and checkout functions will utilize specific test support equipment and the operational equipment. The operational equipment is utilized to conduct operational tests in order to ensure that the operational equipment will indeed properly interface with STS elements, and function in the operational environment.

Preparatory to the testing, certain Orbiter, payload, GSE, CCDS and satellite user/contractor support equipment or facilities are activated and operability verified. Communication interfaces are established, verified and maintained. For safety reasons, the verification functions are initially performed from the ground. Once the ground systems have verified the operability of the interfaces and verified that no safety hazard exists, the interfaces, subject to onboard monitoring and control capability, are verified by test and checkout personnel onboard the Orbiter, utilizing the operational onboard systems. The end-to-end testing progressively expands until the payload has been integrated with all necessary STS elements. The criteria for allocating these functions are as follows.

1. The CCDS will have overall responsibility for establishing, maintaining and controlling communications interfaces.

2. The CCDS will monitor the payload's health in order to ensure personnel and equipment safety. Satellite personnel will also monitor and advise the CCDS regarding the payload health.

3. The CCDS will monitor and have command/control capability as required to assure safety of integrated vehicles.

4. The testing concept requires a high degree of centralized control which is best performed by the CCDS.

5. Verification of STS element's operability is vested in that element; e.g., Orbiter, ground or user.

6. Verification of the STS operability is vested in the CCDS.

3.4.1.4 Payload Launch Readiness (Cont'd)

B. Final Payload Servicing. (Refer to appendix A, module A.2.15.) Prior to closing and securing the payload bay doors, the final servicing of the payload subsystems which require physical accessibility are performed. At this time, batteries are replaced, protective shielding secured, special test adapters/jigs removed, payload antenna systems reconnected and carry-on equipment and cabling removed. In addition, the mechanical satellite(s)-to-OOS interface is verified. Concurrent with securing the payload, mission data may be loaded into the payload and verified. The criteria for allocating these functions are as follows.

1. Manual payload servicing functions will be accomplished by user (satellite) or OOS personnel.

2. Orbiter bay activities will be controlled and monitored by the CCDS.

3. Orbiter bay activities will be supervised and directed by Orbiter vehicle personnel.

4. The CCDS may load mission data furnished by the payload user (via Orbiter data lines).

5. The payload user will verify the mission data load.

C. Payload Bay Door Closure. (Refer to appendix A, module A.2.16.) This function includes the mechanical and electrical steps preparatory to payload bay door closure, actual closure, and maintenance of closure integrity. The CCDS will have the primary responsibility for performing (remotely) the associated functions, and will monitor, direct, and control the sequence and operation of the events.

3.4.1.4 Payload Launch Readiness (Cont'd)

D. Establishment/Maintenance of Payload Bay Environment. (Refer to appendix A, module A.2.17.) Following closure of the payload bay doors, the payload bay environment is established and maintained. The environment (temperature, pressure, humidity, cleanliness, etc.) must be controlled to meet payload requirements and to verify proper Orbiter bay door sealing and venting. The criteria for allocating this function to the CCDS was chosen because the environmental support equipment is 1) physically outside the Orbiter, and 2) it is doubtful that the Orbiter needs provision for controlling external payload-oriented facility equipment.

E. Initial Payload Fueling Operations. (Refer to appendix A, module A.2.18.) The purpose of this function is to load payload liquids and gases (excluding cryogenic propulsion fuels) and to begin chilldown of any cryogenic propulsion fuel payload tanks. The CCDS will control, direct, monitor the fuel loading operations. This function also includes verification and control of fuel and consumables venting and unloading capability. The criteria for allocating these functions are as follows.

1. The Orbiter has the capability for fueling of the payload with bay doors closed.

2. Personnel safety requires the fuel loading operation be directed and controlled external from the Orbiter.

F. Payload Launch Readiness CCDS Executive and Management Functions. (Refer to appendix A, module A.2.19.) During the payload launch readiness phase, the CCDS will perform overall executive and management functions in support of payload readiness operations. The CCDS will continue to direct the sequence of critical events; monitor the progress of events; ensure non-interference of operations; ensure

3.4.1.4 Payload Launch Readiness (Cont'd)

personnel and equipment safety; coordinate all flight vehicle, payload, and ground-related activities; reschedule/modify preflight operations as required, and provide payload readiness status data to all cognizant elements. These functions will become more complex and important during this phase because more events will be occurring involving more people, hardware, and software.

Additional payload-oriented functions will also be performed in support of the payload readiness phase. The additional functions have to do primarily with providing and controlling payload data handling and fluid and gas loading. The signal data handling functions include the typical data handling functions such as loading and validating software, receiving, signal processing, data processing, relaying, monitoring, controlling, and recording.

The data handling functions of satellite sensor (experiment) packages and vehicle health will not be performed by CCDS (except for those functions connected with safety). These functions, due to their potential classified nature, are the responsibility of the satellite user or satellite contractor. CCDS will be responsible only for assuring the communications link. The excluded satellite functions will, however, be performed by CCDS for the OOS.

3.4.1.5 Payload Standby Activities. There are two points during prelaunch activities at which a standby condition may be entered. The first occurs at approximately T-3.5 hours (the end of prelaunch readiness activities), and the second at approximately 2 hours before launch. The reasons for these two points are Orbiter-driven, and have no relationship to the payloads except for conditioning of the cryogenic loading system and payload cryogenic tanks during the period from T-minus-3.5 to T-minus-2.0. Except for the cryogenic consideration, the functional support of the payload during either standby period is the same.

During standby, the payload is in a relatively quiescent mode and is maintained in the state at which it was in at the end of payload

3.4.1.5 Payload Standby Activities (Cont'd)

prelaunch readiness activities. The functions described below are associated with maintaining this state; i.e., monitoring and controlling safety, health parameters, and payload bay environment. Non-essential equipment is deactivated and secured at this time. The criteria used for allocating the functions are essentially the same as defined for payload prelaunch readiness activities.

A. Payload Status and Payload Bay Environment Monitoring and Control. (Refer to appendix A, module A.2.20.) In the standby mode, the emphasis is to maintain payload "ready for launch" status, and to prevent the payload creating a hazardous condition that would affect personnel or equipment safety. This necessitates that the appropriate ground support be continued to provide the necessary stimuli, processing, detection, display, monitoring, and control functions.

B. Demating and Removal of Non-Essential Equipment. (Refer to appendix A, module A.2.21.) This task includes demating and removal of excess, test servicing, or related payload GSE. This function is allocated to the responsible service organization under the CCDS overall administrative function.

C. Payload Standby CCDS Executive and Management Functions. (Refer to appendix A, module A.2.22.) The CCDS executive and management functions performed during payload standby are essentially identical to those defined for the payload launch readiness phase. (Refer to paragraph 3.4.1.4,F for a delineation of these functions.) The principal differences are not ones of function but application. Whereas the application was directed towards preparation during the payload launch readiness phase, the application during payload standby is directed towards maintaining a "steady state."

3.4.1.6 Payload Countdown Activities. The purpose of the payload countdown activities is to complete the preparation of the payload for the flight phase. These activities begin approximately two hours before liftoff. The principal payload-related functions performed during this period include the following.

- Loading of payload propellent cryogenics and "topping off" of previously loaded fluids and gases

3.4.1.6 <u>Payload Countdown Activities</u> (Cont'd)

- Making final mission updates to the payload
- Switching payload facilities support (power, thermal control, etc.) from the ground to the Orbiter
- Conducting handover or payload control from the owners to the Orbiter system and crew
- Routing all payload/ground communications through the Orbiter communications system; i.e., deactivation of all direct ground/payload communication links
- Alerting and providing payload and countdown status to payload flight support and monitoring facilities.

Final countdown activities are almost totally under the control of the CCDS or the Orbiter systems and crew. This is necessary in order to ensure adherence to schedules and personnel and equipment safety.

A. <u>Payload Cryogenic Loading and Fluid and Gas Level "Topping"</u>. (Refer to appendix A, module A.2.23.) The purpose of this function is to perform final payload fueling operations up to a point shortly before liftoff. Their operations are functionally controlled, directed, and monitored by the CCDS because of the extremely critical safety hazard to equipment and in particular to the flight crew.

B. <u>Payload Operation Prior to Payload Control Handover to Orbiter</u>. The purpose of this function is to maintain payload integrity and its integration with other STS program elements as well as with the satellite user/contractor. The CCDS continuously monitors and controls the payload prior to handing control over to the Orbiter. During this period, the CCDS monitors the payload C&W parameters, maintains the payload operational status and controls the payload bay environment. Final payload mission parameters may be loaded, verified and/or updated. Concurrently, the Orbiter crew has ingressed, secured for launch and initiated the payload-Orbiter systems checklist. Satisfactory completion of these

3.4.1.6 Payload Countdown Activities (Cont'd)

functions is essential because, after handover to the Orbiter systems and crew, the emphasis shifts to just maintaining payload-Orbiter safety.

At this time, the CCDS must have absolute control of these payload functions. Therefore, the payload user completes and terminates all payload commanding activities and goes into a monitoring-only mode. The functional allocation criteria are as follows:

1. Both the Orbiter and CCDS must possess essentially the same control capabilities.

2. Both the Orbiter and CCDS must possess essentially the same monitoring capabilities.

C. Payload Handover Operations. (Refer to appendix A, modules A.2.24 and A.2.25.) The handover operation involves transferring control of the payload bay environment, the payload facilities support (power, thermal control, etc.), and the payload "flight readiness" state from the CCDS to the Orbiter systems and crew. The CCDS handover procedure involves establishing function status, verifying concurrence of status from the Orbiter, and transfer of function control to the Orbiter. The Orbiter handover procedure involves establishing the function status, verifying concurrence of status to the CCDS, and accepting functional control from the CCDS. The allocation criteria are:

- Both the Orbiter and the CCDS must possess the same control capabilities
- Both the Orbiter and the CCDS must possess the same monitoring capabilities
- The CCDS and user may continue to monitor all available payload data.

3.4.1.6 Payload Countdown Activities (Cont'd)

D. Payload Operations After Control Handover. (Refer to appendix A, module A.2.26.) After payload control handover, the Orbiter has the primary responsibility to monitor the payload caution and warning parameters and maintain the payloads operating status. The CCDS and payload user assume a backup monitoring mode to alert, advise and support the Orbiter function, and continue to record payload data. The allocation criteria include:

1. The Orbiter has prime responsibility to control payload health.

2. The CCDS is in a monitoring mode.

3. The CCDS is in state of readiness to support a payload contingency.

E. Payload Countdown CCDS Executive and Management Functions. (Refer to appendix A, module A.2.27.) The principal concern of the CCDS in this phase is to maintain the integrity of the payload, ensure final fueling, maintain Orbiter crew and equipment safety, and hand control of the payload over to the Orbiter crew. During this phase, it is important that the CCDS exercise control over the payload until handover of payload control to the Orbiter.

The high level of control is necessary for personnel safety. The crew is not onboard at this time due to the hazardous cryogenic fueling operations. Essentially the same functions delineated for payload standby (paragraph 3.4.1.5,C) apply to this phase.

An important additional function during payload countdown is the handover of payload control to the Orbiter and assurance of detachment, clearance and securing of payload-related GSE. CCDS executive control of these functions is mandatory.

3.5 SRB RECOVERY OPERATIONS (Refer to appendix A, module A.2.2.8)

These operations involve the recovery of the spent SRB's from their water impact point. The primary CCDS function for this operation is the overall coordination as a part of operations management and control. Impact predictions are provided to the recovery forces by CCDS as discussed in section 4 of this report.

3.6 CONTINGENCY SUPPORT

The preceding paragraphs assumed a generally nominal flow through the turnaround, assembly, and launch activities. This paragraph addresses four contingency situations in which a mission change or crew safety is the major driver. Contingencies addressed are: payload changeout, retargeting, contingencies after T-minus-2 with no crew onboard, and contingencies after T-minus-2 with the flight crew onboard.

3.6.1 Payload Changeout Support (refer to appendix A, module A.2.29). The payload changeout operation assumes either a controllable and non-hazardous payload failure has occurred or a payload of another program is to replace the one currently in the bay. In addition to a retargeting task required for the difficult payload (see paragraph 3.6.2), payload changeout involves the following tasks:

- Safing of crew, Orbiter, and payload
- Payload deactivation
- Establishing and maintaining support facilities and services
- Bay door opening
- Pre-removal handling, demating, and servicing of payload
- Payload removal
- Payload pre-installation operations.

These tasks are discussed in the subsequent paragraphs.

Before the payload is deactivated, it is made safe through disabling of ordnance, purging or draining fuel systems, and removing payload electrical or hydraulic power.

3.6.1 <u>Payload Changeout Support</u> (Cont'd)

Deactivation of the payload begins after the Orbiter and payloads have been safed and is completed before the payload removal preparation. Deactivation includes that for the electrical, mechanical, and hydraulic support services; the payload's electrical, hydraulic, propulsion, and mechanical (gyro) subsystems; and the payload's electrical, mechanical, hydraulic, fluid, and gases interfaces and/or interfacing devices.

The criteria for allocating functions in Appendix A, module A.2.29 were:

A. The crew will have the first responsibility to safe the payload to the level where they are safe.

B. After the crew is safe, the remaining safing operation is controlled by the CCDS.

C. Deactivation is a cooperative task between Orbiter personnel, ground crew, and CCDS support personnel and capabilities.

CCDS operations management support provided during this phase will consist primarily of work scheduling, configuration control, and anomaly reporting and resolution.

The CCDS will command, control, and monitor those facility services required to support payload changeout operations.

3.6.2 <u>Contingency Retargeting</u>. In the event of a mission change (e.g., deploy payload B instead of payload A) retargeting of the SSV must occur. Retargeting is defined in the DOD Shuttle System Requirements "... as the process whereby all of the guidance equation impacts of a new target ephemeris are calculated, specified for coding purposes and validated. Generally, the retargeting will result in changes to guidance equation parameters, which will have minor impacts on the coded flight program and which can easily and quickly be loaded into the flight computer." Under normal conditions, all orbital targeting data will be predeveloped by mission planners/designers and be available at the launch site (resident in CCDS processing storage) for uplink to Orbiter processor storage during on-pad operations. These targeting "packages" comprise major portions of the guidance, navigation, and control software, and include the following major categories:

A. <u>General-Purpose Maneuver Targeting (On-Orbit)</u>

1. Attain orbital conditions for payload deployment on Orbiter.

3.6.2 <u>Contingency Retargeting</u> (Cont'd)

2. Orbit maintenance: maintain orbit within specified bounds for long periods of time.

3. Groundtrack adjustments: maintain nominal groundtrack.

B. Rendezvous Targeting: Initial Phase

1. Rendezvous targeting performed by Orbiter to intercept a target vehicle.

2. Rendezvous targeting module generates targeting parameters to powered flight guidance.

   NOTE: The rendezvous targeting package for initial load will be capable of targeting any contingency rendezvous plan consisting of standard rendezvous maneuvers.

3. Standard rendezvous sequences will be developed on the ground by mission planners and loaded into the rendezvous targeting module.

C. Rendezvous Targeting: Terminal Phase

1. Initial intercept trajectory maneuver.

2. Midcourse correction.

3. Braking.

4. Rendezvous targeting module generates parameters to powered flight guidance software.

5. Constraints are preloaded.

D. Station Keeping Target Maneuvering.

E. Pre-Ignition Deorbit Targeting

1. Initiated on-orbit.

3.6.2 Contingency Retargeting (Cont'd)

2. Satisfies entry interface target conditions:

   a. Entry downrange position from landing position.

   b. Entry crossrange position from landing position.

The general targeting data development flow and related CCDS support capabilities are illustrated in figures 3-6 and 3-7, respectively.

Those processes shown are the nominal cases and are performed in a timeframe compatible with preplanned mission objectives. Contingencies may occur, however, requiring retargeting to a dissimilar mission (e.g., retrieval of a disabled payload or disabled Orbiter). In these cases, contingency is considered a situation other than those accounted for in predeveloped contingency support programs which are contained in nominal mission GN&C software.

CCDS support in the dissimilar retargeting mode may invoke all the procedures depicted in figures 3-6 and 3-7, depending on the scope and time-constraints involved. Under the latter constraints, an obvious turnaround time compression would be necessary. However, certain of these functions impact CCDS in all retargeting contingencies regardless of constraints. In summary, these are:

- Maintenance of and access to mission profile and flight program data bases

- Provision of flexible voice conferencing configurations among mission planners, mission designers, launch control onboard personnel, and (as applicable), payload offices

- Provision of code-validation and simulation processing support in real-time mode for targeting maneuver updates

- Provision of real-time access support to JSC-resident mission planning data bases, JSC mission agents (for NASA launches at VAFB), and JSC software development support facilities (e.g., SDL).

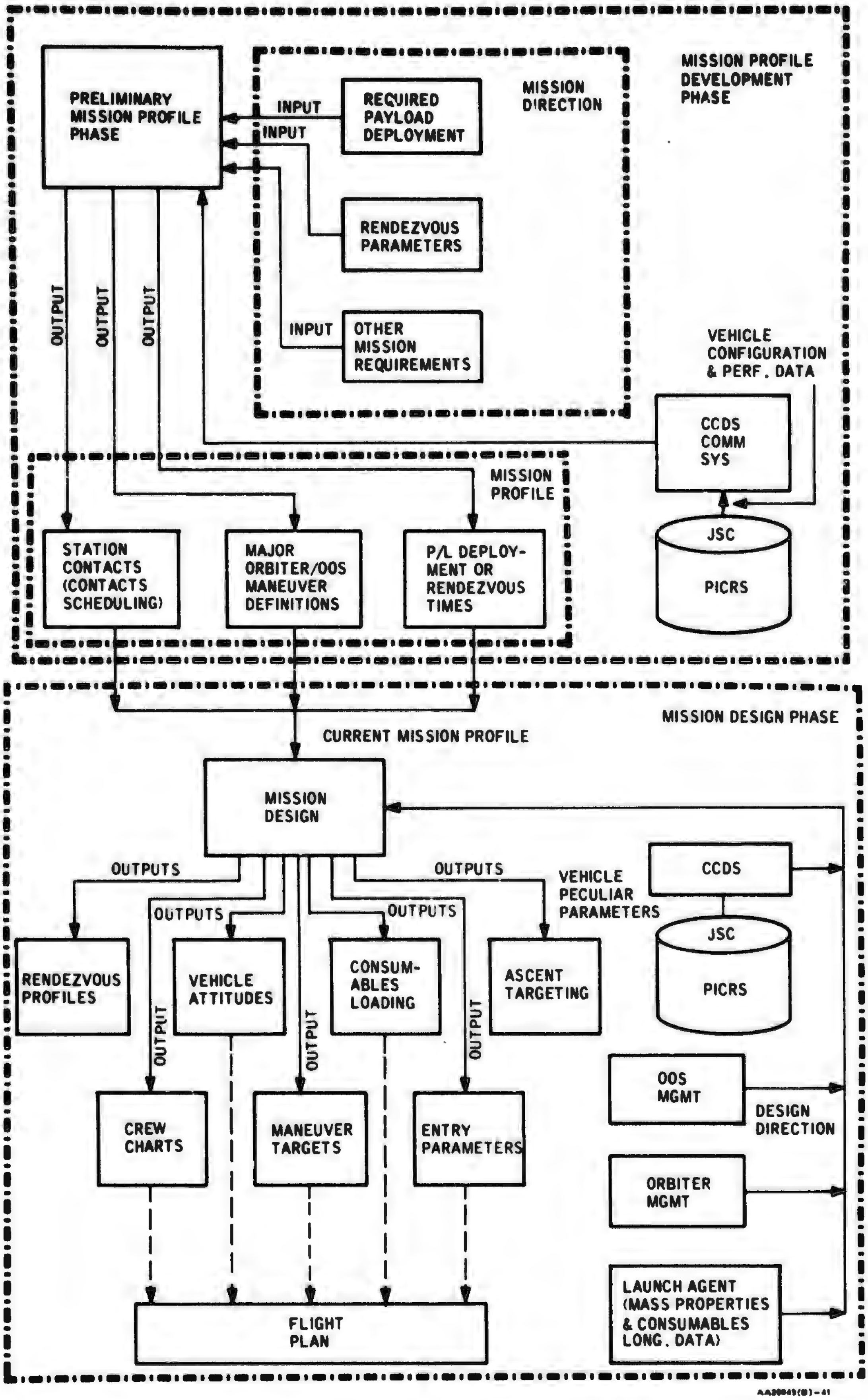


Figure 3-6 Targeting Data Development Flow

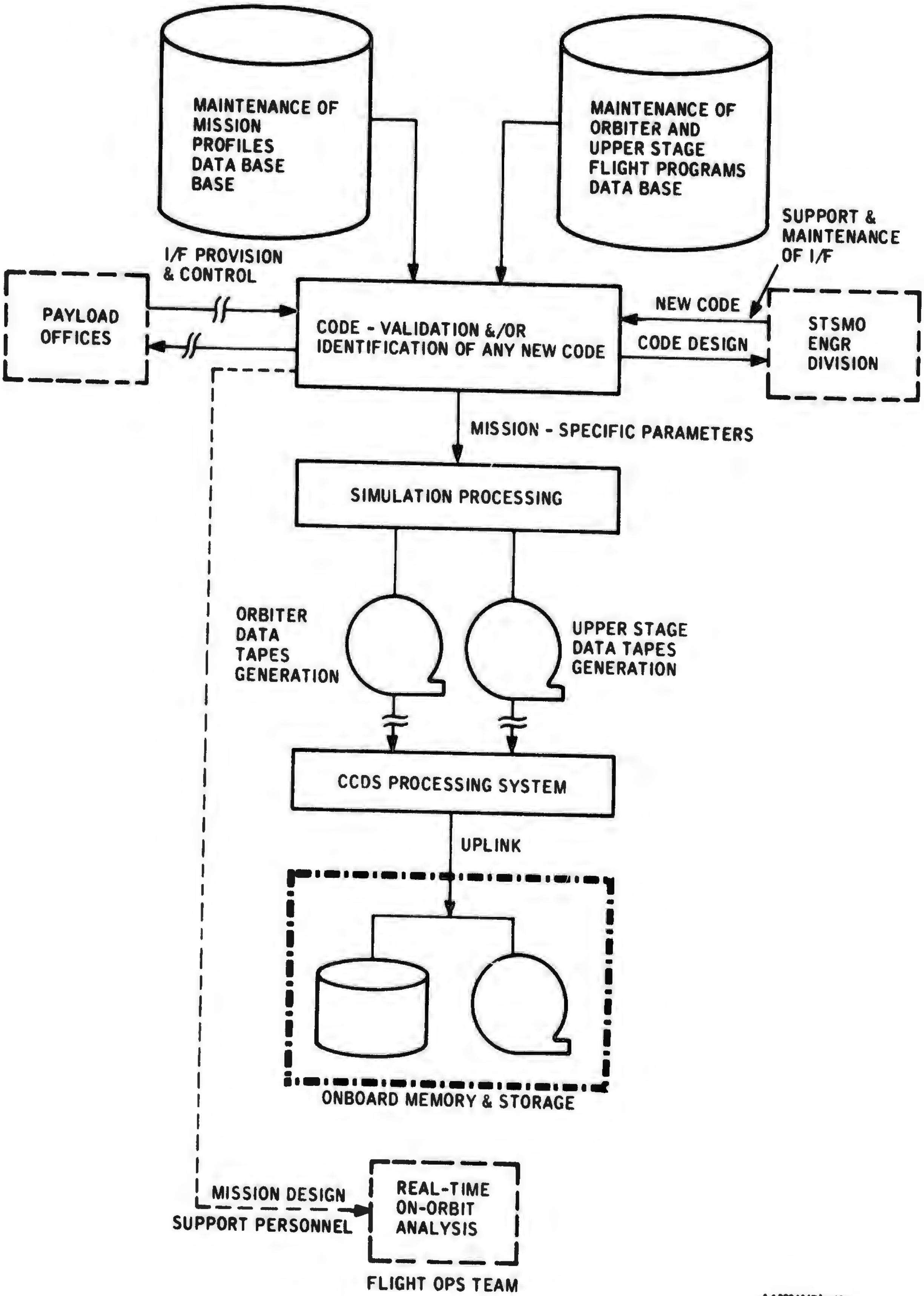


Figure 3-7 Nominal CCDS Support for Targeting

3.6.3 On-Pad Launch Operations Contingencies (refer to appendix A, module A.2.30)

3.6.3.1 Contingency Definition. On-pad contingencies are defined to include any failure which interrupts mission countdown and which occurs in the vehicle and/or ground system while the mated vehicle is on the pad after the T-minus-2 hours mission time mark. There are two major categories of on-pad contingencies: those which occur prior to flight crew ingress, and those which occur after flight crew ingress. Prior to crew ingress, the CCDS will maintain control of the mated vehicle and the activity required to establish the system configuration necessary to resolve the malfunction.

After crew ingress, primary control of the STS vehicle will reside with the flight crew. The CCDS will provide backup control in the event that a crew egress is required, and will exercise control of all ground systems supporting the mated shuttle vehicle. Payload actions will be the responsibility of the payload specialist station onboard with backup support provided by the payload user.

3.6.3.2 Anomaly Resolution

A. Hold Conditions. A failure in either the mated vehicle or ground subsystems will result in a hold being initiated in the mission countdown sequence. A "tech-hold" can be initiated by the flight crew or CCDS and requested by the payload user. A "tech-hold" usually results from a situation in which the ground crew is attempting to circumvent a problem. Other types of holds which may be initiated include those resulting from management direction and those resulting from evaluation of trend analysis.

   If an extended hold, not to exceed 24 hours, is necessary, the propellent loading system will be configured for a replenish mode of operation. The system will continue to maintain the replenish mode until countdown is resumed, at which time propellent loading will be terminated.

   During the hold period, selected onboard and AGE parameters will be monitored to ascertain vehicle system status and to control the propellent replenish operation.

3.6.3.2 Anomaly Resolution (Cont'd)

A hold may be terminated by correction of the failure or by manual action such as mission cancellation.

B. Fault Isolation. Interrogation of a ground or vehicle system failure can be accomplished by one of the following modes:

- Automatically by the vehicle systems
- Manual action by the crew
- CCDS ground application program.

The onboard performance monitor function (PMF) is capable of monitoring onboard subsystems readiness to the switchable functional path level. In the event of an onboard critical failure, the PMF has the capability to automatically switch to the redundant functional path. The PMF outputs the failed condition on the flight crew's CRT display and annunciator panel. Isolation of line replaceable units (LRU's) is not possible unless the LRU is switchable. For LRU isolation involving non-switchable LRU's, ground applications software must be utilized.

Failures not involving fire, leaks, rupture, or explosions provide the crew with the opportunity to interrogate the onboard vehicle systems. To aid the flight crew in the isolation of the malfunction, the CCDS ground applications program, used during checkout, can be accessed and the checkout operations conducted from the cockpit using onboard CRT's for display, keyboards, and dedicated controls for configuration control. The access to the CCDS ground applications program is accomplished via umbilical hookup to the command decoders or PMS computer-to-ground computer communications.

Prior to crew ingress, the fault isolation is accomplished by the CCDS computers, displays, etc., in conjunction with

3.6.3.2 Anomaly Resolution (Cont'd)

the onboard processes, with measurement data provided from the PCM master, and remote control exercised through the vehicle command decoders.

C. LRU Repair or Replacement. After the failure has been isolated and the decision made to replace or repair the faulty subsystem element, the vehicle systems must be safed prior to boarding by the SSV or payload ground crew. Safing operations will include draining, purging, and venting the onboard propellents and safing the pyrotechnics.

Changeout or repair of a faulty payload subsystems element requires that a clean room environment be established prior to opening the payload bay doors. The proper environment and security protection of the payload are also to be established prior to correcting any subsystem failure. After the fault has been corrected, by replacement or repair, reverification of interface compatibility must be performed.

D. On-Pad Mission Termination. Mission termination will be initiated under any one or combination of the following conditions:

- LRU failure which recurs or continues after LRU has been repaired or replaced
- Fire or explosion onboard the vehicle or in the vicinity of the launch pad
- Leak in one or more of the propellent or cryogenic systems
- Crew directive
- Mission management directive.

After the decision has been made to terminate the mission, all pyrotechnics will be placed in a safe condition in preparation for detanking of propellents.

3.6.3.2 <u>Anomaly Resolution</u> (Cont'd)

Propellent detanking will be accomplished via the loading system. Propellents, both cryogenic and storable, will be drained back to the pad storage tanks. Both LH_2 and LO_2 will be drained from the ET and upper stage simultaneously. Monitoring of the detanking will be performed remotely to minimize the number of personnel on the pad. The remote monitoring area will be provided with manual override of the detanking system should such action be required.

When the propellent tanks have been drained, the corrective action necessary to make the vehicle flight ready will be accomplished. Repair will require the launch readiness tests to be rerun for the affected subsystems.

If extensive corrective action is required, the vehicle will be returned to the IMF. In this instance, the vehicle and launcher-to-pad interfaces will be disconnected, the transporter-to-launcher interfaces will be reestablished, and the vehicle transported to the integrating and mating facility (IMF) for disassembly and repair as required.

E. <u>On-Pad Abort</u>. On-pad abort operations are distinguished from on-pad mission termination in that they are initiated only when a crew is onboard and emergency egress is required. Subsequent to crew safing, the CCDS will perform the command and control functions as discussed previously (no crew aboard).

Emergency egress of the passengers and crew will be accomplished in a maximum time of 2 minutes (from crew/passenger ingress to up to SRB ignition). Of this time, 30 seconds are allowed to clear the Orbiter to the access arm and 90 seconds to move the crew/passengers to a secure area. The access arm and high-speed elevators will be positioned in the egress position after crew/passenger ingress, and remain in that position until retraction during the terminal portion of countdown which begins at T-minus-4 minutes.

3.7 MULTIPLE VEHICLE PROCESSING

Preceding paragraphs assumed a single Orbiter landing at VAFB which was turned around, assembled, and launched on another DOD mission. This paragraph considers the effect of a second Orbiter at VAFB which is also in preparation for a launch, and discusses the effect of an Orbiter at KSC in preparation for a DOD mission.

3.7.1 Second Orbiter in Turnaround/On-Pad. For the purposes of this evaluation, the "worst-case" concept assumed consists of two Orbiters being processed simultaneously in the same area (maintenance or pad).

Based on the Level II requirements, which state that the Orbiter shall have the capability to perform checkout of the onboard system to the functional path level and that there will be two firing rooms; and the *Shuttle System Ground Operations Plan*, which states that the station sets shall be composed of multifunction, programmable, nondedicated units which will allow for configuration variations to meet various checkout modes, there is no requirement for dual checkout lines if proper scheduling is maintained.

The greatest impact upon the CCDS will be in the areas of data handling requirements and operations management support. The increase in the data handling requirements would result in a much heavier load being placed on the Central Data System, especially in the areas of real-time data recording, data analysis, data transmission, data recall, and software programs in real-time support of Orbiter checkout. The demands placed upon operations management support would be doubled in areas such as work scheduling, logistic support, technical documentation, configuration control, and maintenance scheduling/planning. These impacts are very important and must be considered when sizing the CCDS, especially in the Central Data System area.

3.7.2 DOD Orbiter in Turnaround/On-Pad at KSC. The NASA/DOD Memo of Understanding states:

A. NASA will manage and operate the equipment and facilities and perform the ground, launch, and landing activities for all Space Shuttle operations at KSC (paragraph 4.11).

3.7.2 DOD Orbiter in Turnaround/On-Pad at KSC (Cont'd)

B. The launch agent at each operational site (KSC or VAFB) will provide all personnel and will be responsible for all common Shuttle vehicle ground turnaround activities except payload operations (paragraph 4.1.1).

C. Each agency will be responsible for its own mission planning and detailed mission design (paragraph 4.2.1).

D. Each agency will provide for management, integration, mission operations, and control for all payloads for which it is the responsible agency; regardless of launch or landing site used (paragraph 4.10).

Based on the above agreement there will be little impact on launch and turnaround operations at VAFB. The major impacts are in the areas of mission planning, detailed mission design, and provision of the required communications interfaces for prelaunch support. A further analysis of these functions and their allocation will be accomplished in Tasks III and IV of this study. The unique DOD functions/operations which must be implemented to accomplish the ground processing of a vehicle at KSC for a DOD mission are discussed in Section 5 of this TOR.

3.8 NASA LAUNCHES AT VAFB

3.8.1 Management Concept. NASA is the mission agent for non-DOD payload missions launched from VAFB. The mission agent functions will include mission planning, schedule coordination, training, and support resource allocation.

The NASA mission agent at VAFB will utilize the CCDS to the maximum extent possible. A data interface will be provided by the CCDS to the Vehicle Management and Mission Planning System (VMMPS) and Program Information Control and Retrieval System (PICRS) for the accomplishment of the mission agent functions.

3.8.2 Ground Turnaround Operations. DOD will provide all personnel and will be responsible for all common Shuttle vehicle ground turnaround activities at VAFB except payload operations. NASA will be responsible for checkout and processing of all NASA payloads. NASA will provide payload-peculiar personnel to support the payload checkout and processing.

3.8.2 Ground Turnaround Operations (Cont'd)

The CCDS will be used to the same extent as for nominal turnaround operations on DOD missions. For details refer to paragraph 3.2.

3.8.3 On-Pad Operations. A DOD/NASA team will mate the payload to the upper stage and perform an integrated checkout of the mated payload interfaces. Final integration checkout of the total payload-upper stage-Orbiter will be accomplished on the pad (for NASA payloads) by the DOD-prime/NASA-support team using the CCDS.

During the prelaunch phase at the launch pad, NASA payload monitoring and checkout will be the responsibility of NASA under the overall test direction of DOD. NASA will be responsible for assurance that the NASA payloads meet Shuttle safety requirements while installed in the Orbiter prior to launch at VAFB.

All prelaunch and launch activities and support up to vehicle lift-off will be provided by DOD under the control of the CCDS except for network compatibility checks of the NASA STDN, which will be accomplished by NASA.

The capability will be provided to transmit NASA payload telemetry data to payload checkout equipment and facilities without any interference with the Orbiter communications system. A dedicated hard-wire link between ground and the payload will be provided for use by the NASA payload agent.

In addition to the Orbiter data, the CCDS will process and display NASA payload subsystems health status data normally maintained by the onboard Orbiter systems for DOD missions. Payload data will be made available to the NASA payload agent in the Launch Control Center and for transmission to the NASA SMCC.

3.9 FERRY OPERATIONS (reference appendix A, module A.2.31)

For the purposes of this study, the following assumptions were made relative to ferry operations.

- Ferry flights will be accomplished by employing the "piggy-back" method

3.9 FERRY OPERATIONS (CONT'D)

- The Orbiter subsystems will not be monitored during the ferry flight
- All ferry aircraft operations (flight plans, clearances, takeoffs, ferry flights, and landings) will be accomplished in the standard method of regular aircraft operations.

The CCDS will provide only operations management support for ferry operations, primarily for scheduling.

After the Orbiter has been removed from the ferry aircraft, and the ground support equipment has been connected, the Orbiter will begin a normal ground turnaround sequence of processing.

3.10 SUPPORT EQUIPMENT AND FACILITIES (refer to appendix A, module A.2.32)

Safing and deactivation of the launch pad facilities will be performed under the control of the CCDS and will commence at liftoff.

Personnel will be prohibited from reentering the launch pad area until a PAD CLEAR is given. This alarm will be activated by the CCDS after the power and pad fluid distribution systems have been safed and all hazardous gases eliminated.

Following the PAD CLEAR, the launch pad facilities will be subjected to a visual inspection to determine pad conditions and refurbishment requirements. The mobile launcher-to-pad interfaces will be demated and the mobile launcher moved to a parking area for refurbishment.

Primary functions of the CCDS during the pad refurbishment and recycle phase will be to control pad safing activities; process and record data on pad subsystems conditions following launch; perform historical data retrieval on systems performance; perform postmission data analysis on pad subsystems performance; process and output for display test data; and process maintenance schedules, test procedures, logistics, calibration data, component drawings, schematics, and output data for display and printout.

Following refurbishment, functional tests will be performed on the launch pad and launcher by the CCDS to ensure the integrity of all systems to support a subsequent launch.

SECTION 4

DOD STS FLIGHT OPERATIONS

Section 4 discusses the allocation of functions required during flight operations of the DOD Space Transportation System (STS). Flight operations are considered to begin at liftoff and extend until rollout has been accomplished. Both nominal flights and aborts, as well as inflight contingencies, have been considered.

The analysis of Orbiter operations involved primarily the Orbiter PDR avionics systems and the functions required to be performed. This was done in order to determine which functions should be allocated to the flight elements and which to the Command and Control Data System (CCDS). Therefore, analysis of Orbiter operations concentrated on the ground or CCDS functions required to support those operations. This allocation of functions was based on well-defined study requirements that "all functions which can be performed on-board shall be allocated to the orbiter" and that all CCDS functions be traceable to a NASA/DOD Level II requirement. In the absence of documented systems data for payloads or payload operations, and in view of the virtual non-existence of Level II requirements on the same subject, a satellite description had to be synthesized and an orbit-to-orbit Shuttle (OOS) functional description, provided by the SAMSO, had to be augmented to provide a payload baseline. Payload operations were defined, the functions developed, and allocations made to the various elements. Because of this, traceability to existing NASA/DOD Level II requirements for CCDS functions in support of the payloads could not be provided.

This section also considers two Orbiters simultaneously in different orbits. This combination has been investigated briefly in Task II, and will be looked at in further detail in Task III to develop the delta functional requirements caused by this situation.

4.1 ORBITER/SRB/ET OPERATIONS

This section discusses the CCDS functions required to support the Orbiter/solid rocket booster (SRB)/external tank (ET) flight operations. Flight operations support is divided into three major flight

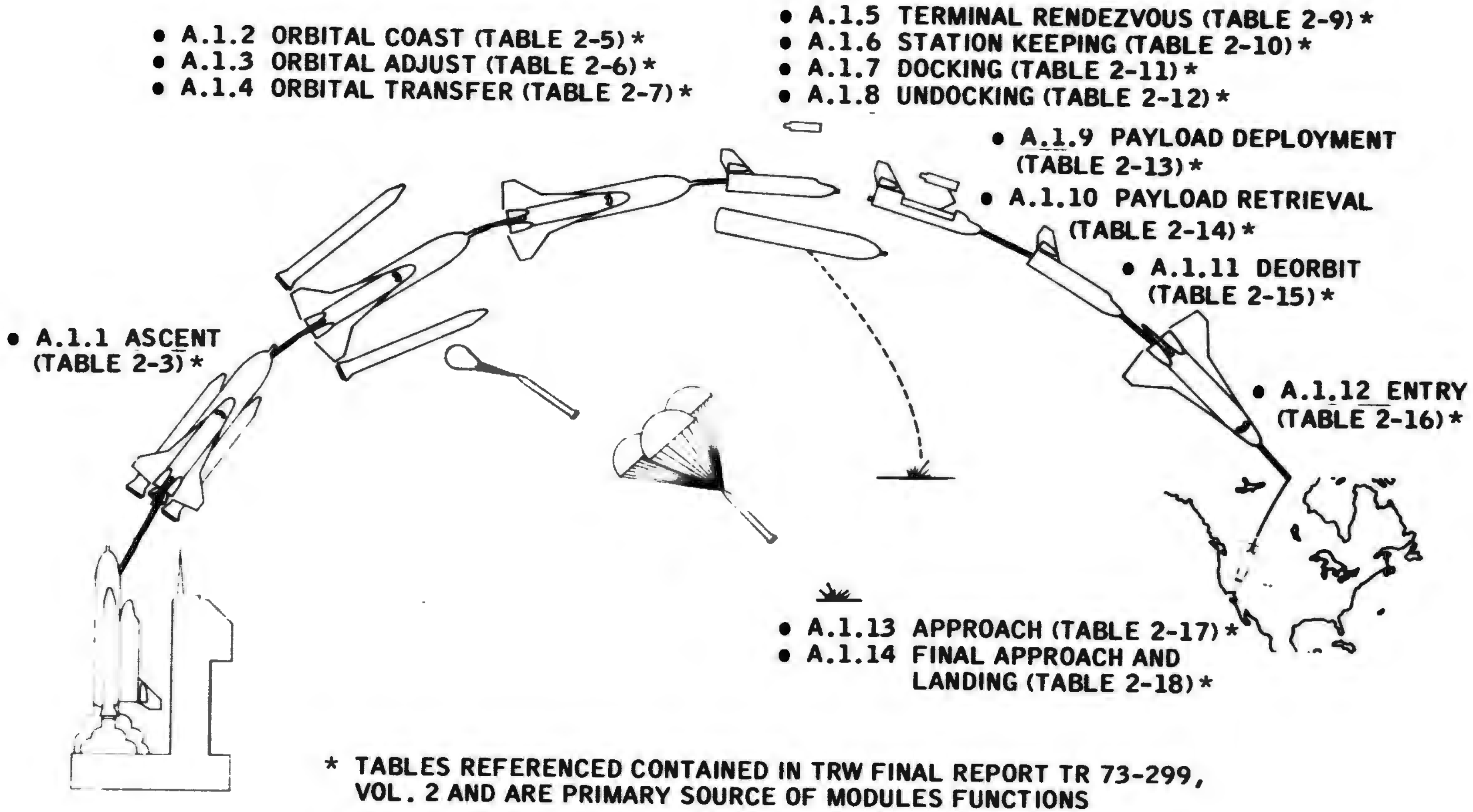
4.1 ORBITER/SRB/ET OPERATIONS (CONT'D)

phases: ascent, on-orbit, and entry and landing. Figure 4-1 illustrates the relative time phasing of the modules pertaining to these three phases, together with an indexing of the reference number of the module and the primary source of that module's functions.

The CCDS functions to support each of these phases were derived from an analysis of the mission modules as defined in the TRW report, *DOD STS Mission Planning and Software Requirements Study*, in conjunction with RI FFD 1.0 (Perform Mission Operations) and 4.1 (Provide Flight Support). Through this analysis, flight operations functions were allocated to Orbiter; OOS/tug satellite; other (to include manual, facilities, GSE and SE); and the CCDS. The basis for this allocation was the functional allocation criteria defined in paragraph 1.4.

Appendix A presents the results of this analysis and provides a tabulation of flight operations functions by mission module, defines the CCDS functions, and provides Level II traceability for the CCDS functions. Modules A.1.1 thru A.1.14 of appendix A present a tabulation of flight operations modules. Module A.1.15 presents flight support functions applicable to the mission modules analyzed.

A DOD Shuttle system requirement is that, "The Shuttle shall be capable of performing the on-orbit phases of the DOD missions independent of any external support except ... (for reaction to contingencies)." Based on this requirement, the CCDS functions for nominal flight operations are limited to maintaining mission status in order to provide support to inflight contingencies when required, coordinating SRB recovery operations, providing a communications interface between the Orbiter and the satellite MCC, coordinating operations with the satellite MCC, and providing a stable signal for Orbiter one-way doppler extraction and, if required, navigation updates. Consistent with the autonomy requirement, these functions will be performed as station contact permits, and are not required for increased ground contact nor constraints on when maneuvers, orbital transfer, rendezvous, etc. can occur.



* TABLES REFERENCED CONTAINED IN TRW FINAL REPORT TR 73-299, VOL. 2 AND ARE PRIMARY SOURCE OF MODULES FUNCTIONS

NOTE: FIGURE ADAPTED FROM TRW FINAL REPORT TR 73-299, VOL. 1

Figure 4-1 Mission Phase Functional Modules, Orbiter

4.1 ORBITER/SRB/ET OPERATIONS (CONT'D)

Additional areas of flight operations support performed by the CCDS are:

- Provide current and projected meteorological data in support of Shuttle launch and landing
- Coordinate flight support elements
- Coordinate airspace interfaces for approach and landing operations.

The following paragraphs discuss CCDS functions in support of ascent, on-orbit, and entry and landing flight operations.

4.1.1 Ascent.

Shuttle ascent begins with the execution of the boost ignition command and encompasses the vertical rise, mated ascent, SRB separation, Orbiter ascent, suborbital external tank separation, and Orbiter insertion.

During the ascent phase, the prime functions of the CCDS will be to monitor systems and trajectory data, maintain voice and data communications, and track SRB's for coordination of recovery operations.

Systems and trajectory data will provide the ground support elements with information to alert responsible control elements to impending contingency situations, and information for coordination of alternate mission to landing operations. For short duration missions, which require accurate in-plane placement to minimize fuel expenditure, azimuth update capability during the early ascent phase has been considered; however, no requirement can be established for this ground-based navigational correction. Ascent tracking and data monitoring will also assist the ground in predicting insertion parameters and the initial flight profile.

Voice and data communications will be maintained between the Orbiter and Shuttle Mission Control Center (SMCC) to support possible mission aborts. The SMCC will maintain voice communications with the landing facilities and range safety for the same purpose.

4.1.1 Ascent (Cont'd)

Ground tracking data will provide trajectory data for prediction of SRB impact point and subsequent SRB recovery operations.

Landing sites will remain on alert status pending verification of insertion into a stable orbit, which will occur at the first remote tracking station (RTS) contact.

4.1.2 Orbital Operations. Orbital operations are dependent on the objective of the mission and are composed of various mission modules as presented in appendix A, modules A.1.2 thru A.1.11. Functions performed by the CCDS in support of orbital operations are presented in table 4-1 by the mission module. These functions are in preparation for reacting to contingency situations and for overall mission coordination. Four major functions will be performed by the CCDS in support of orbital operations. They are: to maintain mission status, to coordinate Orbiter/satellite operations, to manage communication between ground and flight elements, and to provide a stable signal for onboard one-way doppler extraction. These functions are not constraints on the mission; however, constraints may be imposed by mission rules and procedures for specific missions or mission situations.

Mission status will be maintained by the CCDS. This requirement is based on the need for, and the ability of, mission management to redirect to an alternate mission or alternate flight plan as a function of inflight contingencies. Mission status encompasses the status of the Orbiter and the payload systems (when Orbiter-attended), and includes information from which mission management can project the remaining systems capabilities for the continuation of the planned mission or a switch to an alternate mission. The precise orbital position data is a significant parameter in describing the overall mission status. The following generic CCDS functions are defined to support inflight status monitoring.*

- Receive Orbiter and payload system status data (including onboard-generated caution and warning)

*As used in this report, the term "monitor" refers to the CCDS remaining aware of mission events, trajectory, and system or crew status either through automated checking of real-time or recorded data, voice contact with the Orbiter crew during station contact, or through a computer operated or controlled display presented to ground support personnel. The form the monitoring takes is dependent upon the mission circumstances and will be developed in subsequent tasks of this study.

TABLE 4-1

CCDS ORBITAL OPERATIONS FUNCTIONS

CCDS FUNCTIONS \ MISSION MODULES	ORBITAL COAST	ORBITAL ADJUST	ORBITER TRANSFER	RENDEZVOUS	STATION KEEPING	DOCKING	UNDOCKING	PAYLOAD DEPLOYMENT	PAYLOAD RETRIEVAL	DEORBIT
MAINTAIN MISSION STATUS										
• RECEIVE ORBITER AND PAYLOAD SYSTEM STATUS DATA	X	X	X	X	X	X	X	X	X	X
• PERFORM LONG-TERM TRENDING FOR STATUS PROJECTIONS	X	X	X	X	X	X	X	X	X	X
• RECEIVE ONBOARD CONSUMABLES DATA	X	X	X	X	X	X	X	X	X	X
• RECEIVE PRECISE ORBITAL-STATE DATA	X	X	X	X	X	X	X	X	X	X
• PROVIDE ON-LINE MISSION PLANNING	X	X	X	X	X	X	X	X	X	X
• PROVIDE UPLINK DATA	X	X	X	X	X	X	X	X	X	X
• PERFORM MALFUNCTION ANALYSIS	X	X	X	X	X	X	X	X	X	X
COORDINATE ORBITER/SATELLITE OPERATIONS										
• ROUTE VOICE AND DATA TO USER	X	X	X	X	X	X	X	X	X	X
• COORDINATE RENDEZVOUS				X						
• COORDINATE SATELLITE HANDOVER								X	X	
MANAGE COMMUNICATIONS BETWEEN GROUND AND FLIGHT ELEMENTS										
• MANAGE GROUND COMMUNICATION SYSTEM	X	X	X	X	X	X	X	X	X	X
• ALLOCATE CCDS SCF RESOURCES	X	X	X	X	X	X	X	X	X	X
PROVIDE NAVIGATION UPDATES										
• PROVIDE SIGNAL FOR ONBOARD ONE-WAY DOPPLER	X	X	X	X	X	X	X	X	X	X
• PROVIDE GROUND-DERIVED NAVIGATION UPDATES	X	X	X	X	X	X	X	X	X	X

4.1.2 Orbital Operations (Cont'd)

- Perform long-term trending for status projections
- Receive onboard consumables data
- Receive precise orbital-state data
- Provide mission planning for alternate missions and flight plans
- Provide updata link (voice and data) to effect mission redirection
- Perform malfunction analysis to a level sufficient for determining the requirement to call up contingency support team.

Communications functions required to effect status monitoring and mission direction include vehicle and trajectory data downlinks and voice/data uplinks to the flight vehicle when in station contact.

The CCDS will provide coordination of Orbiter/satellite operations as related to deployment, retrieval, rendezvous, and related satellite operations. In support of this coordination role, the CCDS will route voice and data to the user as required for satellite operations. Support will be provided as required for rendezvous operations and may involve target systems preconditioning and trajectory and maneuver planning prior to Orbiter/target signal acquisition. Coordination will be provided between the user and the orbiter crew for satellite handover operation after checkout and deployment of a satellite. Once the satellite has been handed over to the satellite user, the user will have the responsibility of direct communications with the satellite.

The management of the ground communication system and the scheduling of CCDS resources throughout the mission will be performed in support of orbital operations. This will include program control and coordination of data acquisition and distribution to users as required throughout the mission. Contingency support will require control of resources for data acquisition, resolution of problems and evaluation of the contingency situation to determine whether support should be requested from NASA.

4.1.2 Orbital Operations (Cont'd)

The CCDS will provide two types of navigation updates. The first, a one-way doppler signal, will be provided whenever the Orbiter is in contact with a ground transmission station. The second, navigation updates based on ground tracking data, will be a backup capability.

4.1.3 Entry, Approach, and Landing. This phase begins after the Orbiter has executed the deorbit maneuver and has reached the entry interface; it consists of those activities required for the approach and landing of the Orbiter. Major events in this phase are blackout, transition maneuver, energy management, final approach, and landing. Final approach and landing may be automatically controlled by the Orbiter flight control system or manually controlled by the crew.

During the entry, approach, and landing period, communications will be maintained as constrained by communications blackout, and as line-of-sight permits. The CCDS will monitor systems and trajectory profile data; update wind, weather, and traffic data; and through voice advisories, assist in energy management. Navigation data will be provided by landing aids. Coordination will be provided for airspace interface clearance as required.

4.2 ABORT MODES

The abort modes discussed are those defined by NASA memorandum dated 14 September 1973 for the Flying Qualities Requirements, JSC-07151. CCDS functions in support of aborts were derived from analysis of the abort modes defined in the DOD STS Mission Planning and Software Requirements Study.

Appendix A, modules A.1.16 thru A.1.21, provides a tabulation of flight activity and CCDS functions for each abort mode. Level II traceability for the CCDS functions is provided. Figures 4-2 through 4-6 illustrate the abort modes and provide a time phasing of major events.

The following paragraphs discuss the abort modes and the CCDS functions in support of aborts.

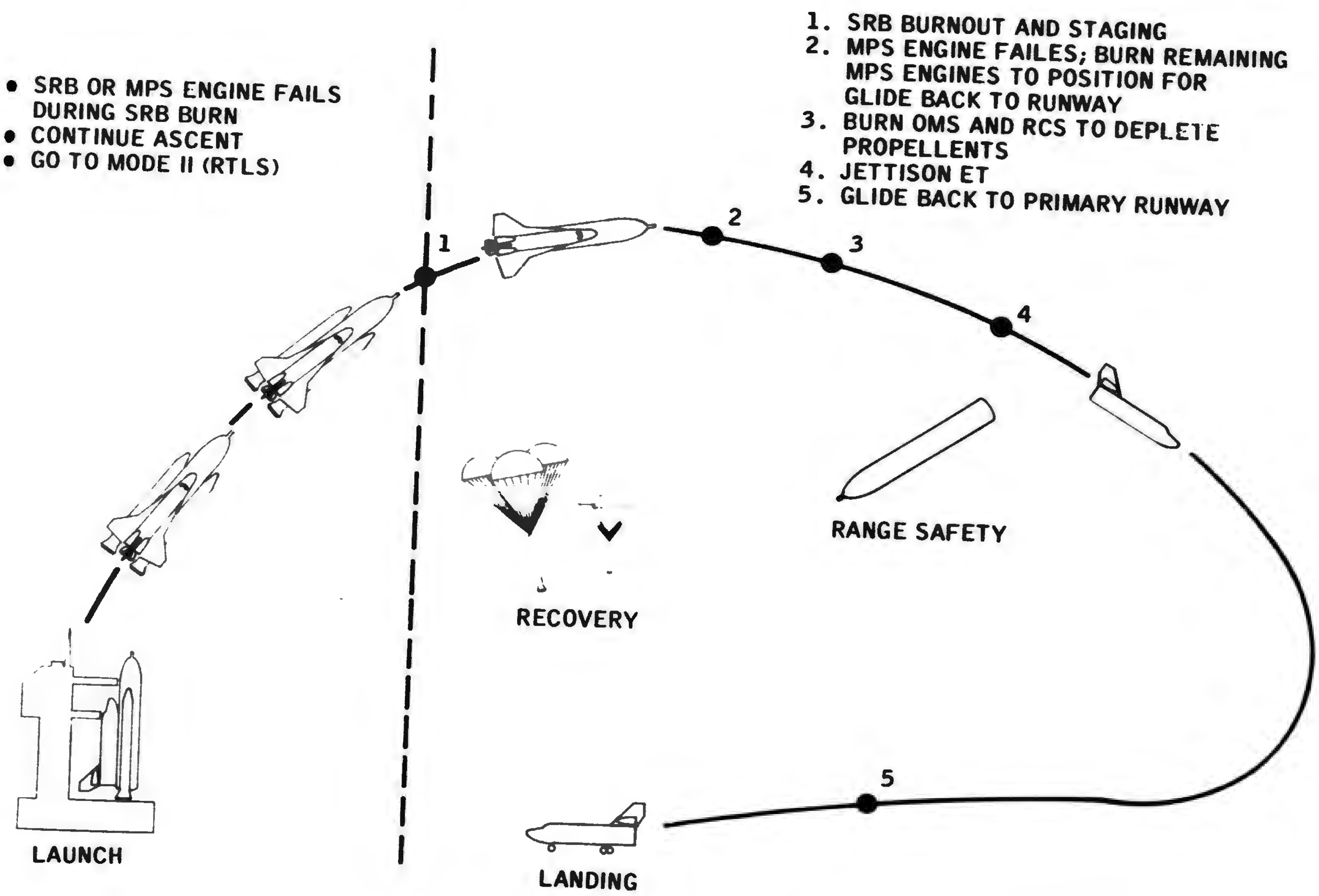


Figure 4-2 Mode I Abort, Continue Ascent;
Mode II Abort, Powered Return to Launch Site (RTLS)

1. LIFTOFF
2. SRB CUTOFF AND STAGING
3. SRB RECOVERY
4. ONE MPS ENGINE FAILS
5. RETARGET FOR FREE RETURN PROFILE AND BURN REMAINING MPS ENGINES AT EPL. BURN OMS AND RCS.
6. MPS CUTOFF; ET SEPARATION
7. ET IMPACT
8. BEGIN COAST TO ENTRY INTERFACE
9. ENTRY INTERFACE
10. LANDING

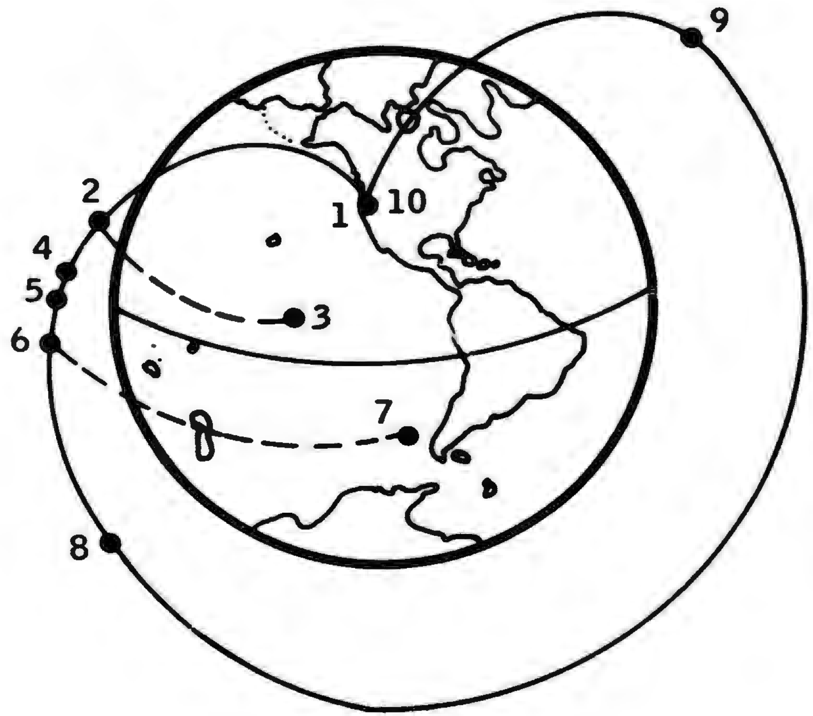


Figure 4-3 Mode III Abort Once Around -- MPS Failure (AOA/MPS)

1. LIFTOFF
2. SRB CUTOFF AND STAGING
3. SRB RECOVERY
4. ONE MPS ENGINE FAILES
5. ADVANCE REMAINING MPS ENGINE THROTTLES. BURN OMS AND RCS
6. MPS OFF; ET SEPARATION
7. ET IMPACE
8. ΔV IS MADE UP BY USING OMS PROPELLENT PLANNED FOR PRIMARY MISSION
9. STABLE ORBIT ACHIEVED. PRIMARY MISSION PRECLUDED DUE TO INSUFFICIENT OMS PROPELLENT. ALTERNATE MISSION POSSIBLE.

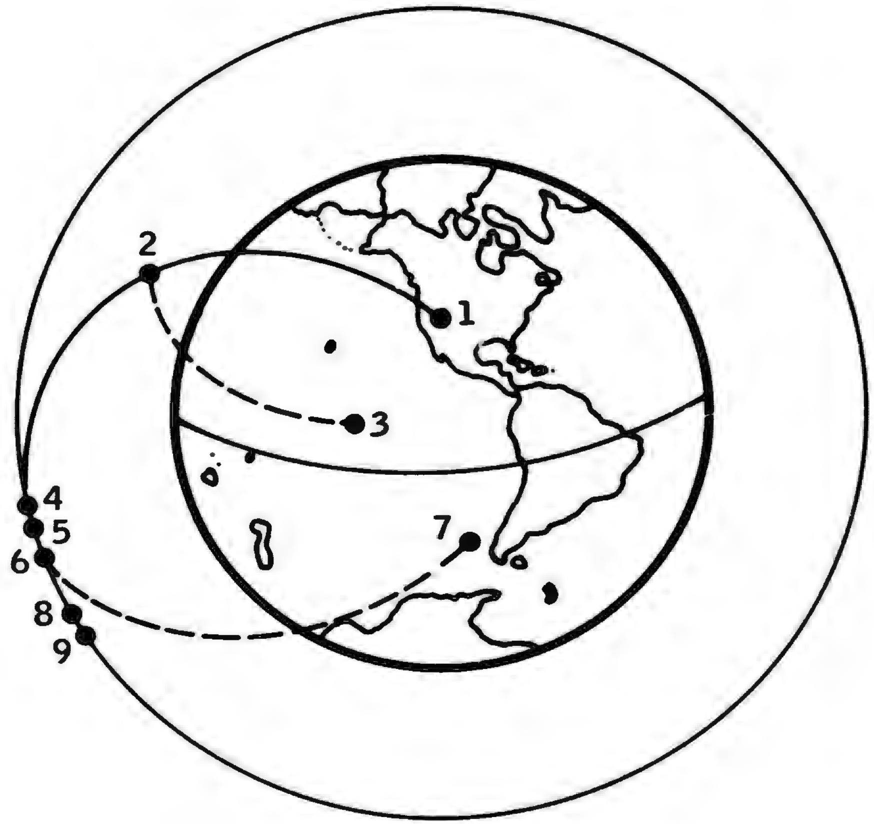


Figure 4-4 Mode IV Abort to Orbit (ATO)

1. LIFTOFF
2. SRB CUTOFF AND STAGING
3. SRB RECOVERY
4. MPS CUTOFF; ET SEPARATION
5. ET IMPACT
6. ONE OMS ENGINE FAILS
7. RETARGET FOR ONCE AROUND PROFILE AND BURN REMAINING OMS ENGINE
8. BEGIN COAST TO ENTRY INTERFACE
9. ENTRY INTERFACE
10. LANDING

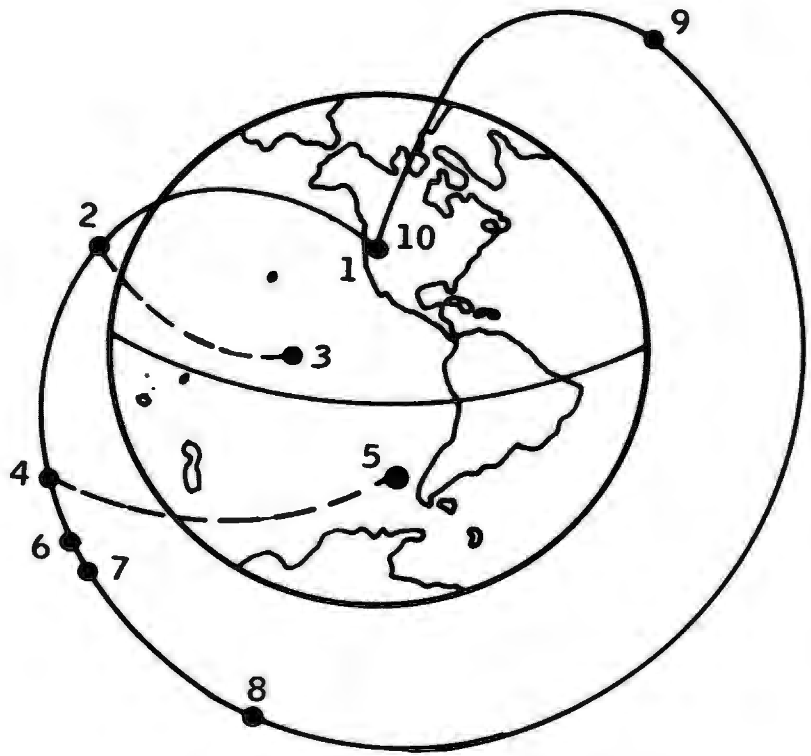


Figure 4-5 Mode V Abort Once Around -- OMS Failure (AOA/OMS)

1. LIFTOFF
2. SRB CUTOFF AND STAGING
3. SRB RECOVERY
4. ONE MPS ENGINE FAILES
5. ADVANCE REMAINING MPS ENGINE THROTTLE
6. V MADE UP; MPS OFF; ET SEPARATION
7. ET IMPACT
8. NOMINAL INSERTION; CONTINUE PRIMARY MISSION

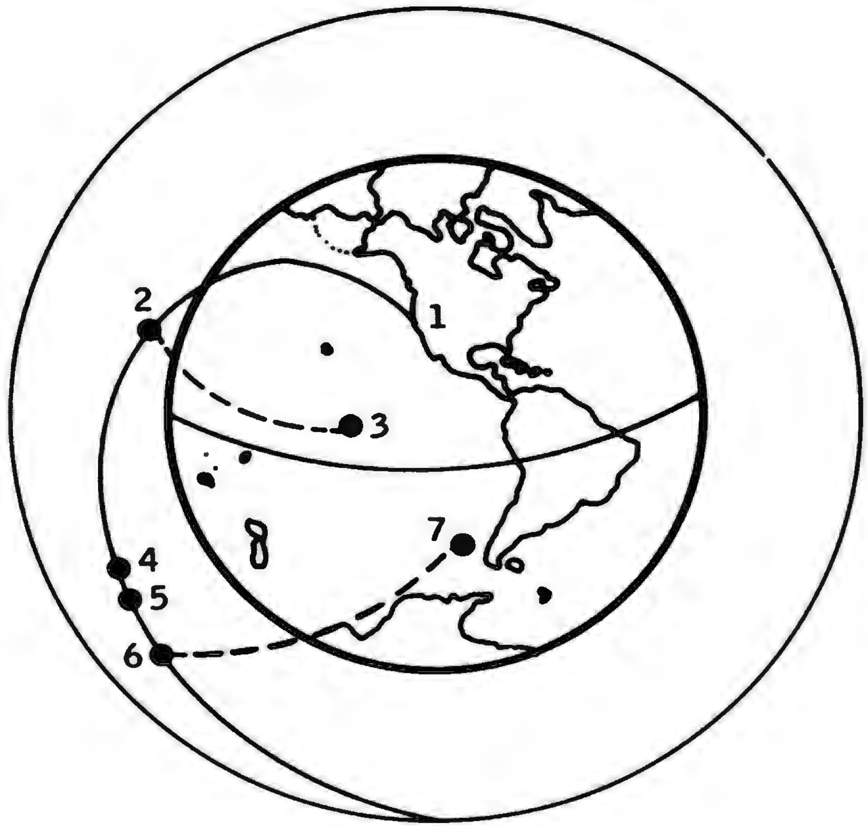


Figure 4-6 Mode VI Abort -- Complete Mission

4.2.1 Aborts from Ascent. Abort from ascent is divided into six modes, as follows.

A. Mode I, Continue Ascent. This mode starts at SRB ignition and ends at SRB burnout. The basic abort action required is to continue ascent after failures involving loss of thrust or control on one Main Propulsion System (MPS) engine or loss of control on one SRB. After SRB separation, the Orbiter/ET performs as in Mode II.

B. Mode II, Powered Return to the Launch Site (RTLS). This capability is available after staging, and involves failure of one MPS engine (thrust or control). The remaining main propellent in the ET and the remaining MPS engines are used to maneuver the Orbiter to a flight condition and location from which it can glide to the primary runway. An acceptable impact location for the ET must also be provided. The Orbiter Maneuvering Subsystem (OMS) and Reaction Control Subsystem (RCS) +X engines are ignited to deplete propellents.

C. Mode III, Abort Once Around due to MPS Failure (AOA/MPS). This is a once-around abort due to a failure of one of the MPS engines, wherein the insertion target is changed to the Mode III abort (free return orbit insertion conditions). The remaining MPS engines (at EPL), the RCS +X engines, and the OMS engines are ignited. After this type of abort, the Orbiter nominally coasts to an entry interface condition (at 400,000 feet), which will allow near-normal entry and landing at the launch site.

D. Mode IV, Abort to Orbit (ATO). Subsequent to a failure of one of the MPS engines and prior to Mode VI, the remaining MPS engines' throttles are advanced and the OMS and RCS engines are ignited. The delta V loss is made up by using the nominal mission OMS propellent prior to insertion. A stable orbit is achieved, but the primary mission cannot be completed because of insufficient OMS propellent. Return from orbit can be accomplished.

E. Mode V, Abort Once Around due to OMS Failure (AOA/OMS). Subsequent to a nominal MPS burn, loss of one OMS engine

4.2.1 Aborts from Ascent (Cont'd)

will require retargeting to a once-around abort. The remaining OMS engine will be burned to achieve the proper conditions to allow landing at the launch site.

F. Mode VI, Mission Completion. Subsequent to a failure of one MPS engine and prior to insertion, the remaining MPS engines' throttles are advanced to compensate for the failed MPS engine. OMS usage is nominal. The primary mission can be completed.

4.2.2 CCDS Support for Aborts. Abort decision and initiation is an onboard Orbiter function for all modes of abort operation. CCDS support for aborts falls into three general categories.

4.2.2.1 General Support for all Abort Modes. In all abort modes, as in normal launch, the CCDS will provide for two-way voice with the Orbiter, and receive and display telemetry and trajectory data. Command uplink during normal launch or in abort cases cannot be functionally justified; however, a command capability will exist. The CCDS will provide SRB trajectory and impact point (IP) data to range safety and recovery forces. Communication is maintained with the landing site and the landing site is alerted to abort decisions.

4.2.2.2 Modes I and II Support (In View). Abort modes I and II are executed in view of the launch/landing site. In these modes, immediate emergency landing operations are initiated, utilizing the CCDS for coordination among the landing facilities, the Orbiter, and mission control. Trajectory and IP data for the jettisoned ET is coordinated with range safety. Voice assistance and coordination to the Orbiter is provided. Monitoring of vehicle systems is continuous through landing.

4.2.2.3 Modes III through VI Support (Out of View). Aborts in modes III through VI for Vandenberg Air Force Base (VAFB) launches will generally occur after launch area loss of signal following

4.2.2.3 Modes III through VI Support (Out of View) (Cont'd)

normal CCDS launch support. Following an apparently normal launch, the landing site will remain on alert until a stable orbit is verified. Orbital status will not be known until contact is made at the first supporting network station or at the landing site. The first indication of a possible abort is a non-nominal acquisition time at the remote station. If acquired by an RTS, the Orbiter will transmit a status message to the SMCC, either verifying a stable orbit or reporting an abort. The landing site will either be released from alert status or advised of the abort condition at this point. If an abort exists, the landing site will be prepared to support landing operations. If the landing site is the first contact, landing support will be provided.

