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DOD SPACE TRANSPORTATION SYSTEM (STS) COMMAND AND CONTROL DATA SYSTEM STUDY. VOLUME III. COMMAND AND CONTROL DATA SYSTEM CONCEPT DEVELOPMENT

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

Volume III - Command and Control Data System Concept Development

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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.

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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

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE 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. This report describes the development of the command and control data system.

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 Department of Defense (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 the STS and its mission. In terms of functional elements, the CCDS baseline consisted of mission, landing, turnaround, launch, range, recovery, and payload checkout functional control elements. As a result of analysis in this task, two additional elements, an Operations Management Control Element (OMCE) and a Central Data Element (CDE), have been added, and landing and recovery were deleted as functional elements.

The CCDS is neither a single nor a totally new system. Much of the CCDS currently exists in the United States Air Force (USAF) Satellite Control Facility (SCF) and the Vandenberg Air Force Base (VAFB) data and communications systems. The National Aeronautics and Space Administration (NASA)-operated systems and facilities are to be utilized where possible to avoid expensive duplications (e.g., mission planning systems or optional use of the Tracking Data Relay Satellite (TDRS) for contingency reaction). NASA systems, for this study, are 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 (LPS)]. 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.

1.1 GENERAL (CONT'D)

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.

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

E. Provide an 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 STS Control Mission Simulator (SMS) requirements; and an initial Orbital Requirements Document (ORD).

This volume documents the results of Task III, Command and Control Data System Concept Development which developed the CCDS concept, its functional requirements, and interfaces. Figure 1-1 illustrates the relationship of this task and volume to the other tasks and final report volumes of the DOD STS CCDS Study.

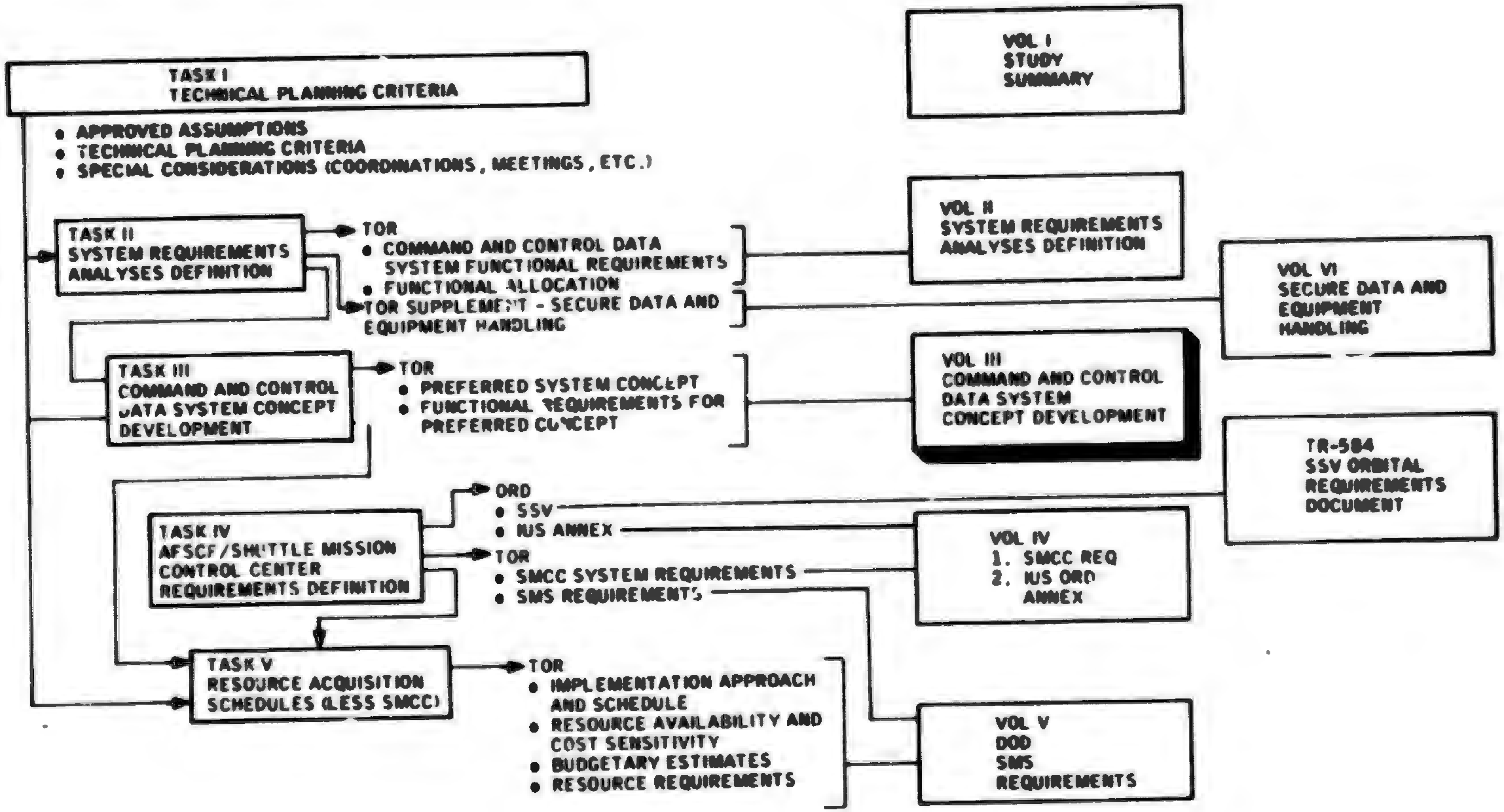

Figure 1-1 Task Interrelationships

1.2 TASK III OBJECTIVES

Task III objectives were to develop:

- A concept for a DOD CCDS to support all STS operations phases
- Functional requirements for each major control element of the CCDS
- Functional interface requirements between control elements and to elements external to the CCDS.

1.3 METHOD

1.3.1 Work Flow. Figure 1-2 illustrates the work flow followed in the performance of Task III. Functions of the CCDS established in Task II were allocated to functional control elements according to criteria that outlined the general responsibilities of each of the control elements. If analysis of functions revealed the need for additional elements, these were identified and appropriate functions allocated to them. Alternate concepts for the CCDS were postulated in areas where:

- Functions could be performed by more than one agency (e.g., JSC/DOD contingency support)
- Functions are drivers on the system (e.g., Real-Time Processing System).

The concepts selected were synthesized into a preferred concept and presented to the USAF SAMSO in a briefing for concurrence in the deletion of alternatives. Based on comments received at, and subsequent to, this briefing, the preferred concept was modified as necessary. Its operations were described and the functions subdivided into data processing, display, command/control, personnel, and communications. Functional interface requirements between the elements and between control elements and systems/agencies external to the CCDS were then developed.

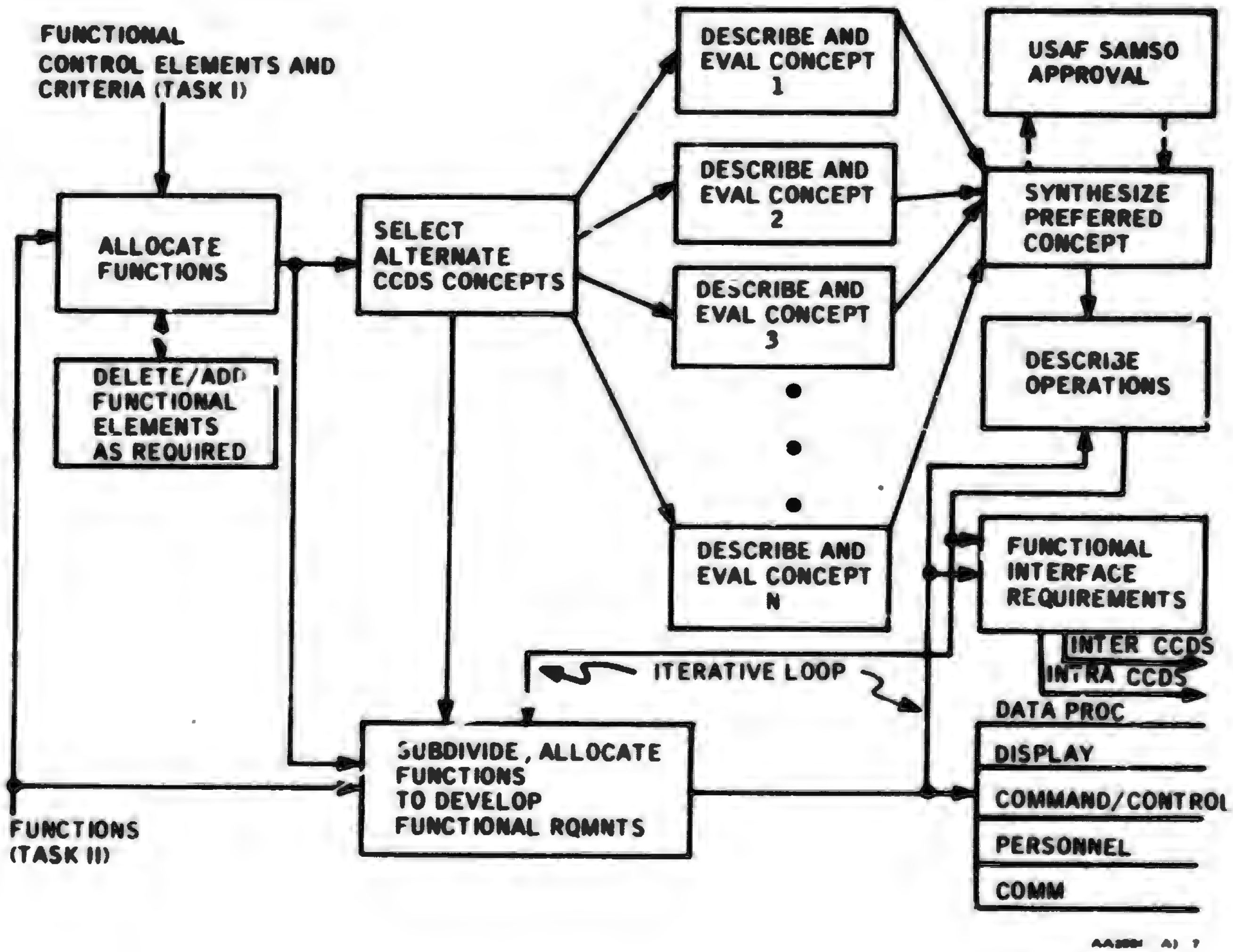

Figure 1-2 Task III Work Flow

1.3.2 Boundaries of Task III. This task was primarily concerned with the CCDS as a series of functional elements. It also developed the communication requirements for each control element; however, it has not, to any substantial degree investigated or considered existing USAF resources/capabilities. For example, Mission Control is a functional control element. As such, it includes the Satellite Test Center (STC) resources which will be applied to the STS Program. Communication requirements are defined functionally and many of these will be implemented using the current remote tracking stations (RTS's). Task IV of this study investigated and developed the tracking, telemetry, commanding, data processing and handling, and any other support required from the AFSCF.

1.4 SCOPE

Subsequent sections of this volume are organized to present:

- A summary overview of the conclusions and observations of Task III in section 2
- An overview of the CCDS defining its control elements and top level functions in section 3
- A narrative description of the CCDS operations, its drivers, and a summary rationale for the concept selection in section 4.
- The functional requirements for each control element including data processing, display, command/control, personnel, and communications in section 5
- The functional interfaces between the control elements contained in section 6
- A discussion of communication support of multiple space vehicles and a brief presentation of alternatives for implementing control of turnaround in appendix A.

SECTION 2

CONCLUSIONS AND OBSERVATIONS

2.1 GENERAL

This section presents the conclusions reached during the performance of the Command and Control Data System (CCDS) Concept Development Task and lists two observations noted during the performance period.

2.2 CONCLUSIONS

2.2.1 CCDS Elements. The functional CCDS operations comprise seven elements; five elements baselined at the start of the study remain and two have been added. The five remianing are the Mission Control Element (MCE), Turnaround Control Element (TCE), Launch Control Element (LCE), Range Element (RE), and Payload Checkout Control Element (PLCE). The two functional elements required to be added are Operations Management Control Element (OMCE) and a Central Data Element (CDE).

2.2.2 Operations Management. Because of the large number of activities and the relatively short time period available for landing to launch activities, an OMCE is required at the launch site. This element will perform administration and control of scheduling, resource allocation, and similar functions to coordinate the operations of the CCDS ground elements. Its major tool will be the automated work control systems.

2.2.3 Work Station Checkout/Test Environment. The rapid ground turnaround operations commitments will be satisfied by utilization of work stations capable of performing automated checkout with applications software executing in the work stations themselves. A CDE will support the stations by providing a master data base for program storage and maintenance.

2.2.4 Central Data Element. Because the several STS ground control elements located at the VAFB launch site require access to large quantities of stored information and processing support, a CDE was established as a resource shared by the several elements for providing this support.

2.2.5 Landing Control. As stated in the Joint Program Plan, control of the Orbiter remains with the mission agent until rollout is complete. For this reason, landing control was deleted as a functional control element.

2.2.6 Recovery Control. No need for a Recovery Control Element (RCE) could be substantiated. Solid rocket booster (SRB) impact coordinates will be provided to the Range by Mission Control for the dispatching of recovery ships to the area for SRB pickup and return to the launch site.

2.2.7 On-Pad Payload Operations. Since less than 1 day of launch pad activity is scheduled for the Space Transportation System (STS) missions, lengthy testing and checkout of payloads at the launch pad is precluded. The primary launch pad payload activities should be restricted to installing and integrating the payload and to verifying and maintaining its operational integrity once installed.

2.2.8 Payload Caution and Warning (C&W) Functions. To provide greater assurance of payload safety to the launch agency, control of the payload's C&W parameters should be exercised from the LCE.

2.2.9 On-Pad Interim Upper Stage (IUS) Control. To reduce the need for DOD IUS trained personnel at Kennedy Space Center (KSC) and to increase the operating efficiency by utilizing an experienced, dedicated IUS team from mission to mission, a tentative selection of National Aeronautics and Space Administration (NASA) control of the on-pad IUS system tests, checkout, update, and monitoring functions for both Department of Defense (DOD) and NASA missions launched from KSC was made.

2.2.10 On-Orbit Support. Because of vehicle autonomy, the requirements for on-orbit support to the nominal mission are limited. During orbital operations, the Shuttle Mission Control Center (SMCC) exists to provide:

- Support in the event of an emergency
- Overall mission management during multiorbit missions
- Control of the IUS after separation from the Orbiter

2.2.10 <u>On-Orbit Support</u> (Cont'd)

- A stable frequency (through the RTS when station coverage exists) from which the Orbiter can update its state vector.

2.2.11 <u>Real-Time Processing Requirements for the SMCC</u>. Due to the SMCC requirement to provide support in emergency situations, a real-time processing and dynamic display capability is required for the SMCC.

2.2.12 <u>JSC/DOD Division of Responsibility</u>. Because of the Orbiter fail operational-fail safe design philosophy for critical systems, NASA, as a general guideline, will not be required to provide on-orbit contingency support until the third failure in a redundant system. NASA support may be required for any single point failure, however.

2.2.13 <u>Near-Real-Time Mission Planning</u>. All resources for the performance of near-real-time (during the mission) mission planning will be located at the SMCC. This resource location is based on response time and DOD mission security requirements for real-time mission planning.

2.2.14 <u>NASA Interfaces</u>. Because of the incompletely defined role of NASA's Vehicle Management and Mission Planning System (VMMPS) and Program Information Control and Retrieval System (PICRS), DOD's potential use of these resources is recognized but its extent cannot be defined.

2.2.15 <u>IUS Control</u>. To prevent duplication of IUS management operating consoles and personnel, IUS operations will be directed from the SMCC as opposed to the satellite Mission Control Center (MCC).

2.2.16 <u>Dual Mission Support</u>. Since there is a probability that two DOD missions will be in orbits simultaneously, the CCDS must be sized accordingly. A limited number (TBD) of fixed control positions are required to support each mission while a common set of reconfigurable positions (number TBD) are required which can support a contingency for either mission.

2.2.17 <u>Orbiter-SMCC Communications for Emergency Alert</u>. To permit alerting the SMCC of an onboard emergency/contingency when operational considerations do not require contacts, a nominal once-per-orbit station contact should be scheduled for this purpose.

2.3 OBSERVATIONS

During the performance of this study, observations were made which impact methods of system implementation for STS support. These observations are discussed in the following paragraphs.

2.3.1 <u>DOD Communications through Space Tracking and Data Network/Tracking Data Relay Satellite (STDN/TDRS)</u>. Communications to the Orbiter via the STDN/TDRS represent a possible compromise to the mission since the STDN/TDRS SMCC communication links are unencrypted. One method to circumvent this problem, when only voice contact is required, is to program one of the telemetry downlink formats premission so that it contains no classified parameters. This would permit unclassified voice between the Orbiter crew and the SMCC without classified telemetry being sent at the same time.

2.3.2 <u>SMCC/JSC and SMCC/STDN/TDRS Interface</u>. The joint use of NASA/DOD resources for contingency support requires a data and voice interface between the SMCC and JSC and between the SMCC and STDN/TDRS. Although implementation of the requirement is a NASA function, it may be advantageous to consider implementation of a direct SMCC to Goddard Space Flight Center (GSFC) interface. This will permit STDN/TDRS support without requiring JSC callup or involvement.

SECTION 3

COMMAND AND CONTROL DATA SYSTEM CONCEPT OVERVIEW

3.1 CONCEPT DEVELOPMENT

The initial baseline Command and Control Data System (CCDS) analyzed in the development of the recommended concept comprised seven functional control elements. Each was responsible for a major function of the STS operations cycle. These functional control elements were:

- Mission Control Element (MCE)
- Landing Control Element (LCE)
- Turnaround Control Element (TCE)
- Launch Control Element (LCE)
- Range Element (RE)
- Payload Checkout or Processing Element (PLCE)
- Recovery Control Element (RCE).

As concept development progressed it became evident the the control elements above were not totally sufficient to describe the overall CCDS concept. Many of the functions to be accomplished by the ground-based data systems did not logically fall into these functional control groupings. One such category of functions is that associated with the total Vandenberg Air Force Base (VAFB) operations management; i.e., the element that manages the total STS flow process from landing (or receipt of the vehicles) through lift-off for the next flight. This element was added as the Operations Management Control Element (OMCE) at VAFB. Another category of functions identified for VAFB included the data processing functions necessary to support centralized information management and work control-type functions and provide centralized processing in support of the distributed work stations. The CDE was therefore added

3.1 CONCEPT DEVELOPMENT (CONT'D)

as a CCDS "shared" element to support the turnaround and launch operations at VAFB.

Recovery and landing were deleted as functional control elements. Landing functions were incorporated into the MCE; range, although a functional element in the study, was assumed to be a VAFB-resident organization and the recovery functions were assigned to it.

It must be emphasized these control elements are functional and do not necessarily represent physical control elements. For example, one can easily visualize the classical LCE or MCE and can correlate the respective functional control elements with these. A control element like the TCE cannot be so visualized, since, when implemented, it may remain a functional grouping of multiple physical elements and be controlled from a central facility such as launch control.

Subsequent paragraphs of this section describe the key features of the CCDS concept. The concept is then defined in terms of its elements and their functions for DOD missions launched from VAFB. Paragraph 3.4 examines the delta functions for DOD missions launched from KSC. In addition, each functional element is related to an existing or planned resource where possible for clarification.

3.2 KEY FEATURES

Some key features of the concept to be presented include a CCDS that provides/permits:

- Maximum utilization of NASA-developed systems for use at VAFB

- Maximum utilization of existing or planned capabilities of NASA systems for mission planning, training, and simulations consistent with DOD unique mission and/or security requirements

3.2 KEY FEATURES (CONT'D)

- Real-time processing for mission evaluation decisions, contingency reaction, and anomaly resolution
- An automatic checkout scheme for the refurbishment and checkout of the STS flight elements
- A central data element used by the VAFB elements for large-scale information storage and retrieval and associated data processing
- An automated work control system for resource scheduling, anomaly reporting, and related functions
- A vehicle processing scheme permitting multiple vehicle and vehicle elements to flow through the system.

3.3 SYSTEM OVERVIEW - VAFB LAUNCH

For DOD missions launched from VAFB, the CCDS functional elements are: MCE, TCE, LCE, RE, OMCE, CDE, and PLCE. The functions of each are described below.

3.3.1 Mission Control Element. The MCE exercises overall control of the STS's mission to deploy and/or retrieve earth orbiting payloads. Since the MCE's responsibilities range from long lead time functions, such as mission planning to continuous or recurring functions (simulations), to near-real-time and real-time functions (contingency support); the MCE function has been divided into three major subfunctions. These are mission support, mission planning, and training and simulations. Mission control would be exercised from facilities within the United States Air Force (USAF) Satellite Test Center (STC).

A. Mission Support. During preflight, mission support participates/directs exercises to ensure all STS supporting elements are ready to support flight operations. During flight, mission support exercises overall management of the mission, including real-time replanning and providing assistance to the crew as dictated by contingencies. It acts as the mission agent, assumes direct mission control at

3.3.1 Mission Control Element (Cont'd)

liftoff, and retains control until rollout. Mission support functions would be exercised from a minimally manned Shuttle Mission Control Center (SMCC), with provisions to augment the SMCC manning if contingencies occur. Mission support is the MCE function which is investigated almost exclusively in subsequent sections of this TOR. The functions of mission support for nominal and emergency operations are:

1. Mission Management. Provides overall control of the STS deployment/retrieval mission, including redirection of mission in real-time as circumstances warrant.

2. Mission Status Awareness. Maintains cognizance of mission status through automated or manual monitoring (selectable) of mission events, trajectories, orbits, and systems status. If anomalies occur, MCE provides real-time capability for systems analysis and/or mission replanning.

3. Impact Prediction. Provides VAFB recovery forces predicted and calculated impact coordinates of the SRB's.

4. Orbiter/Satellite Operations Coordination. Coordinates communications with satellite user for rendezvous, handover, and routing of satellite data to the user.

5. Flight Support Element Coordination. Maintains communications and provides required data transfer between mission support and other elements supporting flight operations (e.g., landing area).

6. Real-Time Mission Planning. Compares, assesses, predicts, decides, commands/informs the SMCC support team and flight crew of real-time mission extension/shortening, alternate landing areas, and similar emergency alternatives.

3.3.1 Mission Control Element (Cont'd)

7. Communications Management. Requests SCF resource allocations; coordinates RTS-SCF-mission support operations; and directs RTS prepass, pass, and postpass activities, all RTS tracking and commanding of STS flight elements, and data routing of tracking, telemetry, and command data between the RTS and SMCC.

8. Navigation Source Data. Through the RTS's, provides one-way doppler for Orbiter onboard state vector updates, determines upper stage state vector through two-way doppler, and updates upper stage state vector.

9. Landing. Maintains landing area alert from liftoff until insertion is verified at first RTS contact, or, if no contact occurs, until landing is effected. Provides weather and other advisories to Orbiter for atmospheric flight phases.

10. NASA Network Support Coordination. Provides interface with NASA to request STDN or TDRS support as required.

11. JSC Support Coordination. Provides interface with JSC to request SMCC, simulator, or computational facility support or assistance, if required, in responding to contingencies or anomalous conditions on the Orbiter.

B. Mission Planning. The mission planning function provides the premission planning and design. It develops the mission events, trajectories, Orbiter, and Orbiter support requirements for specific missions pertaining to the STS flight elements (Orbiter and upper stage). Top-level functions of mission planning include:

1. Mission Definition and Scheduling. Identifies the initial mission specifics to satisfy user requirements and develops both long- and short-range schedules to meet users requirements.

3.3.1 Mission Control Element (Cont'd)

2. Mission Design and Analyses. Performs mission specific functions including feasibility analysis, profile definition, program resource requirements, parameter determinations, and flight plan development.

C. Simulation and Training. The simulation and training function is responsible for the training of the flight crew and ground controller personnel. It is primarily a premission activity, but has a significant role in preflight readiness testing and in mission support for malfunction analysis and contingency resolution. Significant functions of the training and simulation functions include:

- Flight crew/flight controller simulation and training
- Crew performance evaluation
- Preflight readiness testing.

Simulations will be examined in more detail in a subsequent task.

3.3.2 Turnaround Control Element (Part of Vandenberg LPS). The TCE assumes the primary support responsibility for the Orbiter at the end of rollout. It is responsible for the receipt, maintenance, refurbishment, and checkout of the STS flight elements in preparation for the next flight. The TCE hands support responsibility to the LCE when the flight elements arrive at the launch pad. In this role, the TCE performs the top-level function of maintenance and checkout. It supports automated checkout capability at various vehicle maintenance and checkout locations [e.g., safing and deservicing, Orbiter Maintenance Facility (OMF), etc.] and remoted processing. It provides inter- and intra-system data and voice distribution control, and man-machine interface communications to permit control of checkout.

3.3.3 Launch Control Element (Part of VLPS). The LCE provides the primary support to the STS flight elements from arrival at the launch pad until liftoff. It directs all on-pad operations, and its major functions are as follows:

A. Control of On-Pad Activity. Provides an on-pad activity control capability using automated checkout software via an interactive man-machine interface, controls flight software loading, and initiates discrete commands to ground support equipment (GSE) and to the Orbiter.

B. Voice Communications Management. Provides centralized control of voice communications during on-pad activities.

C. Monitoring On-Pad Activities. Provides the capability to monitor on-pad activities through status displays and "prompting" displays (e.g., requests for command initialization). Provides assistance to the crew when onboard, to resolve contingencies, or to make recommendations on mission go/no go decisions.

D. Payload Launch Readiness. Activates, initializes, and controls payload support systems; monitors satellite C&W and environmental parameters, and controls cryogenic fuel loading.

3.3.4 Range Element. RE is assumed to be a VAFB-resident organization. A requirement, levied by the STS on the RE, is to recover the expended SRB's and return them to the launch site using impact predictions and impact coordinates provided by the DOD SMCC for DOD launches and by the NASA MCC for NASA launches. The RE will also provide range communication management for the STS. The STS Program Office has no requirement for tracking of any Space Shuttle Vehicle (SSV) element by range.

3.3.5 Operations Management Control Element (Part of VLPS). The relatively rapid and complex operations required at the launch site to turnaround and launch the flight elements within the established time limits present severe scheduling considerations to ensure resources are available when needed. The operations are performed both serially and in parallel and at different locations. This necessitates an operations management function for scheduling, resource allocation, and similar tasks to coordinate the activities. The OMCE has been established as the functional element responsible to perform, in support of STS ground operations at VAFB, the following tasks.

A. Work Control. Provides task scheduling and reporting; the assignment of work task requirements; procedures for storage, update and retrieval; cost analysis; generation of maintenance requirements documentation; and resources planning.

B. Problem Reporting, Reliability and Quality Assurance. Provides hardware problem and/or equipment failure reporting, processing, storage, and/or retrieval; the documentation of anomalies; generation/storage of historical data for analysis; and maintains status reporting of open problems.

C. Spares Inventory. Provides information base maintenance and display on request of such information as spares status, spares provisioning, equipment inventory usages and identured parts list.

D. Engineering Information Control. Maintains released drawings, cross-references to procedures, and configuration management; provides for storage and display of specifications/standards, operations and maintenance (O&M), calibration and validation procedures, and computer programs.

E. Configuration Management. Identifies and statuses the VAFB Shuttle facilities systems and equipment baseline from requirements definition to installation, operation, and close out.

F. Information Management Support. Provides the OMCE data base management and the STS data handling under operating systems services. Data handling includes data formatting, buffering, routing, and input/output (I/O) control.

3.3.6 Central Data Element. Since several STS ground control elements, located at the VAFB launch site, require access to large quantities of stored information, a CDE is required for the common use of these elements. It is a shared resource among the STS VAFB support elements. This element is discussed in this report as a functional element; when implemented, it can be expected to be part of the VLPS, but existing VAFB resources satisfying the requirements may be included. Functions of the CDE are as follows.