4.2.3 Payload Ascent Abort Operations. Payload-oriented functions performed during ascent abort operations are essentially the same for all six abort modes. The principal Orbiter functions include:

- Monitor and control payload health
- Monitor payload caution and warning (C&W) parameters
- Initiate and control dumping of payload fluids and gases as required (landing weight management)
- Monitor and control payload bay environment
- Monitor flight dynamic effects upon payload
- Monitor and control payload tank pressures
- Monitor payload interfaces and ordnance devices
- Safe the payload for landing.

Because the ground will not command the Orbiter or payload during ascent, the ground role is primarily one of monitoring, advising, and preparing to conduct emergency servicing of the payload upon landing. The ground (CCDS and satellite user/contractor) will monitor the same payload-related parameters as accomplished onboard for the purposes of advising the crew and establishing the actions to be accomplished following landing.

4.3 PAYLOAD FLIGHT OPERATIONS

4.3.1 General Discussion

4.3.1.1 Definition. Payload flight operation is defined to commence at the moment of liftoff from the launch pad and to end after all procedures related to deployment and/or retrieval of the payload have been completed. When a retrieval (by the Orbiter) is involved, payload flight operation ends upon completion of all retrieval functions, stowage of the retrieved spacecraft in the Orbiter cargo bay, and closure of the bay doors. In most, but not all cases, the ending of payload flight operation will be followed immediately by preparation for the Orbiter to return to the earth's surface.

4.3.1.2 Orbiter Activities. The primary purposes of the Orbiter, in support of payload flight operations, are (1) to convey payloads into the near-earth space environment (approximately 100-400 NMi altitude), (2) deploy the payloads (in the case of an OOS, the Orbiter will also initiate the OOS orbital transfer sequence), and (3) to retrieve spacecraft and return them to the earth. In addition, on any particular flight, an Orbiter may perform other duties unrelated to payload support. Only those activities relating to payload flight operation are discussed in this section.

4.3.1.3 Flight Operation Modules. In broad terms, the payload flight operation may be divided into two modules, namely ascent and insertion, and on-orbit operation. The material in this section discusses only normal flight operation; i.e., no contingencies or flight anomalies are considered. The purpose is to outline functions which must be accomplished during a successful mission when all systems perform as intended.

4.3.1.4 Discussion of the Major Modules. The discussions of major modules listed above have been further subdivided into second-level treatments as follows.

A. Ascent/Insertion. This module imposes minimal requirements on the payload and on those aspects of the Orbiter relating directly to the payload. Functions are confined to monitoring of stowed spacecraft health and status, particularly

4.3.1.4 Discussion of the Major Modules (Cont'd)

regarding possible hazardous conditions which may endanger the Orbiter (fuel and/or vapor leakage) or otherwise jeopardize the safety of the flight.

B. Orbital Operation Options. A number of options pertain to payload on-orbit operation, including the following.

1. The Orbiter may ascend with its cargo bay empty, retrieve one or more spacecraft, and return to earth.

2. The Orbiter may ascend with one or more satellites stowed in the cargo bay, to be placed into low-altitude orbits. Following satellite deployment, the Orbiter may return empty.

3. The Orbiter may ascend with an OOS/satellite(s) mated pair (the payload), deploy this combination, initiate the OOS orbital transfer, and then return empty (expendable OOS).

4. The Orbiter may ascend with a mated OOS/satellite(s), deploy and initiate the combination, then recover the OOS and return it to earth (recoverable OOS).

5. The Orbiter may ascend with only an OOS which will be deployed to retrieve a satellite, and return with it to the Orbiter. The Orbiter will then recover the mated OOS/satellite and return to earth. This is considered an advanced mission, to appear only well downstream in the overall STS program; consequently, no functional analysis is given.

Figure 4-7 illustrates these options in a block diagram form and includes both the primary submodules and the flight profile branch points which define the option. (It should not be inferred that these branches, designated by the circled OR in figure 4-7, represent on-orbit decisions. Instead, these branches indicate only that the option constitutes part of the planning of any given flight.)

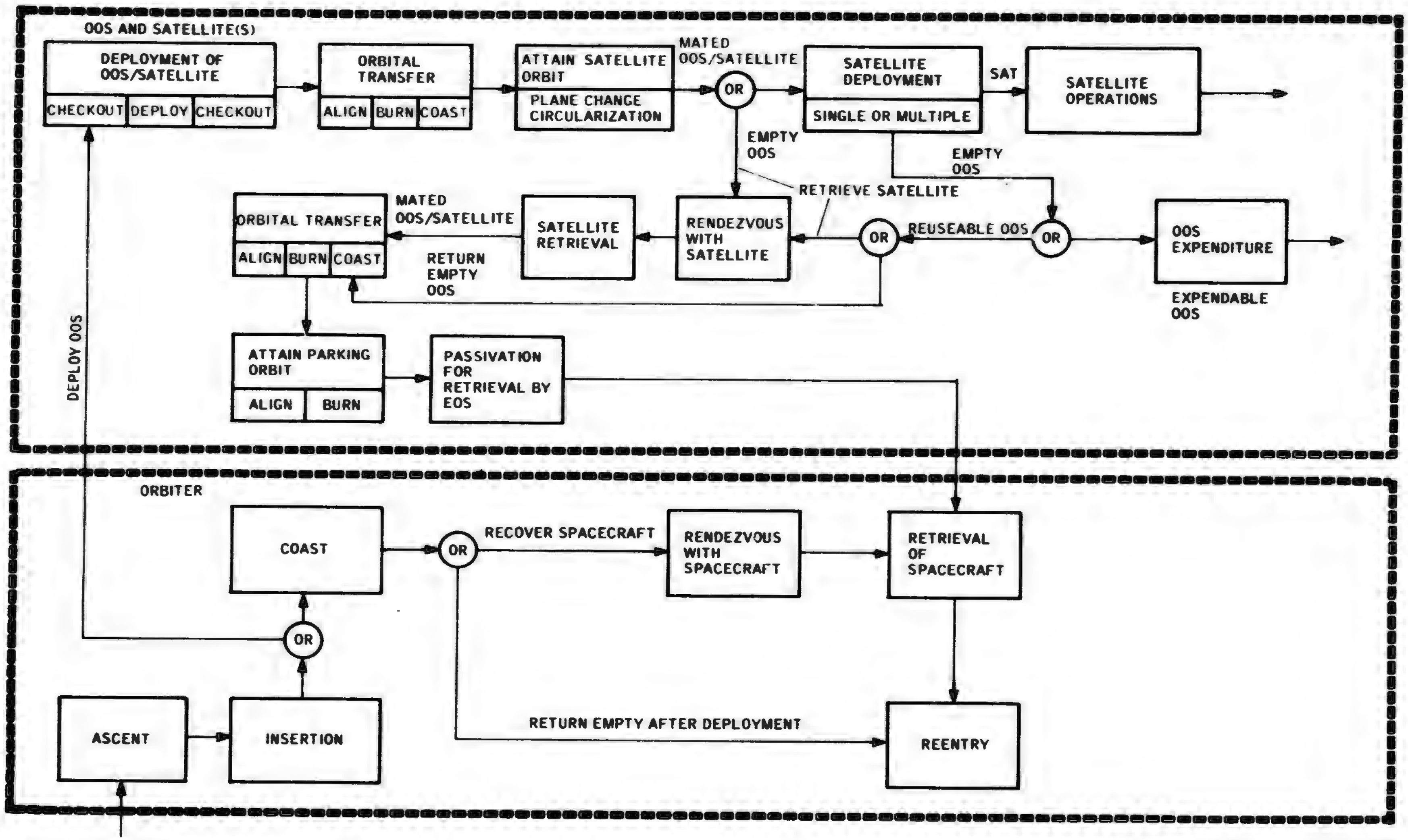


Figure 4-7 Orbital Operations, With Major Options

4.3.1.4 Discussion of the Major Modules (Cont'd)

C. Orbital Operation Modules. Orbital operation modules discussed in the following paragraphs are as follows.

1. Deployment from the Orbiter; this module is subdivided into predeployment checkout, spacecraft ejection and separation, and postdeployment checkout.

2. Orbital transfer (of the OOS); major subdivisions consist of sequence initiation, attitude alignment, engine burn and cutoff, and a coasting period.

3. Satellite orbit attainment; a module executed near the apogee of the transfer orbit, and consisting of both plane change and orbit circularization maneuvers.

4. Single satellite deployment from the OOS.

5. Multiple satellite deployment from the OOS.

6. Orbital transfer, reusable OOS (return to parking orbit).

7. Rendezvous, payload with Orbiter.

8. Retrieval of the payload, with or without a mated satellite, by the Orbiter.

9. Rendezvous and retrieval of a satellite by the OOS (not analyzed here).

10. Satellite operations, discussed briefly only for continuity, but not analyzed.

These modules are discussed in subsequent paragraphs as follows:

- Paragraph 4.3.3.1 - mission profiles and timelines
- Paragraph 4.3.3.2 - OOS/satellite deployment
- Paragraph 4.3.3.3 - OOS Orbiter transfer and attainment of final satellite orbit

4.3.1.4 <u>Discussion of the Major Modules</u> (Cont'd)

- Paragraph 4.3.3.4 - single satellite deployment from the OOS
- Paragraph 4.3.3.5 - multiple deployment from the OOS
- Paragraph 4.3.3.6 - orbital transfer of a reusable OOS
- Paragraph 4.4.3.7 - rendezvous with OOS by Orbiter
- Paragraph 4.4.3.8 - retrieval of the OOS by the Orbiter
- Paragraph 4.4.3.9 - satellite operations (outlined briefly).

4.3.1.5 <u>Basis of Analysis and Assumptions</u>. The baseline of this study is a reusable OOS, but one having no docking aid capability to rendezvous with and retrieve a satellite. Although satellite retrieval is an ultimate objective for the upper stage, it is assumed this capability will not appear for considerable time after the first DOD STS flights.

It is assumed the OOS and all satellites contain completely independent communications packages, even when mated. When the OOS and one or more satellites are mated in the Orbiter cargo bay, the OOS provides only a hardwire feedthrough umbilical connection between the Orbiter and the satellite(s).

The current art of satellite deployment from an upper stage is highly developed, highly sophisticated, and highly reliable. To a large extent, existing upper stages (Centaur, Agena, Transtage) may be preprogrammed to deploy one or more satellites. Ground functions primarily involve deployment monitoring, satellite checkout after deployment, satellite orbit verification, and contingency situation support. This study draws heavily upon the current art.

It is an assumption of the study that, although OOS autonomy and OOS astrionics are currently ill-defined, a high degree of OOS autonomy is desirable. Furthermore, communication via TDRS will be utilized at most for contingency support.

The level of confidence in the OOS module function is lower than that pertaining to the Orbiter. Additional study is required for modules associated with OOS retrieval of a satellite.

4.3.2 Payload Ascent Operations. Ascent starts at liftoff and terminates at Orbiter insertion into earth orbit. During this flight phase, the payload remains in a relatively quiescent state; i.e., stimulation of the payload is kept at a minimum.

A. Payload Functions. The primary functions related to the payload that must be performed during ascent are directed toward the following.

1. Ensuring crew and vehicle safety (e.g., venting, temperature, pressure, mechanical interfaces, and fuel leakage).
2. Ensuring proper environmental control of payload bay (e.g., maintaining proper temperature, pressure, and humidity).
3. Ensuring that payload subsystems are maintained in a safe and "healthy" state (e.g., maintaining proper temperature, pressures, and voltages).
4. Evaluating the effects of flight dynamic forces upon the payload(s) (e.g., axial and torsional acceleration, vibration, shock, harmonics, and stresses).
5. Detecting faults and planning contingencies.
6. Establishing and maintaining a payload-related data base.

B. Functional Allocation Criteria. Functions were allocated according to the following criteria.

1. The Orbiter will perform all functions within its capability.
2. CCDS will serve as the control point for collection and distribution of data, because the only communications links with the payload during ascent are through the Orbiter.
3. The Orbiter will not be commanded from the ground during launch.
4. Payloads cannot be directly commanded from the ground.
5. CCDS need only "look" at satellite data pertaining to the safety of the flight vehicle and crew.
6. All satellite data will be forwarded to the user or user designer.
7. CCDS will handle all OOS data.

C. CCDS Functions. The primary payload-related role of CCDS during ascent will be as follows.

4.3.2 <u>Payload Ascent Operations</u> (Cont'd)

1. Monitor the payload data representing a possible safety hazard to the flight crew and vehicle.

2. Receive, record, and distribute payload data to the designated areas.

3. Maintain interface with satellite user.

4. Ensure proper collection, processing, and distribution of payload data and status.

5. Establish and maintain a payload data base (OOS only).

6. Initiate anomalous and/or contingency support activities related to payloads as required.

As currently conceived, vehicle/ground communications will terminate well before the insertion point is reached. No requirement has been established for extending the range network to permit continuous communications throughout the ascent. Therefore, the ground system functions delineated on the function allocation sheets, which are dependent upon vehicle/ground communications, will terminate at loss of line-of-sight.

4.3.3 <u>On-Orbit Operations</u>. This paragraph is concerned primarily with a top-level functional analysis of various modules pertaining to on-orbit activities of the upper stage and the satellite(s).

Each section discusses a particular module, although it is recognized that frequently the modules overlap so that the overall flight operation is continuous. Nevertheless, each module is represented as containing a logical subset of functions to be accomplished. The primary objective of the section is to list the required functions, to discuss possible constraints or "most logical approaches" affecting the function allocation, and to summarize the major functions.

Figures 4-8 and 4-9 illustrate, in block diagram form, major requirements for on-orbit operations, when the OOS is reusable (4-8) and expendable (4-9), respectively. Paragraph 4.3.3.1 is a narrative

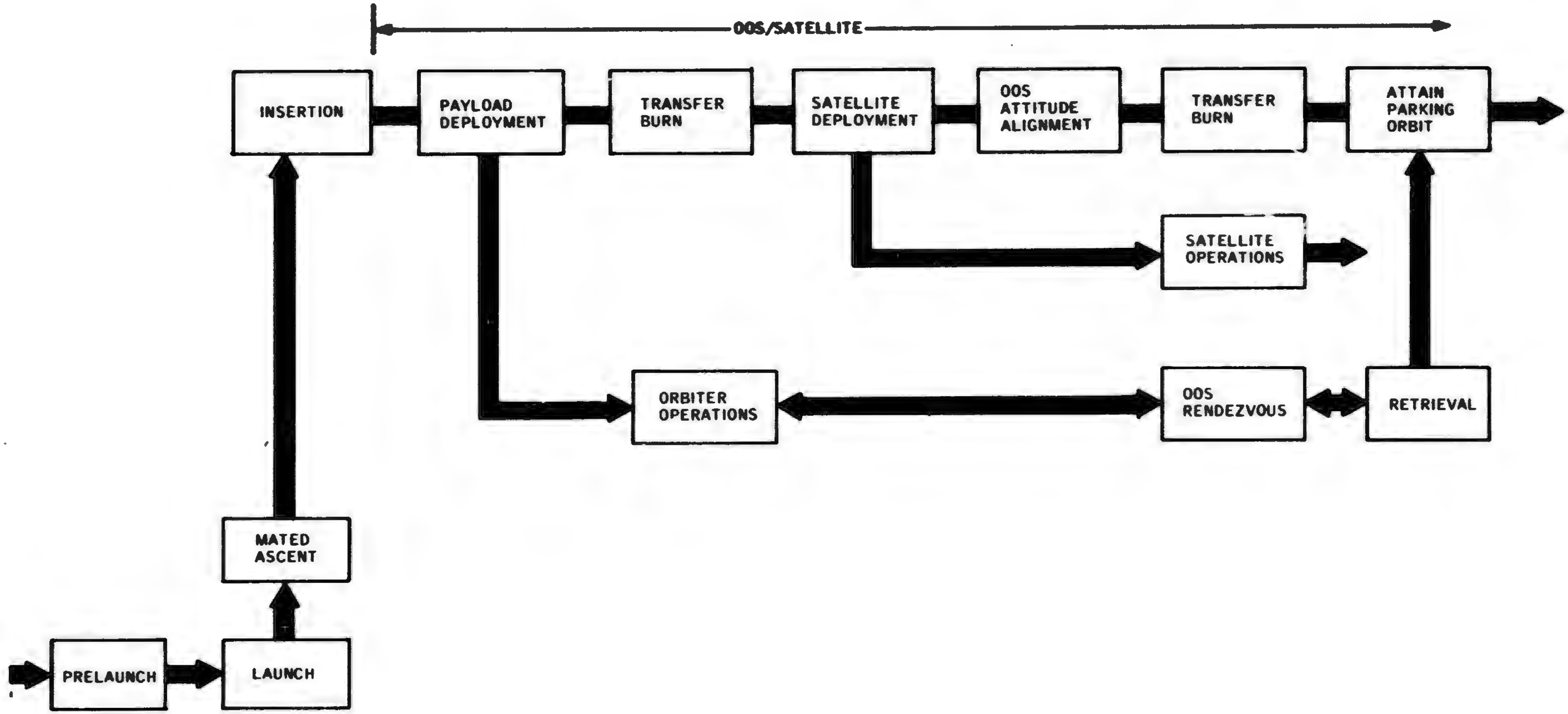


Figure 4-8 Block Diagram, OOS Deployment Mission, Reusable OOS

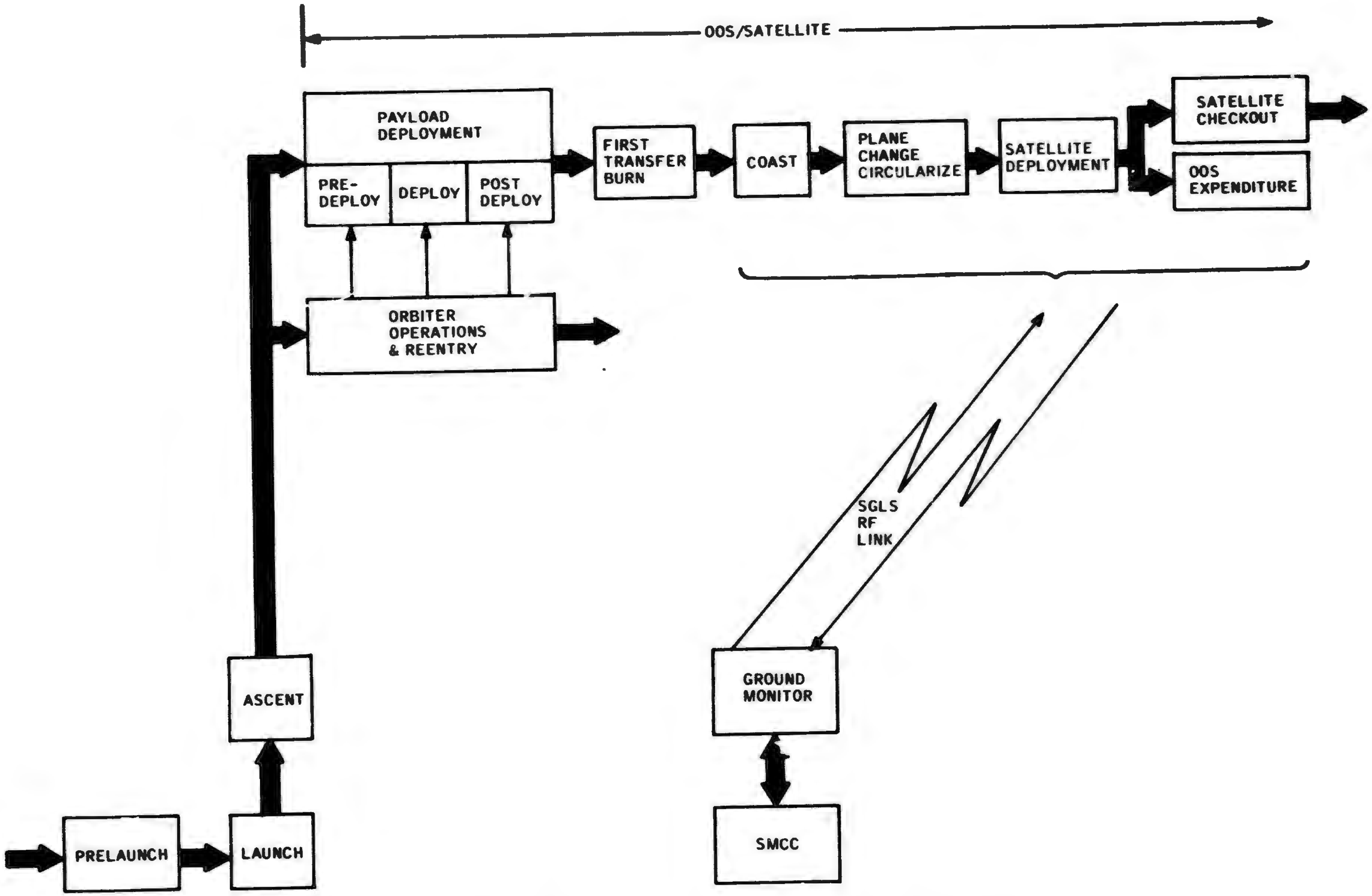


Figure 4-9 Block Diagram, OOS Deployment Mission, Expendable OOS

outlining three general types of missions; namely, once-around, deploy/retrieve, and high-energy orbits. It discusses salient features of these generalized missions, and also presents representative timelines in view of the fact that functional allocations are occasionally the result of time constraints, rather than logical optimization.

Subsequent paragraphs (4.3.3.2 through 4.3.3.9) discuss the Orbiter/OSS/satellite/ground operations and interrelations in further detail, but again, only to a level permitting top-level allocations to be made.

It is stated in several places that radio links from the ground to low-altitude spacecraft are possible only very infrequently. For higher altitude (say, above a few thousand miles), links become possible for extended periods (many consecutive hours). This fact influences functional allocation in at least two important ways.

A. Many functions cannot be allocated to the ground simply because, in the absence of a radio link, the function could not be performed.

B. Although it might be desirable for the CCDS to monitor continuously the health and status of numerous payload subsystems in real-time, frequently the data must be recorded in the Orbiter, and played back to the ground only when a link of sufficient duration is possible.

The analysis presented herein includes these limitations. Where the CCDS is expressly excluded, even as a monitor, it is only because the ground is not required to execute the particular function, and not because the ground has no interest in what is transpiring.

4.3.3.1 Mission Profiles and Timelines. A first step in analyzing payload flight operations was to review the missions defined by DOD in the "DOD Mission Requirements Annex," dated 24 October 1972, revised 1 March 1973. This classified document defines several mission profiles. The review revealed that several of the missions had many functions in common. The high degree of commonality permitted synthesizing a much smaller, simplified set of mission profiles that were sufficient to identify the important flight activities, identify time-critical events, and outline the major roles to be played by various segments of the operating STS.

4.3.3.1 Mission Profiles and Timelines (Cont'd)

For the purposes of this study, three basic mission profiles and attendant timelines were synthesized. The three mission profiles are as follows:

- A once-around mission in which deployment or retrieval of a satellite is done on a single revolution (liftoff to touchdown is less than 2 hours)
- Deployment and/or retrieval of payload(s) by the Orbiter over several revolutions
- High-energy orbit.

The remainder of paragraph 4.3.3.1 provides brief scenarios of the three missions. For detailed mission information, refer to the "DOD Mission Requirements Annex."

A. Once-Around Mission. This mission is representative of the deployment or retrieval of a single satellite by the Orbiter. The mission commences with launch from Western Test Range (WTR) and ascent into a nominal 50 × 100 nmi orbit. Before or near apogee, the satellite is deployed/retrieved. Return to earth is accomplished shortly thereafter. The entire mission is expected to require less than 2 hours. As a result, satellite checkout and deployment time is limited. From liftoff until deployment, the satellite will be under Orbiter hardwire monitor and control.

Satellite predeployment checkout is in progress approximately 16 minutes after liftoff, and the payload bay doors are opened. The satellite is released 19 minutes later. The Orbiter is moved (translated) 200 feet away and the satellite is initialized; i.e., the sequence of events that brings the satellite to an operational status is started. Five minutes are devoted to further translation of the Orbiter a safe distance away from the satellite. Fifty-nine minutes after liftoff, the Orbiter begins deorbit operations. Figure 4-10 presents a representative timeline of deployment events.

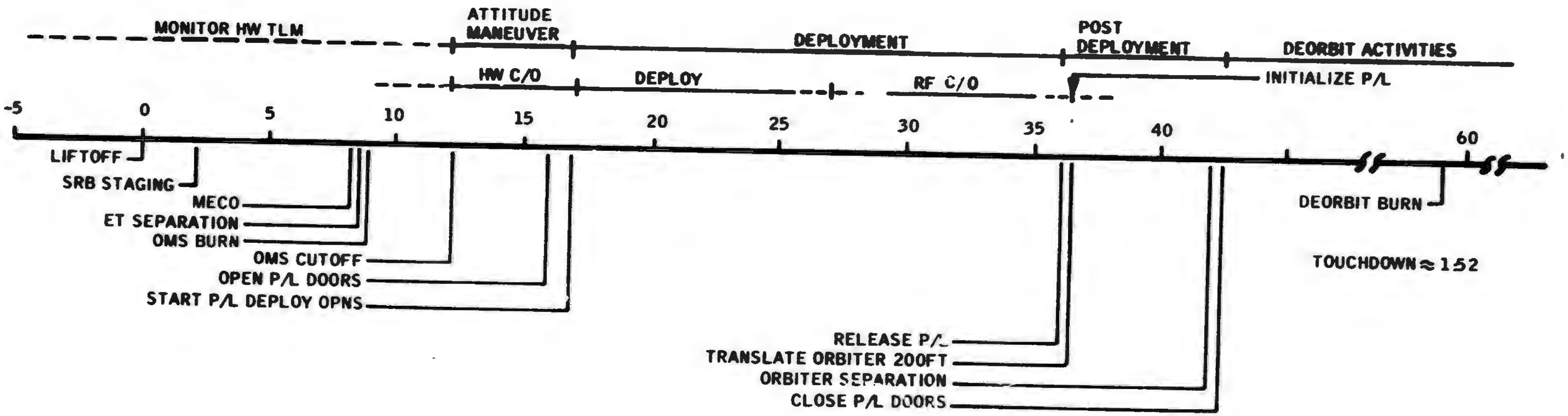


Figure 4-10 Once-Around Deployment Mission

4.3.3.1 Mission Profiles and Timelines (Cont'd)

The once-around retrieval mission is similar, with the exception that the time described above for deployment is given over to satellite track, braking burns, retrieval maneuvers, safing, and retraction and stowing of the retrieved satellite. Figure 4-11 is a representative timeline of retrieval events.

In either case, it is necessary that hardwire and radio frequency contact be maintained with the satellite; in one case, from liftoff through deployment; in the other, from track through touchdown.

B. Multiple Orbit, Orbiter Satellite Deploy/Retrieve. This mission is representative of the deployment and/or retrieval of one or more satellites in low orbit requiring only the Orbiter. Launch is from the Eastern Test Range (ETR) or WTR, depending upon desired inclination, and ascends into the initial orbit (nominally 50 × 100 nmi). The Orbiter circularizes into a parking orbit (nominally 100 × 100 nmi). Satellites may be deployed or retrieved using the parking orbit, elliptical excursion orbits, or phasing orbits from the parking orbit. This mission requires the Orbiter to be active for several revolutions, and may be planned for several days, depending upon satellite requirements and distributions. In addition, this mission provides a capability for the Orbiter to remain in the vicinity of a satellite while extensive satellite checkout by the ground system is performed. It also provides for the retrieval of any satellite which fails to check out properly.

All satellites will be under Orbiter hardwire monitor from liftoff through the separate deployment tasks. Predeployment checkout by the Orbiter will consist of nominal functional checks. Following release of a satellite, a radio frequency check may be performed by the Orbiter to verify operation of a command and control function. Full operational check is deemed the responsibility of the ground system.

Deployment event timelines are shown in figure 4-12. Because the mission duration may be variable, the separate segments

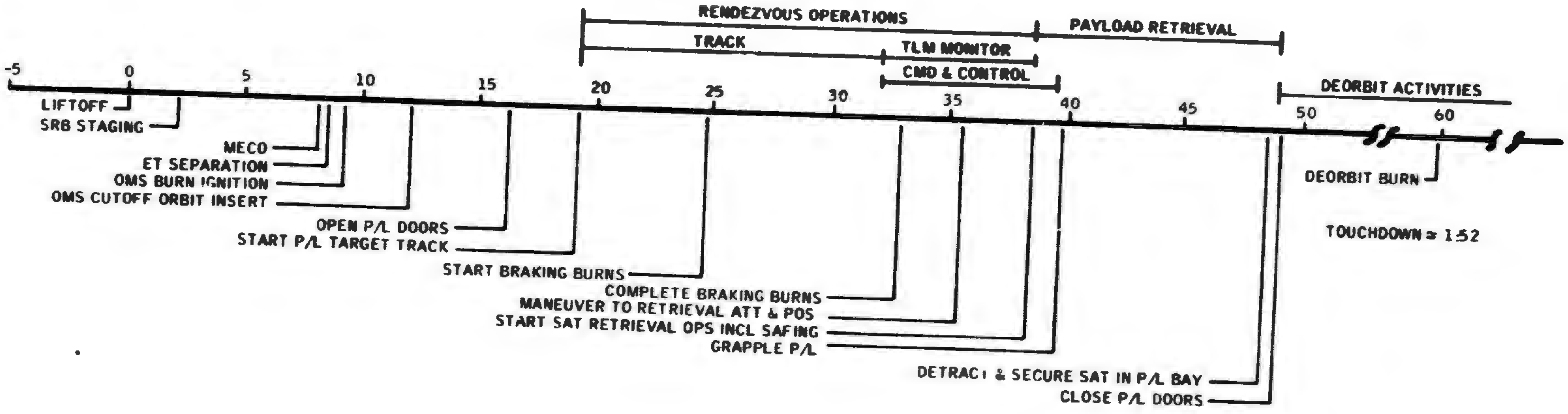


Figure 4-11 Once-Around Retrieval Mission

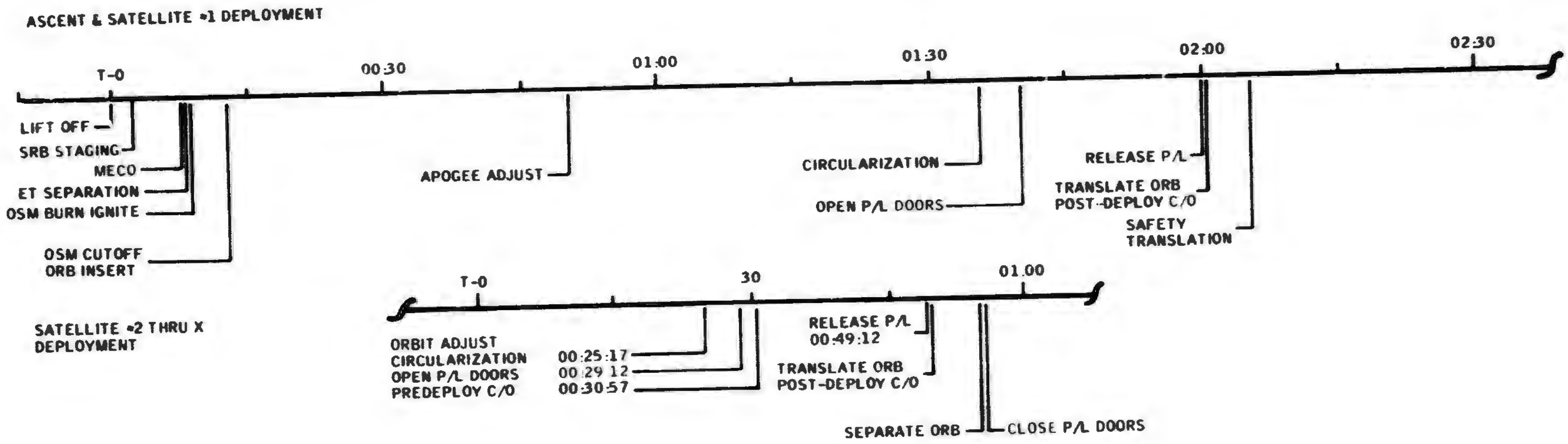


Figure 4-12 Multiple-Orbit, Orbiter Satellite Deploy/Retrieve

4.3.3.1 Mission Profiles and Timelines (Cont'd)

are not time-identified to ground elapsed time, but are time-tagged with respect to sequential events; i.e., liftoff is tagged T-0, and the beginning of first satellite deployment will be T+17 minutes. The beginning of the second satellite deployment will be time-tagged T-0 again. In this manner, the number of satellites and mission duration can be varied. The functions and functional time sequence remain the same.

Satellite retrieval operations parallel those described in the once-around mission. The major difference is the potentially greater amount of Orbiter maneuvering required and the extended time available to perform the operation.

C. High-Energy Orbit. This mission is representative of the deployment of a payload into a high-energy orbit. The Orbiter, OOS (upper stage), and satellite are launched due east from ETR and ascend into a 50 × 100 nmi, 28.5° inclined orbit. The Orbiter circularizes into a 100 × 100 nmi, 28.5° parking orbit. The OOS/satellite separates from the Orbiter and performs the necessary phasing, transfer, and plane change maneuvers to place the satellite into the desired orbit.

After satellite deployment, the resuable OOS returns to an orbit approximately 15 nmi above the Orbiter parking orbit. Since the return is not time-constrained, a coelliptical rendezvous technique may be used by the Orbiter to rendezvous with the OOS. After retrieval, the Orbiter will remain in parking orbit until phasing and return to ETR.

An expendable OOS will be oriented to fire into a harmless orbit to expend all remaining consumables.

The OOS/satellite will be under Orbiter hardwire monitor from liftoff through parking orbit deployment. Predeployment checkout of the OOS and the satellite will consist of a hardwire, minimal check of the satellite and OOS functions. After OOS/satellite deployment, initialization of the OOS, and separation, a radio frequency check will be performed by the Orbiter to verify the command and control function.

4.3.3.1 Mission Profiles and Timelines (Cont'd)

A typical high-energy orbit mission is presented in figure 4-13. The mission described is a geosynchronous deployment mission. A more detailed description of this complex mission is provided in appendix B.

4.3.3.2 OOS/Satellite Deployment

A. Introduction. This module encompasses those activities associated with the activation, checkout, deployment, and post-deployment verification of a payload. The time required to accomplish this module, and the number of functions which can be included, are dependent upon the specific payload and its functional requirements (viz, empty OOS, single satellite with no OOS, OOS mated to single or multiple satellites, etc.). From a functional requirements point of view, the driving items for this phase are:

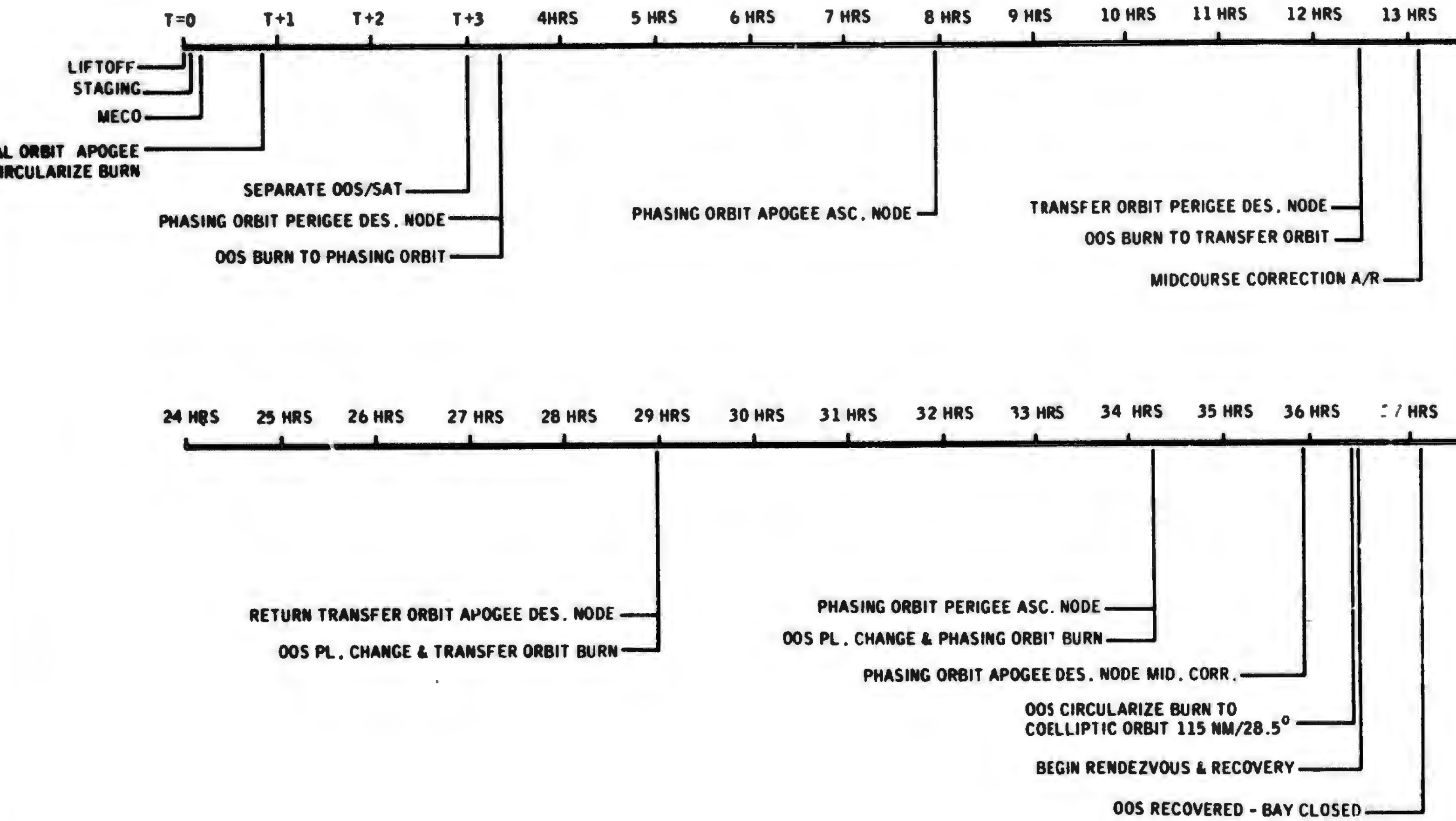
- The nature of the payload to be deployed
- Payload-peculiar functional requirements
- Timelines for the module.

B. Definition. Deployment is separated into three submodules as follows.

1. Predeployment. This begins with the verification that pyrotechnic and gaseous systems are disabled, and includes those activities within the payload bay concerned with activites of the payload for extension.

2. Extension. This begins when the payload bay doors are opened and includes the mechanical extension and demating actions.

3. Postdeployment. This begins with a deactivation of the release mechanism, includes those activities involved in securing the deployment mechanism and payload bay, and ends with the arming of pyro devices and activation of the Attitude Control System (ACS).


T=0
T+1
T+2
T+3
4HRS
5 HRS
6 HRS
7 HRS
8 HRS
9 HRS
10 HRS
11 HRS
12 HRS
13 HRS
LIFTOFF
STAGING
MECO
AL ORBIT APOGEE
IRCULARIZE BURN
SEPARATE OOS/SAT
PHASING ORBIT PERIGEE DES. NODE
OOS BURN TO PHASING ORBIT
PHASING ORBIT APOGEE ASC. NODE
TRANSFER ORBIT PERIGEE DES. NODE
OOS BURN TO TRANSFER ORBIT
MIDCOURSE CORRECTION A/R
24 HRS
25 HRS
26 HRS
27 HRS
28 HRS
29 HRS
30 HRS
31 HRS
32 HRS
33 HRS
34 HRS
35 HRS
36 HRS
RETURN TRANSFER ORBIT APOGEE DES. NODE
OOS PL. CHANGE & TRANSFER ORBIT BURN
PHASING ORBIT PERIGEE ASC. NODE
OOS PL. CHANGE & PHASING ORBIT BURN
PHASING ORBIT APOGEE DES. NODE MID. CORR.
OOS CIRCULARIZE BURN TO
COELLIPTIC ORBIT 115 NM/28.5°
BEGIN RENDEZVOUS & RECOVERY
OOS RECOVERED - BAY CLOSED

A

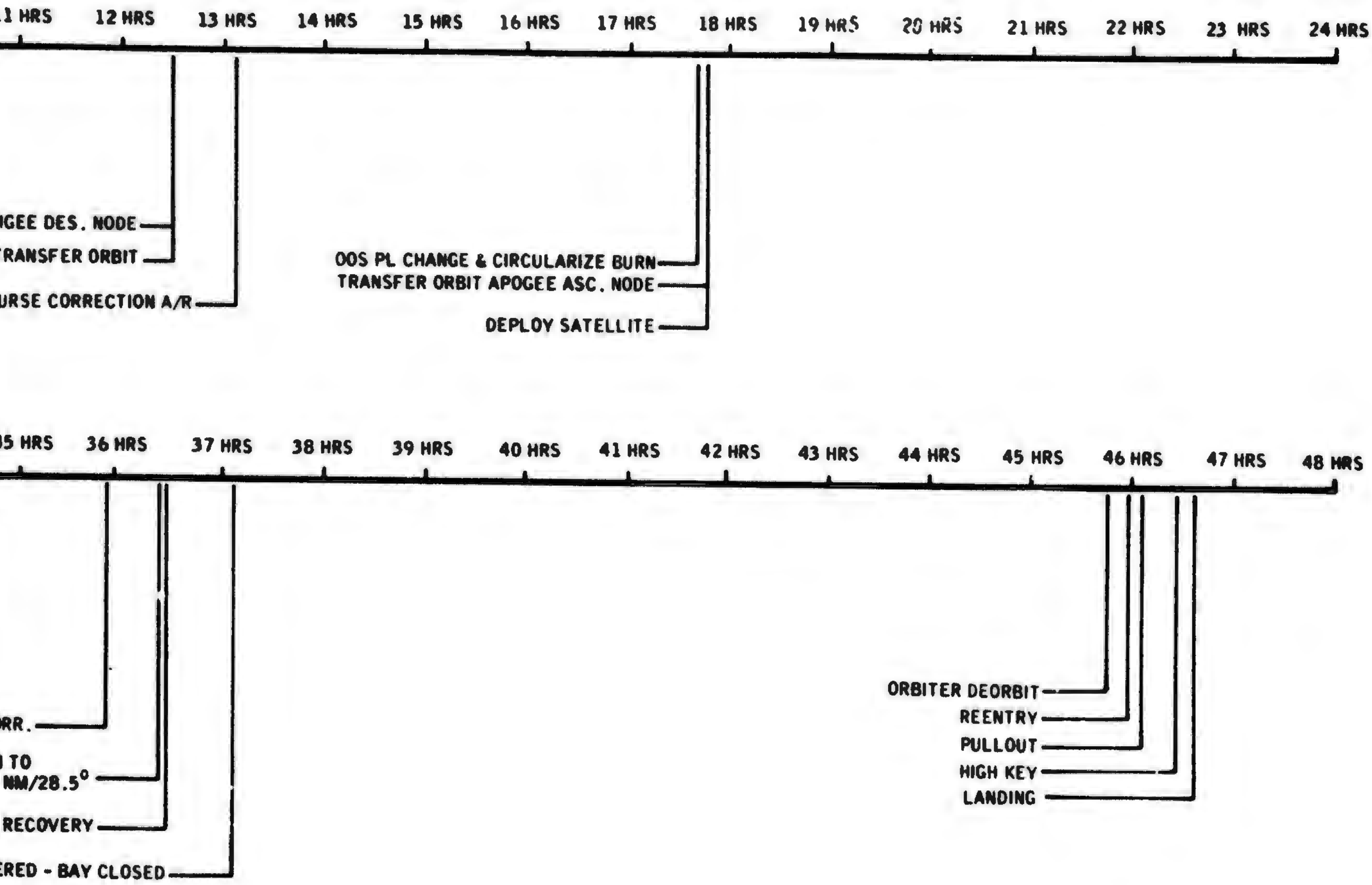


Figure 4-13 High Energy Orbit-Geo-Synchronous Deployment

B

4.3.3.2 <u>OOS/Satellite Deployment</u> (Cont'd)

Major module events are the following:

- Preparation for payload deployment
- Open cargo bay doors
- Activate payload manipulator
- Deploy payload
- Orient payload
- Initiate station keeping
- Initialize payload sequencer
- Secure payload manipulator
- Monitor first OOS transfer burn
- Transfer control to OOS.

During the deployment module, the Orbiter will be out of radio line-of-sight to DOD ground station most of the time, and when a line-of-sight does occur, it will generally endure for only a few minutes. Therefore, the only possible continuous communication to the ground would be via a tracking data relay satellite (TDRS), but this would violate a system operation requirement; namely, that TDRS shall be used at most for contingency support. It follows that the ground will not provide direct support of, nor real-time monitor of, the total deployment sequences. Functions are therefore allocated among the Orbiter, the OOS, and the satellite(s).

On the other hand, recordings may be made within the Orbiter of certain monitored signals, either for ground-based diagnosis upon the next Orbiter landing, or to be conveyed to the ground via telemetry when a line-of-sight opportunity next occurs.

4.3.3.2 OOS/Satellite Deployment (Cont'd)

In brief summary, during the payload deployment module, the Orbiter will accomplish the following tasks:

- Prepare the payload for deployment, including activation of the payload communications subsystems
- Open the cargo bay doors and deploy the payload
- Verify that the deployment has been properly executed and that the payload is in a stable (non-tumbling) condition
- Verify that all payload subsystems are functional
- Move out to a safe station keeping distance, and initiate those events which will transfer the payload to its intended orbit
- Verify that the orbital transfer has properly commenced.

Appendix A, module A.1.23 lists major functions to be accomplished during the deployment module, together with an allocation of each function to the appropriate segment of the system.

C. CCDS Functions. Because of line-of-sight limitations, the role of CCDS during payload deployment from the Orbiter will be as follows, but only as a line-of-sight is available:

- Monitor payload data (OOS and satellite as required)
- Receive, record, and distribute payload data to satellite users
- Maintain interface with satellite users
- Monitor Orbiter data and status

4.3.3.2 OOS/Satellite Deployment (Cont'd)

- Maintain a voice link between Orbiter crew and SMCC
- Initiate contingency support activities related to payloads, based on request from Orbiter crew or from interpretation of payload data.

CCDS functions/tasks will be in response to either real-time or recorded/playback transmissions from the Orbiter and/or the payload.

4.3.3.3 OOS Orbital Transfer

A. Introduction. This module is used to execute orbit-to-orbit transfer and midcourse correction maneuvers. The module consists of a first orbital adjust maneuver, a transfer coast, and a second orbital adjust maneuver. The purpose of the module is to transfer the OOS from the deployment orbit to a desired satellite placement orbit at an altitude above that attainable by the Orbiter. In many cases, especially those concerned with placing a satellite in a synchronous equatorial orbit, the second adjust maneuver includes both orbit circularization (in-orbit velocity increase) and a plane change (from the Orbiter inclination to zero inclination).

B. Definition. Transfer orbit maneuver initialization begins at the commencement of an OOS transfer orbit sequence activation and ends after the last burn. The burn and control sequences of the OOS are preloaded before separation from the Orbiter.

C. Functional Analysis Drivers. Major considerations impacting the functional analysis of this module are as follows.

- Initial OOS orbit, especially inclination
- Target orbit, especially altitude and inclination
- Attainable maneuver times

4.3.3.3 OOS Orbital Transfer (Cont'd)

- Degree of OOS autonomy
- Availability of a radio line-of-sight between the OOS and the ground
- Number of satellites to be deployed (usually only one, but occasionally several)
- Possible constraints on the transfer orbit
- Propellent limitations of the OOS
- Requirement for a ground override command capability to the OOS.

Immediately following deployment from the Orbiter, the OOS/satellite combination will be out of radio line-of-sight from the ground most of the time. It is therefore a task for the Orbiter to initiate the OOS orbital transfer. As the OOS gains altitude, especially if it is targeted for synchronous altitude, the situation reverses -- radio communications between OOS and Orbiter are lost, but a long-duration (many hours) communication link between the OOS and a ground station becomes possible. This situation is reflected in the allocations of monitor and control functions to the CCDS (the ground).

Similarly, when the first OOS engine burn occurs, the Orbiter has essentially fulfilled its responsibility for the OOS (except for verifying a OOS engine burn).

Existing capabilities of candidate upper stages permit an initial functional allocation to be executed under the assumption that the OOS transfer will be highly autonomous; i.e., in a normal mission the OOS may be preprogrammed for alignments and engine burn sequences. However, ground support is required to provide an override capability and to support contingency situations. Ground support is also desirable to monitor the OOS and its satellite(s) during the coast.

4.3.3.3 OOS Orbital Transfer (Cont'd)

It is assumed that, in a normal DOD mission, including an OOS orbital transfer, ground support will be provided via the Satellite Control Facility (SCF) remote tracking station. These stations have many duties to perform completely outside the STS program; for this reason, it should be a systems operation objective to minimize demands upon an RTS for long time periods (i.e., for many consecutive hours). A possible danger is that an anomaly may occur to the OOS or a satellite when the RTS is otherwise occupied.

D. Brief Summary of the Module

1. Orbiter functions are completed upon verification that the first OOS engine burn has been performed.

2. The OOS aligns itself and executes the first burn.

3. The OOS then coasts to its apogee, possibly undergoing a rotisserie roll along the way.

4. The ground begins to monitor and track the OOS when a line-of-sight becomes available.

5. On command from the ground, the OOS will execute a mid-course correction.

6. Near apogee, the OOS aligns itself and executes whatever engine burns are required to achieve the target orbit (plane change, circularization).

E. Possible Constraints

1. Maintenance of a communication link to the OOS and mated satellite(s) for all attitudes of the OOS.

2. Time constraints on the availability of an RTS.

3. Possible need for a midcourse correction.

4. RTS equipment limitation which may preclude monitoring both the OOS and a satellite simultaneously.

4.3.3.3 OOS Orbital Transfer (Cont'd)

F. CCDS Functions. Support of an OOS orbital transfer by the CCDS will include the following:

- Monitor both OOS and satellite data, status, and health
- Receive, record, and distribute satellite data to satellite owners
- Maintain interface with satellite users
- Track OOS trajectory
- Initiate contingency support activities, based upon tracking data, OOS status and health data, or satellite status and health data.

Top level functional allocations for this module are given in appendix A, module A.1.24.

4.3.3.4 Single Satellite Deployment

A. Introduction. This module includes all activities associated with the deployment and activation of a satellite. The module does not include final checkout of the satellite, which occurs after deployment. The module commences when the OOS has achieved the final target orbit, and ends after the satellite has been released, or, in the case of an expendable OOS, the OOS has executed whatever engine burns are required to clear the OOS away from the satellite.

B. Major Module Events. The major events of the satellite deployment module are as follows:

- Preparation for payload deployment and alignment
- Satellite spinup (if required)
- Satellite separation from the OOS (deployment)
- OOS expenditure (expendable OOS only).

4.3.3.4 Single Satellite Deployment (Cont'd)

C. Basis of the Analysis. It is assumed that, in a normal mission, the OOS has been preprogrammed to execute whatever alignment and satellite spinup may be required to deploy the satellite. It is also assumed that the OOS has no ability to retrieve a satellite once release has occurred. Once the satellite is released, the OOS has completed its deployment task, and no remedial action will be possible if the satellite malfunctions.

In most cases, when the OOS carries a satellite to high altitude, the OOS will not possess enough fuel to return to a retrieval by the Orbiter. After deployment of the satellite, the OOS can then align itself only according to a preprogrammed plan, burn its remaining fuel to exhaustion, and thereby move off as far as possible. However, when the satellite is deployed at a relatively low altitude, the OOS may well be capable of return to a point near the Orbiter; this would be a reusable OOS.

Because of the complexity of full-scale checkout of the DOD satellites, including sensor stimulation/response testing, satellite checkout is allocated to the ground after deployment of the satellite. This does not impose an extra burden on the ground, since a ground-to-satellite communication link would be required in any event immediately following satellite checkout, should that task be allocated to the OOS. Allocation of the checkout function to the ground avoids the need for high-speed, wideband communications between the OOS and the satellite, and avoids a requirement for complex, satellite-peculiar software aboard the OOS.

D. Possible Problem Areas. There is a possible requirement for simultaneous SGLS-compatible communication between OOS and the ground, and between the satellite and the ground. (An SGLS ground station can currently communicate on only one link at a time except at dual sites; channel selection and changeover is a lengthy process.)

E. Functional Allocation. The major functions to be accomplished and allocation among the system elements are listed in appendix A, module A.1.25.

4.3.3.4 Single Satellite Deployment (Cont'd)

F. CCDS Functions. The primary OOS and satellite-related role of the CCDS during a satellite deployment by the OOS is as follows:

- Track predeployment trajectory of mated vehicles
- Monitor OOS and satellite data, status, and health
- Monitor deployment sequence
- Receive, record, and distribute satellite data to satellite owners
- Maintain interface with satellite users and designers
- Verify satellite orbit by tracking
- Hand over control of satellite to satellite owner following deployment
- Initiate contingency support or command override of deployment sequence, based upon tracking, OOS station and health, or satellite status and health data.

The CCDS will not have responsibility for postdeployment satellite checkout; this function will be performed by the satellite owner.

4.3.3.5 Multiple Satellite Deployment

A. Discussion. Although most missions will involve only a single satellite, occasionally the upper stage will be tasked to deploy several satellites. From a functional point of view, multiple deployment is little different from a single deployment, except that the upper stage may have to execute an alignment, brief engine burn, and coast between successive deployments.

4.3.3.5 Multiple Satellite Deployment (Cont'd)

On the other hand, multiple deployment is considerably more sophisticated than single deployment and there is a greater chance of malfunction, presumably in proportion to the number of satellites deployed. For this reason, close ground monitoring, together with quick reaction capability, is more critical. Although the upper stage will, as a baseline capability, be preprogrammed to execute all required functions, a lower confidence factor is placed upon completion of a successful mission with no support from the ground.

It is assumed that multiple deployment will occur only at altitudes high enough to ensure a long-duration line-of-sight to the ground. Also, because of the presumed altitude and the relatively large total mass of the satellite cluster, it is assumed that the OOS will necessarily be expended after the final deployment.

Problems concerning communications are identical with those concerning a single deployment.

B. Functional Allocation. Major functions and their allocations to system elements are listed in appendix A, module A.1.26.

C. CCDS Functions. The CCDS functions to be accomplished during a multiple-deployment sequence are identical with those pertaining to a single deployment (see paragraph 4.3.3.4,F).

4.3.3.6 Reusable OOS Orbital Transfer

A. Discussion. This module is essentially the reverse of the OOS orbital transfer described in paragraph 4.3.3.3. The comments, functional requirements, and functional allocations in that paragraph are directly applicable. The module begins after the satellite has been deployed (i.e., released) by the OOS, and terminates when the OOS has returned to a parking orbital position near the Orbiter.

It is assumed that, since the OOS cannot retrieve a satellite, the OOS alone is returning from a deployment flight. This

4.3.3.6 Reusable OOS Orbital Transfer (Cont'd)

serves to ease communication requirements to the ground and/or the Orbiter, since only one link is required, and eases thermal control requirements, since the OOS might have to execute a roll only to assure its own thermal integrity.

Because the OOS must attain a parking position from which it can be retrieved by the Orbiter, timing is critical. That is, the OOS must not only descend to a proper orbit, but must also reach its final position at the proper time, consistent with the location of the Orbiter and its orbit. A midcourse correction by the OOS may very well be required to achieve proper timing. In this event, update data to the OOS can be conveyed only from the ground, since the OOS would be far beyond communication range with the Orbiter when the update is required. Such ground support would be especially required if the Orbiter had maneuvered since it first released the OOS.

B. Functional Allocations. Module A.1.27, appendix A, lists major functions and their allocation for this module.

C. CCDS Functions. All the CCDS tasks listed in paragraph 4.3.3.3,F, OOS Orbital Transfer, will also pertain to a reusable OOS orbital transfer back to a parking orbit. In addition, the CCDS will:

- Compute and convey OOS trajectory data to the Orbiter
- Compute and convey firing sequence and/or midcourse maneuver data to the OOS, as required for proper timing and position in the parking orbit.

These functions must be accomplished while a line-of-sight between the OOS and a tracking station exists.

4.3.3.7 Payload/Orbiter Rendezvous

A. Discussion. When the OOS is reusable, it must, after completing its deployment tasks, transport itself back to a

4.3.3.7 Payload/Orbiter Rendezvous (Cont'd)

low-altitude position, from which it can be retrieved by the Orbiter. For a mechanically successful and safe retrieval, the OOS must be deactivated upon reaching its parking orbit; the Orbiter must locate and maneuver close to the OOS. During this portion of a mission, the OOS is simply coasting in a parking orbit, so that most of the activity is performed by the Orbiter, the OOS being passive and cooperative.

Alternatively, the rendezvous module may be concerned with the Orbiter retrieving a low-altitude satellite, rather than the OOS. From a functional point of view there is little difference to the Orbiter; the spacecraft to be retrieved must be located, maneuvered to, made passive, approached from the correct direction, and manipulated into the cargo bay.

The primary rendezvous aids are assumed to be (1) a tracking radar carried by the Orbiter, (2) an OOS tracking beacon, (3) the Orbiter navigation/guidance computer, (4) Orbiter optics and (5) visual acuity of the Orbiter crew. It is assumed the payload communications package remains operational during the rendezvous maneuvers, permitting the Orbiter to command the payload for safing and attitude alignment. Because the rendezvous occurs at a relatively low altitude, both the payload and the Orbiter will be out of radio contact with the ground most of the time.

B. Definition. The rendezvous module commences after the returning OOS has completed its final transfer burn and has become passive/cooperative; the module ends when the payload is within retrieval-mechanism reach of the Orbiter, and the closing velocity is less than 1 foot per second.

4.3.3.7 Payload/Orbiter Rendezvous (Cont'd)

C. Module Drivers. This module encompasses all maneuvers and coast periods necessary to bring the Orbiter to a specified station keeping position relative to the payload. Primary considerations for the functional analysis of the module are as follows:

- Constraints on operation of the Orbiter rendezvous radar
- Desired rendezvous time
- Payload orbit
- Initial Orbiter orbit
- Desired approach path and rate
- Orbiter fuel limitations
- Almost complete absence of radio contact with the ground during the rendezvous.

D. Primary Module Functions. The major functions to be executed during the rendezvous module are:

1. Prepare for terminal phase initiation (TPI) maneuver, during which sequence the payload must be radar-located, and calculations performed aboard the Orbiter to control the rendezvous maneuver.

2. Perform maneuver, during which sequence the Orbiter executes its primary movements toward the target vehicle.

3. Trim residual ΔV's.

4. Terminal braking maneuvers.

5. Attainment of station keeping position.

4.3.3.7 Payload/Orbiter Rendezvous (Cont'd)

E. Functional Allocation. The top-level module functions and their allocations are listed in appendix A, module A.1.28.

F. CCDS Functions. Radio lines of sight among the Orbiter, the payload, and a ground tracking station are necessarily limited during rendezvous and retrieval by the Orbiter; the role of CCDS is therefore correspondingly limited, but will consist of all those functions outlined in paragraph 4.3.3.2,C, OOS/Satellite Deployment, as line-of-sight is available.

4.3.3.8 Payload Retrieval by Orbiter

A. Introduction. This module includes those activities associated with moving the Orbiter from the station keeping position to docking with, mechanical retrieval of, and securing of the target vehicle with the cargo bay. The module is assumed to begin at the point at which docking constraints are imposed; i.e., attitude, closure range, and closure range rate become controlling parameters. Procedures are essentially the reverse of the payload deployment module (paragraph 4.3.3.2).

As was pointed out in the rendezvous module discussion (paragraph 4.3.3.7), it matters little from a functional point of view whether the Orbiter is about to retrieve an OOS or a satellite; the major procedures are identical in both cases. Also, again because the retrieval occurs at a relatively low altitude, radio line-of-sight to the ground will be largely unavailable.

It is assumed the target vehicle is passive during the retrieval; i.e., all velocity and position maneuvers will be executed solely by the Orbiter. It is also assumed the target vehicle communications package remains active and operational, permitting the Orbiter to command as required. Finally, it is assumed that a nominal retrieval will not require EVA by the Orbiter crew.

The retrieval module starts in a station keeping phase, which will normally last only a few minutes. The objectives of

4.3.3.8 Payload Retrieval by Orbiter (Cont'd)

this phase are (1) to permit observation of the target vehicle, (2) to perform a checklist search aimed at verifying that all systems are configured for the retrieval, and (3) to execute whatever commands may be required to ensure a docking that subjects the Orbiter crew to no undue hazards, simultaneously minimizing the risk of damage to the vehicles.

B. Definition. The retrieval module commences when the payload is within reach of the Orbiter retrieval mechanism, and ends when the payload has been manipulated into the payload bay, the bay doors are closed, and orbital coast preparation for reentry is commenced.

C. Functional Analysis Drivers. Primary considerations for the functional analysis of the payload retrieval by Orbiter are as follows:

- Desired docking attitude
- Time required for docking
- RCS propellent requirements
- Relative vehicle motions (closing rates, approach angles)
- Lack of radio line-of-sight to the ground
- Desired station keeping relation between vehicles
- Time required for station keeping.

D. Brief Summary of the Module. The major functions to be performed in this module are as follows:

- Maintain station keeping
- Verify systems readiness for docking
- Prepare to dock

4.3.3.8 Payload Retrieval by Orbiter (Cont'd)

- Maneuver to required docking corridor
- Final closure maneuver
- Activate retrieval mechanism
- Capture target vehicle
- Stow and secure in cargo bay
- Establish cargo bay environment
- Initiate coasting flight procedures.

E. Functional Allocation. Major functions of the module and their allocations are listed in appendix A, module A.1.29.

F. CCDS Functions. The CCDS functions for this module are essentially the same as for payload/Orbiter rendezvous.

4.3.3.9 Satellite Operations. Once a satellite has been deployed, either by the OOS or by the Orbiter, and successfully checked out, the responsibility of the STS to that satellite is essentially completed. A brief discussion of orbital operation is presented here only for continuity and completion.

Following deployment, a satellite must be thoroughly checked out; sensors, cameras, and all subsystems must be stimulated, exercised and verified, and a final adjustment of the satellite position, the attitude, or both may be required. In some DOD satellites this is a rather time-consuming process and may involve elaborate software for system verification, as well as a wideband (up to 1.024 MHz) communication link.

Regardless of which STS element is delegated responsibility for satellite checkout, following the checkout the satellite operation will be handed over completely to the ground. A full wideband

4.3.3.9 Satellite Operations (Cont'd)

communication link must be established from the satellite to the ground, and the ground must possess full software capability for commanding and interpretation during any subsequent checkout, attitude control, or station keeping maneuvers.

Since this capability must exist on the ground, and since specific requirements for checkout are satellite-peculiar, it seems pointless to consider reproducing this capability in a space-borne segment of the STS; i.e., either the Orbiter or the OOS. Therefore, it is asserted simply that postdeployment satellite checkout is allocated only to the ground, with no backup or secondary allocation to either the Orbiter or the OOS.

The OOS is assumed to have no satellite retrieval capability once the satellite has been released. If the satellite malfunctions beyond that point, the satellite can neither be recovered, nor assisted by the OOS.

Later in the STS program it is expected that a more sophisticated upper stage, the tug, will become operational. When this occurs, recovery of a malfunctioning satellite will presumably become feasible, but it will still be an onerous burden to require the tug to perform postdeployment checkout. This function should still be allocated to the ground segment.

It is anticipated that the NASA OOS will carry a monitor TV camera to be used for examining a satellite immediately after its deployment; because the use of such equipment on the DOD OOS is tentative, no consideration is given to the camera in this report.

4.4 CONTINGENCY SUPPORT (ORBITER)

The DOD study requirements that state "... all functions which can be performed on-board shall be allocated to the orbiter" and "The traceability of requirements to the NASA/DOD Level II documents shall be required ...," together with the explicit DOD requirements on autonomy, preclude any ground support requirement for the ascent or on-orbit phases of the nominal mission. All ground support for

4.4 CONTINGENCY SUPPORT (ORBITER) (CONT'D)

these phases must be justified in terms of "...support in the event of an emergency" (DOD requirement 3.2.1a). This study interprets "emergency" as "contingency" in the sense of a possible or unforeseen occurrence during a mission and has used this as the vehicle for introducing functions in the general category of Mission Operations Support. This type of support is involved with making decisions/recommendations to the crew that include change in mission objectives and enhancement of mission success and crew safety probabilities. The actual contingency situations selected are not significant from the standpoint of the contingency per se, but are significant in terms of the CCDS functions involved and the interfaces required with systems external to the CCDS.

Contingencies selected are:

- An abort to an alternate mission
- A payload failure at deployment
- A malfunction is a nonredundant system.

4.4.1 Contingency 1 - Abort to Alternate Mission

4.4.1.1 Description. Contingency 1 exemplifies the limited SCF/SGLS station coverage at VAFB during critical ascent phase activity. This limited coverage results in the orbital status being unknown to mission control until the first postlaunch station has acquisition of signal (AOS). In the analysis of this contingency, two assumptions were made:

- Alternate missions are preplanned for each mission at least to the extent of determining minimum acceptable conditions for payload deployment
- Orbiter has the capability of maintaining a safe orbit for 24 hours under abort to orbit (ATO) conditions.

Contingency 1 depicts a mission in which a payload is to be delivered to a 120 × 180 mile eliptical orbit from VAFB. Following a normal launch through launch site loss of signal (LOS), one MPS engine shuts down prematurely prior to insertion. The remaining MPS

4.4.1.1 Description (Cont'd)

engine throttles are advanced to emergency power level (EPL), and the OMS and RCS engines are burned to achieve a stable orbit (ATO). The remaining OMS propellent is insufficient for completion of the primary mission. The crew reports status at acquisition of the first remote site, and the payload user is notified that the primary mission is precluded but an alternate mission may be possible. The Orbiter is determined to be in a safe orbit for a minimum of 24 hours.

After verifying the Orbiter is in a safe, stable orbit, all Orbiter systems are analyzed to determine remaining Orbiter capability. It is determined through coordination between mission control, Orbiter crew and payload user that the Orbiter has the capability to deploy the payload into an alternate mission that is acceptable from a mission objective standpoint. Computational facilities and ground simulators are used to refine and verify the alternate mission based upon Orbiter systems and consumables status.

The alternate mission is approved. Revised flight plans are uplinked to the Orbiter. Targeting updates are generated and uplinked. The payload is checked out, required maneuvers are completed, and the payload is deployed in accordance with the alternate mission plan. Subsequent orbital coast reentry and landing are normal.

4.4.1.2 CCDS Functions. CCDS functions exercised during contingency 1 include:

- Verification of stable orbit by ground tracking data
- Analysis of Orbiter systems data to determine Orbiter capability in relation to payload mission requirements
- Coordination with payload user in determining if Orbiter capability meets any alternate mission criteria based on pre-mission contingency planning
- Provision of computational facilities and/or ground simulators to refine and verify alternate mission plan based upon Orbiter capability
- Uplink of updated flight plan and new targeting information.

4.4.1.2 CCDS Functions (Cont'd)

Table 4-2 indicates the event and the related CCDS function in reacting to a contingency of this type.

4.4.2 Contingency 2 - Deployed Payload Anomaly

4.4.2.1 Description. This contingency involves a mission planned to deploy a payload into a circular orbit with the Orbiter returning to earth empty approximately 24 hours after launch. The mission cannot be completed as planned due to a failure in the deployed payload. It is assumed that a total RF failure of the payload could occur without affecting other payload systems and that the payload and orbiter characteristics permit retrieval and recovery.

All mission phases are completed successfully through payload deployment. During postdeployment station keeping, the payload RF system fails, precluding all communications to and from the detached payload. Previously received payload data is analyzed and the payload is visually inspected by the crew. No cause or corrective action can be determined. Retrieval of the payload by the Mission Director is approved, and orbiter-payload communications are restored upon connection of the payload umbilical. Payload telemetry data confirms total failure of the payload RF system. It is desirable to return to earth with the payload. Payload characteristics, potential hazards, and safety procedures are considered, the mission is replanned, and payload return is approved. Subsequent deorbit and landing are normal.

4.4.2.2 CCDS Functions. CCDS functions exercised during this contingency include:

- Assisting in problem isolation to the payload
- Providing capability for mission control, payload user and Orbiter crew coordination in determining problem cause and corrective action
- Providing for callup of previously recorded payload data and assisting in data reduction and analysis

TABLE 4-2

CONTINGENCY 1

MET HR:MIN	EVENT	CCDS FUNCTION
00:00	NORMAL LAUNCH THRU LAUNCH SITE LOS	NORMAL LAUNCH PHASE MONITORING AND STATUS DISPLAY
00:07	PRIOR TO INSERTION ONE MPS ENGINE SHUTS DOWN PREMATURELY	NONE - NO GROUND STATION IN VIEW
00:07	THROTTLES ARE ADVANCED ON REMAINING MPS ENGINES (EPL)	NONE - NO STATION IN VIEW
00:10	OMS AND RCS ENGINES ARE BURNED. ΔV LOSS IS MADE UP AND A STABLE ORBIT IS ACHIEVED. (ABORT TO ORBIT)	NONE - NO STATION IN VIEW
01:10	CREW REPORTS STATUS TO MCC	FIRST SUPPORTING NETWORK STATION HAS AOS PROVIDE COMM AND MONITORING STABLE ORBIT IS VERIFIED BY GROUND TRACKING DATA AND/OR TLM
01:15	COORDINATION BETWEEN CREW AND MCC DETERMINES PRIMARY MISSION CANNOT BE ACHIEVED WITH REMAINING OMS PROPELLENT. PRESENT ORBIT DETERMINED TO BE SAFE FOR 24 HOURS, MINIMUM	DETERMINE ORBITER CAPABILITY BASED UPON SYSTEM STATUS, CURRENT ORBIT, REMAINING CONSUMABLES, TIME CONSTRAINTS, OPTIONS, ETC. IN RELATION TO P/L MISSION REQUIREMENTS
01:15 THRU 04:00	COORDINATION BETWEEN P/L USER, MCC, AND ORBITER CREW TO DETERMINE POSSIBILITY OF ALTERNATE MISSIONS	PROVIDE P/L USER AND MCC COMM. PROVIDE ORBITER COMM WHEN IN VIEW OF RTS ADVISE P/L USER OF ORBITER CAPABILITY AND TREND ANALYSIS AND PROVIDE ASSISTANCE IN DETERMINING IF CAPABILITY FALLS WITHIN MINIMUM P/L REQUIREMENTS OR MEETS ANY ALTERNATE MISSION CRITERIA
04:00 THRU 08:00	ORBITER DETERMINED TO BE CAPABLE OF DEPLOYING P/L TO ACCEPTABLE ALTERNATE MISSION WHICH MEETS MANDATORY REQUIREMENTS	PROVIDE COMPUTATIONAL FACILITIES AND/OR GROUND SIMULATORS AS REQUIRED TO REFINE ALTERNATE MISSION PLANS BASED UPON ORBITER CAPABILITIES
08:30	ALTERNATE MISSION APPROVED	PROVIDE UPDATED FLIGHT PLAN TO ORBITER INCLUDING NECESSARY MANEUVER UPDATES AND P/L DEPLOYMENT TIME
12:00 THRU 13:00	CHECK OUT P/L AND DEPLOY IN ACCORDANCE WITH ALTERNATE MISSION PLAN	NORMAL MONITORING
13:00 THRU 24:00	NORMAL ORBITAL COAST, REENTRY AND LANDING AT PRIMARY LANDING SITE	NORMAL SUPPORT

4.4.2.2 CCDS Functions (Cont'd)

- Evaluating Orbiter and payload characteristics in relation to safety requirements and potential hazards of retrieval and payload recovery

- Providing computer updates to the Orbiter for reentry with payload.

Table 4-3 indicates the mission events and the related CCDS functions in reacting to a contingency of this type.

4.4.3 Contingency 3 - Manipulator Malfunction

4.4.3.1 Description. This contingency involves a mission planned to retrieve a payload from orbit. Following retrieval and securing the payload in the bay, one manipulator arm fails in a partially extended position. This prevents closure of the payload bay doors.

The crew reports the problem to the ground and telemetry confirms that the manipulator control motor does not drive, has overheated, and draws excessive current when the crew tries to move the arm. The crew visually examines the manipulator using the closed circuit TV (CCTV) system and finds mechanical and structural damage to the base of the arm which is causing the motor to bind. The crew describes the damage in detail to the ground and requests a conference to determine options. SMCC first confirms the Orbiter conclusions that there is no immediate danger, the orbit is safe, and consumables are ample. The problem is not time-critical, but it must be corrected before reentry. JSC is alerted, the manipulator vendor is contacted, and a conference is held among the Orbiter crew, JSC, CCDS, and the vendor. The simulator at JSC is provided with data and initialized. Simulator crewmen and controllers begin working the problem based upon current information and periodic updates.

It soon becomes apparent that the limited SCF tracking station coverage does not provide the minimum voice and data capability needed to effectively continue air/ground troubleshooting coordination. CCDS requests that STDN support be provided utilizing

TABLE 4-3

CONTINGENCY 2

MET HR:MIN	ACTIVITY	CCDS FUNCTION
00:00 THRU 03:00	ALL MISSION PHASES THROUGH P/L DEPLOYMENT ARE NOMINAL	NORMAL MONITORING AND STATUS KEEPING
03:30	DURING POST DEPLOYMENT STATION KEEPING ALL RF COMM FROM THE P/L ABRUPTLY STOPS. P/L WILL NOT RESPOND TO GROUND OR ORBITER COMMANDS	NORMAL MONITORING AND STATUS KEEPING
05:00	CONTINUE STATION KEEPING. ORBITER CREW VISUALLY INSPECTS P/L AND COORDINATES WITH MCC AND P/L USER TO DETERMINE PROBLEM CAUSE AND POSSIBLE REMEDIAL ACTION	PROVIDE FOR ORBITER/P/L USER/MCC VOICE CONFERENCING PROVIDE FOR DATA REDUCTION AND ANALYSIS OF PREDEPLOYMENT P/L DATA
06:00	DATA ANALYSIS AND VISUAL INSPECTION DISCLOSE NO CAUSE FOR THE PROBLEM AND SUGGEST NO CORRECTIVE ACTIONS	CONTINUE MONITORING AND COORDINATION
06:15	P/L USER REQUESTS THE P/L BE RETRIEVED AND FURTHER CHECKS BE ATTEMPTED UTILIZING THE P/L HARDLINE	PROVIDE FOR EVALUATION OF P/L CHARACTERISTICS AND REVIEW OF SAFETY REQUIREMENTS AND POTENTIAL HAZARDS INVOLVED IN RETRIEVAL AND RECONNECTION WITH THE ORBITER APPROVE P/L RETRIEVAL AND RECONNECTION TO ORBITER
07:00	P/L IS RETRIEVED, UMBILICALS RECONNECTED, AND P/L COMMUNICATION RESTORED	NORMAL MONITORING
08:00	P/L TELEMETRY DATA INDICATES TOTAL FAILURE OF P/L RF SYSTEM	COORDINATE WITH P/L USER AND ASSIST IN DATA ANALYSIS AND DATA REDUCTION
10:00	P/L USER REQUESTS P/L BE RETURNED TO EARTH	REPLAN MISSION FOR RECOVERY WITH P/L REVIEW SAFETY PROCEDURES AND POTENTIAL HAZARDS APPROVE RECOVERY WITH P/L GENERATE AND UPLINK REQUIRED COMPUTER UPDATES AND REVISED MISSION PLANS NOTIFY LANDING SITE
24:30	REENTRY AND LANDING IS SUCCESSFUL	NORMAL REENTRY SUPPORT COORDINATE WITH P/L USER FOR P/L DISPOSITION

4.4.3.1 <u>Description</u> (Cont'd)

TDRS so that coverage can be maximized. JSC begins the necessary scheduling coordination with GSFC, and call up of available STDN stations is initiated. At this point, the Orbiter crew ends participation in the voice conference and begins a rest period while waiting for STDN readiness.

The CCDS informs the payload user that the downlink will no longer be secure when the STDN/TDRS relay begins. This presents no problem to the payload user since the payload mission is complete. The user requests that the crew inhibit all downlink from the payload just prior to configuring for STDN operation.

When STDN activation is complete, the crew is awakened and briefed on mission status and the STDN schedule. The payload downlink is inhibited by the crew and verified by the ground. The crew configures the Orbiter transponders for STDN/TDRS operation, and the voice conference is resumed utilizing the STDN/TDRS relay. After a period of continuous voice coordination and data analysis, it is agreed that an attempt should be made to jettison the defective arm (a capability to jettison the manipulators selectively is assumed). In addition, crewmen in the JSC simulator have successfully demonstrated a capability to use one good manipulator arm to position and secure a disabled arm such that bay door closure is possible. Arm jettison is determined to be most advisable and is attempted. The attempt is unsuccessful. Crew observation of the attempt determines that the structural damage prevented the arm from separating.

After a brief conference, the crew is given authorization to use the good manipulator in an attempt to secure the bad arm. This attempt is successful and the payload bay doors may be closed. STDN support is retained until onboard systems are checked out and deorbit preparations are underway to the extent that continuous ground coverage is no longer determined to be necessary. The crew then configures the Orbiter for SGLS operation, and, following the first SCF station acquisition, the STDN is released. The remainder of the mission through entry and landing is nominal.

4.4.3.2 <u>CCDS Functions</u>. CCDS functions exercised for this contingency include:

- Ground verification of a problem through analysis of downlinked telemetry
- Evaluation of all Orbiter systems to determine total problem impact and time criticality of corrective action
- Providing for real-time coordination among external vendor organizations, JSC, simulation facilities and the Orbiter crew in determining appropriate corrective measures and possible options
- Determining a need for STDN/TDRS support and coordinating with NASA facilities in scheduling and implementing that support
- Utilization of ground simulators in developing and demonstrating corrective actions to flight problems in real-time.

Table 4-4 indicates the events and the related CCDS functions in reacting to a contingency of this type.

4.5 OOS CONTINGENCY ANALYSIS

Because an almost indefinitely large number of anomalies could be postulated and analyzed for on-orbit operations of the OOS, an all-encompassing contingency analysis is beyond the scope of this study. Instead, what is presented is a brief discussion of what role the ground network can, and cannot, play in support of on-orbit contingencies. One or two major functions have been selected from each of the major modules outlined in paragraph 4.3.3, and the possible role of the ground network in correcting unplanned events is dis- discussed.

No attempt is made to explore worst case anomalies, e.g., those wherein the lives of the Shuttle crew are in serious jeopardy; these must be the result of an in-depth contingency analysis. On the other hand, it is believed the contingencies selected represent a fair cross-section of problems solvable either by decisive action on the part of the crew or only through concerted and timely action from the ground.

TABLE 4-4

CONTINGENCY 3

MET HR:MIN	ACTIVITY	CCDS FUNCTION
06:00	MISSION NOMINAL THROUGH P/L RETRIEVAL AND SECURING	NORMAL MONITORING
06:00	ONE OF THE MANIPULATOR ARMS FAILS IN A PARTIALLY EXTENDED POSITION PREVENTING CLOSURE OF THE P/L BAY DOORS	PROVIDE FOR ANALYSIS OF DOWNLINKED TELEMETRY DATA PROVIDE VOICE COORDINATION WITH THE ORBITER FOR DISCUSSION OF PROBLEM SYMPTOMS AND POSSIBLE CORRECTIVE ACTION
06:15	CREW VISUALLY EXAMINES MANIPULATOR BY UTILIZING THE CCTV AND FINDS MECHANICAL, STRUCTURAL DAMAGE NEAR THE BASE OF THE ARM WHICH APPEARS TO BE BINDING THE CONTROL MOTOR	TELEMETRY INDICATIONS VERIFY THAT THE CONTROL MOTOR IS BINDING EVALUATION OF SYSTEMS DATA REVEALS NO IMMEDIATE DANGER FOR THE ORBITER. PROBLEM SOLUTION NOT TIME-CRITICAL
07:00	JSC IS ALERTED AND CONFERENCE IS HELD AMONG THE ORBITER CREW, JSC, MCC, AND MANIPULATOR VENDOR	PROVIDE FOR NOTIFICATION OF JSC AND VENDOR AND CONFIGURE VOICE CONFERENCE
08:00	MISSION SIMULATOR AT JSC IS INITIALIZED FOR UTILIZATION AS A TROUBLESHOOTING AID	PROVIDE JSC SIMULATION FACILITIES WITH INITIALIZATION INFORMATION AND CONTINUE UPDATES AS DATA BECOMES AVAILABLE
08:30	CCDS REQUESTS STDN/TDRS GROUND STATION SUPPORT	DETERMINE NEED FOR STDN/TDRS SUPPORT COORDINATE WITH NASA TO SCHEDULE AND IMPLEMENT STDN SUPPORT
09:00	CREW REST PERIOD	CONTINUE MONITORING WHEN STATION IN VIEW
16:00	CREW AWAKENED. P/L DATA TRANSMISSION TO GROUND TERMINATED FOR SECURITY REASONS	COORDINATION WITH CREW AND P/L USER
16:30	CREW CONFIGURES ORBITER FOR STDN/TDRS OPERATION	CONTINUE COORDINATION WITH NASA TO PROVIDE STDN GROUND SUPPORT
19:00	JETTISON OF MANIPULATOR DECIDED UPON AND ATTEMPTED BUT STRUCTURAL DAMAGE PREVENTS SEPARATION OF ARM	CONTINUE MONITORING AND PROVIDING VOICE CONFERENCING COORDINATE WITH JSC SIMULATION FACILITIES TO DETERMINE IF REMAINING GOOD MANIPULATOR ARM CAN BE USED TO POSITION THE DAMAGED ONE
20:00	CREW IS AUTHORIZED TO USE OTHER MANIPULATOR TO POSITION DAMAGED ARM. FAULTY ARM IS POSITIONED AND LATCHED AND BAY DOORS CLOSED	CONTINUE MONITORING
24:00	NORMAL REENTRY AND LANDING	NORMAL REENTRY AND LANDING SUPPORT

4.5 OOS CONTINGENCY ANALYSIS (CONT'D)

The key to contingency support is communications. The detection, diagnosis, and remedial correction of most contingencies among segments of the STS will be possible only as appropriate communications links are available. Therefore, it is useful to list the predominant communication links among the major STS segments, i.e., the Orbiter, the OOS, satellites and the ground network. (It is assumed communication links of adequate capability to handle any postulated anomaly will always be available on the ground between SMCC and the various tracking stations.) These links are:

A. Hardwire between OOS and Orbiter, and between payload and Orbiter, while these are stowed in the Orbiter cargo bay.

B. RF-SGLS compatible link between Orbiter and the ground, between the OOS and the ground, and between a payload and the ground when a direct line of sight occurs. These links are not distance limited (at least not until well beyond a synchronous orbit).

C. RF-SGLS compatible links between the Orbiter and the OOS, and between the Orbiter and satellites; these links are limited to not over TBD nmi. No RF link occurs between the OOS and a satellite.

D. The Orbiter will possess unified S-band communication equipment, but for normal DOD missions this capability will be inactive. On the other hand, when contingencies occur, it will be feasible for the Orbiter to establish communication with NASA via USB stations when a line of sight occurs or via TDRS. Neither the OOS (DOD) nor satellites (DOD) will carry USB communication packages.

E. The Orbiter carries a TDRS communication package, to be used, at most, for contingency support. The availability of a TDRS link would be a tremendous aid to the Shuttle in dealing with complicated contingencies because TDRS would provide near continuous communication to the ground instead of the occasional, time-limited communication provided by radio links to any of the DOD or NASA ground stations.

4.5 OOS CONTINGENCY ANALYSIS (CONT'D)

On the other hand, TDRS cannot be considered a panacea for contingency support for two primary reasons:

- Although TDRS planning has progressed to an advanced stage, there is no guarantee that TDRS satellites will actually be operational when the DOD-STS program is fully active
- The DOD Orbiter will ordinarily conduct classified missions involving secure (digital-encrypted) communications. The end point of any ground based communication link must be able to decrypt if it is to be of any help to the Orbiter; or otherwise the Orbiter must switch to nonencrypted transmissions, in possible violation of COMSEC requirements.

The use of TDRS must therefore be examined from two points of view; i.e., either a TDRS link will be available, or it will not. If the link is not available, the priority order of communications between the Orbiter and CCDS will be 1) SGLS links and 2) USB links.

As a direct consequence of communication link limitations, the Orbiter crew will necessarily be responsible for dealing with most on-orbit contingencies relevant to low-altitude vehicles. Thus, for example, an anomaly may occur during a payload deployment sequence or during a payload rendezvous, passivation and retrieval sequence.

In these events, problems will either be solved by the crew or the crew will seek ground assistance via the SGLS and/or USB links.

If the TDRS link is potentially available, near continuous communication to the ground will be possible. Because of the relatively long time required to call up the USB link from the Orbiter back to either JSC or SMCC (up to 8 hours), it may be much more desirable for the TDRS link to be activated immediately. However this possibility must be evaluated in terms of where, on the ground, the Orbiter is to obtain its assistance (viz, secure signals cannot be decrypted at JSC), and the feasibility of conveying nonsecure contingency recovery messages.

One possibility employs nonsecure communication from the Orbiter, through TDRS and the TDRS ground system, to JSC. A second possibility is for the TDRS ground system to provide bent-pipe linkage all the way into SMCC. In this case, encrypted messages present no particular problems.

After the payload is deployed from the Orbiter, and the Orbiter and payload have moved beyond the SGLS communication range, contingency reaction becomes entirely a problem for the ground. For example, when the OOS is in an orbit transfer, only the ground can track the OOS and take appropriate steps if an unplanned midcourse maneuver is required.

4.5.1 <u>Recovery from a Contingency</u>. Contingencies can usually be traced either to the malfunction (or outright failure) of a hardware component or to an improper software item. In either case, recovery requires 1) an identification of what went wrong; 2) the selection of a recovery plan; and 3) verification of the effectiveness of the recovery plan. Identification includes:

- Troubleshooting
- Fault isolation
- Identification of malfunctioning/failed unit.

A recovery plan can take many forms, dependent upon the seriousness of the malfunction. A partial list would include:

- Replacement of failed component

4.5.1 Recovery from a Contingency (Cont'd)

- Replacement of a module
- Bypass of the failed component/module
- Switch to a redundant unit
- Manual override
- Adoption of a secondary system configuration
- Adoption of an alternate flight plan
- Scrub of a segment of the mission (i.e., do not deploy, or do not retrieve a malfunctioning vehicle)
- Extravehicular activity by Orbiter crew members.

Verification similarly can take many forms, but might include such actions as:

- Communication lock attempt
- Power check
- Memory readout verification
- Subsystem checkout
- Indicator tests
- Visual observations
- Continuity checks.

4.5.2 Selected Contingency Listing. Table 4-5 lists contingencies pertinent to selected top level functions listed in paragraph 4.3. At least one function from each major on-orbit module is analyzed, partly to illustrate how the recovery can be broken down into elements, and partly to highlight how CCDS may contribute to the recovery.

4.5.3 CCDS Functions

In the event of a contingency, the role to be played by CCDS (i.e., the functions to be accomplished) obviously will vary with the particular contingency. In general, CCDS will provide technical analysis, technical evaluation, technical inputs to SMCC, maintenance of communication between SMCC and the vehicles, and conveyance of command/control decisions made at SMCC to the vehicles. Specific CCDS functions include:

- Provision of communication, monitoring, and tracking
- Verification of orbit stabilities
- Maintenance of communication with satellite users, and provision of status advice
- Provision of computational facilities and simulation as required
- Provision of updated flight plans to all vehicles, and state vector updates to vehicles as required
- Monitoring of health and status data
- Coordination with satellite owner and assistance in data analysis and data reduction
- Maintenance of history bank and data management system
- Provision of voice conferencing among Orbiter/satellite user/ SMCC

TABLE 4-5

CONTINGENCY LISTING

FUNCTION	CONTINGENCY	ACTION	POSSIBLE PROBLEMS	RESULTANT VERIFICATION	GROUND FUNCTION	ALTERNATIVES
DEPLOYMENT (EXTENSION)	INABILITY TO EXTEND INABILITY TO RELEASE FAILURE OF BACKUPS SYSTEMS FAILURES	TROUBLESHOOT	HARDWARE RUPTURE DEPLOYMENT MECHANISM MALFUNCTION INTERNAL POWER TRANSFER FAILURE RELEASE MECHANISM FAILURE	VISUAL OBSERVATIONS CONTINUITY CHECKS AND SUBSEQUENT ACTIVATION	MINIMAL DUE TO LINE-OF-SIGHT LIMITATIONS COMM VIA SGLS, USB, OR TDRS AS AVAILABLE FOR TECHNICAL ANALYSIS AND EVALUATION, AND/OR COMMAND DECISION TO PROCEED OR CANCEL OPERATIONS	RESECURE P/L IN BAY, CANCEL MISSION, RETURN TO BASE (RTB) POSSIBLE EVA TO ASSESS AND FIX PROBLEM EXPLOSIVE RELEASE MECHANISM
SEPARATION CONTROL AND MONITORING	OMS BURN HANGUP OMS BURN DELAY LOSS OF CONTACT WITH OOS BEFORE PREPARED	TROUBLESHOOT REPAIR REESTABLISH CONTACT IF SEQUENCE PERMITS	OMS SYSTEM COMM FAILURE OOS ATTITUDE ASSUMPTION FAILURE	INITIATOR INDICATOR FAILURES/TESTS POWER CHECK DATA VERIFICATION	MINIMAL DUE TO LINE-OF-SIGHT LIMITATIONS COMM VIA SGLS, USB, OR TDRS AS AVAILABLE TO PROVIDE TECHNICAL ANALYSIS/EVALUATION	STOP OOS SEQUENCE, PERFORM ORBITER BURN, RESTART OOS SEQUENCE GROUND CONTROL OF OOS ORBITER BURN, GROUND INITIATION OF OOS SEQUENCING
ORBIT TRANSFER MANEUVERS	OOS MALFUNCTION	TROUBLESHOOT CONTINGENCY COMMANDING IF POSSIBLE	LOSS/INABILITY OF GROUND-TO-AIR COMM OOS ATTITUDE MALFUNCTION ENGINE MISFIRE OR BURN FAILURE SEQUENCING MALFUNCTION	COMM LOCK ATTEMPTS TLM TO GROUND CONTROL	PERFORM TECHNICAL ANALYSIS/EVALUATION, COMMAND AND CONTROL OOS AS LINE-OF-SIGHT PERMITS	GROUND ACTION TO EFFECT SUCCESSFUL SEQUENCE RETRIEVAL BY ORBITER, CANCEL MISSION RTB
ORBITER RENDEZVOUS WITH PAYLOAD	RENDEZVOUS DELAYED DUE TO MALFUNCTIONS	TROUBLESHOOT EFFECT SOLUTION BEFORE PROCEEDING	COMM PROBLEMS BETWEEN GROUND AND ORBITER OOS BEACON FAILURE OOS MALFUNCTION	COMM LOSS, TLM DATA INITIATOR/INDICATOR TESTING	MINIMAL - LIMITED BY LINE-OF-SIGHT COMM VIA SGLS, USB, OR TDRS AS AVAILABLE FOR TECHNICAL ANALYSIS	SLOWER THAN PLANNED CLOSURE OF ORBITER AND P/L, PROCEED TO NEXT SUBMODULE VISUAL INSPECTION OF P/L BY ORBITER CREW. CANCEL RETRIEVAL; ORBITER RTB WITHOUT OOS RETRIEVAL
STATION KEEPING	FAILURE IN SYSTEMS WHICH DELAY OR PREVENT STATION KEEPING SEQUENCE	TROUBLESHOOT RESOLVE REACTION	OOS BEACOR OR ORBITER TRACKER FAILURE OOS COMMAND SYSTEM FAILURE OOS ACS MALFUNCTION	TELEMETRY DATA INITIATOR/INDICATOR TESTS	MINIMAL - LIMITED BY LINE-OF-SIGHT COMM VIA SGLS, USB, OR TDRS AS AVAILABLE FOR TECHNICAL ANALYSIS	RESOLVE MALFUNCTIONS BY UTILIZING BACKUP CAPABILITIES; PROCEED WITH NEXT MODULE BREAK OFF RENDEZVOUS IF PROBLEMS CANNOT BE CORRECTED. RTB WITHOUT P/L
RETRIEVAL OF PAYLOAD	DELAY OR MALFUNCTION IN RETRIEVAL OPERATION	TROUBLESHOOT RESOLVE IF POSSIBLE	FINE ALIGNMENT OF THRUSTING MALFUNCTIONS BAY DOOR MALFUNCTIONS MECHANICAL MALFUNCTIONS REMATING PROBLEMS	TELEMETRY DATA VISUAL INDICATOR TESTS	MINIMAL - LIMITED BY LINE-OF-SIGHT COMM AS AVAILABLE FOR TECHNICAL ANALYSIS, ON SGLS, USB, OR TDRS	SLOWDOWN IN RETRIEVAL OPERATIONS POSSIBLE EVA ACTIVITY CANCEL RETRIEVAL RTB

4.5.3 CCDS Functions (Cont'd)

- Review of safety procedures and potential hazards
- Coordination with landing site.

4.6 DUAL MISSIONS

Except for satellite support, dual mission support by the CCDS is considered the exception rather than nominal operations. For the purpose of establishing a mission model, a hypothetical dual mission has been projected. This model employs an Orbiter in orbit launched from VAFB for payload deployment and an Orbiter with OOS/satellite launched from KSC. Launches do not occur simultaneously, and it is assumed that the VAFB mission has attained orbital status prior to the KSC launch.

Support functions by the CCDS for the VAFB mission will be for a nominal mission. Support will be dependent on premission planning and support requirements established prior to the mission. Support functions by the CCDS for the KSC mission will be for a nominal mission with the additional requirements of OOS control.

The following paragraphs address those CCDS function that result from dual mission support. Single mission support functions are assumed to be supplied for each mission without interference to the other.

4.6.1 CCDS Support Functions

Table 4-6 shows a simplified timeline of the dual mission model. As noted by the table, support activities will be time phased differently for each vehicle; i.e., while one vehicle has attained orbital status and begun payload operations, vehicle 2 will be performing prelaunch checks and attaining launch and orbital status.

The basic additional requirements resulting from supporting both missions will be the capability to identify, accept, and display data from each mission and the scheduling of the CCDS assets in support of both missions. Status information will be maintained from each mission in sufficient detail to permit mission management

TABLE 4-6

HYPOTHETICAL DUAL MISSION BY SIMPLIFIED MISSION PHASES

ORBITER 1 LAUNCHED FROM VAFB	ORBITER 2 (WITH OOS) LAUNCHED FROM KSC
PRELAUNCH	
LAUNCH, ATTAIN REQUIRED ORBITAL ALTITUDE	PRELAUNCH
ON-ORBIT OPERATIONS	LAUNCH, ATTAIN REQUIRED ORBITAL ALTITUDE
DEORBIT PREPARATION	ON-ORBIT OPERATIONS
DEORBIT AND LANDING	OOS MISSION OPERATIONS
POSTLANDING OPERATIONS	DEORBIT PREPARATION
	DEORBIT AND LANDING
	POSTLANDING

4.6.1 CCDS Support Functions (Cont'd)

decisions based on current data. The CCDS must be capable of interfacing and identifying with each mission by mission phase or contingency situation.

Mission rules and procedures will be defined premission for dual mission situations. Functions to be supported by the CCDS for dual mission operations are as follows:

- Maintenance of ephemeris data from both missions in order to calculate AOS and LOS times for both missions at each tracking station during normal contact periods.
- Maintenance of contingency deorbit data for both missions. The requirement for this function is the same as for a single mission, with the added scheduling problem and the possibility of assigning priority network coverage to a mission with impending contingency deorbit.
- Provision of status monitoring for systems and trajectory data for both vehicles. The requirement for this function is the same as for a single mission, with the added scheduling problem and the assignment of a priority to a vehicle as the result of either a contingency situation or a mission phase which requires ground support (e.g., handover of satellite to satellite control center).
- Provision of command and control of OOS while maintaining status of both missions.
- Scheduling and receiving data dumps from both vehicles. This will require scheduling of network resources and communication links for transmission of data to CCDS elements.
- Coordination of satellite deployment and retrieval operations with satellite mission control.

4.6.2 Scheduling Functions. Two missions with vehicles in unrelated orbits will at times be in acquisition range of a single RTS. A prime scheduling function will be tracking of both missions to

4.6.2 Scheduling Functions (Cont'd)

determine periods of overlap. Premission planning of orbits and launch times will minimize or eliminate areas of overlap so that they will occur only at times when no need exists to provide ground support from a single station to both vehicles.

Scheduling facilities will be required to analyze oribtal and mission timeline considerations, to schedule the two missions for minimum conflict as described above, and to provide real-time resolution of priorities.

4.6.3 Real-Time Functions. For the mission model, real-time functions will be provided as follows:

- Response as required by mission rules and procedures for contingency operation including uplink of commands and command loads (backup navigation updates) to both vehicles if required
- Real-time scheduling of CCDS resources to include tracking stations
- Coordination of satellite operations with satellite control center
- Control of OOS upon handover from Orbiter to CCDS for satellite deployment
- Normal ascent support and deorbit and landing support via voice/data link as permitted by tracking station coverage.

SECTION 5

DOD STS OPERATIONS AT KSC

5.1 GENERAL

Many shuttle flights from Kennedy Space Center (KSC) will be for the deployment/retrieval of DOD satellites into or from earth orbit. DOD will be the executive agent for these flights, but NASA will be the launch agent and is responsible for Space Transportation System (STS) operations from the end of the landing rollout until liftoff. This section presents the results of the analyses to determine the unique functions DOD operations from KSC levy on the KSC systems and the functions involved in the NASA-DOD handover at liftoff and the DOD-NASA handover at landing.

5.2 TURNAROUND AND LAUNCH OPERATIONS

Modules A.2.33 and A.2.34 of appendix A tabulate the unique DOD functions required for DOD operations from KSC. The analysis concluded that the driver is the DOD requirements for physical security and secure data handling. Both functions are described in detail in section 6, "Secure Data and Equipment Handling," of this Technical Operating Report (TOR) which is bound separately.

5.3 HANDOVER OPERATIONS

5.3.1 Handover at Liftoff. The Command and Control Data System (CCDS) will be required to be on-line and actively supporting the readiness testing, simulations and launch operations of a DOD payload being launched from KSC. Prior to launch, the CCDS will validate the quality of voice and data circuits to the KSC facility for payload and vehicle data. The CCDS will also perform network compatibility checks to verify support interface capability of the Air Force Satellite Control Facility (AFSCF).

During countdown operations, the CCDS will monitor the payload and vehicle data and provide mission software updates to the vehicle and payload up to terminal count at T-minus-5 minutes.

5.3.1 Handover at Liftoff (Cont'd)

At liftoff the control of the vehicle will reside with the flight crew. The CCDS will provide backup capability to support communications data flow for a contingency mode of operation and to provide voice/data link continuity for normal operations. Overall mission control will be exercised by the DOD.

The point at which handover is currently baselined to occur is at liftoff, or "tip lock" release. Prior to tip-lock release, NASA will have responsibility of launch operations. At handover, the DOD becomes the mission agent. If an abort occurs after a vehicle is launched from the KSC, the DOD will retain mission responsibility until landing.

5.3.2 Landing Handover Operations (KSC Flights). Although the launch agent resumes responsibility at the end of rollout, handover from DOD to KSC will be a "phased-in" process beginning in the flight terminal phase as defined in the following paragraphs and culminating in complete handover at the end of rollout, except for DOD secure data handling and payload related activities. These will require continued DOD support in the removal of secure data, purging memories, maintaining responsibility for distribution of payload data, and either dispersing payload equipment to the user or, if applicable, managing payload recycling for reuse.

NASA participation in the DOD orbiter landing operations will begin with a call to station in the KSC Landing Operations Area (LOA) at landing minus 4 (L-4) hours. At time L-3 hours, after the station communications checks will have been completed, landing site status and an area weather update will be obtained and passed to DOD for update to the crew prior to deorbit burn. Upon restoration of communications following reentry blackout, DOD landing support operations will perform a communications check with the orbiter pilot by S-Band voice. KSC will stand by to assist as required for the Orbiter landing approach. Weather data, NAVAID status and other appropriate information, will be passed to the DOD for update of the Orbiter flight crew as required. The weather information will be derived from a weather surveillance radar and the Meteorological Prediction Center, located at KSC and supported by NASA. Also, at post-blackout, the Orbiter guidance system will

5.3.2 <u>Landing Handover Operations (KSC Flights)</u> (Cont'd)

obtain a position update from the TACAN NAVAID at the NASA supported LOA. The initial phase of the landing approach, known as the TAEM (Terminal Area Energy Management), is the final DOD decision point for choosing the direction of landing at KSC. The objective of TAEM is to place the Orbiter in a favorable position (determined from NASA-provided approach area data) to intercept the final landing approach plane at the correct altitude and speed. The Autoland System on the Orbiter or the flight crew then maintains the correct energy management profile to guide the Orbiter down a nominal glideslope.

NASA personnel responsible for Orbiter landing operations at KSC (augmented with a DOD representative for those landings involving DOD payload) will be located at consoles in the LOA. Consoles currently planned by NASA will provide for the following functions: KSC Landing Operations Director, Ground Operations Director, Ground Operations Coordinator, Safety, Security, NAVAIDS, Weather Radar, Tracking Radar, and Meteorological (*NASA Station Set Requirements Document*, Vol. 17, "Landing," dated 15 January 1974). Some NASA personnel supporting the Orbiter landing operations may be at other locations; however, all landing operations coordination will be routed through the LOA.

Major CCDS support impact reflected in the landing handover phases, whether direct or indirect, will involve:

- Telecommunications/teleprocessing between the CCDS and KSC LOA/ground station
- Support of alternate mission procedures development (e.g., landing approach contingencies resolution).

All of the above support requirements will invoke CCDS capabilities such as data base maintenance, display generation, and presentation, scheduling status update generation, logistics support information management and payload user communication system (voice conferencing, status generation) management.

SECTION 6

OPERATIONS SUPPORT

6.1 GENERAL

Operations support consists of those premission, mission and post-mission functions in support of mission operations. These functions are related to overall Shuttle mission planning, preparation and management and will be supported by the Command and Control Data System (CCDS). Major categories of operations support functions are:

- Mission planning and analysis
- Onboard software development and verification
- Flight crew and mission support personnel training
- Simulations
- Program resource scheduling
- Mission information support

Module A.3 of appendix A presents the operations support functions, allocates these functions to Space Transportation System (STS) elements, and provides traceability to Level II reference material. The point of departure for these functions was the RI FFD 4.2.

The operations support functions are essential to STS operations; however, they are performed almost entirely external to the phase of operations specified in the CCDS statement of work. For this reason, they will not be discussed at the same level of detail as the functions for ground and flight operations. The discussion that follows is intended to provide completeness to the total CCDS definition task and to identify areas that must be investigated further in efforts subsequent to this study.

The following paragraphs discuss operations support activities which may be supported by or interfaced with CCDS functions related to these activities.

6.2 MISSION PLANNING AND ANALYSIS

Mission planning and analysis will provide for all mission scheduling and mission analysis and design. In the definition of CCDS elements in support of mission planning, maximum use will be made of NASA mission planning systems.

6.2.1 Mission Scheduling. The mission scheduling function provides for the generation of integrated plans and schedules for the STS. These schedules will assure that compatible satellite groupings are achieved. The CCDS will provide support for the following scheduling functions:

- Changes in flight readiness and flight schedules
- Definition of mission objectives
- Generation of long-range and short-range schedules considering user requirements, satellite buildup, vehicle maintenance, and trajectory launch constraints
- Identification of schedule conflicts
- Development of integrated top-level operations plans
- Determination of alternate plans and schedules
- Analysis and forecast of operations cost
- Assignment of specific vehicles and cargo loads for each shuttle flight
- Analysis of operational support requirements
- Coordination of satellite servicing and retrieval operations planning data.

6.2.2 Mission Analysis and Design. Mission analysis and design provides for the determination of ground support requirements and definition and analysis of mission profiles. Mission analysis and

6.2.2 Mission Analysis and Design. (Cont'd)

design tasks will be conducted premission and will be based on mission constraints, flight objectives and requirements, hardware capabilities, and operational support factors. The CCDS will support the following analysis and design activities:

- Definition of mission plans noting exceptions from nominal mission and new support requirements relative to satellites
- Generation of new procedures (onboard and ground) for new missions or mission phases
- Definition of simulation plans and data for flight crew or ground controllers
- Maintenance of mission design and analysis information
- Development of trajectories and mission profiles to the level of detail required for unique mission requirements
- Detailed analysis of unique mission phases
- Development of data required for onboard and ground mission support
- Verification of operational status of onboard software package for mission support
- Definition of data acquisition plans for recovery of data while mission is in progress
- Definition of flight plans and timelines
- Performance of consumables analysis.

6.3 ONBOARD SOFTWARE DEVELOPMENT AND VERIFICATION

Prior to each Shuttle flight onboard mission-peculiar software will be developed and verified. It is assumed that general software modules for areas such as guidance and navigation, flight control, and

6.3 ONBOARD SOFTWARE DEVELOPMENT AND VERIFICATION (Cont'd)

performance monitoring will have been developed for general mission phases. Payload modules will be mission specific and will be dependent on mission requirements. The CCDS will support the generation of any changes, additions or development of onboard software and the verification of the onboard program. As in the case of the mission analysis and design function, maximum use will be made of NASA facilities such as the Software Development Laboratory (SDL) and the Shuttle Avionics Integration Laboratory (SAIL) in development and verification of onboard software for the orbiter.

Functions to be supported by the CCDS in the development and verification of onboard software are:

- Definition of onboard software requirements based on analysis of mission design
- Definition of new software modules or modifications to existing modules
- Development and verification of flight program
- Testing of flight program in simulated environment
- Generation of flight program tapes for loading into flight computers
- Interface to the Lyndon B. Johnson Space Center (JSC) SDL for onboard software development support.

6.4 FLIGHT CREW AND MISSION SUPPORT PERSONNEL TRAINING

Flight crews and mission support personnel will require general mission training with specific training as necessary to meet mission requirements. Training will consist of academic classes, simulator and part task trainer exercises, and integrated simulations (flight crew and mission support personnel). The CCDS will support these flight crew and mission support personnel training activities. The following paragraphs describe flight crew and flight controller training and CCDS support for training activities.

6.4.1 Flight Crew Training. In establishing the framework for DOD training, the following guidelines have been applied:

- Each agency will provide its own crews
- NASA and DOD will jointly use major training facilities at JSC
- The Shuttle Training Aircraft (STA) will be scheduled and deployed to Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB) as required
- DOD will provide part task simulators or trainers as required
- JSC will have the necessary facilities to accomplish the background training.

6.4.1.1 Background and Initial Shuttle Training. New crew members will participate in background and initial Shuttle training classes and simulator exercises. Background training will consist of classes on academic subjects, space flight experience, Shuttle program, and environmental familiarization. Initial Shuttle training will be related to mission reviews, systems briefings, spacecraft tests, simulator exercises and special training. Both background and initial Shuttle operations training will be provided by JSC.

Background training is projected to be 300 hours for pilots and mission specialists and 48 hours for payload specialists. Initial training is projected to be 810 hours for commander and pilot, 700 hours for mission specialist, and 105 hours for payload specialist. The source for the training projections is the preliminary *Shuttle Operations Crew Training Plan* prepared by the JSC Flight Crew Operations Directorate.

The CCDS will not perform support functions for background and initial crew training. However, common storage facilities may be shared by the CCDS and the training record keeping, evaluation, and scheduling function.

6.4.1.2 Proficiency Training. Proficiency training will be conducted based on mission requirements using both JSC and DOD facilities. This training will be in addition to background and initial Shuttle training and will be a minimum of 3 to 4 weeks for the more routine missions, with longer training periods for specific payload packages. Training will fall into two general categories: commander and pilot, and mission and payload specialist. Commander and pilot training will review applicable mission phases such as launch and aborts, rendezvous and docking, entry, and approach and landing. Mission specialist and payload specialist training will be dependent upon type of payload and mission and will be concentrated in areas such as basic Shuttle systems, remote playload manipulator system, payload systems and payload operations. There may be cases in which the payload specialist may fly on a one-time-only mission with a special payload. This will require special training consideration. Table 6-1 presents projected operational phase training requirements.

Training courses will be conducted at both JSC and the Air Force training facilities with courses at the Air Force facility directed to specific Air Force mission requirements.

Simulation exercises will be performed using the Shuttle Mission Simulator (SMS), STA and part task trainers. Exercises requiring motion base capability will be performed at JSC. Fixed base capability will be provided by the Air Force training facility. Special part task trainers will be provided by the Air Force as required by mission-unique requirements.

The CCDS will provide support for the following crew proficiency training functions:

- Establishment of crew training requirements based on analysis of mission requirements
- Scheduling of crew training in cooperation with JSC crew training personnel
- Maintenance of simulator software and hardware as required by mission requirements and vehicle changes

*TABLE 6-1

RECURRING TRAINING REQUIREMENTS (HOURS) FOR SHUTTLE OPERATIONAL MISSIONS

ACTIVITY	COMMANDER & PILOT MISSION	COMMANDER & PILOT ANNUAL	MISSION SPECIALIST MISSION	MISSION SPECIALIST ANNUAL
REVIEWS				
FLIGHT PLAN, CHECKLISTS,	25		25 TO 35	
PROCEDURE, MISSION RULES, RESCUE				
LAUNCH, ENTRY & RECOVERY OPS				
EVA, EGRESS, FIRE			0 TO 20	
RENDEZVOUS, ORBITAL NAVIGATION				
TRANSFER, PAYLOAD, MANIPULATOR OPS	5		10 TO 20	
SYSTEM BRIEFINGS				
VEHICLE, PAYLOAD, BOOSTER	15			
SOFTWARE				
SHUTTLE TRAINING AIRCRAFT				
SPACECRAFT TESTS				
FRR, COUNTDOWN	5		5	
VEHICLE ANOMALIES BRIEFING				
SIMULATORS				
SHUTTLE MISSION SIMULATOR	25	150	17	100
SHUTTLE TRAINING AIRCRAFT	8	50		
PART-TASK (SPS, HFS)	8	50		
AIRCRAFT FLYING (T-38)				
60-1 (100 HRS. YR./MINIMUM)		250		
SPECIAL FACILITIES/MOCKUPS				
EMERGENCY EGRESS - PAD, LAND, WATER, EJECTION				
FIRE/SMOKE/DECOMPRESSION				
STOWAGE, HOUSEKEEPING	5		10	
ZERO G - A/C/WIF	0 TO 10		0 TO 10	
ONE - G WALKTHRUS	5		15 TO 30	
APPROX. TOTAL (EXCLUDES AIRCRAFT FLYING)	105 - 115		80 - 150	

NOTES: REQUIREMENTS BASED UPON SIX MISSIONS PER YEAR FOR COMMANDERS, PILOTS AND MISSION SPECIALISTS. TRAINING COVERS NOMINAL, CONTINGENCY AND EMERGENCIES. ASTERISK PERFORMED IN EITHER THE SMS OR ONE-G TRAINER--NOT BOTH. VARIABLE HOURS FOR MISSION SPECIALIST IS PRIMARILY DUE TO MISSIONS WITH AND WITHOUT EVA.

* TABLE EXTRACTED FROM: *SHUTTLE OPERATIONS CREW TRAINING PLAN (PRELIMINARY)*, JSC FLIGHT CREW OPERATIONS DIRECTORATE INTERNAL NOTE, AUGUST 1973.

6.4.1.2 Proficiency Training (Cont'd)

- Maintenance and evaluation of crew training records
- Simulation of mission problems using simulators and special hardware and software.

6.4.2 Mission Support Personnel. Mission support personnel training will consist of academic training, on-the-job training and mission simulations.

Academic courses are divided into basic courses related to space flight, qualification courses on Shuttle systems, CCDS support hardware and software, aerodynamics, aviation weather and FAA familiarization. General academic and procedures training are dependent upon the flight support function.

The CCDS will not perform support functions for mission support personnel background training. However, common storage facilities may be shared by the CCDS and the training record keeping, evaluation and scheduling function.

On-the-job training will be conducted prior to assignment of mission responsibilities. This training will be performed during actual mission support periods under direction of qualified flight support personnel.

Mission simulation will instruct the flight support personnel in general Shuttle flight evaluation and status, malfunction detection, and malfunction isolation. Mission support personnel will require some degree of simulation on all mission phases in which they may be involved either in normal operations or contingency operations. Emphasis will be placed on launch, launch aborts, rendezvous, and deorbit activities with specific mission situations simulated for these phases.

The CCDS will provide support for the following simulation functions:

- Modeling of applicable vehicles, satellites, ground tracking systems, and remote tracking station (RTS) network

6.4.2 Mission Support Personnel (Cont'd)

- Control of simulation and software, and evaluation reactions to simulator-generated flight support problem cases

- Simulation of mission problems using simulators and special hardware and software

- Evaluation of flight controller performance.

6.5 SIMULATIONS

Simulations will be performed in training of flight crew and flight support personnel, preflight readiness testing and malfunction analysis. Simulations related to flight crew and flight controller training are discussed in the preceding paragraph. The following paragraphs discuss CCDS support related to preflight readiness testing and malfunction analysis.

6.5.1 Preflight Readiness Testing. In addition to verifying onboard software during Shuttle turnaround operations, the CCDS will support the development and verification of mission specific onboard software, network verification, CCDS verification and calibration of CCDS equipment. Software development and verification is discussed in paragraph 7.3. Prior to Shuttle launches, communications interfaces and RTS operations will be verified. Prior to the mission, tests will be run on the CCDS to verify operational status. Equipment such as recorders and test and timing equipment will require calibration prior to mission operations.

The CCDS will provide support to the following preflight readiness testing functions:

- Definition of preflight readiness test requirements

- Development of test procedures and test plans

- Definition of simulation configurations and special hardware and software

6.5.1 Preflight Readiness Testing (Cont'd)

- Development and test of special hardware and software
- Verification of test results.

6.5.2 Malfunction Analysis. Malfunction analysis will be performed in case of onboard failures which require alternate procedures and/or system configurations for corrective action. The CCDS will provide support to the following malfunction analysis functions:

- Development of malfunction analysis procedures
- Simulations to isolate problems and/or develop alternate procedures
- Data exchange between NASA and other DOD facilities
- Data exchange between simulators and flight controllers.

6.6 MISSION INFORMATION SUPPORT

Mission information support will be provided by the CCDS for the acquisition, storage, processing, retrieval and display of management, technical and operational information related to Shuttle operations. Stored information will be related to Shuttle vehicle and satellite operational performance capabilities, performance limitations and constraints, and support requirements. Interfaces will be provided as required to DOD and NASA agencies.

6.7 PROGRAM RESOURCE SCHEDULING

Due to flight frequency and complex nature of the Shuttle support elements, program resource scheduling will be provided to allow maximum utilization of facilities, support systems, and personnel. The CCDS will provide support for the scheduling of these program resources. These program resources include data systems, simulators, tracking stations, ground support equipment, personnel, and vehicle and satellite assignments.

6.7 PROGRAM RESOURCE SCHEDULING (Cont'd)

Functions to be supported by the CCDS for resources scheduling are:

- Analysis of mission support requirements to define resource requirements
- Definition of additional resources
- Evaluation of priorities
- Determination of schedule conflicts and resolution of conflicts
- Definition of resource schedules
- Routing and coordination of resources schedules to/with support elements.

SECTION 7

EXTERNAL INTERFACES

7.1 GENERAL

In this section the Command and Control Data System (CCDS) is considered as a functional entity, and interfaces between it and external elements are defined and analyzed. Three separate phases of mission readiness are considered: Premission (planning); Ground Operations (assembly, mating, verification, and launch preparation); and Flight Operations (launch through landing). For each of these phases, the agency with which interfaces will be established is listed, and the operational nature of the interface is defined. Functional interfaces are defined; the same interface may serve more than one function, but each function will be addressed separately.

7.2 PREMISSION

Premission interfaces will be provided for mission planning, software development, training and simulations. The following paragraphs discuss these CCDS interfaces with both NASA and DOD agencies.

7.2.1 Mission Planning. CCDS external interfaces for premission planning functions are presented in figure 7-1. These interfaces are with the Lyndon B. Johnson Space Center (JSC), Kennedy Space Center (KSC), Air Force Logistics Command, and the payload user.

The *Joint NASA/DOD Space Transportation System Program Plan* states that "in developing mission planning and design, DOD will use NASA-developed capabilities to the maximum extent practical." Mission planning systems currently under development at JSC include the Vehicle Management and Mission Planning System (VMMPS) and Program Information Control and Retrieval System (PICRS). The concept of DOD use of these facilities has not been determined. However, systems which may be interfaced, and type of data transmitted are:

- VMMPS: Mission design and analysis data

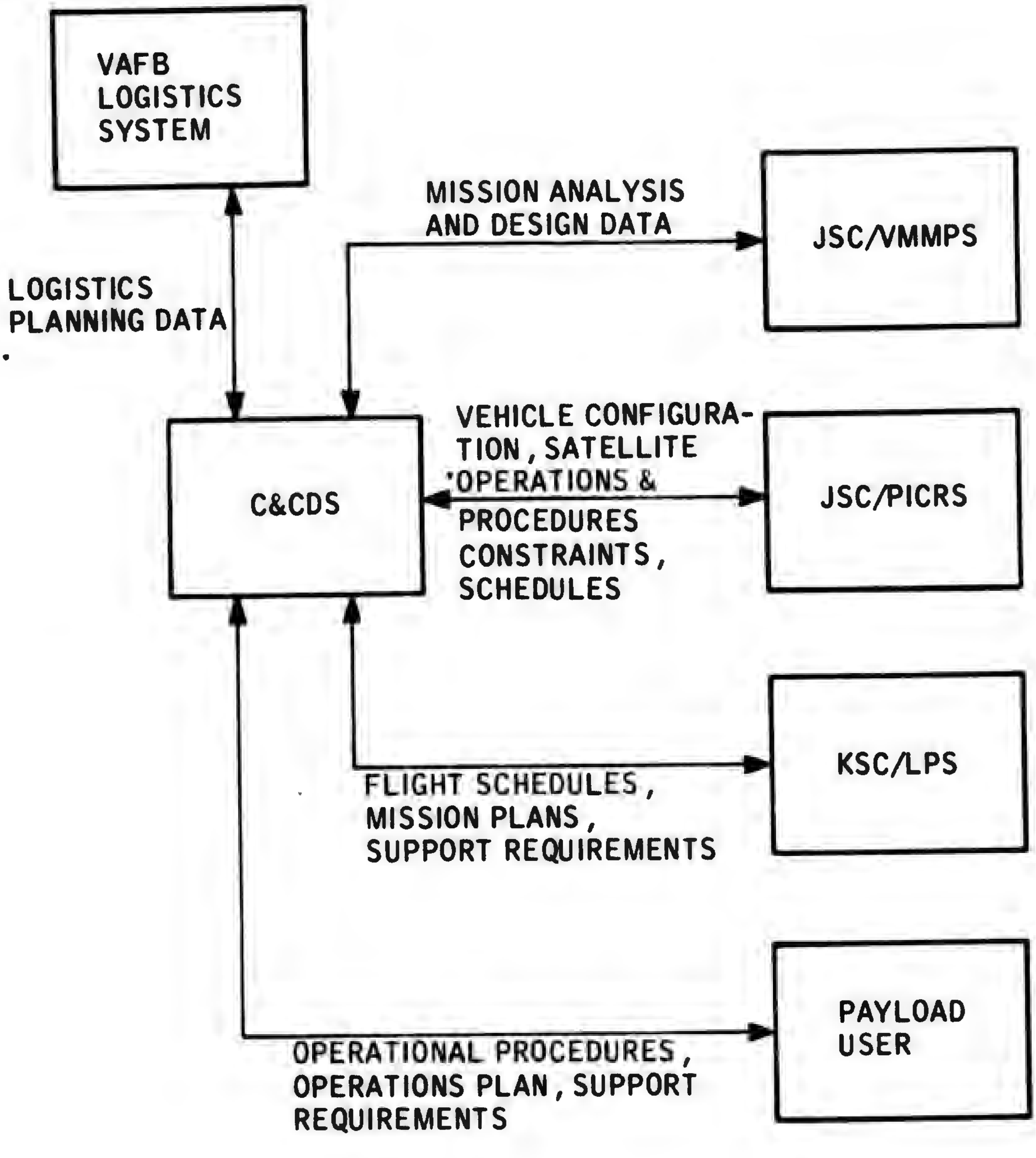


Figure 7-1 CCDS Mission Planning External Interfaces

7.2.1 Mission Planning (Cont'd)

- PICRS: Vehicle configuration, operational procedures, vehicle constraints, and schedule data. Payload data will be maintained by DOD exclusive of PICRS.

The CCDS interface with the KSC/Launch Processing System (LPS) will be for the coordination of DOD missions at KSC. The interface will provide for the transmission of data related to flight schedules, mission plans, mission support requirements, and special turnaround requirements.

The *Joint NASA/DOD Space Transportation System Program Plan* states that "....logistics management for support of VAFB (Vandenberg Air Force Base) will be provided by DOD." Data transmitted between the CCDS and the Air Force Logistics Command will be related to engineering support, operational technical documentation, program schedules and logistics problems.

7.2.2 Software Development. CCDS external interfaces for flight software development are presented in figure 7-2 and are primarily with the JSC and the payload user.

The *NASA/DOD Memorandum of Understanding on Mangement and Operation of the STS* states that "The resources of both agencies which can contribute to the development, test, production, training and operation for the STS will be used to the maximum extent possible." JSC systems to be used in software development for NASA missions include the Software Development Laboratory (SDL) and the Shuttle Avionics Integration Laboratory (SAIL). The VMMPS and PICRS will provide mission planning and vehicle configuration and performance data. As in the case of mission planning, the concept of DOD use of these facilities has not been defined. However, interfaces and types of data transmitted which may be applicable for software development are:

- VMMPS: Mission planning and scheduling data

- SDL: 1) Flight software development data for common software modules and for changes to existing software modules 2) data for verification of flight software modules and integrated flight software modules

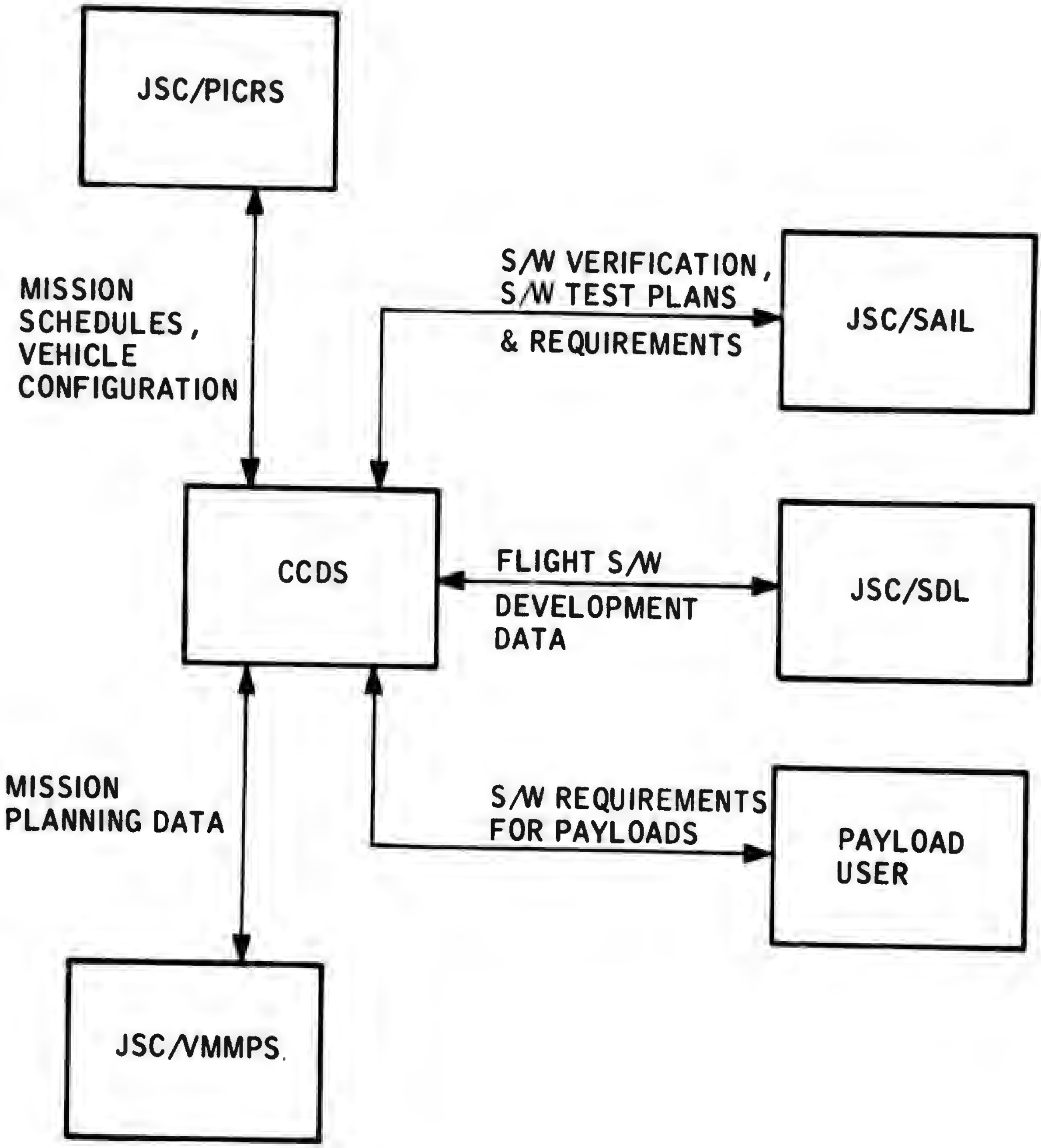


Figure 7-2 CCDS External Interfaces for Software Development

7.2.2 Software Development (Cont'd)

- PICRS: Mission schedules, vehicle configuration and mission status
- SAIL: Flight software tapes consisting of complete flight software package or flight software module for verification with actual avionics hardware.

Interface with the payload user will be for payload software requirements and payload software test plans.

7.2.3. Training. Training of flight crews and mission support personnel will consist of background training and proficiency training. Background training will be conducted at JSC, with personnel training status maintained by CCDS. Proficiency training will utilize trainer facilities at JSC, and DOD part-task trainers (PTT's) for DOD-unique requirements.

Interfaces provided for training are those necessary to coordinate scheduling of the training facilities and maintain crew training progress and goals.

7.2.4 Simulations. Simulator facilities will be provided both at JSC and in the CCDS. Simulators will provide complete facilities for simulating a mission or phases of a mission, without Shuttle Mission Control Center (SMCC) support. The simulator interfaces with JSC will be for schedule coordination and simulation progress evaluation.

JSC simulator interface may be required to support flight anomaly resolution; this is discussed in paragraph 7.4.

7.3 GROUND OPERATIONS EXTERNAL INTERFACES

7.3.1 External Interfaces to NASA Agencies (DOD GND OPS). The *Joint NASA/DOD STS Program Plan* has identified the major functions which require an interface between the CCDS and NASA agencies (JSC KSC) for ground operations. These are categorized as follows (refer to figure 7-3):

- STS engineering support

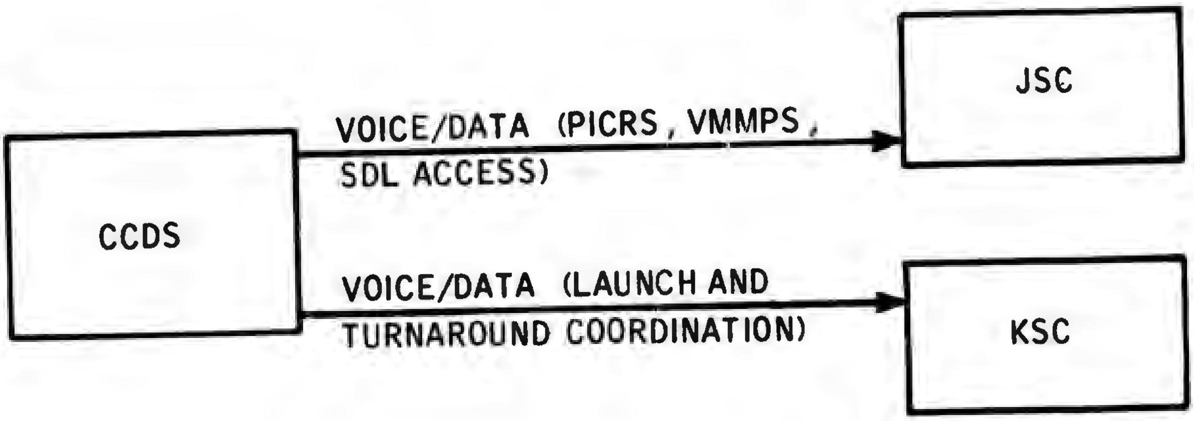


Figure 7-3 CCDS/NASA Agency Interfaces

7.3.1 External Interfaces to NASA Agencies (DOD GND OPS) (Cont'd)

- Joint DOD and NASA resource scheduling
- Headquarters direction and coordination
- Launch site turnaround planning
- Mission coordination, planning, and simulations.

To support these functions the CCDS will require a voice/data interface capability with each of the NASA agencies. The CCDS will be required to routinely interface with NASA/KSC for DOD launch coordination from that site, and NASA/JSC for mission coordination, planning, and simulation. The CCDS will also require an interface with NASA/JSC and KSC agencies for launches conducted at the VAFB. This interface will be required for readiness testing, simulations, and launch support of NASA payloads and vehicles launched from VAFB.

Figure 7-3 illustrates the various interfaces required.

7.3.2 DOD Agency Interfaces for Ground Operations. The CCDS will interface with several other DOD agencies in order to support STS ground operations. These external interfaces and their functions are discussed in the following paragraphs and are illustrated in figure 7-4.

7.3.2.1 CCDS External Interfaces

A. Strategic Air Command (SAC). The CCDS will interface with the following SAC units:

1. Base Supply. Will stock, issue, and reorder STS spares as determined by utilizing CCDS support (e.g., failure trend analysis). Base supply will provide the interfaces to Air Force Logistics Command (AFLC), AF depots, appropriate vendors, contractors, and KSC line replaceable unit (LRU) repair sections.

2. Base Communications. Will provide the communications support which is normally furnished by the host base (i.e., telephone).

7.3.2.1 CCDS External Interfaces (Cont'd)

3. Airfield. Will provide the standard airfield support (maintenance, tower control, emergency equipment, ILS, TACAN, aircraft maintenance).

4. Photo. Will provide photo support for STS operations.

5. POL. Will provide STS propellents as required.

B. 6th Weather Wing. CCDS will interface with the 6th Weather Wing which will provide meteorological information in support of STS operations from VAFB.

C. Edwards AFB. The CCDS will interface with Edwards AFB which will provide support to STS operations as the alternate landing site.

D. Payload Processing Facility. The CCDS will interface with the Payload Processing Facility (PPF) which will provide payload support during STS ground operations.

E. DOD User Agencies. The CCDS will interface with the DOD user agencies and provide them with vehicle status, payload status, and payload data received from the PPF and launch area during STS ground operations.

F. DOD/KSC. The CCDS will interface with DOD/KSC which will provide the support required for a DOD operation at KSC.

7.4 FLIGHT OPERATIONS

The flight operations phase, extending from liftoff through rollout, will require interfaces with NASA agencies, factory agencies, and Government agencies to provide mission support, coordinate mission flight activities with the other agencies, and receive assistance in resolving flight contingency situations. These interfaces are depicted in figure 7-5.

7.4.1 NASA Agencies. If a contingency of a nature requiring support from NASA should occur during the flight operations phase, appropriate interfaces with NASA must be provided as follows:

A. JSC. The JSC interface will consist of voice and data lines to access STDN (through Goddard Space Flight Center) for

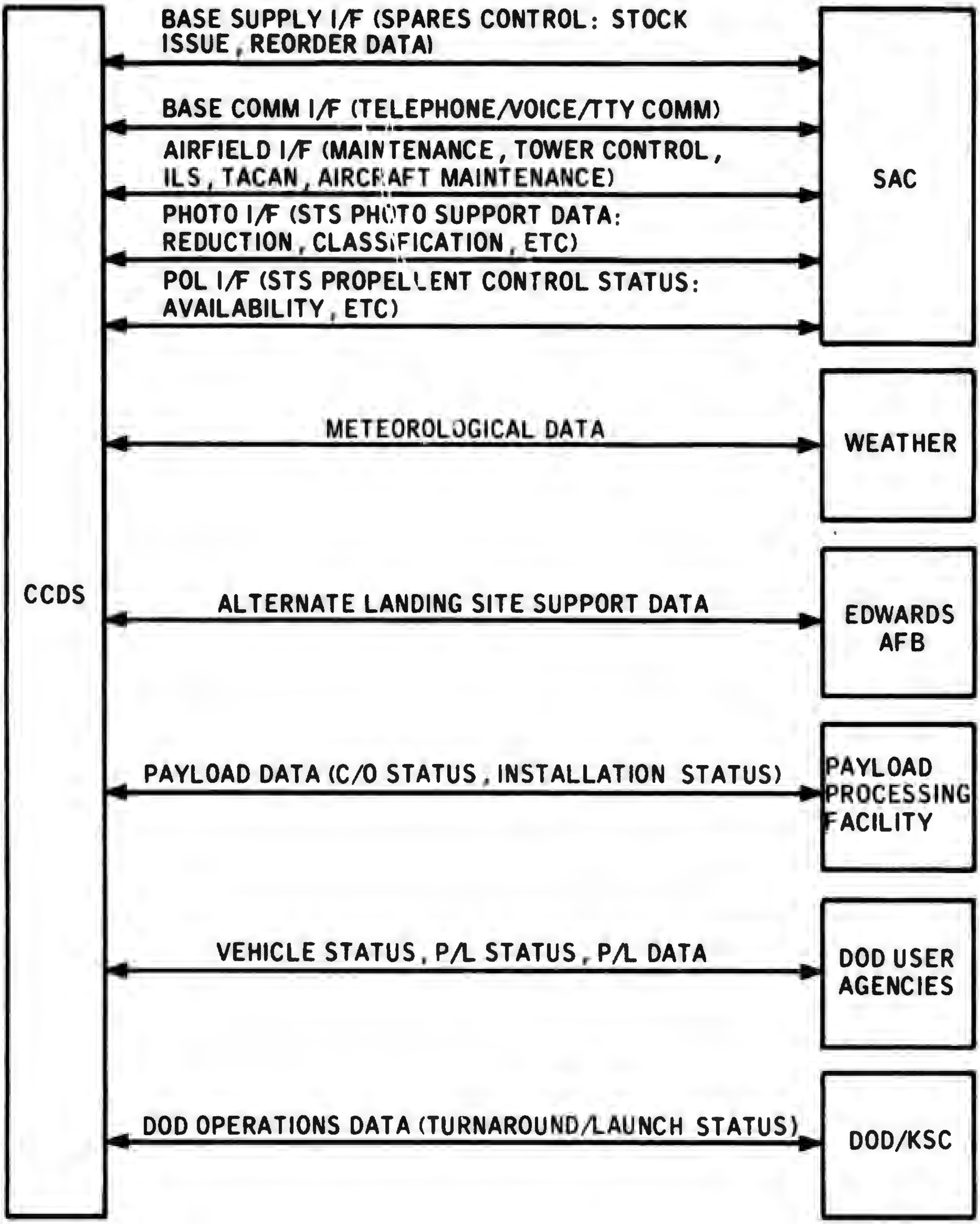


Figure 7-4 CCDS/DOD Agency Interfaces

7.4.1 NASA Agencies (Cont'd)

use of the network in resolving contingency situations. This interface will augment the coverage available from the remote tracking stations (RTS's). When using JSC/STDN augmented coverage, it is assumed that STDN/TDRS tracking and acquisition functions will reside in the JSC computers, while telemetry and command data will be throughput by JSC to the DOD CCDS. This interface with JSC will also provide for the transmission of data to be used in simulating anomalies and evaluating proposed remedies.

Another interface with JSC will consist of access to the SAIL for the purpose of investigating avionics systems problems and anomalies, evaluating proposed modifications, and providing real-time mission data evaluation support.

B. KSC. Interfaces with KSC will be required to communicate with the Orbiter crew during KSC launch and ascent to coordinate abort procedures, to verify onboard systems performance for advising in abort decisions, for coordinating with Range Safety during ascent and, in the event of malfunction, to coordinate landing plans (either upon abort or on normal landing at mission completion), and to coordinate SRB recovery activities.

7.4.2 Government Agencies. Interfaces will be required with the following Government agencies to support STS flight operations.

A. NORAD. Interfaces with NORAD will consist of voice coordination circuits and data lines for transmitting Orbiter and payload trajectory data and receiving advisories of other orbiting objects approximating or intercepting the planned orbits.

B. FAA. Voice interface will be required with FAA for launch and landing air space clearance coordination during normal launches and landing, and for real-time abort planning.

C. NOAA. Interfaces with NOAA will consist of voice and data lines for receipt of weather advisories affecting launch and landing activities, and solar radiation and flare activity reports affecting orbital operations.