A. Data Base Management. Establishes and maintains a central, large-scale data base required in support of STS ground operations.

B. Data Management (Data Handling). Provides the interface handling for peripherals data transfer, communications data processing, remote terminal interfaces, checkout area keyboard interfaces and display processing.

C. Real-Time Operating System Support. Provides capability to respond to inputs as they occur during on-pad and landing activities.

D. Batch Processing Support. Provides capability for offline, non-real-time batch processing supporting STS ground operations.

E. Interactive (Demand) Processing Support. Provides a processing capability for online, "query/response" type man-machine functions, particularly oriented to terminal and teleprocessing activities.

3.3.7 Payload Checkout Element. Throughout this study, it has been assumed that a checked out payload is delivered to the launch pad for integration into the vehicle. Within this constraint, the functions shown for the PLCE are those performed subsequent to receipt of the payload at the launch pad until liftoff. These are:

- Premission checkout of payload
- Payload verification testing
- Safety/readiness validation of payload
- Monitor payload installation.

3.4 SYSTEMS OVERVIEW - KSC LAUNCHES

For DOD missions launched from KSC, DOD remains the mission agent, but NASA becomes the launch agent. The following paragraphs present the major top-level functions of the elements in terms of deltas to those presented in paragraph 3.3.

3.4.1 Mission Control Element. Functions of the MCE remain the same as for VAFB launches with the following exceptions:

A. Impact coordinates are provided to KSC for use by the NASA SRB recovery forces.

B. Interface is required with the NASA KSC for participation in launch readiness testing and network compatibility tests.

3.4.2 Turnaround Control Element. NASA is responsible for the turnaround of the Orbiter. DOD involvement relates only to safing, deservicing, payload removal, and to the flight data dump.

- Flight Data Dump - Encrypt and dump flight data via RF to KSC Launch Control Center (LCC) secure vault.
- Safing and Deservicing - Maintain physical security of payloads during safing, deservicing, removal, and movement to payload facility; remove key to desensitize onboard encryption/decryption devices.

3.4.3 Launch Control Element. The directing and monitoring of unique DOD events is accomplished from the LCC secure vault for DOD missions from KSC. The tasks include the following.

A. Flight Data. After landing and before launch, the LCE strips out classified data from flight data, and routes unclassified data to KSC Launch Processing System (LPS).

B. Flight Software. The LCE loads flight software and mission updates from the LCC vault.

3.4.3 Launch Control Element (Cont'd)

C. Uplink/Downlink (Umbilical). The LCE encrypts downlink data at the pad secure vault and routes it to the LCC secure vault. It decrypts uplink data before routine it to Orbiter.

3.4.4 Range Element. RE receives impact data from the DOD SMCC for use in SRB recovery.

3.4.5 Operations Management Control Element. No unique DOD functions are levied as requirements on the KSC OMCE.

3.4.6 Central Data Element. The KSC CDE will not be used for secure data; however, interfaces with the DOD will be switched through the KSC CDE.

3.4.7 Payload Checkout Element. The PLCE will be DOD-owned. Its functions remain as discussed for VAFB launches; however, DOD will require processing of the IUS at KSC as well as the satellite. Payload functions addressed in paragraph 3.4.6 are extended to include the IUS.

SECTION 4

COMMAND AND CONTROL DATA SYSTEM OPERATIONS CONCEPT DESCRIPTION

4.1 INTRODUCTION

A discussion of the preferred CCDS operations concept and the alternates selected in its development are presented in the following paragraphs. It is a preliminary description of the CCDS operation and describes how all operations cause the total task to be accomplished.

Paragraph 4.2 provides a discussion of the turnaround operations at VAFB and then at KSC. Paragraph 4.3 discusses the VAFB pad operations for the Space Shuttle Vehicle (SSV) elements; the KSC pad operations for DOD missions in terms of deltas to the VAFB operations; and a combined discussion of the payload operations as applied to both VAFB and KSC DOD launches. Flight operations are discussed in paragraph 4.4. Paragraph 4.5 discusses the effect of a second Orbiter in turnaround at VAFB and of a NASA launch from VAFB. An overview of the total communication links is contained in paragraph 4.6.

4.2 TURNAROUND OPERATIONS

4.2.1 <u>Introduction</u>. Turnaround operations are defined for this task as one of two major ground operations phases (the other is on-pad operations, paragraph 4.3); it includes those activities required to recycle the SSV components from end of rollout to delivery of an integrated vehicle at the launch pad, in addition to support of payload activities. The entire turnaround phase encompasses postlanding, deservicing, maintenance and checkout [of Orbiter/solid rocket booster (SRB)/external tank (ET)] vehicle integration/mating, and SRB recovery.

Preceding the selection and analysis of candidate concepts for performing these operations, a list of drivers was derived to permit selection relative to common issues or considerations. The four major drivers identified are as follows:

- The need for 160-hour complete SSV recycling (turnaround/pad operations combined)

4.2.1 Introduction (Cont'd)

- Baseline operations commitments (launch agent, mission agent, joint NASA/DOD, etc.)
- Secure data handling requirements
- Economics and implementation schedules.

Within each of these major considerations, numerous subissues were utilized to guide the concept evolution. They are briefly defined in the following paragraphs under their respective major topics.

4.2.1.1 160-Hour Turnaround Considerations. The need to satisfy a 160-hour rollout-to-launch commitment was a critical issue and presented the greatest impact on turnaround philosophy. It arose from baseline considerations previously identified by NASA and from the preliminary STS traffic model for Western Test Range (WTR) shown in table 4-1.

TABLE 4-1

WTR STS TRAFFIC MODEL

AGENCY	YEAR									
	82	83	84	85	86	87	88	89	90	91
DOD		8	9	9	9	9	9	9	9	9
NASA	1	7	10	9	10	8	9	11	11	9
TOTAL	1	15	19	18	19	17	18	20	20	18

Based on these figures, and assuming one Orbiter, a nominal expected period for VAFB turnaround and pad operations would be 15 days, which closely approaches the NASA-derived KSC goal of 160-hour turnaround within 14 days. Additional emphasis on the 160-hour requirement arose from the launch-on-failure philosophy adopted by the DOD.

Accepting the 160-hour figure as baseline, important concept sub-issues became:

- Partitioning of turnaround checkout responsibility (ground vs. Orbiter)

4.2.1.1 <u>160-Hour Turnaround Considerations</u> (Cont'd)

- Automated checkout requirements
- Utilization of distributive processing
- Resource allocation (equipment and personnel)
- The need for "operations management" as a major turnaround control function.

4.2.1.1.1 <u>Partitioning of Checkout Responsibility (Ground vs. Orbiter)</u>. Assessment of this issue for concept development was directed towards the following three subissues:

- Defining partitioning guidelines
- Defining a general checkout philosophy
- Categorizing types of checkout software encountered.

Results of these considerations included establishment of a set of rules or standard definitions utilized throughout the task; they are defined briefly in the following paragraphs.

A. <u>General Partitioning Guidelines</u>

1. If a function is required inflight and the resultant onboard capability is applicable to ground checkout, the onboard function shall be utilized in support of ground testing.

2. Where a specific preflight function requires the control of both onboard and ground systems, the ground system will normally be in control.

3. Supervision of ground test activities shall be a ground system function. Checkout and servicing functions which cannot be performed by the ground system due to vehicle design characteristics will be performed onboard.

4.2.1.1.1 Partitioning of Checkout Responsibility (Ground vs. Orbiter) (Cont'd)

B. General Checkout Philosophy

1. Onboard Checkout and Servicing Functions

a. At the integrated vehicle level, the onboard checkout capability shall be utilized to perform checkout to a level consistent with the inherent onboard instrumentation, stimuli capability, and vehicle configuration. As a minimum, the onboard system shall be utilized to validate Shuttle functional paths. Where practical, stimulation and/or activation of vehicle subsystems shall be provided by the inherent flight software capability.

b. To the maximum extent possible, signal generation for stimuli to exercise vehicle subsystems shall be accomplished onboard. Execution of commands which initiate stimuli for checkout may be accomplished from the cockpit, the onboard computer, or the ground system.

c. The onboard computers shall be used to accomplish checkout to the functional path and support detailed checkout below the functional path. This may be accomplished by loading appropriate checkout programs into the onboard computer and/or by manual operations.

2. Combined Onboard/Ground Fault Isolation. Combined onboard and ground checkout capability shall be utilized to isolate failures to the line replaceable electronic unit or mechanical/servicing system module. Fault isolation to a group of units or modules may also occur if it becomes evident that there is a requirement and ground turnaround time is not significantly impacted, Shuttle program costs are not increased, or where further isolation is impractical due to resultant vehicle design penalties.

4.2.1.1.1 Partitioning of Checkout Responsibility (Ground vs. Orbiter) (Cont'd)

3. Ground Checkout and Servicing Functions. Ground checkout below the functional path shall be minimized. For functional path verification, the ground system shall be phased to a minimum operation required to monitor and record onboard checkout results, and support prelaunch operations and vehicle servicing. Checkout below the functional path will be allocated to the ground or onboard systems based on optimum turnaround considerations and cost effective operations.

C. Types of Checkout Software. There are two types of checkout software: onboard and ground system. The onboard software includes:

1. Flight software required to fly the vehicle which is used to support ground checkout.

2. Ground checkout software including software required to communicate between the ground system and onboard computers, and software not needed for flight but necessarily resident in the onboard computer during ground checkout.

Ground system software is required for ground checkout/control and not provided for by onboard software.

4.2.1.1.2 Automated Checkout Philosophy. The extensive scope of vehicle checkout activities and recognition of the tightly compressed "periods of performance" permissible within 160 hours preclude traditional manual checkout techniques in favor of software-driven, automatically sequenced stimuli generation, response monitoring and evaluation. Concept assessments relative to this issue, other than location and complexity of software, dealt with the needs for, and methods of, manual intervention during checkout initialization, during normal processing sequences (e.g., key-entr· branching to automated subroutines at prescribed points in the checkout sequence), and primarily, during contingency situations.

4.2.1.1.3 Concept of Distributive Processing. The apparent need for automated, software-driven checkout necessitated the consideration of checkout program locations, program loading and distribution control, critical program redundancy, duty cycles on major computer system components, etc. Assessment of these issues in light of current state-of-the art techniques (including results of investigations to date by NASA KSC) indicated the desirability of incorporating distributive processing philosophies in the proposed concepts. Inherent in these philosophies are characteristics which lend themselves to the online, multitasking applications expected for STS turnaround operations (refer to figure 4-1). Examples include:

A. Allocation of specific software tasks to remoted small-scale programmable processors (e.g., console-resident processors in checkout areas) from a large-scale centralized data system. Several desirable features of this technique are:

   1. Reduced I/O Processing Required From the CDE. Complete software tasks are allocated to remote processors, with interrupts to the CDE required only for task termination status, limited display generation, and contingency situations. A typical advantage of this technique is maximum utilization of the CDE's computational processing capabilities, a desirable systems design goal from a cost enhancement standpoint.

   2. Elimination of Redundant Multitasking Operating Systems. Supervisory systems in remoted processors would be concerned with one programming task at a time, and overall multitask control would be levied on the CDE's operating software.

B. Requirements for only one master data base (in CDE) for management information gathering and maintenance.

C. Flexibility of Programmable Remoted Processors. In the particular application (processors within consoles in the checkout area), a given remoted checkout processor can be dynamically reconfigured (reprogrammed) from one application to another from a central system, without having to maintain its own extensive applications program library. Obvious advantages of this approach are reductions in dedicated or redundant hardware and software, and elimination of time-consuming manual reconfiguration activities.

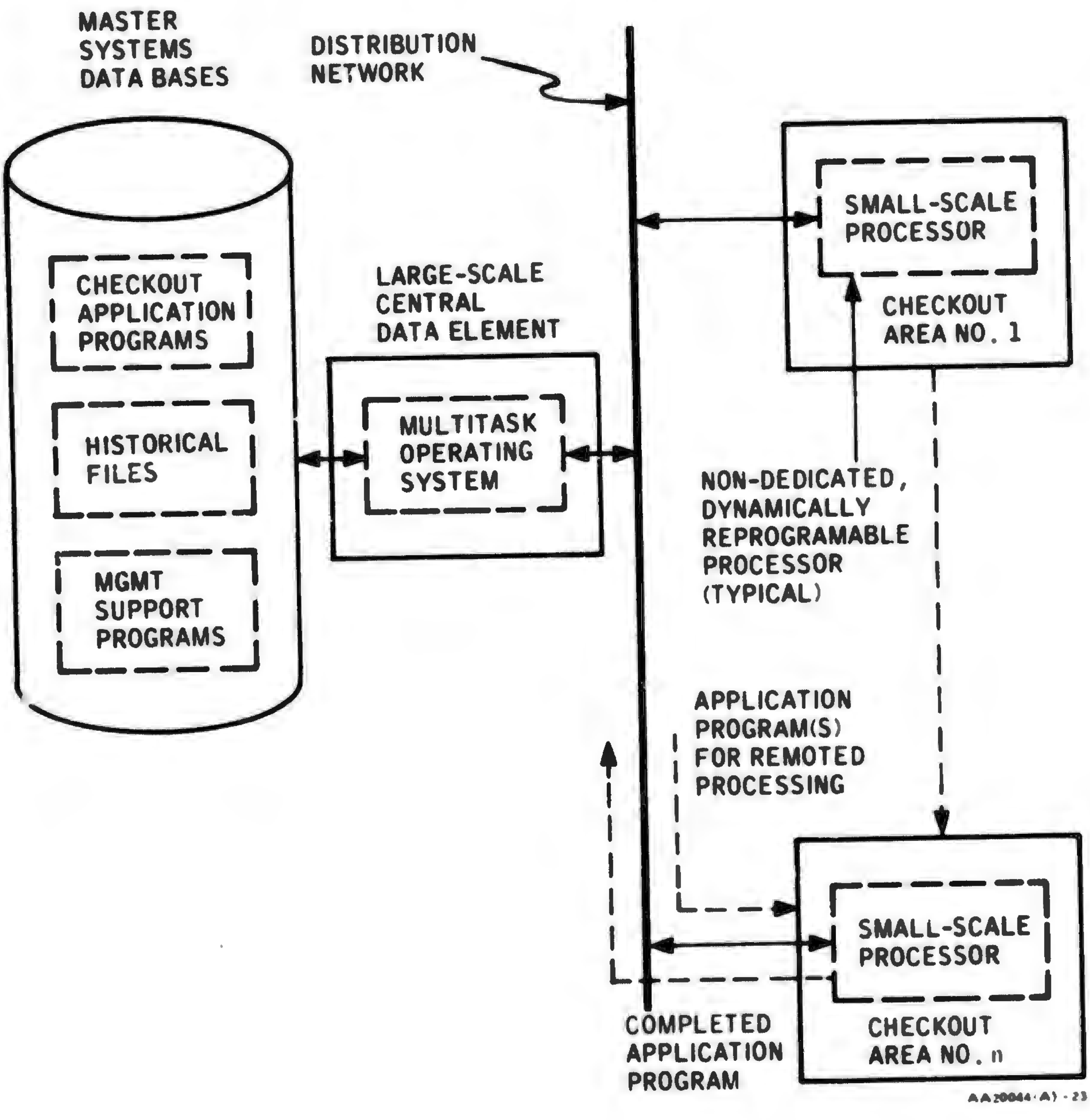

Figure 4-1 Distributive Processing for Turnaround Operations (Basic Flow)

4.2.1.1.4 Resource Utilization Considerations (Equipment and Personnel). Satisfying the 160-hour turnaround requirement with minimum equipment and personnel resources was an issue that gave rise to the concept of operations management (paragraph 4.2.1.1.5), particularly those characteristics which lend themselves to automated "work control" functions such as procedure development, task assignments, scheduling, logistics support, planning, etc. These considerations become more obvious in the following paragraphs.

4.2.1.1.5 Operations Management and Work Control. Early in the concept assessment phase it became evident that the 160-hour turnaround requirement generated complex scheduling, procedure updating, task monitoring, real-time anomaly resolution, and logistics control problems. The solution to these problems evolved in the form of an Operations Management Control Element (OMCE, illustrated in figures 4-2, 4-3 and 4-4) comprising a set of six applications programs (systems), resident within a CDE, permitting automated and semi-automated performance of the planning and administrative control functions associated with turnaround. As shown, the major OMCE programs (systems) identified were:

- Work control
- Problem reporting, reliability and QA
- Engineering information
- Spares inventory
- Configuration control
- Information management support.

The key features of each system are shown in figure 4-2. Their utilization for turnaround operations (defined in more detail in the preferred turnaround concept description, paragraph 4.2.2) stresses the work control system capabilities which are invoked in two distinct phases: 1) the preturnaround or planning phase, and 2) the online operations phase. In the planning phase (figure 4-3), operations management is envisioned as a terminal system employed to accept schedule and resource commitment data from

OPERATIONS MANAGEMENT

DESCRIPTION:
THE OPERATIONS MANAGEMENT CONTROL WILL BE DATA BASE-ORIENTED FUNCTIONAL SYSTEMS SUPPORTING VAFB OPERATIONS, GROUND SYSTEMS MANAGEMENT AND ADMINISTRATION. THESE SYSTEMS WILL BE SUPPORTED IN COMMON BY DATA BASE MANAGEMENT SOFTWARE AND DATA MANAGEMENT SOFTWARE, WHICH PERFORM DATA BASE ACCESS AND I/O DEVICE SUPPORT FUNCTIONS, RESPECTIVELY.

INFORMATION MANAGEMENT SUPPORT SYSTEM

DESCRIPTION:
THE INFORMATION MANAGEMENT SUPPORT SYSTEM WILL CONSIST OF THOSE FUNCTIONS THAT ARE NECESSARY FOR THE EXECUTION AND SUPPORT OF OPERATIONS MANAGEMENT SYSTEM APPLICATIONS. INCLUDED IN THIS CATEGORY ARE DATA BASE MANAGEMENT FUNCTIONS, WHICH SUPPORT CREATION OF AND ACCESS TO LOGICAL DATA STRUCTURES AND MANAGEMENT OF MASS STORAGE; AND DATA MANAGEMENT FUNCTIONS, WHICH SUPPORT ACCESS TO THE INTERFACES AND DEVICES REQUIRED BY IMS APPLICATIONS AND PERFORM STANDARD DATA HANDLING OPERATIONS.

DATA BASE MANAGEMENT FUNCTION

DESCRIPTION:
DATA BASE MANAGEMENT FUNCTIONS ENCOMPASS THOSE CAPABILITIES OF A GENERALIZED DATA MANAGEMENT SYSTEM WHICH PERMITS DATA TO BE STRUCTURED IN LOGICAL INTERRELATED STRUCTURES AND TO ACCESSED BASED ON THE DATA CONTENT AND ITS LOGICAL RELATIONSHIPS TO OTHER DATA. THE DBM FUNCTIONS ALSO INCLUDE THE SUPPORT OF ACCESS TO MASS STORAGE, CONTROL OF ACCESS TO DATA FROM MULTIPLE APPLICATIONS, AND THE FACILITIES TO MAINTAIN A CONTINUING MASS DATA BANK.

DATA MANAGEMENT FUNCTIONS

DESCRIPTION:
DATA MANAGEMENT FUNCTIONS ARE THOSE FUNCTIONS WHICH PERFORM STANDARD OPERATIONS AND SUPPORT THE HANDLING OF THE DATA FOR APPLICATION PROGRAMS, TO INCLUDE:
- DATA FORMATTING
- DATA BUFFERING
- DATA ROUTING
- INPUT/OUTPUT CONTROL

DATA MANAGEMENT SERVICES WILL BE USED BY OMC APPLICATIONS DIRECTLY, VIA OPERATING SYSTEM SERVICES, AND INDIRECTLY, VIA DATA BASE MANAGEMENT INTERFACES WITH MASS STORAGE.

FUNCTIONAL REQUIREMENTS:
- INTERNAL SYSTEM INTERFACES SUPPORT
  - -- STANDARD PERIPHERALS
  - -- COMMUNICATIONS PROCESSOR
  - -- REMOTE HARDCOPY
  - -- REMOTE TERMINALS
  - -- CHECKOUT CONSOLE CRT/KEYBOARD SUPPORT
- EXTERNAL SYSTEM INTERFACE
  - -- DEFENSE LOGISTICS SERVICE CENTER
  - -- VEHICLE MANAGEMENT MISSION PLANNING SYSTEM (VMMPS)
  - -- PROGRAM INFORMATION CONTROL AND RETRIEVAL SYSTEM (PICRS)
- DISPLAY SUPPORT PROCESSING
  - -- FIXED FORMAT DISPLAYS
  - -- GRAPHIC DISPLAYS
  - -- GENERATION OF UNIQUE DISPLAYS BY USER
  - -- TERMINAL USER PROMPTING
  - -- TERMINAL USER INSTRUCTION

WORK CONTROL SYSTEM

DESCRIPTION:
THE WORK CONTROL SYSTEM WILL BE AN AUTOMATED SCHEDULING AND WORK ASSIGNMENT SYSTEM THAT WILL BE USED TO DIRECT, VERIFY AND REPORT VAFB SHUTTLE OPERATIONS AND MAINTENANCE ACTIVITIES. IT WILL BE A TERMINAL-ORIENTED APPLICATION EXECUTING IN THE CDE AND INTERFACING MASS STORAGE FOR STORAGE OF DATA BASES.

FUNCTIONAL REQUIREMENTS:
- TASK SCHEDULING AND STATUS REPORTING
- WORK TASK REQUIREMENTS ASSIGNMENT
- PROCEDURE STORAGE, UPDATE AND RETRIEVAL
- TASK HISTORY DATA STORAGE AND RETRIEVAL
- COST ANALYSIS
- REQUIREMENT DOCUMENTATION GENERATION AND TRACKING
- RESOURCES PLANNING SUPPORT FOR SUPPORT OPERATIONS

PROBLEM REPORTING, R&QA

DESCRIPTION:
THE PROBLEM REPORTING, RELI
QUALITY ASSURANCE SYSTEM W
A CAPABILITY TO TRACK HARDW
EQUIPMENT FAILURES AND DOCU
ANOMOLIES, TO STATUS PROBLE
AND TO PERFORM HISTORICAL DA
THE SYSTEM INTERFACES TERM
AT STS WORK SITES THROUGHO
EXECUTES IN THE CDE MAINTAI
IN MASS STORAGE.

FUNCTIONAL REQUIREMENTS:
- REPORTING, PROCESSING, ST RETRIEVAL OF HARDWARE PR EQUIPMENT FAILURES, DOCUM ANOMOLIES
- GENERATION AND STORAGE OF DATA FOR ANALYSIS
- STATUS REPORTING OF OPEN AND/OR DOCUMENTATION AN
- HISTORICAL DATA PROCESSIN
  - -- TREND ANALYSIS OF HARD AND EQUIPMENT FAILURES
  - -- REPETITIVE FAILURE REP

ENGINEERING INFORMATION SYSTEM

DESCRIPTION:
THE ENGINEERING INFORMATION SYSTEM WILL MAINTAIN AND DISPLAY ENGINEERING AND SOFTWARE PROGRAM INFORMATION TO SUPPORT STS CHECKOUT AND MAINTENANCE, TO MAINTAIN STATUS ON DRAWINGS, EO'S AND EQUIPMENT AND TO SUPPORT MAINTENANCE OF SOFTWARE DOCUMENTATION. THE SYSTEM SOFTWARE WILL EXECUTE IN THE CDS, UTILIZING REMOTE TERMINALS FOR USER INTERFACE AND MASS STORAGE FOR DATA BASE STORAGE.

FUNCTIONAL REQUIREMENTS:
- STATUS MAINTENANCE FOR RELEASED DRAWINGS AND ENGINEERING DATA, BOTH INCORPORATED AND OUTSTANDING
- INDENTURED DRAWING LIST MAINTENANCE FOR VAFB FACILITIES, SYSTEMS AND EQUIPMENT
- DRAWING CROSS-REFERENCE TO APPLICABLE PROCEDURES AND CONFIGURATION MANAGEMENT DOCUMENTATION MAINTENANCE
- SPECIFICATIONS AND STANDARDS STORAGE AND DISPLAY
- CATALOGS OF O&M, CALIBRATION AND VALIDATION PROCEDURES STORAGE AND DISPLAY
- COMPUTER PROGRAM DOCUMENTATION STORAGE, UPDATE AND DISPLAY
- VAFB FACILITIES AND EQUIPMENT STATUS REPORTING WITH RESPECT TO REQUIREMENT, UTILIZATION, AND AVAILABILITY
- DRAWING DISPLAY DURING REAL-TIME OPERATIONAL TESTING

SPARES INVENTORY SYSTEM

DESCRIPTION:
THE SPARES INVENTORY SYSTEM WILL MAINTAIN STATUS FOR DISPLAY OF THE OPERATIONAL SUPPORT SYSTEMS, SPARES AND EQUIPMENT AND WILL ALLOW ORDERING FROM SUPPLY VIA TERMINALS. THE SYSTEM SOFTWARE WILL EXECUTE IN THE CDS UTILIZING REMOTE TERMINALS FOR USER INTERFACE AND MASS STORAGE FOR DATA BASE STORAGE. INTERFACES ARE IDENTIFIED WITH THE SHUTTLE INVENTORY MANAGEMENT SYSTEMS AND THE AFLC.

FUNCTIONAL REQUIREMENTS:
- SUPPORT MAINTENANCE AND DISPLAY OF THE FOLLOWING INFORMATION:
  - -- OPERATIONAL SUPPORT SYSTEMS SPARES STATUS
  - -- EQUIPMENT INVENTORY USAGE AND OPERATIONAL STATUS
  - -- INDENTURED PARTS LIST OF KSC EQUIPMENT
  - -- APPROVED COMPONENTS USED ON LAUNCH SYSTEMS PREVIOUSLY DESIGNED FOR KSC
- PROVIDE THE CAPABILITY FOR REQUESTING PARTS AND MATERIALS FROM SUPPLY VIA REMOTE TERMINAL
- RELATIONSHIP BETWEEN SPARES INVENTORY SYSTEM AND THE AFLC

CONFIGURA

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AND TRACK
SYSTEMS,
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FUNCTIONAL
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- TRACK M WARE OR STALLAT SCHEDUL
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- GENERAT LISTING BASELIN
- LIST DIF AND OPE

A

B

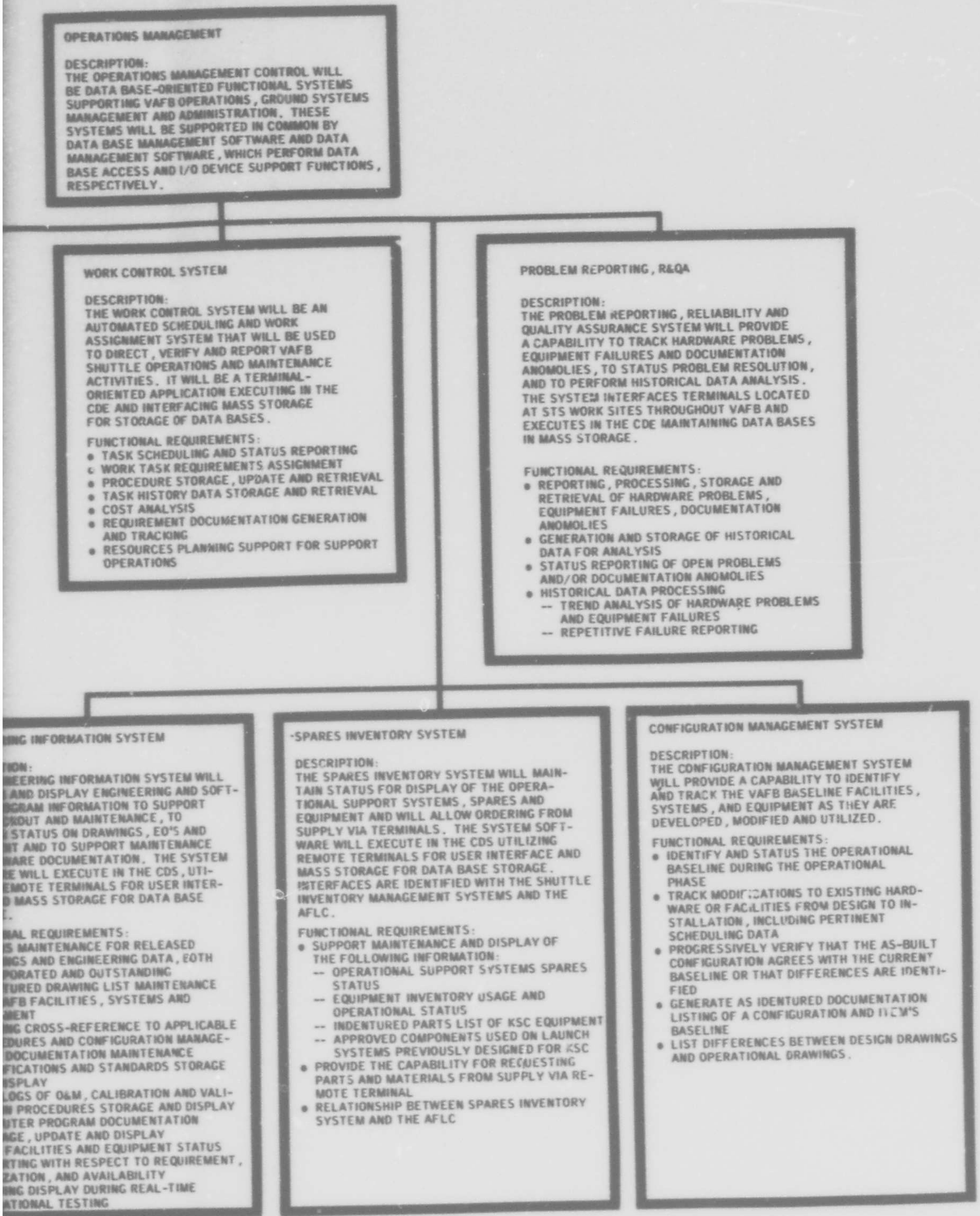


Figure 4-2 Operations Man... ment Functions

B

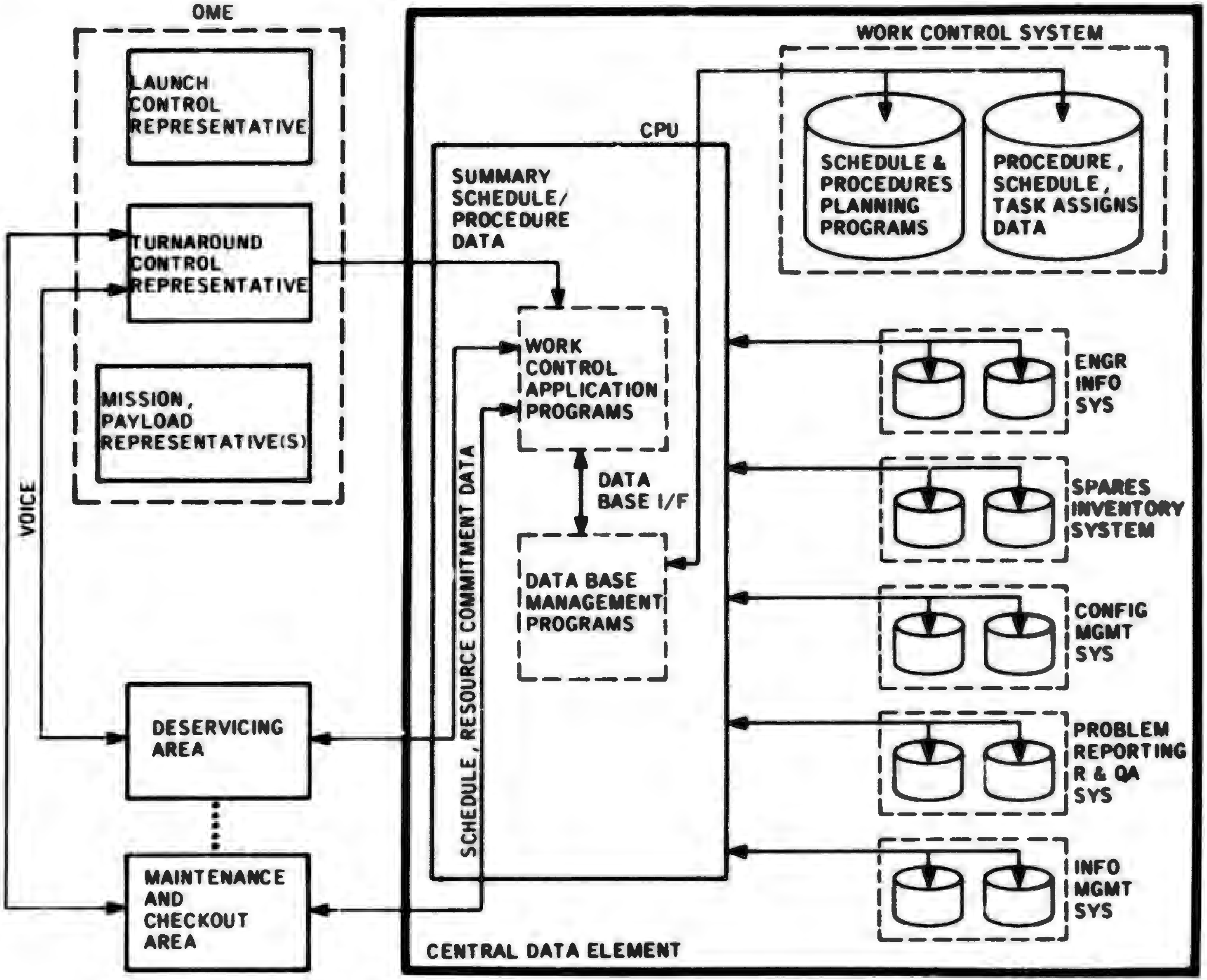


Figure 4-3 Typical Operations Management Control Functional Flow (Shown in Planning Phase of Turnaround)

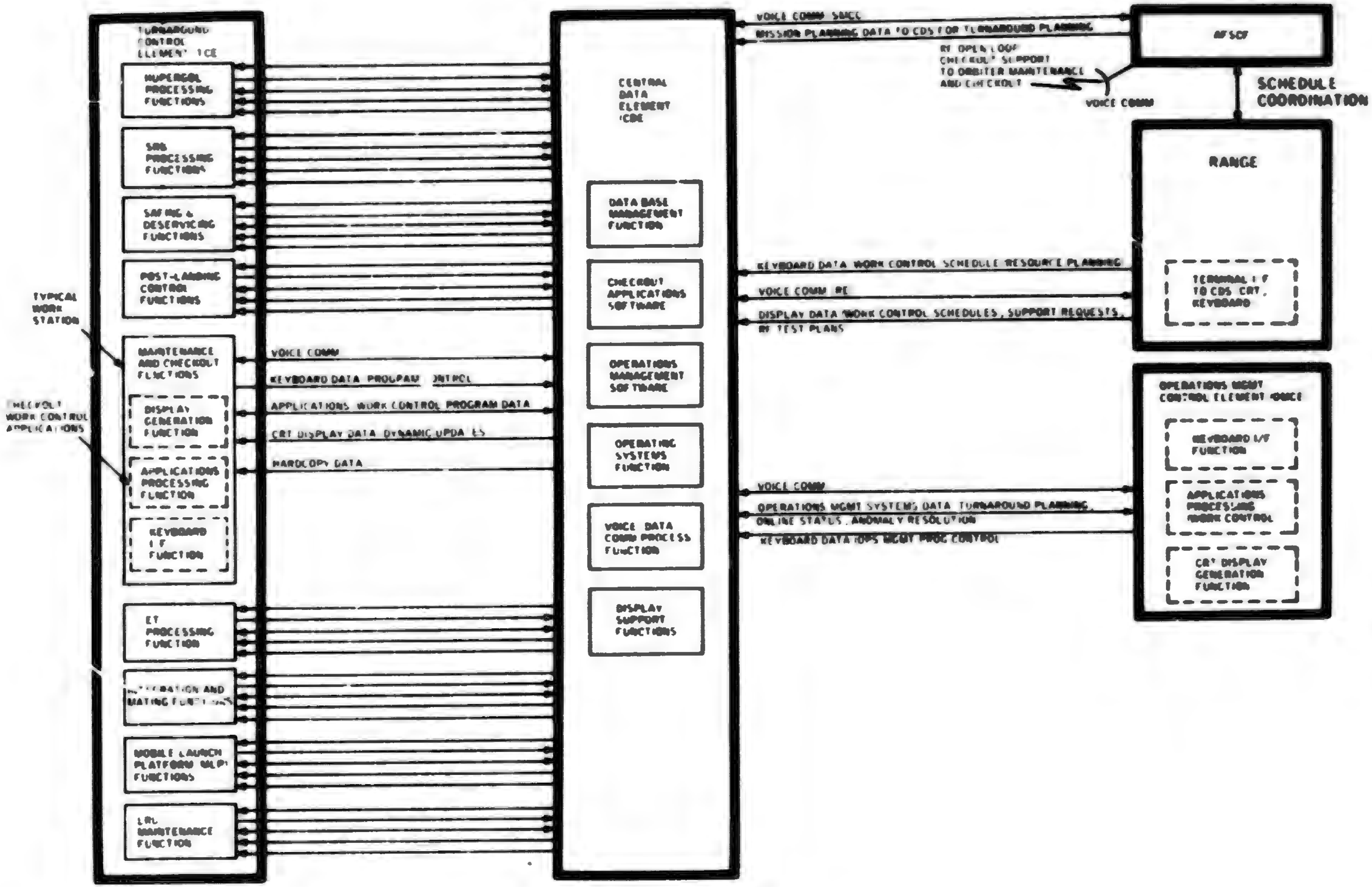


Figure 4-4 Turnaround Operations Concept Functional Block Diagram

4.2.1.1.5 Operations Management and Work Control. (Cont'd)

turnaround planning personnel (e.g., deservicing operations manager, maintenance and checkout operations manager) in order to establish master schedules and procedures lists prior to actual operations. As indicated in the figure, the need for an Operations Management Control Element (OMCE) or its equivalent was also identified, to serve as a focal point for final evaluation and resolution of resource conflicts identified by the OMCE applications systems from subelement representatives' inputs. In the particular example shown, a turnaround control representative in the OMCE is stressed. Note, however, that representatives from other ground or flight control elements (launch, mission, payload, range) would be capable of utilizing operations management capabilities in a similar manner for their respective scheduling and procedures development requirements. In addition, they would be required to resolve resource and schedule conflicts with their OMCE counterparts.

In summary, the operations management concept is predicated upon the need to satisfy complex and time-critical planning and administrative control requirements levied by the 160-hour rollout-to-launch design goal. It is recognized that in the initial STS operations phases, a much less sophisticated system may suffice (e.g., "schedule-board") and growth to a full-scale OMCE concept or its equivalent would probably be a modular growth paced by growth in VAFB STS traffic.

4.2.1.2 Baseline Operations Commitments. Another major concept driver (on the level of 160-hour turnaround) was the existence of baseline operations requirements defined in program level documentation. Several primary considerations in this area were to define concepts compatible with launch agent-to-mission agent handover requirements [e.g., Launch Control/Mission Control (LC/MC) on-pad prelaunch support responsibilities], control of mission/flight operations from an SMCC, requirements for dual turnaround operations, and the current KSC Launch Processing System (LPS) concepts.

4.2.1.3 Secure Data Handling Considerations. The third major turnaround concept driver identified was the need for secure data handling, particularly as it applied to DOD operations at KSC or when utilizing joint DOD/NASA systems. Important sub-issues were:

- Location and function of secure areas at KSC and VAFB

4.2.1.3 Secure Data Handling Considerations. (Cont'd)

- Required distribution of classified and/or encrypted data both at KSC and VAFB
- Secure data link requirements between AFSCF and KSC.

4.2.1.4 Cost and Implementation Considerations. Economics and adherence to committed DOD STS implementation timelines comprised the fourth major driver. The primary issue involved was the DOD requirement for incorporation of previously-developed KSC concepts and planned systems to the maximum extent possible to avoid costly and time-impacting repetition of analysis, design, and development.

4.2.2 Turnaround Operations Concept Definition (VAFB). The selected concept for vehicle turnaround operations (illustrated in figure 4.4) is a system requiring support at various phases in the operations from one or more of four major CCDS elements:

- Turnaround Control Element
- Range Element
- Mission Control Element
- Operations Management Control Element

The primary responsibility for actual online operations (receipt, maintenance, refurbishment, and checkout of the STS flight elements) is within the TCE and its subelements; i.e., Orbiter maintenance and checkout, deservicing, integration and maintenance, hypergol servicing, ET processing and SRB processing. Prior to these operations, however, a significant scheduling and operations planning function is envisioned which would be primarily under the control of the OMCE. Concept descriptions in the following paragraphs reflect these two major phases, i.e., turnaround planning phase and online turnaround operations phase.

This paragraph assumes turnaround is being conducted at VAFB. KSC turnaround for DOD missions is described in 4.2.3.

4.2.2.1 Turnaround Planning Phase Operations. Prior to actual online turnaround, the development of procedures and schedules will be required. For these operations, the concepts of OMCE defined in paragraph 4.2.1.1.5 (in particular its "work control" capabilities) are assumed to be applicable. The total planning phase will include definition of tasks to be accomplished, manpower and equipment requirements, time allocated to accomplish tasks, work stations involved, support requirements, task start times, projected task completion times, applicable procedures and their status, and any operational constraints.

Planning operations under the selected concept would employ a terminal-based configuration similar to that shown in figure 4-5. Keyboard interface to a CDE and display capability (CRT) would be functional requirements on the system. Utilization for turnaround planning assumes an operations management control area exists whose personnel communicate with planning personnel in the subelements of the TCE, i.e., deservicing, Orbiter checkout, integration and mating, etc. (Refer to figure 4-3.)

A representative planning phase operation would be the development of turnaround schedules for an upcoming mission. Initation of the sequence would occur from the operations management control area. Based on evaluation of the given mission plans/schedules (available in the CDE for call-up presentation in predefined display format), a preliminary schedule could be generated by work control programs in the CDE and issued for display on CRT's at the subelement work stations. Utilizing the interactive voice and keyboard communications capabilities of the work stations, work station planning personnel would enter into the CDE their particular area's resource commitment data, concurrence or exception to expected task start/finish times, etc. The work control system in CDE in turn would function to assimilate each separate input into a master schedule to confirm concurrence with the preliminary schedule or to flag exceptions for the OMCC representative for resolution. The subsequent resolution would invoke other work control functions (figure 4-6) such as supply/logistics control, configuration management, problem reporting and corrective action.

Sequences similar to that briefly described above would also occur during the planning phase for procedures development, logistics

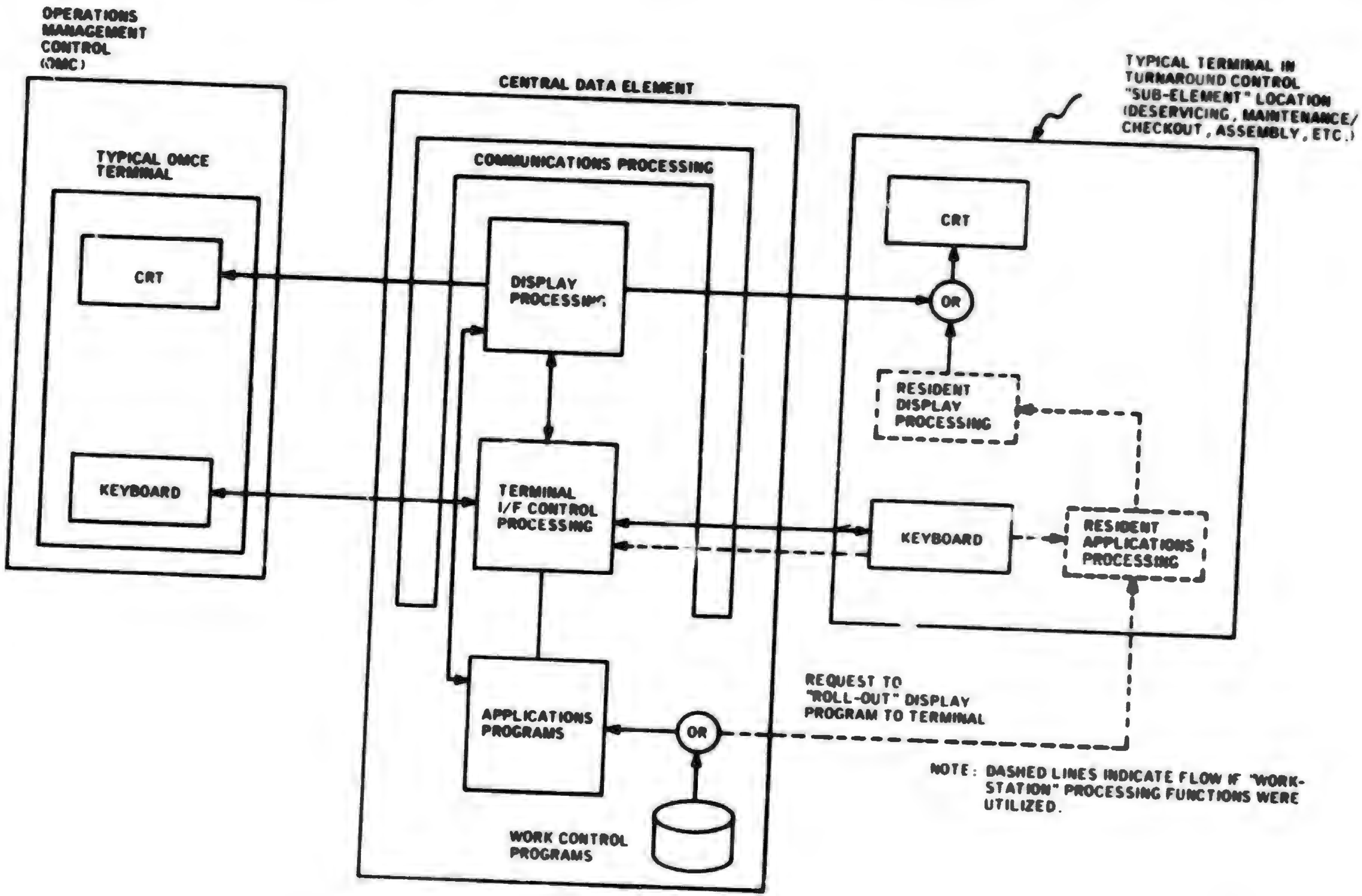


Figure 4-5 Terminal-System Configuration for Turnaround Operations Planning

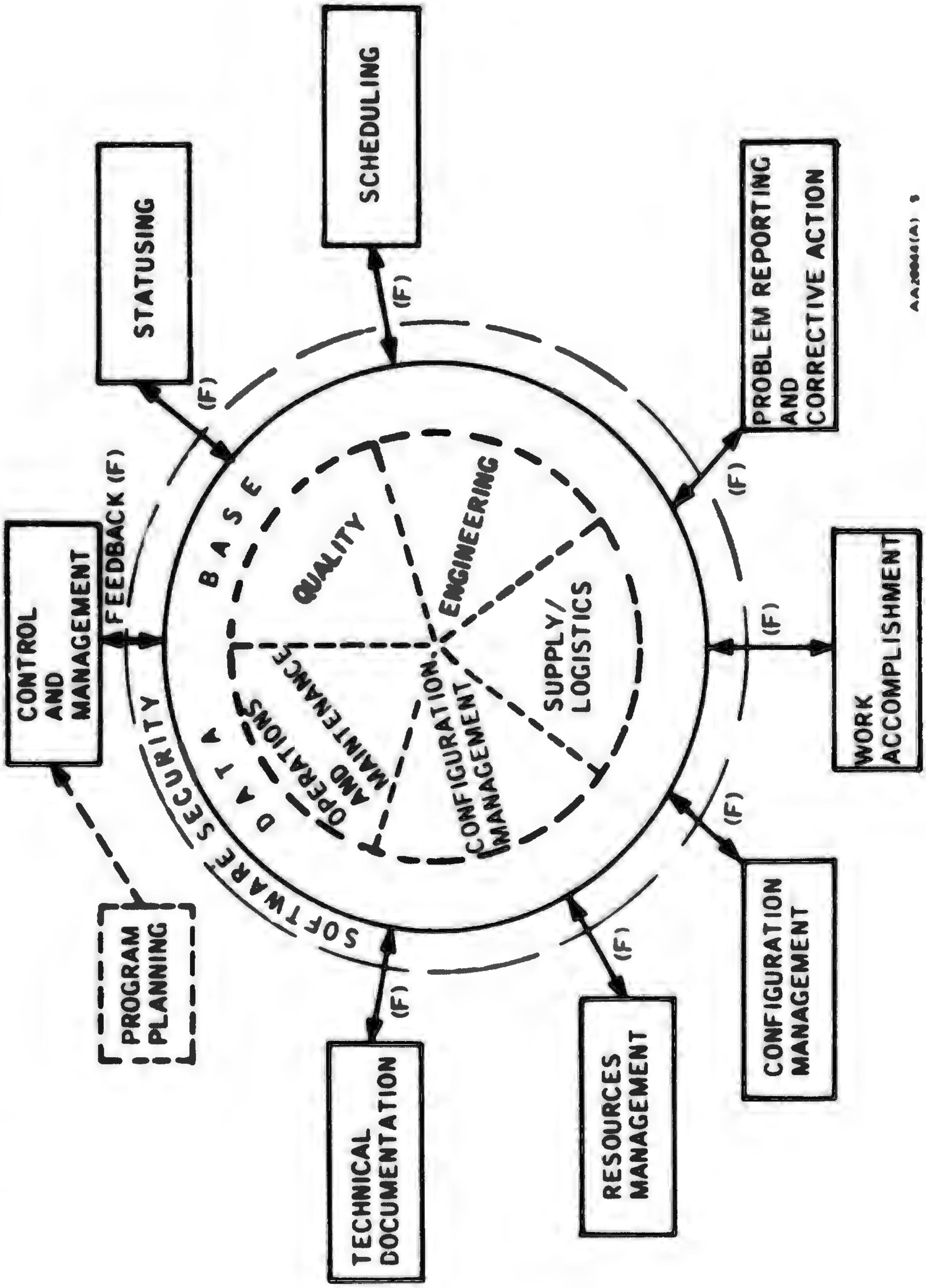


Figure 4-6 Work Control System Functional Diagram

4.2.2.1 Turnaround Planning Phase Operations. (Cont'd)

determination, etc. The important implications to note, however, are those functions common to all such operations:

A. Support of a terminal-based system with the inherent requirements for interactive demand (via keyboard) communication support, display generation, etc.

B. Provision of a data base management system. Based on anticipated types and amounts of data, this system would be relatively complex in scope.

C. Provision and maintenance of various work control applications support programs compatible with automated scheduling techniques.

4.2.2.2 Online Turnaround Operations Phase. Online turnaround operations are defined as those occurring after the planning phase; they begin with receipt of the STS flight elements (Orbiter, ET, SRB) and are those "hands-on" functions involving actual checkout, maintenance, refurbishment and assembly. The TCE is responsible for these operations (as opposed to OMCE in planning); however, many of the operations management functions previously described (work control and problem reporting in particular) are still active during the online turnaround phase. Examples of these functions (shown in figures 4-7 and 4-8) include open work statusing, problem resolution, work accomplishment, progress monitoring, resource management, etc., throughout online turnaround.

4.2.2.2.1 Task Initialization (Online Operations Phase). The description given in this paragraph applies essentially to any of the turnaround work stations shown in the TCE concept block diagram of figure 4-4. At task initialization time the station set operator(s) will be required to establish communications with the CDE by entering the information, via keyboard, about the operation or test to be accomplished such as the application program to be run, work station identification, and Orbiter number. During this period the work station processor's memory would be loaded from the CDE with applicable checkout programs. An alternate method of initialization would be to load checkout programs directly into the console's processor from program libraries (disk/tape) in the immediate checkout area. This latter technique may be required regardless for backup capability.