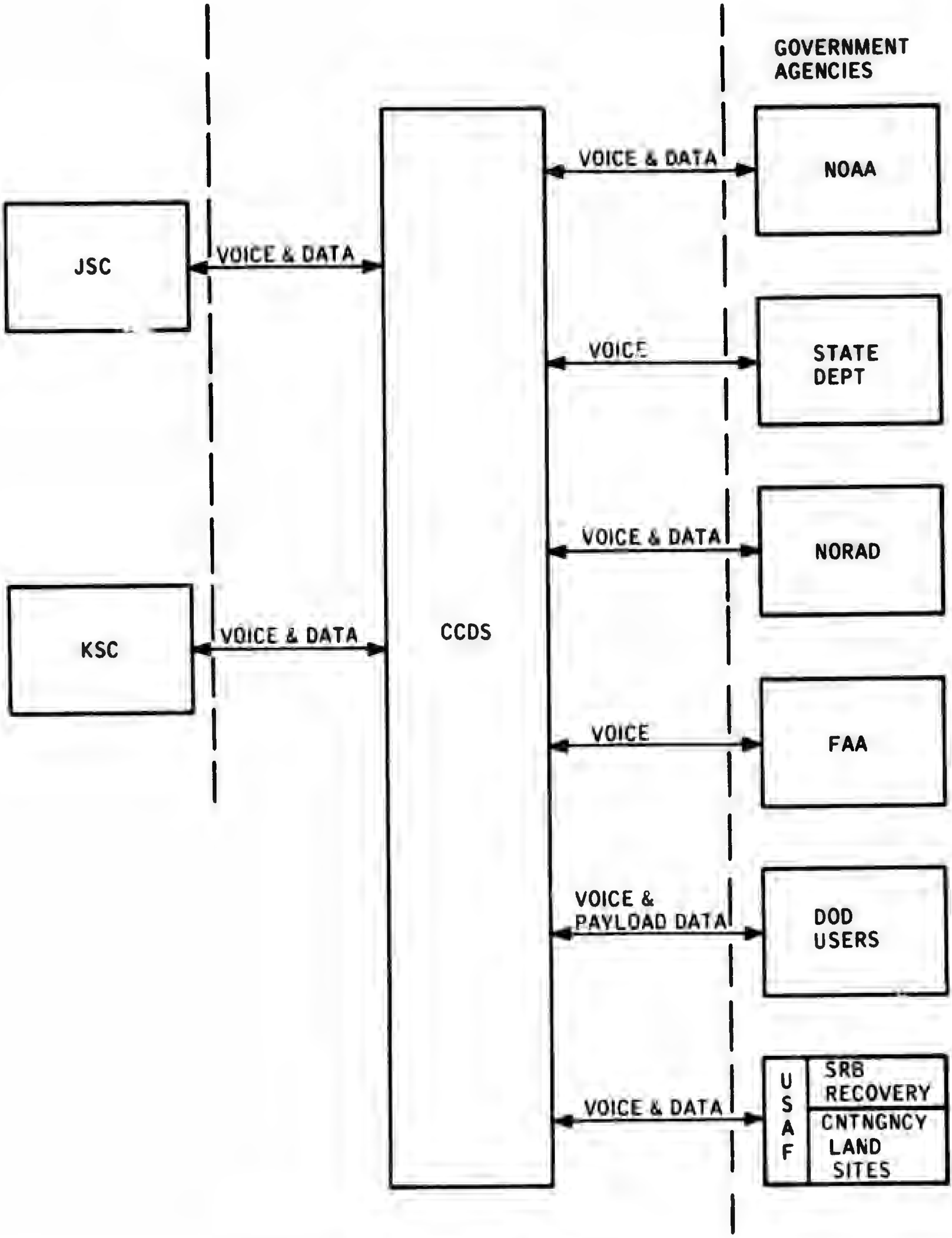


Figure 7-5 External Interfaces - Flight Operations

7.4.2 Government Agencies (Cont'd)

D. State Department. Voice coordination will be required with the State Department for contingency situations in which coordination with foreign powers is necessary.

E. DOD Users. Interfaces to payload users will be required for transmission of secure payload data and voice.

F. USAF (Recovery Operations). Voice coordination and trajectory data circuits will be required with the forces assigned to solid rocket booster (SRB) recovery.

G. USAF (Contingency Landings). Voice coordination will be required with possible landing sites, both to alert contingency sites of an impending landing, and to secure the once-around abort site from standby status.

APPENDIX A

FUNCTIONAL ALLOCATIONS

Appendix A contains a listing of the STS functions and indicates their allocation to the several elements of the STS. They are included in their entirety to:

- Ensure completeness of the operations discussed in the text of the TOR.
- Provide traceability of a CCDS function to a level II NASA/DOD requirement.
- Identify those functions that will not be considered further in subsequent efforts of this study.

The following paragraphs provide an explanation of the columns of the functional allocation sheets that follows.

- Module. An identification of the major function being analyzed.
- Function Number. A numbering of the functions and subfunctions, used as an internal reference identification for purposes of this study.
- Function. A listing of the function and its subfunctions to a level that permitted their allocation.
- Orbiter. An "X" in this column indicates the function has been allocated to the Orbiter.
- OSS/tug. As above, but allocated to the OOS/tug.
- P/L. As above, but allocated to the payload or satellite (excludes OOS/tug).
- Other. An "X" in this column indicates the function was not allocated to any of the above and will not be considered in subsequent efforts of this study.

FUNCTIONAL ALLOCATIONS (CONT'D)

- CCDS. An "X" in this column indicates the function has been allocated to the CCDS, or the CCDS is required to support the function that has been allocated to another element.

- CCDS Function. A restatement of the STS function, requiring ground support to give it specificity to the CCDS.

- Level II Reference. A reference to the NASA/DOD Level II requirements documentation from which the CCDS function can be traced.

- Remarks. Explanatory or supplemental comments as required.

Functional allocation sheets are organized as follows:

- Flight Operations (Orbiter/SRB/ET) - A.1.1 thru A.1.14
- Flight Support - A.1.5
- Abort Modes - A.1.16 thru A.1.21
- Payload Flight Operations - A.1.22 thru A.1.30
- Ground Operations - A.2.1 thru A.2.34
- Operations Support - A.3

MODULE: A.1.1 ASCENT

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.1.1	ENABLE MPS IGNITION SEQUENCE & ARM SRM					X	CONTROL ME AND SRM START CMDS	VOL. X 4.5.7	THROUGHOUT THE ASCENT PHASE THE CCDS WILL PROVIDE FOR MONITORING DOWNLINK DATA & VOICE & PROVIDE VOICE & CMD UPLINK CAPABILITY. ORB WILL OBTAIN ONE-WAY DOPPLER DATA FROM THE UPLINK BASEBAND.
A.1.1.2	XMIT MPS IGNITION COMMAND	X				X	MONITOR EVENT		
A.1.1.3	MONITOR IGNITION & ENGINE PERFORMANCE	X				X	MONITOR EVENT		
A.1.1.5	RETRACT UMBILICAL TOWER					X	MONITOR EVENT		
A.1.1.6	XMIT SRM IGNITION COMMAND					X	MONITOR EVENT		
A.1.1.7	GENERATE LAUNCH COMMIT & MET START SIGNALS	X							
A.1.1.8	PERFORM POWERED FLIGHT NAVIGATION	X				X	MONITOR TRAJECTORY & MAINTAIN VOICE COMM WITH RANGE SAFETY & LANDING FACILITIES		
A.1.1.8.1	COMPUTE & COMMAND VEHICLE PITCH & ROLL MANEUVERS	X				X		DOD RQMTS 3.2.1 4.1.4	
A.1.1.8.2	CONTROL STEERING & THROTTLING TO PROVIDE FOR A 3G LOAD LIMIT FLIGHT	X				X	FOR ABORT COORDINATION		
A.1.1.8.3	PROVIDE ABORT DECISION DATA	X				X	MONITOR EVENT		THESE FUNCTIONS ARE PROVIDED DURING ALL MISSION PHASES THAT OCCUR WITHIN GROUND TRACKING STATION VIEW.
A.1.1.9	DETECT INITIATION OF SRB THRUST DECAY	X				X	MONITOR EVENT		
A.1.1.9.1	ARM SRB SEPARATION & CMD STAGING	X				X	MONITOR EVENT		
A.1.1.9.2	MONITOR SEPARATION & RELATIVE MOTION BETWEEN SRB'S & ORBITER	X				X	MONITOR EVENT		
A.1.1.9.3	ACTIVATE SRB RECOVERY BEACONS	X							ASSUMED AUTOMATICALLY ACTIVATED AT SEPARATION.
A.1.1.9.4	PROVIDE SRB TRAJECTORY & IMPACT POINT DATA					X	GROUND TRACKING BY RANGE & RECOVERY FORCES TO DETERMINE IP	VOL. XVIII 4.6.2	
A.1.1.9.5	SRB DROGUE & MAIN CHUTE DEPLOY								CHUTES ASSUMED DEPLOYED AS A FUNCTION OF ATMOSPHERIC PRESSURE.
A.1.1.9.6	SRB SPLASHDOWN & RECOVERY					X	RECOVERY FORCE FUNCTION	VOL. I 2.13	
A.1.1.10	CONTINUE ORBITER POWERED NAVIGATION								
A.1.1.10.1	CONTINUE MONITORING VEHICLE & PAYLOAD SYSTEMS & LAUNCH PROFILE & PROVIDE ABORT DECISION DATA	X				X	MONITOR SYSTEMS & TRAJECTORY DATA		
A.1.1.11	COMPUTE TIME OF MPS CUTOFF & ISSUE MPS CUTOFF COMMAND	X				X	MONITOR EVENT	DOD RQMTS 3.2.1 4.1.4	
A.1.1.11.1	CONFIGURE ET FOR SEPARATION	X				X	MONITOR IF TRACKING STATION IN VIEW		
A.1.1.11.2	ET SEPARATION & JETTISON	X				X	MONITOR IF TRACKING STATION IN VIEW		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.1 ASCENT (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.1.12	DETERMINE OMS DELTA V REQUIRED	X				X	MONITOR IF TRACKING STATION IN VIEW	DOD RQMTS 3.2.1	
A.1.1.12.1	BURN OMS TO ORBIT	X				X	MONITOR IF TRACKING STATION IN VIEW	4.1.4	

*... FACILITIES, GSE AND SE

MODULE: A.1.2 ORBITAL COAST

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.2.1	PERFORM ORBITAL NAVIGATION	X				X	MAINTAIN VEHICLE EPHEMERIS DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.2.1.1	PREDICT NAVIGATION AIDS, ACQUISITION & CALCULATE VEHICLE ATTITUDE REQUIRED FOR NAVIGATION	X				X	PROVIDE ONE-WAY DOPPLER UPLINK SIGNAL TO VEHICLE	VOL. XIV 5.3.2.4	
A.1.2.1.2	PERFORM REQUIRED ATTITUDE MANEUVERS	X							
A.1.2.1.3	CALIBRATE NAVIGATION SENSORS AS REQUIRED	X				X	PERFORM NAV. SYSTEM TREND ANALYSIS	DOD RQMTS 3.2.1 4.1.4	
A.1.2.3	CONTROL VEHICLE ATTITUDE	X							
A.1.2.4	MAINTAIN COMMUNICATION WITH GROUND, OOS & PAYLOAD AS REQ'D	X				X			
A.1.2.4.1	PERFORM AUTOMATIC SWITCHING OF ALL ANTENNAS	X							
A.1.2.4.2	CALCULATE ACQUISITION & LOSS TIME FOR ALL TARGETS	X				X	CALCULATE AOS AND LOS OF ORBITING VEHICLES	DOD RQMTS 3.2.1 4.1.4	
A.1.2.5	MISSION PLANNING AND/OR TARGETTING FOR THE ORBITER & THE OOS WHEN REQUIRED	X							
A.1.2.5.1	UPDATE MANEUVER PLAN & TARGETS USING LATEST STATE VECTORS & CURRENT VEHICLE CONFIGURATION	X							
A.1.2.5.2	UPDATE CONSUMABLES PREDICTIONS	X				X	MAINTAIN CONSUMABLES DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.2.5.3	GENERATE NEW MISSION PLAN WHEN CONDITIONS WARRANT	X				X	ASSIST IN MISSION PLANNING		
A.1.2.5.4	UPDATE CONTINGENCY DEORBIT PLAN	X				X	MAINTAIN CONTINGENCY DEORBIT DATA	VOL. I 3.10	
A.1.2.5.5	UPDATE EXPERIMENT OPERATION PLAN	X				X	MAINTAIN COGNIZANCE OF EXPERIMENT OPERATION PLAN		
A.1.2.5.6	PREPARE COMMAND LOADS FOR OOS OR PAYLOAD AS REQUIRED & SEND CMDS	X				X	PROVIDE USER COORDINATION AND COMMAND UPLINK CAPABILITY	DOD RQMTS 3.2.1 4.1.4	
A.1.2.5.7	MAIN MASS PROPERTIES INFORMATION	X				X	MAINTAIN STATUS AS AVAILABLE		
A.1.2.6	MONITOR SYSTEMS	X							
A.1.2.6.1	MONITOR VEHICLE SYSTEMS	X				X	PERIODIC SYSTEMS MONITORING		
A.1.2.6.2	MONITOR PAYLOAD SYSTEMS	X				X	PERIODIC PAYLOAD MONITORING	DOD RQMTS 3.2.1 4.1.4	
A.1.2.6.3	MONITOR OOS SYSTEMS	X				X	PERIODIC PAYLOAD MONITORING		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.2 ORIBITAL COAST (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.2.6.4	PERFORM ONBOARD SYSTEMS CHECK-OUT AS REQUIRED	X				X	MONITOR PERIODIC C/O STATUS DATA W/VOICE ADVISORY & CMD CAPABILITY	DOD RQMTS 3.2.1	
A.1.2.7	OPERATE ORBITAL EXPERIMENTS (IF REQUIRED)	X							
A.1.2.7.1	INITIATE EXPERIMENTS (SET-UP OR ACTIVATE)	X				X	VOICE COORDINATION WITH USER	4.1.4	
A.1.2.7.2	MONITOR EXPERIMENTS & EVALUATE RESULTS AS REQUIRED	X				X	PERIODIC MONITORING OF P/L DATA. ASSIST ONBOARD PERSONNEL AS REQ'D		
A.1.2.7.3	INITIATE DATA DUMPS OR RECORDING AS REQUIRED	X				X	RECEIVE & RECORD DATA DUMPS; PROCESS AS REQUIRED	VOL XVIII 5.4.1	
A.1.2.7.4	TERMINATE EXPERIMENTS & STORE EQUIPMENT	X							
A.1.2.8	CONFIGURE VEHICLE SYSTEMS FOR REST PERIOD	X							
A.1.2.9	PREPARE FOR INITIATION OF NEXT PHASE	X							
A.1.2.9.1	PERFORM CHECKLIST SEARCH TO DETERMINE IF ALL SYSTEMS ARE CONFIGURED FOR NEXT PHASE	X							
A.1.2.9.2	INITIATE OOS OR PAYLOAD C/O IF NEXT PHASE IS DEPLOYMENT PHASE	X							
A.1.2.9.3	MANEUVER TO PRE-BURN ATTITUDE IF NEXT PHASE IS MANEUVER	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.3 ORBITAL ADJUST

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.3.1	PREPARE FOR MANEUVERS					X	COORDINATION FOR SCHEDULING	DOD RQMTS 3.2.1 4.1.4	ORBITAL ADJUST IS USED TO CORRECT SHAPE OR ORIENTATION OF AN ORBIT
A.1.3.1.1	INITIATE ORBITAL NAVIGATION	X						↕	
A.1.3.1.2	MONITOR VEHICLE & PAYLOAD SYSTEMS	X				X	MAINTAIN STATUS		
A.1.3.1.3	REALIGN, IF NECESSARY, THE INERTIAL REFERENCE	X							
A.1.3.1.4	MAINTAIN MASS PROPERTIES INFO	X				X	MAINTAIN CONSUMABLES DATA		
A.1.3.1.5	UPDATE MANEUVER PLAN & TARGETS	X							
A.1.3.1.6	PERFORM PRE-THRUST COMPUTATIONS USING NEW TARGETS	X							
A.1.3.1.7	MANEUVER TO DESIRED THRUST ATTITUDE & MAINTAIN THAT ATTITUDE	X							
A.1.3.1.8	DETERMINE IF RCS OR OMS IS REQUIRED FOR EACH MANEUVER	X							
A.1.3.1.9	UPDATE CONTINGENCY DEORBIT PLAN (IF REQUIRED)	X				X	COORDINATE FOR CONTINGENCY DEORBIT		
A.1.3.1.10	PERFORM CHECKOUT SEARCH TO DETERMINE ALL SYSTEMS CONFIGURED FOR NEXT PHASE	X							
A.1.3.1.11	MONITOR VEHICLE & PAYLOAD SYSTEMS DURING MANEUVER	X							
A.1.3.1.12	MONITOR FLIGHT PROFILE	X							
A.1.3.1.13	MAINTAIN MASS PROPERTIES INFORMATION	X				X	MAINTAIN STATUS OF MASS PROPERTIES DATA		
A.1.3.2	PERFORM MANEUVER								
A.1.3.2.1	TERMINATE COASTING FLIGHT NAV.	X							
A.1.3.2.2	INITIATE POWERED FLIGHT NAV.	X							
A.1.3.2.3	PERFORM AUTO G&C OF MANEUVER, ISSUE ENGINE "ON-OFF" COMMANDS	X							
A.1.3.2.4	PERFORM TVC + RCS ATTITUDE CONTROL DURING MANEUVER	X							
A.1.3.2.5	PROVIDE DATA & CONTROL FOR MANUAL BACKUP CONTROL BY CREW	X							
A.1.3.2.6	MONITOR MANEUVER	X						↕	
A.1.3.2.7	MAINTAIN MASS PROPERTIES INFO	X				X	MAINTAIN STATUS OF MASS PROPERTIES DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.3.3	TRIM RESIDUAL V'S								

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.3 ORBITAL ADJUST (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.3.3.1	COMPUTE RESIDUAL DELTA VELOCITIES	X							
A.1.3.3.2	NULL RESIDUAL VELOCITIES (IF REQUIRED)	X							
A.1.3.3.3	TERMINATE POWERED FLIGHT NAV	X						DOD RQMTS 3.2.1	
A.1.3.4	COMPUTE RESULTANT TRAJECTORY	X				X	MAINTAIN VEHICLE EPHEMERIS & COMPUTE NEW TRAJECTORY DATA	4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.4 ORBITAL TRANSFER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.4.1	PREPARE FOR MANEUVERS					X	COORDINATION FOR SCHEDULING	DOD RQMTS 3.2.1 4.1.4	ORBITAL TRANSFER CONSISTS OF TWO OR MORE MANEUVERS & ACCOMPANYING COAST PERIODS TO ACHIEVE DESIRED ORBIT. THE FUNCTIONS LISTED ARE PERFORMED FOR EACH BURN REQUIRED IN THE ORBITAL TRANSFER.
A.1.4.1.1	INITIATE ORBITAL NAV.	X							
A.1.4.1.2	MONITOR VEHICLE & PAYLOAD SYSTEMS	X				X	STATUS MONITORING AS AVAILABLE	DOD RQMTS 3.2.1 4.1.4	
A.1.4.1.3	REALIGN, IF NECESSARY, THE INERTIAL REFERENCE	X							
A.1.4.1.4	MAINTAIN MASS PROPERTIES INFO	X					MAINTAIN STATUS AS AVAILABLE	DOD RQMTS 3.2.1 4.1.4	
A.1.4.1.5	UPDATE MANEUVER PLAN & TARGETS	X							
A.1.4.1.6	PERFORM PRE-THRUST COMPUTATIONS USING NEW TARGETS	X							
A.1.4.1.7	MANEUVER TO DESIRED THRUST ATTITUDE & MAINTAIN THAT ATTITUDE	X							
A.1.4.1.8	UPDATE CONTINGENCY DEORBIT PLAN (AS REQUIRED)	X				X	COORDINATE FOR CONTINGENCY DE-ORBIT	VOL. I 3.10	
A.1.4.1.9	PERFORM CHECKLIST SEARCH TO DETERMINE THAT ALL SYSTEMS PROPERLY CONFIGURED FOR NEXT MANEUVER	X							
A.1.4.2	PERFORM MANEUVER								
A.1.4.2.1	TERMINATE RENDEZVOUS OR COASTING FLIGHT NAVIGATION	X							
A.1.4.2.2	INITIATE POWERED FLIGHT NAVIGATION	X							
A.1.4.2.3	PERFORM AUTO G&C OF MANUEVER, ISSUE ENGINE "ON-OFF" CMDS	X							
A.1.4.2.4	PERFORM TVC & RCS ATTITUDE CONTROL DURING THE MANEUVER	X							
A.1.4.2.5	PROVIDE DATA & CONTROL FOR MANUAL BACKUP CONTROL BY CREW	X							
A.1.4.2.6	MONITOR MANEUVER	X							
A.1.4.3	TRIM RESIDUAL ΔV'S								
A.1.4.3.1	COMPUTE RESIDUAL Δ VELOCITIES	X							
A.1.4.3.2	NULL RESIDUAL VELOCITIES (IF REQUIRED)	X							
A.1.4.3.3	TERMINATE POWERED FLIGHT NAV.	X							
A.1.4.4	COMPUTE RESULTANT TRAJECTORY	X				X	MAINTAIN VEHICLE EPHEMERIS DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.4.5	REPEAT FOR EACH BURN REQUIRED IN THE TRANSFER								

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.5 TERMINAL RENDEZVOUS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.5.1	PREPARE FOR TP1 MANEUVER	X				X	PROVIDE ORBITER WITH TARGETTING INFORMATION AS REQUIRED	VOL. X 3.3.1.1.3	DATA PROVIDED PRIOR TO TPS MANEUVER
A.1.5.1.1	INITIATE RENDEZVOUS NAVIGATION	X							
A.1.5.1.2	MONITOR RELATIVE MOTION BETWEEN TWO VEHICLES	X				X	RENDEZVOUS COORDINATION	DOD RQMTS 3.2.1 4.1.4	
A.1.5.1.3	PERFORM TP1 TARGETTING TO PLACE ORB ON INTERCEPT COURSE W/TARGET	X							
A.1.5.1.4	MONITOR VEHICLE & PAYLOAD SYS	X				X	PERIODIC STATUS AS AVAILABLE	DOD RQMTS 3.2.1 4.1.4	
A.1.5.1.5	REALIGN INTERTIAL REF (IF NEC)	X							
A.1.5.1.6	MANEUVER TO DESIRED THRUST ATTITUDE & MAINTAIN THAT ATTITUDE	X							
A.1.5.1.7	PERFORM CHECKLIST SEARCH TO DETERMINE THAT ALL SYSTEMS ARE CONFIGURED PROPERLY FOR THIS MANEUVER								
A.1.5.2	PERFORM MANEUVER								
A.1.5.2.1	TERMINATE RENDEZVOUS NAVIGATION	X							
A.1.5.2.2	INITIATE POWERED FLIGHT NAV.	X							
A.1.5.2.3	INITIATE GUIDANCE	X				X	MAINTAIN MASS PROPERTIES STATUS	DOD RQMTS 3.2.1 4.1.4	
A.1.5.2.4	PROVIDE DATA & CONTROL FOR MANUAL BACKUP CONTROL BY CREW	X							
A.1.5.2.5	MONITOR MANEUVER	X							
A.1.5.3	TRIM RESIDUAL ΔV'S								
A.1.5.3.1	COMPUTE RESIDUAL Δ VELOCITIES	X							
A.1.5.3.2	NULL RESIDUAL VELOCITIES	X							
A.1.5.3.3	TERMINATE POWERED FLIGHT NAV.	X							
A.1.5.4	TERMINAL PHASE BRAKING MANEUVERS								
A.1.5.4.1	PERFORM TARGETTING COMPUTATIONS REQUIRED TO BRAKE ORBITER INTO A STATION KEEPING POSITION WITH RESPECT TO TARGET	X							
A.1.5.4.2	CONTINUE RENDEZVOUS RELATIVE NAV.	X							
A.1.5.4.3	PERFORM GUID. COMP. & CONTROL RCS BRAKING MAN.	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.5 TERMINAL RENDEZVOUS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							PEMARKS
		ORBI-TER	DOS/TUC	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.5.4.4	PROVIDE BACKUP MANUAL CONTROL OF THE BRAKING MANEUVERS	X							
A.1.5.4.5	CONTINUE TO MONITOR RELATIVE MOTION BETWEEN TWO VEHICLES	Y					COORDINATION (VOICE & DATA) AS AVAILABLE	DOD RQMTS 3.2.1 4.1.4	
A.1.5.4.6	CONTINUE TO MONITOR ORBITER SYSTEMS	X							
A.1.5.4.7	MONITOR TARGET SYSTEMS, IF REQUIRED	X							
A.1.5.4.8	CALCULATE & ISSUE CMDS TO TARGET VEHICLE IF REQUIRED	X				X	PRECONDITION TARGET VEHICLE FOR RENDEZVOUS	VOL. X 3.3.1.1.3	
A.1.5.4.9	TERMINATE POWERED FLIGHT NAV. AT COMPLETION OF BRAKING MANEUVERS	X							
A.1.5.4.10	ACHIEVE STATION KEEPING POSITION	X				X	STATUS COORDINATION	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.6 STATION KEEPING

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	ALLOCATION: OOS/TUG	ALLOCATION: P/L	ALLOCATION: OTHER*	ALLOCATION: CCDS	ALLOCATION: CCDS FUNCTION	ALLOCATION: LEVEL II REFERENCE	REMARKS
A.1.6.1	MAINTAIN STATION KEEPING POSITION					X	COORDINATE WITH ORBITER AS GROUND CONTACT PERMITS	DOD RQMTS 3.2.1 4.1.4	
A.1.6.1.1	INITIATE STATION KEEPING NAVIGATION UTILIZING RADAR, OPTICS, LASER TRACKING SYSTEM	X							
A.1.6.1.2	CONTINUE TO MONITOR VEHICLES & PAYLOAD SYSTEMS					X	PERIODIC SYSTEM MONITORING	DOD RQMTS 3.2.1 4.1.4	
A.1.6.1.3	CONTINUE TO MONITOR TARGET SYSTEMS, IF REQUIRED	X				X	PERIODIC SYSTEM MONITORING		
A.1.6.1.4	MAINTAIN TARGET/ORBITER ATTITUDE RELATION TO RETAIN LINE-OF-SIGHT	X							
A.1.6.1.5	MONITOR RELATIVE MOTION (TARGET/ORBITER)	X							
A.1.6.1.6	PROVIDE DATA FOR MANUAL BACKUP CONTROL OF ALL STATION KEEPING MANEUVERS	X							
A.1.6.1.7	PERFORM AUTOMATIC GUIDANCE & CONTROL	X							
A.1.6.1.8	SEARCH CHECKLIST TO DETERMINE IF ALL SYSTEMS CONFIGURED FOR NEXT PHASE	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.7 DOCKING

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.7.1	TERMINATE STATION KEEPING GUIDANCE	X							NO CURRENT DOD REQUIREMENT FOR DOCKING, BUT BECAUSE OF NASA REQUIREMENT REPRESENTS A CAPABILITY
A.1.7.1.1	COMPUTE MANEUVERS FOR APPROACH CORRIDOR	X							
A.1.7.1.2	CONTINUE MONITORING VEHICLE & TARGET SYSTEMS	X				X	PERIODIC MONITORING DURING TRACKING STATION VIEW PERIODS	DOD RQMTS 3.2.1 4.1.4	
A.1.7.2	PERFORM COMPUTATIONS TO CONTROL ORBITER ATTITUDE WITH RESPECT TO TARGET	X							DOCKING MANEUVERS MAY BE EITHER AUTOMATIC OR MANUAL
A.1.7.2.1	PERFORM AUTOMATIC GUIDANCE & CONTROL OF RCS DOCKING MANEUVERS	X							
A.1.7.2.2	PROVIDE CAPABILITY FOR MANUAL CONTROL OF ALL DOCKING MANEUVERS	X							
A.1.7.2.3	MONITOR RELATIVE MOTION BETWEEN ORBITER & TARGET	X							
A.1.7.3	SENSE SOFT DOCK & MANEUVER TO HARD DOCK	X							
A.1.7.3.1	DAMP DOCKING INDUCED RATES	X							
A.1.7.3.2	PERFORM POST DOCKING CHECKLIST SEARCH	X							
A.1.7.4	INITIATE COASTING FLIGHT NAVIGATION	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: **A.1.8 UNDOCKING**

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.8.1	PERFORM CHECKLIST SRCH TO VERIFY ALL SYS CONFIGURED FOR UNDOCKING	X							NO CURRENT DOD REQUIREMENT FOR UNDOCKING
A.1.8.1.1	INITIATE RELATIVE NAV. UTILIZING RADAR, OPTICS/LASER TRACKING SYS	X							
A.1.8.1.2	REALIGN INERTIAL REFERENCE & COMPUTER UNDOCKING MANEUVERS	X							
A.1.8.1.3	MONITOR VEHICLE SYSTEMS & TARGET VEHICLE SYSTEMS IF REQUIRED	X				X	PERIODIC MONITORING DURING TRACKING STATION VIEW PERIODS	DOD RQMTS 3.2.1 4.1.4	
A.1.8.2	ISSUE UNDOCKING COMMAND	X							
A.1.8.2.1	PERFORM COMPUTATION TO CNTL ORBITER ATTITUDE W/RESPECT TO TGT	X							
A.1.8.2.2	PERFORM AUTOMATIC GUIDANCE & CONTROL OF RCS UNDOCKING MANEUVERS	X							UNDOCKING MANEUVERS MAY BE EITHER AUTOMATIC OR MANUAL
A.1.8.2.3	PROVIDE FOR MANUAL CONTROL OF ALL UNDOCKING MANEUVERS	X							
A.1.8.3	MONITOR RELATIVE MOTION BETWEEN ORBITER & TARGET	X							
A.1.8.3.1	CONTINUE TO MONITOR VEHICLE SYSTEM & TARGET VEHICLE SYSTEM	X				X	PERIODIC MONITORING DURING TRACKING STATION VIEW PERIODS	DOD RQMTS 3.2.1 4.1.4	
A.1.8.3.2	INITIATE STATION KEEPING GUIDANCE	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.9 PAYLOAD DEPLOYMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.9.1	INITIATE COASTING FLIGHT NAVIGATION	X				X	MONITOR WHEN IN VIEW		
A.1.9.2	VERIFY ORBITER & PAYLOAD SYSTEMS ARE CONFIGURED FOR DEPLOYMENT	X		X		X	COORDINATION BETWEEN ORBITER & GROUND (VOICE & DATA)		
A.1.9.3	MAINTAIN REQUIRED VEHICLE ATTITUDE	X						DOD RQMTS 3.2.1 4.1.4 5.5.1.2	
A.1.9.4	PERFORM PAYLOAD ACTIVATION & CHECKOUT	X		X		X	COORDINATION BETWEEN ORBITER & GROUND (VOICE & DATA)		
A.1.9.5	PROVIDE TARGETTING, ALIGNMENT, ATTITUDE & STATE VECTOR DATA TO PAYLOAD	X		X					
A.1.9.6	MONITOR VEHICLE & PAYLOAD SYSTEMS	X		X		X	MONITOR WHEN IN VIEW		
A.1.9.7	OPEN PAYLOAD BAY DOORS	X							IF NOT ALREADY OPEN
A.1.9.8	ACTIVATE & CHECKOUT PAYLOAD MANIPULATOR	X							
A.1.9.9	UNLATCH & EXTRACT PAYLOAD	X							
A.1.9.9.1	CONTINUE MONITORING PAYLOAD SYSTEMS	X		X		X	COORDINATION BETWEEN ORBITER & GROUND	DOD RQMTS 3.2.1 4.1.4 5.5.1.2	
A.1.9.10	ORIENT & RELEASE PAYLOAD	X		X		X	COORDINATION BETWEEN ORBITER & GROUND		
A.1.9.11	INITIATE STATION KEEPING	X							
A.1.9.12	RETRIEVE PAYLOAD MANIPULATOR	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.10 PAYLOAD RETRIEVAL

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.10.1	INITIATE STATION KEEPING	X				X	MONITOR WHEN IN VIEW	DOD RQMTS 3.2.1 4.1.4 5.5.1.2	
A.1.10.2	VERIFY ORBITER & PAYLOAD SYSTEMS ARE CONFIGURED FOR RETRIEVAL	X		X		X	COORDINATION BETWEEN ORBITER & GROUND (VOICE AND DATA)		
A.1.10.3	MAINTAIN ORBITER ATTITUDE AS REQUIRED	X							
A.1.10.4	MONITOR ORBITER & PAYLOAD SYS & EXECUTE REQUIRED RETRIEVAL CMDS	X		X		X	DATA MONITORING & VOICE COORDINATION BETWEEN GROUND & ORBITER	DOD RQMTS 3.2.1 4.1.4 5.5.1.2	
A.1.10.5	OPEN PAYLOAD BAY DOORS	X							IF NOT ALREADY OPEN
A.1.10.6	ACTIVATE & CHECKOUT PAYLOAD MANIPULATOR	X							
A.1.10.7	CAPTURE PAYLOAD & DEACTIVATE PAYLOAD ATTITUDE CONTROL SYSTEM	X							
A.1.10.8	RETRIEVE & LOCK PAYLOAD INTO BAY	X							
A.1.10.9	CONNECT & VERIFY PAYLOAD TO ORBITER SYSTEMS INTERFACE	X		X		X	MONITOR WHEN IN VIEW	DOD RQMTS 3.2.1 4.1.4 5.5.1.2	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.11 DEORBIT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.11.1	INITIATE DEORBIT TARGETING					X	DEORBIT COORDINATION (ONBOARD)	DOD RQMTS 3.2.1 4.1.4	
A.1.11.1.1	CLOSE PAYLOAD BAY DOORS, IF NECESSARY	X							
A.1.11.1.2	SELECT LANDING SITE & CALCULATE LANDING TARGETS	X				X	LANDING SITE COORDINATION	VOL. X 3.3.1.2 3.1.1	
A.1.11.1.3	PERFORM TARGETING TO PROVIDE DESIRED ENTRY CONDITIONS AT ENTRY INTERFACE	X							
A.1.11.1.4	REALIGN INERTIAL REFERENCE IF REQUIRED	X							
A.1.11.1.6	MANEUVER ORBITER TO THRUST ATTITUDE & MAINTAIN	X							
A.1.11.1.7	MONITOR ORBITER SYSTEMS	X				X	MONITOR WHEN IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	
A.1.11.1.8	CHECKLIST SRCH TO VERIFY ALL SYS CONFIGURED FOR DEORBIT MANEUVER	X							
A.1.11.1.9	CHECKOUT THE TVC & AERO SURFACE CONTROL HARDWARE	X							
A.1.11.1.10	DUMP OOS PROPELLANT, IF REQUIRED	X							
A.1.11.1.11	MAINTAIN MASS PROPERTIES INFO	X				X	MAINTAIN STATUS OF MASS PROPERTIES	DOD RQMTS 3.2.1 4.1.4	
A.1.11.2	PERFORM DEORBIT MANEUVER								
A.1.11.2.1	INITIATE POWERED FLIGHT NAVIGATION	X							
A.1.11.2.2	PERFORM AUTOMATIC GUIDANCE & CNTL OF MANEUVERS TO ENSURE SMALL V	X							
A.1.11.2.3	COMMAND ENGINE "ON"	X							
A.1.11.2.4	PERFORM THRUST VECOTR CONTROL DURING MANEUVER	X							
A.1.11.2.5	CALCULATE "TIME-TO-GO" & COMMAND ENGINE "OFF"	X							
A.1.11.2.6	TERMINATE THRUST & POWERED FLIGHT NAVIGATION	X							
A.1.11.2.7	PROVIDE FOR MANUAL CONTROL OF DEORBIT MANEUVERS	X							
A.1.11.2.8	MONITOR ORBIT SYSTEMS	X				X	MONITOR WHEN IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	
A.1.11.2.9	BURNOUT THE RESIDUAL V IF REQUIRED	X							
A.1.11.3	PREPARE FOR REENTRY								
A.1.11.3.1	INITIATE COASTING FLIGHT NAVIGATION	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.11 DEORBIT (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.11.3.2	DEACTIVATE OMS ENGINES	X							
A.1.11.3.3	PROVIDE CAPABILITY TO INCORPORATE GROUND DETERMINED NAV DATA	X				X	PROVIDE DATA & UPLINK CAPABILITY	DOD RQMTS 3.2.1 4.1.4	
A.1.11.3.4	REALIGN INERTIAL REF. UNIT, IF REQUIRED	X							
A.1.11.3.5	UPDATE ENTRY PROFILE & CALCULATE BACKUP GUIDANCE COMMANDS & ENTRY PARAMETERS	X							
A.1.11.3.6	ACCEPT GROUND UPDATES PRIOR TO BLACKOUT	X				X	PROVIDE DATA & UPLINK CAPABILITY	DOD RQMTS 3.2.1 4.1.4	
A.1.11.3.7	ORIENT ORBITER TO CORRECT ATTITUDE	X							
A.1.11.3.8	PERFORM CHECKLIST TO DETERMINE IF ALL SYS CONFIGURED FOR REENTRY	X							
A.1.11.3.9	INITIATE POWERED FLIGHT PRIOR TO ENTRY	X							
A.1.11.3.10	CONTINUE TO MONITOR ORBITER SYSTEMS	X				X	MONITOR WHEN IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.12 ENTRY

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.12.1	ENTRY INTERFACE								
A.1.12.1.1	CONTINUE POWERED FLIGHT NAV	X							
A.1.12.1.2	INITIATE ENTRY GUIDANCE & CONTROL OF ORBITER THROUGHOUT ATMOS ENTRY	X							
A.1.12.1.3	CALCULATE BACKUP CONTROL CMDS FOR CONTINGENCY MANUAL CONTROL	X							
A.1.12.1.4	PROVIDE FOR MANUAL CONTROL OF ENTRY MANEUVERING	X							
A.1.12.1.5	CONTINUE TO MONITOR VEHICLE & PAYLOAD SYSTEM	X				X	MONITOR VEHICLE SYSTEMS	DOD RQMTS 3.2.1 4.1.4	VOICE, DATA & TRACKING
A.1.12.1.6	CONTINUE TO MONITOR ENTRY PRO-FILE	X				X	MONITOR ENTRY TRAJECTORY		
A.1.12.1.7	RETRACT & SECURE RCS WHEN AERO SURFACE COMPLETELY EFFECTIVE	X							
A.1.12.2	ENTER BLACKOUT								
A.1.12.3	EXIT BLACKOUT								
A.1.12.3.1	REESTABLISH VOICE COMMUNICATIONS					X	PROVIDE VOICE COMMUNICATIONS	DOD RQMTS 3.2.1 4.1.4	
A.1.12.4	START TRANSITION								
A.1.12.4.1	CONTINUE POWERED FLIGHT NAV	X							
A.1.12.4.2	CONTROL TRANSITION MANEUVER FROM HIGH ANGLE ATTACK PROFILE TO LOW ANGLE CRUISE PROFILE	X							
A.1.12.4.3	PROVIDE FOR AERODYNAMIC CONTROL OF ORBITER	X							
A.1.12.4.4	CONFIGURE VEHICLE FOR CRUISE (NAV AIDS ON)	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.13 APPROACH

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.13.1	END TRANSITION MANEUVER, BEGIN GLIDE								
A.1.13.1.1	CONTINUE POWERED FLIGHT NAV	X							
A.1.13.1.2	INITIATE AUTONOMOUS CRUISE NAV USING AIRWAYS NAV AIDS & RADAR ALTIMETER	X							
A.1.13.1.3	PERFORM ORBITER GUIDANCE IN CONNECTION WITH GROUND TO ATTAIN APPROACH CORRIDOR	X							
A.1.13.1.4	MONITOR VEHICLE & PAYLOAD SYSTEMS	X				X	MONITOR SYSTEM STATUS	DOD RQMTS 3.2.1 4.1.4	
A.1.13.2	APPROACH FLIGHT								
A.1.13.2.1	CONTINUE AUTONOMOUS NAVIGATION	X							
A.1.13.2.2	PERFORM ENERGY MANAGEMENT TO ASSURE PROPER ATTITUDE UPON LANDING AID ACQUISITION	X							
A.1.13.2.3	PROVIDE AERO SURFACE CONTROL	X							
A.1.13.2.4	PROVIDE MANUAL CONTROL DURING APPROACH	X							
A.1.13.2.5	PROVIDE FLIGHT DATA TO GROUND CONTROLLERS	X				X	PROCESS & ROUTE DATA TO GROUND PERSONNEL		
A.1.13.2.6	MONITOR APPROACH PROFILE & LANDING SYSTEMS	X				X	MONITOR VEHICLE PROFILE & SYSTEMS		
A.1.13.2.7	LANDING CHECKLIST SEARCH TO VERIFY ALL SYSTEMS CONFIGURED FOR LANDING	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.14 FINAL APPROACH & LANDING

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.14.1	FINAL APPROACH								
A.1.14.1.1	COMPLETE LANDING CHECKLIST	X							
A.1.14.1.2	CONTINUE POWERED FLIGHT NAV	X							
A.1.14.1.3	CONTINUE AUTONOMOUS CRUISE NAV USING AIRWAYS NAV AIDS & RADAR ALTIMETER	X							
A.1.14.1.4	INITIATE FINAL APPROACH GUIDANCE USING APPROACH & LANDING SENSORS	X							
A.1.14.1.5	MAINTAIN CONTACT WITH LANDING CONTROLLERS	X				X	MAINTAIN VEHCILE APPROACH PROFILE & VOICE COMMUNICATION	DOD RQMTS 3.2.1 4.1.4	
A.1.14.1.6	PROVIDE AERO SURFACE CONTROL	X							
A.1.14.1.7	PROVIDE MANUAL BACKUP OF FINAL APPROACH & LANDING	X							
A.1.14.2	LOWER LANDING GEAR & FLAPS	X							
A.1.14.2.1	INITIATE LANDING GEAR DEPLOYMENT	X							
A.1.14.2.2	MONITOR APPROACH PROFILE & VEHICLE SYSTEM	X				X	MONITOR APPROACH PROFILE & VEHICLE SYSTEMS	DOD RQMTS 3.2.1 4.1.4	
A.1.14.3	ESTABLISH FINAL APPROACH GLIDE PATH & ANGLE OF ATTACK	X							
A.1.14.4	TOUCHDOWN								
A.1.14.4.1	DEPLOY DRAG CHUTE	X							
A.1.14.4.2	PROVIDE FOR AUTOMATIC NOSE WHEEL STEERING & SPEED BRAKE COMMANDS	X							
A.1.14.4.3	PROVIDE FOR MANUAL NOSE WHEEL STEERING & SPEED BRAKE AS BACKUP	X							
A.1.14.4.4	CONFIGURE FOR SHUTDOWN	X							
A.1.14.5	SHUTDOWN	X							
A.1.14.5.1	POST LANDING CHECKLIST SEARCH TO DETERMINE THAT ALL SYSTEMS ARE SHUTDOWN	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.15 PROVIDE FLIGHT SUPPORT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.15.1	PROVIDE METEOROLOGICAL SUPPORT					X		VOL. 8 INTRO	FLIGHT SUPPORT FUNCTIONS CONSTITUTE A SUMMARY OF THE FUNCTIONS PERFORMED BY THE CCDS FROM LIFTOFF TO LANDING. THE SHUTTLE MODULES FROM LIFTOFF TO LANDING ARE PRESENTED IN MODULES A.1.1 THRU A.1.24
A.1.15.1.1	COORDINATE METEOROLOGICAL SUPPORT					X		VOL. 10 3.2.1.4.1	
A.1.15.1.2	OBTAIN CURRENT & PREDICTED DATA					X			
A.1.15.1.3	SUPPORT LAUNCH SITE, LANDING SITES & FERRY ROUTES					X			
A.1.15.2	PROVIDE VOICE COMMUNICATIONS							VOL. 8 INTRO	
A.1.15.2.1	CONTROL ALL VOICE TRANSMISSION TO ORBITER					X		VOL. 1 2.16	
A.1.15.2.2	MONITOR ALL VOICE TRANSMISSION FROM ORBITER					X		DOD RQMTS 4.4,5.5.1	
A.1.15.2.3	PROVIDE ORBITER WITH PATCHED VOICE LOOPS TO ATC/LANDING SITE/STATION WHEN REQUIRED					X			
A.1.15.3	PROVIDE DATA COMMUNICATIONS								
A.1.15.3.1	PROVIDE VEHICLE CAPABILITY FOR CONTINUOUS RECEIVE/TRANSMIT OF DATA	X							
A.1.15.3.2	PROVIDE GROUND RECEIVE/TRANSMIT OF DATA	X				X		DOD RQMTS 4.4,5.5.1 VOL. 1 2.16	
A.1.15.3.3	PROVIDE MEANS TO RECORD DATA	X				X	RECORD DOWNLINK DATA AS REQUIRED	DOD RQMTS 3.2.1 4.1.4	
A.1.15.4	PROVIDE COORDINATION OF FLIGHT SUPPORT ELEMENTS							VOL. 8 INTRO	
A.1.15.4.1	REPORT MISSION STATUS	X				X	MAINTAIN MISSION STATUS		
A.1.15.4.2	INTERFACE WITH LAUNCH FACILITY					X			
A.1.15.4.3	INTERFACE WITH LANDING SITE					X			
A.1.15.4.4	INTERFACE WITH AF NETWORK					X			
A.1.15.4.5	COORDINATE SCHEDULING WITH OTHER SPACE PROGRAMS					X			
A.1.15.4.6	COORDINATE OPERATIONS OF ALL COMMUNICATIONS					X			
A.1.15.4.7	COORDINATE ALL GROUND SUPPORT COMMUNICATIONS					X			

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.15 PROVIDE FLIGHT SUPPORT (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.15.4.8	SCHEDULE MAJOR FLIGHT SUPPORT FUNCTION					X			
A.1.15.4.9	INTERFACE WITH MISSION CONTROL					X			
A.1.15.5	MONITOR BOOST								
A.1.15.5.1	MONITOR MATED ASCENT	X				X	MONITOR EVENT	VOL. 18 5.3.3	
A.1.15.5.2	MONITOR SRB SEPARATION	X				X	MONITOR EVENT		
A.1.15.5.3	MONITOR ET SEPARATION	X				X	MONITOR EVENT		
A.1.15.6	PROVIDE AIRSPACE INTERFACES							VOL. 10 3.3.1.2.3.1.1	
A.1.15.6.1	COORDINATE AIR TRAFFIC CONTROL							VOL. 8 INTRO	
A.1.15.6.2	PROVIDE FLIGHT PLAN DATA TO FAA					X		VOL. 10 3.4.1.2.5	
								THRU 3.4.11.2.11	
A.1.15.6.3	SUPPORT LAUNCH SITE, LANDING SITES & ENROUTE FERRY ROUTES					X			
A.1.15.7	PROVIDE LANDING AIDS								
A.1.15.7.1	PROVIDE VISUAL AIDS				X				
A.1.15.7.2	PROVIDE ELECTRONIC AIDS				X				
A.1.15.8	SUPPORT MISSION								
A.1.15.8.1	SUPPLY NAVIGATION AIDS					X		VOL. 10 3.3.1.2.3.1.1	
A.1.15.8.2	PROVIDE CONTINGENCY SUPPORT					X		DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.16 ABORT MODE I (CONTINUE ASCENT)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.16.1	ABORT CONDITION DETECTED DURING SRB BURN	X							ALL EVENTS OCCURRING DURING THIS MODE ARE IN VIEW OF GROUND TRACKING FACILITIES. THE CCDS WILL PROVIDE FOR TWO WAY VOICE, TELEMETRY & TRAJECTORY MONITORING THROUGHOUT IN A BACKUP CAPACITY.
A.1.16.1.1	VERIFY PRESENCE OF ABORT CONDITION THROUGH INDEPENDENT MEANS	X							
A.1.16.1.2	ALERT CREW & GROUND PERSONNEL	X				X	ONBOARD/GROUND COORDINATION: ALERT LANDING SITE. EVALUATE SYSTEM & TRAJECTORY DATA.	DOD RQMTS 3.2.1 4.1.4	
A.1.16.1.3	PERFORM AUTOMATIC SAFING FUNCTIONS	X							
A.1.16.1.4	DISPLAY REQUIRED MANUAL SAFING FUNCTIONS FOR CREW RESPONSE	X					COORDINATE & MONITOR	DOD RQMTS 3.2.1 4.1.4	
A.1.16.2	ABORT DECISION	X							
A.1.16.2.1	DETERMINE MODE OF ABORT & COMMAND ABORT	X				X	ONBOARD/GROUND COORDINATION	DOD RQMTS 3.2.1 4.1.4	
A.1.16.2.2	ALERT LANDING SITE					X	ADVISE LANDING SITE OF ABORT		
A.1.16.2.3	INITIATE ABORT GUIDANCE & CNTL	X				X	MONITOR ONBOARD SYSTEM STATUS & TRAJECTORY DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.16.2.4	MONITOR VEHICLE SYSTEMS & ABORT PROFILE	X							
A.1.16.3	SRB THRUST TERMINATION & STAGING	X				X	GROUND TRACKING TO PREDICT SRB IP	DOD RQMTS 3.2.1 4.1.4	
A.1.16.4	UTILIZE AVAILABLE MPS ENGINES TO ACHIEVE DESIRED TRAJECTORY	X							
A.1.16.5	TERMINATE MPS THRUST & COMMAND ET SEPARATION	X				X	PROVIDE ET IMPACT POINT DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.16.6	DUMP OOS PROPELLENTS & SAFE ITS SYSTEM, IF REQUIRED	X	X						
A.1.16.7	PREPARE ORBITER FOR GLIDEBACK	X							
A.1.16.8	CONTINUE TO LANDING SITE UTILIZING NOMINAL END OF MISSION PHASE	X				X	COORDINATION FOR REENTRY & LANDING	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.17 ABORT MODE II (RTLS)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.17.1	AFTER SRB BURNOUT AND SEPARATION AN ABORT CONDITION IS DETECTED INVOLVING LOSS OF THRUST OR CONTROL ON ONE MPS ENGINE	X							SAME AS MODE I
A.1.17.1.1	VERIFY PRESENCE OF ABORT CONDITION THROUGH INDEPENDENT MEANS	X							
A.1.17.1.2	ALERT CREW & GROUND PERSONNEL	X				X	ONBOARD/GROUND COORDINATION; ALERT LANDING SITE, EVALUATE SYSTEM & TRAJECTORY DATA.	DOD RQMTS 3.2.1 4.1.4	
A.1.17.1.3	PERFORM AUTOMATIC SAFING FUNCTIONS	X							
A.1.17.1.4	DISPLAY REQUIRED MANUAL SAFING FUNCTIONS FOR CREW RESPONSE	X				X	COORDINATE & MONITOR	DOD RQMTS 3.2.1 4.1.4	
A.1.17.2	ABORT DECISION	X							
A.1.17.2.1	DETERMINE MODE OF ABORT & COMMAND ABORT	X				X	ONBOARD/GROUND COORDINATION	DOD RQMTS 3.2.1 4.1.4	
A.1.17.2.2	ALERT LANDING SITE					X	ADVISE LANDING SITE OF ABORT		
A.1.17.2.3	INITIATE ABORT GUIDANCE & CNTL	X				X	MONITOR ONBOARD SYSTEMS STATUS & TRAJECTORY DATA	DOD RQMTS 3.2.1 4.1.4	
A.1.17.2.4	MONITOR VEHICLE SYSTEMS & ABORT PROFILE	X							
A.1.17.3	UTILIZE AVAILABLE MPS ENGINES TO ACHIEVE DESIRED TRAJECTORY	X							
A.1.17.4	TERMINATE MPS THRUST & COMMAND ET SEPARATION	X				X	PROVIDE ET IMPACT POINT DATA	DOD RQMTS 3.2.1 & 4.1.4	
A.1.17.5	PREPARE ORBITER FOR GLIDEBACK	X							
A.1.17.6	ᴗONTINUE TO LANDING SITE UTILIZING NOMINAL END OF MISSION PHASE	X				X	COORDINATION FOR REENTRY & LANDING	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.18 MODE III (ONCE-AROUND ABORT-MPS FAILURE)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.18.1	ABORT CONDITION DETECTION (MPS ENGINE FAILURE)	X							
A.1.18.1.1	VERIFY PRESENCE OF ABORT CONDITIONS THROUGH INDEPENDENT MEANS	X							SAME AS MODE V
A.1.18.1.2	ALERT CREW & GROUND PERSONNEL OF ABORT CONDITIONS	X				X	ONBOARD/GROUND COORDINATION; ALERT LANDING SITE IF ABORT OCCURS IN VIEW OF TRACKING STATION	DOD RQMTS 3.2.1 4.1.4	
A.1.18.1.3	PERFORM AUTOMATIC SAFING CONDITIONS	X				X			
A.1.18.1.4	DISPLAY MANUAL SAFING FUNCTIONS FOR CREW RESPONSE	X							
A.1.18.2	ABORT DECISION	X							
A.1.18.2.1	DETERMINE ABORT MODE & COMMAND ABORT	X							
A.1.18.2.2	DETERMINE TARGET FOR ABORT	X							
A.1.18.2.3	INITIATE ABORT GUIDANCE & CNTL	X							
A.1.18.3	MPS CUTOFF	X							
A.1.18.4	FROM THIS POINT THE ORBITER WILL COAST TO AN ENTRY INTERFACE CONDITION & PROCEED WITH NORMAL ENTRY, APPROACH & LANDING SYS	X				X	RECEIVE ORBITER SYSTEMS & TRAJECTORY DATA AT FIRST CONTACT. COORDINATE FOR REENTRY & LANDING	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.19 MODE IV (ABORT TO ORBIT-ATO)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.19.1	DETECT ABORT CONDITION (MPS ENGINE FAILURE)	X							SAME AS MODE V
A.1.19.1.1	VERIFY PRESENCE OF ABORT CONDITIONS THROUGH INDEPENDENT MEANS	X							
A.1.19.1.2	ALERT CREW & GROUND PERSONNEL OF ABORT CONDITIONS	X				X	ONBOARD/GROUND COORDINATION; ALERT LANDING SITE IF ABORT OCCURS IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	
A.1.19.1.3	PERFORM AUTOMATIC SAFING CONDITIONS	X							
A.1.19.1.4	DISPLAY MANUAL SAFING FUNCTIONS FOR CREW RESPONSE	X							
A.1.19.2	ABORT DECISION	X							
A.1.19.2.1	DETERMINE ABORT MODE & COMMAND ABORT	X							
A.1.19.2.2	DETERMINE ADJUSTMENT TO NOMINAL ASCENT TO ACHIEVE NEW INSERTION ORBIT	X							
A.1.19.2.3	INITIATE ABORT GUIDANCE & CNTL	X							
A.1.19.3	MPS CUTOFF	X							
A.1.19.4	TRIM RESIDUAL Δ V'S	X							
A.1.19.5	PREPARE FOR ORBIT OPERATIONS	X				X	COMPUTE ORBITAL PARAMETERS AT EARLIEST CONTACT	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.20 MODE V (ABORT ONCE AROUND-OMS FAILURE)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.20.1	DETECT ABORT CONDITION (OMS FAILURE)	X							ALL EVENTS OCCURRING AFTER APPROXIMATELY 5 MINUTES WILL BE
A.1.20.1.1	VERIFY PRESENCE OF ABORT CONDITION (OMS ENGINE FAILURE)	X							OUT OF STATION VIEW. FIRST CONTACT WILL BE APPROXIMATELY 75
A.1.20.1.2	ALERT CREW & GROUND OF ABORT CONDITION (OMS ENGINE FAILURE)	X				X	ONBOARD/GROUND COORDINATION; ALERT LANDING SITE IF ABORT OCCURS IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	MINUTES WHEN GROUND WILL BE NOTIFIED OF ABORT CONDITION.
									SUBSEQUENTLY, LANDING SITE WILL BE NOTIFIED.
A.1.20.1.3	PERFORM AUTOMATIC SAFING FUNCTIONS	X							
A.1.20.1.4	DISPLAY REQUIRED MANUAL SAFING FOR CREW RESPONSE	X							
A.1.20.2	ABORT DECISION	X							
A.1.20.2.1	DETERMINE ABORT MODE & COMMAND ABORT	X							
A.1.20.2.2	DETERMINE TARGET FOR ONCE AROUND-OMS FAILURE	X							
A.1.20.2.3	INITIATE ABORT GUIDANCE & CNTL	X							
A.1.20.3	OMS ENGINE CUTOFF	X							
A.1.20.4	FROM THIS POINT THE ORBITER WILL COAST TO ENTRY INTERFACE CONDI-	X				X	RECEIVE ORBITER SYSTEMS & TRAJECTORY DATA AT FIRST CONTACT	DOD RQMTS 3.2.1	
	TION & PROCEED WITH NORMAL ENTRY APPROACH & LANDING PHASES					X	EVALUATE SYSTEMS & TRAJECTORY DATA AND ALERT LANDING SITE. COORDINATE & MONITOR THROUGH LANDING	4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.21 MODE VI (MISSION COMPLETION)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.21.1	ABORT CONDITION DETECTION	X							SAME AS MODE V
A.1.21.1.1	VERIFY PRESENCE OF ABORT CONDITION (FAILURE OF ONE MPS ENGINE)	X							
A.1.21.1.2	ALERT CREW & GND PERSONNEL OF ABORT CONDITION (FAILURE OF ONE MPS ENGINE)	X				X	ONBOARD/GROUND COORDINATION; ALERT LANDING SITE IF ABORT CONDITION OCCURS IN STATION VIEW	DOD RQMTS 3.2.1 4.1.4	
A.1.21.1.3	PERFORM AUTOMATIC SAFING FUNCTIONS	X							
A.1.21.1.4	DISPLAY AUTOMATIC SAFING FUNCTIONS FOR CREW RESPONSE	X							
A.1.21.2	ABORT DECISION	X							
A.1.21.2.1	DETERMINE MODE OF ABORT & COMMAND ABORT	X							
A.1.21.2.2	DETERMINE ADJ'MENT TO MPS ENGINE THROTTLES TO ACHIEVE INSERTION	X							
A.1.21.3	MPS CUTOFF & ET SEPARATION	X							
A.1.21.4	DETERMINE OMS ΔV REQUIRED	X							
A.1.21.5	BURN OMS TO ORBIT	X							
A.1.21.6	TRANSMIT STABLE ORBIT CONDITION TO GND AT EARLIEST CONTACT	X				X	RECEIVE ORBITER SYSTEMS & TRAJECTORY DATA. RELEASE LANDING STATION FROM STANDBY STATUS	DOD RQMTS 3.2.1 4.1.4	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.22 PAYLOAD ASCENT OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.1.22.1	MONITOR PAYLOAD SUBSYSTEMS FOR CREW SAFETY HAZARDS	X			X†	X	MONITOR FOR CONTINGENCY SUPPORT	4.1.1	
A.1.22.2	CONTROL PAYLOAD SUBSYSTEMS	X							
A.1.22.3	CONTROL PAYLOAD CONSUMABLES VENTING	X						5.4.4.1 5.4.5	
A.1.22.4	CONTROL PAYLOAD BAY ENVIRONMENT	X						5.4.3	
A.1.22.5	MONITOR PAYLOAD BAY ENVIRONMENT	X			X†	X†	MONITOR FOR CONTINGENCY SUPPORT	5.4.3	
A.1.22.6	MONITOR OOS HEALTH	X				X†	MONITOR FOR CONTINGENCY SUPPORT	4.1.1	
A.1.22.7	MONITOR SATELLITE HEALTH	X			X†	X†	MONITOR FOR CONTINGENCY SUPPORT	4.1.1	
A.1.22.8	MONITOR FLIGHT DYNAMIC FORCES ON OOS	X				X†	MONITOR FOR CONTINGENCY SUPPORT		
A.1.22.9	MONITOR FLIGHT DYNAMIC FORCES ON SATELLITE	X†			X				PRIME EVALUATION FUNCTION PERFORMED BY USER
A.1.22.10	RECEIVE, PROCESS, DISTRIBUTE, DISPLAY & EVALUATE TRANSMITTED OSS DATA					X	DEVELOP DATA BASE FOR OOS UPDATE & CONTINGENCY SUPPORT		
A.1.22.11	RECEIVE & DISTRIBUTE TRANSMITTED SATELLITE DATA					X	RECEIVE & FORWARD RAW RF DATA TO SATELLITE GROUND SYSTEMS		
A.1.22.12	PROCESS, DISPLAY & EVALUATE ALL SATELLITE DATA				X				
A.1.22.13	RECEIVE, PROCESS, DISTRIBUTE, DISPLAY & EVALUATE SATELLITE DATA CRITICAL TO CREW & ORBITER SAFETY				X†	X	PROCESS & EVALUATE SAFETY DATA		
A.1.22.14	ASSURE ALL AREAS RECEIVING PAYLOAD DATA AS REQUIRED					X	MAINTAIN & CONTROL DISTRIBUTION OF PAYLOAD DATA		
A.1.22.15	RECORD ALL DOWNLINK DATA PERTAINING TO PAYLOADS					X	RECORD DATA		
A.1.22.16	CONDUCT PAYLOAD SAFING OPS IN EVENT OF ABORT	X			X†	X†	MONITOR FOR CONTINGENCY SUPPORT & POST-FLIGHT ANALYSES		

*USER OR USER DESIGNER
†MONITOR ONLY

MODULE: A.1.23 PAYLOAD DEPLOYMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.23.1	INITIATE PAYLOAD CHECKOUT TASKS	X							
A.1.23.2	VERIFY PAYLOAD SYSTEMS READINESS FOR DEPLOYMENT	X					RECEIVE DATA FROM ORBITER AS LINE OF SIGHT PERMITS; PROVIDE CONTINGENCY SUPPORT AS REQUIRED		
A.1.23.3	ACTIVATE SATELLITES & OOS; VERIFY STATUS AS REQUIRED	X							
A.1.23.4	PROVIDE UPDATES TO OOS G&N AS REQUIRED	X							
A.1.23.5	OPEN BAY DOORS	X							
A.1.23.6	EXTEND OOS/SATELLITE(S)	X							
A.1.23.7	VERIFY PAYLOAD STABILITY	X							
A.1.23.8	TRANSLATE EOS FROM PAYLOAD	X							
A.1.23.9	INITIALIZE PAYLOAD & VERIFY	X							
A.1.23.10	SECURE MANIPULATOR	X							
A.1.23.11	MONITOR ORBITAL TRANSFER BURN	X							
A.1.23.12	TRANSFER CONTROL TO OOS	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.24 OOS ORBITAL TRANSFER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.24.1	STATE VECTOR UPDATE TO OOS, AS REQUIRED	X							
A.1.24.2	INITIATE OOS SEQUENCER	X							
A.1.24.3	XFER ORBIT ATTITUDE ALIGNMENT	X**	X						ORBITER RELINQUISHES CONTROL AFTER INITIATING SEQUENCER
A.1.24.4	FIRST TRANSFER BURN	X**	X						
A.1.24.5	COAST		X			X**	AS LOS PERMITS		
A.1.24.6	TRACK OOS TRAJECTORY					X	AS LOS PERMITS		
A.1.24.7	MIDCOURSE MANEUVER (ALIGN, BURN, COAST, AS REQUIRED)		X			X**	COMMANDED FROM CCDS		
A.1.24.8	ALIGN FOR APOGEE MANEUVERS		X			X**	AS LOS PERMITS		
A.1.24.9	PLANE CHANGE & CIRCULARIZATION BURN		X			X**	AS LOS PERMITS		
A.1.24.10	ENTER SATELLITE DEPLOYMENT ORBIT		X			X**	AS LOS PERMITS		
A.1.24.11	PREPARE TO DEPLOY SATELLITE		X			X**	AS LOS PERMITS		

*MANUAL, FACILITIES, GSE AND SE
**MONITOR ONLY

MODULE: A.1.25 SINGLE SATELLITE DEPLOYMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.25.1	NAVIGATION & ALIGNMENT PREPARATION FOR DEPLOYMENT		X			X**			
A.1.25.2	MONITOR/CHECK OUT SATELLITE SYSTEMS AS REQUIRED					X			
A.1.25.3	ACTIVATE SATELLITE SYSTEMS AS REQUIRED					X			
A.1.25.4	SATELLITE/LAUNCH PLATFORM SPINUP		X			X**			
A.1.25.5	RELEASE SATELLITE		X			X**			
A.1.25.6	TRANSLATE FROM SATELLITE		X			X**			
A.1.25.7	COMMENCE SATELLITE OPERATIONS					X			
A.1.25.8	OOS ORBITAL TRANSFER (HIGH ALT)		X			X	SEQUENCE INITIALIZATION WILL BE GROUND COMMANDED		EXPENDABLE OOS BURNS TO DEPLETION
A.1.25.9	OOS ORBITAL TRANSFER (LOW ALT)		X				OOS WILL BE PRE-PROGRAMMED		REUSABLE OOS BURN IS PROGRAMMED

*MANUAL, FACILITIES, GSE AND SE
**MONITOR ONLY

MODULE: A.1.26 MULTIPLE SATELLITE DEPLOYMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.26.1	MANEUVER TO REQUIRED ATTITUDE		X						
A.1.26.2	ACTIVATE SATELLITE COMM FOR STATUS CHECK		X			X**	AS LOS PERMITS		
A.1.26.3	VERIFY EACH SATELLITE ABILITY TO OPERATE WITHIN REQUIRED LIMITS			X		X**	LOS TO GROUND MUST OCCUR		
A.1.26.4	PREPARE FOR FIRST DEPLOYMENT		X			X**			
A.1.26.5	RELEASE SATELLITE		X			X**			
A.1.26.6	ATTITUDE ALIGNMENT		X			X**			
A.1.26.7	BURN & COAST		X			X**			
A.1.26.8	PREPARE FOR SECOND DEPLOYMENT (ITERATE STEPS 4 THROUGH 7)		X			X**			
A.1.26.9	COMMENCE SATELLITE OPERATIONS AS EACH DEPLOYMENT OCCURS					X			
A.1.26.10	TRANSLATE FROM FINAL SATELLITE		X			X**			
A.1.26.11	OOS ORBITAL TRANSFER		X			X**			EXPENDABLE OOS

*MANUAL, FACILITIES, GSE AND SE
**MONITOR ONLY

MODULE: A.1.27 REUSABLE OOS ORBITAL TRANSFER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.27.1	STATE VECTOR UPDATE TO OOS					X	UPDATES OOS AS REQUIRED		
A.1.27.2	TRANSFER ORB ATTITUDE ALIGNMENT		X			X**	MONITORS AS LOS PERMITS		
A.1.27.3	TRANSFER BURN		X			X**			
A.1.27.4	TRACK OOS TRAJECTORY					X			
A.1.27.5	MIDCOURSE NAVIGATION UPDATE					X	UPDATES AS REQUIRED, AND AS LOS PERMITS		
A.1.27.6	MIDCOURSE MANEUVER		X			X**			
A.1.27.7	TRACK OOS TRAJECTORY					X			
A.1.27.8	FINAL TRANSFER ORBIT ATTITUDE ADJUSTMENT		X			X**	AS LOS PERMITS		
A.1.27.9	FINAL TRANSFER BURN		X			X**	AS LOS PERMITS		
A.1.27.10	ENTER PARKING ORBIT		X						
A.1.27.11	OOS PASSIVATION FOR RETRIEVAL	X**	X						

*MANUAL, FACILITIES, GSE AND SE
**MONITOR ONLY

MODULE: A.1.28 PAYLOAD/ORBITER RENDEZVOUS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/ T'G	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.28.1	ACTIVATE SEARCH/TRACK EQUIPMENT	X							
A.1.28.2	ACTIVATE OOS BEACON	X	X						
A.1.28.3	ACQUIRE TARGET ON RADAR TRACKER	X					RENDEZVOUS OPERATIONS ARE PERFORMED BY THE ORBITER		ORBITER WILL PROVIDE BACKUP COMMAND CAPABILITY
A.1.28.4	PERFORM RENDEZVOUS SEQUENCE CAL	X					PERIODIC MONITORING & COORDINATION ARE PROVIDED BY CCDS FOR OVERALL MISSION STATUSING & COORDINATION		
A.1.28.5	UPDATE MISSION PLAY FOR RENDEZVOUS	X							
A.1.28.6	RENDEZVOUS ENGINE BURN	X							
A.1.28.7	PERFORM RENDEZVOUS ADJUSTMENT BURN	X							
A.1.28.8	VERIFY OOS SYSTEMS/ATTITUDE CONFIGURED FOR RENDEZVOUS	X							
A.1.28.9	ESTABLISH COMM CONTROL OF OOS	X							
A.1.28.10	PASSIVATE OOS	X							
A.1.28.11	ORIENT OOS ATTITUDE FOR RETRIEVAL	X							
A.1.28.12	SWITCH OOS ACS TO FINE CONTROL	X							
A.1.28.13	COMMENCE STATION KEEPING	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.29 PAYLOAD RETRIEVAL BY ORBITER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.29.1	MAINTAIN STATION KEEPING	X							OOS OR SATELLITE RESPOND TO ORBITER COMMANDS
A.1.29.2	VERIFY SYSTEMS READINESS FOR DOCKING	X	X	X					ORBITER WILL BE PRIME
A.1.29.3	MANEUVER TO DOCKING CORRIDOR	X							
A.1.29.4	CONFIGURE CARGO BAY FOR OPENING	X							
A.1.29.5	OPEN CARGO BAY	X							
A.1.29.6	PERFORM FINAL CLOSURE	X							
A.1.29.7	EXTEND RETRIEVAL MECHANISM	X							
A.1.29.8	CAPTURE TARGET VEHICLE	X							
A.1.29.9	DISABLE PAYLOAD SYSTEMS	X							
A.1.29.10	PURGE/VENT PAYLOAD AS REQUIRED	X							
A.1.29.11	INGEST & SECURE PAYLOAD	X							
A.1.29.12	ESTABLISH CARGO BAY ENVIRONMENT	X							
A.1.29.13	CLOSE BAY DOORS	X							
A.1.29.14	ESTABLISH UMBILICAL CONNECTIONS	X							
A.1.29.15	INITIATE COASTING FLT PROCEDURES	X							

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.1.30 SATELLITE OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.1.30.1	POST-DEPLOYMENT					X			