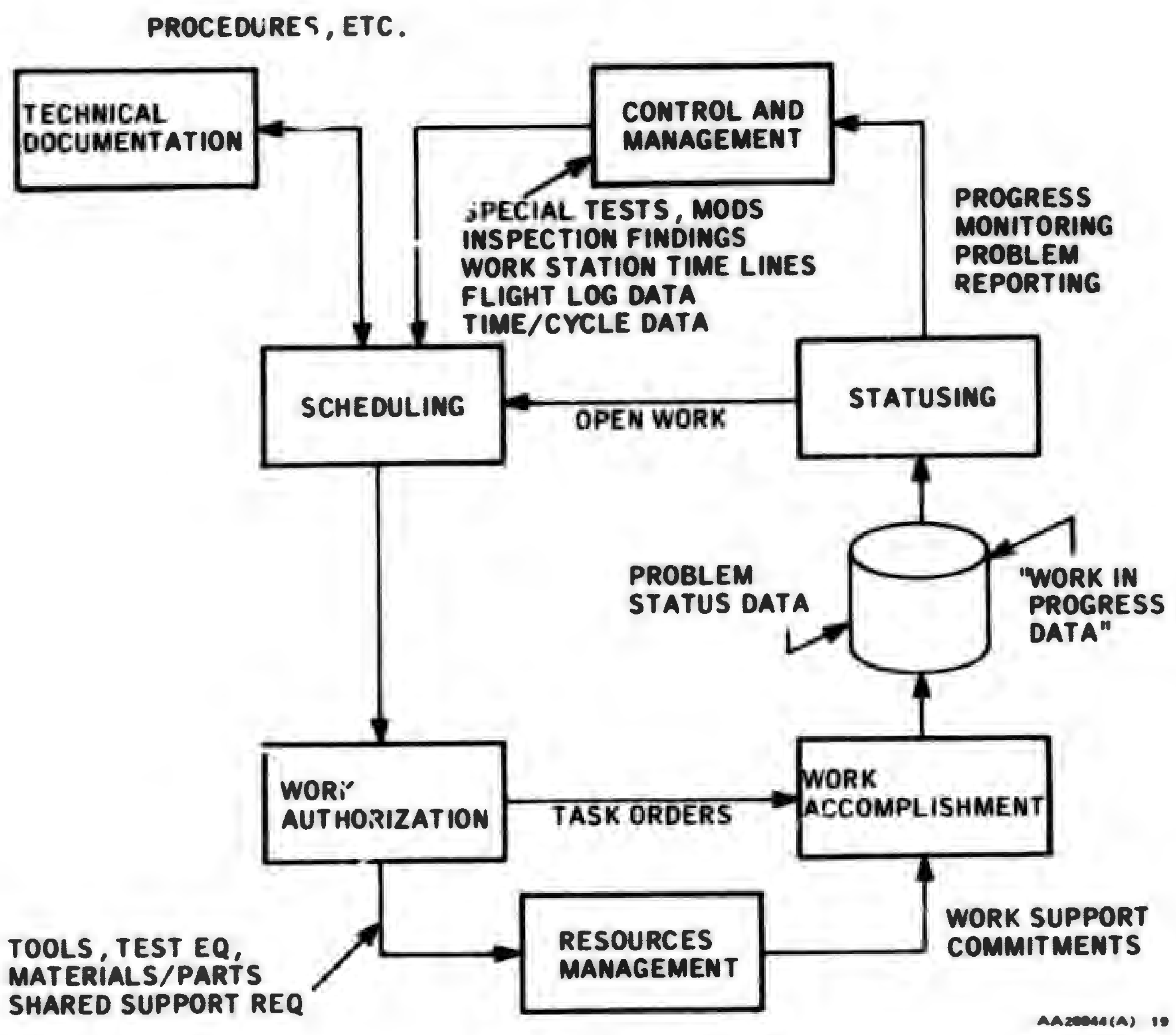


Figure 4-7 Work Control System Data Flow

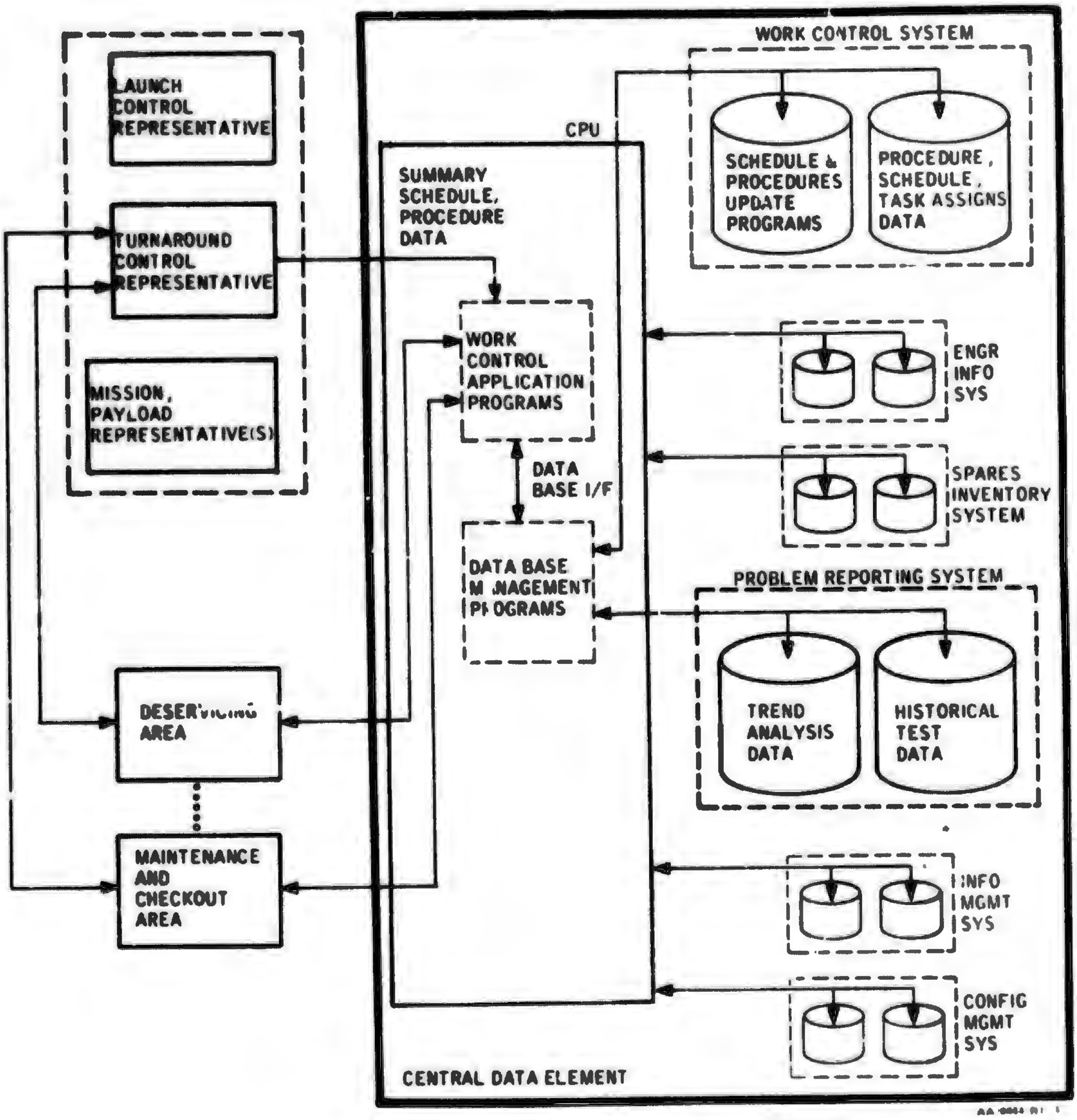


Figure 4-8 Typical Operations Management Control Functional Flow (Shown for Problem Resolution During Online Operations)

4.2.2.2.2 Online Checkout Control Operations. The VLPS concept, shown in figure 4-4, will provide for automatic sequencing and control of vehicle and ground support systems/subsystems from applications programs resident in work station processors. It permits initiation of all commands required to accomplish checkout software loading, both the work station processors and onboard, and of discrete command generation (e.g., GSE stimulus). Automatic switchover to redundant systems or paths will be provided when applicable. Automatic alert/safing will also be provided. These functions will be accomplished through the use of application programs providing automatic and semi-automatic run mode, allowing for step-by-step or automatically sequenced subroutine execution. Manual command control will also be provided, allowing interruption of automatic sequencing to interject special tests, emergency procedures, real-time fault isolation, or troubleshooting.

4.2.2.2.3 Monitoring of Checkout Operations (Online Operations Phase). The selected concept will provide for alert monitoring during critical functions and operations monitoring during dynamic testing, manipulation of system/subsystems data, and comparison of test parameters against pre-established criteria. To accomplish this, the VLPS will work in conjunction with the CDE and the Orbiter Systems Management (SM). Two typical monitoring functions to be supported include:

A. Hazardous Monitoring. This function will be active prior to and during any operation involving propellents or where hazardous vapors may be present. Working from stimuli provided by the onboard hazardous monitoring system, work station processors will determine the presence of hazardous vapors and in turn generate stimuli to audible warning systems. The detected condition will also appear on appropriate CRT's in the work station, with display generation being performed by the programs in the station.

B. Exception Monitoring. The work station checkout program will automatically evaluate and display selected out-of-tolerance measurements during operations. A capability would exist to alter exception monitoring lists and associated parameters under control of the programs and/or keyboard entry via the consoles. The work station processors will work in conjunction with CDE and the Orbiter PMS to accomplish this function.

4.2.2.2.4 Display Generation Functions (Online Operations Phase). The VLPS will provide for display of the systems data maintenance and checkout work stations. Typical display devices anticipated include CRT's, event lights, meters/counters, and hardcopy devices. Display generation functions will be provided by work station-resident applications processors, by dynamic updates from the CDE or by the CDE upon request (via keyboard) from work station personnel.

4.2.2.2.5 Fault Isolation (Online Operations Phase). If an anomaly occurs during checkout, the onboard system will isolate the anomaly to the functional path. At this point, work station personnel can call up (from the CDE) and initiate ground fault detection programs from the work station to isolate the anomaly to the line replacement unit (LRU) level.

4.2.2.3 Online Support from Other Control Elements. Support is required from other functional elements to support turnaround operations, i.e., RE, MCE, and CDE. These are discussed in the following paragraphs.

A. RE Function. The RE will provide clearance and range coordination for all RF open-loop checkout tests during turnaround operations. The AFSCF will provide the resources for this testing at the Vandenberg Tracking Station (VTS).

B. MCE Functions. The MCE will be involved in systems checkout phase only to the extent of remaining cognizant of vehicle/systems status during processing. This will be accomplished by means of voice communications via the CDE. If required, the data links from the MCE to the CDE would permit access (by SMCC) to task status summaries or revised schedules (due to anomalies).

C. CDE Functions. The CDE will support ground turnaround operations by providing real-time operation/test data storage and retrieval, simulation support, technical data management, engineering analysis and computation, online post-test data analysis, program storage, test summary evaluation, and operations management systems support data such as work control, configuration management, logistics data, and failure reporting, program maintenance and execution. It will receive and record all

4.2.2.3 Online Support from Other Control Elements (Cont'd)

pertinent operational/test data, including commands, system/subsystem events, and ground systems events. Portions of the operational/test data may also be recorded at the local test area.

4.2.2.4 RF Open-Loop Checkout/Verification of Shuttle/Satellite/ Upper Stage. A requirement exists during turnaround of the Orbiter to perform checkout of the Communications and Tracking (C&T) System via RF transmission and reception. The requirement also exists to validate the compatibility of this system with the USAF Satellite Control Facility (SCF) prior to liftoff. Satellites and upper stages may also have a requirement for RF checkout and validation both before and after their mating with the Orbiter. This requirement will also exist for NASA launches from VAFB using the unified S-band (USB); however no requirement has been levied on the Air Force for providing a USB-compatible station at VAFB. The RF link checks are generally required to establish the following:

- Systems compatibility
- Signal strength
- Voice quality
- Video quality (if required).

RF interfaces with the test site may be required to/from the Maintenance and Checkout Facility (MCF), Satellite Processing Facility, IUS Processing Facility, and the launch pad. Two concepts for accomplishing RF checkout were considered. Concept one employed a facility dedicated to support of the STS RF checkout during turnaround and launch operations and that could participate in both Space Ground Link Subsystem (SGLS) and USB checkout. This concept was rejected because of the significant cost of implementing such a dedicated new facility. Concept two (figure 4-9) employs the VTS to support STS RF checkout. This was the concept selected because of the cost savings realized using an existing facility. (It was assumed that the added work load could be met by the VTS.)

4.2.3 Turnaround Operations (KSC). The following paragraphs describe the turnaround operations at KSC for DOD missions. These are not described in detail, but as deltas to the VAFB operations.

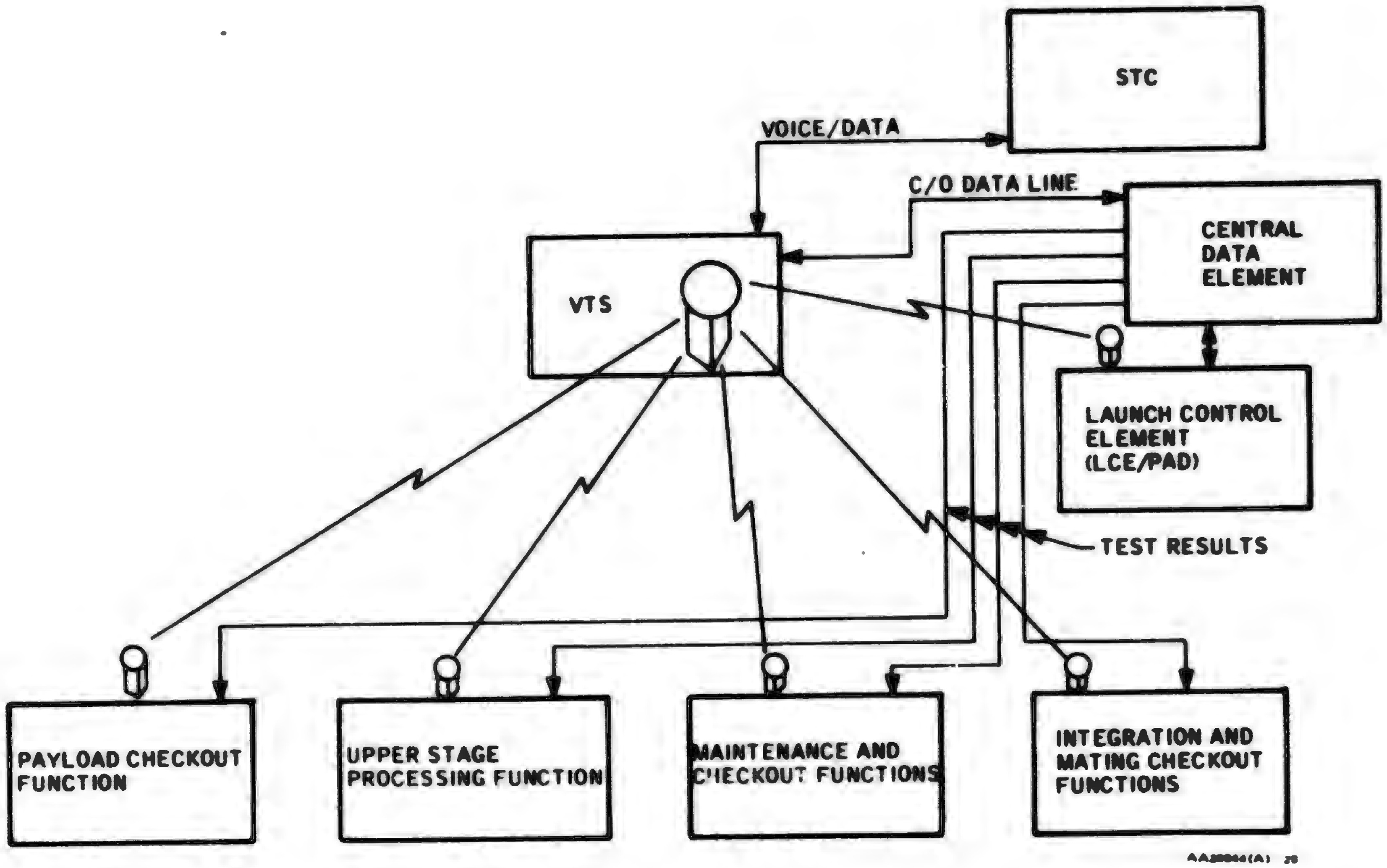


Figure 4-9 Open Loop Checkout Network Using VTS

4.2.3 Turnaround Operations (KSC) (Cont'd)

NASA will be responsible for those non-DOD unique functions involved in turnaround operations at KSC; however, there are DOD-unique functions which must also be accomplished for a DOD mission at KSC. The largest impact is in the area of physical and data security. DOD security requirements impose special restrictions upon the communication/data system at KSC due to the handling of classified data. In addition, the USAF CCDS must interface with KSC in order to accomplish the DOD mission at KSC. The following paragraphs define the DOD-unique functions that must be accomplished.

4.2.3.1 Landing Area Security. The unique functions in this phase are flight data dumps and physical security due to payload classification.

A. Physical Security. A security guard will be posted at the Orbiter at the end of rollout. This guard will maintain security control until the payload has been removed from the Orbiter and delivered to its appropriate area.

B. Flight Data Dump. Since the data is classified, normal NASA procedures do not apply. The data must be encrypted prior to accomplishing the data dump and will be done by the onboard system. The encrypted data will be dumped by RF means to the SCF. The unclassified Orbiter data will then be routed to the KSC LPS. All real-time telemetry data radiated during and after landing operations will be processed in the same manner. If payload data is not on a removable tape, it will be dumped in the same manner.

The onboard computers must be purged after the data is dumped. This may be accomplished by a program residing onboard the vehicle.

4.2.3.2 Safing and Deservicing. Safing and deservicing will be accomplished in accordance with standard NASA procedures. DOD procedures will be used for safing and deservicing of the payload. The present KSC baseline is that these functions will be accomplished in the Orbiter Processing Facility (OPF). The payload will

4.2.3.2 Safing and Deservicing (Cont'd)

also be removed in the OPF by a joint DOD/NASA team, supervised by DOD. Physical security will be maintained during this period. After removal from the Orbiter, the payload will be taken to the satellite assembly and encapsulation facility (if the payload includes an upper stage) or to the DOD satellite facility for further processing.

During the safing phase the onboard encryption/decryption device will be neutralized. The present baseline calls for a "do-all" box which will be keyed. Removal of the key will declassify the box, thus eliminating the security protection problem. The system can be checked out during turnaround with black data. The key would be re-inserted once the vehicle is on the pad just prior to the final secure communication system check and prior to loading mission software, thus verifying proper operation of the total system. This concept should eliminate the requirement for any KG except in the secure vault areas at the launch pad and the LCC.

4.3 ON-PAD OPERATIONS

4.3.1 Introduction. On-pad operations begin upon delivery of the mated STS elements to the launch pad and terminate upon achieving liftoff. The major functions performed during on-pad operations include SSV installation, payload installation, flight and payload readiness verification, and countdown operations. Paragraphs 4.3.2, 4.3.3 and 4.3.4 address the operations related to SSV flight elements in nominal, standby, and contingency modes for VAFB DOD launches. Paragraph 4.3.5 addresses the deltas involved with a DOD mission launched from KSC and payload operations are discussed separately in paragraph 4.3.6.

CCDS control elements involved during on-pad operations include the LCE, MCE, PLCE, and RE. (Refer to figure 4-10.)

The LCE will have prime responsibility for on-pad operations. Control and management of these operations will be achieved utilizing "work station" generated checklist displays and command/requests which direct the data flow required to manage work scheduling; track vehicle and GSE configurations; and monitor and control systems activation, interface testing, and flight readiness verification testing.

4.3.1 Introduction (Cont'd)

The MCE will perform a monitoring role during nominal on-pad operations, receiving progress and status data from other control elements as a function of its mission management responsibility. The MCE will have prime responsibility for directing any mission-related standby/go/no-go decisions, based on consultation with, and data received from, other control elements.

The PLCE will be primarily responsible for premission checkout of the payload and payload verification testing and safety/readiness validation.

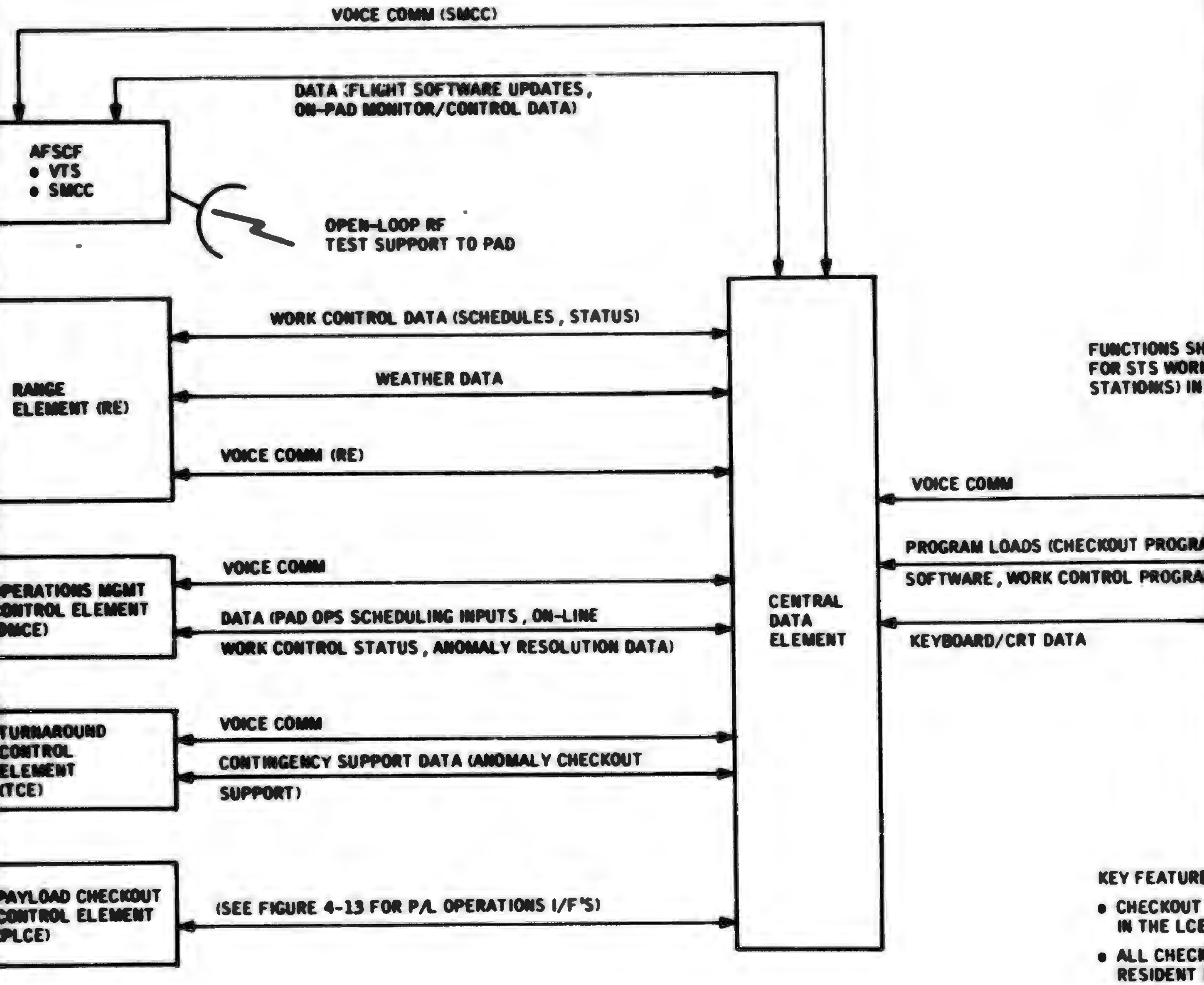
The RE will be primarily responsible for assuring range support readiness, and monitoring pad operations and weather conditions for compliance with range/area safety conditions.

4.3.2 Nominal SSV Element On-Pad Operations. Functional operations in the nominal flow of on-pad SSV operations for VAFB-launched missions include pad installation, flight readiness verification and countdown operations. (Note: payload activities are described in paragraph 4.3.5.)

4.3.2.1 SSV Pad Installation. Pad installation activities commence upon arrival of the Mobile Launch Platform (MLP)/vehicle on the crawler/transporter (C/T) at the pad and end with mating completion of the MLP/vehicle to the pad and verifying their interfaces. Major installation activities are those involving connection and activation of mechanical GSE for simple electrical continuity tests and leak checks. Control elements involved with pad installation activities consist of the LCE, MCE, and RE. Figure 4-10 illustrates communication links between control elements, the CDE, and the launch pad.

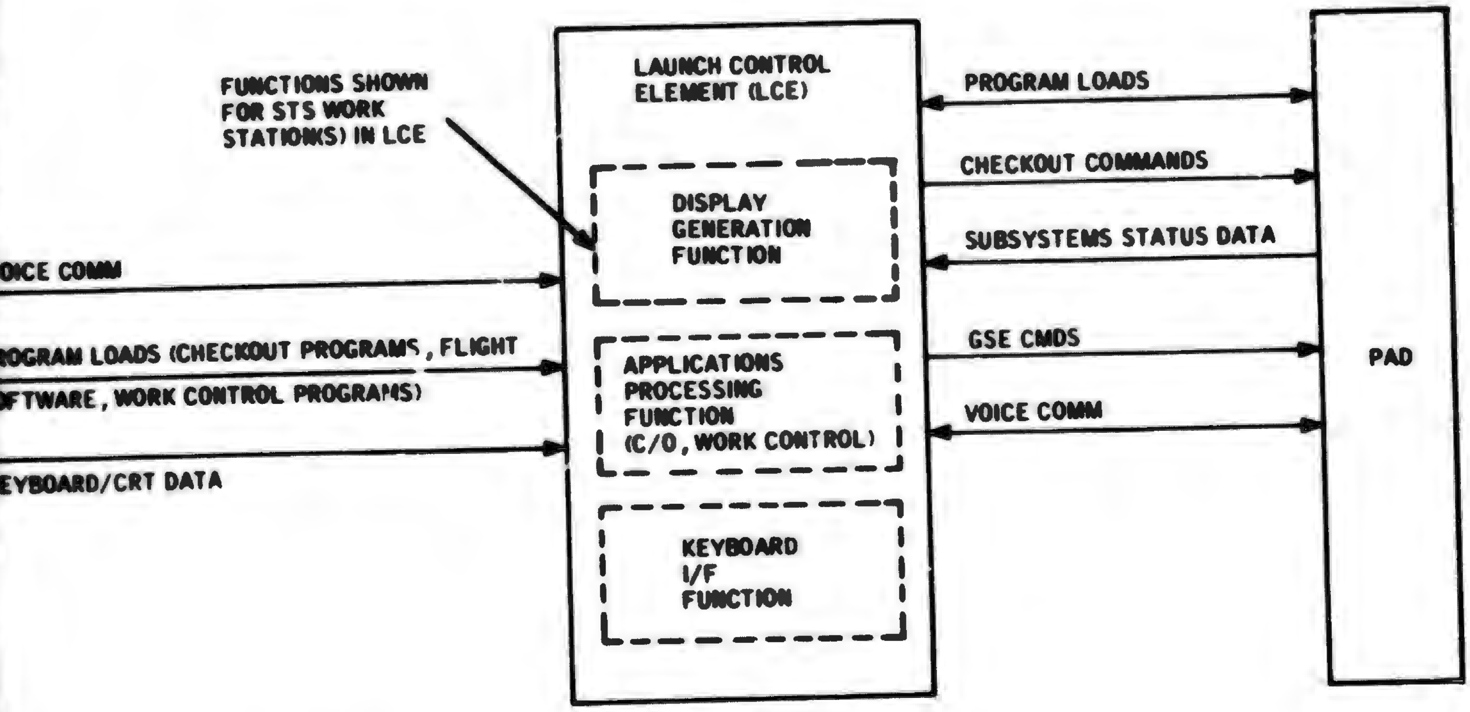
The LCE will interface with the CDE for loading work station computers with checkout software for interface testing, maintenance and access to failure history and trend analysis data bases for problem reporting/investigation, and for history storage of pad interface data and work task start/stop times.

LCE communications with the launch pad will include voice links to ground support personnel and hardware links for activiation and monitoring of pad/MLP systems. Voice communications with ground



KEY FEATURE

- CHECKOUT IN THE LCE
- ALL CHECK RESIDENT
- LCC HAS T (CALL-UP BOTH ONBO
- GSE CHEC LCE WORK COMPUTER CHECKOUT EXTENT P
- COMMAND ROUTINES LEVEL) WI STATION P
- PAD SYST ENTIRELY



KEY FEATURES:

- CHECKOUT IS PERFORMED FROM "WORK STATIONS" IN THE LCE
- ALL CHECKOUT SOFTWARE IS ORIGINALLY RESIDENT IN THE CDE
- LCC HAS THE RESPONSIBILITY OF LOADING (CALL-UP OF) CHECKOUT SOFTWARE, BOTH ONBOARD AND FOR GSE
- GSE CHECKOUT SOFTWARE WILL REMAIN IN LCE WORK STATION PROCESSOR(S), ONBOARD COMPUTERS WILL CONTAIN THE VEHICLE CHECKOUT SOFTWARE TO THE MAXIMUM EXTENT POSSIBLE
- COMMAND LOADS FOR ALTERNATE CHECKOUT ROUTINES (SUCH AS FOR C/O TO THE LRU LEVEL) WILL ORIGINATE FROM THE WORK STATION PROGRAMS
- PAD SYSTEMS CHECKOUT WILL BE CONDUCTED ENTIRELY FROM THE LCE WORK STATION(S)

Figure 4-10 On-Pad Operations Concept Functional Block Diagram

4.3.2.1 SSV Pad Installation (Cont'd)

support personnel shall be maintained to coordinate connection and activiation of mechanical GSE and to communicate status of checklist work tasks. Pad mating interface data shall be sampled through hardline communication links, processed and displayed for nominal status and/or anomaly evaluation, and routed to the CDE for history data base storage.

The LCE will interface with the MCE primarily via voice link to report status during nominal operations.

The RE will monitor pad installation activities to assure compliance with pad/area safety regulations and report status to LCE personnel.

4.3.2.2 SSV Flight Readiness Verification. SSV flight readiness verification consists of flight systems checkout, mission software loading, secure communication checks, and preparation of propellent systems for loading.

Control elements involved in SSV flight readiness verification testing consist of LCE, MCE, and RE. Figure 4-10 illustrates communication links between control elements, the CDE, and the launch pad.

The LCE will be responsible for GSE checkout monitoring, loading and activation of checkout software, loading of mission software, systems checks, and appropriate monitoring and recording of data communications acquired during the flight readiness verification phase.

The LCE will interface with the CDE as required to retrieve checkout and mission software for subsequent loading and testing of Orbiter flight systems, and for data base storage and evaluation of data received in response to test sequences.

Launch/mission coordination is provided through interfaces between the LCE and the MCE. Mission updates will be provided from the MCE to the CDE and flagged to appropriate LCE work stations for subsequent retrieval from the CDE and loading into Orbiter computers.

Data and voice links from the LCE to GSE/facility ground support personnel at the launch pad provide for on-pad test data and requests for systems checkout support.

4.3.2.2 <u>SSV Flight Readiness Verification</u>. (Cont'd)

Voice and data links between the LCE and the RE provide for weather, range clearance, and coordination between launch and range operations.

4.3.2.3 <u>SSV Countdown Operation Elements</u>. Countdown operations will occur after the Shuttle flight systems have been fully checked out, mission and flight software have been installed, payload and/or upper stage has been installed, and payload bay doors have been closed. The shuttle is in launch readiness except for propellent loading and crew ingress. The range and SCF systems required for launch support will have achieved a standby status; the SRB recovery forces will be on station; and the launch corridor will have been cleared and verified.

Control elements involved with countdown operations consist of the LCE, MCE, and RF. Figure 4-10 illustrates the functional data flow between control elements during precountdown and countdown periods, respectively.

The LCE will be responsible for management and scheduling of ground systems configurations and pad crew support required to perform loading of final perishable cargo (if any) and STS cryogenics. The LCE will direct and monitor ground crew operations and, in coordination with the RE, assure pad safety adherence during hazardous fuel loading operations.

After flight crew ingress, the LCE will control and monitor final countdown operations such as flight crew checklist performance, Guidance, Navigation, and Control (GN&C) alignment verification, SSV subsystem status checks, APU startup, transfer of electrical and hydraulic power to internal, retraction of the forward umbilicals, and obtaining required clearances for launch. The LCE will be flagged whenever mission updates have been transmitted to the CDF from mission control and will retrieve updates from the CDE for subsequent loading of Orbiter computers (refer to paragraph 4.3.2.2). The MCE will be provided with current countdown status data through voice and digital data link communications with the flight crew and the LCE, and will perform mission update calculations (as required) and transmit data for updating mission data bases resident in the CDE.

4.3.3 Standby Status On-Pad Operations. Upon completion of launch readiness verification tests, the SSV will be in a configuration either to proceed directly into countdown as discussed above or to be placed in a standby status. When the standby condition is exited, countdown operations will begin but the SSV can remain in this standby status for an extended period. The countdown preparations will be held at this point whenever mission management at the SMCC or the launch director at LC identifies the need for a "built-in" hold, or whenever the launch is in a true standby status wherein the desired launch time has not yet been determined. Holding at this point in the launch preparations sequence represents the most economical point, considering systems which can be easily placed on inactive status. A hold capability will also exist at T minus 2 hours, but because of the systems which must be active, standby at this point will be limited to 24-hour duration.

The decision to enter standby status may result from the need for LRU repair or replacement after start of countdown, payload changeout or retargeting to a dissimilar mission utilzing the same payload, or after payload changeout.

The voice communications link between the LCE and the RE via CDE (refer to figure 4-10) will allow for standby status entry/exit notification (LCE to RE), range safety status communications (e.g., pad safety during propellent detanking) and other general rescheduling or standby monitoring functions.

Any requirements for operations management functions (rescheduling of pad support personnel and resources, new logistics requirements, etc.) would be provided by the link between the LCE and the OMCE via CDE. This provision would allow, for example, new schedule display generation, revised work control inputs, etc., in the manner defined in paragraph 4.2.1.1.5.

The primary LCE functions during standby (vehicle status monitoring and control of SSV facilities services) will be provided by the interfaces between work station and pad, and between work station and CDE. These interfaces allow for vehicle status processing in the work station processor, uplinking of discrete checkout commands to onboard systems, maintenance of historical data bases in the CDE, callup of checkout applications from the CDE (if required), voice communications with the RE, SMCC, and payloads personnel (see paragraph 4.6), etc.

4.3.4 On-Pad Contingency Operations. On-pad contingencies have been previously 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 hour mission time mark. That definition has been expanded here to include payload changeout, (refer to paragraph 4.6) and retargeting to dissimilar missions. The timeframe has also been expanded to include the time the mated vehicle arrives at the pad until launch.

The operational concept presented in figure 4-10 satisfies requirements for hold conditions, fault isolation, LRU repair/replacement, countdown termination, payload changeout, and retargeting to dissimilar missions.

4.3.4.1 Hold Conditions. Previous analysis identified the types of contingency holds which may be initiated as: 1) those resulting from a failure or emminent failure (from trend analyses) in either the mated vehicle or ground systems, 2) tech-holds, and 3) those resulting from management direction (built-in hold).

The LCE will be the prime control point during hold conditions (refer to figure 4-10). It will have the capability to process the data received from onboard systems and display the outputs as required in real-time to personnel located at work stations within the element. Selected data can be routed to the CDE for incorporation into historical data files via the LCE-CDE interface.

Communications links to the MCE will provide capabilities for mission control notification and status monitoring during the hold periods. Voice coordination and status advisories would also be provided to the RE

4.3.4.2 Fault Isolation. Applications programs developed for isolating faults onboard the Orbiter to the LRU level (or strings of LRU's) will reside in the CDE for callup to the work stations as required. During on-pad operations these programs will be loaded into the LCE work station processors for end-to-end verification tests. A digital uplink (refer to figure 4-10) will provide the means for loading the onboard computers with those portions of the checkout programs required to reside onboard.

4.3.4.2 <u>Fault Isolation</u> (Cont'd)

The majority of LRU fault isolation will be accomplished by the work station processors, displays, etc., in conjunction with the onboard computers, using data downlinked through the onboard pulse coded modulated (PCM) master units as a result of remote commands initiated from the work stations and uplinked to the LRU's through the vehicle command decoders.

Flight crew support will provide additional isolation testing using displays on the flight crew's CRT's and annunciator panels. The flight crew can reset the fault or accumulated number of faults via individually coded entries from a keyboard. If the fault persists, the flight crew can coordinate with launch control for the action to be taken which may include uplinking of different checkout applications programs from the work station processors.

Isolation of faults relating to payloads will be coordinated with the payload users at the LCE, PLCE, and the SMCC (refer to paragraph 4.6). Voice coordination and downlinked telemetry data from mission/flight software and the payload applications program will be available via the pad-work-station-CDE configuration for use to determine if the payload can be repaired or if it should be replaced.

After a fault has been corrected, reverification of interfaces will be performed utilizing the CDE-to-work-station-to-pad configuration for checkout program callup, uplink to onboard computer, work station command generation, etc.

4.3.4.3 <u>Countdown Terminations</u>. Countdown terminations are initiated as the result of either failures causing the crew to utilize emergency egress procedures or situations such as the continuing failure of a functional path or LRU. In both cases, the vehicle is assumed to be configured in an inflight mode; propellent load is complete; the flight crew is onboard, and flight software is resident in the onboard computers. The crew, utilizing the flight software, is in control of the vehicle. Emergency operations are initiated as the result of time-critical failures such as fires, leaks, or explosions. The crew must egress the vehicle. The LCE will be capable of providing backup control for any shutdown or safing operations. The onboard systems data will be monitored and online real-time status maintained in the LCE work station processors and in the CDE for assumption of control of the vehicle or participation in time-critical decisions.

4.3.4.3 Countdown Terminations (Cont'd)

Countdown termination because of non-time-critical failures or recurring failures will be initiated by the flight crew for all onboard failures.

Monitoring of failures requiring countdown termination which are detectable from the ground only, such as GSE failures, will be provided by work station applications processing, with voice/data uplinks to the vehicle permitting notification of such failures to the crew.

The decision to terminate the countdown, as opposed to going into a hold, is made by mission control. The CCDS voice and data processing capabilities defined in preceding paragraphs will satisfy the communications requirements for countdown termination notifications.

4.3.5 On-Pad Operations (KSC Launch). DOD missions launched from KSC will have unique requirements on the NASA KSC operations. These are in the areas of secure data and involve the utilization of secure vaults and the requirement for a Mission Control-to-KSC interface.

4.3.5.1 LCC Secure Vault. During pad operations the LCC secure vault will be responsible for directing and monitoring the sequence of DOD-unique events (refer to figure 4-11). The KSC LCC secure vault will be responsible for overall control of all DOD-unique functions involving the vehicle and payload. These functions will include receipt and decryption of data from the pad secure vault, stripping out the classified data, and routing of black data to KSC Launch Processing System (LPS) as required and classified data to the appropriate DOD areas, i.e., SMCC, Payload Checkout Control (PLCE). Also included will be receipt and encryption of uplink data and routing of that data to the pad secure vault. The LCC vault will receive required mission flight software and mission updates from SMCC and will load them into the onboard systems. It will monitor vehicle and payload, including caution and warning parameters, and provide status to the SMCC and/or the PLCC. The vault functions will also include monitoring systems after control is turned over to the flight crew.

4.3.5.2 KSC Launch Pad Secure Vault (LPSV). All hardwire uplink/downlink data to the Orbiter and payload will be routed through this vault for decryption/encryption, respectively. The vault will receive and encrypt any other data which may require encryption, and route that data to the secure vault in the LCC. In the case of uplink data, the vault will receive and route the data to the Orbiter/payload.

4.3.5.3 SMCC. DOD will be the mission agent for DOD operations at KSC. In fulfilling this role, SMCC will be responsible for providing

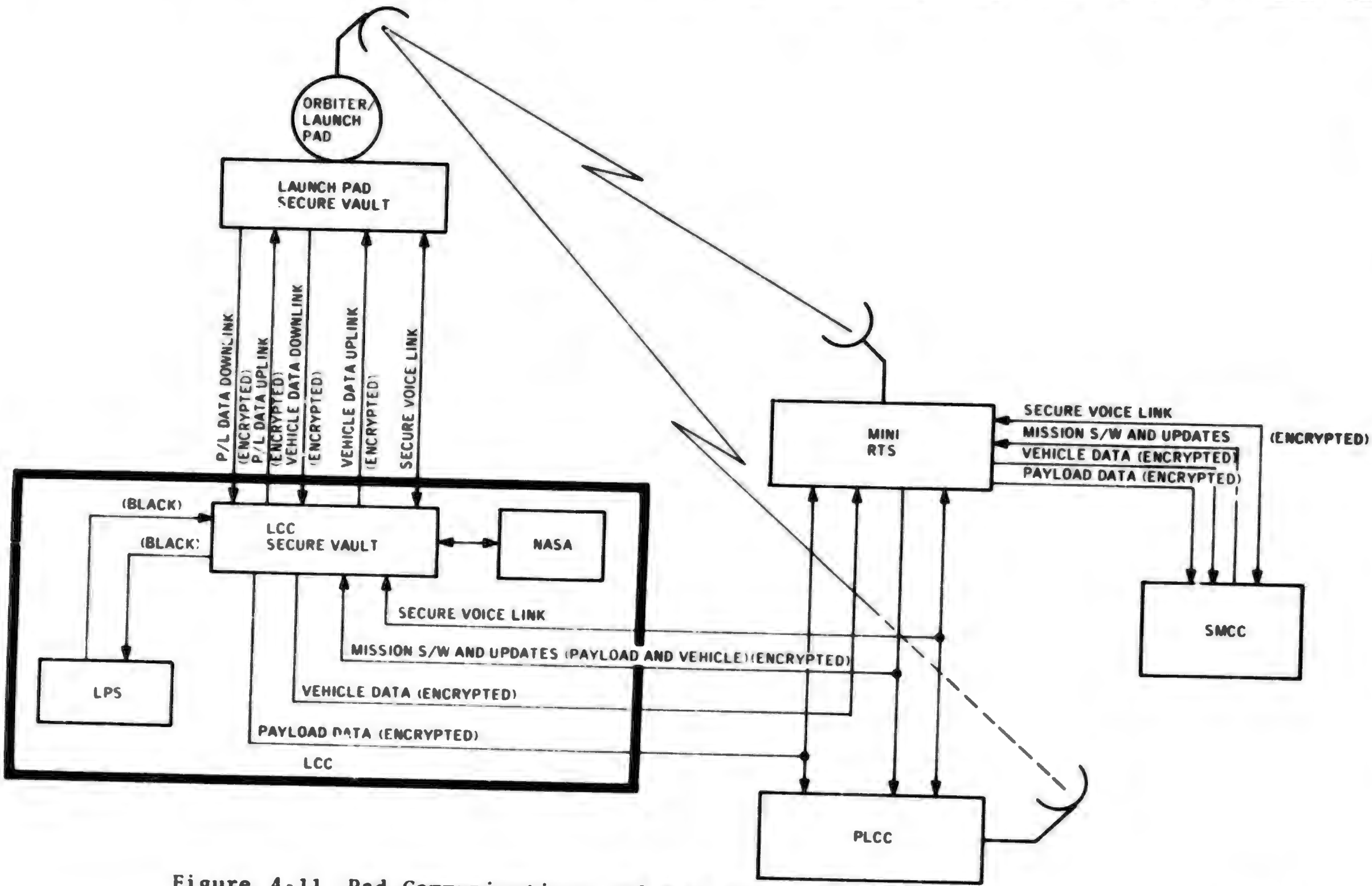


Figure 4-11 Pad Communications and Data Flow - DOD Mission at KSC

4.3.5.3 SMCC (Cont'd)

mission planning, mission software, mission scheduling/coordination and special checkout software. SCF will be responsible for validating voice and data circuits from STC to KSC and verifying their compatibility. During countdown operations at KSC, SMCC will monitor vehicle and payload status as provided by the LCC secure vault (KSC) and will provide mission updates to the LCC secure vault up to terminal count (T-5 minutes). SMCC will coordinate and verify that the applicable RTS's are operational and ready to support the mission prior to liftoff. SMCC will receive predefined payload data from KSC and route it to the user.

4.3.5.3.3 Mini-Remote Tracking Station (MRTS). The MRTS will act as a throughput station for data from/to the SMCC and the LCC secure vault. It will provide ascent support and will route the data to SMCC. It will also provide support in RF open-loop checkout of the payload and the vehicle data systems. The MRTS may have capability to reformat, encrypt/decrypt, and route data.

4.3.6 On-Pad Payload Operations

4.3.6.1 Introduction. The *Joint NASA/DOD Space Transportation System Program Plan* and *DOD Shuttle System Requirements* were the principal sources of guidelines for the development and selection of on-pad payload operations concepts.

A. Guidelines. The most important guidelines are the following:

1. Overall control and direction of on-pad payload activities will reside with the launch agent (DOD at VAFB and NASA at KSC).

2. Satellite agent will be responsible for satellite monitoring and checkout under the overall direction of the launch agent.

3. Satellite agent will be responsible for assuring the launch agent that the satellite meets Shuttle safety requirements while installed in the Orbiter.

4. Payload installation (or removal) and integration checkout of the total satellite/IUS/Orbiter will be performed by a joint launch agent/satellite team.

4.3.6.1 Introduction (Cont'd)

B. Concept Considerations. In addition to the above guidelines, the concept gave full consideration to the following restrictions: Within the current turnaround baseline of approximately 14 days, less than 1 day of launch pad activity is scheduled. This short timeframe 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, and to verifying and maintaining the operational integrity of the payload once installed.

C. Key Points. There are three key points concerning on-pad payload activities; they are as follows:

1. On-pad IUS activities are conducted by TBD under overall control and direction of the launch agent and are largely carried out from Launch Control. IUS mission data generation is the responsibility of the STC-SMCC for DOD programs using the IUS and the JSC-SMCC for NASA programs using the IUS. Mission data will be loaded via the CDE and LCE.

2. Satellite processing will be the responsibility of the satellite agent but under the overall direction of the launch agent. Satellite C&W parameter control, while under the control of the satellite agent, will reside within the LCE.

3. Overall direction and control of on-pad payload activities will reside with the LCE.

The following paragraphs discuss the alternate concepts considered and the preferred concept. The discussions apply to both VAFB and KSC launched DOD missions as indicated.

4.3.6.2 CCDS Concepts for On-Pad Payload Activities. As stated, the *Joint NASA/DOD Space Transportation System Program Plan* clearly indicates that overall control and direction of on-pad payload (IUS and/or satellites) activities will reside with the launch agent (NASA at KSC and DOD at VAFB). The program plan also clearly indicates that the NASA and DOD payload agents will, to a great extent, 4.3.6.2 <u>CCDS Concepts for On-Pad Payload Activities</u> (Cont'd)

actually perform the on-pad operation. These guidelines plus the requirements delineated in *DOD Shuttle System Requirements* form the basis for the on-pad payload activities CCDS operations concepts.

The concepts defined include consideration of the fact that primary responsibility for a given function may transfer from one point to another depending upon mission phase -- e.g., control of the payload may transfer from ground control to Orbiter Flight System (crew and equipment) control at some point prior to liftoff. Furthermore, the concepts include recognition that control exists at various levels -- for example, the satellite user may control the commands to be transmitted to a satellite; yet the launch agent may control or direct when the commands can be sent.

4.3.6.2.1 <u>Payload C&W Control Functions</u>. The control of payload parameters which potentially pose a safety hazard to life and/or property is of paramount importance. The *Joint NASA/DOD Space Transportation System Program Plan* states that the payload agency will be responsible for: 1) monitoring and checkout of the payload during the prelaunch phase under the overall test direction of the launch agency, and 2) assuring the launch agency that the payload meets Shuttle safety requirements while installed in the Orbiter prior to launch. These and other guidelines contained in the program plan indicate that the payload agency will maintain active control over the payload, including the C&W parameters.

Under the above guidelines, the C&W parameters remain under the control of the payload agency -- at least to the point of handover of this control to the Orbiter. Control could be exercised from the following:

- Orbiter
- Launch site payload facility
- Remote payload facility (e.g., MCC at STC)
- Launch Control Element.

4.3.6.2.1 Payload C&W Control Functions (Cont'd)

A. Orbiter. The advantages of using the Orbiter to control the C&W parameters include:

- Utilizing Orbiter systems that will be used during the flight phase to verify onboard systems
- Transfer control of these parameters at some point prior to liftoff
- Possibly reduce the number of ground software, hardware and personnel.

The principal disadvantage is that personnel will be required onboard continuously from installation to liftoff, exposing personnel to greater safety hazards. It also limits the personnel to examining only that data displayable by the Orbiter systems.

B. Launch Site Payload Facility. The principal advantages in controlling C&W parameters from the payload facility are that the amount of CCDS control and display equipment and the number of personnel required are minimized, and accessibility to additional information is greater. The primary disadvantages are that, for some programs, such a facility may not exist and coordination with other launch data and personnel is more restricted than if co-located with the other launch control personnel.

C. Remote Payload Facility. The principal advantage of this alternative is that it may tend to minimize launch site equipment, software and personnel costs. The disadvantages include those delineated in paragraph A above plus the reliance upon long-range communications. From a safety point of view, it is doubtful that this is an acceptable alternative because any significant loss in communications could be catastrophic. C&W parameter control must be continuously maintained.

4.3.6.2.1 Payload C&W Control Functions (Cont'd)

D. Launch Control. This alternative, and the one selected, offers the advantages of relative safety, minimum communication problem potential, and close coordination with other launch personnel, data, and systems. By having this function in the same locale as the other launch functions, the launch agency will have greater assurance of payload safety. It also satisfies the requirement when a launch site payload facility does not exist. The principal disadvantage is cost, i.e., more equipment, software, personnel, and facilities support. Principally because of safety considerations, this alternative appears to be the most desirable.

It is recognized that access to the payload uplink will transfer at times between hardwire, Orbiter, and RF. In any event, there must be hardwire, uplinks and downlinks to the payload continuously available while the ground has C&W control. This means that the capability must exist to quickly take control of the uplink to the payload and exclude simultaneous use of the payload uplink when necessary to control the C&W parameters.

4.3.6.3 IUS Control Alternatives. A mission using an IUS (whether DOD or NASA mission) will be launched only from KSC. On-pad IUS systems tests, checkout, update, and monitoring functions can be performed and controlled by the satellite agent, DOD STS, or NASA.

4.3.6.3.1 Satellite Agent Control. The mated IUS/satellite may be considered as a single payload and the responsibility of the satellite agent. The only particular advantage to this approach is that it alleviates the DOD STS and/or NASA of a significant amount of responsibility. However, it adds considerable effort and cost to the satellite agents since each satellite agent utilizing the IUS would need to fund and gear up for IUS support. This would result in more unnecessary redundant capability and cost, which subverts the attractiveness of STS as a lower cost means for deploying/retrieving satellites.

4.3.6.3.2 DOD CCDS Control. The mated IUS/satellite may be considered as a DOD payload with the DOD CCDS responsible for the IUS and the satellite agent responsible for the satellite. Under this

4.3.6.3.2 DOD CCDS Control (Cont'd)

concept the CCDS functions associated with the on-pad operations can be performed at KSC or from the SMCC (given sufficient communications capability).

The advantages and disadvantages of allocating the functions to the SMCC include the following.

A. It is recognized that the Orbiter capability to check out a payload needs to be validated and is hence an argument for designating the SMCC as a prime location. However, it must also be recognized that the checkout capability may be highly limited in comparison with ground capability. Furthermore, assurance is needed that the payload/Orbiter responses are proper; this will require verification by the ground.

B. Installation of the payload into the Orbiter payload bay starts approximately 10-12 hours before scheduled liftoff time. This limits the opportunity to test and check out the installed IUS to the few hours between completion of installation and closure of the payload bay doors (approximately 2 hours before liftoff). Well before this time, the necessary SMCC and AFSCF support capabilities will have been committed to come up several hours before launch. Therefore, the impact upon SMCC and AFSCF to support on-pad IUS test, checkout, update, and monitoring should be minor unless extended on-pad operations are performed or there is an extended hold.

C. The SMCC will have the necessary capability, in any event, since similar types of operations will be conducted during the flight phase from the SMCC.

D. The SMCC will have a high level of IUS technical expertise available for flight support which can also perform these on-pad IUS support functions. These technical support personnel can direct ground support personnel for nominal and contingency operations.

4.3.6.3.2 DOD CCDS Control (Cont'd)

E. Performance of these functions from the SMCC would serve as a means to validate the capability of the SMCC systems for IUS support.

F. Reliance upon long-range communication and extensive communications capability is required.

G. Loss of communications between the launch area and the SMCC could result in an unnecessary hold and possible "roll-back."

The basic arguments for allocating the CCDS control, direction, and monitoring functions to the launch site (Launch Control) are basically the same arguments for allocating Orbiter launch functions to Launch Control. (Mission data generation would be accomplished by the SMCC.) As a standard STS element, the IUS can be readily integrated in a standard launch processing scheme usable by DOD or NASA. Standardization tends to drive overall costs down and promote efficiency of operation. In addition, the close proximity to other launch control functional positions: 1) facilitates closer coordination, efficient operation, and control; and 2) reduces the problem (reliability and ready access to greater amount of information) of long-range communications.

The principal disadvantage of DOD STS IUS control from Launch Control is the need to specially train additional DOD personnel and to support the IUS at KSC. (Two to three crews could be required if on-pad activities become extended.) This would duplicate (to a great extent) SMCC capability and NASA capability. IUS data would still need to be transmitted to the SMCC to initialize and update the SMCC systems to support the flight phase.

4.3.6.3.3 Launch Agent Control. If the IUS could be considered as a standard STS element and addressed in a manner similar to the Orbiter, then there is rationale for allocating the functional responsibility for IUS on-pad activities (excluding mission data generation) to NASA. This concept significantly reduces (or eliminates) the need for specially IUS-trained DOD personnel at KSC. Operating efficiency is increased because an experienced, dedicated team would perform the support on a

4.3.6.3.3 Launch Agent Control (Cont'd)

mission-to-mission basis. Another advantage is the legacy established for transition to the Tug as the standard upper stage In this concept IUS data would be transmitted to the SMCC for monitoring and to initialize and update the SMCC systems in preparation for flight phase support.

While this concept would be preferrable primarily because of the standardization and continuation of the Launch Agent responsibility for standard STS elements, it is undesirable from a DOD satellite agent standpoint due to the intimate association between the IUS and the satellite and its security implications. Considerable study remains to be accomplished to firmly establish the optimum concept.

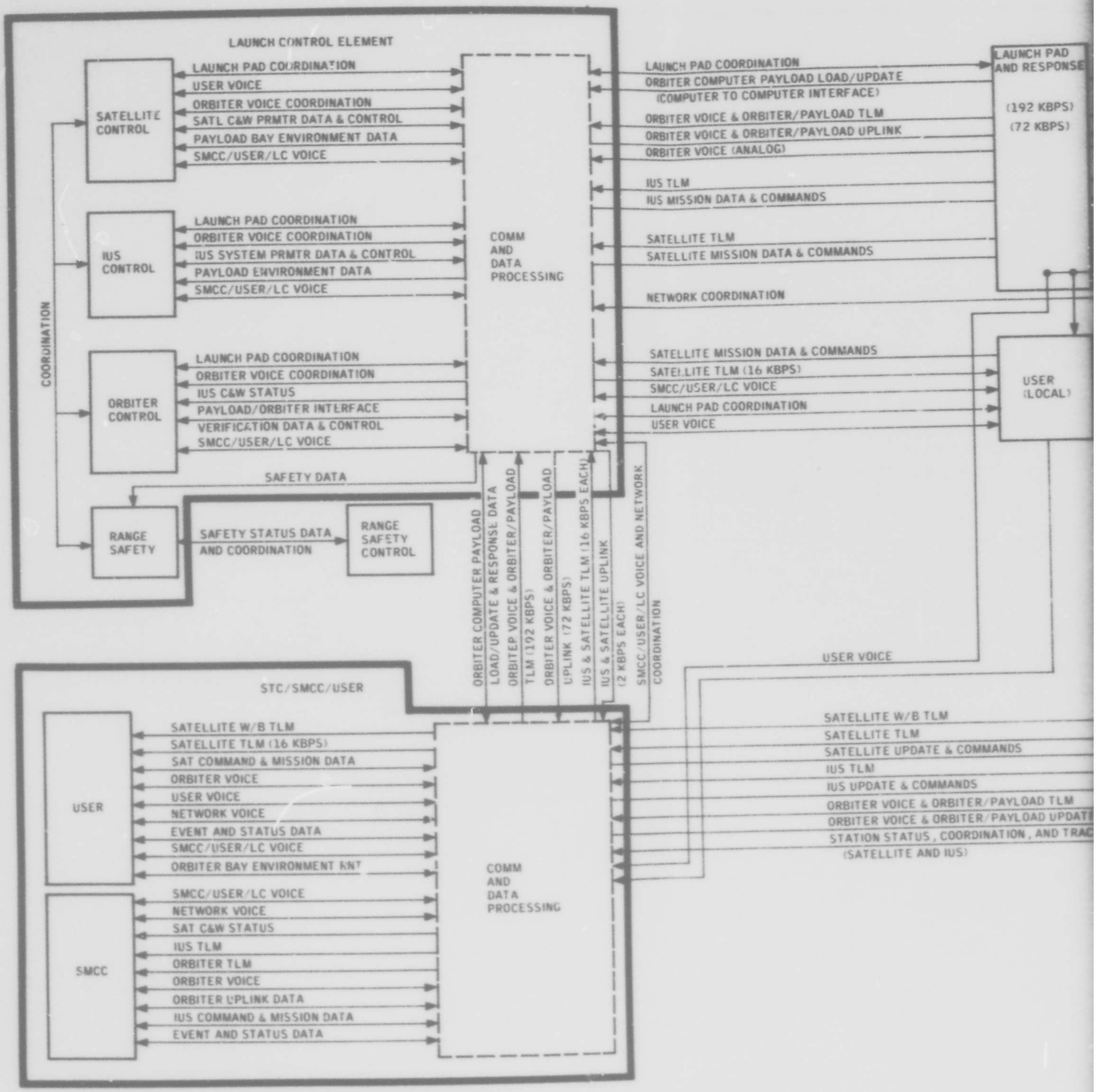
4.3.6.4 Concept Description. There are four distinct phases of on-pad payload operations (see figure 4-13). These phases are as follows:

- Installation
- Launch readiness
- Standby
- Countdown.

Because virtually no new payload operations are performed during standby, the standby phase has been combined with countdown for ease of presentation.

4.3.6.4.1 Payload Installation. Payload installation activities begin with verification that the launch pad payload installation and support facilities and the Orbiter are ready and activated. They 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.

Control elements involved with payload installation activities consist of LCE, MCE, PLCE, and RE. Figure 4-13 illustrates communication links between control elements, the CDE, and the launch pad.