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.1 POST LANDING & SECURING OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.1.1	POSITION EMERGENCY EQUIPMENT				X	X	MAINTAIN SCHEDULE ADHERENCE, MONITOR TASK FOR SAFETY ASSURANCE	VOL. X 3.4.1.1	PRIMARILY PHYSICAL PLACEMENT OF MECHANICAL EQUIPMENT
A.2.1.2	SECURE ORBITER					X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.1.1	OPS MANAGEMENT ENCOMPASSES PROVISION OF & CONTROL OF ALL CCDS
A.2.1.2.1	INSTALL CHOCKS & ESTABLISH COMM				X				ALLOCATIONS NOTED THROUGH ENTRY A.2.1.2.11
A.2.1.2.2	ESTABLISH PAYLOAD SECURITY				X				
A.2.1.2.3	PERFORM ONBOARD SAFING	X							
A.2.1.2.4	PROVIDE ACCESS				X				
A.2.1.2.5	CONDUCT TPS IR SCAN				X				
A.2.1.2.6	POWER DOWN SUBSYSTEMS	X							
A.2.1.2.7	CONNECT GROUND SERVICES				X				
A.2.1.2.8	DUMP FLIGHT DATA (RF OR HARDWIRE)				X	X	RECEIVE & RECORD ALL DATA DUMPED		
A.2.1.2.8.1	INSTALL GROUND UMBILICAL FOR DATA DUMP				X				NOT REQUIRED FOR RF DUMP
A.2.1.2.8.2	ACTIVATE GROUND RECORDERS					X	ACTIVATE/VERIFY GROUND RECORDERS READY TO RECEIVE DATA		
A.2.1.2.8.3	ACTIVATE PCM/MAINTENANCE RCDR	X							
A.2.1.2.8.4	PLAYBACK DATA	X				X	RECEIVE & RECORD DATA		
A.2.1.2.8.5	DEACTIVATE PCM/MAINTENANCE RCDR	X							
A.2.1.2.8.6	ACTIVATE OFI RECORDER	X							
A.2.1.2.8.7	PLAYBACK DATA	X				X	RECEIVE & RECORD DATA		
A.2.1.2.8.8	DEACTIVATE OFI RECORDER	X							
A.2.1.2.8.9	ACTIVATE WIDEBAND RECORDER	X							
A.2.1.2.8.10	PLAYBACK DATA	X				X	RECEIVE & RECORD DATA		
A.2.1.2.8.11	DEACTIVATE WIDEBAND RECORDER	X							
A.2.1.2.8.12	ACTIVATE PAYLOAD RECORDER	X		X					
A.2.1.2.8.13	PLAYBACK DATA	X		X		X	RECEIVE & RECORD DATA		
A.2.1.2.8.14	DEACTIVATE PAYLOAD RECORDER	X		X					

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.1 POST LANDING & SECURING OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.1.2.9	DEACTIVATE GROUND RECORDERS					X	TURN OFF RECORDERS	VOL. X 3.4.1.1	
A.2.1.2.10	ANALYZE FLIGHT DATA					X	ACCOMPLISH DATA REDUCTION & ANALYSIS OF DATA; NOTIFY OPS MANAGEMENT OF ANY ANOMALIES AFFECTING TURNAROUND OPERATIONS	↓	
A.2.1.2.11	PURGE CLASSIFIED DATA FROM ON-BOARD COMPUTER MEMORY	X				X	INITIATE SOFTWARE PROGRAM FOR DESTRUCTIVE READOUT	↓	REFERENCE PARAGRAPH 5.6
A.2.1.2.12	INSTALL GIMBAL LOCKS				X			↓	
A.2.1.2.13	INSTALL PROTECTIVE COVERS				X			↓	
A.2.1.2.14	EGRESS FLIGHT CREW/INGRESS GROUND CREW				X			↓	
A.2.1.2.15	PREPARE ORBITER FOR TOWING & TOW TO DESERVICING AREA				X			↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.2 DESERVICING OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	ALLOCATION: OOS/TUG	ALLOCATION: P/L	ALLOCATION: OTHER*	ALLOCATION: CCDS	ALLOCATION: CCDS FUNCTION	ALLOCATION: LEVEL II REFERENCE	REMARKS
A.2.2.1	PERFORM POST FLIGHT DESERVICING OPERATIONS						PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.4.1	OPS MANAGEMENT ENCOMPASSES THOSE CCDS FUNCTIONS THROUGH A.2.2.1.19
A.2.2.1.1	PROVIDE DESERVICING AREA SECURITY				X			↓	
A.2.2.1.2	POSITION ORBITER; ESTABLISH ACCESS & APPLY GROUND SERVICES				X	X	ACTIVATE COMMAND, CONTROL, & MONITOR FACILITY SYSTEMS		
A.2.2.1.3	PERFORM PRELIMINARY EXTERIOR INSPECTION				X				
A.2.2.1.4	PERFORM POST FLIGHT ORDNANCE SAFING				X				
A.2.2.1.5	COOL TPS & PURGE COMPARTMENTS					X	COMMAND, CONTROL, & MONITOR PURGE		
A.2.2.1.6	ACTIVATE HAZARDOUS MONITORING					X	ACTIVATE & MONITOR SYSTEM		
A.2.2.1.7	CONNECT DESERVICING LINES				X				
A.2.2.1.8	VENT HIGH PRESSURE GASES					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.9	OFF-LOAD PAYLOAD PROPELLENTS					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.10	PURGE P/L PROPELLENT SYSTEMS					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.11	PURGE OME INJECTOR					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.12	REMOVE OMS, RCS, & APU MODULES				X				THIS FUNCTION OPTIONAL
A.2.2.1.13	DRAIN & PURGE OMS, RCS, & APU PROPELLENT LINES					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.14	DRAIN & PURGE PRSD & FUEL CELLS					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.2.1.15	REMOVE PAYLOAD	X			X				
A.2.2.1.16	DESENSITIZE CRYPTO EQUIPMENT				X				
A.2.2.1.17	RELEASE SECURITY REQUIREMENTS				X				
A.2.2.1.18	REMOVE DESERVICING LINES				X				
A.2.2.1.19	SECURE & REMOVE GND SERVICES				X	X	DEACTIVATE FACILITY SYSTEMS		
A.2.2.1.20	PREPARE ORBITER FOR TOWING				X				
A.2.2.1.21	TOW ORBITER TO MCF				X			↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.1	PREPARE FOR HANGAR OPERATIONS						PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.4.1	OPS MANAGEMENT SUPPORT ENCOMPASSES ALL CCDS FUNCTIONS THROUGH ENTRY A.2.3.9
A.2.3.1.1	CONNECT & ACTIVATE FACILITY SYS				X	X	ACTIVATE GROUND SUPPORT SYSTEMS	↓	
A.2.3.1.2	OPEN PAYLOAD BAY DOORS	X			X				
A.2.3.1.3	REMOVE FERRY KIT (IF INSTALLED)				X				IF PIGGY-BACK CONFIGURATION HAS KIT
A.2.3.1.4	PERFORM INSPECTIONS				X				
A.2.3.1.5	PERFORM TPS INSPECTION/REPAIR				X				
A.2.3.1.6	REMOVE PASSIVE EQUIPMENT				X				
A.2.3.2	PERFORM POST FLIGHT ANOMALY CHECKOUT								MAY BE DISCONTINUED AS SYSTEM BECOMES OPERATIONAL
A.2.3.2.1	PERFORM HYD PREPOWER CHECK	X							
A.2.3.2.2	VERIFY HYD POWER SOURCE CONNECTED				X				
A.2.3.2.3	ACTIVATE HYD SYSTEM	X				X	ACTIVATE GROUND HYDRAULIC SYSTEM		
A.2.3.2.4	INSPECT FOR HYD SYSTEM LEAKS				X				
A.2.3.2.5	PERFORM HYD LRU FUNCTIONAL CHECKS	X				X	CHECK SYSTEM TO LRU LEVEL		
A.2.3.2.6	DEACTIVATE HYD SYSTEMS	X				X	DEACTIVATE GROUND HYD SYSTEMS		
A.2.3.2.7	PERFORM HYD POWER SHUTDOWN CHECKS	X							
A.2.3.2.8	INSTALL ET/ORB FLUID CHECKOUT COVERS				X				
A.2.3.2.9	PRESSURIZE MPS DUCTING					X	COMMAND, CONTROL, & MONITOR PRESSURES		
A.2.3.2.10	LEAK CHECK ET/ORBITER FLUID INTERFACES				X				
A.2.3.2.11	LEAK CHECK AFT UMBILICAL MPS INTERFACE VALVES				X				
A.2.3.2.12	CHECK ET PRESSURE CONTROL SETTING	X				X	MONITOR CHECKOUT		
A.2.3.2.13	HELIUM SYSTEM GROSS LEAK CHECK	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.14	ET PRESSURE CHECK VALVE VERIFICATION	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.15	REMOVE SSME-TVC LOCKS				X				
A.2.3.2.16	REMOVE ET/ORBITER FLUID CHECKOUT COVER				X			↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.2	PERFORM POST FLIGHT ANOMALY CHECKOUT (CONT'D)							VOL. X 3.4.4.1	
A.2.3.2.17	INSTALL ET/ORBITER FLUID INTERFACE COVERS				X			↓	
A.2.3.2.18	CHECK PREVALVES RELIEF PRESSURE					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.19	ACTIVATE C&T SUBSYSTEM	X				X	ACTIVATE C&T GROUND SYSTEM		
A.2.3.2.20	PERFORM SYSTEM CHECKOUT & FAULT ISOLATION	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.21	DEACTIVATE C&T SUBSYSTEM	X				X	DEACTIVATE GROUND SYSTEM		
A.2.3.2.22	ACTIVATE EPD&C SYSTEM	X				X	ACTIVATE EPD&C GROUND SYSTEM		
A.2.3.2.23	PERFORM SYSTEM CHECKOUT & FAULT ISOLATION	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.24	PERFORM CHECKOUT & FAULT ISOLATE SEQUENCER	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.25	ACTIVATE PRIMARY GN&CS	X				X	MONITOR SYSTEM		
A.2.3.2.26	ACTIVATE BACKUP GN&CS	X				X	MONITOR SYSTEM		
A.2.3.2.27	ACTIVATE ASAS	X				X	MONITOR SYSTEM		
A.2.3.2.28	PERFORM GN&CS CHECKOUT & FAULT ISOLATION	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.29	DEACTIVATE GN&CS	X				X			
A.2.3.2.30	ACTIVATE INSTRUMENTATION SYS	X							
A.2.3.2.31	PERFORM CHECKOUT & FAULT ISOLATION	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.32	DEACTIVATE INSTRUMENTATION SYSTEM	X							
A.2.3.2.33	PERFORM ABSORPTION & EMISSION CHECKOUT S RAD	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.34	ACTIVATE HYD SYSTEM	X				X	ACTIVATE GROUND HYDRAULIC SYSTEM		
A.2.3.2.35	ISOLATE EXTERNAL LEAK SOURCE				X				
A.2.3.2.36	CHECK LRU INTERNAL LEAK RATE	X				X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.37	VERIFY LRU ACTUATOR RATE					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.3.2.38	DEACTIVATE HYD SYSTEM	X				X	DEACTIVATE GROUND HYDRAULIC SYSTEM		
A.2.3.2.39	SSME AUTO CHECKOUTS	X				X	MONITOR SYSTEM CHECKOUT	↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.2	PERFORM POST FLIGHT ANOMALY CHECKOUT (CONT'D)							VOL. X 3.4.4.1	
A.2.3.2.40	CHECK OUT MPS VALVES ACTUATING TIMES	X				X	MONITOR SYSTEM CHECKOUT	↓	
A.2.3.2.41	CHECK HELIUM REGULATION SYS	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.42	CRITICAL CHANNELS READOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.43	VERIFY/CLEAR SSME AREA				X				
A.2.3.2.44	CHECK MPS TVC SYSTEM	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.45	POSITION & SECURE SSME - MAINT				X				
A.2.3.2.46	CHECK OUT FUEL CELL POWER PLANTS	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.47	CHECK OUT FUEL CELL COOLING SYSTEM	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.48	CHECK FUEL CELL CONDENSER REMOVAL	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.49	CHECK OUT PRSD	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.2.50	AMBIENT CHECKOUT OF INSTRU-MENTATION	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.3	ACTIVATE HYD SYSTEM	X				X	ACTIVATE GROUND HYDRAULIC SYSTEM		
A.2.3.4	LEAK CHECK LANDING GEAR SYSTEM				X				
A.2.3.5	DEACTIVATE HYD SYSTEM	X				X	DEACTIVATE GROUND HYDRAULIC SYS		
A.2.3.6	PRESSURIZE MPS DUCT					X	COMMAND, CONTROL, & MONITOR SYS		
A.2.3.7	PRESSURIZE DOWNSTREAM SSME MAIN VALVE					X	COMMAND, CONTROL, & MONITOR SYS		
A.2.3.8	LEAK CHECK SYSTEM				X				
A.2.3.9	VENT OFF PRESSURE					X	INITIATE VENTING COMMAND		
A.2.3.10	INSTALL OMS DELTA V TANK KIT (IF REQUIRED)				X				NASA PAYLOADS WOULD BE INSTALLED HERE
A.2.3.11	CLOSE PAYLOAD BAY DOORS	X			X				
A.2.3.12	PERFORM SERVICING OF SYSTEMS				X				
A.2.3.13	PERFORM CORRECTIVE MAINTENANCE & MODS				X				
A.2.3.14	INSTALL PASSIVE EQUIPMENT				X			↓	

*MANUAL, FACILITIES, GSE AND SF

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.15	INSTALL HYPERGOL MODULES (IF REMOVED)				X			VOL. X 3.4.4.1	
A.2.3.16	PERFORM PREMATE CHECKOUT							↓	
A.2.3.16.1	POWER UP AUDIO SYSTEMS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.2	POWER UP VHF SYSTEMS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.3	POWER UP S-BAND SYSTEMS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.4	POWER UP L-BAND SYSTEMS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.5	POWER UP C-BAND SYSTEMS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.6	ACTIVATE COMPUTERS	X				X	ACTIVATE GROUND COMPUTERS	↓	
A.2.3.16.7	VERIFY ORBITER POWER ON	X				X	MONITOR SYSTEM	↓	
A.2.3.16.8	ACTIVATE PRIMARY GN&CS	X				X	MONITOR SYSTEM	↓	
A.2.3.16.9	ACTIVATE BACKUP GN&CS	X				X	MONITOR SYSTEM	↓	
A.2.3.16.10	ACTIVATE ASAS	X				X	MONITOR SYSTEM	↓	
A.2.3.16.11	POWER UP INSTRUMENTATION SYS	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.12	POWER UP MPS ELECTRICAL	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.13	POWER UP MPS INSTRUMENTATION	X				X	POWER UP GROUND SYSTEM	↓	
A.2.3.16.14	VERIFY SSME COMPUTER SELF CHECK	X				X	MONITOR OPERATION	↓	
A.2.3.16.15	POWER UP HYD - REMOVE TVC LOCK	X			X	X	MONITOR OPERATION	↓	
A.2.3.16.16	VERIFY He REGULATOR PRESSURE	X				X	MONITOR OPERATION	↓	
A.2.3.16.17	VERIFY SSME PURGE PRESSURE (GN2)	X				X	MONITOR OPERATION	↓	
A.2.3.16.18	VERIFY MPS VALVE POSITION	X				X	MONITOR OPERATION	↓	
A.2.3.16.19	VERIFY ac/dc BUSES ON	X				X	MONITOR OPERATION	↓	
A.2.3.16.20	CHECK OUT ALL EPD&C FUNCTIONS	X				X	MONITOR SYSTEM CHECKOUT	↓	
A.2.3.16.21	VERIFY CAUTION & WARNING	X				X	MONITOR SYSTEM CHECKOUT	↓	
A.2.3.16.22	PERFORM UMBILICAL I/F CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT	↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.16.23	CONNECT INITIATOR SIMULATOR				X			VOL. X 3.4.4.1	
A.2.3.16.24	VERIFY ORDNANCE SEQUENCER	X				X	MONITOR SYSTEM CHECKOUT	↓	
A.2.3.16.25	POWER ON - STRAY VOLTAGE C/O	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.26	DISCONNECT ORDNANCE INITIATOR SIMULATOR				X				
A.2.3.16.27	POWER DOWN VEHICLE SYSTEM	X							
A.2.3.16.28	POWER DOWN EPD&C	X							
A.2.3.16.29	LOAD GN&CS SOFTWARE	X				X	LOAD GN&CS SOFTWARE INTO ONBOARD COMPUTER		
A.2.3.16.30	LOAD & VERIFY ALL SYS SOFTWARE	X				X	LOAD SOFTWARE INTO ONBOARD SYSTEMS		
A.2.3.16.31	PERFORM PRIMARY GN&C CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.32	PERFORM BACKUP GN&C CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.33	PERFORM ASAS CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.34	CONDUCT SSME AUTOMATIC C/O	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.35	FUNCTIONAL CHECK ALL REPLACED LRU'S	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.36	VERIFY SSME ALIGNMENT (IF REQUIRED)				X				
A.2.3.16.37	RUN SSME CLEARANCE CHECKS	X			X	X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.38	CONDUCT SSME I/F LEAK CHECKS				X				
A.2.3.16.39	CHECK OUT REPLACED SSME	X				X	MONITOR CHECKOUT SYSTEM		
A.2.3.16.40	VERIFY REDUNDANT HEATERS	X				X	MONITOR CHECKOUT SYSTEM		
A.2.3.16.41	VERIFY REDUNDANT THERMAL CNTLS	X				X	MONITOR CHECKOUT SYSTEM		
A.2.3.16.42	PERFORM COMPUTER I/F CHECKOUT	X				X	MONITOR CHECKOUT SYSTEM		
A.2.3.16.43	PERFORM INSTRUMENTATION SUBSYSTEM CHECKOUT	X				X	MONITOR CHECKOUT SYSTEM		
A.2.3.16.44	PERFORM AUDIO CHECKOUT	X				X	PROVIDE SUPPORT FOR SYSTEM C/O		
A.2.3.16.45	PERFORM VHF CHECKOUT	X				X	PROVIDE SUPPORT FOR SYSTEM C/O		
A.2.3.16.46	PERFORM S-BAND CHECKOUT	X				X	PROVIDE SUPPORT FOR SYSTEM C/O	↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.16.47	PERFORM L-BAND CHECKOUT	X				X	PROVIDE SUPPORT FOR SYSTEM C/O	VOL. X 3.4.4.1	
A.2.3.16.48	PERFORM C-BAND CHECKOUT	X				X	PROVIDE SUPPORT FOR SYSTEM C/O	↓	
A.2.3.16.49	VERIFY R/h & L/h UMBILICAL DOOR ACTUATORS	X							
A.2.3.16.50	VERIFY REDUNDANT PRESSURE FUNCTION	X				X	PROVIDE SYSTEMS CHECKOUT SUPPORT		
A.2.3.16.51	VERIFY REDUNDANT ELECTRICAL FUNCTION	X				X	PROVIDE SYSTEMS CHECKOUT SUPPORT		
A.2.3.16.52	ANALYZE MPS CHECKOUT DATA					X	ANALYZE MPS CHECKOUT DATA		
A.2.3.16.53	DEACTIVATE COMPUTER SYSTEM	X				X	MONITOR DEACTIVATION		
A.2.3.16.54	DEACTIVATE COMPUTERS	X				X	MONITOR DEACTIVATION		
A.2.3.16.55	VERIFY VEHICLE & SUPPORT EQUIPMENT	X			X	X	VERIFY SYSTEMS		
A.2.3.16.56	DEACTIVATE GN&CS	X							
A.2.3.16.57	DEACTIVATE INSTRUMENTATION SYS	X							
A.2.3.16.58	SECURE ENGINES FROM MOVEMENT				X				
A.2.3.16.59	REMOVE MPS HYD PRESSURE	X				X	DEACTIVATE GROUND HYD SYSTEM		
A.2.3.16.60	POWER DOWN MPS ELECTRICAL SYS	X				X	DEACTIVATE GROUND MPS ELECT SYS		
A.2.3.16.61	POWER DOWN MPS INSTRUMENTATION	X				X	DEACTIVATE GROUND MPS INST SYSTEM		
A.2.3.16.62	POWER DOWN SUPPORTING GSE					X	POWER DOWN SELECTED GROUND SYS		
A.2.3.16.63	AMBIENT INSTRUMENTATION C/O	X							
A.2.3.16.64	PRSD VALVE CYCLE CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.65	PRSD QUANTITY GAUGING	X							
A.2.3.16.66	FUEL CELL START/SHUTDOWN SEQUENCE CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.67	FUEL CELL COOLING CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.68	PRSD HEATER CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.16.69	FUEL CELL CONDENSATE CHECKOUT	X				X	MONITOR SYSTEM CHECKOUT		
A.2.3.17	SECURE FROM HANGAR OPERATIONS				X			↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.3 HANGAR OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.3.17.1	DEACTIVATE GROUND SERVICES				X	X	DEACTIVATE GROUND SUPPORT SYSTEMS	VOL. X 3.4.4.1	
A.2.3.17.2	DISCONNECT GROUND SERVICES				X	X	MONITOR ACTIVITY SCHEDULES	↓	
A.2.3.18	PREPARE ORBITER FOR TOWING	X			X	X	MONITOR ACTIVITY SCHEDULES	↓	
A.2.3.19	TOW ORBITER TO ASSEMBLY AREA				X	X	MONITOR ACTIVITY SCHEDULES	↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.4 OFF LINE OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.4.1	PREPARE SRB'S FOR ASSEMBLY				X	X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.8.1	OFF-LINE OPERATIONS ARE THOSE OPERATIONS INVOLVING STS ELEMENTS BEING PROPOSED OUTSIDE THE ORBITER FLOW
							PROVIDE COMMAND, CONTROL, & MONITOR TVC & NOZZLE LEAK & FUNCTIONAL TESTS		
A.2.4.2	PREPARE ET FOR MATING				X	X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.7.1	
							PROVIDE COMMAND, CONTROL, & MONITOR TVC & NOZZLE LEAK & FUNCTIONAL TESTS		
A.2.4.3	HYPERGOL OPERATIONS						PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.11.1	OPS MANAGEMENT ENCOMPASSES CNTL OF ALL FUNCTIONS THROUGH ENTRY A.2.4.3.72
A.2.4.3.1	HAZARD VAPOR MONITOR					X	ACTIVATE VAPOR MONITORING SYSTEM & MONITOR OPERATIONS		
A.2.4.3.2	INSPECT OMS LEFT + RIGHT NDT				X				
A.2.4.3.3	INTEGRITY CHECK - INSTRUMENTATION					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.4	INTEGRITY CHECK - ENGINES					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.5	INTEGRITY CHECK - VALVE MODS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.6	INTEGRITY CHECK - TANKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.7	INTEGRITY CHECK - THERMAL CNTL					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.8	PROPELLENT HANDLING DE-TANK NTO					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.9	PROPELLENT HANDLING FLUSH NTO					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.10	PROPELLENT HANDLING PURGE NTO					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.11	PROPELLENT HANDLING DRYING NTO					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.12	DRYNESS SAMPLING					X	SAMPLE SYSTEM		
A.2.4.3.13	PROPELLENT HANDLING DE-TANK MMH					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.14	PROPELLENT HANDLING FLUSH MMH					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.15	PROPELLENT HANDLING PURGE MMH					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.16	PROPELLENT HANDLING DRYING MMH					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.17	DRYNESS SAMPLING MMH, ISOP ALKY					X	SAMPLE SYSTEM		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.4 OFF LINE OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.4.3.18	CORRECTIVE MAINTENANCE RETEST					X	COMMAND, CONTROL, & MONITOR RETEST	VOL. X 3.4.11.1	
A.2.4.3.19	EXTERNAL LEAK CHECKS				X			↓	
A.2.4.3.20	ELECTRICAL CHECKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.21	PROPELLENT HANDLING LOAD NTO					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.22	PROPELLENT HANDLING LOAD MMH					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4 3.23	DEMATE OMS/RCS ELECT AFT R				X				
A.2.4.3.24	DEMATE OMS/RCS STRUC AFT R				X				
A.2.4.3.25	DEMATE OMS/RCS ELECT AFT L				X				
A.2.4.3.26	DEMATE OMS/RCS STRUC AFT L				X				
A.2.4.3.27	REMOVE RCS FROM OMS LEFT				X				
A.2.4.3.28	REMOVE RCS FROM OMS RIGHT				X				
A.2.4.3.29	POSITION AFT L RCS FOR S/M/CO				X				
A.2.4.3.30	POSITION AFT R RCS FOR S/M/CO				X				
A.2.4.3.31	POSITION FWD RCS FOR S/M/CO				X				
A.2.4.3.32	INSPECT SYS - NON-DESTRUCTIVE				X				
A.2.4.3.33	INTEGRITY CHECK - INSTRUMENTATION					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.34	INTEGRITY CHECK - ENGINES					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.35	INTEGRITY CHECK - VALVE MODS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.36	INTEGRITY CHECK - TANKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.37	INTEGRITY CHECK - THERMAL CNTL					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.38	PROPELLENT HANDLING DE-TANK HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.39	PROPELLENT HANDLING FLUSH HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.40	PROPELLENT HANDLING PURGE GN2					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.41	PROPELLENT HANDLING DRYING GN2					X	COMMAND, CONTROL, & MONITOR OPS	↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.4 OFF LINE OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.4.3.42	DRYNESS SAMPLING					X	PERFORM SAMPLE	VOL. X 3.4.11.1	
A.2.4.3.43	EXTERNAL LEAK CHECKS				X				
A.2.4.3.44	ELECTRICAL CHECKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.45	CORRECTIVE MAINTENANCE				X				
A.2.4.3.46	CORRECTIVE MAINTENANCE RETEST					X	COMMAND, CONTROL, & MONITOR RETEST		
A.2.4.3.47	PROPELLENT HANDLING LOAD HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.48	SERVICE OMS ENGINE GN2 BOTTLE LFT					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.49	SERVICE OMS ENGINE GN2 BOTTLE RT					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.50	MATE RCS TO OMS STRUCTURAL L				X				
A.2.4.3.51	MATE RCS TO OMS ELECTRICAL L				X				
A.2.4.3.52	MATE RCS TO OMS STRUCTURAL R				X				
A.2.4.3.53	MATE RCS TO OMS ELECTRICAL R				X				
A.2.4.3.54	ELEC I/F CU PATH TEST					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.55	POSITION L APU FOR S/M/CO				X				
A.2.4.3.56	POSITION R APU FOR S/M/CO				X				
A.2.4.3.57	APU L + R DOOR INSPECTION				X				
A.2.4.3.58	INTEGRITY CHECK - INSTRUMENTATION					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.59	INTEGRITY CHECK - VALVE MODS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.60	INTEGRITY CHECK - TANKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.61	INTEGRITY CHECK - THERMAL CNTL					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.62	PROPELLENT HANDLING DE-TANK HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.63	PROPELLENT HANDLING FLUSH HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.64	PROPELLENT HANDLING PURGE GN2					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.65	PROPELLENT HANDLING DRYING GN2					X	COMMAND, CONTROL, & MONITOR OPS		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.4 OFF LINE OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.4.3.66	DRYNESS SAMPLING					X	PERFORM SAMPLE	VOL. X 3.4.11.1	
A.2.4.3.67	EXTERNAL LEAK CHECKS				X				
A.2.4.3.68	ELECTRICAL CHECKS					X	COMMAND, CONTROL, & MONITOR C/O		
A.2.4.3.69	CORRECTIVE MAINTENANCE				X				
A.2.4.3.70	CORRECTIVE MAINTENANCE RETEST					X	COMMAND, CONTROL, & MONITOR RETEST		
A.2.4.3.71	PROPELLENT HANDLING LOAD HZN					X	COMMAND, CONTROL, & MONITOR OPS		
A.2.4.3.72	REMOVE SERVICE EQUIPMENT/ CLOSEOUT				X				

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.5 VEHICLE ASSEMBLY

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.5.1	PREP FACILITIES/SE FOR MATING				X	X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.5.1 ↓	OPS MANAGEMENT ENCOMPASSES ALL CCDS FUNCTIONS THROUGH ENTRY A.2.5.8
							PROVIDE COMMAND, CONTROL, & MONITOR SYSTEMS VERIFICATION		
A.2.5.2	ASSEMBLE SRB'S ON MLP				X				
A.2.5.3	MATE ET TO SRB'S				X				
A.2.5.4	PREPARE ORBITER & MATE TO ET	X			X				
A.2.5.5	CONNECT & INSPECT MLP/SRB/ET/ORBITER INTERFACES				X				
A.2.5.5.1	LEAK CHECK INTERFACES				X				
A.2.5.6	PERFORM POST MATE STS INTERFACE VERIFICATION								
A.2.5.6.1	ACTIVATE GROUND SUPPORT SYS					X	PROVIDE COMMAND, CONTROL, & MONITOR GROUND SYSTEMS		
A.2.5.6.2	PERFORM PREPOWER SWITCH CHECKLIST	X							
A.2.5.6.3	VERIFY ECLSS COOLING TO ORB					X	VERIFY GROUND SYSTEM ACTIVATED		
A.2.5.6.4	ACTIVATE ORBITER POWER	X							
A.2.5.6.5	INITIATE GROUND COOLING TO ORB					X	ACTIVATE GROUND SYSTEM		
A.2.5.6.6	ACTIVATE AUDIO SYSTEM (C&T)	X				X	ACTIVATE GROUND SYSTEM		
A.2.5.6.7	ACTIVATE COMPUTER FOR MONITOR & DISPLAY	X				X	VERIFY COMPUTER ACTUATION		
A.2.5.6.8	POWER UP ac/dc BUSES	X							
A.2.5.6.9	VERIFY PARAMETERS IN TOLERANCE	X				X	VERIFY GROUND PARAMETERS		
A.2.5.6.10	ACTIVATE EPD&C CAUTION & WARNING DISPLAY	X				X	ACTIVATE GROUND SYSTEM		
A.2.5.6.11	ACTIVATE SELECTED SYSTEM C/B'S	X							
A.2.5.6.12	ACTIVATE BATTERY CHARGER (AS REQUIRED)	X				X	MONITOR SYSTEM		
A.2.5.6.13	ACTIVATE INSTRUMENTATION SYSTEM (ORBITER)	X				X	MONITOR SYSTEM		
A.2.5.6.14	ACTIVATE ET INSTRUMENTATION	X				X	MONITOR SYSTEM		
A.2.5.6.15	ACTIVATE SRB INSTRUMENTATION	X				X	MONITOR SYSTEM		
A.2.5.6.16	POWER UP ECLSS COOLING	X				X	MONITOR SYSTEM		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.5 VEHICLE ASSEMBLY (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	ALLOCATION: OOS/TUG	ALLOCATION: P/L	ALLOCATION: OTHER*	ALLOCATION: CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.5.6	PERFORM POST MATE STS INTERFACE VERIFICATION (CONT'D)							VOL. X 3.4.5.1	
A.2.5.6.17	VERIFY GSE HYD POWER AVAILABLE					X	VERIFY SYSTEM	↓	
A.2.5.6.18	VERIFY SUBSYSTEM OFF	X				X	VERIFY SYSTEM	↓	
A.2.5.6.19	TURN ON GSE HYD POWER					X	ACTIVATE SYSTEM	↓	
A.2.5.6.20	VERIFY INSTRUMENTATION READY FOR SSV INTERFACE CHECK	X				X	VERIFY GROUND SYSTEMS READY TO SUPPORT	↓	
A.2.5.6.21	ACTIVATE GN&C COMPUTERS	X				X	VERIFY COMPUTER ACTIVATION	↓	
A.2.5.6.22	LOAD/VERIFY CHECKOUT SOFTWARE	X				X	LOAD ONBOARD COMPUTERS	↓	
A.2.5.6.23	ACTIVATE ORBITER/SRB TVC SYS	X				X	MONITOR SYSTEM	↓	
A.2.5.6.24	PERFORM SRB TVC CHECKOUT	X				X	MONITOR CHECKOUT	↓	
A.2.5.6.25	DEACTIVATE ORBITER/SRB TVC SYS	X						↓	
A.2.5.6.26	PERFORM GN&C ET I/F CHECKOUT	X				X	MONITOR CHECKOUT	↓	
A.2.5.6.27	PERFORM GN&C/SRB SEQUENCER INTERFACE CHECKOUT	X				X	MONITOR CHECKOUT	↓	
A.2.5.6.28	POWER UP MPS ELECTRICAL SYSTEM	X				X	ACTIVATE GROUND SYSTEM	↓	
A.2.5.6.29	ACTIVATE MPS INSTRUMENTATION	X				X	ACTIVATE GROUND SYSTEM	↓	
A.2.5.6.30	VERIFY PNEUMATIC/PURGE PRESSURE	X				X	MONITOR SYSTEM	↓	
A.2.5.6.31	ACTIVATE LOX TANK VENT - CHECK INTERFACE CONNECTION	X				X	MONITOR SYSTEM	↓	
A.2.5.6.32	ACTIVATE LH2 TANK VENT - CHECK INTERFACE CONNECTION	X				X	MONITOR SYSTEM	↓	
A.2.5.6.33	INSPECT ORBITER/ET INTERFACE FOR LEAKAGE				X			↓	
A.2.5.6.34	VERIFY AIR FLOW					X	VERIFY SYSTEM ON & MONITOR SYSTEM	↓	
A.2.5.6.35	LEAK CHECK HYD INTERFACE				X			↓	
A.2.5.6.36	VERIFY ELECTRICAL POWER AT ET/ORBITER INTERFACE	X				X	MONITOR SYSTEM	↓	
A.2.5.6.37	CHECK LOX TANK VENT VALVES	X				X	MONITOR SYSTEM	↓	
A.2.5.6.38	CHECK LH2 TANK VENT VALVES	X				X	MONITOR SYSTEM	↓	
A.2.5.6.39	CHECK LOX TANK LEVEL INDICATORS	X				X	MONITOR SYSTEM		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.5 VEHICLE ASSEMBLY (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.5.6	PERFORM POST MATE STS INTERFACE VERIFICATION (CONT'D)							VOL. X 3.4.5.1	
A.2.5.6.40	CHECK LH2 TANK LEVEL INDICATORS	X				X	MONITOR SYSTEM	↓	
A.2.5.6.41	CHECK ET PRESSURE SENSORS	X				X	MONITOR SYSTEM		
A.2.5.6.42	CONDUCT LOW LEVEL C/B CHECKS	X				X	MONITOR SYSTEM		
A.2.5.6.43	POWER DOWN MPS INSTRUMENTATION SYSTEM	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.6.44	POWER DOWN MPS ELECTRICAL SYS	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.6.45	DEACTIVATE C&T	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.6.46	VERIFY SUBSYSTEM OFF	X							
A.2.5.6.47	VERIFY BATTERY CHARGER OFF	X							
A.2.5.6.48	POWER DOWN ORBITER	X							
A.2.5.6.49	POWER DOWN GSE					X	POWER DOWN GROUND SYSTEMS		
A.2.5.6.50	REMOVE GSE CABLES				X				
A.2.5.6.51	DEACTIVATE GN&CS	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.6.52	DEACTIVATE INSTRUMENTATION	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.6.53	POWER DOWN ECLSS	X				X	POWER DOWN GROUND SYSTEM		
A.2.5.7	PREPARE FOR ROLLOUT				X				
A.2.5.8	INSTALL & CONNECT ORDNANCE (EXCEPT SRB IGNITION & TT)				X			↓	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.6 TRANSPORT TO PAD

FUNCTION NO.	FUNCTION	ALLOCATION ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.6.1	TRANSPORT STS TO PAD				X	X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.5.2	OPS MANAGEMENT CONSISTS OF MONITORING ACTIVITIES FOR ADHERENCE TO SCHEDULE TIMELINES AND SUPPORT OF ANOMALY RESOLUTION.

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.7 PAD INSTALLATION

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.7.1	EMPLACE STS ON PAD				X			VOL. X 3.4.6.1	
A.2.7.2	CONNECT/VERIFY PAD/MLP I/F'S				X			↓	
A.2.7.2.1	CONNECT/VERIFY PAD/MLP I/F'S				X			↓	
A.2.7.2.2	CONNECT/VERIFY ORB/PAD I/F'S				X			↓	
A.2.7.2.3	ACTIVATE PAD/MLP SYSTEMS					X	ACTIVATE GROUND SUPPORT SYSTEMS	↓	
A.2.7.2.4	ACTIVATE SUPPORT EQUIPMENT				X	X	VERIFY ACTIVATION	↓	
A.2.7.2.5	INSTALL PAYLOAD				X			↓	REFER TO A.2.11 THROUGH A.2.13

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.8 FLIGHT READINESS VERIFICATION

FUNCTION NO.	FUNCTION	ALLOCATION ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.8.1	PERFORM INITIAL STS SWITCH CONFIGURATION	X						VOL. X 3.4.6.1	OPS MANAGEMENT SUPPORT WILL BE PROVIDED THROUGHOUT THIS PHASE
A.2.8.2	CONFIGURE FACILITIES FOR VEHICLE C/D & SERVICING					X	CONFIGURE GROUND SUPPORT SYSTEMS	↕	
A.2.8.3	CONFIGURE GSE FOR VEHICLE C/D & SERVICING				X	X	CONFIGURE GROUND SUPPORT SYSTEMS		
A.2.8.4	CONFIGURE STS FOR VERIFICATION	X							
A.2.8.5	PERFORM SECURE COMM VERIFICATION	X	X	X		X	SUPPORT COMM CHECK		
A.2.8.6	PERFORM PAYLOAD VERIFICATION	X		X		X	MONITOR CHECK		REFER TO A.2.14 THROUGH A.2.19
A.2.8.7	PERFORM STS VERIFICATION								
A.2.8.7.1	ACTIVATE GROUND SUPPORT SYS					X	ACTIVATE SYSTEMS		
A.2.8.7.2	ACTIVATE ONBOARD SYSTEMS	X				X	MONITOR ONBOARD SYSTEMS		
A.2.8.7.3	CHECKOUT C&W SYSTEM	X				X	MONITOR CHECKOUT		
A.2.8.7.4	PERFORM PRIMARY GN&CS CHECKOUT	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.5	PERFORM BACKUP GN&CS CHECKOUT	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.6	PERFORM ASAS CHECKOUT	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.7	PERFORM APU CHECKS	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.8	PERFORM CHECKOUT OF RECORDERS	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.9	PERFORM INSTRUMENTATION CHECKS	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.7.10	PERFORM PROPULSION CHECKS	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.8	LOAD REMAINING CARGO				X				
A.2.8.9	CONDITION PRSD CRYO SYSTEM					X	COMMAND, CONTROL, & MONITOR SYSTEM		
A.2.8.10	PURGE FAC LH2 VENT & FILL SYSTEM					X	COMMAND, CONTROL, & MONITOR SYSTEM		
A.2.8.11	VERIFY COMM SYSTEMS	X				X	SUPPORT SYSTEMS CHECKS		
A.2.8.12	PERFORM MPS CHECKS	X				X	MONITOR CHECKOUT & PROVIDE BACKUP		
A.2.8.13	LOAD & VERIFY MISSION SOFTWARE	X				X	COMMAND, CONTROL, & MONITOR OPS	↕	
A.2.8.14	CLOSE OUT ALL VEHICLE ACCESS				X			VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.8 FLIGHT READINESS VERIFICATION (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.8.15	PROVIDE OMS PRESSURANT SERVICING					X	COMMAND, CONTROL, & MONITOR OPS	VOL. X 3.4.6.1	
A.2.8.16	CONDITION PAYLOAD CRYO SYSTEM					X	COMMAND, CONTROL, & MONITOR OPS	↕	
A.2.8.17	CONDITION ET TANKS & MPS PROP SYS					X	COMMAND, CONTROL, & MONITOR OPS	↕	
A.2.8.18	SECURE STS FROM VERIFICATION TEST							↕	
A.2.8.18.1	POWER DOWN ORBITER SYSTEMS	X						↕	
A.2.8.18.2	POWER DOWN GND SUPPORT SYSTEMS					X	POWER DOWN SELECTED GROUND SYSTEMS	VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.9 ATTAIN STANDBY STATUS

FUNCTION NO.	FUNCTION	ALLUCATION							REMARKS
		ORBI-TER	OOS/ TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.9.1	CONFIGURE STS FOR STANDBY	X						VOL. X 3.4.6.1 ↑	OPS MANAGEMENT PROVIDED FOR THIS PHASE
A.2.9.2	CONFIGURE PAYLOAD FOR STANDBY & ATTAIN STANDBY STATUS		X	X		X	VERIFY STATUS		REFER TO A.2.20 THROUGH A.2.22
A.2.9.3	CONFIGURE GND SYS FOR STANDBY					X	ACTIVATE SYSTEMS FOR MONITORING		
A.2.9.4	POWER DOWN ORBITER SYSTEMS TO MONITOR LEVEL	X							
A.2.9.5	MAINTAIN GROUND CONTROL OF VEHICLE SYSTEMS					X	COMMAND, CONTROL, & MONITOR SYS	↓	
A.2.9.6	EXECUTE STANDBY MONITORING ROUTINE					X	MONITOR VEHICLE SYSTEMS	VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.10 LAUNCH OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.10.1	PERFORM PRECOUNT OPERATIONS							VOL. X 3.4.6.1 ↓	OPS MANAGEMENT PROVIDED FOR THIS PHASE
A.2.10.1.1	SECURE FROM STANDBY MONITORING	X	X	X		X	CONTINUE MONITORING VEHICLE		
A.2.10.1.2	CONFIGURE GROUND SYSTEMS FOR CRYO LOADING					X	CONFIGURE GROUND SYSTEMS		
A.2.10.1.3	CONFIGURE STS FOR CRYO LOADING	X							
A.2.10.1.4	POWER UP STS SUBSYSTEMS	X							
A.2.10.1.5	UPDATE/VERIFY MISSION SOFTWARE	X				X	UPDATE & VERIFY ONBOARD SOFTWARE		
A.2.10.2	T-2 HOUR STANDBY HOLD (IF REQ'D)	X	X	X		X	MONITOR SYSTEMS		
A.2.10.3	STS CRYOGENIC LOADING								
A.2.10.3.1	CLEAR PAD				X				
A.2.10.3.2	INITIATE STS PURGES					X	ACTIVATE & MONITOR PURGES		
A.2.10.3.3	INITIATE SERVICING LINES CHILLDOWN					X	ACTIVATE SYSTEMS FOR CHILLDOWN		
A.2.10.3.4	PERFORM P/L PROPELLANT LOADING					X	COMMAND, CONTROL & MONITOR LOADING		REFER TO A.2.23 THROUGH A.2.27
A.2.10.3.5	PERFORM HYPERGOL LOADING					X	COMMAND, CONTROL & MONITOR LOADING		
A.2.10.3.6	PERFORM PRSD PROP LOADING					X	COMMAND, CONTROL & MONITOR LOADING		
A.2.10.3.7	INITIATE PRSD TANK PRESSURIZATION					X	COMMAND, CONTROL & MONITOR OPS		
A.2.10.3.8	FUEL CELL STARTUP					X	COMMAND, CONTROL & MONITOR OPS		
A.2.10.3.9	TRANSFER PARTIAL POWER TO FUEL CELL POWER					X	COMMAND, CONTROL & MONITOR OPS		
A.2.10.4	INITIATE PERSONNEL LOADING				X				
A.2.10.5	PERFORM TERMINAL COUNTDOWN								
A.2.10.5.1	VERIFY GN&C ALIGNMENT	X				X	MONITOR SYSTEM & PROVIDE BACKUP		
A.2.10.5.2	TRANSFER TO INTERNAL POWER	X				X	MONITOR SYSTEM & PROVIDE BACKUP		
A.2.10.5.3	VERIFY ALL SYSTEMS READY	X	X	X	X	X	VERIFY SYSTEMS		
A.2.10.5.4	APU STARTUP	X				X	MONITOR OPERATION	↑	
A.2.10.5.5	TRANSFER HYD & ELEC POWER	X				X	MONITOR OPERATION	VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.10 LAUNCH OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.10.5.6	RETRACT FORWARD UMBILICAL					X	COMMAND UMBILICAL RETRACT	VOL. X 3.4.6.1	
A.2.10.5.7	VERIFY STS READY FOR LAUNCH	X	X	X		X	VERIFY ALL SYSTEMS	↕	
A.2.10.6	PERFORM AUTOMATIC COUNTDOWN	X				X	MONITOR SYSTEMS & PROVIDE BACKUP	VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.11 PAYLOAD INSTALLATION

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.11.1	PREPARE P/L INSTALLATION EQUIP				X	X	PROVIDE OPS MANAGEMENT SUPPORT	VOL. X 3.4.6.1	OPS MANAGEMENT ENCOMPASSES SUPPORT OF ALL CCDS FUNCTIONS THROUGH ENTRY A.2.11.5.7
A.2.11.2	POSITION P/L EXCHANGE ENCLOSURE				X			↕	
A.2.11.3	ESTABLISH SECURITY REQUIREMENTS				X			↕	
A.2.11.4	ESTABLISH ENVIRONMENTAL CONTROL							↕	
A.2.11.4.1	INITIATE AIR CIRCULATION					X	ACTIVATE GROUND SYSTEM & MONITOR	↕	
A.2.11.4.2	SAMPLE INCOMING AIR					X	PERFORM SAMPLE	↕	
A.2.11.4.3	BLOW DOWN VOL					X	PERFORM BLOW DOWN	↕	
A.2.11.5	INSTALL PAYLOAD							↕	
A.2.11.5.1	TRANSFER P/L FROM TRANSPORTER				X			↕	
A.2.11.5.2	OPEN PAYLOAD BAY DOORS	X						↕	
A.2.11.5.3	INSTALL PAYLOAD IN BAY				X			↕	
A.2.11.5.4	CONNECT PAYLOAD/ORBITER I/F'S				X			↕	
A.2.11.5.5	VERIFY PAYLOAD/ORBITER I/F'S	X				X	MONITOR INTERFACE CHECKOUT	↕	
A.2.11.5.6	CLOSE PAYLOAD BAY DOORS	X						↕	
A.2.11.5.7	SECURE PAYLOAD INSTALLATION EQUIPMENT				X	X	DEACTIVATE SELECTED GROUND SYSTEMS	VOL. X 3.4.6.1	

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.12 INTERFACE VERIFICATION

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.12.1	VERIFY PAYLOAD RETENTION MECHANISM ATTACHED				X				PHYSICAL AND/OR VISUAL VERIFICATION
A.2.12.2	VERIFY PAYLOAD - BULKHEAD CABLES ATTACHED				X				
A.2.12.3	VERIFY PAYLOAD - UMBILICAL PANEL CONNECTOR ATTACHED				X				
A.2.12.4	VERIFY PAYLOAD - REMOTE ANTENNA CABLE ATTACHED				X				
A.2.12.5	VERIFY PAYLOAD - FUEL LOADING LINES ATTACHED				X				
A.2.12.6	VERIFY PAYLOAD FUEL PURGE LINES ATTACHED				X				
A.2.12.7	VERIFY EXTERNAL PAYLOAD UMBILICAL CABLES ATTACHED				X				
A.2.12.8	VERIFY EXTERNAL PAYLOAD FUEL LINES ATTACHED				X				
A.2.12.9	VERIFY EXTERNAL PAYLOAD PURGE LINES ATTACHED				X				
A.2.12.10	VERIFY PAYLOAD AGE OFF				X				
A.2.12.11	VERIFY PAYLOAD TO GSE CABLES ATTACHED				X				EXTERNAL GSE STATUS VERIFIED BY PAYLOAD OPS TO PREVENT DANGER TO PAYLOAD/ORBITER
A.2.12.12	VERIFY FUEL SAFETY EQUIPMENT INSTALLED & OPERATING				X				

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.13 PAYLOAD INSTALLATION CCDS EXECUTIVE & MANAGEMENT FUNCTIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.13.1	ESTABLISH & MAINTAIN COMM WITH P/L INSTALLATION AREAS, P/L USER AREAS, AND GSE				X	X	INTERFACE WITH RANGE COMM CONTROL & COGNIZANT AREAS		
A.2.13.2	DIRECT & CONTROL SEQUENCER OF P/L INSTALLATION EVENTS				X	X	COORDINATE THIS PROGRESS ON INSTALLATION EVENT		
A.2.13.3	MONITOR PROGRESS OF EVENTS				X	X	MAINTAIN STATUS OF EVENT PROGRESS		
A.2.13.4	DISTRIBUTE P/L INSTALLATION STATUS DATA TO COGNIZANT AREAS				X				
A.2.13.5	ASSURE EACH SIDE OF EACH I/F IS INACTIVE & SECURE BEFORE & AFTER CONNECTION				X	X	ESTABLISH & MAINTAIN POSITIVE CONTROL OVER ALL STIMULUS WHICH WILL SUBSEQUENTLY PASS ACROSS THE I/F		
A.2.13.6	ASSURE PHYSICAL SECURITY OF P/L INSTALLATION AREA & FACILITIES				X	X	COORDINATE SECURING ACTIVITIES		
A.2.13.7	MAINTAIN EVENT CHECKLIST					X	MAINTAIN STATUS OF EVENT PROGRESS		
A.2.13.8	ASSURE ALL SAFETY PRECAUTIONS ARE STRICTLY ENFORCED & ADHERED TO					X	COORDINATE WITH ALL SAFETY MONITORS & MONITOR C&W PARAMETERS		C&W PARAMETERS INCLUDE GROUND EQUIPMENT AS WELL AS VEHICLE
A.2.13.9	ASSURE NON-INTERFERENCE OF OPS					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.13.10	COORDINATE ALL FLIGHT VEHICLE, P/L, & GROUND ACTIVITIES ASSOCIATED WITH PAYLOAD INSTALLATION					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.13.11	RESCHEDULE/MODIFY PREFLIGHT P/L OPS & SCHEDULES AS REQUIRED					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS TO DEVELOP REVISED SCHEDULE & IMPLEMENT CONTINGENCY SCHEDULES		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.14 PAYLOAD/STS READINESS TESTING

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.14.1	PREPARE ORBITER FOR TESTING	X				X	MONITOR ACTIVITY STATUS FOR SCHEDULE COMPATIBILITY		PREPARE, ACTIVATE, CONFIGURE, & CHECK OUT PAYLOAD TEST EQUIPMENT & FOR FACILITIES
A.2.14.2	PREPARE OOS FOR TESTING		X			X	MONITOR ACTIVITY STATUS FOR SCHEDULE COMPATIBILITY		
A.2.14.3	PREPARE PAYLOAD FOR TESTING			X		X	MONITOR ACTIVITY STATUS FOR SCHEDULE COMPATIBILITY		
A.2.14.4	PREPARE FACILITIES & SUPPORT SERVICES				X	X	MONITOR ACTIVITY STATUS FOR SCHEDULE COMPATIBILITY		
A.2.14.5	VERIFY PAYLOAD/ORBITER INTERFACE	X			X	X	REMOTELY CONTROL, MONITOR, & RECORD TEST RESULTS		
A.2.14.6	MONITOR PAYLOAD - USER INTERFACE OPERATION				X	X	RECEIVE & DISTRIBUTE MONITORED DATA		
A.2.14.7	VERIFY PAYLOAD - CCDS INTERFACE	X			X	X	RECEIVE & DISTRIBUTE MONITORED DATA		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.15 FINAL PAYLOAD SERVICING

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.15.1	REMOVE AND/OR INSTALL BATTERIES		X	X		X	MONITOR ACTIVITY PROGRESS		
A.2.15.2	INSTALL, FASTEN AND/OR REMOVE COVERS, SHIELDS, & LIDS		X	X					
A.2.15.3	ADJUST PAYLOAD SUBSYSTEM		X	X					
A.2.15.4	REMOVE, REPLACE & ATTACH COMMUNICATIONS, DATA, & ELEC CABLES		X	X					
A.2.15.5	INSTALL FRESH PAYLOAD FUEL CONTAINERS			X					
A.2.15.6	REMOVE OR INSTALL MECH RETENTION SYSTEMS SAFETY DEVICES		X	X					
A.2.15.7	ENABLE OR DISABLE OOS-PAYLOAD DEPLOYMENT MECHANISM	X							
A.2.15.8	ENABLE AUTOMATIC PAYLOAD FUEL SYSTEM	X				X	REMOTE COMMAND INITIATION		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.16 PAYLOAD BAY CLOSURE

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.16.1	PREPARE DOOR FOR CLOSURE				X				
A.2.16.2	CLOSE BAY DOOR	X				X	MONITOR OPERATION		
A.2.16.3	SECURE & VERIFY BAY DOOR				X	X	MONITOR OPERATION		
A.2.16.4	MONITOR BAY DOOR ALARMS	X				X	RECEIVE, PROCESS, & DISPLAY ALARM STATUS		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.17 ESTABLISH/MAINTAIN PAYLOAD BAY ENVIRONMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.17.1	MONITOR BAY AREA ENVIRONMENT					X	RECEIVE, PROCESS, DISTRIBUTE, & DISPLAY RECORD DATA		
A.2.17.2	MAINTAIN CONTROL OF BAY AREA ENVIRONMENT					X	PREPARE, TRANSMIT, SELECT, & PROCESS RECORD CONTROL DATA		
A.2.17.3	ASSURE PROPER BAY DOOR CLOSURE, SEALING, & VENTING					X	MONITOR OPERATION		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.18 PAYLOAD PRE-STANDBY FUEL OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.18.1	ESTABLISH & VERIFY FUELING SYS CONFIGURATIONS					X	SELECT, SWITCH, ALERT, & CHECK CONFIGURATION STATUS		
A.2.18.2	LOAD FUEL					X	INITIATE, MONITOR & CONTROL		
A.2.18.3	SECURE FROM FUELING OPERATIONS					X	DIRECT, CONTROL, DEACTIVATE FUELING CONFIGURATION		
A.2.18.4	MONITOR PAYLOAD FUEL SYSTEM	X				X	MONITOR SYSTEM		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.19 PAYLOAD LAUNCH READINESS CCDS
EXECUTIVE & MANAGEMENT FUNCTIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.19.1	MAINTAIN COMMUNICATIONS WITH COGNIZANT AREAS					X	INTERFACE WITH RANGE COMMUNICATION CONTROL & COGNIZANT AREAS		
A.2.19.2	DIRECT & CONTROL SEQUENCER OF PAYLOAD LAUNCH READINESS EVENTS					X	COORDINATE PROGRESS OF EVENTS		
A.2.19.3	MONITOR PROGRESS OF EVENTS					X	MAINTAIN STATUS OF EVENT PROGRESS		
A.2.19.4	DISTRIBUTE PAYLOAD READINESS STATUS DATA TO COGNIZANT AREAS					X			
A.2.19.5	PROVIDE & CONTROL DATA HANDLING ACT SUPPORTING LAUNCH READINESS					X	PERFORM TYPICAL DATA HANDLING & PROCESSING ACTIVITY CONTROL		
A.2.19.6	ASSURE PHYSICAL SECURITY OF P/L ACTIVITY AREAS & FACILITIES					X	COORDINATE SECURITY ACTIVITIES		
A.2.19.7	MAINTAIN EVENT CHECKLIST					X	MAINTAIN EVENT CHECKLIST PROGRESS		
A.2.19.8	ASSURE SAFETY PRECAUTION ADHERENCE					X	COORDINATE WITH ALL SAFETY MONITORS & MONITOR C&W PARAMETERS		
A.2.19.9	ASSURE NON-INTERFERENCE OF OPS					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.19.10	COORDINATE ALL FLIGHT VEHICLE, P/L, & GROUND ACTIVITIES ASSOCIATED WITH P/L LAUNCH READINESS					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.19.11	RESCHEDULE/MODIFY PREFLIGHT P/L OPS & SCHEDULES AS REQUIRED					X	SUPPORT COORDINATION AMONG ALL TEST & SUPPORT GROUPS TO DEVELOP REVISED SCHEDULES & IMPLEMENT CONTINGENCY SCHEDULES		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.20 PAYLOAD STATUS & PAYLOAD BAY ENVIRONMENT MONITORING & CONTROL

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.20.1	ESTABLISH/MAINTAIN PAYLOAD BAY ENVIRONMENT DATA LINKS					X	RECEIVE, DISTRIBUTE, & TRANSMIT DATA		
A.2.20.2	MONITOR PAYLOAD BAY ENVIRONMENT				X	X	RECEIVE, PROCESS, DISTRIBUTE, DISPLAY, & RECORD DATA		
A.2.20.3	CONTROL PAYLOAD BAY ENVIRONMENT					X	PREPARE, TRANSMIT, SELECT, PROCESS, & RECORD CONTROL DATA		
A.2.20.4	MAINTAIN PAYLOAD COMMUNICATIONS DATA LINKS					X	RECEIVE, DISTRIBUTE & TRANSMIT DATA		
A.2.20.5	MONITOR PAYLOAD STATUS				X	X	RECEIVE, PROCESS, DISTRIBUTE, & DISPLAY RECORD DATA		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.21 DEMATING & REMOVAL OF NON-ESSENTIAL EQUIPMENT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.21.1	SECURE PAD-RESIDENT PAYLOAD GSE				X				
A.2.21.2	REMOVE EXCESS OR TEST SERVICING EQUIPMENT				X				
A.2.21.3	POWER DOWN NON-ESSENTIAL FACILITIES & EQUIPMENT				X	X	POWER DOWN GROUND SYSTEMS		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.22 PAYLOAD STANDBY CCDS EXECUTIVE & MANAGEMENT FUNCTIONS

FUNCTION NO.	FUNCTION	ALLOCATION: ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.22.1	MAINTAIN COMMUNICATIONS WITH COGNIZANT AREAS					X	INTERFACE WITH RANGE COMM CONTROL & COGNIZANT AREAS		
A.2.22.2	DIRECT & CONTROL P/L STANDBY					X	COORDINATE STANDBY PROGRESS		
A.2.22.3	MONITOR P/L STANDBY PROGRESS					X	MAINTAIN STATUS PAYLOAD STANDBY PROGRESS		
A.2.22.4	DISTRIBUTE P/L INSTALLATION STATUS DATA TO COGNIZANT AREAS					X	DISTRIBUTE DATA		
A.2.22.5	CONTINUE TO PROVIDE & CONTROL NECESSARY DATA HANDLING ACTIVITIES SUPPORTING STANDBY					X	PERFORM DATA HANDLING & PROCESSING ACTIVITY CONTROL		
A.2.22.6	ASSURE PHYSICAL SECURITY					X	SUPPORT COORDINATION OF SECURITY ACTIVITY INTERFACES		
A.2.22.7	MAINTAIN EVENT CHECKLIST					X	MAINTAIN CHECKLIST		
A.2.22.8	MONITOR FOR ASSURANCE OF SAFETY PRECAUTIONS ADHERENCE					X	SUPPORT COORDINATION WITH ALL SAFETY MONITORS & MONITOR C&W PARAMETERS		C&W PARAMETERS INCLUDE GROUND EQUIPMENT AS WELL AS VEHICLE
A.2.22.9	ASSURE NON-INTERFERENCE OF OPS					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.22.10	COORDINATE ALL FLIGHT VEHICLE, P/L, & GROUND ACTIVITIES ASSOCIATED WITH PAYLOAD STANDBY					X	SUPPORT COORDINATION AMONG ALL TEST & SUPPORT GROUPS		
A.2.22.11	RESCHEDULE/MODIFY PREFLIGHT P/L OPERATIONS & SCHEDULE AS REQ'D					X	SUPPORT COORDINATION AMONG ALL TEST & SUPPORT GROUPS TO DEVELOP REVISED SCHEDULE & IMPLEMENT CONTINGENCY SCHEDULES		
A.2.22.12	CONTROL RF RADIATION, FACILITIES SUPPORT, ACCESS, ETC.					X	MAINTAIN POSITIVE CONTROL OF ALL INTERFACES WITH THE PAYLOAD		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.23 PAYLOAD CRYOGENIC LOADING

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.23.1	ESTABLISH & VERIFY FUEL CONFIG	X				X	MONITOR, DISPLAY, & COMMAND		
A.2.23.2	LOAD FUEL	X				X	MONITOR & CONTROL		
A.2.23.3	MAINTAIN TOPPING-OFF OPERATION	X				X	MONITOR & CONTROL		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.24 PRE-PAYLOAD-TO-ORBITER CONTROL HANDOVER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.24.1	VERIFY PAYLOAD C&W STATUS	X				X	MONITOR, COMMAND, & DISPLAY		
A.2.24.2	UPDATE OOS MISSION DATA					X	TRANSMIT, RECEIVE, & MONITOR		
A.2.24.3	UPDATE SATELLITE MISSION DATA				X	X	TRANSMIT, RECEIVE, & MONITOR		P - CCDS SCHEDULES WHILE USER DOES UPDATING
A.2.24.4	VERIFY PAYLOAD BAY ENVIRONMENT	X				X	MONITOR		
A.2.24.5	VERIFY P/L POWER SYSTEM STATUS	X				X	MONITOR		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.25 PAYLOAD HANDOVER OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.25.1	CONFIRM PAYLOAD STATUS	X				X	MONITOR		
A.2.25.2	CONFIRM PAYLOAD POWER STATUS	X				X	MONITOR		
A.2.25.3	CONFIRM BAY ENVIRONMENT STATUS	X				X	MONITOR		
A.2.25.4	SWITCH TO INTERNAL POWER	X				X	MONITOR		
A.2.25.5	MAINTAIN EXTERNAL PWR IN STANDBY					X	MONITOR		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.26 POST-PAYLOAD CONTROL HANDOVER

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.26.1	VERIFY PAYLOAD C&W STATUS	X				X	MONITOR		
A.2.26.2	VERIFY PAYLOAD OPERATIONAL STAT					X	INITIATE & MONITOR CHECKOUT		
A.2.26.3	VERIFY BAY AREA ENVIRONMENT	X				X	MONITOR		
A.2.26.4	MAINTAIN PAYLOAD POWER	X				X	MONITOR		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.27 PAYLOAD COUNTDOWN CCDS EXECUTIVE & MANAGEMENT FUNCTIONS

FUNCTION NO.	FUNCTION	ALLOCATION ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.27.1	ESTABLISH & MAINTAIN COMMUNICATIONS WITH P/L COGNIZANT AREAS					X	INTERFACE WITH RANGE COMM CONTROL & COGNIZANT AREAS		
A.2.27.2	DIRECT & CONTROL SEQUENCE OF P/L INSTALLATION EVENTS					X	COORDINATE THE PROGRESS OF PAYLOAD COUNTDOWN EVENTS		
A.2.27.3	MONITOR PROGRESS OF EVENTS					X	MONITOR STATUS OF EVENT PROGRESS		
A.2.27.4	DISTRIBUTE PAYLOAD COUNTDOWN STATUS DATA TO COGNIZANT AREAS					X	DISTRIBUTE DATA		
A.2.27.5	CONTINUE TO PROVIDE & CONTROL NECESSARY DATA HANDLING ACTIVITIES SUPPORTING COUNTDOWN					X	PERFORM TYPICAL DATA HANDLING & PROCESSING ACTIVITY CONTROL		
A.2.27.6	ASSURE PHYSICAL SECURITY					X	COORDINATE SECURITY ACTIVITIES		
A.2.27.7	MAINTAIN EVENT CHECKLIST					X	MAINTAIN CHECKLIST		
A.2 27.8	ASSURE ALL SAFETY PRECAUTIONS ARE STRICTLY ENFORCED AND ADHERED TO					X	COORDINATE WITH ALL SAFETY MONITORS & MONITOR C&W PARAMETERS		C&W PARAMETERS INCLUDE GROUND EQUIPMENT AS WELL AS VEHICLE
A.2.27.9	ASSURE NON-INTERFERENCE OF OPS					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS		
A.2.27.10	COORDINATE ALL FLIGHT VEHICLE, P/L, & GROUND ACTIVITIES ASSOCIATED WITH PAYLOAD COUNTDOWN					X	SUPPORT COORDINATION AMONG ALL TEST & SUPPORT GROUPS		
A.2.27.11	RECHARGE/MODIFY PREFLIGHT PAYLOAD OPS & SCHEDULE AS REQUIRED					X	COORDINATE WITH ALL TEST & SUPPORT GROUPS TO DEVELOP REVISED SCHEDULE & IMPLEMENT CONTINGENCY SCHEDULE		
A.2.27.12	MAINTAIN POSITIVE CONTROL OF ALL INTERFACE WITH THE PAYLOAD					X	MONITOR & CONTROL RF, RADIATION, FACILITIES SUPPORT & ACCESS CAPABILITY		
A.2.27.13	CONTROL PAYLOAD HANDOVER TO ORBITER CREW					X	SUPPORT TEST, CHECKOUT, FACILITIES SUPPORT & STATUS UPDATING		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.28 SRB RECOVERY

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.28.1	PERFORM SRB RECOVERY				X	X	PROVIDE OPS MANAGEMENT SUPPORT.	VOL. X 3.4.9.1	
							PROVIDE IMPACT PREDICTIONS. PROVIDE SUPPORT TO CHECK OUT COMM & TRACKING SYSTEMS ON RECOVERY SHIPS (IF DOD MAINTAINS RECOVERY FLEET)		

*MA'UAL, FACILITIES, GSE AND SE

MODULE: A.2.29 SATELLITE/OSS CHANGEOUT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.29.1	CONFIGURE ORBITER SYSTEM FOR PAYLOAD REMOVAL								OPS MANAGEMENT SUPPORT WILL BE PROVIDED FOR THIS PHASE
A.2.29.1.1	POSITION GSE				X				
A.2.29.1.2	INITIATE AIR CIRCULATION					X	ACTIVATE GROUND SYSTEM		
A.2.29.1.3	SAMPLE INCOMING AIR					X	PERFORM SAMPLE		
A.2.29.1.4	BLOW DOWN VOLUME					X	PERFORM BLOW DOWN		
A.2.29.2	CHANGE OUT PAYLOAD								
A.2.29.2.1	OPEN PAYLOAD BAY DOORS	X							
A.2.29.2.2	REMOVE PAYLOAD				X				
A.2.29.2.3	LOWER P/L TO BASE OF LAUNCHER				X				
A.2.29.2.4	INSTALL P/L ON TRANSPORTER				X				
A.2.29.2.5	REMOVE NEW PAYLOAD FROM TRANSPORTER				X				
A.2.29.2.6	HOIST P/L TO P/L BAY LEVEL				X				
A.2.29.2.7	INSTALL PAYLOAD IN BAY				X				
A.2.29.2.8	CONNECT PAYLOAD/ORBITER I/F'S				X				
A.2.29.2.9	VERIFY PAYLOAD/ORBITER I/F'S	X				X	MONITOR INTERFACE CHECKOUT		
A.2.29.2.10	CLOSE PAYLOAD BAY DOORS	X							
A.2.29.2.11	SECURE PAYLOAD INSTALLATION SUPPORT EQUIPMENT				X	X	DEACTIVATE SELECTED GROUND SYSTEMS		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.30 ON-PAD CONTINGENCIES

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.30	DETECT ON-PAD CONTINGENCIES							VOL. X 3.2.1.5	
A.2.30.1	PRIOR TO CREW INGRESS								
A.2.30.1.1	VERIFY SUBSYSTEMS ACTIVATION			X		X	INITIATE COMMANDS & MONITOR ACTIVATION		P/L USER VERIFIES OPS OF HIS P/L
A.2.30.1.2	MONITOR STATUS OF DATA ACQ & PROCESSING EQUIPMENT			X		X	MONITOR - NOTE TRENDS		P/L USER MONITORS HIS PAYLOAD
A.2.30.1.3	MONITOR STATUS OF IND VEH PARAM OR GROUP OF PARAMS			X		X	MONITOR - NOTE TRENDS		
A.2.30.1.4	EVALUATE VEHICLE AND/OR GND SUBSYSTEMS CONFIGURATION					X	MAINTAIN COGNIZANCE OF ON-LINE/ BACKUP EQUIPMENT STATUS		
A.2.30.1.5	EVALUATE EACH SUBSYSTEM (GROUND & VEHICLE)					X	MAINTAIN COGNIZANCE OF SWITCHABLE FUNCTION PATHS & SWITCHABLE LRU'S		
A.2.30.1.6	EVALUATE LIMIT TOLERANCES & CALCULATIONS			X		X	MONITOR & PERFORM TREND ANALYSIS		
A.2.30.1.7	DETECT FAILURE			X		X	MONITOR SUBSYSTEMS DISPLAYS, RE-CORD FAILURE & TIME OF OCCURRENCE		IF P/L IS INVOLVED, P/L USER MAKES RECOMMENDATIONS TO CCDS
A.2.30.1.8	FAILURE CRITICALITY EVALUA-TION & ACTION DETERMINATION			X		X	DISPLAY CORRECTIVE ACTION		
A.2.30.1.9	INITIATE HOLD	X		X		X	INTERRUPT PROGRAM SEQUENCE		CERTAIN FAILURES CAUSE AN AUTO HOLD TO BE INITIATED BY ORB VEH
A.2.30.1.10	INITIATE MISSION TERMINATION					X	INITIATE COMMAND TO ONBOARD SYS		IF P/L INVOLVED AS PRI CAUSE, USER MAKES RECOM TO CCDS
A.2.30.2	FOR HOLD								AFTER CREW INGRESS: ONBOARD SYS & CREW HAS PRIME RESPONSIBILITY
A.2.30.2.1	ACKNOWLEDGE FAILED CONDITION	X		X		X	DENOTE TIME; DISPLAY FAILURE CONDITION		IF P/L IS PROBLEM AFTER CREW INGRESS: THE P/L SPEC HAS PRIME RESPONSIBILITY DURING HOLD
A.2.30.2.2	RECORD DATA	X		X		Y	PROCESS & RECORD DATA		IF P/L IS PROBLEM PRIOR TO CREW INGRESS, P/L USER HAS PRIME RESPONSIBILITY DURING HOLD
A.2.30.2.3	PERFORM FAULT ISOLATION	X		X		X	CMD & CNTL VEH INSTR PROVIDED PM EQUIP FAILURE; OTHERWISE MONITOR		
A.2.30.2.4	PERFORM LRU FUNCTIONAL CKS	X		X		X	LOAD APPLICATIONS SOFTWARE; INTER-ROGATE VEH S/S; DISP FUNCTIONAL CKS	VOL. X 3.5.1.1.5	IF CREW ONBOARD, LRU ISOLATION DONE BY ONBOARD SYS W/APPLI S/W
A.2.30.2.4	DETECT FAILED LRU OR	X		X		X	DISPLAY FAILURE CONDITION	VOL. X 3.2.1.5	
A.2.30.2.5	RECYCLE VEHICLE TO COUNTDOWN STATUS	X		X		X	REINITIALIZE CLOCKS: RESTART COUNTDOWN		P/L USER NOTIFIED CCDS OF COMPLETED TASKS
A.2.30.2.4	RE: DETECT FAILED LRU						DISPLAY FAILURE CONDITION		
A.2.30.2.4.1	REPAIR OR REPLACE FAULTY ELEMENTS	X		X		X	MONITOR		P/L USER WOULD INITIATE CORREC-TION INCLUDING SECURITY ARRANGE-MENTS