LAUNCH CONTROL ELEMENT
SATELLITE CONTROL
LAUNCH PAD COORDINATION
USER VOICE
ORBITER VOICE COORDINATION
SATL C&W PRMTR DATA & CONTROL
PAYLOAD BAY ENVIRONMENT DATA
SMCC/USER/LC VOICE
IUS CONTROL
LAUNCH PAD COORDINATION
ORBITER VOICE COORDINATION
IUS SYSTEM PRMTR DATA & CONTROL
PAYLOAD ENVIRONMENT DATA
SMCC/USER/LC VOICE
COORDINATION
ORBITER CONTROL
LAUNCH PAD COORDINATION
ORBITER VOICE COORDINATION
IUS C&W STATUS
PAYLOAD/ORBITER INTERFACE
VERIFICATION DATA & CONTROL
SMCC/USER/LC VOICE
SAFETY DATA
RANGE SAFETY
SAFETY STATUS DATA AND COORDINATION
RANGE SAFETY CONTROL
COMM AND DATA PROCESSING
LAUNCH PAD COORDINATION
ORBITER COMPUTER PAYLOAD LOAD/UPDATE
(COMPUTER TO COMPUTER INTERFACE)
ORBITER VOICE & ORBITER/PAYLOAD TLM
ORBITER VOICE & ORBITER/PAYLOAD UPLINK
ORBITER VOICE (ANALOG)
IUS TLM
IUS MISSION DATA & COMMANDS
SATELLITE TLM
SATELLITE MISSION DATA & COMMANDS
NETWORK COORDINATION
LAUNCH PAD AND RESPONSE
(192 KBPS)
(72 KBPS)
SATELLITE MISSION DATA & COMMANDS
SATELLITE TLM (16 KBPS)
SMCC/USER/LC VOICE
LAUNCH PAD COORDINATION
USER VOICE
USER (LOCAL)
ORBITER COMPUTER PAYLOAD LOAD/UPDATE & RESPONSE DATA
ORBITER VOICE & ORBITER/PAYLOAD TLM (192 KBPS)
ORBITER VOICE & ORBITER/PAYLOAD UPLINK (72 KBPS)
IUS & SATELLITE TLM (16 KBPS EACH)
IUS & SATELLITE UPLINK (2 KBPS EACH)
SMCC/USER/LC VOICE AND NETWORK COORDINATION
USER VOICE
STC/SMCC/USER
USER
SATELLITE W/B TLM
SATELLITE TLM (16 KBPS)
SAT COMMAND & MISSION DATA
ORBITER VOICE
USER VOICE
NETWORK VOICE
EVENT AND STATUS DATA
SMCC/USER/LC VOICE
ORBITER BAY ENVIRONMENT KNT
SMCC
SMCC/USER/LC VOICE
NETWORK VOICE
SAT C&W STATUS
IUS TLM
ORBITER TLM
ORBITER VOICE
ORBITER UPLINK DATA
IUS COMMAND & MISSION DATA
EVENT AND STATUS DATA
COMM AND DATA PROCESSING
SATELLITE W/B TLM
SATELLITE TLM
SATELLITE UPDATE & COMMANDS
IUS TLM
IUS UPDATE & COMMANDS
ORBITER VOICE & ORBITER/PAYLOAD TLM
ORBITER VOICE & ORBITER/PAYLOAD UPDATE
STATION STATUS, COORDINATION, AND TRAC
(SATELLITE AND IUS)

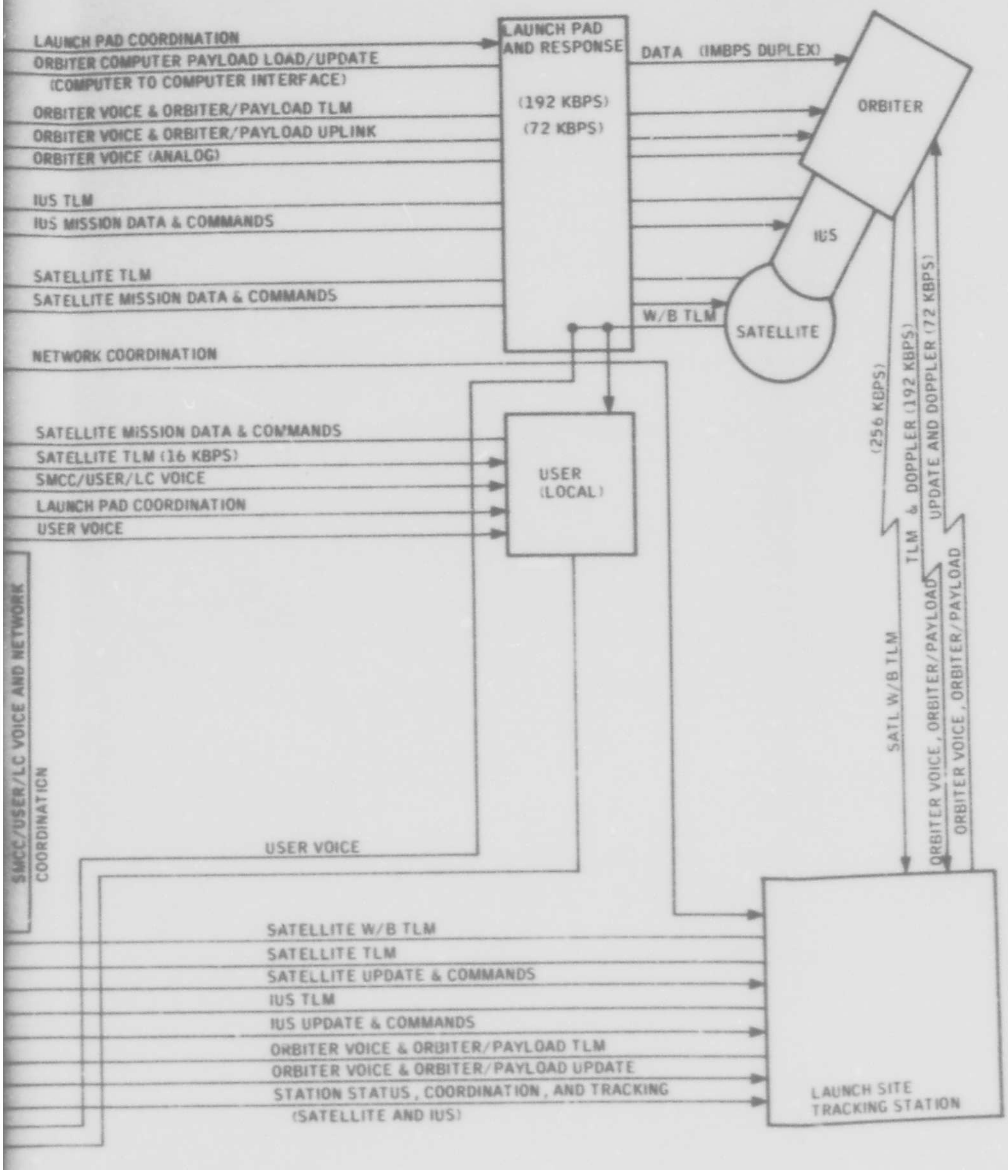


Figure 4-12 On-Pad Payload Activity Functional Flow Diagram

B

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

The LCE in conjunction with the OMCE will be responsible for work scheduling and activities management, and control and monitoring of GSE and ground support personnel required in coordination with PLCE teams to accomplish payload installation. Requirements for management and control functions, command/response data links, data processing and displays capabilities, and types of data exchanged by the LCE with other control elements/facilities are much the same as those described under pad installation of SSV elements (paragraph 4.3.2.1).

The physical handling and mating operations will be performed by payload installation personnel. Supporting services such as electrical and hydraulic power, water, air conditioning, etc., shall be GSE. The PLCE will monitor installation activities in coordination with the LCE. Orbiter-to-payload interface confirmation testing will be a sole responsibility of LCC, with checkout commands and responses originating in the LCC work stations.

The MCE will maintain communication links with the LCE and the PLCE to obtain cognizance and status of overall installation progress and payload health/safety conditions.

The RE shall act in the same capacity as that exercised during pad installation; i.e., monitoring installation activities for compliance with pad/area safety regulations and status reporting to the LE.

4.3.6.4.2 <u>Payload Launch Readiness</u>. The purposes of payload launch readiness operations are to: 1) verify that the payload has been properly integrated into the STS system; 2) assure that the operational integrity of the payload is maintained; 3) assure payload/Orbiter/AFSCF compatibility; 4) initiate loading/updating of Orbiter computers with payload data; 5) verify Orbiter capacity to monitor and control the payload; and 6) conduct final payload servicing (excluding loading of cryogenics).

Integration verification operations are conducted in concert with the operational integrity checkout operations. The operations are a cooperative effort between the satellite agent and the launch agent under the overall direction of the launch agent.

4.3.6.4.2 Payload Launch Readiness (Cont'd)

The satellite agent is responsible for activating, initializing, and controlling the satellite systems, and monitoring the environmental data. The satellite agent may perform these functions from a local satellite facility or from a remote facility such as the STC. LCE responsibilities will include the capability to continuously monitor the satellite C&W and environment parameters. The satellite agent will be responsible for arranging all data processing and display of satellite data used or generated at satellite agent locations. The LCE will be responsible for:

- Activating, initializing, and controlling the IUS and Orbiter support systems
- Controlling the payload external environment
- Processing and displaying payload C&W and Orbiter support system data
- Controlling the interfaces/access to the payload
- Distributing payload C&W data to Range Safety
- Distributing environmental data to the satellite agent and Range Safety
- Coordinating and directing the integration and checkout activities
- Determining and distributing status data to the satellite agent, SMCC, Range agent, and the OMCE
- Forwarding Orbiter and payload downlink data (unprocessed) to the STC/SMCC/User MCC (UMCC).

4.3.6.4.2 Payload Launch Readiness (Cont'd)

Payload/AFSCF compatibility provides assurance of open-loop RF communication between the Orbiter/payload and the STC/SMCC/UMCC via an RTS.

The open-loop RF checkout includes accessing the payload directly via the Orbiter RF communication system.

While these operations essentially involve only the Orbiter/payload, local RTS, and STC/SMCC/UMCC, other control elements are monitoring the operations via hardwire lines to the Orbiter/payload. The LCE (with satellite agent assistance) controls the configuring of the Orbiter/payload for the payload/AFSCF compatbility checkout operations and transfers uplink control to the STC/SMCC/UMCC. The LCE then continues to perform essentially the same functions that will be performed during the payload integrity checkout operations.

Generation of the payload data to be loaded into the Orbiter computers will be accomplished at the STC. (The UMCC will be responsible for the satellite data and the SMCC will be responsible for the IUS data.) The data will be transmitted to the LCE for subsequent storage, formatting, and loading into the Orbiter.

Mission data to be loaded into the satellite will be generated by the satellite agent and loaded directly through the payload umbilical. IUS mission data will be generated at the SMCC and forwarded via the CDE and LCE for loading into the IUS via the payload umbilical.

After the payload interfaces have been thoroughly checked out and safety assured, a checkout crew will board the Orbiter and verify the Orbiter's capability to command and control the payload utilizing the onboard systems. The checkout crew will assure its monitoring capability and then progressively assume control of the payload from the satellite agent and the LCE. Command/response sequences will be performed and control returned to the satellite agent and the LCE upon successful completion of the checkout.

4.3.6.4.2 Payload Launch Readiness (Cont'd)

The satellite agent and LCE will continue to monitor operations and advise the checkout crew as needed. The LCE will continue to provide overall direction and carry on as during payload integrity checkout. Range Safety will continue to observe operations, monitor C&W and cabin and bay environment data, and enforce safety regulations.

Non-cryogenic fuel loading of the payload may be initiated during payload launch readiness. The LCE will configure the Orbiter and ground support equipment for loading. The satellite agent will configure the satellite for fueling. The LCE will direct and monitor fueling operations and the satellite agent will monitor satellite fueling. Range Safety will observe the fueling operations, monitor fueling, environment, and payload C&W parameters, and enforce safety regulations.

The final payload launch readiness operation is the closing of the bay door. This operation is conducted remotely from the LCE.

4.3.6.4.3 Standby/Countdown (Payload Activities). Prior to closure of the Orbiter payload bay doors, the payload is placed in a relatively quiescent condition which, except for cryogenics loading, would constitute a "ready-for-launch" state. Until liftoff, the principal payload-oriented activities are directed towards maintaining this state, loading the cryogenics, and transferring control of the payload to the Orbiter crew and systems.

Control and data flow remains the same as described in paragraph 4.3.4.2 until payload control transfer to the Orbiter crew and systems. Control of the cryogenics loading resides with launch control and is monitored by the flight crew (onboard) and the satellite agent (if cryogenics are loaded into the satellite).

Control of the payload is progressively transferred from the LCE and the satellite agent to the Orbiter crew following crew ingress at approximately T-2 hours. As control is transferred, the role of the LCE and the satellite agent becomes one of monitoring and advising the flight crew. Mission update data generation, however, continues to be the responsibility of the SMCC and satellite agent

4.3.6.4.3 Standby/Countdown (Payload Activities) (Cont'd)

and loaded via CDE and LCE. Range Safety will continue to observe hazardous operations (including cryogenic loading), monitor the payload safety parameters, and enforce safety regulations.

4.3.6.4.3 Payload Operations Information Flow (Summary). Figure 4-12 summarizes the flow of payload related data under the on-pad payload operations concept. The diagram is a composite representing DOD missions launched from KSC and VAFB and NASA launches from VAFB.

The diagram shows hardwire and RF links. The hardwire links carry the indicated information almost continuously for on-pad operations (uplink control is assumed by the Orbiter crew following ingress). The RF links are established only during AFSCF/payload compatibility checkout and shortly before liftoff via the Orbiter RF communication system.

The dashed blocks are not control elements but are included as a matter of illustrative convenience to represent the communication, data processing, and distribution functions performed by the LCF and STC/SMCC/UMCC elements.

4.4 FLIGHT OPERATIONS AND OPERATIONS SUPPORT

4.4.1 General. Flight operations are defined to include all vehicle and mission activity commencing at liftoff of the integrated vehicle from the launch pad and ending at rollout. The operations support activity includes those functions required premission to perform mission planning, analysis and design; mission software requirements development; and crew and ground personnel training (not part of this TOR, but will be in TOR IV).

For the flight phase of the STS mission, the functions to be performed can summarily be described as follows (from Task II):

- Provide overall mission direction and management
- Maintain awareness of overall mission status, i.e., vehicle system status, vehicle orbital state, and mission plan vs. mission execution

4.4.1 <u>General</u> (Cont'd)

- Provide the Orbiter an RF reference uplink for onboard doppler extraction and orbital navigation updating
- Provide command and control functions to the IUS after deployment (for midcourse corrections required for rendezvous with Orbiter)
- Provide SRB impact point predictions to recovery forces
- Respond to inflight contingency situations
- Provide USER/STS MCC coordination
- Coordinate communications and other program shared resources
- Provide online mission/flight planning.

For the premission operations support activity the major functions include the following (from Task II):

- Mission planning, analysis and design
- Software requirements development
- Flight and ground crew training and simulations.

In general, all CCDS functions required to support the above operations are allocated to the functional MCE with specific support required from other elements. It is realized, however, that many of the premission (operations support) functions may be performed using personnel and data system resources external to a classical mission control environment. For this reason the CCDS concept for performing those functions is discussed separately within this section.

The following paragraphs address those operations that are primarily in the province of the MCE. Paragraph 4.4.2 presents the flight operations CCDS concept drivers, and the alternate and selected concepts to satisfy these drivers. Paragraph 4.4.3 discusses the

4.4.1 General (Cont'd)

flight operations including support to the nominal mission, IUS/satellite operations, support to contingency operations, and the role of the MCE in simultaneously supporting two Orbiter missions. Paragraph 4.4.4 discusses the operations support functions.

4.4.2 Concept Drivers and Concepts. In developing the CCDS concept, the items listed in table 4-2 and discussed below were identified as concept drivers. The following paragraphs present those drivers, discuss the concepts considered for each, and provide the selection rationale for the preferred concept.

4.4.2.1 Autonomous Orbiter Vehicle. The Orbiter is being designed with a high degree of autonomy for on-orbit operations. This autonomy should minimize CCDS real-time processing requirements for STS operations and require fewer ground support personnel than current manned operations. However, the CCDS must be able to respond to contingency/emergency situations by providing effective ground support and means must be provided for the Orbiter crew to alert the SMCC of such situations. As a result, the alternatives discussed below were examined for the mission control operations environment, a manning scheme for the SMCC which would be used as a guideline in determining (in Task IV) the number of operating positions required, and a means of alerting the SMCC of the existence of an emergency/contingency situation.

4.4.2.1.1 Mission Control Operations Environment (Real-Time Processing). Two concepts for the operations environment for control of the STS were postulated and considered.

A. Concept 1. The characteristics of the first concept provide an SMCC with the capability of real-time processing and dynamic displaying of STS vehicle/mission status and orbital state based on telemetry processing, tracking, and voice communications during scheduled RTS contact periods.

B. Concept 2. Concept 2 provides the capability of real-time communications processing and data recording, with vehicle/mission status monitored by voice communications with crew (historical data available at the MCE).

TABLE 4-2
MAJOR FLIGHT/MISSION OPERATIONS CCDS CONCEPT DRIVERS

STS ORBITER VEHICLE AUTONOMOUS FOR ALL NOMINAL FLIGHT PHASES

- MINIMIZES REAL-TIME PROCESSING FOR ROUTINE STS OPERATIONS
- REQUIRES CAPABILITY FOR GROUND SUPPORT IN EMERGENCIES
- MINIMIZES FLIGHT CONTROLLER MANNING FOR ROUTINE STS OPERATIONS
- REQUIRES ORBITER/SMCC COMMUNICATION FOR EMERGENCY ALERT

BACKUP SUPPORT FOR CONTINGENCIES MAY BE REQUESTED FROM NASA (JSC MCC AND NETWORK)

- DETERMINES LEVEL OF DOD SMCC CONTINGENCY SUPPORT PRIOR TO NASA CALLUP
- INFLUENCES METHODS OF IMPLEMENTING DOD/NASA INTERFACES FOR CONTINGENCY SUPPORT BY NASA
- EFFECTS SECURITY CONSIDERATIONS FOR CONTINGENCY MODES

DOD USE OF NASA-DEVELOPED RESOURCES TO THE MAXIMUM EXTENT PRACTICABLE INCLUDING:

- MISSION PLANNING METHODS, TOOLS, AND DATA BASES
- EXISTING TRAINING PROCEDURES

DUAL MISSION IMPACTS OF SMCC

4.4.2.1.1 Mission Control Operations Environment (Real-Time Processing. (Cont'd)

For the nominal mission, Concept 2 would be preferred since it minimizes the number of ground support personnel and the amount of data processing required. However, the SMCC must be able to respond/react to emergency situations and this requirement demands a real-time data processing and dynamic display capability. Concept 2 is not compatible with this requirement since it cannot provide real-time assessments, validations, or bases from which a procedural circumvention of contingencies can be developed.

Concept 1 is the concept selected, either in a continuous real-time mode, or with a fast response (turnaround) from the limited capabilities described for Concept 2 to those of Concept 1 as a contingency occurs.

4.4.2.1.2 SMCC Manning Concepts. Two concepts of manning the SMCC during flight operations were evaulated and will be used as guidelines (during Task IV) when identifying the number of operation positions required.

A. Concept 1. Concept 1 provides a full complement of operating positions for all mission phases and functions and full-time manning at each position during the mission.

B. Concept 2. Concept 2 provides fixed, dedicated operating positions only to the extent required to support mission aspects requiring near-continuous observation or analysis to maintain an awareness of mission progress and status. In addition, it provides a number of positions (flexible, general purpose positions) which can be assigned in real-time to any area, either for contingency support or manned as determined premission for monitoring or analysis during specific events or sequence of events. Personnel would be on an "on-call" basis to augment the SMCC manning as contingencies occur.

Concept 2 was selected because the vehicle autonomy should require a lower level of full-time support and the lower level results in lower operating costs. Additionally, the unassigned general purpose-type operating positions have an inherent flexibility not found in the dedicated positions.

4.4.2.1.3 Orbiter-SMCC Communications for Emergency Alert. When an Orbiter crew determines that an onboard emergency/contingency exists, they should have a means by which they can communicate this to the ground at the earliest time possible. Although there are no stated requirements for emergency/contingency alert, three concepts were considered for accomplishing this function.

A. Concept 1. Concept 1 would routinely schedule the RTS for an Orbiter contact nominally once each orbit. This concept was ultimately selected primarily because of the redundancy provided onboard for flight-critical systems.

B. Concept 2. Concept 2 would alert the SCF through the TDRS, then prepare for and accomplish communications via the SGLS network. This concept is not feasible without using the TDRS high gain antenna or changing the baseline Orbiter communications system.

C. Concept 3. Concept 3 would augment the RTS with a low gain, broad lobe emergency alarm receiving system. Upon receipt of an alarm, contact would be established through the primary SGLS receiver and transmitter. This concept would result in higher costs because of the required augmentation.

4.4.2.2 NASA Contingency Support. DOD may request support from NASA in responding to contingencies. This would permit the DOD to make use of the extensive systems expertise and computational/simulation facilities at JSC without having to duplicate these capabilities. The driver on the DOD SMCC becomes the point at which NASA support is requested, i.e., the capability limitation designed into the SMCC.

The DOD may require network support (STDN/TDRS) from NASA without requiring JSC MCC support. When requesting support from NASA, only non-secure voice and data can be provided by the NASA resources. The following paragraphs discuss the NASA-DOD division of responsibility for contingency response; discuss (without recommendation) alternates for implementing the DOD-NASA interface; and suggest a method for using the NASA network with unclassified voice and data.

4.4.2.2.1 JSC/DOD Division of Responsibility for Contingencies. Shuttle Level II requirements state that both NASA and DOD will operate dedicated SMCC's. For contingency support, each SMCC and

4.4.2.2.1 <u>JSC/DOD Division of Responsibility for Contingencies</u> (Cont'd)

each agency's network can be made mutually available to the other agency. NASA's SMCC and/or the network would be made available for contingency support only if requested by the DOD.

While recognizing that each contingency situation is unique and will require real-time mission management decisions, or in many cases, that mission rules will specify the action to be taken, a general DOD/JSC division of responsibility determination is re-required in order to define or bound the DOD SMCC system requirements. The concept selection is based on the triply redundant flight critical systems on the Orbiter. It considers the classified nature of most DOD missions while the NASA network will be used only for unencrypted data and voice transmissions, and it recognizes that NASA requires up to 8 hours before full network/MCC capability can be provided to support DOD emergencies/contingencies. With these considerations, the general guideline discussed below is that NASA support will be requested only when crew safety is endangered.

A. <u>First Failure</u>. A first failure of a redundant system leaves the Orbiter in a fail-operational mode. The crew is in no danger and the mission is still possible. Use of the DOD SMCC for first failure contingencies results in a lower relative cost (no JSC involvement) and a quicker reaction time (JSC requires up to 8 hours for providing full contingency support). For these reasons, the concept selected was that DOD would perform system analyses functions and exercise mission management during first failure contingencies. Although DOD will perform system analyses to determine trends, a ground capability to determine a corrective action to restore the system or a procedure to circumvent the failure is not required. JSC would not be involved unless put on a standby alert by DOD.

B. <u>Second Failure</u>. A second failure of a redundant system puts the Orbiter in a fail safe condition. The mission may not be completed but the crew is in no danger. It is not essential that the failure be corrected or a procedure developed

4.4.2.2.1 JSC/DOD Division of Responsibility for Contingencies (Cont'd)

to circumvent the failure. The lower relative cost and the quicker reaction time of the DOD SMCC are the rationale for selecting DOD to continue to perform system analyses and mission management during second failure contingencies; however, JSC would be alerted to a standby status.

C. Third or Single Point Failure. The third failure in a redundant path jeopardizes the crew and vehicle safety, and vigorous efforts to correct or circumvent the failure must occur. The same is true for a single point failure (e.g., payload doors will not close). For this contingency, the concept selected is for DOD to continue to make management decisions but JSC will provide systems, simulations, and computational support required to determine the failure's cause and the corrective action to be taken. DOD will transfer the pertinent data to the NASA MCC to provide this support. The rationale for this concept selection is the high cost to duplicate the extensive JSC systems, simulation, and computational capability at the STC; mission security no longer being a consideration; and if a rescue mission were required, it would be conducted by NASA.

4.4.2.2.2 SMCC/JSC and SMCC/STDN/TDRS Interface. The joint use of NASA/DOD resources, if requested for contingency support, requires a data and voice interface between the SMCC and NASA. Three distinct contingency situations requiring NASA assistance can be postulated for the purpose of defining the interface requirements:

- Increased contact with Orbiter desired through NASA STDN/TDRS
- NASA's JSC resources required which may/may not also require STDN/TDRS
- Failure in DOD SMCC which requires transfer of mission control to the JSC.

The interface requirements for NASA support therefore are to provide:

- A voice/data link from the Orbiter to the DOD SMCC via the STDN and TDRS

4.4.2.2.2 SMCC/JSC and SMCC/STDN/TDRS Interface. (Cont'd)

- A voice/data link between the DOD SMCC and the JSC/MCC
- A voice/data link from the Orbiter to the JSC/MCC via STDN or the TDRS.

Although NASA and the DOD will jointly determine how the SMCC-NASA interface will be implemented, there are some operational factors DOD may want to consider when stating the requirements to NASA. There are essentially three methods of implementing the interface.

A. Concept 1. Concept 1 interfaces the SMCC to JSC and, through JSC, to the Goddard Space Flight Center (GSFC) to the TDRS/STDN (see figure 4-13).

B. Concept 2. Concept 2 interfaces the SMCC to STDN/TDRS through GSFC and to JSC through GSFC. (See figure 4-14.)

C. Concept 3. The third method involves a direct SMCC to GSFC interface and a direct SMCC to JSC interface.

When considering which way to recommend implementing the interface, an important consideration is that the SMCC may want increased contact with the Orbiter vehicle, but does not require or desire JSC MCC support. A direct interface to GSFC from the SMCC (concept 2) would permit this increased contact without JSC involvement. However, since there may be frequent and routine JSC-SMCC data interchanges for mission planning and training, the direct SMCC to JSC link (concept 1) may be advantageous. The third concept combines both features but at an increased cost because of the multiple links. Concept 1 is the currently preferred concept.

4.4.2.2.3 Security Considerations - DOD Communication through STDN/TDRS. As discussed above, the Orbiter or SMCC may require communication with each other through STDN/TDRS for contingency response. Since the STDN/TDRS SMCC communication links are unencrypted, this represents a possible compromise of the mission. There may be many contingencies, however, where only an unclassified voice contact between the SMCC and the Orbiter is required. Such situations could be for a crew illness, requests to lengthen/shorten the mission because of some observation external to the vehicle, or through human

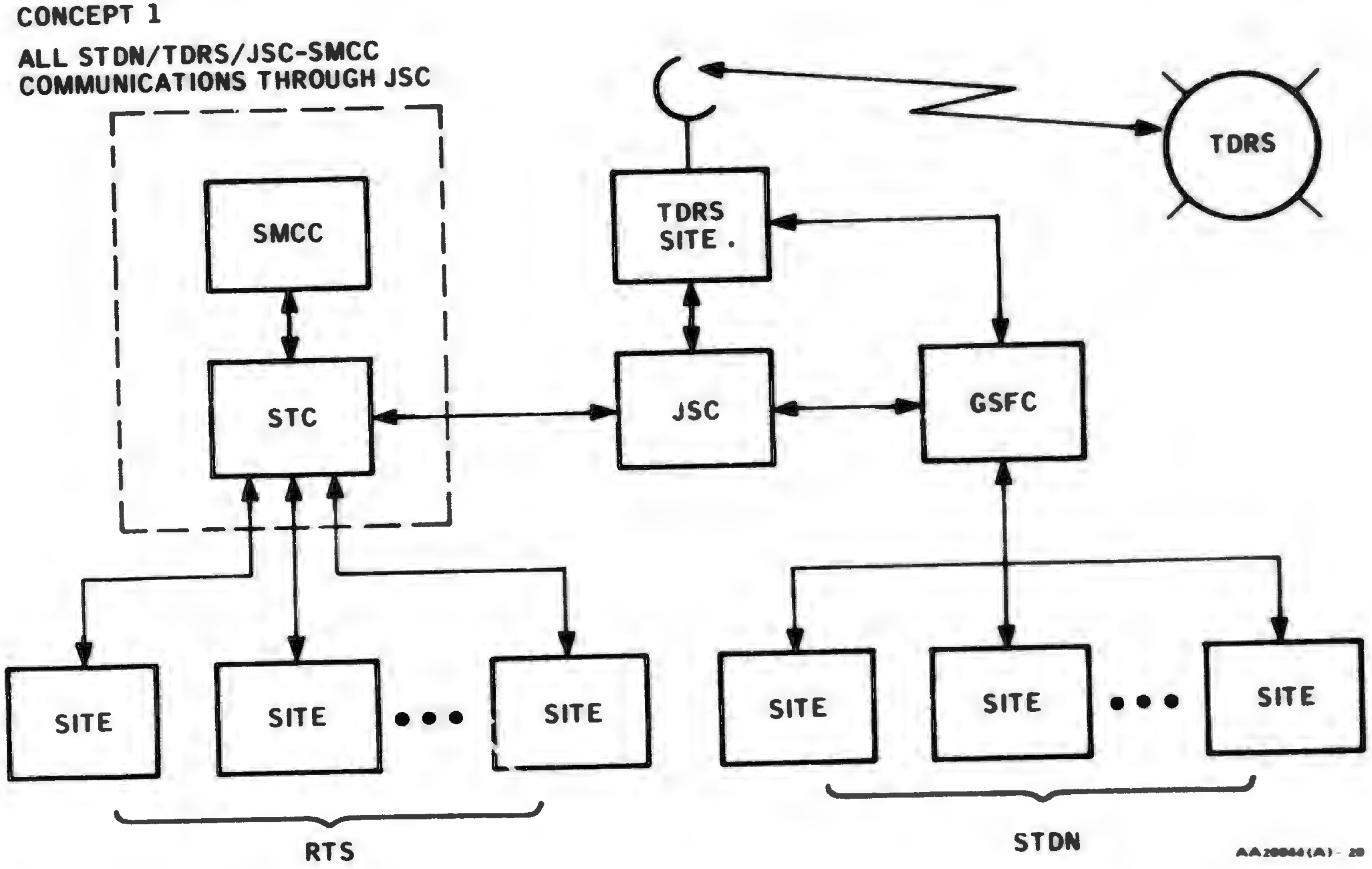


Figure 4-13 SMCC/JSC and SMCC/STDN/TDRS Data Flow (Concept 1)

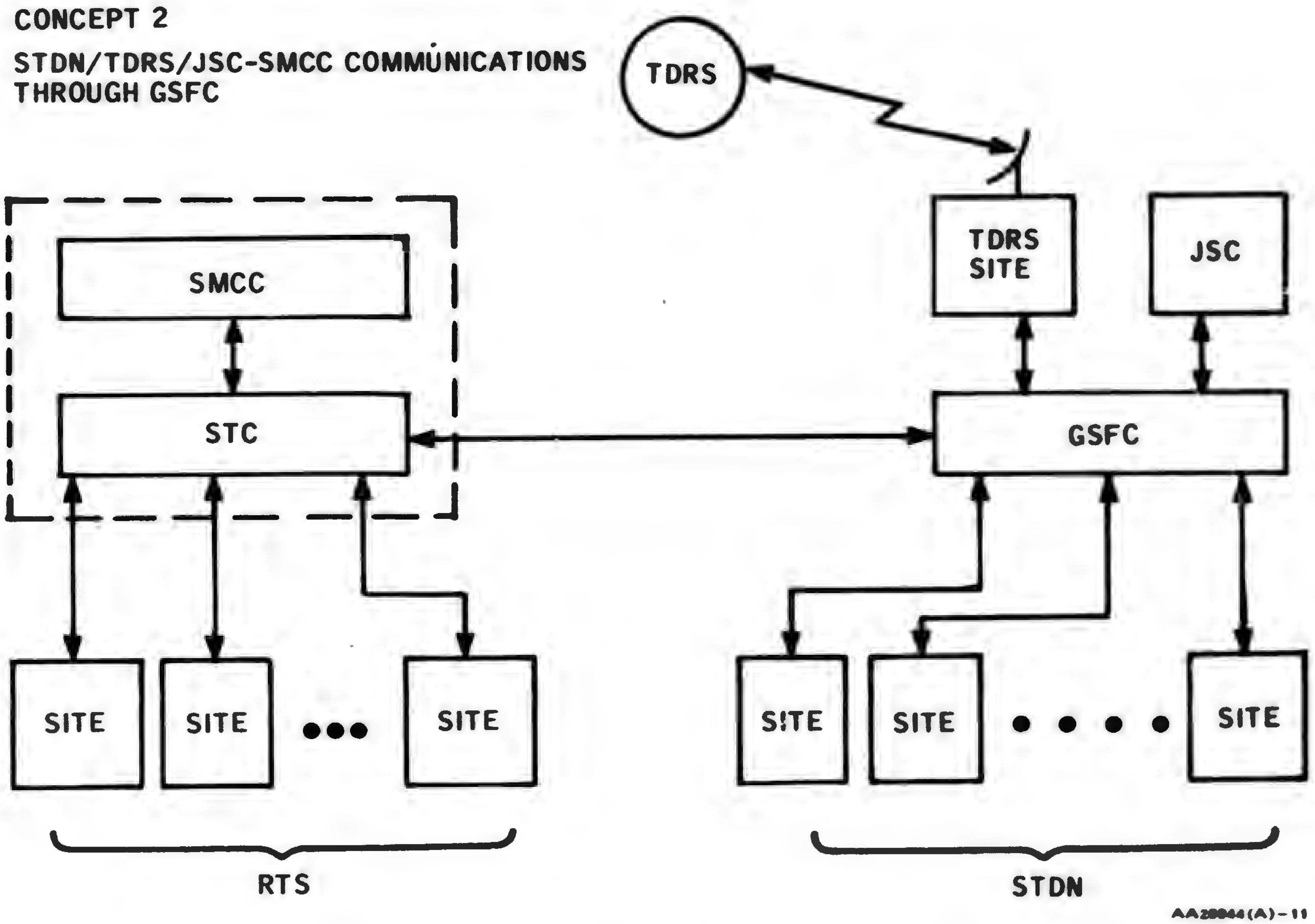


Figure 4-14 SMCC/JSC and SMCC/STDN/TDRS Data Flow (Concept 2)

4.4.2.2.3 <u>Security Considerations - DOD Communication through STDN/ TDRS</u> (Cont'd)

error a necessary procedure was not accomplished. Based on this, the possibility was investigated of using "clear" voice communications "only" for certain contingencies requiring NASA support (deleting the telemetry data from the downlink). This was not possible due to the design of the downlink time division multiplexed (TDM) voice/telemetry format.

Other contingencies postulated and analyzed required the ground to rely heavily on the telemetered measurement in the resolution of anomolies, e.g., the failure of the onboard performance monitoring capability in the presence of other vehicle anomolies.

Based on this analysis, the vehicle capability for multiple downlink formats with the data contents selectable (premission) was examined to determine applicability of this feature for providing nonclassified system data to NASA for contingency support. It was determined that four different formats could be designed premission with the data contents defined by the data user. The AF should investigate this potential method for deleting classified data in a unique contingency format to be used when NASA STDN, TDRS and/or MCC resources are called on to support contingencies.

4.4.2.3 <u>Utilization of NASA Resources</u>. A program goal is to reduce cost by making the maximum use practicable of the NASA resources for mission planning and in training crews. Although concepts associated with training crews are a subject for the subsequent task, the requirements for mission planning during the mission were analyzed. This analysis determined that during both the nominal mission and the mission provided contingency support, there is a requirement for a near-real-time mission planning system. This system will perform such functions as optimizing flight/maneuver plans based on current status, determining effects of lengthening/shortening missions, and selecting alternate landing sites. Two concepts for such a near-real-time system were considered.

A. <u>Concept 1</u>. Concept 1 would utilize the VMMPS at JSC with an SMCC-terminal interface to the VMMPS for use during mission for near-real time mission planning.

4.4.2.3 Utilization of NASA Resources (Cont'd)

B. Concept 2. Concept 2 would provide all required resources for this mission planning at the SMCC. These resources could include the portions of the VMMPS applications software and data bases required to accomplish the planning/replanning necessary while the mission is in progress and the vehicle is in orbit.

Concept 2 was selected because of operational considerations (e.g., will the NASA VMMPS be immediately available whenever required by DOD?) and DOD mission security requirements. Selection of this concept does not preclude a full capability VMMPS being implemented at the STC if analysis (during other study efforts) of the total mission planning and design function indicates that a full capability VMMPS is required by DOD.

4.4.2.4 Dual Mission Capability. Because of the projected DOD operational mode of "launch on failure," the CCDS may be required to support two Orbiters in simultaneous orbits. The SMCC (or SMCC's) capability to support two Orbiters simultaneously then becomes an important consideration.

In developing concepts for the SMCC to support two Orbiters, the following assumptions were made: 1) one Orbiter is in a polar orbit, launched from VAFB, and the second is in a low inclination orbit launched from KSC; and 2) dual support would not be required until CY83 or after both VAFB and KSC have been used as DOD launch sites.

Three SMCC concepts for providing dual support were developed.

A. Concept 1. The first concept is an SMCC with a dual set of fixed operating positions required for all missions with a single set of reconfigurable (general purpose) positions that can be used for either mission, for support to specific mission phases, or in the event of a contingency.

B. Concept 2. This concept is the same as concept 1 except the operating positions for support to specific mission phases or contingencies are fixed and not reconfigurable.

C. <u>Concept 3.</u> Concept 3 is a single set of operating positions time-shared between missions.

Concept 1 was selected as the preferred concept because of its increased flexibility when compared to Concept 2. Concept 3 was rejected because of its operational disadvantages in reconfiguring between station contacts to provide alternating support to both missions.

The preferred concept has:

- Growth capability for dual mission support (permitted by assumption 2)
- Providing real-time contingency support to one Orbiter while providing nominal support to the second Orbiter (consistent with station coverage constraints and limitation of the single station RTS). Data from the second mission will be recorded but voice contact will be maintained.
- Rapid reconfiguration from supporting two Orbiters nominally to providing contingency support to one.

This task has not investigated the operating position requirements for the SMCC in sufficient depth to state quantitatively the operating positions required; however, the concept selected above will be used as a guideline in the subsequent task when the quantitative SMCC requirements will be developed.

NOTE: Computational resources hardware and software required for dual support capability were not considered in assessing dual mission impact because of the many available methods of implementing this capability. For example, one approach might be reconfiguration from primary to secondary support from Mission A to Mission B, or vice versa in a system sized almost equally to that for a worst case contingency for one mission only. A second approach might make optimum use of redundancy required to meet reliability factors for a single mission.

4.4.3 Support of Flight Operations. The following paragraphs discuss the role of the CCDS, most specifically the MCE, in support of nominal and contingency operations of the STS flight elements, i.e., the ascent operations from liftoff until insertion or abort; support of orbital operations including support to both nominal and contingency Orbiter operations, support to the IUS/satellite, and the role of mission control in supporting dual missions; and the support to the entry and landing phase of flight operations.

4.4.3.1 Ascent Operations. This period of flight extends from liftoff of the integrated STS vehicle and payload until orbital insertion or the Orbiter's entry into any of the defined ascent abort modes.

The major vehicle activity includes liftoff, SRB/main engine thrusting, SRB staging and return to water impact for recovery, external tank staging and return to a water impact (expendable), and orbital insertion.

The execution of this critical phase of operations is totally performed and controlled by the Orbiter and crew.

CCDS functions in support of ascent include the maintenance of communications between the Orbiter and the CCDS, determination of SRB spent stages impact point, and the voice coordination with the landing site for abort or on-orbic return operations. Vehicle status, performance, and flight profile data will be monitored by the CCDS to maintain mission execution status, to alert to contingency modes (aborts or anomalous trajectory profiles) and to calculate any anomalous site acquisition data for relay to the RTS's.

Prior to liftoff the MCE will be online receiving telemetry and voice data and exercising uplink data channels via the RTS at the launch site. This function allows the verification of the SCF integrity to support the mission after liftoff, and results in having and maintaining RF acquisition from liftoff until RTS loss of signal (LOS).

During ascent (until RTS LOS) Orbiter and payload telemetry and voice communications with the crew will be established via the launch site RTS. Selected telemetry and trajectory data will be

4.4.3.1 Ascent Operations (Cont'd)

displayed to the MCE to provide the mission support team (both SMCC and UMCC) an awareness of the vehicle systems status and general performance. Maintenance data will be stripped from the Orbiter telemetry at the MCE and provided to the TCE for analysis (VAFB or KSC).

In addition, all telemetry and voice data will be recorded for postflight (phase) analysis in the event of a failure/abort.

SRB impact predictions will be calculated by the MCE for all DOD missions launched from either launch site. The prediction will be based on the state vector at SRB staging. SRB impact coordinates would be provided by the MCE to recovery forces for subsequent pickup and return of the SRB's to the launch site. No requirement for range tracking of the SSV elements by range has been identified by the STS Program Office.

For STS missions terminating in an abort during ascent, the MCE will maintain or establish first opportunity communications with the Orbiter and support entry and landing (as described in paragraph 4.4.3.3). No requirement can be substantiated for ground tracking and trajectory processing to support the Orbiter execution of aborts.

4.4.3.2 Orbital Operations

4.4.3.2.1 Level of Support Required. The autonomous characteristics of the Orbiter vehicle and the fact that there are some DOD STS flights that may occur totally without a station contact from the ascent to the landing area coverages reduces requirements for the MCE to provide specific support to each mission. For missions of this type, the MCE's function is to be prepared to respond to an onboard emergency situation. However, for DOD missions which are multiorbit, the role of the MCE increases substantially. The MCE currently must perform the following for a multiorbit mission:

- Total mission management

- Monitoring in preparation for contingency response and respond appropriately when required

4.4.3.2.1 Level of Support Required (Cont'd)

- Communications network coordination
- An active role in control/monitor of the deployed IUS/satellite combination
- Conduct handover operation from the SMCC to the payload user
- Provide, through the RTS, a stable frequency from which the Orbiter can extract doppler frequency for onboard update of the state vector.

Since there are several levels of support required, several levels of mission control room manning will also apply. The manning concept for STS mission which is applicable to the total period for flight operations is discussed in the following paragraph. This is followed by a discussion of the ground role in supporting the nominal Orbiter operations, the role of the MCE to support the IUS/satellite, and the MCE actions when onboard emergency exists.

4.4.3.2.2 Mission Manning. Mission manning will vary with mission status (nominal/contingency), and personnel will provide for two basic functions: 1) overall mission management, and 2) support related to direction, scheduling, and acquistion of Orbiter, IUS and payload telemetry. Mission operations personnel are concerned with the overall mission management, mission status and events, Orbiter and payloads systems, trajectories, and orbits. The concept for manning the control center for STS missions is to provide personnel as mission status or phase requirements dictate. SMCC operation will be on a 24-hour basis during missions with two levels of personnel manning used. The first level will be for the nominal mission. The status of the mission will be maintained during these periods. The second level of manning will be for contingency support from the SMCC. Functions performed and the numbers of personnel called will be dependent on the type of contingency and premission planned procedures.

Flight operations support personnel will be directed to the management coordination of resources providing support to the Orbiter, IUS and payloads. Support functions include communications, computer

4.4.3.2.2 Mission Manning (Cont'd)

operations, RTS operations, network control, display, and command and control. Flight operations support manning is expected to be directly proportional to the mission operations manning.

4.4.3.2.3 Orbiter Operations. The nominal mode of operation of the STS vehicle places no unique event or phase-related requirements on the MCE to support that event/phase. It further implies that the Orbiter does not have to be in contact with a station in order to execute an event or activity. This does not preclude mission rules for certain missions directing certain events be accomplished only when ground monitoring is possible. For these events station contact will be scheduled whenever the Orbiter is in the coverage pattern of that site and data between the Orbiter and the MCE will be exchanged. Mission management decisions may be made at the MCE based on analysis of the voice and data received from the Orbiter or from data received from other elements (e.g., landing area). These decisions are of the type that cause a mission to be lengthened/shortened, orbit adjustment, cancellation of a deployment, or return to an alternate landing site.

A. Data Handling Concept. The data handling concept assumes a central computational capability will be used to provide processing required for incoming and outgoing data to/from the SMCC. SMCC personnel will interface the central processing with display and control equipment in the SMCC. The SMCC will provide processing for data received from the RTS to extract tracking (backup for Orbiter, primary for deployed IUS), onboard telemetry, payload telemetry, and voice, and further process each as required to provide command, acquisition, and voice data to the RTS for uplinking. Figure 4-15 illustrates the data flow for nominal on-orbit operations.

   During on-orbit operations, the SMCC will support both mission management and flight operations support functions. The following paragraphs discuss data handling related to tracking, telemetry (Orbiter and payload), voice, command and acquisition data. The processing of tracking data and telemetry data and the generation of real-time command data for the nominal vehicle are provided only as required.

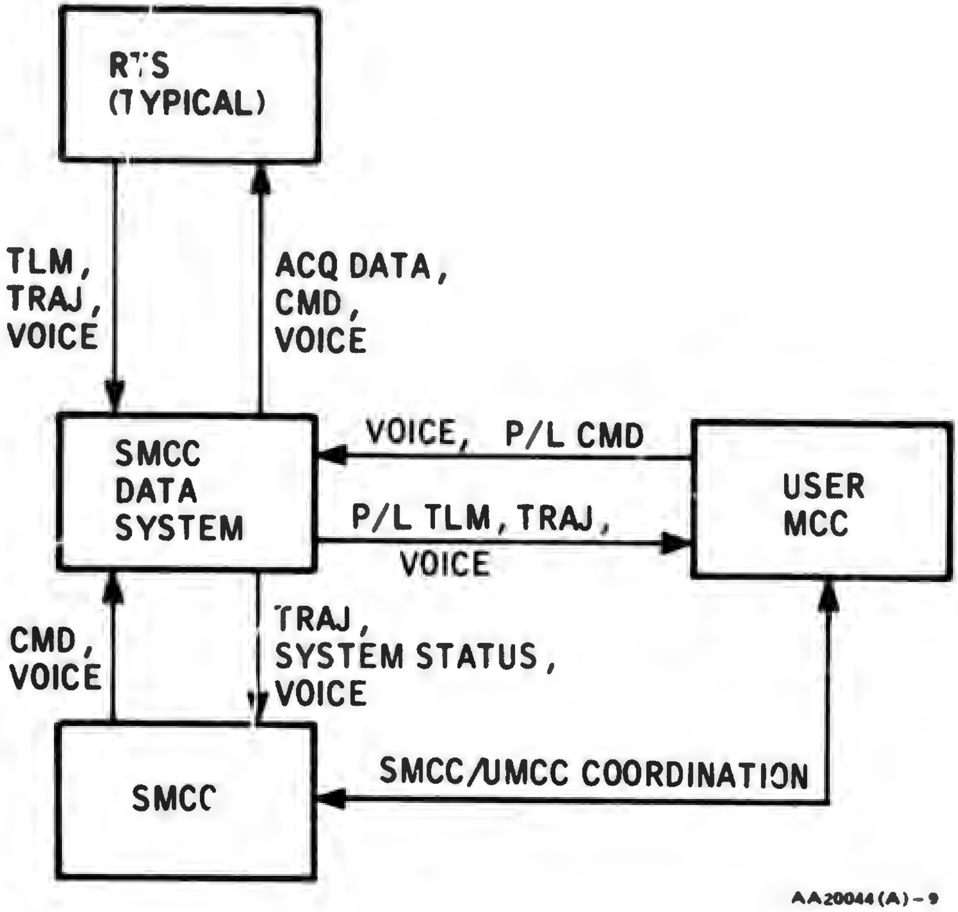


Figure 4-15 On-Orbit Data Flow

4.4.3.2.3 Orbiter Operations (Cont'd)

1. Tracking Data. Tracking data* will be processed and displayed in sufficient detail to permit determinations by SMCC personnel that orbits are as desired. If an anomaly or other factors are detected which require early mission termination, tracking data will provide the basis on which corrections or de-orbit burns may be generated. The tracking data will also be used to update the ephemerides and compute RTS acquisition data. During normal operations, with no anomaly present, a trajectory status display will be provided. Data provided to Mission Management and Orbit Analysis personnel will be in the form of next station contact and that the orbit is/is not nominal.

2. Onboard Telemetry - Orbiter Systems. Onboard Orbiter telemetry data will be processed to extract and monitor those parameters indicative of vehicle health that, if non-nominal, may indicate a need for termination of the mission or a switch to contingency or alternate mission plans. Detailed analysis of parameters will not be performed unless anomalies occur. Indications of normal conditions will be provided to mission management and Orbiter systems personnel. Audio and visual alarm capability will be provided for anomaly indication.

3. Payload Telemetry. During orbital operations with a stowed payload, IUS/satellite telemetry processing and display will be primarily of those parameters that indicate impending danger to the crew. Indications of nominal conditions will be provided to mission management and Orbiter systems personnel. During deployed payload operations, after satellite control has been handed over to the UMCC, it will be responsible for directly interfacing with the STC for data transfer. The UMCC/SMCC coordination will be effected to the extent required for Orbiter/payload and IUS/satellite operations.

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* This data may be ground derived based on ground tracking or extracted from the Orbiter telemetry downlink (orbital state parameters) for the nominal case.

4.4.3.2.3 Orbiter Operations (Cont'd)

4. Voice. Digital voice data, received from the RTS, will be converted to analog for use at the SMCC. Voice conference/switching capability will permit extending the voice circuit for conferences between SMCC, UMCC, launch site, remote user site, and Orbiter.

5. Commands. Command and uplink data will be generated as required by SMCC systems personnel. Command transmission for uplinking will be coordinated with site availability through the flight operations support personnel. Command acceptance verification will be provided via the downlink telemetry data stream.

6. Acquistion Data. Acquistion data will be derived from the ephemeris data maintained in the trajectory processor. SMCC personnel will have the ability to evaluate orbital status and compute and generate acquistion messages for transmission to the RTS's.

7. Doppler Updates. During station contacts, the RTS will provide the Orbiter with a signal from which the Orbiter can extract relative velocity information. The Orbiter will update its state vector onboard using 1-way doppler techniques.

B. Near-Real-Time Mission Planning. Near-real-time mission planning is required to generate changes to the flight plan resulting from variations in actual mission performance and in responding to contingency situations.

The mission planning program and the required flight planning parameters will be located at the STC and will provide the processing functions for timeline analysis and replanning.

Major mission planning functions to be accomplished in the SMCC include: flight plan updates, revised station contacts, trajectory replanning, rendezvous replanning, targeting updates, deorbit replanning, and alternate landing site selection.

4.4.3.2.4 IUS and Satellites Operations. The following paragraphs describe the CCDS role in support of the IUS/satellite mated pair, starting after the Shuttle has been inserted into its intended orbit, and continuing through payload deployment, the IUS orbital transfer, deployment of the satellite, and the possible retrieval of the IUS by the Shuttle. They discuss the CCDS concept for these operations.

A. Payload Control Element Description. Control of the payload, i.e., IUS and/or mated satellite(s) of the STS during the launch, ascent and predeployment phases of a flight, is a function to be accomplished by the Orbiter. During launch and ascent the control function is predominantly confined to monitoring of caution and warning parameters; during predeployment the Orbiter will additionally engage in these control functions required to prepare the payload for separation from the Orbiter.

Following deployment, the payload will be controlled by the Orbiter until ignition of the IUS engines, following which payload control will be handed over to the ground (SMCC). The overall information flow during the on-orbit phase is illustrated in the form of a simplified block diagram in Figure 4-16.

B. Payload Control Responsibilities. The primary functions of payload command, control and telemetry monitor consist of a variety of subfunctions including satellite operations, IUS operations, network operations, and operations support, each of which has its own subfunctions such as evaluation, orbit planning and determination, pass and command plan generation. The SMCC, as the central location for data gathering, processing, and dissemination is the preferred location for performing these functions.

Flight executive decisions pertaining to the IUS and/or the satellite will be made at the SMCC by the IUS manager and the payload manager, respectively. The IUS and payload manager are the best qualified to provide critical decisions from both a systems point of view, and from a mission-success point of view.

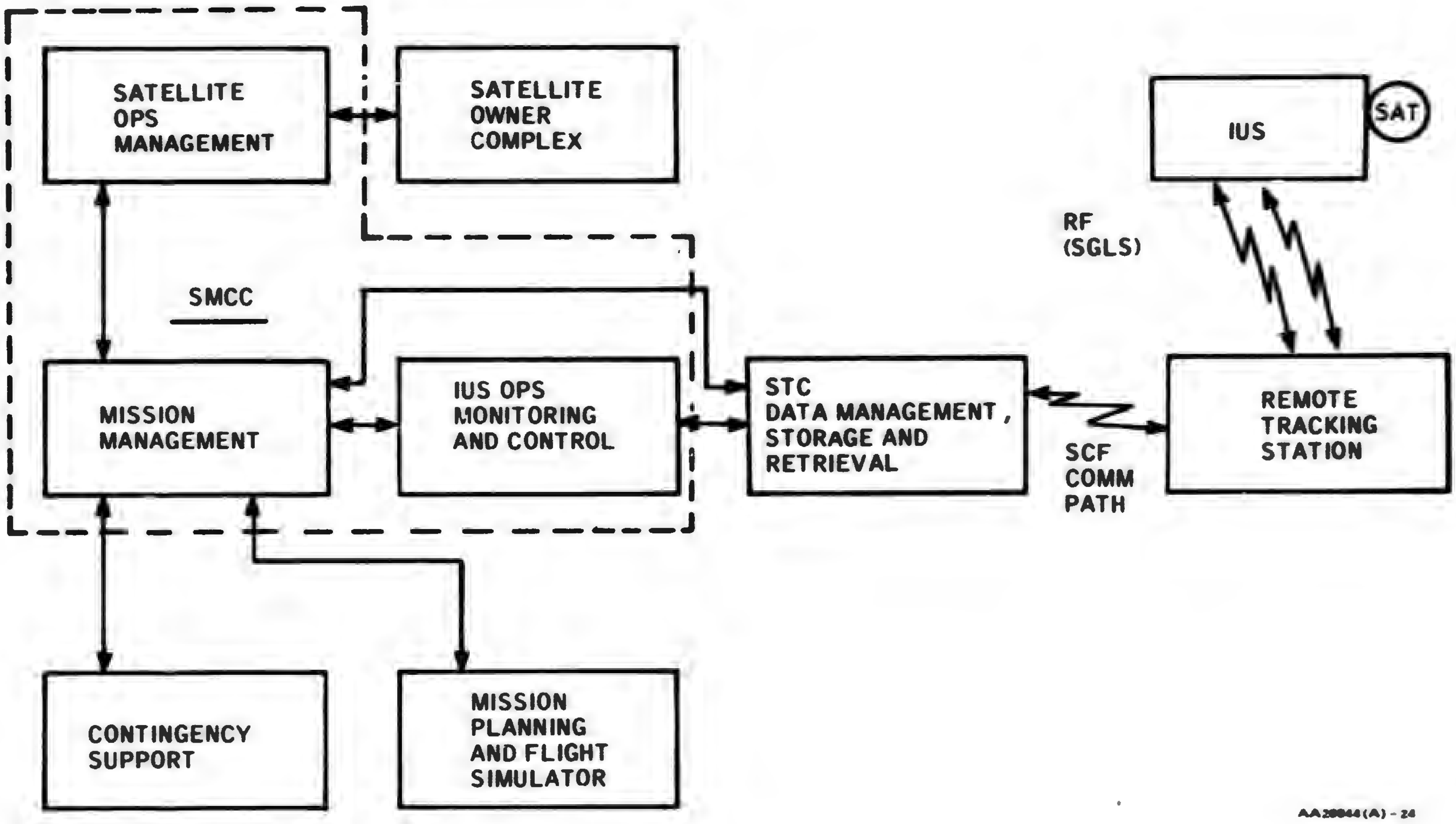


Figure 4-16 Information Flow CCDS Elements IUS On-Orbit

4.4.3.2.4 <u>IUS and Satellites Operations</u> (Cont'd)

To perform these functions, the SMCC will require data/command links to the orbiting spacecraft. Specific functions include the following:

- Communications
- Computer operations
- RTS operation
- Network scheduling coordination
- Data display
- Command control.