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.30 ON-PAD CONTINGENCIES (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.30	DETECT ON-PAD CONTINGENCIES (CONT'D)								
A.2.30.2.4.2	PERFORM ASSEMBLY	X		X	X	X	MONITOR SUBSYSTEMS		PERFORMED BY GROUND CREW
A.2.30.2.4.3	PERFORM SUBSYSTEMS TEST	X		X	X	X	RECYCLE LRU FUNCTIONAL CHECKS, THEN PERFORM SUBSYSTEMS TEST		CONTINUITY TESTS BY GND CREW; ON-BOARD VEH PM TEST IF MANNED
A.2.30.2.4.4	REPLENISH PROPELLANTS	X		X		X	MONITOR PRESSURES, INITIATE & MONITOR LEAK TESTS		AUTOMATIC CONTROL BY CCDS
A.2.30.2.4.5	MONITOR STATUS OF S/S DATA (AIRBORNE & AGE PARAMETERS)	X		X		X	MONITOR DISPLAY SUBSYSTEM DATA & PROCESS TREND ANALYSIS		IF MANNED-MONITOR; P/L USER MON-ITORS & CNTLS P/L PROPELLANTS
A.2.30.2.4.6	TERMINATE PROPELLANT LOADING	X		X		X	MONITOR PRESSURES, CNTL LEAK CKS VERIFY TERMINATION		
A.2.30.2.6	PERFORM LAUNCH COUNTDOWN	X				X	MONITOR, PROCESS, & DISPLAY VEH DATA		
A.2.30.2.7	PERFORM LIFTOFF OR					X	MONITOR, RECORD TIMES; PROCESS DISPLAY EVENTS		
A.2.30.2.8	RE: RECYCLE VEHICLE TO COUNTDOWN STATUS					X	REINITIALIZE CLOCKS; RESTART COUNTDOWN		
A.2.30.2.6	PERFORM LAUNCH COUNTDOWN	X		X		X	MONITOR AIRBORNE & AGE PARAMETERS		
A.2.30.2.7	PERFORM LIFTOFF	X		X		X	DISPLAY LIFTOFF CONDITION; MARK TIME; MONITOR		
A.2.30.3	FOR MISSION TERMINATION							VOL. X 3.2.1.5	
A.2.30.3.1	SAFE PYROTECHNICS				X				
A.2.30.3.2	DRAIN LH2 & LO2 FROM ET & UPPER STAGE SIMULTANEOUSLY	X			X	X	INITIATE VALVE CONTROL; MONITOR PRESSURES; TEST FOR LEAKS		AUTOMATIC AFTER INITIATION BY GROUND
A.2.30.3.3	MONITOR DETANKING OPERATIONS	X		X	X	X	MONITOR: DISPLAY, GSE & VEH DATA		
A.2.30.3.4	PERFORM MANUAL OVERRIDE ON DE-TANKING SYSTEM					X	CONTROL VALVES IN CASE OF LEAKS, EXPLOSION OR FIRE		
A.2.30.3.5	POWER OFF ALL SYSTEMS NON-ESSENTIAL TO SAFING	X		X		X	DISABLE VEH SYS PWR; DISPLAY STAT; MONITOR SYS ESSENTIAL TO SAFING		
A.2.30.3.6	SAFE CRITICAL SYSTEMS	X		X		X	COMMAND & MONITOR EXECUTION		INCLUDING PAYLOADS
A.2.30.3.7	DISCONNECT VEHICLE & LAUNCHER-TO-PAD INTERFACES				X	X	MONITOR; CONTROL REMOTE CAMERAS		PERFORMED BY GROUND CREWS
A.2.30.3.8	REESTABLISH TRANSPORTER-TO-LAUNCHER INTERFACES					X	COMMAND & TEST INTERFACE		
A.2.30.3.9	MOVE MATED STS TO DESIGNATED REFURBISHMENT & TURNAROUND AREA				X				
A.2.30.3.10	PERFORM REFURBISHMENT & TURN-AROUND OPERATIONS OR			X		X	MAINTAIN COGNIZANCE OF STATUS		IF REFURBISHMENT IS FOR P/L, P/L USER KEEPS CCDS INFORMED ON STAT
A.2.30.3.11	CORRECT DEFICIENCY				X	X	PERFORM INSTRUMENTATION TESTS AS REQUIRED		GROUND CREW REMOVES/REPLACES LRU, ETC.
A.2.30.3.12	RESUME COUNT	X				X	START TIMER; REMOVE HOLD ON SEQUENCE		IF CREW ONBOARD, THEY PERFORM REINIT OF COUNTDOWN SEQUENCE

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.30 ON-PAD CONTINGENCIES (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.30	DETECT ON-PAD CONTINGENCIES (CONT'D)								
A.2.30.4	FOR TIME CRITICAL FAILURES (AFTER CREW INGRESS)								
A.2.30.4.1	DETECT FAILURE	X		X		X	MONITOR CONDITION, DISPLAY STATUS DATA; VERIFY TO CREW		IF P/L, P/L SPECIALIST HAS PRIME RESPONSIBILITY
A.2.30.4.2	SWITCH TO REDUNDANT FUNCTIONAL PATH	X				X	MONITOR; PERFORM COMMAND BACKUP IF REQUIRED		PERFORMED AUTOMATICALLY BY ON-BOARD SYSTEMS
A.2.30.4.3	MONITOR CRT'S & ANNUNCIATOR PANELS	X				X	MONITOR VEHICLE & GROUND SYSTEMS PARAMETERS		IF GROUND SYSTEM FAILURE, CCDS NOTIFIED CREW OF EXTENT
A.2.30.4.4	CREW EVALUATION & ACTION DETERMINATION	X				X	MONITOR SYSTEMS PARAMETERS, CO-ORDINATE WITH CREW		P/L SPECIALISTS MAINTAIN COMM WITH P/L USER
A.2.30.4.5	INITIATE HOLD OR	X				X	MONITOR; EVALUATE HOLD FOR SYSTEM/MISSION UPDATE		COUNTDOWN HOLD IS AUTO AFTER FAI CREW HAS OPTION TO CONTINUE HOLD
A.2.30.4.6	INITIATE ABORT	X				X	DISPLAY SEQ INITIATION, RECORD TIME	VOL. X 3.3.1.2.3.4.1	
A.2.30.5	FOR ABORT								
A.2.30.5.1	POSITION ACCESS ARM IN EGRESS POSITION					X	INITIATE COMMAND; MONITOR & CONTROL REMOTE CAMERAS		
A.2.30.5.2	POSITION HIGH-SPEED ELEVATORS					X	INITIATE COMMAND; MONITOR & CONTROL REMOTE CAMERAS		
A.2.30.5.3	DETECT FAILURE	X		X		X	MONITOR SUBSYSTEM DISPLAYS, RECORD FAILURE & TIME		
A.2.30.5.4	INITIATE ABORT COMMAND	X				X	MONITOR INIT; IF PRIOR TO CREW EGRESS, INIT IS BY CMD FROM CCDS	VOL. X 3.3.1.2.3.4	CONTROLLED BY ORBITER OR FLT CREW - DEPENDENT ON SEVERITY OF FAILURE: FAILURES RESULTING FROM FIRE OR EXPLOSIONS CAUSE AUTOMATIC ABORT INITIATION
A.2.30.5.5	INITIATE AUTOMATIC ABORT SEQUENCE	X				X	MONITOR INIT; IF PRIOR TO CREW EGRESS, INIT IS BY CMD FROM CCDS	VOL. X 3.3.1.2.3.4.1	CREW DEPENDENT ON SEVERITY OF FAILURE; (SAME AS ABOVE)
A.2.30.5.6	TERMINATE MISSION COUNTDOWN SEQUENCE	X				X	VERIFY TERMINATION; INDICATE TIME	VOL. X 3.5.4.1.2	
A.2.30.5.7	DISPLAY ABORT SIGNALS	X		X		X	MONITOR ONBOARD DISPLAY DATA; INIT ABORT INDICATION TO GND CREW		P/L USER MONITORS & DETER IMPACT ON P/L; INIT ACTIONS ACCORDINGLY
A.2.30.5.8	ACTIVATE STS & GND ALARMS	X				X	INITIATE GND ALARMS; MONITOR PAD CLEAR CONDITIONS		
A.2.30.5.9	OPEN TOP & SIDE HATCHES	X				X	MONITOR - PROVIDE BACKUP CONTROL IF REQUIRED		INITIATED BY ORBITER; BACKUP BY CREW INITIATION
A.2.30.5.10	PERFORM BACKOUT OPERATIONS	X		X		X	MONITOR ACT; CONTROL REMOTE CAMERA PROCESS & DISPLAY VEHICLE DATA		P/L USER DEPENDENT UPON PAD CLEAR
A.2.30.5.11	CREW & PASSENGER EGRESS TO TOWER PLATFORM ≤ 30 SECONDS						MONITOR ACT; CNTL REMOTE CAMERAS; MONITOR AUTO ABORT SEQ ONBOARD		CREW & PASSENGERS HAVE 30 SECS TO CLEAR MATED ORBITER VEHICLE
A.2.30.5.12	MOVE CREW & PASSENGERS TO SECURE AREA ≤ 90 SECONDS				X	X	MONITOR ACT; CMD PAD EXTERNAL COMM; MANAGE VEH OPERATIONS PROCESS & DISPLAY VEHICLE DATA		ASSISTS CREW; ELEVATORS OPERATE BY CREW INITIATED ACTION

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.30 ON-PAD CONTINGENCIES (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.30	DETECT ON-PAD CONTINGENCIES (CONT'D)								
A.2.30.5.13	PERFORM MISSION TERMINATION					X	INTERRUPT COUNTDOWN SEQ; DISPLAY MISSION SEQ INITIATION, RCD TIME		DETAILED FUNCTIONS PREVIOUSLY DELINEATED
A.2.30.6	FOR ABORT (NON-TIME CRITICAL)								PRIOR TO CREW INGRESS P/L USER HAS PRIME RESPONSIBILITY
A.2.30.6.1	DETECT FAILURE	X		X		X	MONITOR SUBSYSTEMS DISPLAYS, RECORD FAILURE & TIME		AFTER CREW INGRESS, CREW HAS PRIME RESPONSIBILITY FOR VEHICLE
A.2.30.6.2	DISPLAY FAILURE	X				X	MONITOR VEHICLE & GND SYSTEM DATA; NOTIFY CREW OF GND FAILURES		SYSTEM & P/L SPECIALIST HAS RESPONSIBILITY FOR P/L'S
A.2.30.6.3	CREW EVALUATION & ACTION DETERMINATION	X		X		X	COORDINATE ACTION WITH CREW		P/L SPECIALISTS COORDINATE WITH P/L USERS
A.2.30.6.4	PERFORM MANUAL ABORT SEQUENCING	X				X	MONITOR EXECUTION; PROVIDE BACKUP	3.3.1.2.3.4.1	
A.2.30.6.5	POWER-OFF ALL SYSTEMS NON-ESSENTIAL TO SAFING OR CREW EGRESS	X				X	MONITOR EXECUTION; PROVIDE BACKUP		P/L SPEC POWERS OFF P/L
A.2.30.6.6	SAFE CRITICAL SYSTEMS	X				X	MONITOR EXECUTION		INCLUDING PYROTECHNICS & P/L'S
A.2.30.6.7	POSITION ACCESS ARMS, IF RETRACTED					X	INITIATE COMMAND & MONITOR	3.3.1.2.3.4.1	
A.2.30.6.8	POSITION HIGH-SPEED ELEVATORS					X	INITIATE COMMAND & MONITOR		
A.2.30.6.9	OPEN DOORS	X				X	MONITOR; PROVIDE BACKUP		
A.2.30.6.10	CREW EGRESS				X	X	MONITOR ACTIVITY; COORDINATE VIA EXT VOICE AT PAD; CONTROL REMOTE CAMERAS		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.31 FERRY OPERATIONS

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.31.1	PREPARATION FOR FERRY FLIGHT					X	CCDS WILL PROVIDE OPERATIONS MANAGEMENT SUPPORT DURING THIS PHASE, CONSISTING PRIMARILY OF ACTIVITY SCHEDULE MONITORING, LOGISTICS SUPPORT, PLANNING MODIFICATION SUPPORT, & ANOMALY RESOLUTION, AS REQUIRED		
A.2.31.1.1	INSTALL/VERIFY GIMBAL LOCKS				X				
A.2.31.1.2	INSTALL/VERIFY FLIGHT SURFACE CONTROL LOCKS				X				
A.2.31.1.3	INSTALL ORBITER/FERRY AIRCRAFT MATING HARDWARE				X				
A.2.31.1.4	INSTALL/VERIFY ALL ACCESS PANELS EXCEPT THOSE REQUIRED TO				X				
	INSTALL FLIGHT MONITORING I/F'S								
A.2.31.1.5	POSITION CRANE				X				
A.2.31.1.6	POSITION ORBITER HANDLING EQUIPMENT OVER ORBITER				X				
A.2.31.1.7	ATTACH ORBITER HANDLING EQUIP				X				
A.2.31.1.8	INGRESS GROUND CREW				X				
A.2.31.1.9	POWER UP ORBITER	X							
A.2.31.1.10	ESTABLISH TWO-WAY COMM	X			X				
A.2.31.1.11	LIFT ORBITER UNTIL WHEELS CLEAR				X				
A.2.31.1.12	POWER UP ORBITER HYD SYSTEM	X							
A.2.31.1.13	RETRACT LANDING GEAR	X							
A.2.31.1.14	VERIFY GEAR UP & LOCKED	X							
A.2.31.1.15	POWER DOWN HYD SYSTEM	X							
A.2.31.1.16	POWER DOWN ORBITER	X							
A.2.31.1.17	LIFT ORBITER TO MATING POSITION				X				
A.2.31.1.18	CONNECT ORBITER/AIRCRAFT MECHANICAL INTERFACES				X				
A.2.31.1.19	DISCONNECT ORB HANDLING EQUIP				X				
A.2.31.1.20	EGRESS ORBITER GROUND CREW				X				
A.2.31.1.21	CLOSE CABIN HATCH				X				
A.2.31.1.22	PERFORM FERRY FLIGHT				X				

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.31 FERRY OPERATIONS (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.31.2	FERRY TO ORBITER CONFIGURATION OPERATIONS								
A.2.31.2.1	POSITION EMERGENCY EQUIPMENT				X				
A.2.31.2.2	POSITION ORBITER REMOVAL GSE				X				
A.2.31.2.3	POSITION FERRY A/C FOR ORBITER REMOVAL				X				
A.2.31.2.4	POSITION ACCESS STANDS				X				
A.2.31.2.5	REMOVE CABIN HATCH				X				
A.2.31.2.6	INGRESS GROUND CREW				X				
A.2.31.2.7	ESTABLISH 2-WAY COMMUNICATIONS	X			X				
A.2.31.2.8	POSITION CRANE FOR ORBITER REMOVAL				X				
A.2.31.2.9	POSITION ORBITER HANDLING EQUIPMENT OVER ORBITER				X				
A.2.31.2.10	ATTACH ORBITER HANDLING EQUIP				X				
A.2.31.2.11	DISCONNECT ORB/AC MECH I/F'S				X				
A.2.31.2.12	LIFT ORB FROM A/C				X				
A.2.31.2.13	POWER UP ORBITER	X							
A.2.31.2.14	POWER UP HYD	X							
A.2.31.2.15	VERIFY HYD PRESSURE	X							
A.2.31.2.16	LOWER LANDING GEAR	X							
A.2.31.2.17	VERIFY LANDING GEAR DOWN & LOCKED	X							
A.2.31.2.18	TURN HYD OFF	X							
A.2.31.2.19	POWER DOWN ORBITER	X							
A.2.31.2.20	LOWER ORBITER TO GROUND				X				
A.2.31.2.21	DISCONNECT ORBITER HANDLING EQUIPMENT				X				
A.2.31.2.22	CONNECT GROUND POWER EQUIPMENT				X				

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.32 RECYCLE LAUNCH FACILITIES & SUPPORT EQUIPMENT

FUNCTION NO.	FUNCTION	ALLOCATION: ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	REMARKS
A.2.32.1	PERFORM GSE & FACILITY MAINTENANCE					X	PROVIDE CONTROL MONITOR & MANAGEMENT OF PADS A & B	VOL. X 3.2.2.2.6	
A.2.32.2	DEACTIVATE GROUND SYSTEM					X	MONITOR & CONTROL		
A.2.32.2.1	DEACTIVATE PAD DELUGE/FLAME BUCKET WATER					X	TERMINATE SEQUENCE CONTROL; MONITOR CUTOFF		
A.2.32.2.2	DEACTIVATE TOWER UMBILICAL ARMS PURGE					X	MONITOR & CONTROL		
A.2.32.2.3	POWER DOWN LAUNCH CONTROL & INSTR SYSTEM					X	MONITOR SYS PERFORMANCE & STATUS; TERM POWER; MONITOR DEACTIVATION		
A.2.32.3	SECURE GROUND SYSTEMS					X	MONITOR & CONTROL		
A.2.32.3.1	SECURE & SAFE EQUIPMENT ON LAUNCH PAD					X	MONITOR & SUPERVISE; CONTROL PAD INST. SYSTEM		
A.2.32.3.1.1	SAFE NONESSENTIAL PAD SYSTEMS					X	DEACTIVATE POWER, PROVIDE COORDINATION & CONTROL		
A.2.32.3.1.2	SAFE & SECURE PAD FLUID DISTRIBUTION SYS					X	TERMINATE AUTOMATIC CONTROL; MONITOR CUTOFF, PRESSURE, SPILLAGE, LEAK DETECTION		
A.2.32.3.1.3	SECURE CREW ESCAPE SYSTEM					X	CONTROL/MONITOR EGRESS ELECT SYS DEACTIVATE FAILURE ALARMS; SECURE EGRESS ARM		
A.2.32.3.1.4	SECURE UTILITIES					X	MONITOR & CONTROL		
A.2.32.3.1.5	OPEN PAD AREA				X	X	ACTIVATE PAD CLEAR ALARM; MONITOR GROUND ACTIVITY IN PAD AREA		
A.2.32.3.1.6	RELOCATE FLAME DETECTOR				X	X	MONITOR RELOCATION ACTIVITY		GROUND CREW ACTIVITY
A.2.32.3.2	SECURE & SAFE ANCILLARY SYSTEMS					X	MONITOR & CONTROL		
A.2.32.3.2.1	SECURE LCC SUPPORT					X	MONITOR & CONTROL		
A.2.32.3.2.2	SECURE CIF TO LAUNCH PAD SUPPORT					X	DEACTIVATE LCC-PAD UMBILICALS & LCC-PAD RF TRANSMITTER		
A.2.32.3.2.3	SECURE RANGE SUPPORT					X	TERMINATE REQUIRED MISSION TRANSMISSION		
A.2.32.3.2.4	SECURE GROUND RESCUE & FIRE-FIGHTING SUPPORT				X				
A.2.32.3.3	SECURE & SAFE SYSTEMS ON MOBILE LAUNCHER PLATFORM				X	X	MONITOR; PROVIDE CONTROL & REF. DATA AS REQUIRED		
A.2.32.3.3.1	SECURE DECK QUENCH & COOLING WATER				X	X	CNTL COOLING WATER CUTOFF & DRAIN MONITOR CUTOFF, PRESSURE FLOW RATE		
A.2.32.3.3.2	SAFE/SECURE MLP FLUID DISTRIBUTION SYSTEMS					X	DEACTIVATE PWR, ENSURE PAD CLEAR, CNTL VALVE SHUTDOWN, MONITOR PRESSURE, LEAK DETECTION ISSUE CLEAR NOTICE WHEN SAFED		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.32 RECYCLE LAUNCH FACILITIES & SUPPORT EQUIPMENT (CONT'D)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.2.32.3.3.3	VERIFY INDUST. SYSTEM OPERATIONAL					X	MONITOR & CONTROL DISPLAY STATUS	VOL. X 3.2.2.2.6	
A.2.32.3.3.4	SECURE SE ON MLP				X	X	MONITOR		PERFORMED BY GROUND CREW
A.2.32.3.3.5	SAFE/SECURE SSV ACCESS EQUIPMENT				X	X	MONITOR & CONTROL		
A.2.32.3.3.6	REPAIR FOR SAFE ACCESS				X	X	ISSUE CLEAR WARNING WHEN SAFE		
A.2.32.4	PERFORM INSPECTION				X	X	MONITOR/RECEIVE & PROCESS STATUS		
A.2.32.5.	PERFORM SE FAULT VERIFICATION ISOLATION					X	CONTROL & MONITOR STATUS; RECORD RESULTS		
A.2.32.5.1	PERFORM TEST TO VERIFY FAULT					X	CONTROL & MONITOR STATUS; RECORD RESULTS		
A.2.32.5.2	CONDUCT DETAILED TROUBLE ANALYSIS				X	X	PROCESS DATA, DISPLAY RESULTS, PERFORM HISTORICAL DATA RETRIEVAL		CCDS TO ASSIST IN TROUBLESHOOTING
A.2.32.5.3	ISOLATE FAULTY ITEM					X	PERFORM FAULT ISOLATION		
A.2.32.6	PERFORM SE SERVICING				X	X	MONITOR; STATUS		REPAIR DONE REMOTE FROM CCDS
A.2.32.6.1	CLEAN, OIL, GREASE, ALIGN & PRESSURIZE				X	X	RECEIVE STATUS & MAINTENANCE PERFORMANCE		
A.2.32.6.2	REPLACE TIME COMPLI. ITEMS				X	X	RECEIVE STATUS & MAINTENANCE PERFORMANCE		
A.2.32.6.3	PERFORM & FUNCTIONAL CHECKOUT & VALIDATE					X	MONITOR & CONTROL; DISPLAY RESULTS		
A.2.32.6.4	LOAD VEHICLE FLUIDS IN SE STORAGE TANKS					X	CNTL & MON PRESSURE, FLUID RATE, TEMP, TANK CAPACITY & SHUTOFF		
A.2.32.7	PERFORM PAD SERVICING				X	X	RECEIVE STATUS; RCD MAINTENANCE		
A.2.32.8	PERFORM CRAWLER TRANSPORTER SERVICE, REPAIR & REFURBISHMENT				X	X	RECEIVE STATUS; RCD MAINTENANCE		
A.2.32.9	REFURBISH MOBILE LAUNCHER				X	X	RECEIVE STATUS; RCD MAINTENANCE		
A.2.32.9.1	PERFORM PRE-ERECTION CHECKOUT					X	PROVIDE AUTOMATIC CONTROL, MONITOR & MANAGEMENT		
A.2.32.10	PERFORM SE REPAIR & VALIDATE				X	X	PERFORM VALIDATION TESTS		
A.2.32.10.1	PERFORM LEAK FUNCTIONAL CHECKOUT FOR VALIDATION					X	PROVIDE AUTOMATIC CONTROL, MONITOR & MANAGEMENT		
A.2.32.11	PREPARE FACILITIES FOR SE MATING				X	X	MONITOR COMPLETION		
A.2.32.12	MATE MLP & CRAWLER TRANSPORTER				X	X	RECEIVE STATUS & MAINTENANCE PERFORMANCE		
A.2.32.13	EMPLACE SSV/LAUNCHER ON PAD				X	X	RECEIVE STATUS		
A.2.32.14	PERFORM TURNAROUND MAINTENANCE OPERATIONS				X	X	PROVIDE OPS MANAGEMENT SUPPORT		

*MANUAL, FACILITIES, GSE AND SE

MODULE: A.2.33 OFF PAD OPERATIONS (DOD AT KSC)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II** REFERENCE	
A.2.33.1	ESTABLISH PAYLOAD SECURITY	X		X	X	X	PROVIDE OPS MANAGEMENT SUPPORT		SECURE ORBITER
A.2.33.1.1	PURGE CLASSIFIED DATA FROM COMPUTER MEMORY	X				X	INITIATE SOFTWARE FOR DESTRUCTIVE READOUT		
A.2.33.1.2	DUMP PAYLOAD DATA	X		X	X	X	RECEIVE PAYLOAD DATA		DUMP FLIGHT DATA
A.2.33.2	LANDING AREA CONTINGENCY			X	X				CONTINGENCY ONLY
A.2.33.2.1	REMOVE HAZARDOUS OR CLASSIFIED PAYLOAD	X		X	X				
A.2.33.2.2	TRANSPORT PAYLOAD TO SECURE POSTFLIGHT FACILITY			X	X				
A.2.33.2.3	RELEASE SECURITY MEASURES				X				
A.2.33.3	ORBITER PROCESSING FACILITY								NOMINAL PROCEDURES
A.2.33.3.1	SECURE TOW TO OFF				X				
A.2.33.3.2	REMOVE PAYLOAD	X		X	X				
A.2.33.3.3	TRANSPORT PAYLOAD TO SECURE POSTFLIGHT FACILITY			X	X				
A.2.33.3.4	REMOVE PAYLOAD SECURITY				X				
A.2.33.4	CRYPTOGRAPHIC EQUIPMENT HANDLING								SECURE SERVICE AREA
A.2.33.4.1	CRYPTOGRAPHIC EQUIPMENT REPAIR				X				
A.2.33.4.2	CRYPTOGRAPHIC EQUIPMENT CHECKS	X			X	X	INITIATE & CONTROL PERFORMANCE OF CRYPTO CHECKS		ORBITER SYSTEM CHECKS

*MANUAL, FACILITIES, GSE AND SE
**AF-SAMSO-TR-73-231, VOL. 2, JULY 1973

MODULE: A.2.34 ON PAD OPERATIONS (DOD AT KSC)

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBI-TER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II** REFERENCE	
A.2.34.1	POSITION MPST				X				MOBILE PAYLOAD SERVICE TOWER
A.2.34.1.1	ESTABLISH MPST/ORBITER BAY SEAL				X		CONTROL & MONITOR OPERATION		
A.2.34.1.2	ESTABLISH ENVIRONMENTAL CONTROL AREA								
A.2.34.1.3	ESTABLISH TOWER SECURITY				X				
A.2.34.1.4	OPEN PAYLOAD BAY DOORS	X							
A.2.34.1.5	TRANSFER PAYLOAD PORTER TO PAYLOAD MANIPULATOR	X		X	X				
A.2.34.1.6	INSTALL P/L INTO CARGO BAY				X				
A.2.34.1.7	CONNECT P/L INTERFACE				X				
A.2.34.1.8	SECURE COMMUNICATION SYSTEM	X		X					
A.2.34.1.9	P/L - ORBITER INTERFACE TEST	X		X		X	VERIFY PAYLOAD/ORBITER INTERFACE		
A.2.34.1.10	INSPECT PAYLOAD BAY				X				
A.2.34.1.11	REMOVE AGE SUPPORT				X				
A.2.34.1.12	CLOSE PAYLOAD DOORS	X							

*MANUAL, FACILITIES, GSE AND SE
**AF-SAMSO-TR-73-231, VOL. 2, JULY 1973

MODULE: A.3 PROVIDE OPERATIONS SUPPORT

FUNCTION NO.	FUNCTION	ALLOCATION							REMARKS
		ORBITER	OOS/TUG	P/L	OTHER*	CCDS	CCDS FUNCTION	LEVEL II REFERENCE	
A.3.1	MISSION PLANNING & ANALYSIS					X	SUPPORT MISSION PLANNING & ANALYSIS	VOL. 8 INTRO	
A.3.1.1	LONG RANGE SCHEDULING & ANALYSIS							VOL. 18 5.1.1,	
A.3.1.2	MISSION ANALYSIS & DESIGN							5.1.2	
A.3.2	ONBOARD SOFTWARE DEVELOPMENT & VERIFICATION					X	SUPPORT ONBOARD SOFTWARE DEVELOPMENT & VERIFICATION	VOL. 18 5.1.2	OPERATIONS SUPPORT FUNCTIONS ARE RELATED TO OVERALL SHUTTLE MISSION MANAGEMENT & MISSION PREPARATION & WILL BE SUPPORTED BY CCDS.
A.3.3	FLIGHT CREW & MISSION SUPPORT PERSONNEL TRAINING					X	SUPPORT FLIGHT CREW & MISSION SUPPORT PERSONNEL TRAINING	VOL. 8 INTRO	
A.3.3.1	FLIGHT CREW TRAINING							VOL. 18 5.1.2	
A.3.3.2	MISSION SUPPORT PERSONNEL TRAINING								
A.3.4	SIMULATIONS					X	SUPPORT SIMULATIONS	VOL. 8 INTRO	
A.3.4.1	FLIGHT CREW & MISSION SUPPORT PERSONNEL SIMULATIONS							VOL. 18 5.2.1	
A.3.4.2	PRE-FLIGHT READINESS TESTING							5.2.2	
A.3.4.3	MALFUNCTION ANALYSIS							DOD RQMTS 3.2.1, 4.1.4	
A.3.5	MISSION INFORMATION SUPPORT					X	MISSION INFORMATION SUPPORT	VOL. 18 5.1.1	
A.3.6	PROGRAM RESOURCE SCHEDULING					X	SUPPORT PROGRAM RESOURCE SCHEDULING	VOL. 8 INTRO VOL. 18 5.1.1	

*MANUAL, FACILITIES, GSE AND SE

APPENDIX B

SYSTEMS BASELINE

B.1 GENERAL

For the performance of this study, a baseline for the Orbiter avionics, upper stage, satellite, and Satellite Control Facility (SCF) systems was required. The Orbiter avionics baselines were established as the preliminary design review (PDR) system as amended 1 March 1974; the upper stage characteristics were provided by the USAF Space and Missile Systems Organization (SAMSO); the staellite's Command and Control Data System (CCDS) related characteristics were derived; and the SCF assumed was that currently existing and as modified by planned implementations. The following material summarizes the systems baselines used.

B.1.1 Reference Documents

A. SS-P-0002-100, *Computer Program Development Specification*, Vol. I, Rockwell International Corp., 21 March 1974.

B. MC615-0001, *Computer, General Purpose - Orbiter*, Revision B, Rockwell International Corp.

C. M3W8XMX-4830000, *Requirements and Architecture of the Space Shuttle Operating System*, Intermetrics Inc., 19 July 1973.

D. MJ070-0001-1, *Orbiter/Vehicle CEI Specification*, Part I, Rockwell International, 20 December 1973.

E. *Avionics Requirements/Definition Document*, Vol. 5, Rockwell International, 23 March 1973.

F. 72-L94-001, *IBM System/4 Pi, Model AP-101 Principles of Operation*, IBM Corp., 29 September 1972.

G. *Space Shuttle Orbiter Avionics Software System Analysis Document*, (Draft), IBM Federal Systems Center, Houston, Texas, 1 November 1973.

B.1.1 <u>Reference Documents</u> (Cont'd)

H. SD72-SH-105-4, *Requirements/Definition Document, Instrumentation*, Vol. 5-4, Rockwell International, 18 January 1974.

I. ICD-2-0D034, *Shuttle Communications and Tracking/United States Air Force Interface Control Document*, NASA JSC.

J. *Master Change Record Uniform Number 0164; Orbiter Avionics System Baseline*, Rockwell International, 4 April 1973.

K. SSV74-4, *Orbiter 101 Preliminary Design Review*, Vol. III, Rockwell International, 4 February 1974.

L. SD72-SH-0105-8, *Requirements/Definition Document; Performance Monitor*, Vol. 5-8, Rockwell International, 15 June 1973.

M. MJ070-0001-1, *Orbiter Vehicle End Item Specification for the Space Shuttle System;* Part I, "Performance and Design Requirements," Rockwell International, 20 December 1973.

N. EE8-73-55, *Minutes of the Third Data and Power Systems Panel Meeting;* JSC, 7 March 1973.

O. EJ5-73-85, *Minutes of the Fourth Data and Power Systems Panel Meeting;* JSC, 3 April 1973.

P. *Space Shuttle System Payload Accommodations*, JSC 07700, Vol. 14, 21 December 1973.

Q. SD72-SH-0105, *Requirements/Definition Document, Avionics*, Book 5, Rockwell International, 18 January 1974.

B.2 FLIGHT COMPUTERS AND THEIR INTERFACES

This baseline covers the five onboard flight computers and their interfaces to the remaining avionics subsystems and crew members. The description emphasizes functional level definitions from which ground data systems requirements could be identified or compared for subsequent allocation.

B.2.1 Baseline System Definition. The onboard flight computers and their interfaces are configured as indicated in figure B-1. Specifically, the configuration consists of the Data Processing Subsystem [general purpose computers and their supporting software, shared mass memory (MM's), multiplexer/demultiplexers (MDM's), engine interface units (EIU's)] and two major subsystem interface groups known as the Multifunction CRT Display Subsystem (MCDS) and the data acquisition control and buffer unit (DACBU), which provide crew interfaces and operational instrumentation interfaces, respectively.

B.2.1.1 System Hardware

B.2.1.1.1 General Purpose Computer (GPC). Five identical general purpose computers comprise the major computational facility in the avionics system. Their capabilities include the provision of guidance, navigation and control (GN&C) computations, payload control for the manipulators, payload monitoring and system performance monitoring for the Shuttle Orbiter.

Each GPC consists of two major processing elements: a central processing unit (CPU), and an input/output processor (IOP), with both processors having access to a common memory. Multiple GPC interface configurations are provided as illustrated in figure B-2.

The GPC performs Orbiter operational functions through a combination of automatic and flight crew commanded software sequences stored in memory or input via the IOP. Control of the sequences and external subsystems is effected via command or data transfer controlled by the CPU or IOP.

Some of the major computer design parameters and functions include the following:

- 65,536 bit memory

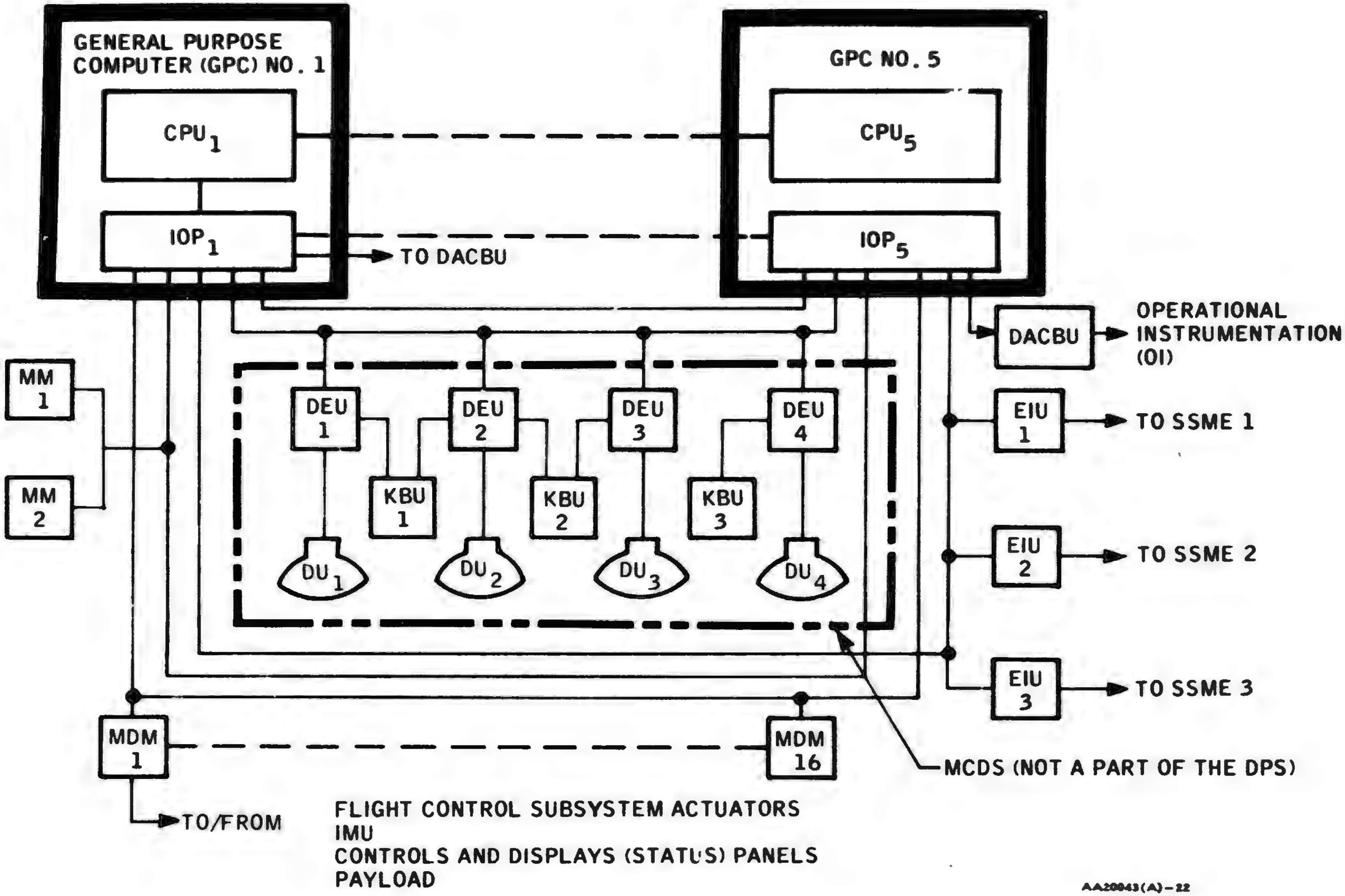


Figure B-1 Data Processing Subsystem and Interfaces

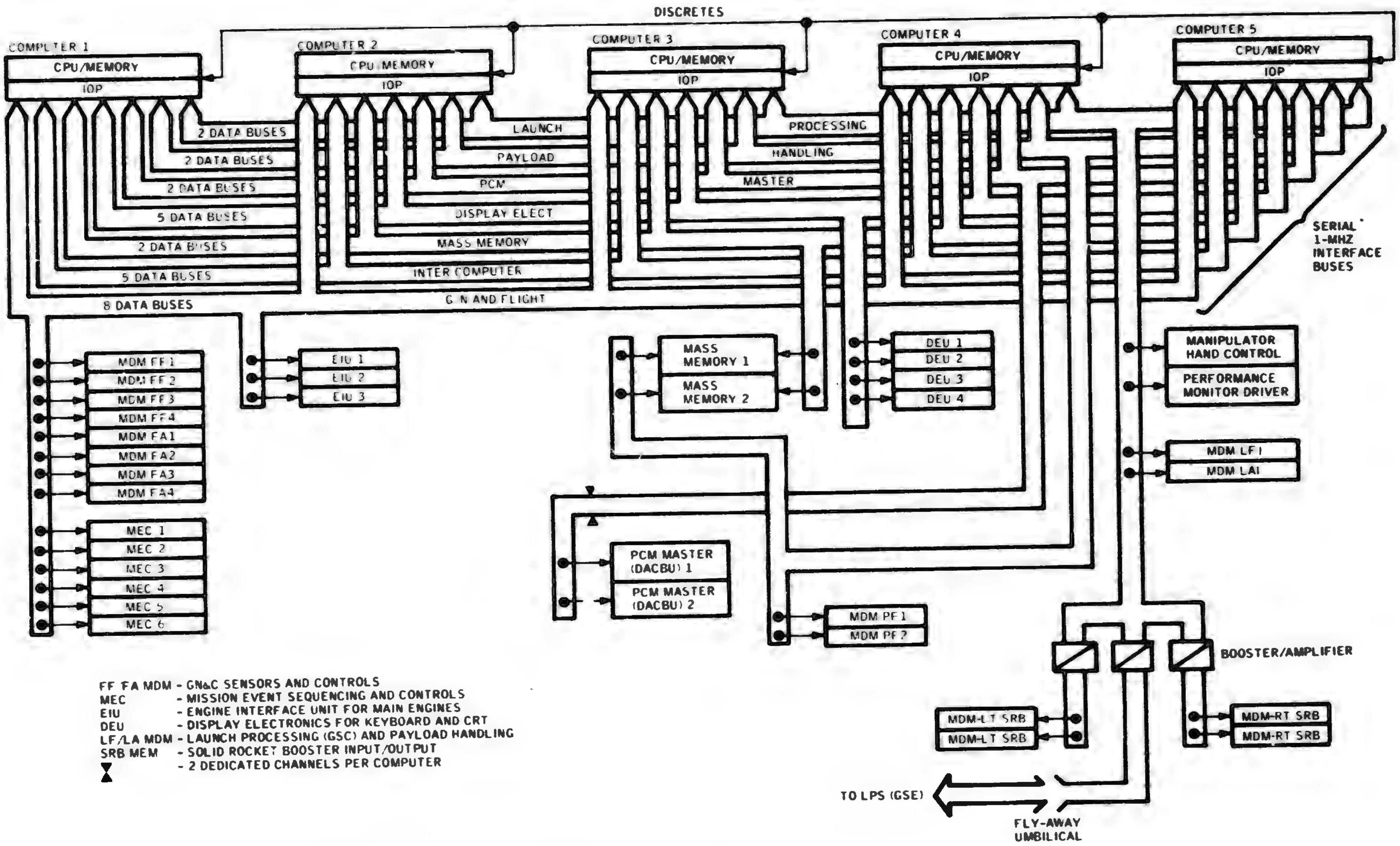


Figure B-2 Multiple Computer Interface Configurations

- 1.050 μs memory cycle time
- Floating and fixed point arithmetic
- 26 I/O ports per GPC
- Built-in test equipment
- Storage protection by memory halfword
- Two real-time clocks
- Interrupt structure (17 priority levels)
- 123 fixed point, 30 floating point and seven special instructions

The GPC provides the following computational capabilities:

- Program-controlled input and output
- Interrupt central control and handling
- Clock synchronization and control
- Instruction execution

The IOP provides central control and interface linkage between the memory and external avionics sybsystems via the 1 MHz serial interface buses. It will also effect the following:

- Direct memory access (DMA) either in a standard or burst mode.
- Discrete input and output capability
- Data Processing Subsystem redundancy management

B.2.1.1.2 Mass Memory (MM). The MM for the Orbiter provides the following storage: display formats and related software, reconfiguration storage for computers, diagnostics, and preflight checkout routines. It has read and write capability.

B.2.1.1.2 Mass Memory (MM) (Cont'd)

The MM is a magnetic tape device which operates as a nonvolatile memory organized to operate in block mode, addressable by block address only.

The MM is capable of operating with the total addressability of 8 × 2048 blocks (eight files) or in a restricted mode limited to any one of the eight files. All blocks are a fixed length, consisting of 512 words. Each word contains 16 bits of data. The total storage capacity is 8,388,608 sixteen-bit words. The MM responds to read requests directed to a starting block address and reads single or multiple blocks.

The MM is capable of writing single or multiple blocks in response to write requests directed to a starting address. Multiple blocks are written in sequence.

The MM interfaces with the primary power and to each GPC via two independent bilateral channels -- one for commands and one for data. The MM responds to read and write requests from both the IOP and ground support equipment (GSE). The access time is 32 seconds worst case, with a time required between adjacent files of 4 seconds. Within a file, the response time is an average of 2 seconds.

The MM consists of the following functional elements:

- Magnetic tape transport and tape
- Read/write electronics
- Transport electronics
- Multiplex interface adapter (MIA)
- Control electronics
- Power converter
- Built-in test equipment and performance monitoring sensors/circuits.

B.2.1.1.3 Multiplexer/Demultiplexer (MDM). The MDM converts and formats data to provide a compatible interface between the computer complex and subsystems. To achieve this interface, the MDM 1) converts analog and discrete vehicle subsystem data to digital serial data for data bus transfer, 2) provides data buffering and format conversion between serial input/output channels, and 3) converts data bus serial data into analog and discrete data for output to the vehicle subsystem. The MDM is a "demand-response" system, performing its functions under control of externally supplied commands. A duplex (redundant) MDM consists of the following:

- Two MIA's
- Two sequence control units (SCU)
- Two analog-to-digital (A/D) modules
- Up to 16 I/O subsystem interface modules
- Two power supplies
- Built-in test equipment (BITE) circuitry

A simplex MDM consists of one each of the above.

The MDM operates under control of external signals in three modes: data transfer between IOP or PCM master unit (DACBU) and the MDM; data acquisition and control between the MDM and vehicle subsystems; and selftest. The MDM is capable of sampling analog, discrete and serial digital signals from the vehicle subsystems on command from the vehicle computers. The MDM is also capable of outputting dc analog signals, discrete signals and serial digital signals to the vehicle subsystems. The MDM is capable of at least three concurrent operations of the following general mix:

- Command and data transfer from IOP to MDM utilizing the data bus
- Response and data transfer from MDM to IOP utilizing the data bus

B.2.1.1.3 Multiplexer/Demultiplexer (MDM) (Cont'd)

- Serial digital I/O channel operation
- Analog-to-digital conversion
- Digital-to-analog data conversion
- Discrete I/O data formatting

B.2.1.1.4 Multifunction CRT Display Subsystem (MCDS). The MCDS (shown in figure B-1) consists of a display electronic unit (DEU), display unit (DU) CRT, and a keyboard unit (KBU). These devices provide the major interface between the crew and the flight computers. The DEU accepts keyboard strokes, performs error-checking functions, displays the characters on the CRT screen, and transmits data to the IOP's upon request from the flight computers. It also receives format and/or dynamic data from the IOP's and causes it to be displayed on the CRT. Each DEU is connected to the IOP's via a half duplex line.

B.2.1.1.5 Data Acquisition Control and Buffer Unit (DACBU). The DACBU provides input interfaces for the purpose of acquiring operational instrumentation (OI) as well as flight control performance data. This data is the source for output through interfaces to the PCM telemetry downlink, loop/maintenance recorders, crash recorder, and a direct hardline link to the Launch Processing System. The DACBU also provides the source for subsystem performance data to implement systems management operations. Two identical DACBU's are provided for redundancy purposes.

B.2.1.2 System Software. The flight computer software shall provide capabilities for GN&C, system performance monitoring, payload management, payload handling, and selected ground functions.

The software accepts input commands and/or data from crew, onboard sensors, and/or external sources; performs computations and processing; and generates output commands and data as necessary to accomplish the requirements specified by major functional elements in the following paragraphs.

B.2.1.2.1 <u>Flight Computer Operating System (FCOS)</u>. The FCOS provides other onboard or ground-based computer programs with the capability to sequence and time the computer program functions, controls the data processing interface between the computer program and other subsystems, detects and isolates computer malfunctions, and initiates or restarts the computer program.

A. <u>Program Sequencing and Timing Function</u>. The FCOS provides the capability to accomplish the following tasks:

- Establish and maintain system mode/mission phase indication
- Provide proper function sequencing
- Supervise input/output (I/O) operations
- Respond to computer and program generated interrupts
- Maintain synchronization as required
- Provide internal timing data
- Establish and maintain system real-time clocks.

B. <u>Computer Malfunction Processing Function</u>. In conjunction with special hardware logic, the FCOS provides the capability to detect and isolate computer malfunctions. Self-test routines are provided to augment the hardware BITE and are operated periodically to determine the status of the computer. This function also provides error recovery routines to allow continued operations following a recoverable error or to logically remove the failed computer from the operating set. The crew is notified of all errors. Malfunction isolation is provided to the level required for error recovery.

C. <u>System Initiation and Restart Function</u>. The FCOS provides the capability to initiate software operations following program load either externally or from the mass memory. It also provides those services necessary to restart the program after processing interruption.

B.2.1.2.1 Flight Computer Operating System (FCOS) (Cont'd)

D. Crew/Ground Interface Control Function. The interface control function provides all software functions required to prepare input data for use by other functions of the program and prepare program generated data for output to the other subsystems. This function monitors all keyboard entries and accepts or rejects the information based on the validity of the entry. If the information is rejected, the crew is notified of the reason for rejection. Crew override is provided. These services are provided for inputs from the crew keyboards, telemetry (TM) uplink GSE, manual flight controls, GN&C Subsystem, other computers and mass memory, and for outputs to the crew displays, TM downlink, GN&C Subsystem, other computers and mass memory controller. The software functions or services include at least:

- Capability to accept manual control inputs for all flight phases for all flight control functions
- Providing display of data entered via a keyboard at the associated CRT for crew verification
- Providing backup displays via the Display and Control Subsystem CRT's for dedicated flight instruments in event of failure of these instruments
- Providing means of transferring control mode authority from auto to manual to auto with acceptable transients for those mission phases where both modes are available
- Capability to accept state vector updates and other mission and vehicle related data from the ground via data link communication
- Providing GN&C Subsystem data to the telemetry system for recording and/or transmission to external destinations
- Providing crew override commands to the Communications and Tracking Subsystem for antenna selection.

B.2.1.2.1 Flight Computer Operating System (FCOS) (Cont'd)

E. Guidance, Navigation, and Control (GN&C). The GN&C program provides the data processing capabilities necessary to perform the executive interface, guidance, navigation, control, GN&C performance monitor, and redundancy management functions in support of the GN&C performance requirements to accomplish at least the following items.

- Vehicle stablization and control throughout ascent, orbital, entry and landing flight regimes
- Capability for automatic and manual start, stop, and thrust vector control commands to the main engines and orbital maneuvering subsystem
- Current abort solutions at all times after launch.
- Capability to coarse align and automatically fine align the primary attitude reference
- Automatic reconfiguration as required by time critical failure modes of the GN&C system upon detection of any time critical failures, with manual reconfiguration override capability
- Calibration and compensation of inertial reference sensors
- Capability to accept and process air data as required during all atmospheric flight phases
- Automatic sequence and command for all mission sequences except rendezvous and docking with manual override and verification capability
- Attitude control stability of the rigid-aerodynamic modes, aeroelastic modes and fluid slosh modes.

The functions required to accomplish these requirements are described in the following paragraphs.

1. Guidance. The guidance functional element generates guidance command data as a function of mission phase, crew commands, vehicle state, and mission profile. This includes abort targeting and steering.

B.2.1.2.1 Flight Computer Operating System (FCOS) (Cont'd)

2. Navigation. The navigation functional element establishes and maintains state vector and attitude data based on data received from the GN&C navigation sensors, ground provided updates, and a model for gravity and atmospheric forces. It also provides sensor torquing data, position feedback data, and search area information, and the guidance functional element with communication antenna pointing information.

3. Control. The control functional element generates outer loop control commands, based on attitude and guidance steering data, and inner loop control commands, based on air data and rate sensors. It provides the capability of generating commands for thrust vector control (TVC), main engine (ME) throttle control, reaction control system (RCS) control, aerosurface control, and sequencing controls as required by the mission phase.

4. Performance Monitoring. The GN&C performance monitor functional element provides the capability to monitor the status of GN&C Subsystem data including that used in GN&C computations. The crew is notified of out-of-tolerance conditions.

5. Redundancy Management. The input redundancy management functional element provides the capability to monitor the redundant data from GN&C sensors and select the best available data for subsequent processing by the other functional elements.

F. Systems Management. The systems management program provides the data processing capability necessary to passively monitor the performance of the non-GN&C Subsystem in support of the following instrumentation subsystem performance requirements.

- Vehicle subsystem performance monitoring and function execution monitoring

B.2.1.2.1 Flight Computer Operating System (FCOS) (Cont'd)

- Capability for CRT display of performance parameters and processed data
- Continuous assessment of the status/health of onboard subsystems during prelaunch and flight phases to the functional path level
- Subsystem status display by functional path groups
- Display of critical vehicle configuration functions, e.g., status of external doors and hatches, external tank (ET) and solid rocket booster (SRB) separation mechanisms, excessive temperatures of selected substructure locations, etc.
- Capability to perform onboard system checkout when practicable, including end-to-end checks
- Control capability to record significant data prior to, during, and after the occurrence of a functional path failure.

The functions required to accomplish these requirements are described in the following paragraphs.

1. Monitor Functional Element. The monitor functional element provides the capability to determine the system configuration and monitor mode, select a subset of the input data for processing, determine the type of test to be performed, establish the test criteria, and perform the tests.

2. Configuration and Mode Determination. The configuration and mode determination function has access to sufficient data, either from discrete or keyboard inputs, to determine the system configuration and the monitor mode.

3. Data and Test Selection. The data selection function provides the capability to select a predefined subset of the input data for processing and establish the type of test required for each parameter. This selection is

B.2.1.2.1 Flight Computer Operating System (FCOS) (Cont'd)

based on the system configuration and monitor mode established by the configuration and mode determination function.

4. Performance Test. The performance test function provides the capability to establish the test criteria for each parameter, selected by the data and test selection function, and to perform the required test. Provisions are made to verify out-of-tolerance results to minimize false alarms. Verified out-of-tolerance conditions result in crew notification.

G. Payload Management. The payload management program provides the data processing capabilities necessary for command, control, and monitoring of payloads and for checkout of the electronic interface with the payload. This includes the capability to display payload parameters in real-time to the Mission Specialist Station (MSS) and to provide the payload with Orbiter vehicle state vector, attitude, GMT, and mission elapsed time. It selects one of 20 RF channels for payload communications and provides proper COMSEC configuration or bypass.

H. Payload Handling. The payload handling program provides the data processing capabilities necessary to control the movement of the payload manipulator arms in response to manual commands received from the crew or automatic commands contained in prestored data describing a predetermined path and rate. Manual override capability is provided in the automatic mode. It further provides the capability to check out and passively monitor the payload status. These capabilities are provided in support of the payload retention and deployment performance requirements.

B.2.1.3 User Input Identification. A user is defined as a person or other source of input of the Flight Software which causes it to do work. Three classes of users, or input sources, have been identified for this system: crew, sensors, and ground.

B.2.1.3.1 Crew Members. Crew members interface with the flight software, primarily via the CRT displays and keyboards, in order to control, monitor and supervise the Shuttle mission and Orbiter.

B.2.1.3.1 Crew Members (Cont'd)

A cluster of three CRT's and two keyboards in two forward flight stations provide for the operation of the Orbiter by a two-man flight crew and the safe return of the Orbiter by one crewman in an emergency. A CRT display and keyboard at the MSS provides for the monitoring of Orbiter Subsystem performance.

Crew inputs of data entry, display requests, and commands are made for the following purposes:

- Selection and control of automated sequences and events
- Crew override of automated critical command functions
- Entry or overlay of selected mission data
- Command for the transfer of one CRT display to another CRT
- Requests for mission phase related information, system related information and critical data
- Requests for data solutions and supervisory messages related to programs and other data available in main storage
- Initiation of processing with a flight computer
- Configuration management decisions.

B.2.1.3.2 Sensor Input. Sensor input is made to the flight software for the purpose of guidance, navigation, and control of the vehicle and for monitoring the status and health of various Orbiter subsystems. Sensors are divided into three general categories: 1) air data sensors; 2) navigation sensors; 3) subsystem measurement data.

Inputs from the manual flight controls are also considered sensor inputs. Depending on the mission phase and the degree of manual control of the vehicle in effect, inputs from the following manual controls can be made to the flight software: 1) rotation hand control; 2) translation hand control; 3) speed brake hand control; 4) master thrust control; and 5) rudder pedal transducer assembly.

B.2.1.3.3 Ground Uplink Data. Data is uplinked from the ground to the flight software (via the network signal processor which interfaces with an MDM) for the following purposes:

- Flight computer updates
- Time system updates
- Real-time commands
- Payload onboard command encoder updates
- Text and graphics

The data rate for this uplink is 2.0 kb/s of information plus 0.4 kb/s of overhead addressing.

B.3 ORBITER FLIGHT INSTRUMENTATION AND COMMUNICATIONS

B.3.1 Instrumentation Subsystem. The Instrumentation Subsystem consists of transducers, signal conditioning equipment, PCM encoding equipment, frequency multiplex equipment, PCM recorders, analog recorders, central timing equipment, and onboard checkout equipment. A block diagram of the Instrumentation Subsystem is provided in figure B-3.

The operational instrumentation is required to sense and acquire, condition, digitize, format and distribute data for onboard display, telemetry downlink, recording and checkout. The system provides for PCM recording, voice recording, flight log recording and master timing for all onboard systems. Telemetry and recording capability is required during boost, deorbit and landing. During orbit, telemetry and recording coverage is required only on a "snapshot" basis. Real-time data is acquired continuously for performance monitoring, display and vehicle control.

Transducers required for data acquisition will be distributed throughout the vehicle. All other instrumentation equipment, with the exception of SRB instrumentation and ET instrumentation, will be located in either the forward avionics equipment bay or aft equipment bay. Multiplexers and signal conditioning equipment will be installed on the ET and SRB's to reduce the wiring interface to the Orbiter.

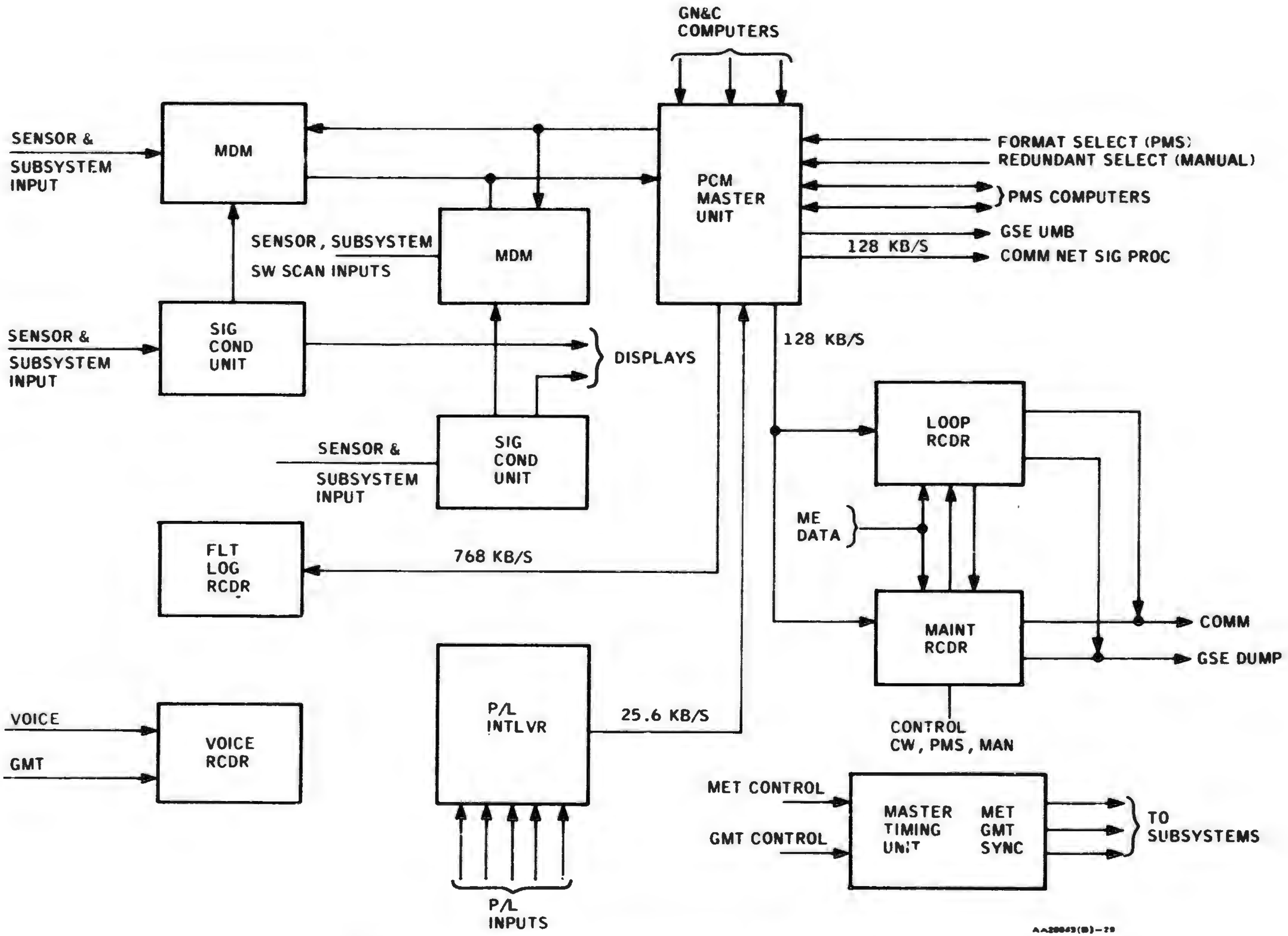


Figure B-3 Instrumentation Subsystem

B.3.1 Instrumentation Subsystem (Cont'd)

Signal conditioning will be time shared as much as possible by preconditioning and low level multiplexing in the PCM remote units (MDM's). Dedicated signal conditioning is provided for continuous measurements for display and for those special signals not easily accommodated for preconditioning.

B.3.2 Equipment Description

B.3.2.1 PCM Master Units. The PCM equipment consists of two switchably redundant PCM master units with the capability to address a number of PCM remote units (MDM's). The PCM master units are stored program, non-destruct, read only memory type, capable of being programmed with several formats selectable by external logic. The data rate baseline is 128 kb/s for telemetry and recording and 768 b/s for flight log data recording. The PCM master units, under internal memory control, acquire data from the MDM's and the payload data interleaver and receive and store data from the onboard computers. The units format and output telemetry data to GSE, to the recorders and to the network signal processor for transmission to the ground.

B.3.2.2 PCM Remote Units. The PCM remote units (MDM's) are under control of the master PCM units. The MDM's sample analog, serial digital and discrete data from vehicle subsystems and convert the subsystem data for data bus transfer to the master PCM units on a demand-response basis.

B.3.2.3 Maintenance Recorder. The maintenance recorder records the 51.2 kb/s data stream from each ME during launch. It records the 128 kb/s telemetry stream from the PCM master unit and records dumps from the loop recorder. The maintenance recorder can be dumped at a 1:1 or an 8:1 rate.

B.3.2.4 Loop Recorder. The loop recorder records the 128 kb/s telemetry stream continuously and is functionally a 5-minute loop recorder. It will, on cue, dump the last 5 minutes of recorded data to the maintenance recorder.

B.3.2.5 Voice Recorder. The voice recorder is a cassette tape capable of recording approximately 6 hours of voice. When one cassette is full it is replaced with an unused cassette. No cassettes are erased or dumped. Timing is recorded for voice-time correlation.

B.3.2.6 Master Timing Unit. The master timing unit contains redundant highly stable oscillators, frequency divider circuits and time accumulators for both GMT and Mission Elapsed Time (MET). The

B.3.2.6 Master Timing Unit (Cont'd)

accumulators may be set and updated and MET may be reset to zero at liftoff. The GMT and MET are a serial time code used for time tagging data, displaying time to the crew, and providing a time reference for the onboard computers and payloads.

B.3.3 Communication and Tracking Subsystem. The Communications and Tracking Subsystem provides for tracking. telemetry, command and voice (TTCV), and payload data transmission compatible with the Space Ground Link Subsystem (SGLS) ground network and the Space Tracking and Data Network (STDN). The dual network compatibility is made possible by transponder switching onboard the Orbiter. The SGLS link accommodates voice and data encryption/decryption for communications security. Air traffic control (ATC) compatible equipment provides navigation, tracking and communication functions when in atmospheric flight. Audio processing and distributing equipment provides onboard intercommunications.

B.3.3.1 Orbital Communications. On-orbit communication with the ground is provided by the direct S-Band PM system. The 128 kb/s operational telemetry data stream, with 16 kb/s of interleaved payload data, is multiplexed with two 32 kb/s digitized voice channels, encrypted, and transmitted to the ground. The PM downlink is shown in figure B-4. The Orbiter receives from the ground an encrypted, multiplexed uplink containing two 32 kb/s digital voice channels and 8 kb/s of encoded command and sync data. The uplink is shown in figure B-5. The Orbiter extracts one-way doppler shift data from the uplinked baseband and provides for baseband turnaround at a ratio of 256/205 for ground two-way doppler extraction. Doppler extraction functional interface is shown in figure B-6.

The wideband direct S-Band FM system provides for downlinking 256 kb/s of attached payload data. The S-Band FM system may be time shared and used for recorder dumps, TV, and ME data. The wideband FM downlink is shown in figures B-7 and B-8.

B.3.3.2 Payload Communications. The Orbiter communicates with attached payloads via hardline and with released payloads through one of 20 dedicated L- and S-Band frequency channels. From both attached and released payloads the Orbiter receives 16 kb/s of telemetry and interleaves this data into the 128 kb/s operational telemetry stream for transmission to the ground. Command capability

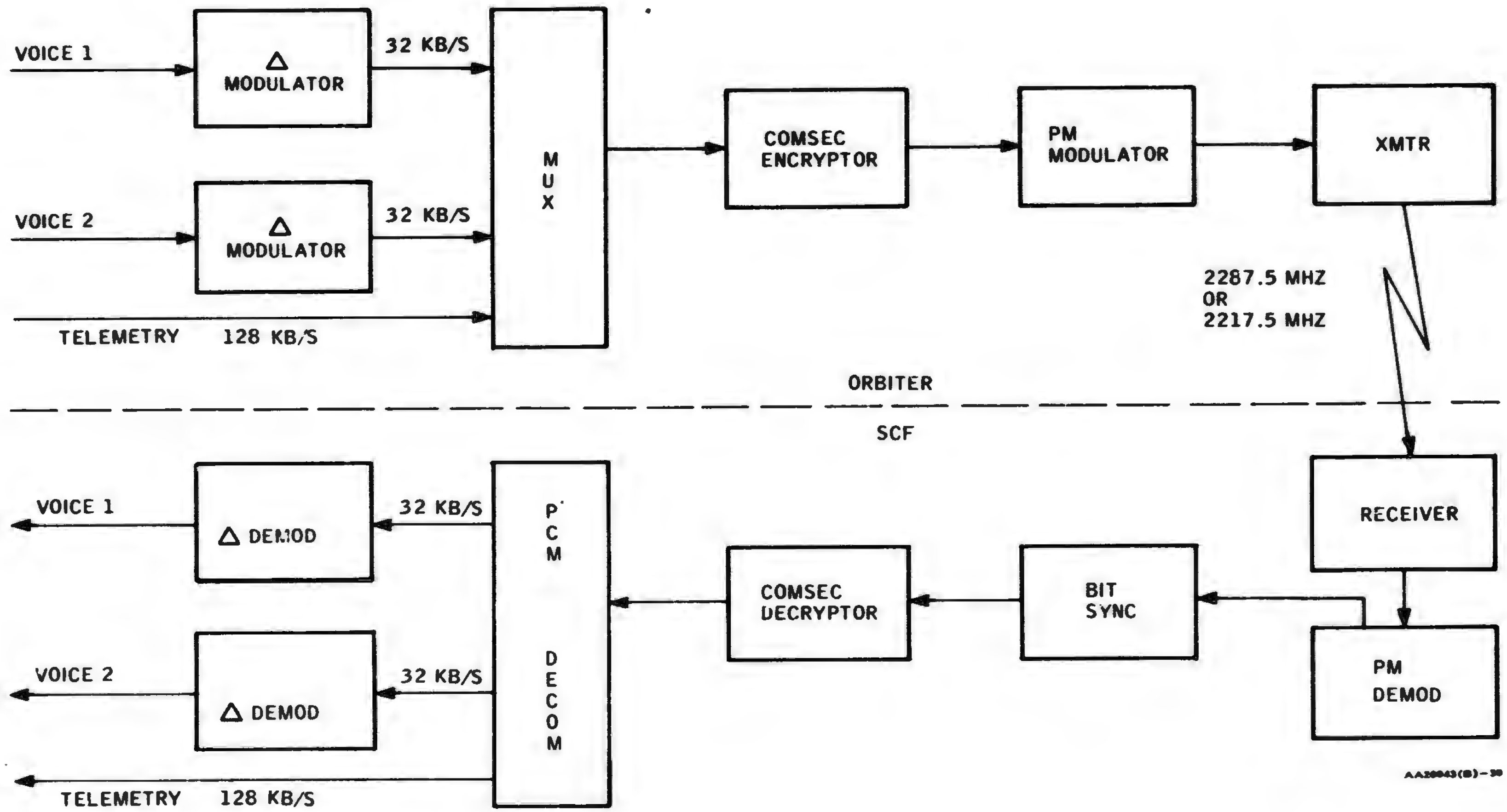


Figure B-4 Orbiter to SCF Direct Downlink (Medium Rate)

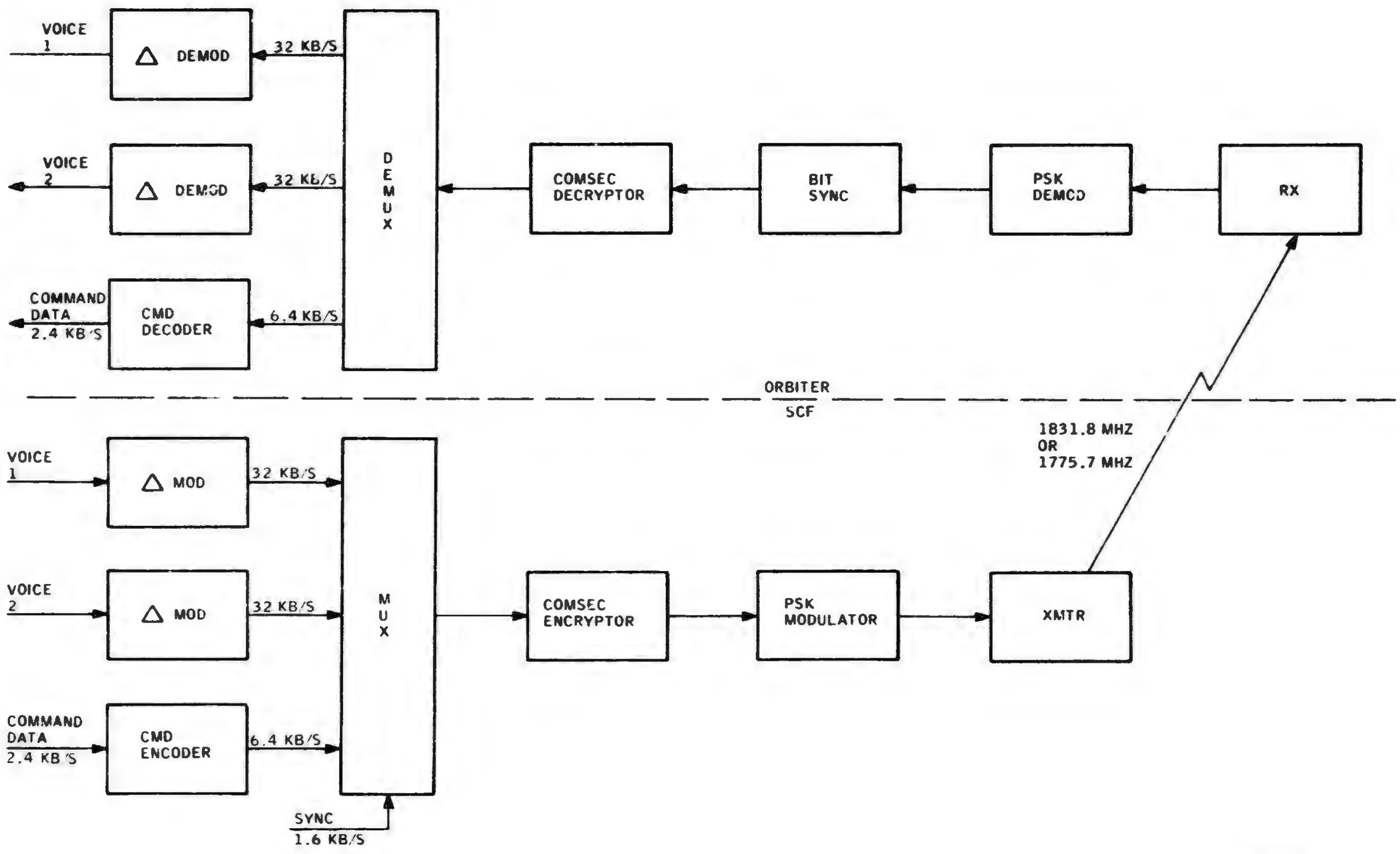


Figure B-5 SCF to Orbiter Direct Uplink

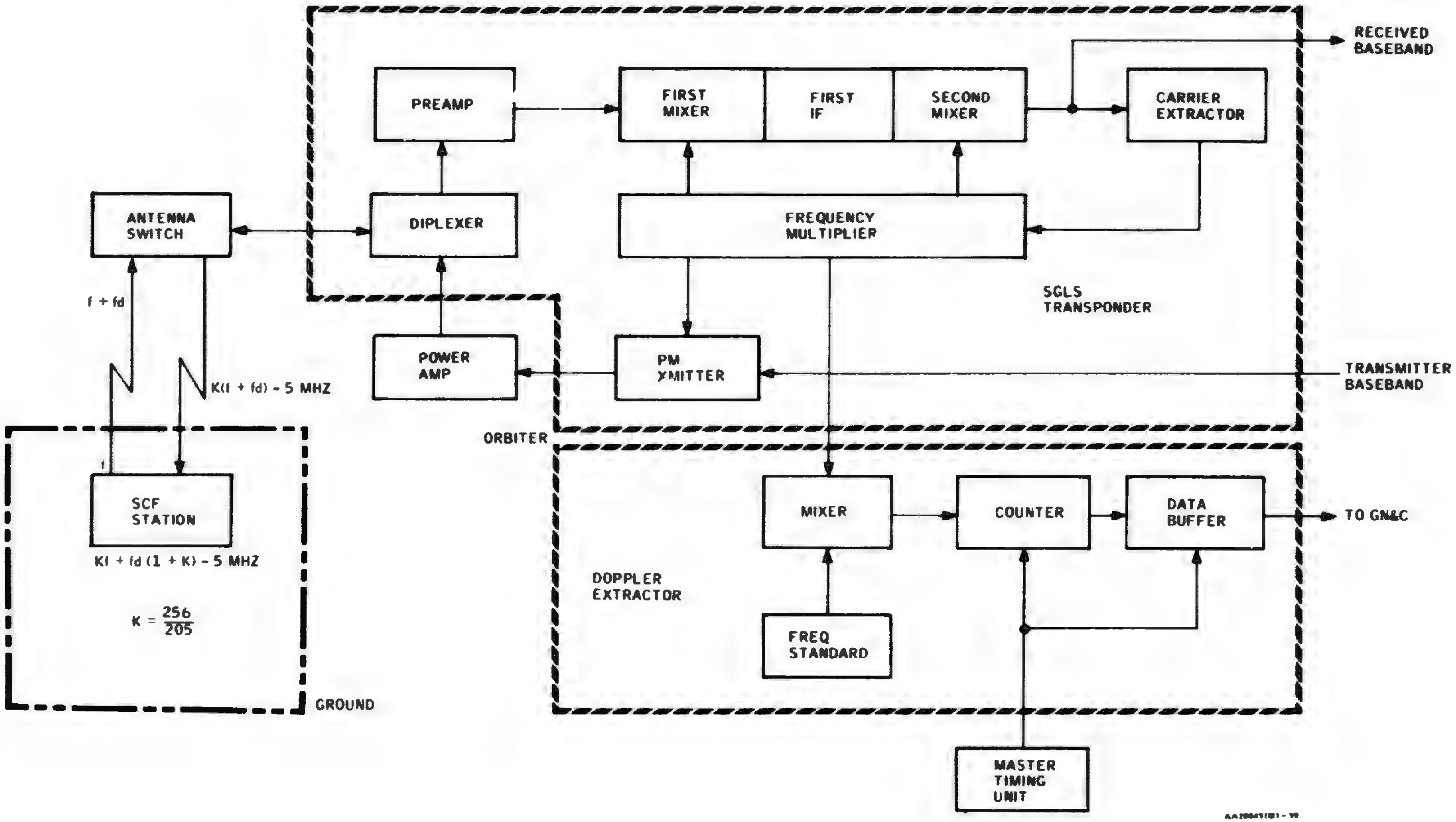


Figure B-6 Doppler Extraction Functional Interface

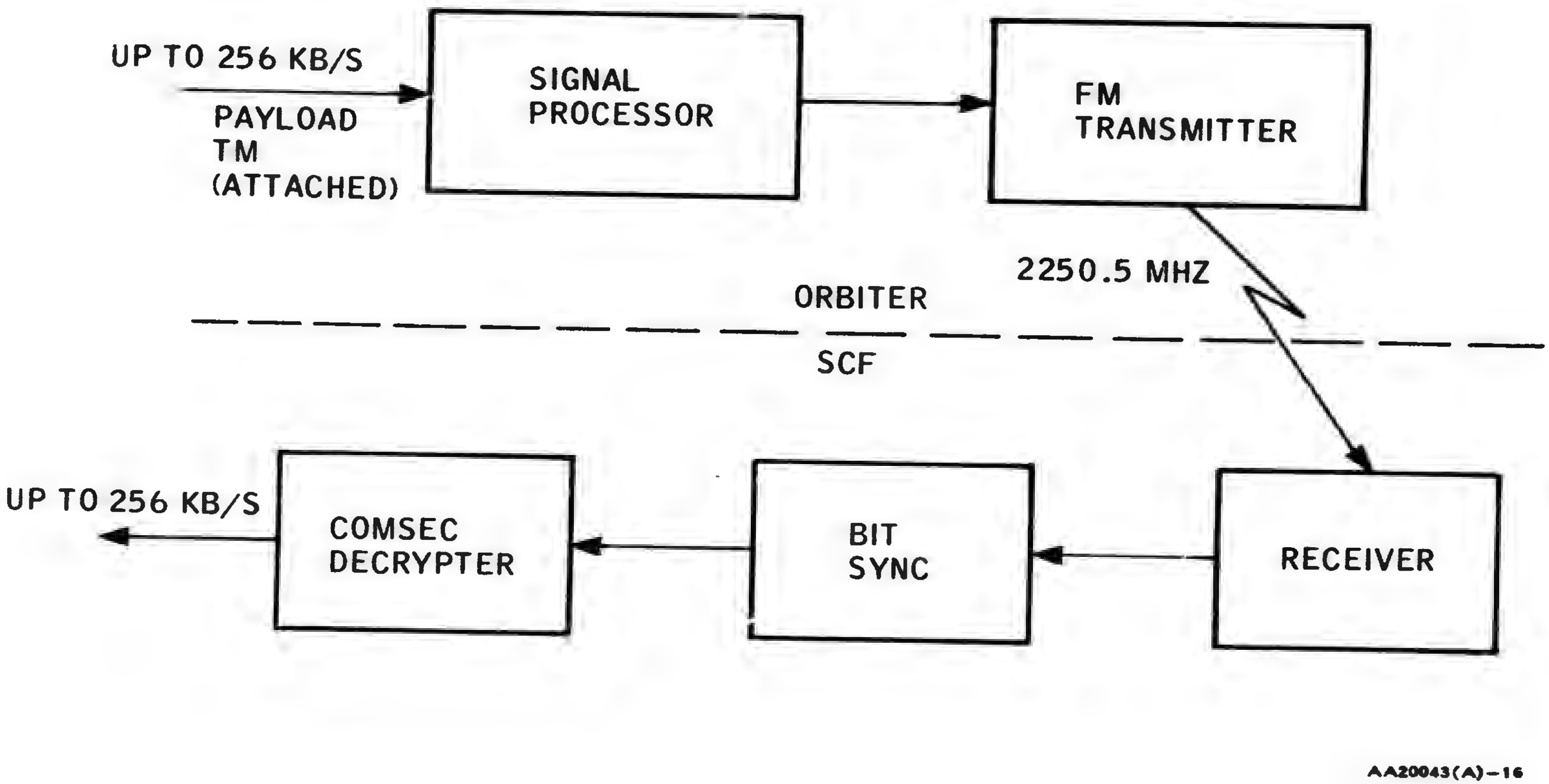


Figure B-7 Orbiter-to-Ground Downlink (Wideband FM)

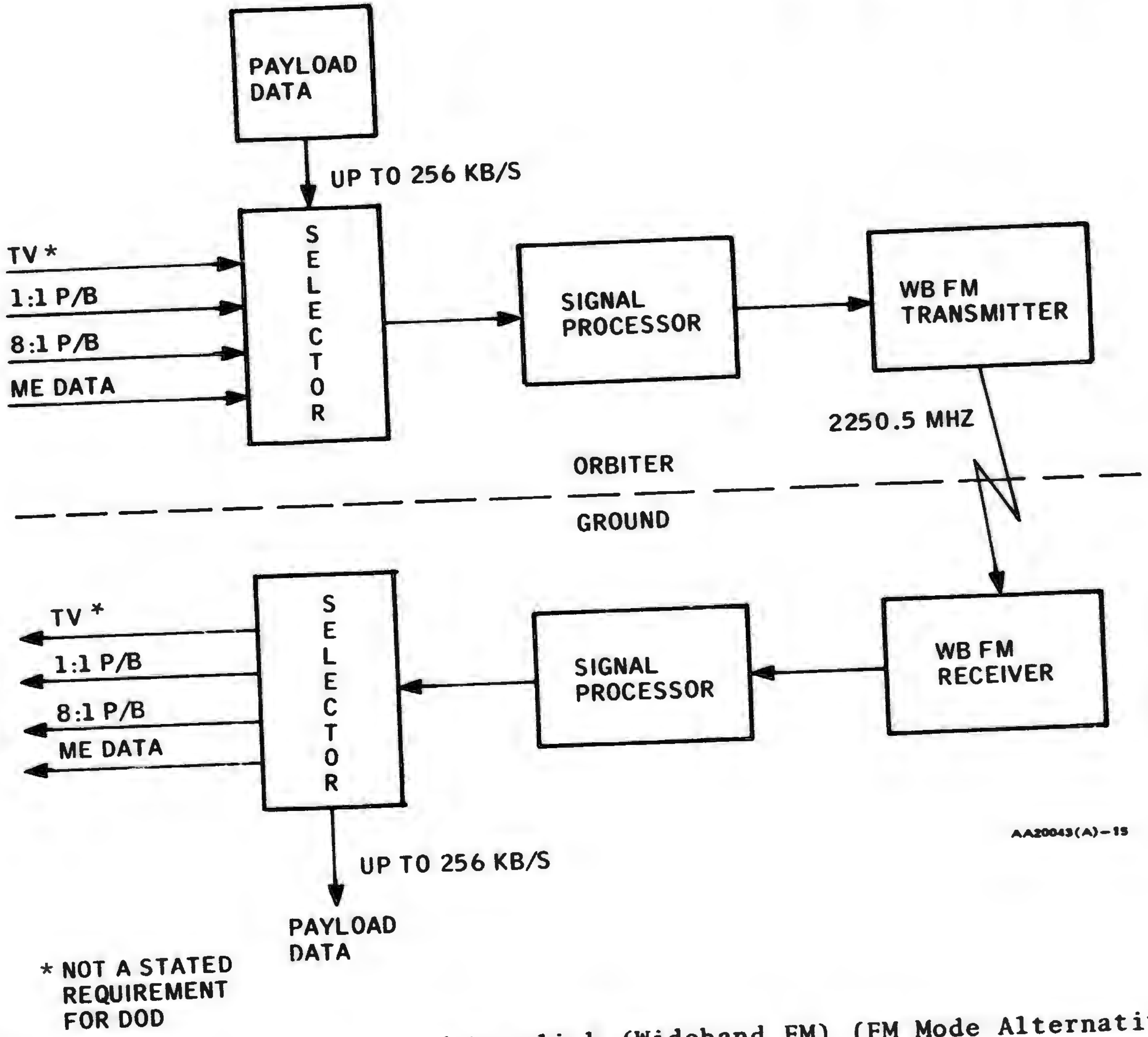


Figure B-8 Orbiter-to-Ground Downlink (Wideband FM) (FM Mode Alternatives)

TABLE B-1

ORBITER TO DOD PAYLOAD

INFORMATION		MULTIPLEXING	MODULATION	CARRIER
CHANNEL	RATE			
COMMAND	1 OR 2K BAUD	TERNARY FSK/AM	TECHNIQUE = PM	TBD
SYNCHRONIZATION	500 CPS OR 1 kHz	FORMAT: NRZ-L TRIANGULAR SYNC	MOD INDEX = 3.0 RADIANS	

TABLE B-2

DOD PAYLOAD TO ORBITER

INFORMATION		SUB-CARRIER FREQUENCY	SUB-CARRIER MODULATION	CARRIER
CHANNEL	RATE			
TELEMETRY	UP TO 16 kb/s	1.024 MHz OR 1.7 MHz	TECHNIQUE = PSK MOD INDEX = 0.3 TO 1.5 RADS FORMAT = NRZ-L	TBD

NOTE: THESE CHARACTERISTICS ARE FOR DETACHED PAYLOADS. DATA RATES ARE THE SAME FOR ATTACHED PAYLOADS EXCEPT DATA TRANSFER IS BY HARDLINE INSTEAD OF RF.

TABLE B-3

ORBITER TO SCF

INFORMATION		MULTIPLEXING	MODULATION	CARRIER
CHANNEL	RATE			
VOICE 1	32 kb/s	TIME DIVISION	TECHNIQUE = PM	2287.5 MHz
VOICE 2	32 kb/s	MULTIPLEX RATE = 192 kb/s	INDEX = 1.1 RADIANS	OR
TELEMETRY	128 kb/s	FORMAT: BI-PHASE-LEVEL		2217.5 MHz

TABLE B-4

SCF TO ORBITER

INFORMATION		MULTIPLEXING	MODULATION	CARRIER
CHANNEL	RATE			
VOICE 1	32 kb/s	TIME DIVISION	TECHNIQUE = PSK	1831.8 MHz
VOICE 2	32 kb/s	MULTIPLEX RATE = 72 kb/s	(SUPPRESSED CAR-RIER)	OR
COMMAND	6.4 kb/s	FORMAT: BI-PHASE-LEVEL		1775.7 MHz
SYNCHRONIZATION	1.6 kb/s			

TABLE B-5

ORBITER TO SCF (WIDEBAND)

INFORMATION		MODULATION	CARRIER DEVIATION	PRE-DETECTION BANDWIDTH	CARRIER
CHANNEL	RATE				
WB PAYLOAD	UP TO 256 kb/s	FM	179.2 kHz	307.2 kHz	2250.5 MHz

B.3.3.2 Payload Communications (Cont'd)

is provided for both attached and released payloads at a 1 or 2K baud rate. The Orbiter to payload interface is shown in figure B-9. There is a capability to transmit up to 256 kb/s of telemetry to the ground from attached payloads utilizing the Orbiter wideband FM transmitter.

The Orbiter rendezvous radar is Ku Band and provides range, range rate, angle and angle rate tracking data by either skin tracking a passive target or beacon tracking an active target equipped with a radar transponder.

B.3.3.3 Atmospheric Communication. During entry, two of three Tactical Air Navigation (TACAN) sets are used for simultaneous distance measurements to two ground TACAN stations. The TACAN equipment provides horizontal position updates to the GN&C Subsystem to correct for inertial system error buildup during entry beginning at approximately 150K feet. TACAN guides the Orbiter to the Microwave Scanning Beam Landing System (MSBLS) at a range of approximately 10 miles. The MSBLS provides azimuth, elevation and slant range data through touchdown. Altitude information is provided by the radar altimeter.

Voice communication to ATC is via UHF. S-Band voice and data communication is available when the Orbiter is in line of sight with ground S-Band stations.

B.4 PERFORMANCE MONITORING SYSTEM (PMS)

The baseline PMS used during this study is described by the following charts and diagrams.

- Performance monitoring characteristics (table B-6)
- Performance monitoring block diagram (figure B-10)
- Performance monitoring functions (table B-7)
- Summary of performance monitoring functional requirements (table B-8)
- Performance monitoring Orbiter/ground interface (figure B-11)
- Open issues (table B-9)

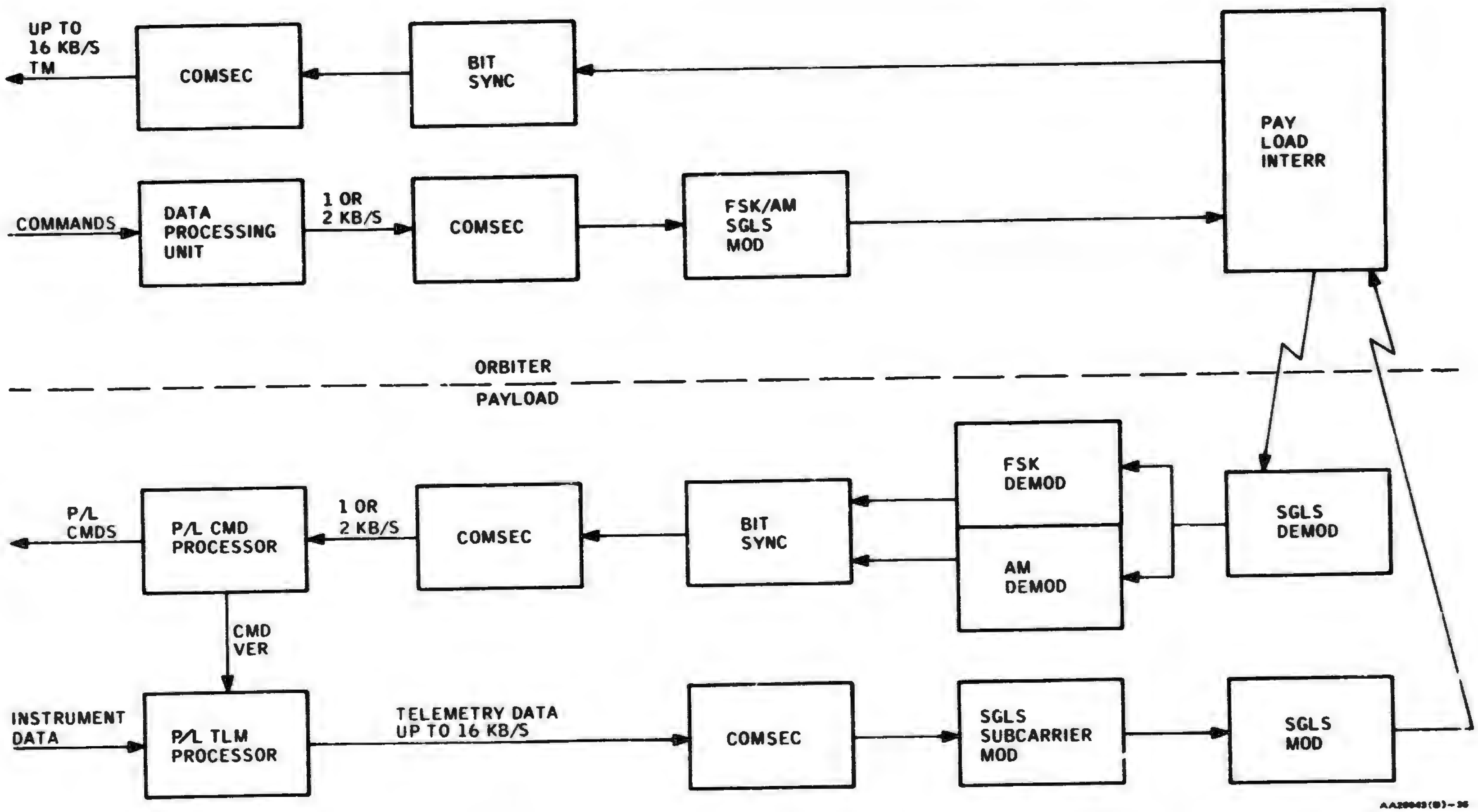


Figure B-9 Orbiter/DOD Payload Interface

TABLE B-6

PERFORMANCE MONITORING CHARACTERISTICS

A. PRIMARILY IMPLEMENTED IN SOFTWARE

B. UTILIZES HARDWARE PROVIDED BY AVIONICS SUBSYSTEM OF

- AVIONICS COMPUTER COMPLEX
- OPERATIONAL INSTRUMENTATION
- DISPLAYS AND CONTROLS

C. AVIONICS COMPUTER SYSTEM PARTITIONED (SOFTWARE) INTO TWO PRIMARY SECTIONS

1. <u>GN&C</u>	
• GN&C ALGORITHMS	TIME-CRITICAL-CLOSED
• SENSOR AND ACTUATOR REDUNDANCY MONITOR AND CONTROL	LOOP AUTOMATIC CONTROL +
• SEQUENCING	NON-TIME-CRITICAL-LOOP CLOSED THROUGH CREW
• GN&C PERFORMANCE MONITORING	
2. <u>SYSTEMS MANAGEMENT</u>	
• OVERALL VEHICLE STATUS (INCLUDING GN&C)	NON-TIME-CRITICAL-LOOP CLOSED THROUGH CREW
• MONITORING OF NON-GN&C SUBSYSTEMS	
• PAYLOAD MONITORING	
• CONSUMABLES MANAGEMENT	

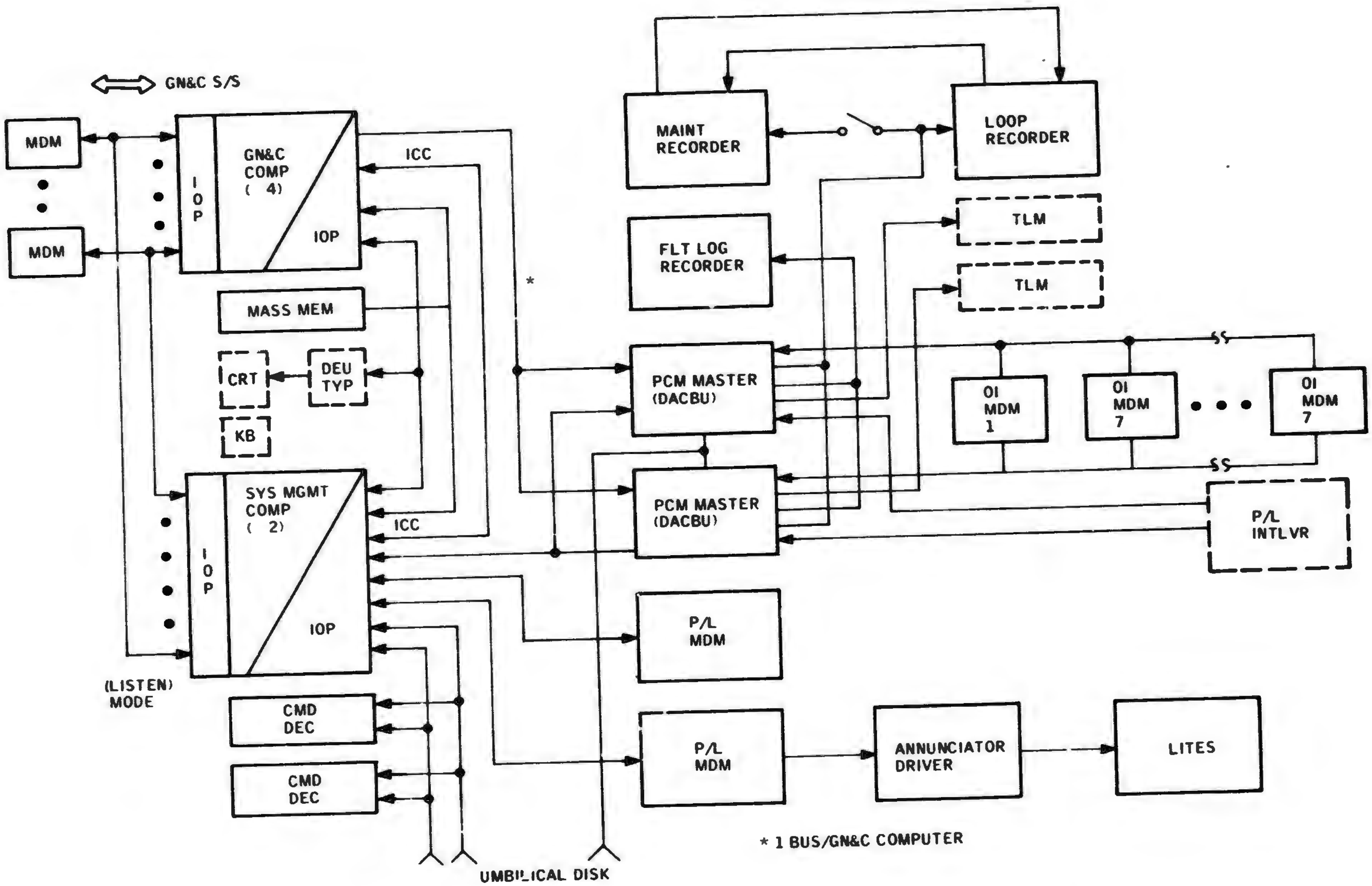


Figure B-10 Performance Monitoring Block Diagram

TABLE B-7

PERFORMANCE MONITORING FUNCTIONS (PMF)

PRIMARY

- AUTOMATIC FAULT DETECTION AND ANNUNCIATION
- SUBSYSTEMS MEASUREMENT MANAGEMENT (CRT DISPLAY)
- SUBSYSTEMS CONFIGURATION MANAGEMENT
- CONSUMABLES MANAGEMENT
- DATA RECORDING MANAGEMENT
- TELEMETRY FORMAT SELECTION
- PAYLOAD SUPPORT

SECONDARY

- MISSION PROFILE STORAGE AND RETRIEVAL
- PERFORMANCE EVALUATION AND TREND ANALYSIS
- CONTINGENCY PLANNING AID

PRIMARY FUNCTIONS TO BE IMPLEMENTED FOR FIRST OPERATIONAL FLIGHT
SECONDARY FUNCTIONS TO BE IMPLEMENTED SUBSEQUENT TO FIRST OPERATIONAL FLIGHT

TABLE B-8

PERFORMANCE MONITORING FUNCTIONAL REQUIREMENTS

FUNCTION	REQUIREMENTS
FAULT DETECTION AND ANNUNCIATION (FDA)	• CONTINUOUS MONITORING OF SUBSYSTEM PERFORMANCE TO FUNCTIONAL PATH LEVEL • ANNUNCIATION OF FAILURE VIA CRT AND ANNUNCIATOR PANEL • PROVIDE CAPABILITY BACKUP FOR CAUTION AND WARNING (C&W) FUNCTION • NON-TIME-CRITICAL REDUNDANCY SWITCHING DONE BY CREW • TIME-CRITICAL REDUNDANCY SWITCHING ACCOMPLISHED AUTOMATICALLY WITHIN SUBSYSTEM • GN&C FAULT DETECTION ACCOMPLISHED WITHIN GN&C PROGRAMS • PAYLOAD FDA DONE WITHIN PAYLOAD MANAGEMENT PROGRAM
SUBSYSTEM MEASUREMENT MANAGEMENT (SMM)	• PROVIDE SUBSYSTEM MEASUREMENT DATA DISPLAY (CRT) • PROVIDE SCALING AND CONVERSION TO ENGINEERING UNITS • FLAG OUT-OF-TOLERANCE PARAMETERS • DISPLAYS ON REQUEST • SUBSYSTEM DATA LIMITED BY ACTIVE DATA ACQUISITION FORMAT • ACCESS BY RELATED GROUPS OF DATA
SYSTEMS CONFIGURATION MANAGEMENT (SCM)	• DETERMINE AND VERIFY VEHICLE SUBSYSTEM CONFIGURATION • DISPLAY CONFIGURATION STATUS TO CREW

TABLE B-8 (CONT'D)

FUNCTION	REQUIREMENTS
SYSTEMS CONFIGURATION MANAGEMENT (SCM) (CONT'D)	• COMPARE ACTUAL CONFIGURATION WITH MODE-REQUIRED CONFIGURATION • SOFTWARE SWITCHING CAPABILITY WITHIN CONSTRAINTS OF PARALLEL SWITCH CONTROL • STATUS PROVIDED ON DEMAND • CREW-INITIATED INPUTS TO IDENTIFY MODE CONFIGURATION • NO AUTOMATIC CLOSED-LOOP REDUNDANCE SWITCHING • PARALLEL SWITCH CONTROL LIMITED TO GROUND OPERATIONS
PAYLOD SUPPORT	• MONITOR PAYLOAD SUBSYSTEMS HEALTH STATUS • MONITOR MEASUREMENTS DEEMED CIRTICAL IN TERMS OF MISSION SAFETY OR SIGNIFICANT IN TERMS OF SHUTTLE VEHICLE FLIGHT CONTROL • INTERFACE WITH PAYLOAD TO CONSIST OF 25 kb/s PCM DATA INTERLEAVED WITH ORBITER OFI DATA FOR TRANSMISSION TO GROUND • ACCOMMODATE VARIABLE PAYLOAD DATA FORMATS • ANNUNCIATION OF ANOMALOUS CONDITIONS DETECTED WITHIN THE PAYLOAD TO BE SAME AS FOR VEHICLE SUBSYSTEMS • PROVIDE THE CAPABILITY TO INITIATE, UPON CREW REQUEST, TRANSMISSION OF COMMANDS/DATA TO THE PAYLOAD AT A RATE OF UP TO 2 kb/s

TABLE B-8 (CONT'D)

FUNCTION	REQUIREMENTS
MISSION PROFILE STORAGE AND RETRIEVAL	• STORE INFORMATION RELATED TO A NOMINAL MISSION TIMELINE • PROVIDE DATA TO THE CREW VIA CRT DISPLAY, UPON REQUEST, FOR USE AS CREW CHECKLIST, CONFIGURATION MANAGEMENT REF, CONSUMABLES MANAGEMENT REF AND INCLUDE THE FOLLOWING: •• SUBSYSTEM CONFIGURATION BY MISSION PHASE •• NOMINAL CONSUMABLES PROFILE •• EVENT SCHEDULES •• NOMINAL VALUES FOR SELECTED MEASUREMENTS BY MISSION PHASE •• ABORT/CONTINGENCY PROCEDURE CUE •• OTHER SELECTED CUES FOR PROCEDURES REQUIRING SPECIFIC SEQUENCING OF EVENTS •• TREND DATA STORAGE
PERFORMANCE EVALUATION AND TREND ANALYSIS	• PERFORM MATHEMATICAL CALCULATIONS ON INFLIGHT MEASUREMENTS TO PREDICT PERFORMANCE AT SPECIFIED POINTS WITHIN THE VEHICLE SYSTEM • MAKE MEANINGFUL PERFORMANCE MEASUREMENTS AT SPECIFIED POINTS WITHIN THE VEHICLE SYSTEM SO THAT A COMPARISON OF ACTUAL AND EXPECTED PERFORMANCE CAN BE EFFECTED • ESTABLISH TREND INFORMATION INCLUDING END-OF-MISSION RESERVES
CONSUMABLES MANAGEMENT (CM)	• MONITOR QUANTITY AND DEPLETION OF CONSUMABLES ASSOCIATED WITH ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS), AUXILIARY POWER UNITS (APU'S), FUEL CELLS, RCS, ORBITAL MANEUVER SUBSYSTEM (OMS), AND EXTRA-VEHICULAR ACTIVITY (EVA) TANKAGES AS A MINIMUM

TABLE B-8 (CONT'D)

FUNCTION	REQUIREMENTS
CONSUMABLES MANAGEMENT (CM) (CONT'D)	• CALCULATE QUANTITY AND DEPLETION RATES OF CONSUMABLES FOR COMPARISON TO NOMINAL MISSION RATES AND DEPLETION PREDICTIONS • ANNUNCIATE DIVERGENT TRENDS OF CONSUMABLES AND PROVIDE CONSUMABLE STATUS FOR CRT DISPLAY UPON CREW REQUEST
DATA RECORDING MANAGEMENT (DRM)	• RECORD INFORMATION PRIOR TO, DURING, AND SUBSEQUENT TO A FAILURE OCCURRENCE DETECTED BY THE FAULT DETECTION AND ANNUNCIATION FUNCTION • INITIATE 'SNAPSHOT' RECORDING OF SIGNIFICANT SUBSYSTEMS DATA DURING DYNAMIC PERIODS OF FLIGHT, SUCH AS ASCENT, RENDEZVOUS, REENTRY, ATMOSPHERIC FLIGHT, ETC. • GENERATES CONTROL SIGNAL TO TRANSFER TEMPORARILY STORED INFORMATION TO PERMANENT STORAGE (ON THE MAINTENANCE RECORDER)
TELEMETRY FORMAT SELECTION (TFS)	• CONTROL THE FORMAT OF DATA REQUIRED FOR RF TELEMETRY, ONBOARD DATA RECORDING, AND THE GROUND SYSTEM (DURING TURNAROUND OPERATIONS) • SELECTED FORMATS ARE A PROGRAMMABLE FUNCTION OF MISSION ELAPSED TIME, GMT, MISSION PHASE, OR DIRECT CREW CONTROL • FOUR UNIQUE FORMATS AVAILABLE FOR SELECTION • ALL DATA REQUIRED FOR ONBOARD PROCESSING BY PMS AVAILABLE IN EACH FORMAT

TABLE B-8 (CONT'D)

FUNCTION	REQUIREMENTS
CONTINGENCY PLANNING AID	• USE THE MISSION PROFILE STORAGE AND RETRIEVAL, CONSUMABLES ANALYSIS AND PERFORMANCE EVALUATION AND TREND ANALYSIS CAPABILITY TO FUNCTION AS A CONTINGENCY PLANNING AID • ACCEPT UPDATES TO THE MISSION PROFILE AND PROCEDURES VIA THE KEYBOARD • PROVIDE PREDICTIONS OF CONSUMABLES LIFE BASED ON QUANTITIES AVAILABLE AND THE CONTINGENCY PROCEDURES TO BE INITIATED
GROUND SYSTEMS INTERFACE	• SOFTWARE LOADING OF THE ONBOARD COMPUTERS • REMOTE CONTROL OF THE VEHICLE SUBSYSTEMS FOR CHECKOUT OPERATIONS • CONTINUOUS DOWNLINK TRANSMISSION OF VEHICLE DATA • INTERFACE WITH THE GROUND SYSTEM, THE ONBOARD COMPUTERS AND COMMAND DECODER MDM'S FOR TRANSMISSION OF DATA AND CONTROL OF THE VEHICLE SUBSYSTEMS (UPLINK) WHEN PM IS USED COOPERATIVELY WITH THE GROUND SYSTEM TO PERFORM CHECKOUT OPERATIONS • MEANS TO EXERCISE THE PM FUNCTIONS BY THE GROUND CHECKOUT SYSTEM TO BE VIA THE SERIAL DIGITAL UPLINK • LOADING AND VERIFICATION OF ONBOARD COMPUTER SOFTWARE PROGRAMS BY THE GROUND CHECKOUT SYSTEM TO BE ACCOMPLISHED VIA THE SERIAL DIGITAL UPLINK

TABLE B-8 (CONT'D)

FUNCTION	REQUIREMENTS
GROUND SYSTEMS INTERFACE (CONT'D)	• SEPARATE PROGRAMS TO BE LOADED INTO THE ONBOARD COMPUTERS FOR SPECIFIC GROUND MAINTENANCE TEST AND FAULT ISOLATION ROUTINES • DOWNLINK TRANSMISSION OF VEHICLE DATA PROVIDED VIA ONBOARD COMPUTER TO GROUND COMPUTER COMMUNICATIONS ON THE SERIAL DIGITAL DATA BUS OR TELEMETRY AND HARDLINK OUTPUTS FROM THE PCM MASTER

TABLE B-9

OPEN ISSUES*

• DEDICATED CAUTION AND WARNING UNIT - MCR 437
• PERFORMANCE MONITOR DEDICATED PREPROCESSING - MCR 484
• IMPLEMENTATION OF VOLUME II (MAINTENANCE MEASUREMENTS) MASTER MEASUREMENTS LIST - MCR 458

*AS OF 1 MARCH 1974 (BASELINE FREEZE DATE)

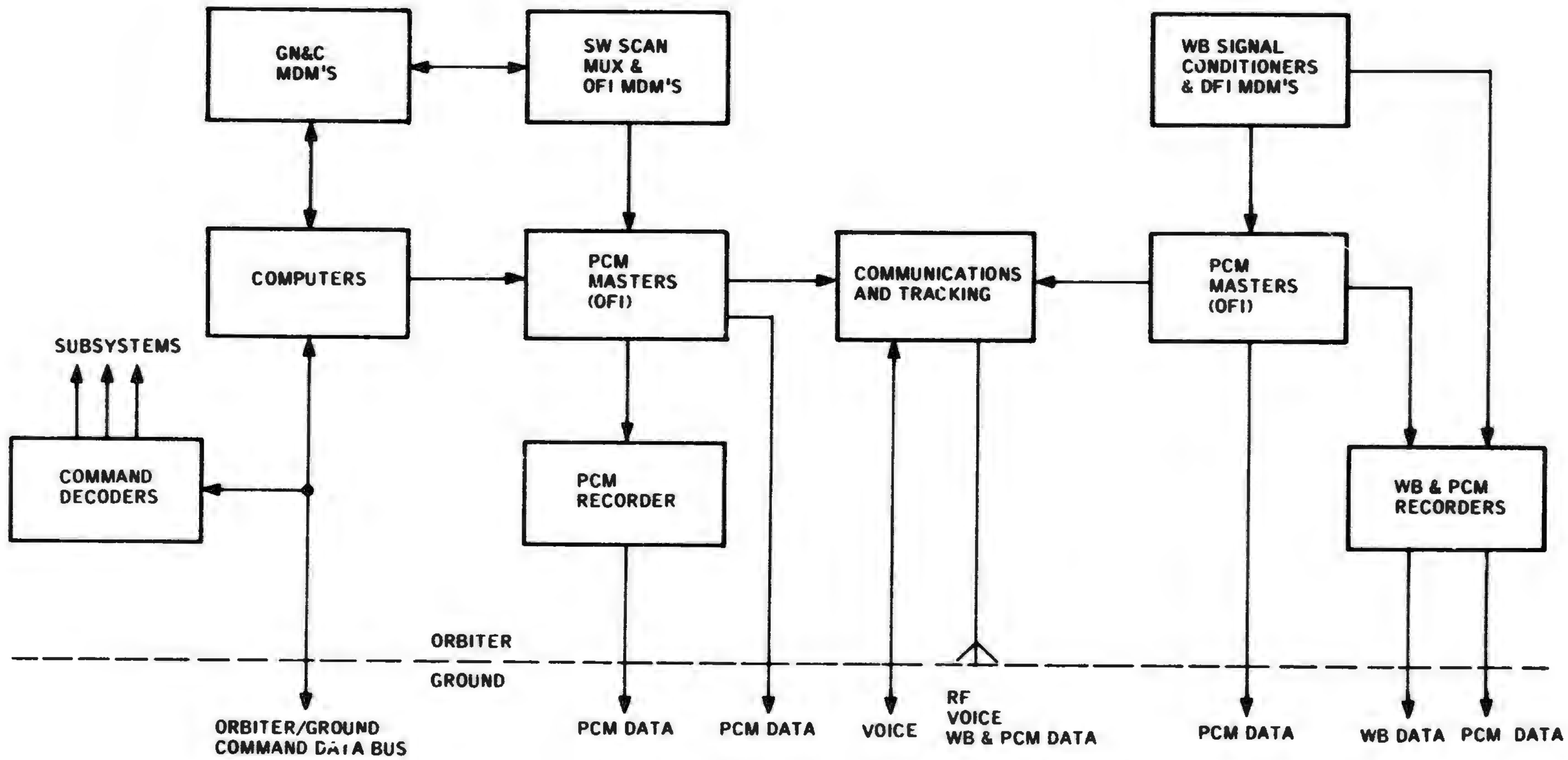


Figure B-11 PMF Orbiter/Ground Interface

B.5 PAYLOAD ACCOMMODATION AND HANDLING

The Shuttle will provide the capability to transport a wide variety of payloads to and from space. Provisions will be made for supporting up to five payloads and a total payload weight of up to 65,000 pounds. Return payload weight provisions are for deorbit and landing with a 32,000 pound maximum. Physically the Shuttle will provide a payload envelope of 15 feet in diameter by 60 feet long. Structural attachments will be provided for accommodating upper stages or tugs, payloads, payload carriers and pallets. Payload deployment/retrieval will be performed by a remote manipulator system.

The capability of the Shuttle to support payload operations will be affected by navigation accuracies, rendezvous limits, additional payload weight, and launch azimuth and inclination limitations.

Navigation accuracies and rendezvous limits are presented in section B.6.

The Shuttle provides basic configuration for payload support. Additional support capabilities which result in added weight are chargeable to the payloads. Items included in this category are:

- OMS Δv kits
- Excess RCS propellent
- Docking adapter
- Transfer tunnel
- EVA/IVA equipment
- Service panels
- Payload retention supports
- Second manipulator arm
- Atmospheric control and revitalization greater than baseline

B.5 PAYLOAD ACCOMMODATION AND HANDLING (CONT'D)

- Payload unique displays and controls
- Fifth to seventh additional crew
- EPS kits.

Launch azimuths and inclinations for KSC and UAFB are:

- Azimuth - KSC, 35° to 120°; VAFB, 140° to 201°
- Inclination - KSC, 39° to 57°; VAFB, 56° to 104°.

The Shuttle Avionics System provides some payload-unique system characteristics. These characteristics are presented in table B-10.

B.6 GUIDANCE, NAVIGATION AND CONTROL (GN&C)

The GN&C Subsystem, in conjunction with associated displays/controls, computer and navigation aids, provides the capability for: 1) automatic and manual control for all mission phases except docking, which is manual only; 2) guidance commands that drive control loops and provide steering displays to the crew; and 3) inertial navigation provided by three gimbaled inertial measurement units (IMU's) and updated by star sensors for autonomous orbital flight and by RF navigation aids for rendezvous, approach and landing.

Figure B-12 provides a functional block diagram of the GN&C Subsystem as reviewed at the orbiter PDR. As indicated on the diagram, the GN&C is divided into guidance and navigation subsystem, flight control subsystem and common subsystems.

B.6.1 Flight Control. Flight control of the Shuttle is provided by a combination of hardware and software. Controllers, sensors, effectors and displays are hardware. Control laws (or algorithms) are software and are programmed in the triple redundant GN&C computers. A fourth computer is also available as a backup.

Flight control is provided through control modes. Table B-11 summarizes the flight control operational modes.

TABLE B-10

SHUTTLE AVIONICS SYSTEM PAYLOAD UNIQUE CHARACTERISTICS

SYSTEM	CHARACTERISTIC
GUIDANCE, NAVIGATION AND CONTROL	• DATA TO INITIALIZE PAYLOAD SUCH AS STATE VECTOR, ATTITUDE, GMT, MET, CLOCK SYNCHRONIZATION PROVIDED BY ORBITER OVER STANDARD INTERFACES • ALTITUDE INFORMATION WILL NOT ACCOUNT FOR MISALIGNMENT BETWEEN ORBITER REFERENCE SYSTEM AND PAYLOAD
DATA PROCESSING AND SOFTWARE	• PAYLOAD CHECKOUT PROVIDED AT MISSION SPECIALIST STATION • CAPABILITY PROVIDED FOR PAYLOAD DATA INTERLEAVING AND PAYLOAD MONITORING • PAYLOAD CAUTION AND WARNING DATA PROVIDED TO FLIGHT CREW AND AT THE MSS • ACCEPTANCE TESTING OF EACH PAYLOAD PERFORMED BY THE USER PRIOR TO INSTALLATION IN ORBITER
COMMUNICATIONS AND TRACKING • VOICE*	• ATTACHED PAYLOAD: ONE DUPLEX VOICE CHANNEL BETWEEN ORBITER CREW MEMBERS AND PERSONNEL IN HABITABLE PAYLOAD • RELEASED PAYLOADS: ONE DUPLEX VOICE CHANNEL BETWEEN THE ORBITER CREW MEMBERS AND PERSONNEL IN A MANNED RELEASE PAYLOAD • EVA: DUPLEX VOICE COMMUNICATIONS WITH A CONFERENCING CAPABILITY FOR VOICE CONVERSATIONS BETWEEN TWO EVA CREW MEN, OTHER MANNED VEHICLES (ORBITER RELAY) AND GROUND PERSONNEL (ORBITER RELAY)

*BASELINE CAPABILITY, NOT A DOD REQUIREMENT.

TABLE B-10 (CONT'D)

SYSTEM	CHARACTERISTIC
COMMUNICATIONS AND TRACKING (CONT'D)	
• TELEMETRY	• ATTACHED PAYLOADS-TO-ORBITER •• UP TO 25 KB/S OF PAYLOAD STATUS DATA (HARDLINE) TO BE INTERLEAVED WITH ORBITER OPERATIONAL TELEMETRY •• UP TO 256 KB/S OF PAYLOAD DATA TO BE RELAYED TO THE GROUND VIA WIDEBAND FM TRANSMITTER • RELEASED PAYLOADS-TO-ORBITER •• S-BAND, PHASE MODULATION •• FREQUENCY BAND, 2200-2300 MHz •• TDM DATA: 1) UP TO 48 KB/S SERIAL DATA TO MANNED PAYLOADS CONSISTING OF ONE 32 KB/S DIGITAL VOICE CHANNEL AND 16 KB/S TELEMETRY; 2) UP TO 16 KB/S TELEMETRY ONLY TO UNMANNED PAYLOADS
• COMMANDS	• ORBITER TO ATTACHED PAYLOADS: 2.4 KB/S COMMAND INFORMATION RATE OF WHICH 0.4 KB/S IS ALLOCATED TO SYSTEM OVERHEAD. ENCODING AND 1.6 KB/S SYNCHRONIZATION PATTERN MAKE UP REMAINDER OF 8 KB/S • ORBITER TO RELEASE PAYLOADS: SAME AS ATTACHED
• TELEVISION AND WIDEBAND EXPERIMENT DATA	• TV OR WIDEBAND EXPERIMENT DATA LINK TO STDN GROUND STATIONS TIME-SHARED WITH WIDEBAND PAYLOAD DATA
• PAYLOAD TRACKING	• CAPABILITY TO TRACK COOPERATIVE TARGET FROM 560 KM TO 30 M • TRACK PASSIVE TARGETS FROM 19 KM TO 30 M

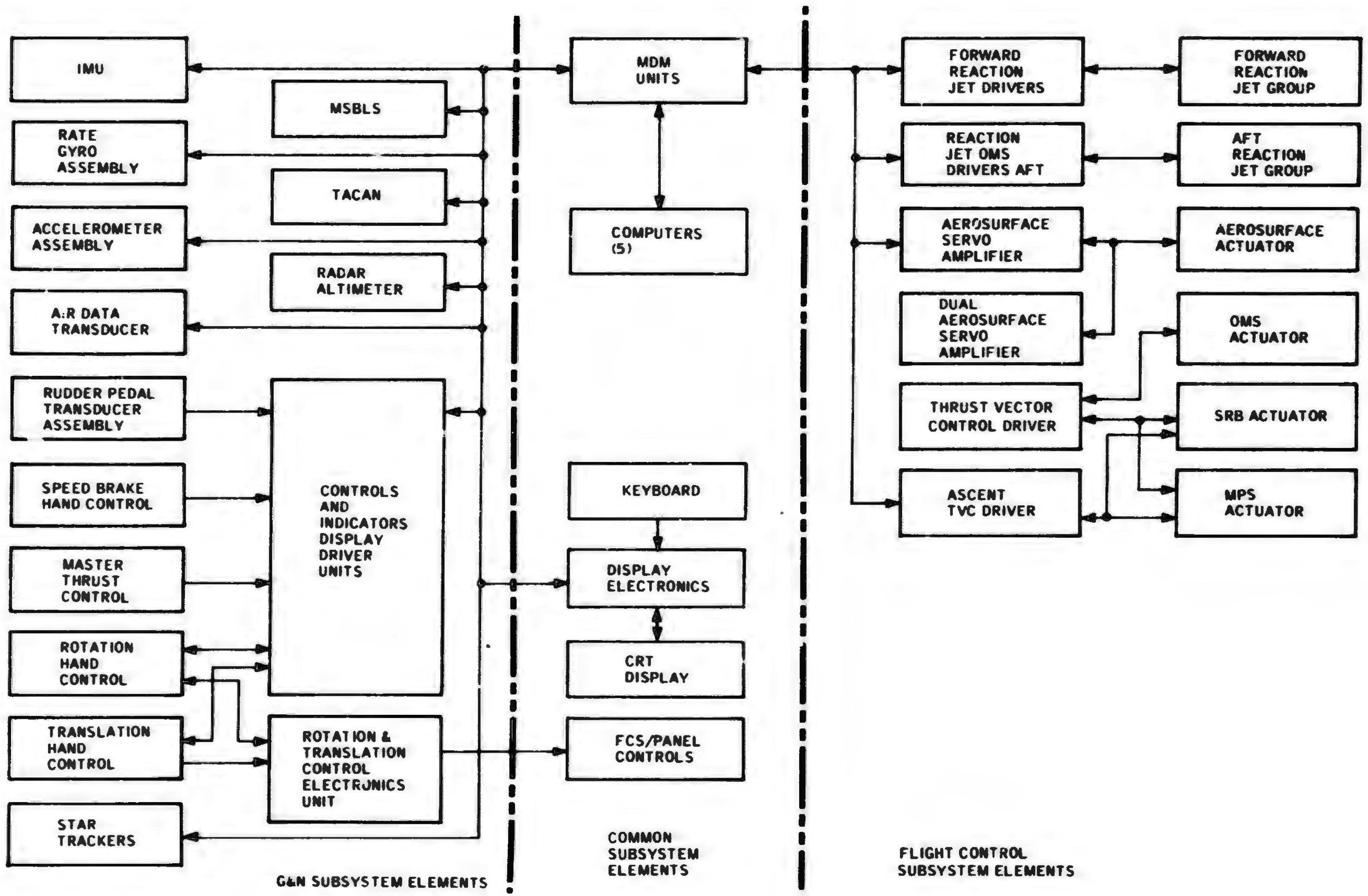


Figure B-12 GN&C Functional Block Diagram

TABLE B-11

FLIGHT CONTROL MODES AND CHARACTERISTICS

FLIGHT CONTROL MODE	MODE CHARACTERISTIC
MANUAL DIRECT	• NO FEEDBACK SIGNALS FROM VEHICLE-MOTION SENSORS ARE USED FOR STABILIZATION AND CONTROL • CREW COMMAND SIGNAL APPLIED TO THE APPROPRIATE FORCE EFFECTOR VIA THE GN&C COMPUTER • REQUIRED COMPENSATION AND LOGIC FOR EFFECTOR SELECTION ACCOMPLISHED WITHIN THE G&N COMPUTER • VEHICLE-MOTION SIGNALS DISPLAYED AS REQUIRED FOR CREW OPERATION • AUTOMATIC G&N COMMANDS INHIBITED
MANUAL COMMAND AUGMENTATION	• SAME AS MANUAL EXCEPT THAT CREW COMMANDS ARE AUGMENTED BY FEEDBACK SIGNALS FROM VEHICLE-MOTION SENSORS TO IMPROVE RESPONSE OR AUGMENT STABILITY, OR BOTH
HOLD	• CONTROLLED PARAMETER IS HELD AT THE VALUE EXISTING WHEN THE HOLD FUNCTION IS ENGAGED • REFERENCE SIGNAL IS NOT ALTERABLE BY THE AUTOMATIC GUIDANCE SYSTEM EXCEPT BY DISENGAGEMENT AND REENGAGEMENT OF THE HOLD FUNCTION
SELECT	• CONTROLLED VEHICLE PARAMETER CONVERGES TO AND HOLDS VALUE SELECTED OR PRESELECTED BY THE CREW
AUTOMATIC	• GUIDANCE FUNCTION PROVIDES AUTOMATIC CONTROL OF THE VEHICLE • MANUAL COMMANDS INHIBITED AND CANNOT ACT TO SUM WITH OR OVERRIDE THE AUTOMATIC COMMANDS FROM THE GUIDANCE SYSTEM • VEHICLE MOTIONS SIGNALS DISPLAYED TO CREW • CREW HAS OPTION TO MANUALLY ENGAGE OR DISENGAGE THE AUTOMATIC FUNCTION

B.6.2 Guidance and Navigation. Navigation elements determine the position and velocity at the Shuttle systems at any given time in the mission. The position and velocity are the primary components of the state vector which is maintained by the GN&C computer based on a combination of onboard sensor, crew and ground relayed information sources.

The prime function of the orbiter guidance is to generate steering commands, discrete on/off commands and throttling commands to the orbiter control systems as well as visual directions for manual crew control. The guidance function is primarily software which takes the current navigation-determined orbiter state vector and, knowing the desired orbiter state vector at some future time, determines how the control systems should be directed to achieve the future state vector. The onboard state vector will be refined based on onboard one-way doppler tracking of ground beacons and by ground determined tracking data.

The G&N operation mode is dependent on flight phase. Table B-12 summarizes the G&N mode characteristics by phase. On-orbit navigation accuracies, pointing accuracies and rendezvous limits are presented in table B-13. Error characteristics for NAVAID and air data system error characteristics are presented in tables B-14 and B-15.

The accuracies contained in table B-13 are based on a minimum of two ground or Tracking Data Relay Satellite (TDRS) contacts subsequent to any maneuver. These accuracy predictions are applicable for either ground derived (two-way doppler) or onboard derived (one-way doppler extraction onboard) corrections. The latter method assumes an onboard frequency standard with a 1 day mean accuracy of two parts in 10^{12}.

TABLE B-12

G&N OPERATIONAL MODES BY PHASE

PHASE	OPERATIONAL MODE	MODE CHARACTERISTIC
PREFLIGHT	IMU GYROCOMPASS GROUND ALIGNMENT IMU GROUND CALIBRATION	• GROUND CALIBRATION OR ALIGNMENT
	STAR TRACKER SELF TEST IMU INTERFACE TEST ADTA SELF TEST	• SELF TEST
ASCENT	ASCENT PHASE THRUSTING G/N	• PROVIDE STEERING COMMANDS AND THROTTLE COMMANDS DURING THE BOOST TO ORBIT
	ABORT DURING ASCENT POWERED PHASE	• LOW ALTITUDE TURN TO PLACE ORBITER WITHIN GLIDE RANGE OF THE LAUNCH SITE RUNWAY
	GLIDE PHASE	• TRANSITION THE ORBITER FROM A HIGH ALTITUDE LOW DYNAMIC PRESSURE CONDITION TO AN EQUILIBRIUM GLIDE PATH WHICH ULTIMATELY INTERFACES WITH THE NOMINAL TEAM INTERFACE CONDITION
ORBITAL	IMU ORBITAL ALIGNMENT	• ALMOST FULLY AUTOMATIC TECHNIQUE USING THREE FIXED FIELD OF VIEW ELECTRONIC STAR SENSORS/TRACKERS • MANUAL POWER UP OF STAR SENSORS • KEYBOARD INITIATION OF STAR TRACKER SELF TEST
	ORBITAL THRUSTING NAVIGATION	• GENERATION AND MAINTENANCE OF AN UPDATED STATE VECTOR • COMMON TO ORBIT INSERTION, ADJUSTMENT AND DEORBIT MANEUVERS USING BOTH THE OMS AND RCS IN A TRANSLATION MODE

TABLE B-12 (CONT'D)

PHASE	OPERATIONAL MODE	MODE CHARACTERISTIC
ORBITAL (CONT'D)	ORBITAL RENDEZVOUS GUIDANCE	• RENDEZVOUS WITH EITHER PASSIVE OR COOPERATIVE TARGETS USING RENDEZVOUS RADAR, STAR TRACKER, RF UPLINK AND IMU
REENTRY	REENTRY	• IMU ACTIVE SENSOR • IMU PRIME SOURCE OF NAVIGATION DATA UNTIL ABOUT 140,000 FEET • TACAN INFORMATION AVAILABLE AT 140,000 FEET FOR REFINEMENT OF STATE VECTOR
ATMOSPHERIC	TERMINAL AREA ENERGY MANAGEMENT	• 70,000 TO 12,000 FEET • AIR DATA PROBES DEPLOYED AT 80,000 FEET UNDER COMPUTER CONTROL AND PRIMARY DATA SOURCE • TACAN SETS USED TO PROVIDE EARTH RELATIVE POSITION INFORMATION TO A GIVEN GROUND BASED TACAN BEACON
	APPROACH/LANDING	• LANDING GUIDANCE SOFTWARE PROVIDES PITCH AND ROLL COMMANDS TO THE CONTROL SYSTEM IN ORDER TO AUTOMATICALLY GUIDE THE ORBITER FROM 12,000 FEET ALTITUDE TO TOUCHDOWN • INPUTS ARE FROM IMU, TACAN, RADAR ALTIMETER, AIR DATA TRANSDUCER ASSEMBLY, AND MSBLS

TABLE B-13

SHUTTLE PERFORMANCE CHARACTERISTICS FOR NAVIGATION, POINTING ERRORS AND RENDEZVOUS LIMITS

PERFORMANCE PARAMETER	CHARACTERISTIC
NAVIGATION ACCURACIES (3 SIGMA FOR 100 NMI)	
STDN - LOCAL (END OF TRACK)	POSITION • ALTITUDE - 130 METERS • DOWNTRACK - 110 METERS • CROSSTRACK - 130 METERS • ROOT SUM SQUARE - 222 METERS VELOCITY • ALTITUDE - 1.2 METERS/SEC • DOWNTRACK - 0.15 METERS/SEC • CROSSTRACK - 0.6 METERS/SEC • ROOT SUM SQUARE - 1.3 METERS/SEC
STDN - PROPOGATED ONE REV.	POSITION • ALTITUDE - 150 METERS • DOWNTRACK - 260 METERS • CROSSTRACK - 130 METERS • ROOT SUM SQUARE - 315 METERS VELOCITY • ALTITUDE - 1.3 METERS/SEC • DOWNTRACK - 0.15 METERS/SEC • CROSSTRACK - 0.6 METERS/SEC • ROOT SUM SQUARE - 1.4 METERS/SEC
POINTING ERRORS (DEG)	LOCAL VERTICAL (STDN) • 100 NMI - 0.16 • 200 NMI - 0.16 • 300 NMI - 0.16 EARTH TARGET LOOKING VERTICAL (STDN) • 100 NMI - 0.18 • 200 NMI - 0.16 • 300 NMI - 0.16

TABLE B-13 (CONT'D)

PERFORMANCE PARAMETER	CHARACTERISTIC
POINTING ERRORS (DEG) (CONT'D)	EARTH TARGET LOOKING 30° OFF VERTICAL (STDN) • 100 NMI - 0.20 • 200 NMI - 0.17 • 300 NMI - 0.16
RENDEZVOUS LIMITS	
• COOPERATIVE TARGET	• RANGE - 560 KM TO 30 M • RANGE RATE - FROM ±450 M/SEC TO ZERO • LOS ANGLE (TWO AXIS): 1) 560 KM TO 45 KM TO 30 M - ±5 DEG • LOS ANGLE RATE (TWO AXIS) FROM 45 KM TO 30 M: 1) ACQUISITION - ±MR/SEC; 2) TRACKING - ±5 DEG/SEC
• PASSIVE TARGET	• RANGE - 19 KM TO 30 M • RANGE RATE - FROM ±150 M/SEC TO ZERO • LOS ANGLE (TWO AXIS): 1) 560 KM TO 45 M - ±5 DEG; 2) 45 KM TO 30 M - ±5 DEG • LOS ANGLE RATE (TWO AXIS) FROM 45 KM TO 30 M: 1) ACQUISITION - ±4 MR/SEC; 2) TRACKING - ±5 DEG/SEC

TABLE B-14

NAVAID PERFORMANCE CHARACTERISTICS

NAVAID	ACCURACY (1 σ)	COVERAGE	OTHER
TACAN	RANGE 0-50 NMI ±0.05 NMI 50-300 NMI ±C.10 NMI BEARING 0-50 NMI ±0.5 DEG 50-300 NMI ±1.0 DEG	300 NMI RANGE LIMITED TO LOS	4500 KNOTS VELOCITY
MSBLS	RANGE, ±100 FT. ELEVATION ANGLE, ±0.03 DEG AZIMUTH ANGLE, ±0.05 DEG	10 NMI IN MM/HR PRECIPITATION CLOUD SYSTEM: ±20° AZIMUTH 0-30° ELEVATION	INITIATE ACQUISITION AT 14,000 FT. ALTITUDE
RADAR ALTIMETER	1.5 FT OR 2% OF ALT, WHICHEVER IS GREATER	2500 FT ALT ±20° BANK ANGLES	

TABLE B-15

AIR DATA SYSTEM PERFORMANCE REQUIREMENTS

PARAMETER	RANGE	ERRORS (3σ)
BAROMETRIC ALTITUDE	0-100,000 FT	±1%
ALTITUDE RATE	0-50,000 FT/MIN	±5% OR 30 FT/MIN
INDICATED AIR SPEED		
AUTOLAND	50-500 KNOTS	±4 KNOTS
CREW INFORMATION	100-340 KNOTS	±2 KNOTS
MACH NUMBER	0.2-3.0	±0.5%
DYNAMIC PRESSURE (Q)	0-500 LB/FT^2	±3%
ANGLE OF ATTACK	-5 - +25 DEG	±0.5 DEG
STATIC AIR TEMP	-50 - +50° C	±2° C

B.7 SATELLITE BASELINE

In order to define the satellite functions impinging upon the CCDS, it was necessary to prepare a functional model representative of DOD satellites. The number and variety of DOD satellites is such that a standard satellite cannot be described. However, from the known requirements, capabilities, and constraints published in available DOD documents, a functional general satellite model has been synthesized to provide a baseline for the definition and allocation of functions.

The baseline satellite was limited in definition to the constraints it places upon Space Transportation System (STS), or how it is impacted by STS in accordance with *Level II Program Definition and Requirements*, Volume XIV "Space Shuttle System Payload Accommodations," and the DOD Shuttle System requirements.

B.7.1 Definition of Satellite. Satellites are defined as "all spacecraft which have as their principal function on-orbit sensing, experimentation, or communications." This definition is distinct from that of an upper stage, which is principally used as an orbit propulsion device for satellites. In the definition and allocation of system functions, it is important to maintain these distinctions.

A satellite may be deployed directly by the Orbiter or by an orbit-to-orbit Shuttle (OOS). Only those satellites deployed directly by the Orbiter will be configured for retrieval.

For retrieval purposes, all satellites shall have state uncertainties of no greater than 1.0 nmi and 10 fps in tangential, radial, and normal components of position and velocity respectively. The satellite must also be either passive cooperative or active cooperative. Definitions and applications of these two terms are as follows:

A. Passive Cooperative. This definition applies to a payload being retrieved by the Orbiter in a non-time-constrained, multi-orbit operation. For this condition, the payload may be assumed to:

- Be in a non-tumbling, stabilized attitude condition
- Provide passive tracking aids such as corner reflectors or mirrors as appropriate

B.7.1 Definition of Satellite (Cont'd)

- Be commandable for necessary safing, verification of subsystems status and preparation for docking

B. Active Cooperative. This definition applies to a payload being retrieved by the Orbiter in a time-constrained, single orbit operation. For this condition, the payload may be assumed to:

- Have maneuvered so as to be at the opportune position for intercept by the Orbiter based on an on-time launch
- Have active rendezvous aids, if required, such as radar transponder
- Have stabilized itself with its attitude control system to aid retrieval; however, it will not jeopardize manipulator operations or orbital safety
- Be commandable from the Orbiter for necessary rendezvous, preparation for docking, safing, and verification of subsystem status.

B.7.2 Description of Baseline Satellite. Most DOD satellites have the following subsystems in common:

- Structural
- Thermal control
- Attitude determination and control (reaction control)
- Astrionics: computation and control, and instrumentation and telecommunications
- Electrical power and distribution
- Sensors
- Fluids and gases

Figure B-13 provides a top level function or block diagram of the generic satellite used as baseline. For the purpose of this study, the principal subsystems of interest are thermal control, attitude

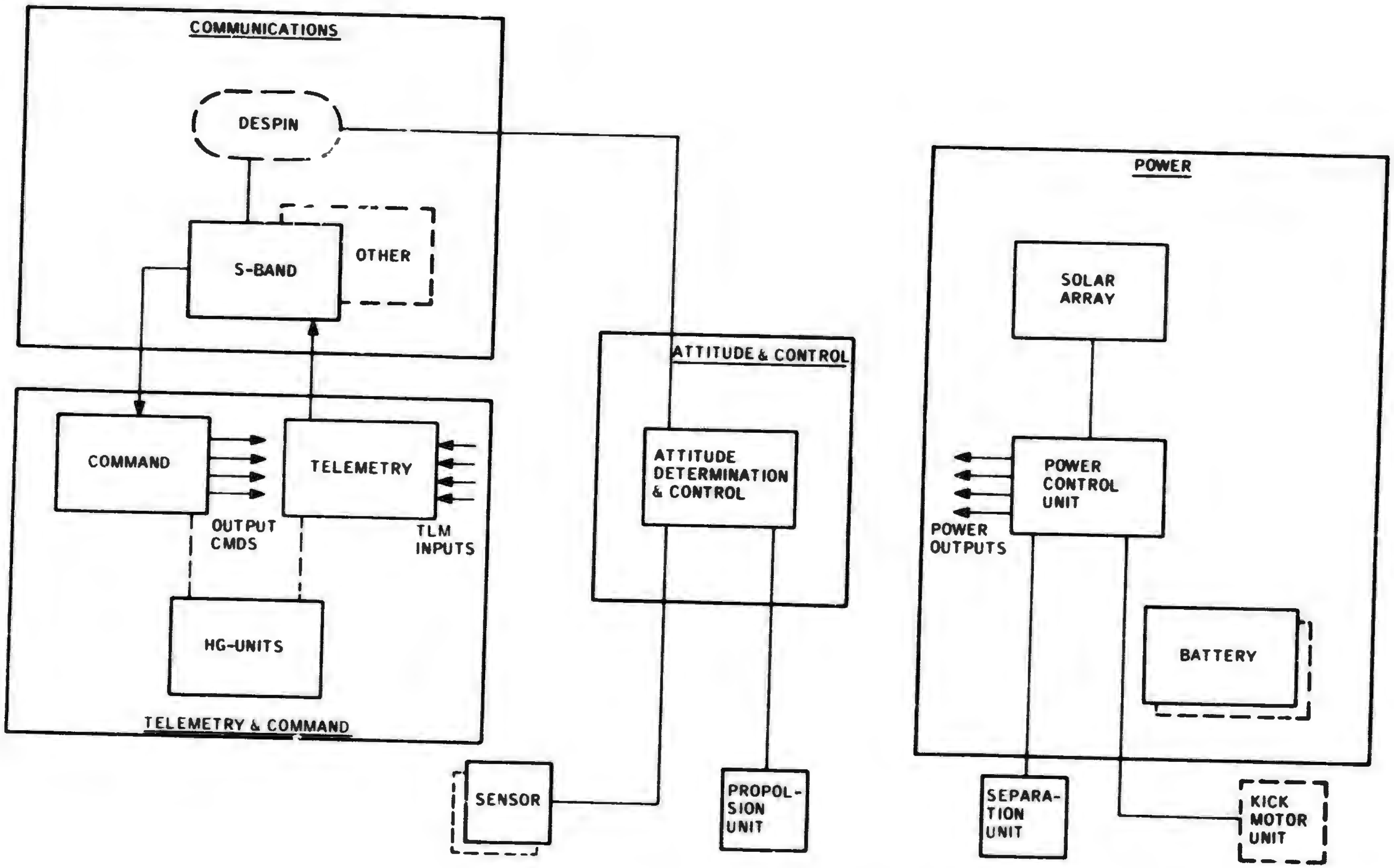


Figure B-13 Functional Block Diagram - SGLS Compatible Satellite

B.7.2 Description of Baseline Satellite (Cont'd)

control, astrionic, electrical power and distribution, and fluid and gas. These subsystems, as they relate to the STS program, are briefly addressed in the following paragraphs.

B.7.2.1 Thermal Control Subsystems. Thermal control of satellites is both active (e.g., heaters and coolants) and passive (e.g., thermal control coatings, thermal shields, thermal insulation assemblies, and conductive/non-conductive structural materials). In order to maintain thermal control of the satellite while contained within the Orbiter payload bay, requirements have been imposed upon the Orbiter and ground support systems. The imposed requirements are as follows:

A. In-Flight Thermal Interface. The Orbiter shall provide a thermal interface for use by the payload during all flight phases and which can accept 5200 Btu/hr. of payload waste heat during critical Orbiter operation periods. The waste heat shall be dissipated through an Orbiter supplied heat exchanger. The cooling medium shall be de-ionized demineralized water circulated by a payload supplied pump at 2-4 pounds per minute. The maximum coolant temperature at the heat exchanger inlet shall be 100° F. The coolant temperature at the heat exchanger outlet shall be 50° F.

B. Ground Coolant Interface. Provisions shall be incorporated in the Orbiter to allow GSE coolant flow to be supplied to the payload while it is installed in the payload bay. The coolant shall be supplied during prelaunch ground operations with the payload bay doors either open or closed. The coolant shall be demineralized, de-ionized water supplied at a flow rate within the range of TBD to TBD lb/min., inlet pressure to the payload of psia, and inlet temperature controlled remotely at the Orbiter inlet to ±3° F within a temperature range of 45° to 100° F. The coolant line shall be connected at payload installation and disconnected within the last 20 minutes prior to launch. The coolant interface to the payload shall be located at the aft bulkhead of the Orbiter payload bay.

B.7.2.1 Thermal Control Subsystems (Cont'd)

In addition, provision should be made that the upper stage be capable of a rotisserie-type roll maneuver to minimize thermal strain on the satellite. Thermal control is peculiar to the individual satellites; therefore, it is a responsibility of the satellite owner to advise the STS of the separate requirements and to comply with Orbiter and OOS constraints.

B.7.2.2 Attitude Determination and Control Subsystem (AD&C). The AD&C Subsystem provides attitude and relative orientation stability for the satellite. This subsystem typically employs one or more attitude sensor devices (e.g., horizon sensor, star sensor, or inertial platform) and reaction control devices such as small thrusters.

The capability will exist to target load the satellite directly from the ground. Target loading must be accomplished within 45 minutes if loading is accomplished during final launch preparations. The Orbiter will have the capability to update, verify, and initialize the AD&C Subsystem prior to completion of deployment. Position and velocity information shall be transferred with the accuracies inherent to the Orbiter GN&C System. Attitude and attitude rate will be transmitted with the accuracy stored in the Orbiter GN&C computer, without consideration of mechanical alignment between the satellite and the Orbiter reference system.

B.7.2.3 Astrionic Subsystem

B.7.2.3.1 Computation and Control. Except for checkout, monitor, update, and initialization, no special control or computation requirements are imposed on the STS by the satellite. Final operational checkout of the satellite functions is the responsibility of ground systems.

B.7.2.3.2 Instrumentation and Telecommunications. This paragraph addresses Orbiter/satellite and prelaunch satellite/ground communication interface requirements and capabilities. The requirements and capabilities are as follows:

A. All communication links between the satellite and Orbiter must be SGLS and AFSCF compatible.

B.7.2.3.2 Instrumentation and Telecommunications (Cont'd)

B. All communication links between the satellite and Orbiter must be securable and, while in the secured mode, meet COMSEC and TEMPEST requirements.

C. All RF communication links between the satellite and the Orbiter must be in a digital format.

D. The Orbiter will have provisions while on the launch pad which will allow satellite telemetry data to be transmitted to satellite checkout equipment (on ground and in the Orbiter) without interference with the Orbiter communications systems.

E. The Shuttle System will provide capability for a dedicated direct hardwire link between the ground and the satellite when the satellite is installed in the Orbiter; this link is for use by the satellite user.

F. During ground checkout, satellite direct hardwire to ground will have the capability to uplink commands to the satellite and downlink telemetry and data from the satellite. This two-way satellite link will handle dedicated signals and will preclude the possiblity of extraneous signals between the Shuttle and the satellite(s).

G. Satellite RF direct to ground will be as follows: satellite-dedicated signals shall be transmitted by an RF carrier TBD directly to satellite aerospace ground equipment (AGE) up to TBD minutes prior to launch.

H. Satellite direct hardwire to the Orbiter payload monitor system will contain the following:

1. The capability to operate at both 1K baud/sec and 2K baud/sec of command to satellites at 10^{-6} BER, up to 16 kb/s of telemetry at 10^{-6} BER, and IRIG FM/FM channel H at 165 kHz center frequency (Orbiter records only).

B.7.2.3. Instrumentation and Telecommunications (Cont'd)

2. Satellite relay through the Orbiter to ground shall provide 256 kb/s of satellite data with 10^{-6} BER. The satellite must provide the encryption for this link.

I. A status check of the satellite will be required when the satellite is installed in the payload bay. The status check is required to determine (as a minimum) that the satellite is not approaching a hazardous condition.

J. Satellite interface compatibility with the MSS shall be verified during Shuttle vehicle countdown.

K. Provision must be made for Orbiter monitoring or satellite caution and warning parameters; particularly those associated with the crew and flight vehicle.

L. The Orbiter shall provide the data management capability to process information to monitor, command, control, provide command authentication and verification, and initialize the satellite when the satellite is attached to (via hardwire), or is in the vicinity of (via RF) the Orbiter. This shall include the capability to provide data transfer, command format, telemetry format, and processing satellite-peculiar display requirements.

Astrionic connections between the Orbiter and satellite must be reconnectable following retrieval without man-in-bay or extravehicular activity (EVA).

B.7.2.4 Electrical Power and Distribution Subsystem. The Orbiter shall provide up to 50 kWh of dc electrical power to the payload bay for use of satellites while they are installed in the payload bay and disconnected from ground systems. Power shall be supplied at a nominal 28 V dc, at an average power level of 1000 watts. The quality of the power transmitted across the interface shall conform to MIL-STD-1541, 15 October 1973.

B.7.2.4 Electrical Power and Distribution Subsystem (Cont'd)

The electrical interface between the satellite and the Orbiter shall have the capability to be remotely remated to transmit power and safety-related data across the interface for a retrieved satellite.

Ground power capabilities for the satellite are the same.

B.7.2.5 Fluid and Gas Subsystems. Fluids and gases may be required for propulsion, attitude control, electrical power, and/or thermal control. The principal impact of satellite fluids and gases are as follows:

A. Provisions must be made for Orbiter control of venting, unloading, and purging satellite fluid and gas subsystems during all portions of the flight phase. All interfaces to permit these functions must be reconnectable during retrieval without man-in-bay or EVA activity.

B. Provisions must be made for loading, unloading, and venting of satellite fluids and gases through the Orbiter while the Orbiter is on the launch pad with the satellite contained within the Orbiter payload bay.

B.8 OOS BASELINE

B.8.1 OOS Operations: General Discussion. On-orbit operations may be logically divided into two broad categories: those pertaining when the entire mission may be accomplished by the Orbiter, and those requiring an upper stage to attain altitudes beyond the reach of the Orbiter. Because of the differing functional requirements, the deployment operation may be separated into 1) satellite deployment (when no upper stage is used), and 2) satellite/OOS deployment (when an upper stage is used). The primary difference between these two deployment operations is that the Orbiter maintains control over satellite deployment through the operational capability checkout, whereas control over the satellite/OOS after deployment is released to autonomous OOS operation, possibly with minimal ground support, for the transfer orbit deployment of the

B.8.1 OOS Operations: General Discussion (Cont'd)

satellite and return of the OOS for retrieval. Operational capability checkout of the satellite before and after separation from the OOS is ground controlled, limited by the availability of a radio line-of-sight. The pre-separation checkout is intended to verify satellite operation prior to separation, such that the satellite can be returned with the OOS for retrieval in the event of failure or malfunction. Further, provision has been included for use of expendable OOS upper stages, thereby modifying the functions to some degree.

Deployment operations, whether by the Orbiter or by an OOS, may involve multiple satellites, may be accomplished in single or multiple orbits, may involve one or more orbiters, and will involve one or more ground support systems; however, this analysis is concerned only with a single satellite, a single orbiter, and not more than one ground station at a time.

The differing functional requirements for "satellite deployment" and "satellite/OOS deployment" are imposed largely on the Orbiter. On the other hand, the functional requirements of the satellite differ little whether orbiter-deployed or OOS-deployed. OOS functional requirements vary only as to its being expendable or reusable, and whether or not it is capable of returning with an undeployed payload for retrieval. All of these alternatives have been taken into consideration in the definition of the functional requirements and in the functional allocations.

B.8.2 Purpose of the OOS. Planned DOD-STS missions include the placement and/or retrieval of satellites from orbits higher than those attainable by the manned earth-orbiting Space Shuttle (EOS). The orbit-to-orbit Shuttle (OOS, tug, upperstage) is a spacecraft carried into orbit by the EOS; it serves the primary function of transferring one or more satellites from the EOS orbit into the final higher-altitude orbit required for the satellite(s). A more sophisticated OOS (the tug), presumably to be developed after initial operations of the STS, will also serve the function of retrieving a satellite from an orbit not attainable by the EOS and carrying that satellite down to the EOS orbit. In a manner of speaking, the OOS is a load-delivery, or load-pickup vehicle (tug), operating between the EOS and whatever satellite(s) orbit is pertinent.

B.8.3 OOS Reusability. Since the primary rationale of the entire STS program is to provide DOD with the means to execute a substantial number of space-oriented missions at a relatively low cost, it is a corollary that the maximum practical re-use should be made of all system hardware. Certain of the planned missions will permit the OOS to leave the EOS, deploy its load, and return empty to a position permitting the EOS to retrieve the OOS. In this eventuality, the OOS is said to be *reusable*.

Certain other mission, however, will be executed subject to the limitation that the OOS simply cannot carry enough fuel to deploy its load and then return to the EOS; such missions largely involve the more massive satellites, multiple satellite deployment, and usually relatively high-altitude (viz, synchronous) satellite orbits. In this case, the OOS is said to be *expendable;* having deployed its satellite(s), the OOS fuel supply does not permit return to the EOS, and so the OOS becomes derelict.

B.8.4 Representative OOS Mission: Synchronous Deployment. This section outlines the major elements of a mission in which the OOS is used to deploy a satellite into an approximately synchronous-equatorial orbit; the OOS may or may not be reusable.

Within the boundaries of this study, the mission begins after the OOS and satellite(s) have been thoroughly checked out (i.e., all subsystems have been checked and established as ready for full operation), the OOS and satellite have been mated and stored in the EOS cargo bay, and the OOS (and kick motor, if applicable) has been loaded with flight propellents. At this time the EOS has been readied for flight, mated to the large solid rocket boosters (SRB's) and the entire spacecraft assemblage is in the vertical, ready-for-launch configuration on the launch pad.

B.8.4.1 Prelaunch. At this point a *prelaunch* sequence is initiated, during which final checkout of OOS, satellite, and EOS subsystems is performed. Near the end of the prelaunch sequence, the EOS crew enter and assume their launch/ascent positions.

Immediately after storage in the EOS cargo bay, the OOS and the satellite(s) are joined to the EOS through hardwire umbilical breakaway connections; the OOS and satellite RF systems are passive, and all communication to the outside is via the umbilicals.

B.8.4.2 Ascent. Following prelaunch checkout, the SRB's ignite, liftoff occurs, and the spacecraft begins the *ascent* phase. During ascent, communications and limited monitoring of OOS and satellite subsystems are maintained through the umbilical connections. In all other respects the OOS and satellite are completely passive.

The ascent phase terminates when all rocket engine firings are completed, the condition of orbital *insertion* has been achieved, and the EOS has achieved its operational orbit (generally circular or slightly elliptical, at an altitude from about 100 miles up to perhaps 350 nmi, but usually below 200 nmi).

B.8.4.3 EOS On-Orbit. At this point the *on-orbit* phase begins. The job of the EOS is now to verify its orbit, maneuver as required to attain the appropriate orbit, update the OOS guidance and navigation subsystems as may be required, deploy the mated OOS/satellite at the appropriate time, and initiate those sequences aboard the OOS which will ultimately transfer the OOS to high altitude.

B.8.4.4 OOS-Satellite Deployment. It is a system operation objective that the OOS be preprogrammed sufficiently such that it will be in complete control of itself after being released into space by the EOS. Just prior to the release, the EOS performs a final checkout of both OOS and satellite(s), and activates the RF communications subsystem aboard both the OOS and the satellite(s). Following release the EOS performs a final, post-deployment checkout, verifies that the OOS is ready to perform its mission, maneuvers to a safe distance from the OOS (thereby separating to a distance as much as 20 nmi), and then, by an appropriate command conveyed to the OOS via the SGLS RF comm link, initiates the OOS sequences.

At this point the EOS has completed its OOS-related task; if the OOS is expendable the EOS then continues with whatever remaining on-orbit tasks it is to perform. However, if the OOS is reusable, the EOS is charged with the task of retrieving the OOS several hours, or even days, later, and must plan and execute its on-orbit activities accordingly.

B.8.4.5 <u>OOS Orbital Transfer</u>. Upon being deployed by the EOS, the OOS/satellite combination is (typically) in a circular earth orbit, approximately 120 nmi high, and inclined about 28 degrees relative to the equatorial plane. The task of the OOS is to transfer the satellite to a much higher altitude (i.e., 19,300 nmi for a synchronous orbit), execute a plane change to coincide with the equator, and circularize the satellite orbit. This sequence of events occurs as follows.

Immediately following the final checkout of OOS and satellite by the EOS, the EOS initiates the preprogrammed OOS sequence; at this point the OOS is in a completely autonomous condition and will, in the absence of any anomalies, place the satellite in its intended orbit without further commands from the EOS or from the ground. Current concepts include ground support of the OOS only under contingency conditions.

The first step is for the OOS, utilizing its internal guidance and navigation subsystems, to adjust its attitude, and at the correct point (time) in its orbit, ignite its main engines. The consequence of these actions will be a velocity increase such as to result in an elliptical "Hohmann transfer" orbit; the engine burn requires a few tens of seconds. The OOS stored program must, of course, shut off the engines when an appropriate velocity increase has been achieved.

The OOS, with the satellite, then coasts toward apogee, a flight which consumes 5 to 6 hours. When the OOS has reached an altitude of a few thousand miles (4000 to 5000), it reaches a favorable condition for long-term line of sight (LOS) communications with one or another of the SCF ground stations; from this point onward to apogee, line-of-sight can be maintained to the ground. When this occurs, both the OOS and the satellite will, using their own onboard communications equipment, transmit status data to the ground.

In order to equalize thermal stresses within either the OOS or the satellite, it may be desirable for the OOS to perform a "rotisserie roll," i.e., a slow spin around its principal axis, while coasting to apogee. Because of constraints pertaining to OOS and/or satellite antenna directional patterns, it will probably be necessary to stop this roll while data is transmitted from either spacecraft and to re-initiate the roll following such transmission.

B.8.5 Reusable OOS. Since it is a major objective of the STS program to perform all missions cost-effectively, it follows that an OOS should be retrieved by the EOS and reused whenever possible. In certain missions, dictated by analysis of stored fuel capabilities of the OOS, it is entirely practical for the OOS to return to a parking orbit after deployment of a satellite, such as to permit OOS retrieval by the EOS; these missions are generally either 1) those in which satellite deployment occurs at a relatively low altitude (i.e., well below synchronous); 2) those involving a relatively low-mass satellite; or 3) some combination of both.

Furthermore, even during those missions for which the OOS is not planned to be reusable, it is possible that contingent occurrences may make it desirable to recover the mated OOS/satellite. For example, it is possible that a satellite, headed for synchronous orbit deployment, may experience a subsystem malfunction or complete failure after the OOS has performed its initial transfer-orbit burn and the mated OOS/satellite are coasting upwards. Such a condition would necessarily be detected by ground-supported monitoring of the satellite during the orbital coast; a decision may be made (on the ground) that the satellite should not be deployed but should be recovered if possible.

In this event, rather than executing the plane change and circularization burns at (synchronous) apogee, the OOS could save its fuel, return a few hours later down to near perigee, and there execute retrofirings intended to place the mated OOS/satellite into a parking orbit, from which retrieval by the EOS would be possible. Without question this type of contingency would require heavy support from the ground and would rely completely on direct communications between the OOS and a ground station.

When the OOS is planned to be reusable, after deployment of the satellite(s) the OOS must begin its return to the EOS-attainable parking orbit. In general, this procedure is divided into four major segments:

A. After satellite deployment, wait until the proper moment to execute the first return orbit transfer burn.

B. Attitude adjustment and transfer burn down to the parking orbit

B.8.5 Reusable OOS (Cont'd)

C. Coast.

D. Final attitude adjustment and transfer burn to attain parking orbit.

When the OOS makes an unscheduled return with a malfunctioning satellite it will automatically return to, or close to, the parking orbit. In this case the major operations consist of:

- Possible midcourse correction on the way down, either to attain the proper final altitude, or to arrive at the final orbit at a position and time permitting EOS retrieval
- Final altitude adjustment and transfer burn to attain parking orbit.

During the normal, non-contingent return of the OOS to parking orbit, the OOS will be pre-programmed to execute all maneuvers; ground support will be required only in the event of anomalous behavior.

B.8.6 Multiple Satellite Deployment. Occasionally the OOS will deploy more than one satellite on a single mission. An outstanding example of such a mission is to be found in the deployment of IDCSP satellites, when as many as eight spacecraft were launched by a TITAN III-C and deployed from a single upper stage (TRANSTAGE). In this case, each spacecraft was released and ejected away from the upper stage by a spring-loaded release mechanism; following the release of a satellite, the TRANSTAGE engine was burned briefly, followed by a drift prior to release of the next satellite. The entire sequence was pre-programmed into the TRANSTAGE, and, although the sequential deployment was monitored by the ground, there was no requirement for ground override.

Thus, multiple deployment by an advanced OOS poses no basically new technology problems on the STS. On the other hand, from a functional point of view, multiple deployment is considered a relatively elaborate procedure, such that close ground monitoring, together with a quick-reaction support capability in the event of a flight anomaly is mandatory to ensure success of the mission.

B.8.7 Tug Retrieval of a Satellite. An advanced capability provides for the retrieval of a satellite by the tug; followed by return of the mated pair to a parking orbit position, permitting final retrieval by the EOS. It is expected that this capability will be developed well downstream in the STS program, since it involves new technology developments and mission risks not currently considered acceptable.

The new problems concerning tug/satellite retrieval are:

- Development of viable docking aid system
- Development of a flight control plan, in which the functions to be accomplished by the tug, ground, and a possible man-in-the-loop are outlined in detail.

Under current concepts, the problem of having a completely autonomous, pre-programmed tug rendezvous with, retrieve, and dock with a satellite is complex; ground support, including some form of manual control of both the tug and satellite, may be required.

From a functional point of view the following must be accomplished:

A. Satellite must be deactivated, including de-spin and furling of appendages (antennas, sensors).

B. Tug must approach satellite from direction ensuring successful mating.

C. Once in contact with tug, satellite must be mechanically joined to tug.

D. Closure velocity must be slow enough to guarantee safety of both spacecraft, but must not be so slow as to unduly prolong operation.

E. Tug energy requirements must not endanger mated spacecraft ability to return to parking orbit.

F. Communication to/from both tug and satellite must be secure and SGLS-compatible (DOD requirement), in real-time, continuous during docking sequences.

B.8.7 Tug Retrieval of a Satellite (Cont'd)

In order to accomplish docking with a satellite, the tug must first be guided to the near vicinity of the satellite (within 20 or 30 nmi) and must then employ one or more docking aids for the final closure. Although final decisions on docking aids will not be made for considerable time, likely candidates are 1) slow-scan TV of sufficient resolution and picture quality to show non-ambiguously the satellite attitude and disposition for a favorable docking, and 2) a scanning laser radar. The dual system has the following major features:

- TV can show very quickly the satellite attitude and disposition
- Laser radar will provide rapid, accurate data on the closure range and range rate; thus, TV and laser together provide complete three-dimensional data required for docking
- Data from both subsystems can be readily digitized for secure relay to the ground.

Operational constraints are associated with TV picture quality because of the limited bit rate of the SGLS system (1.024 Mb/s), and handicaps imposed by limited round trip signal delay times through the system communications network.

Following capture of a satellite the tug will then return to parking orbit, as outlined in paragraph B.8.4.

B.9 AFSCF/SAMTEC BASELINE

Officially the baseline for both the AFSCF and the SAMTEC are as presented in their documentation prepared for potential users, specifically the *SAMTEC Range Users Handbook*, SAMTECM 80-1 and the *AFSCF Space/Ground Interface Document*, Report No. TOR-0059 (6110-01) -3, Reissue B. In addition to these documents, those listed at the end of this paragraph are also available as required from the AFSCF, the SAMTEC, or from the Philco-Ford WDL data base on the AFSCF. These additional documents and more detailed specifications will be most useful in future studies when capabilities will be measured against requirements.

B.9 AFSCF/SAMTEC BASELINE (CONT'D)

The baseline of the SAMTEC and its future plans, exclusive of the STS, will have only minimal effects on this current study effort since the STS will be the *predominant driver* for substantial change to the SAMTEC Space Launch Operation at Vandenberg AFB. There are, however, many programs supported at the SAMTEC and their requirements must be given due consideration when considering any major modifications. Conversely, although the STS will be a major addition to the workload on the AFSCF, it most probably will not be the driver in the same sense as it will be at the SAMTEC. The operations concept for the STS does not differ greatly from that currently followed in support of existing programs. The AFSTC currently houses many mission control centers which will not probably continue to exist in the era of the STS. The addition of a Shuttle mission control center will probably be accommodated within normal expansion procedures, although perhaps on a somewhat larger scale.

One aspect of current AFSCF improvement planning has a significant effort on the support to be provided to the STS. Specifically, the Wideband Real-Time Duplex Data System, expected to be operational in 1979, will be capable of handling all data transmission requirements currently anticipated by the STS; however, this upgrading was not primarily driven by the STS.

Detailed references are as follows:

A. AFSCF

1. TOR-0059 (6110-01) -3 *AFSCF Space/Ground Interface*, Rev. B, September 1972

2. SOM Chapter 5, "Test Operations Mission," 1 August 1973

3. *SCF System General Specification*, 10 May 1973

B. SAMTEC

1. AFWTRM 80-1, *Range Users Manual*, August 1967

2. AFWTRN 127-1, *Range Safety Manual*, July 1971

B.9 AFSCF/SAMTEC BASELINE (CONT'D)

3. TR70-1, *Communications System Handbook,* December 1970

4. TR 70-5, *Ships and Aircraft Handbook,* April 1970

5. TR-70-7, *Landbased Instrumentation Handbook,* August 1970

6. TR 70-6, *Data Handbook,* July 1970

7. TR 71-1, *Frequency Management Handbook,* October 1970

8. SAMTEC M100-1, *C-E Instrumentation Communications Security Frequency Management,* July 1970

B.10 GEO-SYNCHRONOUS DEPLOYMENT MISSION

B.10.1 Mission Description. This mission is representative of the deployment of a payload into a geo-synchronous orbit. The Orbiter, OOS and satellite are launched due east from ETR and ascend into a 50 × 100 nmi, 28.5 degrees parking orbit. The OOS/satellite separates from the Orbiter and performs the necessary phasing, transfer and plane change maneuvers to place the satellite at the desired longitude location in the synchronous orbit. After satellite deployment, the OOS returns to an orbit 15 nmi above the Orbiter parking orbit. After OOS retrieval, the Orbiter will wait in parking orbit (115 nmi) for phasing and return to ETR.

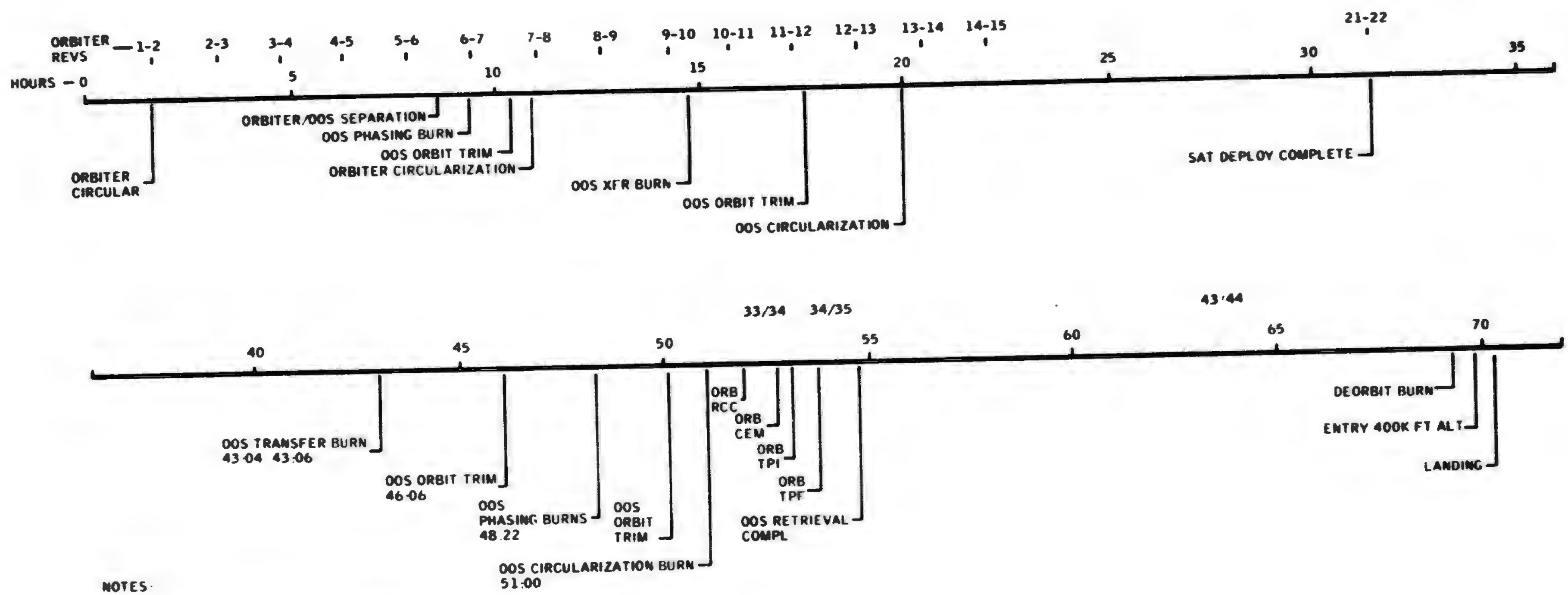
The OOS/satellite payload will be under Orbiter hardwire monitor from liftoff through parking orbit deployment. Pre-development checkout of the OOS and the satellite will consist of a hardwire, minimal functional check. After deployment, initialization and separation, an RF check will be performed by the Orbiter to verify the command and control functions. During rendezvous, the Orbiter will again perform an RF checkout of the OOS and condition it for retrieval.

B.10.2 Orbital Timelines. Two orbital timelines are included in this mission description. Figure B-14 is a timeline for the entire flight phase. Figure B-15 shows the OOS timeline for the deployment mission. Major events are identified on both timelines.

B.10.3 Mission Sequence. The mission sequence is given in table B-16 and is intended for use with figure B-14. Times indicated are representative. This mission sequence includes representative orbit parameters.

B.10.4 Flight Operations. Because of its complexity (this is the most complex of the three synthesized missions), this mission has, for presentation purposes, been separated into five segments. The five segments are as follows:

- Ascent phase
- OOS outbound transfer orbit phase



NOTES:

RCC - RENDEZVOUS CORRECTIVE COMBINATION
CFM - CO-ELLIPTIC MANEUVER
TPI - TERMINAL PHASE INITIATION
TPF - TERMINAL PHASE FINAL

Figure B-14 Orbital Activities for Geo-Synchronous Mission

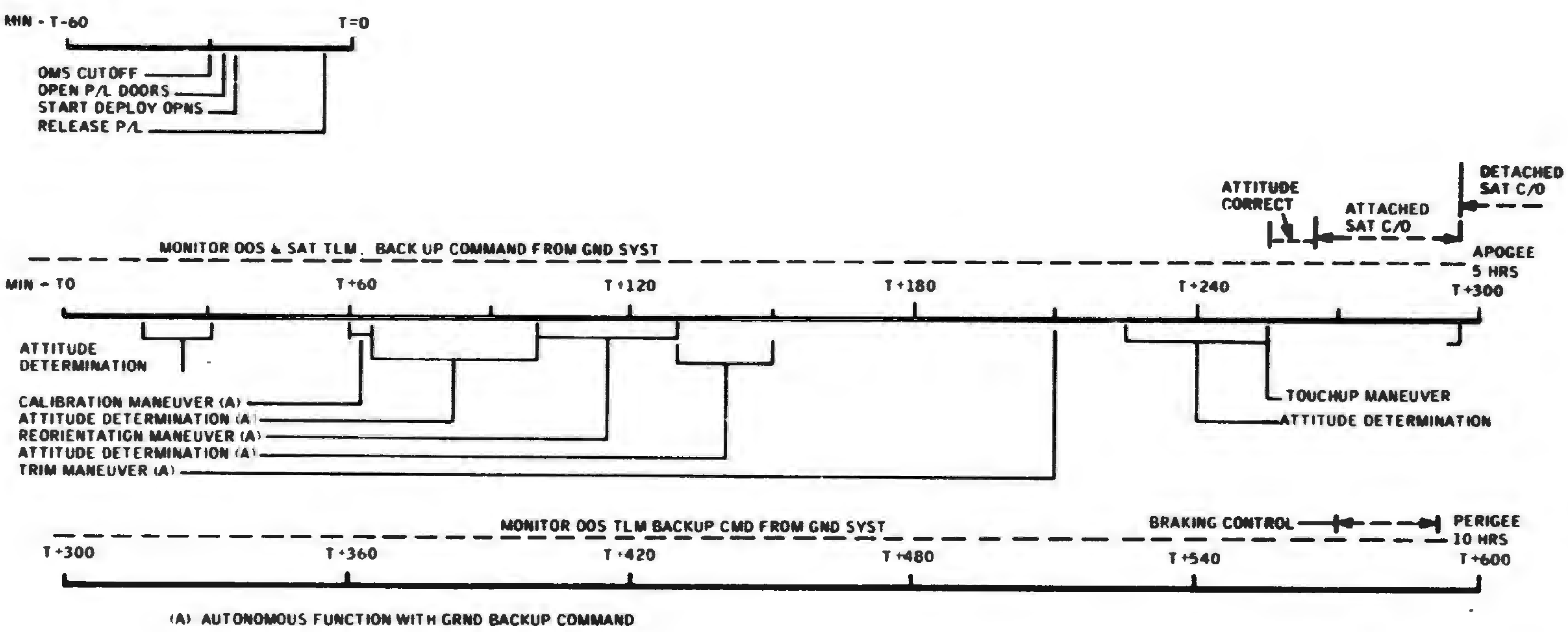


Figure B-15 OOS Deployment of Satellite

TABLE B-16

MISSION SEQUENCE

MISSION	EVENT	TIME (GET)
1	LIFTOFF - ORBITER TARGETED FOR 50/100 nmi/ 28.5°	00:00:00
2	SRB STAGING	00:01:53
3	MECO	00:08:19
4	PARK ORBIT INSERT - 50.21/103.5 nmi/28.5°	00:08:19
5	APOGEE ADJUST - 98/104 nmi/28.49°	00:51:01
6	CIRCULARIZATION - 134/134 nmi/28.49°	01:36:17
7	OOS CHECKOUT - (C/O COMP HALF ORBIT PRIOR TO 7TH DESCENDING NODE. TARGETED TO SYNC ORBITER POSITION)	01:36:17
8	OOS DEPLOY	07:36:15
9	ORBITER SEPARATE - 131/148 nmi	08:36:15
10	OOS PHASING BURN - 7TH DESCENDING NODE 133/3611 nmi	09:18:05
11	ORBITER CIRCULARIZE - 138/138 (BEGIN 33 REV-OLUTIONS	10:50:48
12	OOS PHASING REVOLUTIONS (2)	
13	OOS TRANSFER BURN - 133/19, 394 nmi/25.0°	14:41:57
14	OOS ORBIT TRIM	≈17:35:00
15	OOS CIRCULARIZATION - 19,300/19,296 nmi	19:57:26
16	OOS ORBIT ADJUST (SYNC ORBIT)	AS REQ'D
17	OOS SATELLITE DEPLOY	≈31:09:00
18	OOS TRANSFER BURN - 164/19,323 (SYNC) 2 .12°	43:04:05
19	OOS ORBIT TRIM	≈46:06:00
20	OOS PHASING BURN - 164/3439 nmi/27.24°	48:21:23
21	OOS ORBIT TRIM	≈50:00:00
22	OOS CIRCULARIZATION - 165/161 nmi/28.52°	51:00:08
23	ORBITER RCC BURN - 128/162 nmi/25.51°	51:55:07
24	ORBITER EEM BURN - 162/128 nmi/28.50°	52:43:06

TABLE B-16 (CONT'D)

MISSION	EVENT	TIME (GET)
25	ORBITER TPI BURN - 145/169 nmi/28.51°	53:06:58
26	ORBITER TPF - 154/168 nmi/28.49°	53:42:58
27	OOS RETRIEVAL (START)	≈53:42:00
28	EIGHT REVOLUTIONS	
29	DEORBIT BURN - 10/161 nmi/28.48°	69:25:06
30	LANDING	70:26:01

B.10.4 Flight Operations (Cont'd)

- OOS return transfer orbit phase
- Orbiter/OOS rendezvous
- Retrieval through landing

Each segment is graphically described in figures B-16 through B-20. For the most part, the figures are self explanatory. The following paragraphs briefly address each segment in more detail.

B.10.4.1 Ascent. Mission begins with launch of Orbiter and payload from ETR. Launch is due east (launch azimuth 90 degrees) with insertion target conditions of 50 nmi perigee by 100 nmi apogee and 28.5 degrees inclination. Insertion is intended near apogee (ascent profile is shown in figure B-16).

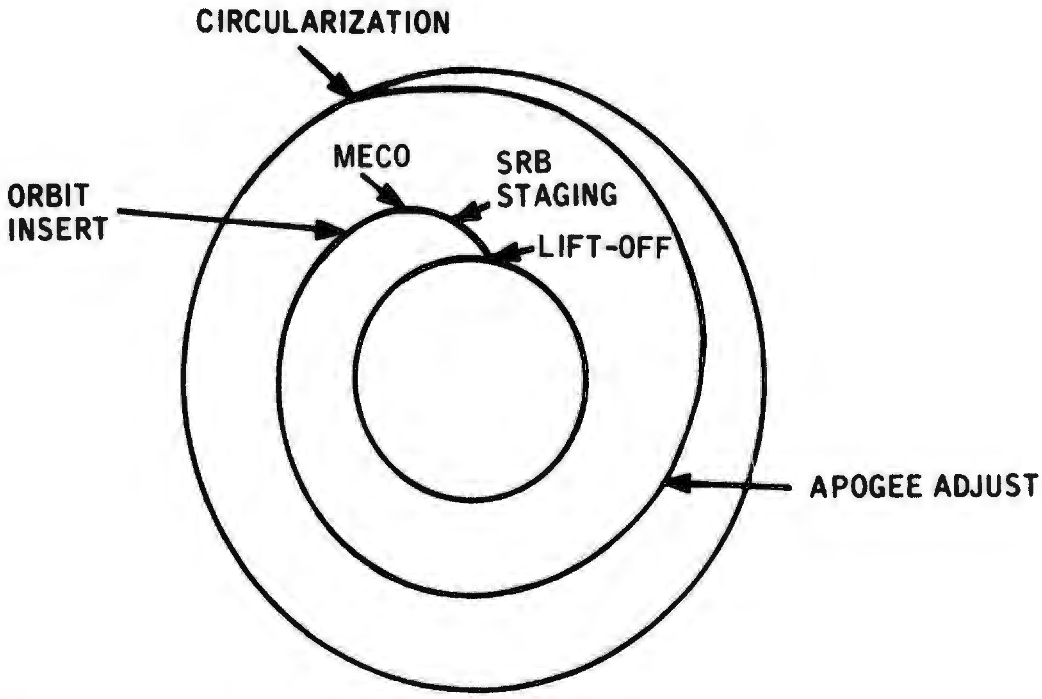
Ascent begins with a 5-second vertical rise followed by a 15-second constant rate pitchover (-0.58°/sec) to a pitch attitude of -8.69 degrees with respect to vertical. A gravity turn profile is flown until the SRB's burn out and separate.

After SRB jettison, the Orbiter follows a pitch polynomial generated by open-loop shaping of the ascent trajectory to maintain the desired attitude. Thrust acceleration reaches 3 g's (maximum allowable) and the main engines are throttled down to maintain the constant 3-g acceleration. At throttle-down, a constant pitch rate is maintained until main engine cut off (MECO) and ET jettison.

Ascent phase ends with MECO; insertion occurs with apogee of 103.5 nmi and perigee of 50.2 nmi, with 28.5 degrees inclination.

B.10.4.2 OOS Outbound Transfer Orbit. As shown in figure B-17, checkout of the OOS/satellite combination begins at approximately 1:36:00 ground elapsed time (GET), and is complete by 08:36:15 GET. At completion of the deployment, the OOS outbound transfer orbit phase begins (figure B-17).

Depending upon the placement location for the satellite, the OOS can begin a direct transfer from the Orbiter parking orbit or can execute one or more phasing orbit revolutions to place the OOS in



ORBITER EVENTS - LIFTOFF THROUGH CIRCULARIZATION

1	LIFTOFF	00:00:00		
2	SRB STAGING	00:01:53		
3	MECO	00:08:19		
4	PARK ORBIT INSERT	00:08:19	50.2/103.5 NMI	28.50
5	APOGEE ADJUST	00:51:01	98/140 NMI	28.50
6	CIRCULARIZATION	01:36:17	134/134 NMI	28.50

OOS CHECKOUT & DEPLOYMENT

7	PRE-DEPLOY CHECKOUT	01:36:17		
8	DEPLOY	07:36:15		
9	POST-DEPLOY CHECKOUT			
10	ORBITER SEPARATE	08:36:15	148/131 NMI	28.52°
11	OOS PHASING BURN	09:18:05	133/3611 NMI	27.19°
12	ORBITER CIRCULARIZE	10:50:48	138/138 NMI	28.52°

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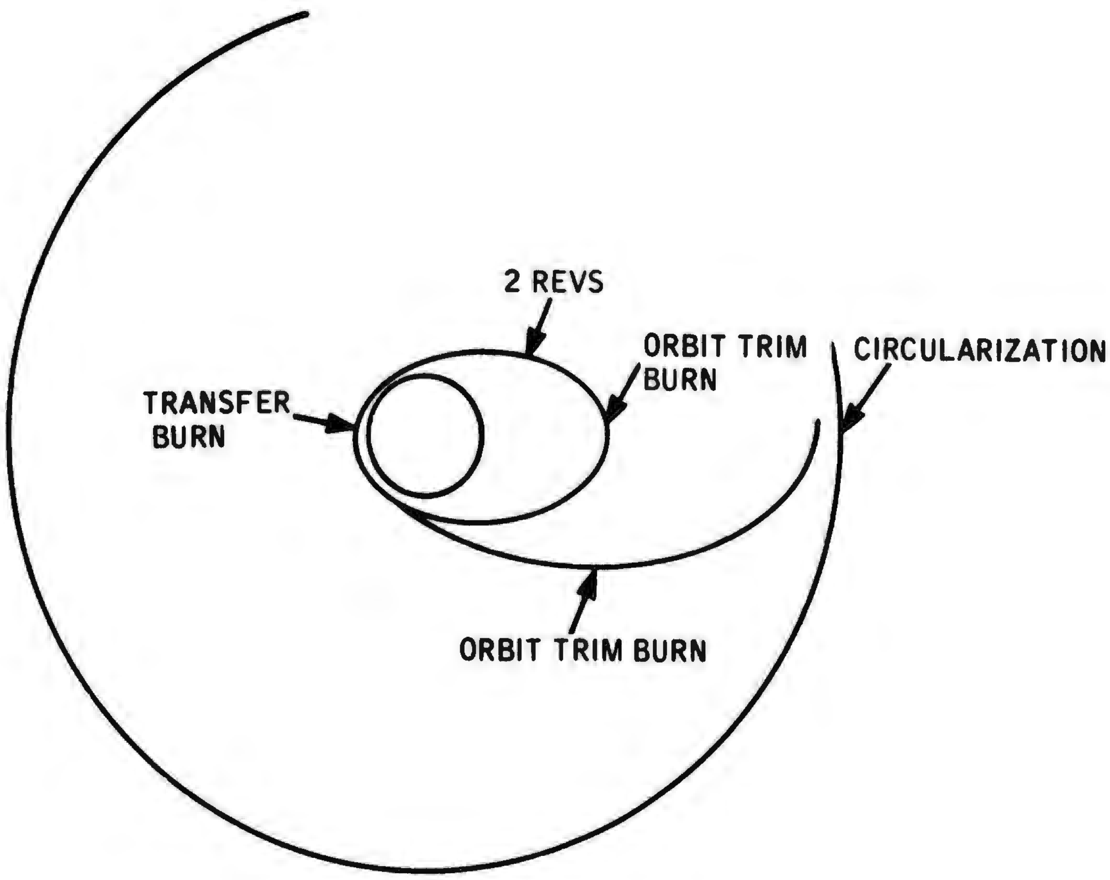
Figure B-16 Ascent Profile



OOS EVENTS PHASING BURN THROUGH OUTBOUND CIRCULARIZATION

11	PHASING BURN	09:18:05	133/3611 NMI	27.19°
12	ORBIT TRIM			
13	TRANSFER BURN	14:41:57	133/19300	26.0°
14	ORBIT TRIM			
15	CIRCULARIZE	19:57:26	19300/19297	0.0°

ORBITER NOT SHOWN
CONTINUES IN PARK ORBIT UNTIL OOS RETURN (33 REVS)
138/138 NM 28.52°

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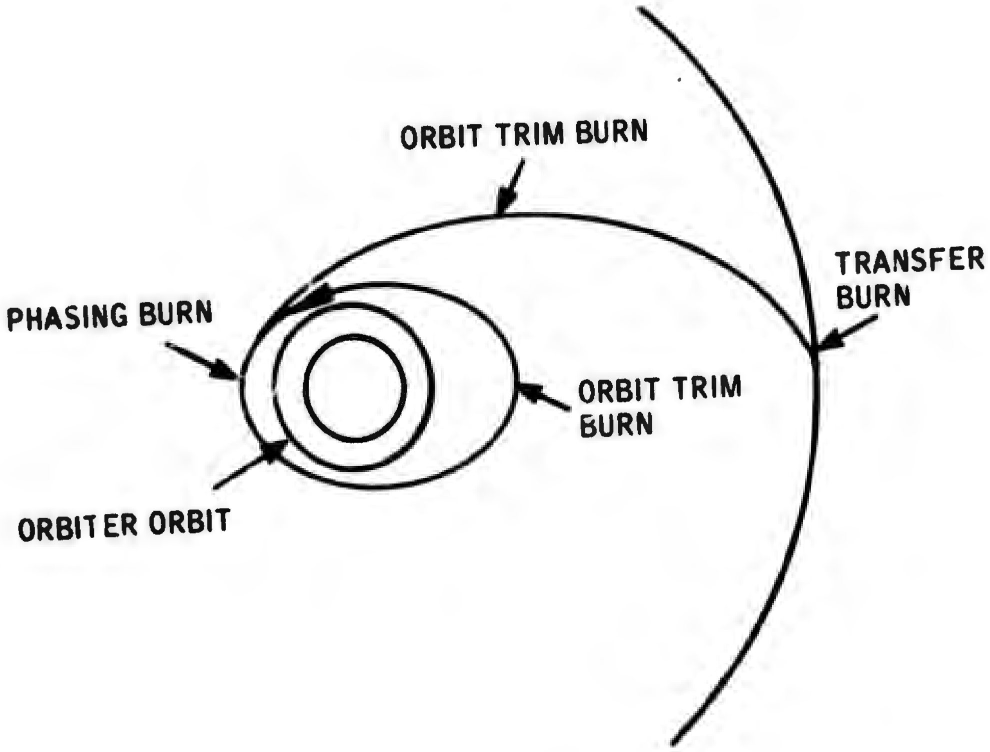
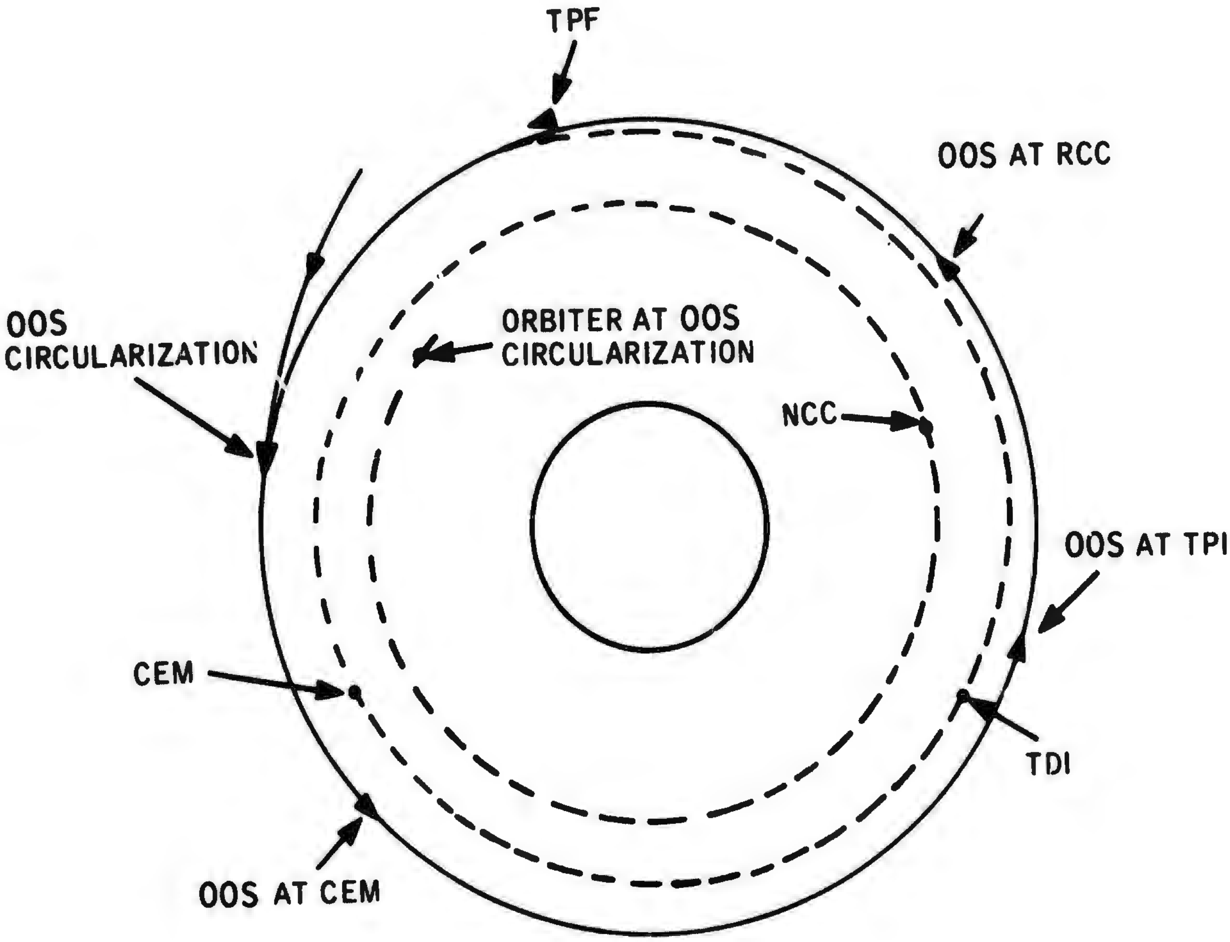
Figure B-17 OOS Cutbound Transfer Orbit Phase



OOS EVENTS POST-DEPLOY (RETRIEVAL)

18	TRANSFER BURN	43:04:05	164/19323	26.12
19	ORBIT TRIM			
20	PHASING BURN	48:21:23	164/3439	27.24
21	ORBIT TRIM			
22	CIRCULARIZATION	51:00:08	161/165	28.52

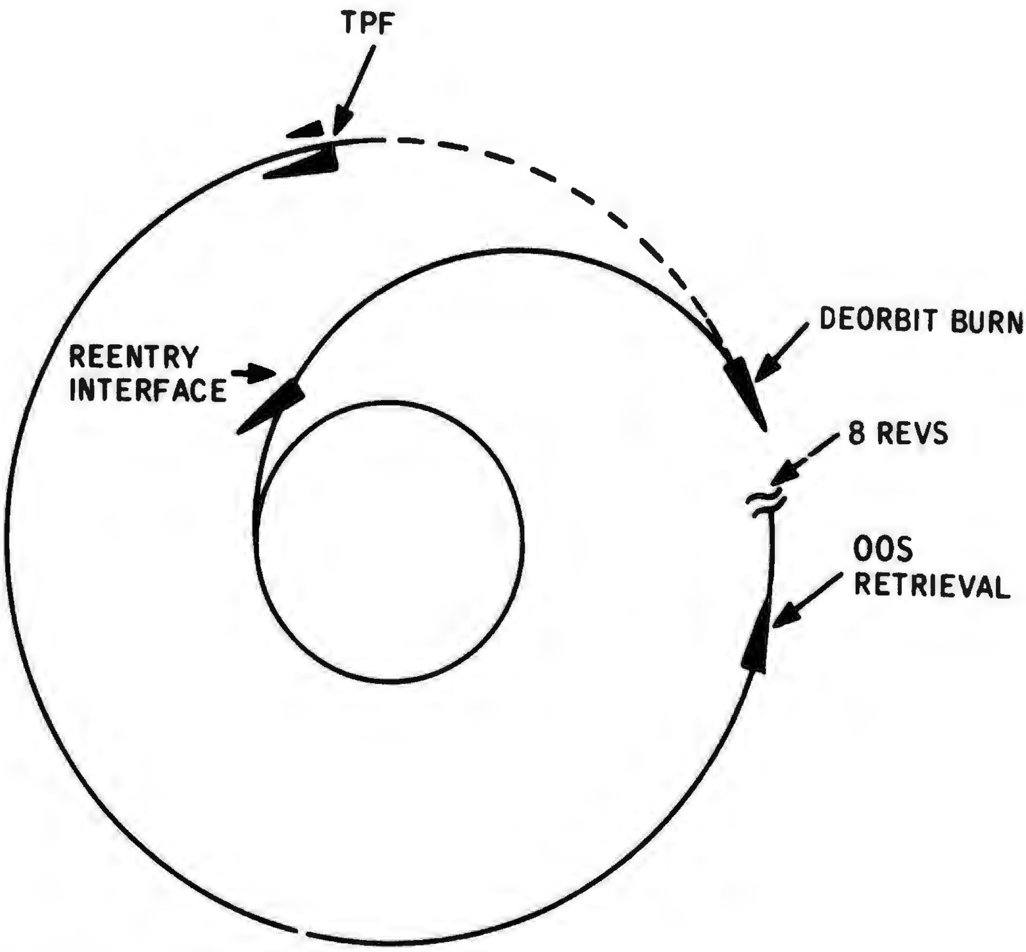
Figure B-18 OOS Return Transfer Orbit Phase



OOS/ORBITER EVENTS - CIRCULARIZATION THROUGH TPF

22	OOS CIRCULARIZATION	51:00:08	161/165	28.52°
23	ORBITER RCC	51:55:07	128/162	28.51°
24	ORBITER CEM	52:43:06	149/155	28.50°
25	ORBITER TPI	53:06:58	145/169	28.51°
26	ORBITER TPF	53:42:58	154/168	28.49°

Figure B-19 OOS/Orbiter Rendezvous



OOS/ORBITER EVENTS - RETRIEVAL, DEORBIT, & LANDING

26	TPF	53:42:58	154/168	28.49°
27	RETRIEVAL	45:02:58		
29	DEORBIT	69:25:06	10/161	28.48°
30	LANDING	70:26:01		

Figure B-20 Retrieval Through Landing

B.10.4.2 OOS Outbound Transfer (Cont'd)

a more favorable transfer burn position (the more complex phasing orbit maneuver sequence is used to illustrate the transfer burn sequence). In the orbit shown (figure B-17) it is essential that the OOS place the satellite at a specific location in geo-synchronous equatorial orbit, requiring plane changes from the 28.5 degree inclination of the parking orbit and two phasing orbit revolutions to place the OOS in the required position for the transfer orbit. As shown on the mission sequence, table B-17, it is mandatory for the OOS to execute the phasing orbit burn at the 7th descending node. The burn is executed at 09:18:05 GET and places the OOS in a 133 × 3611/27.9° elliptical orbit. Two revolutions in this orbit place the OOS in the proper position for the transfer burn such that the OOS arrives at synchronous orbit at the desired location and inclination. Provision is made for an orbit trim during the phasing orbit to adjust the OOS attitude for the transfer orbit burn from 26.0 degree inclination.

At 14:41:57 GET the OOS executes the transfer burn at the perigee of the phasing orbit (133.0 nmi/26.0°). An orbit trim is executed during the transfer orbit ascent to adjust OOS attitude for the circularization burn and plane change. Transfer orbit plane and circular orbit plane coincide at 19,300 nmi and the OOS executes a circularization burn into a 19,300 × 19,300 nmi/0.0° orbit. Any necessary orbit adjustment is accomplished by the OOS and the satellite is deployed. Initiation may be by the OOS separation function or by ground command. Complete operational checkout of the satellite is the responsibility of the ground system. Moreover, a predeployment check may be made to determine basic command and control capability, such that if the checkout is negative, the satellite can be returned with the returning OOS. It is anticipated that the complete operational check can be made only after separation and initialization.

B.10.4.3 OOS Inbound Transfer Orbit. As stated previously, this representative mission has been made complex for illustrative purposes and severe time constraints have been placed on orbit maneuvers to indicate requirements; in this case, the OOS phasing orbits to adjust to specific deployment requirements.

B.10.4.3 <u>OOS Inbound Transfer Orbit</u> (Cont'd)

Were the OOS deorbit time not time-constrained, a simple direct transfer orbit to the Orbiter parking orbit could be made at any time. Assuming, however, that total on-orbit time should be minimized, the OOS phasing orbit has been selected so that the OOS can be placed with 90 nmi of the Orbiter -- thus minimizing rendezvous and retrieval time. The inbound transfer orbit is illustrated in figure B-18.

At 43:04:05 GET, the OOS executes a deorbit transfer burn into a 164 × 19,323 nmi/26.12° elliptical orbit. The inbound descent requires approximately 5 hours during which an orbit trim maneuver may be required to adjust the OOS attitude for the phasing burn. At 48:21:23 GET, the phasing orbit burn is executed at the transfer orbit perigee (164 nmi), placing the OOS in a 164 × 3439 nmi/27.24° phasing orbit. After one orbit, the OOS executes a circularization burn at the perigee of the phasing orbit, placing the OOS in a 165 × 165 nmi/28.52° circular orbit above the Orbiter parking orbit.

As shown in the mission sequence, table B-16, the Orbiter is completing the 33rd revolution in a 134 × 134 nmi/28.5° orbit and is within tracking sensor range of the OOS (behind and below).

OOS circularization into the rendezvous orbit completes the OOS inbound transfer orbit phase.

B.10.4.4 <u>OOS/Orbiter Rendezvous</u>. The Orbiter is capable of at least two types of rendezvous sequences: direct ascent (as described in the first mission description), and the multi-revolution, co-elliptic (as used in this representative mission). Direct ascent rendezvous must be controlled onboard the Orbiter because network support is not available on a continuous basis. Figure B-19 illustrates the rendezvous sequence.

Trajectory calculation for co-elliptic sequence must be accomplished both onboard the Orbiter and by the ground system. The Orbiter crew must be able to analyze the effect of any correct burn on the altitude, phasing, and time of rendezvous, while the ground system processes the same information to determine station contact parameters. The Orbiter assumes prime responsibility as soon as its sensors acquire the target.

B.10.4.4 OSS/Orbiter Rendezvous (Cont'd)

As shown, the OOS returns to an orbit co-elliptical to the Orbiter parking orbit somewhat higher than the parking orbit altitude. The specific orbits, shown on the mission sequence, table B-16, are 134 × 134 nmi for the Orbiter circular parking orbit, and 165 × 161 nmi for the OOS co-elliptic orbit.

Rendezvous between the Orbiter and the returning OOS begins following the OOS circularization burn. As stated, OOS circularization is at the perigee of the inbound transfer orbit or (as in this case) the phasing orbit. The phasing orbit places the rendezvous target within minimum maneuver range of the Orbiter. The Orbiter immediately begins rendezvous sensor acquisition. Fifty-four minutes later, the Orbiter initiates a sequence of maneuvers resulting in rendezvous 2.7 hours after the OOS circularization burn. The Orbiter executes a RCC (rendezvous corrective combination) burn and a CEM (co-elliptic maneuver) burn to bring it in place for the TPI (terminal phase initiation) and TPF (terminal phase final). Due to their small magnitude, only the TPI and TPF maneuvers are performed using the reaction control system (RCS).

The RCC burn is intended to place the OOS orbit 10 nmi above that of the Orbiter and to establish a proper phase angle (about -1.1 degree) at the co-elliptic maneuver point. Residual out-of-plane error would be corrected by this maneuver. The CEM maneuver circularizes the orbit and nulls the residual out-of-plane velocity between the two vehicles. Except for attitude control, the OOS becomes passive/cooperative for the final phase of the mission; the Orbiter becomes the active vehicle. After the co-elliptic maneuver, the phase angle between the Orbiter and the OOS is about 1.1 degrees and the Orbiter reduces this range from the OOS at a near-constant rate. Approximately 45 minutes later, the Orbiter reaches the TPI point, and the final approach phase of the rendezvous is initiated (53:06:58) GET on the mission sequence.

B.10.4.5 Retrieval and Landing. Retrieval operations (illustrated in figure B-20) begin at approximately 53:43:00 GET, and consist of the jettison of any remaining OOS fuel, safing functions, sufficient commands to correct the OOS attitude for retrieval and the deactivation of the OOS reaction control system (attitude control).

B.10.4.5 Retrieval and Landing (Cont'd)

Grapple, retract, and securing of the OOS in the payload bay require no more than 20 minutes and include remating of the OOS umbilicals in the payload bay, primarily for safety purposes.

To return to the WTR landing site requires that the Orbiter be in a specific position for deorbit and on this particlar mission requires eight additional revolutions. At 69:25:06 GET, deorbit burn is executed by the Orbiter from the nominal 161 nmi orbit to approximately 10 miles at entry location where ground flight support is available. Approximately one hour later (70:26:01 GET) the Orbiter touches down and begins rollout.

B.11 LAUNCH COMPLEX FACILITIES

This appendix defines in greater detail the purpose and function of the facilities in the launch complex. Further details are contained in relevant DOD requirements documents.

A. Payload Processing Facility (PPF). A secure facility for the storage, assembly and checkout of satellites. Mating of the satellite and an upper stage, if required, is also performed in this facility.

B. Upper Stage Maintenance and Checkout Facility (U/SF). A secure facility for the storage, assembly, and checkout of upper stages.

C. Orbiter Maintenance Facility (OMF). A non-secure but limited exclusion/access facility for the refurbishment, assembly and checkout of the Orbiter.

D. Integration/Mating Facility (I/MF). A non-secure but limited exclusion/access facility for the integration of the Orbiter with the ET and the solid rocket motors (SRM's).

E. Mobile Launch Platform (MLP). A portable launching facility on which the Orbiter is integrated into launch configuration, moved to the launch area, and launched. Includes a secure vault for cryptographic equipment.

B.11 LAUNCH COMPLEX FACILITIES (CONT')

F. Mobile Service Tower (MST). A mobile service tower which works in conjunction with the MLP to provide specialized prelaunch functions. Includes a secure payload loading room for placing the payload in the cargo area of the Orbiter.

G. Launch Pad (LP). The area to which the integrated vehicle on the MLP is moved for launch. Includes a physically controlled zone of up to 3 miles in radius and a limited exclusion/access area of up to one-half mile in radius.

H. Launch Control Complex (LCC). A facility remotely located from the launch pad from which integrated vehicle checkout and launch is controlled. This facility includes a secure vault for the handling of secure data during checkout and launch and is the heart of secure operations during the prelaunch activities.

I. Remote Tracking Station (RTS). A satellite tracking station utilizing the SGLS up- and downlink system and includes a near-real-time communication link with the USAF SCF Satellite Test Center (STC)/Shuttle Mission Control Center (SMCC).

J. Unified S-Band Facility (USB). A satellite tracking station using the NASA unified S-Band system. Forms a part of a world-wide system used for contingency communication in DOD Shuttle program operations.

K. Landing Area Facility (LAF). The landing strip and associated landing aids dedicated to landing of a winged spacecraft.

L. Flight Control Center (FCC). Functions to control the landing of aerodynamic vehicles, including flight control aids such as TACAN and ILS.

M. Safing and Purging Area (SPA). An area dedicated to payload removal, Orbiter and payload fuel and gas purge, and classified memory purge.

B.11 LAUNCH COMPLEX FACILITIES (CONT'D)

N. Launch Processing System (LPS). A planned integrated system which provides the user with all necessary equipment and supporting software to effect the timely performance of the test, checkout, and launch control missions for the Space Shuttle.

O. Central Data System (CDS). A history bank and data management system (computer memory storage and associated peripherals).

B.12 DEFINITION OF TERMS

The following are terms used herein and are peculiar to the problems of secure data handling. These terms, which are unclassified, are extracted from MIL-HDBK-232, *Red/Black Installation Guidelines*, and are presented to provide clarity to the discussion of this subject.

A. Access. The ability and opportunity to obtain knowledge of classified information.

B. Black. A designation applied to wirelines, components, equipment and systems which handle only unclassified signals and to areas in which no classified signals occur.

C. Black Equipment Area (BEA). The space within a limited exclusion area (LEA) which is designated for installation of Black processing equipment, power, signal control, ground feeder and distribution facilities.

D. Communication Security. The protection resulting from all measures designed to deny unauthorized persons information of value which might be derived from the possession and study of telecommunication or to mislead unauthorized persons in their interpretation of the results of such possession and study.

E. Compromise. Any occurrence which results in unauthorized persons gaining access to classified or other information requiring protection.

B.12 DEFINITION OF TERMS (CONT'D)

F. Compromising Emanation. Unintentional data-related or intelligence-bearing signals which, if interpreted and analyzed, disclose the classified information transmitted, received, handled or otherwise processed by any information processing system, or which could assist the breaking of a security code.

G. Controlled Access Area. The complete building or facility area under direct physical control which can include one or more limited exclusion areas, controlled Black equipment areas, or any combination thereof. Spaces within a facility which are not under direct physical control but to which access is controlled (administration offices, halls, rest rooms) are not a part of the actual controlled access area but are considered as a part of the overall physical control zone (PCZ).

H. Limited Exclusion Area (LEA). A room or enclosed area to which security controls have been applied to provide protection to a Red information processing system's equipment and wirelines equivalent to that required for the information transmitted through the system. An LEA must contain a Red equipment area.

I. Physical Control Zone (PCZ). The space surrounding equipment processing classified information, which is under sufficient physical and technical control to preclude a successful hostile intercept of any classified information from this space.

J. Red/Black Concept. The concept that electrical and electronic circuits, components, equipments, systems, and so forth, which handle classified plain language information in electrical signal form (Red) be separated from those which handle encrypted or unclassified information (Black). Under this concept, Red and Black terminology is used to clarify specific criteria relating to, and to differentiate between such circuits, components, equipments, systems, etc. and the areas in which they are contained.

B.12 DEFINITION OF TERMS (CONT'D)

K. Red. A designation applied to 1) all wirelines within the terminal or switching facility carrying classified plain language, 2) all wirelines between the unencrypted side of the on-line crypto equipment used and individual subscriber sets or terminal equipment, 3) equipments and sets originating or terminating classified plain language processing equipments, and 4) areas containing these wirelines, equipments, and their interconnecting and auxiliary facilities.

L. Red Equipment Area (REA). The space within a limited exclusion area which is designated for installation of Red information processing equipment, power, signal, control, ground feeder, and distribution facilities.

M. TEMPEST. An unclassified short name referring to investigations and studies of comprising emanations. It is sometimes used synonymously for the term "comprising emanations;" for example, TEMPEST tests and TEMPEST inspection.

APPENDIX C

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APPENDIX D

LIST OF ACRONYMS AND ABBREVIATIONS

A

A/D	analog-to-digital
AD&CS	Attitude Determination and Control Subsystem
AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AFSCF	Air Force Satellite Control Facility
AGE	aerospace ground equipment
APU	auxiliary power unit
ASAS	Aerodynamic Stability Augmentation System
ATC	Air Traffic Control

B

BITE	built-in test equipment

C

C/B	circuit breaker
CCDS	Command and Control Data System
CCTV	closed circuit television
CDBFR	common data buffer
CDS	Central Data System
CEM	co-elliptic maneuver
COMSEC	communication security
CPU	central processing unit
CRT	cathode ray tube
C/T	crawler/transporter
C&W	caution and warning

D

DACBU	data acquisition and control buffer unit
DEU	display electronics unit

D (Continued)

DFI	development flight instrumentation
DMA	direct memory access
DOD	Department of Defense
DSCS	defense support communication satellite
DU	display unit

E

ECLSS	Environmental Control and Life Support Subsystem
EIU	engine interface unit
EOS	Earth-to-orbit Shuttle
EPD&C	electrical power distribution and control
EPL	emergency power level
EPS	Electrical Power System
ET	external tank
ETR	Eastern Test Range
EVA	extra-vehicular activity

F

FAA	Federal Aviation Administration
FCC	Flight Control Center
FCOS	Flight Computer Operating System
FEP	front-end processor
FFD	functional flow diagram
FSS	Flight Support System

G

GET	ground elapsed time
GMT	Greenwich Mean Time
GN&C	guidance, navigation and control
GN&CS	Guidance, Navigation and Control System
GPC	general purpose computer
GSE	ground support equipment
GSFC	Goddard Space Flight Center

H

I

I/F	interface
IMF	Integration and Mating Facility
IMU	inertial measurement unit
I/O	input/outout
IOP	input/output processor

J

JSC	Lyndon B. Johnson Space Center (Texas)

K

KBU	keyboard unit
KSC	Kennedy Space Center (Fla.)

L

LAF	Landing Area Facility
LCC	Launch Control Center
LEA	Limited Exclusion Area
LP	launch pad
LPS	Launch Processing System
LOA	Landing Operations Area
LRU	line replacement unit
LSOD	Launch Site Operation Directorate

M

MCDS	Multifunction CRT Display Subsystem
MCF	Maintenance Control Facility
MOM	multiplexer/demultiplexer
ME	main engine

M (Continued)

MECO	main engine cutoff
MET	Mission Elapsed Time
MLP	mobile launch platform
MM	mass memory
MOD	Mission Operations Directorate
MPS	Main Propulsion System
MPST	mobile payload service tower
MSBLS	Microwave Scanning Beam Landing System
MSS	Mission Specialist Station
MST	mobile service tower

N

NASA	National Aeronautics and Space Administration
NAVAID	Navigation Aid
nmi	nautical miles

O

OFI	operational flight instrumentation
OI	operational instrumentation
OMC	Operating Management Center (Sunnyvale, JSC)
OMCF	Orbiter Maintenance and Checkout Facility
OME	Orbiter maneuvering engine
OMF	Orbiter Maintenance Facility
OMS	Orbiter Maneuvering Subsystem
OOS	orbit-to-orbit Shuttle
ORD	orbital requirements document

P

PCM	pulse code modulated
PCZ	Physical Control Zone
PDR	preliminary design review
PGN&CS	Primary Guidance, Navigation and Control System
PHR	payload handling room
PICRS	Program Information Control and Retrieval System

P (Continued)

P/L	payload
PMF	performance monitor function
PMS	Performance Monitoring System
PPF	Payload Processing Facility
PRSD	power readout storage and distribution
PTT	part-task trainer

Q

R

RCC	rendezvous corrective combination
RCS	Reaction Control Subsystem
RF	radio frequency
RMS	Remote Manipulator System
RTS	remote tracking station
RVCF	Remote Vehicle Checkout Facility

S

SAIL	Shuttle Avionics Integration Laboratory
SAMSO	Space and Missile Systems Organization
SCF	Satellite Control Facility
SCU	sequence control unit
SDL	Software Development Laboratory
SE	support equipment
SGLS	Space Ground Link Subsystem
SMCC	Shuttle Mission Control Center
SMS	Shuttle Mission Simulator
SPA	Safing and Purging Area
SRM	solid rocket motor
SRB	solid rocket booster
SSME	Space Shuttle main engine
SSV	Space Shuttle Vehicle
STA	Shuttle Training Aircraft
STC	Satellite Test Center
STDN	Space Tracking and Data Network
STS	Space Transportation System

T

TACAN	Tactical Air Navigation
TAEM	terminal area energy management
TCS	Thermal Control System
TDM	time division multiplexed
TDRS	Tracking Data Relay Satellite
TLM (or TM)	telemetry
TPF	terminal phase final
TPI	terminal phase initiation
TPS	Thermal Protection System
TTCV	tracking, telemetry, command and voice
TVC	thrust vector control

U

USAF	United States Air Force
USB	Unified S-Band
U/SF	Upper Stage Maintenance and Checkout Facility

V

VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VMMPS	Vehicle Management and Mission Planning System

W

WTR	Western Test Range

X

Y

Z