The primary roles of the SMCC-RTS during a nominal IUS/satellite flight will be: 1) to track the IUS/satellite for the purpose of orbit computation, and 2) receive, record, process, and distribute telemetry received from the IUS and the mated satellite(s). Telemetry, consisting largely of health and status data, will be recorded in an SMCC data bank and used for postflight analysis and as history data in the event of a contingency. Satellite health, status, and sensor data will be distributed to the satellite owner for processing.

The satellite agency will be responsible for active control of the satellite (during parking orbit operations this control may be relegated to a payload position in the Orbiter). Payload data is provided to the ground, consistent with the ground communications necessary to provide Orbiter support (data transfer and voice). Where the payload or a part of the payload is an IUS, the IUS data management, operations monitoring, and control functions are accomplished at the concerned RTS under direction of the STS SMCC.

4.4.3.2.4 IUS and Satellites Operations (Cont'd)

C. Communication Considerations. It is assumed the IUS is an adaptation of currently existing upper stage vehicles for use with the Shuttle, and that RF communications to the IUS will be via a standard SGLS communication subsystem, with the optional capability of onboard data encryption/decryption. It is also a groundrule of this study that once the mated IUS satellite(s) combination is separated from the Shuttle, communication links to the IUS and to the satellite(s) will be completely independent.

During certain command sequences from the ground to either the IUS or a satellite, it is essential that the entire sequence be completed once it has been initiated. This requires tailoring of the command sequence to fit the time duration of a pass over an RTS. During a transfer orbit sequence, once the payload has ascended to roughly 3000 nmi, radio lines-of-sight between the payload and one or another of the RTS locations can be maintained on an essentially continuous basis; in fact, for most of the time duration of a transfer to synchronous altitude, the payload will be in view of more than one RTS at any time, thus permitting not only (redundant) communications backup, but also some degree of flexibility and optimization in the selection of an RTS for communications to the payload.

Ground monitor of the payload parameters, including the IUS, presumes ground communications. Parking orbit operations unfortunately preclude continuous ground-to-Orbiter communications. Communications to and from the IUS and the satellite will be performed on a rigidly scheduled basis, in part because:

- Radio lines-of-sight exist only occasionally and for short durations (when the payload is at low altitude)
- Each RTS will be engaged in supporting several programs and not just the STS
- Equipment limitations, both on the spacecraft and on the ground, constrain the establishment of simultaneous links to two or more spacecraft. This point is further elaborated in appendix A.

4.4.3.2.4 IUS and Satellites Operations (Cont'd)

D. C&W Parameter Monitoring. Guidelines contained in the program plan indicate that the payload agency will be responsible for active control over the payload satellite(s), including C&W parameters. C&W parameters pose a special control function problem. Primary monitor and control of satellite C&W parameters from the Orbiter are essential for safety, and from the standpoint of minimizing the communication link, hardware, software, and interface problems. Although C&W parameter monitoring and control will necessarily be performed within the Orbiter, it is highly desirable to convey such data to the satellite agent on the ground, as nearly in real-time as the limitation of radio lines-of-sight permit. Such data transmission of course can occur only during a station pass.

For parking orbit operations, the flight crew and Orbiter systems will assume primary responsibility for monitor and control of the satellite and IUS C&W and vehicle health parameters. The ground system will continue to monitor the payload parameters, provide updates and advise the flight crew, as required, under direction of the SMCC.

For parking orbit payload operations, satellite user and IUS options are limited. Operating systems test, checkout, update, and monitor functions must be conducted largely by the Orbiter, under SMCC cognizance and support when passage within range of a tracking station permits.

E. IUS/Satellite Control. Control of the IUS and/or the satellite (the payload) may be performed from the Orbiter while the payload is stowed within the Orbiter cargo bay, and immediately following release of the payload from the Orbiter. Allocation of the payload command and control functions to the SCF during this near-earth orbital phase is an alternate approach. This approach is less desirable because radio lines-of-sight between the vehicles and any of the various SCF ground stations occur only occasionally, and then at most for only a few minutes at a time. On the other hand, once the payload is well along a high-altitude orbital transfer, and has climbed to several thousand miles above the earth's surface, communications via an RTS becomes possible for extended periods of time, even becoming virtually continuous as the payload approaches synchronous altitude. During this portion of a payload flight, overall control and direction of the IUS will reside at the SMCC, with the SCF network providing communication paths.

Providing of updates and advice for the flight crew from the ground implies a ground command function, i.e., data transfer and voice communication. Although payload telemetry (256 kb/s relayed through the Orbiter, and 16 kb/s interleaved with Orbiter data at 128 kb/s) is transmitted by the Orbiter to the ground when in line-of-sight of an RTS, direct ground command of the payload while within the Orbiter is undesirable for safety reasons. During parking orbit predeployment operations, all payload command will be restricted to the Orbiter and will consist of limited status check (required to determine, as a minimum that the payload is not approaching a hazardous condition), update of payload programs based on Orbiter-generated and/or ground-provided data, and payload initialization. Again, all functions performed by the Orbiter will be under cognizance of the SMCC.

After payload deployment and initialization by the Orbiter, payload control responsibility reverts directly to the SMCC and is exercised through elements of the AFSCF (RTS). The only other option available is autonomous RTS control, which is impractical because of insufficient data processing capability, and the requirement for additional personnel at the RTS.

Required IUS commanding will be in accordance with plans generated at the SMCC, at the direction of SMCC, and transmitted/verified at the designated RTS. All data transmitted by the payload (IUS and satellite) during transfer orbit ascent will be available at the SMCC. Real-time or near-real-time range,

4.4.3.2.4 IUS and Satellites Operations (Cont'd)

range rate data, and other tracking data originated at the separate RTS's, will be available at the SMCC in real-time or near-real-time.

After transfer orbit and satellite deployment by the IUS, the control function is split between the SMCC as the IUS control agency, and the satellite users STC/MCC both using the AFSCF resources. For purposes of this study, no interest in the operating satellite is maintained after the satellite is released by the IUS; satellite control responsibility then rests entirely with the satellite UMCC.

After IUS and satellite separation and satellite initialization, responsibility for the satellite transfers to the satellite UMCC and IUS control remains with the SMCC. IUS deorbit, descent, and rendezvous control is performed at the SMCC through the designated RTS's. All data transmitted by the IUS and gathered by the tracking network will be used for Orbiter and IUS orbit calculations. Results will be made available to the Orbiter for direct use and/or comparison purposes.

Final phases of rendezvous (IUS within rendezvous range) will be under control of the Orbiter. After IUS rendezvous circularization commanding and orbit adjustment from the ground system, ground command of the IUS will be restricted to backup or emergency command under control of the Orbiter.

F. Alternate IUS Control Concept. As an alternate to control of the IUS from the SMCC, consideration has been given to control of the IUS, after deployment from the Orbiter, from the satellite UMCC. The primary advantage of this mode of operation is that it permits the satellite MCC to exercise complete control over the mated IUS/satellite, thereby (at first glance) avoiding a division of responsibility between SMCC and the satellite MCC.

The primary disadvantage of this concept, and the major reason it is not preferred, is that is requires duplication of IUS-manager operating consoles and personnel. During ascent,

4.4.3.2.4 IUS and Satellites Operations (Cont'd)

insertion, and predeployment portions of on-orbit operations, communication to/from the IUS is through the Orbiter, and any control/monitor functions pertaining to the IUS performed on the ground, will be located at the SMCC. Furthermore, managerial control of a recoverable IUS after release of the satellite is an SMCC function, and cannot logically be delegated to the satellite MCC.

Therefore, an IUS control/monitor function must be located at the SMCC for certain portions of the overall mission; if IUS control is delegated to the MCC for portions of the mission, at least one additional console, additional personnel, and at least two additional handover procedures must be added. The preferred concept avoids this complication.

4.4.3.2.5 Contingency Flight Operations

4.4.3.2.5.1 Onboard System Failures. Ground assistance will not be required for all on-orbit contingencies. The autonomous Orbiter design, its redundant critical systems operating in a "fail operational-fail safe" mode, and crew response to the C&W system will provide for onboard correction of most problems.

However, resolution/reaction to most contingencies will require coordination with the ground and some may require ground assistance. Major ground functions for contingency reaction involve mission management, systems management, and systems analysis. SMCC support to these functions requires one or more of the following: near-real-time mission planning, mission management decisions, anomaly resolution, and coordination with NASA. The degree of system failure and its effect on mission success and crew safety probabilities will be the determining factors for requesting assistance from NASA.

As addressed in paragraph 4.4.3.1.2, SMCC manning during normal on-orbit operations will be minimal. SMCC key personnel performing non-operational duties will be scheduled on telephone standby alert during all missions. In the event of a contingency requiring ground assistance, standby personnel will be called in as required to man functional positions effected by the contingency.

In all cases of contingencies, the existence of a contingency or emergency condition is established by one of several methods: 1) annunciation by a data processing routine that an Orbiter-anamolous condition has occurred, 2) voice link from the Orbiter of a problem onboard, or 3) SMCC determination that a mission should be terminated, extended, or an alternate landing site selected because of a ground failure or similar occurrence.

The determination of the SMCC/JSC division of responsibilities for contingency support is constrained by the following: 1) no large ground support operation will be provided within either NASA or the DOD SMCC, and 2) up to 8 hours will be required before JSC can provide detailed contingency support. Another consideration is the classified nature of most DOD missions. The remainder of this paragraph addresses the actions that occur at various levels of

4.4.3.2.5.1 Onboard System Failures (Cont'd)

onboard system failures. The discussion is in terms of a general failure response philosophy. Mission rules and procedures may govern specific responses.

A. First Failure (Redundant System). Because of the triply redundant flight critical systems of the Orbiter, a single failure causes the system to become fail operational. The STS can still meet its objectives and the crew is in no danger. For a single failure in a redundant system, no NASA assistance is required and actions to be accomplished in the SMCC are:

- Alert standby personnel of an onboard problem
- Analyze previous telemetry or real-time telemetry for trends or an indication of the cause of failure
- Attempt to predict probability of second failure
- Determine if present network contact is sufficient, and if increased contact is available through the NASA network if subsequently required
- Analyze the effect on the mission of the failure and determine if it is in jeopardy.

B. Second Failure (Redundant System). A second failure in a triply redundant system reduces the Orbiter to a fail safe condition. The mission is terminated and plans are made to return the Orbiter and crew at the earliest opportunity. Assistance from JSC still is not required; however, JSC will be alerted and put on standby condition for providing assistance. NASA STDN/TDRS support will be requested if it results in increased contact with the Orbiter crew. The mission remains under control of the DOD SMCC. Actions to be taken by the SMCC personnel in the event of a second failure or if analysis reveals a high probability of it occurring are:

- Call in standby personnel

4.4.3.2.5.1 Onboard System Failures (Cont'd)

- Continue to analyze previous real-time telemetry for trends or indication of the failure's cause
- Initiate request for increased ground contact, if available
- Analyze effect on mission and begin planning for crew return
- Alert JSC to standby mode.

C. Single Point Failure or Third Failure (Redundant System). In a third or single point failure, the Orbiter and crew may be in danger and corrective action is required before they can be returned. Because of its systems expertise, extensive computational facilities, and full capability Shuttle Mission Simulator, JSC will be requested to provide all system support. DOD will retain executive control of the mission, however. Actions to be taken are:

- DOD continues in mission management and network support functions
- DOD requests JSC assistance and transfers unencrypted pertinent data to them
- NASA JSC performs malfunction analysis (using SMS as required) and determines cause of failure and corrective actions
- DOD relays all NASA results and recommendations to the Orbiter.

4.4.3.2.5.2 Ground System Failures. In addition to onboard system failures, the possibility of a major failure in the DOD SMCC cannot be discounted. The Joint Program Plan states that, if requested by the mission agent, the other agency's SMCC will be made available for support of on-orbit contingencies. This establishes

4.4.3.2.5.2 Ground System Failures (Cont'd)

a requirement for an interface between the Orbiter and the JSC SMCC through the STDN/TDRS, and contingency support (because of a ground failure) becomes procedural. Premission contingency planning will establish whether JSC SMCC support will be provided y NASA personnel of if DOD personnel will travel to JSC to man o-sitions in the control center. The latter case will permit the DOD to remain in control of the DOD mission although all dat. transmitted between the Orbiter and the JSC SMCC will be uncrypted.

4.4.3.2.6 Dual-Mission Support. Dual missions will be supported with functions similar to those described in paragraph 4.4.3.2.1. Differences addressed here arise from the fact that certain mission- and vehicle-oriented functions will need to be duplicated in order to provide simultaneous support to both Orbiters, and the overall SCF network coordination effort will need to be expanded to include support to both STS missions.

The operating concept for dual support provides redundant mission-oriented groups of consoles operating functionally as two SMCC's; display and command/control system elements to serve each mission; data processing capability for identification and integration of the vehicle, RTS, SMCC and MCC by mission; and augmentation of the SCF resource allocation function to support both missions.

It is anticipated that conduct of two simultaneous missions will be accomplished by two groups of fixed operating positions, one assigned to support each mission's routine functions, and a group of reconfigurable operating positions, which can support mission-phase peculiar requirements or contingency situations, and which can be operationally used in conjunction with either mission's fixed positions. Although no physical location is implied, for convenience in referencing, each group of fixed positions and those reconfigurable positions supporting a specific mission, as well as the associated display and control elements will be referred to as an SMCC. Thus, although all positions may be in the same operating room, the terms SMCC 1 and SMCC 2 will be used.

4.4.3.2.6 Dual-Mission Support (Cont'd)

A. SMCC Operations. The dual-mission SMCC operations will differ from those described above only in increased size and complexity. The size increase will arise from the fact that additional display and command/control elements will be required to support additional consoles. The complexity increase will arise from the fact that all inputs to the data system must be identifiable as to source (RTS and/or vehicle ID, SMCC number, MCC number) and managed so as to assure that output data will be routed to the proper output (RTS or SMCC/MCC display element). That is, the data system must maintain scheduling cognizance so that a command from a particular SMCC or MCC will be recognized as being destined for a particular vehicle and will be routed to the appropriate RTS for uplinking; similarly, downlinked data must be identified as to mission, processed, and routed for display to the correct SMCC or MCC. The capability for the recording of data and the handling of digital voice for dual STS missions will always be provided consistent with RTS LOS and pass support scheduling. Figure 4-17 shows the data flow for dual-mission operations.

B. Mission Manning. Mission manning will vary with mission phase within each functional SMCC and with the type support being provided. Personnel will provide for overall mission management and for flight operations support.

1. Mission Operations Personnel. Mission operations personnel will follow the procedure described in paragraph 4.4.3.2.2 except that two SMCC's will be utilized; each will be manned as required to support its associated mission. The fixed (dedicated) operating positions will be manned for each mission to provide the intended routine mission services, and the reconfigurable positions will be configured and manned as required to support unique functions for either mission.

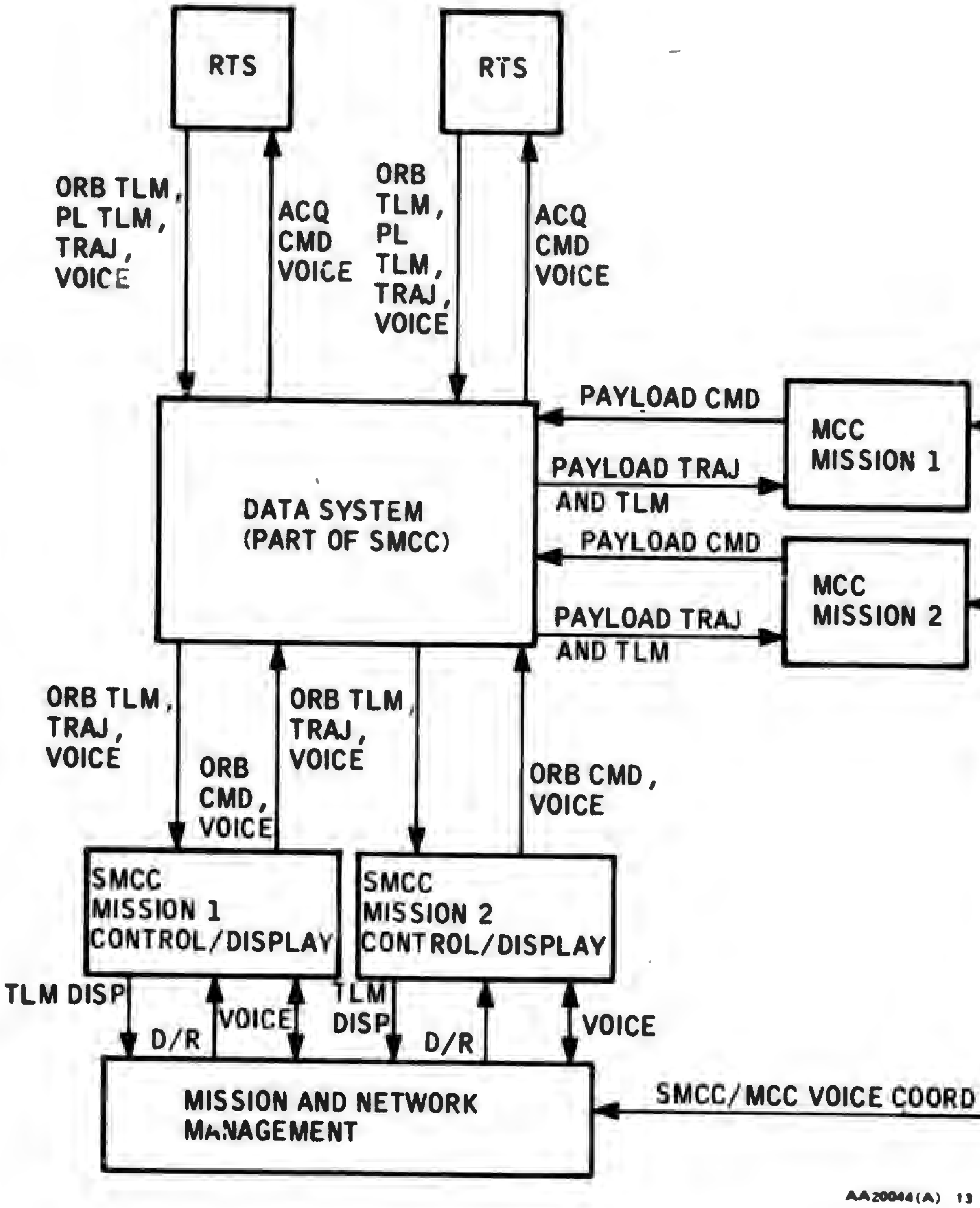


Figure 4-17 Dual Mission Data Flow

4.4.3.2.6 Dual-Mission Support (Cont'd)

2. Flight Operations Support Personnel. Flight operations support personnel will direct the management and coordination of SCF assets to provide support to the two Orbiters, IUS, and payloads. It also will follow the procedure described in paragraph 4.4.3.2.2, but additional displays of mission conditions from each SMCC will be provided to permit monitoring status of both missions in order to resolve schedule conflicts between the two missions as well as conflicts between STS and non-STS operations.

4.4.3.3 Entry and Landing. Primary support to the Orbiter during entry and landing is provided by the SMCC. The major difference in support provided during atmospheric flight as opposed to orbital flight is the involvement of other elements in this phase. The SMCC will establish communications with the Orbiter subsequent to blackout and when within line-of-sight to an RTS. A voice link between the SMCC and the landing area will also be established to ensure a mutual awareness of landing site and Orbiter status. Coordination will have been established with the Federal Aviation Administration (FAA) by the SMCC to alert that agency to the atmospheric flight path of the returning Orbiter. The FAA will continue to be advised of the progress of the Shuttle during atmospheric flight so it can ensure air corridor clearances and reroute other aircraft from the vicinity of the Shuttle corridor.

Weather information will be received from the landing site and relayed to the Orbiter crew by the SMCC. The Orbiter flight path will be monitored by the SMCC and voice advisories provided to the crew throughout the phase.

Throughout the landing phase data handling functions are similar to those described in paragraph 4.4.3.2.3.A. While telemetry is being received, it will be recorded for use in postmission analysis and turnaround preparation.

Navigation and landing aids required by the Shuttle will be maintained by the landing area. The landing area and the Orbiter crew can, if necessary, communicate via the UHF voice link.

4.4.4 Operations Support. Certain functions in the province of the MCE are accomplished premission and initially were not in the scope of the study which essentially investigated the support required from liftoff through Orbital operations, landing, and turnaround activities. As such the study assumed the mission planning, training, and software development had occurred. Subsequently, a Shuttle Mission Simulator subtask has been added to the task; its results will be documented in the TOR's to be published in September 1974. Therefore simulations and training are not discussed in this document, and other operations support functions are discussed below for completeness but will not be examined further during this study.

4.4.4.1 Mission Planning. Mission planning functions are performed both premission (offline) and during mission support periods (near-real-time) based on support requirements levied by payload users and mission operations personnel.

4.4.4.1 Mission Planning (Cont'd)

The following paragraphs present a discussion of 1) premission mission planning activities, and 2) flight software development and verification. The near-real-time mission planning functions have been discussed previously.

4.4.4.1.1 Mission Planning (Premission). Premission mission planning activities require access to the mission planning and analysis data base, software, vehicle configuration, and performance data. This data/capability is assumed to be as described in the *Vehicle Management and Mission Planning Systems*, JSC-08055, 29 June 1973; and *Program Information Control and Retrieval System (PICRS) Final Report*, LEC 1787, March 1974.

Primary use of these systems will be by mission planning personnel to perform: mission definition and scheduling and mission design and analysis.

How JSC resources will be used for performing the mission planning function by DOD is not to be determined in this study; however, possibilities include:

- Use of an input/output remote terminal at the STC with access to the VMMPS and PICRS. Mission planning and design data would be transmitted via high-speed data lines
- Use of VMMPS and PICRS by DOD personnel located at JSC
- Use of input/output terminal at the STC for the input of mission-specific parameters with subsequent outputs generated at JSC and hand-carried to the STC by DOD personnel.

Although the use of VMMPS and PICRS at JSC has been assumed for the baseline system, factors which may affect this assumption and require consideration prior to the implementation of the DOD mission planning system are:

- Security associated with mission-specific parameters used in performing the detailed trajectory and mission activities planning
- Operational problems associated with scheduling and use of JSC VMMPS for DOD mission planning
- Capability of the real-time mission planning system located at the SMCC.

4.4.4.1.2 Mission Definition and Scheduling. Mission definition begins when the payload, its characteristics and support requirements, orbital characteristics, and mission constraints are specified by the payload user. These are stored in a payload data base for use by mission planners when analyzing mission feasibility and optimizing schedules.

After a mission's payload and orbital characteristics have been determined, a preliminary schedule and activity sequence must be developed using inputs from the data base for vehicle configuration and performance.

4.4.4.1.3 Mission Design and Analysis. The mission design and analysis function performs a feasibility analysis and develops a mission profile including timelines and activities, a support schedule, and a flight plan.

When a mission has been defined, a feasibility analysis must be conducted which will analyze it in terms of fuel and time constraints, launch inclinations, activity sequence, and launch windows.

A mission profile may be defined using the JSC VMMPS. Activities and events necessary to perform the mission must be defined.

Mission parameters to be defined include event sequences, crew charts (checklists), software constants, consumables, entry parameters, ascent targeting, vehicle targeting, vehicle attitudes, and rendezvous profiles.

Based on standard mission modules, a timeline of mission activities and a preliminary trajectory profile must be developed. Three mission types need to be considered in developing the mission timeline. These are payload deployment, payload retrieval and payload servicing. Combinations of categories must consider areas such as:

- Overall Orbiter performance capability
- Total time availability
- Power, size, and weight constraints
- Payload-to-payload compatibility
- Payload-to-carrier compatibility.

4.4.4.1.3 <u>Mission Design and Analysis</u> (Cont'd)

Mission design must also include the definition of support requirements and schedules. This requires establishment of priorities for payload support. Areas to be considered in defining schedules include: RTS support timelines, SRB recoveries, and mission simulations to ensure readiness of personnel and equipment.

Close coordination between the mission planners, the launch site, and the communications networks will be required to determine resource availability and provide support schedules.

Based on payload objectives and constraints, crew activities, network support requirements and mission rules, a flight plan must be defined which includes: detailed activities from prelaunch to postflight (crew oriented); checklist referrals for procedures, mission rules, etc.; site contacts; and mission times (ground elapsed time, phase elapsed time) per revolution number.

4.4.4.2 <u>Flight Software Development and Verification</u>. Development and verification of flight software includes development and verification of new or modified software for Orbiter flight computers and incorporation of unique flight parameters into the flight program tape. These can be performed using both the JSC Software Development Laboratory (SDL) and STC facilities.

4.4.4.2.1 <u>Development of New or Modified Software</u>. New or modified flight software is developed based on new mission requirements or as the result of postmission analysis.

The JSC SDL can provide the capability for development of new software maintained under joint NASA/DOD configuration control. The typical change procedure for flight software is anticipated to be:

A. During the development of a DOD mission, DOD mission planning establishes the need for a new or modified flight program.

B. DOD mission planning develops a set of funct onal software requirements which are sent to the Orbiter Flight Software Configuration Control Board for review and approval.

C. The approved functional software requirements are sent to the JSC SDL where a new or modified flight program is developed and assembled.

4.4.4.2.1 Development of New or Modified Software (Cont'd)

D. Initial checkout is accomplished at the module level using simulated environmental and vehicle parameters.

E. Final checkout is accomplished at the flight program (module set) level using simulated mission phase programs.

F. The new mission program is sent to STC mission design for validation over the range of parameters which may be used.

G. The new mission flight modules and programs are retained in the Orbiter flight software library for future use.

H. DOD security requirements should not restrict the basic program modules and flight programs, but may affect the flight parameter information added to the basic programs.

4.4.4.2.2 Development of Flight Program Tape. Missions require the incorporation of mission-specific parameters into flight programs. These are incorporated premission using DOD facilities and include parameters related to:

- Ascent targeting
- Consumables loading
- Vehicle attitude
- Rendezvous profiles
- Entry and landing
- Sequence of events
- Maneuver targeting.

These parameters are incorporated into flight program modules generated at the SDL. Once the parameters have been inserted and the flight tape initialized, the flight tape can be verified using the Shuttle Mission Simulator (SMS) or the Shuttle Avionics Integration Laboratory (SAIL) at JSC. The verified basic flight tape is loaded into the Orbiter flight computer under control of the launch control element. Any required updates prior to liftoff will be provided by the SMCC in close coordination with the LCE.

4.5 TWO ORBITERS IN TURNAROUND

The functional requirements, and allocation of these functions to specific elements involved with a second Orbiter in turnaround, remain the same as described in paragraph 4.2 of this report (one Orbiter in turnaround). Due to the versatility of the multifunctional, programmable station set units, the unit can be scheduled to accomplish a wide variation of tests. This versatility will allow the processing of two Orbiters from one checkout line by scheduling a particular unit to accomplish a specific checkout. When that test is complete, the unit would be scheduled to accomplish a different checkout, as required.

The greatest impact upon the CCDS, as previously stated in the Task II TOR (PHO-TR570), paragraph 3.7.1, will be in the areas of operations management support and data handling requirements. The following is a summary of those impacts on operations management support.

The major impact will be the significant increase in the complexity of scheduling, logistics support and resource allocation in light of near-simultaneous dual checkout sequences. The obvious resource allocation impact is that of maintaining continuity of flow in two Orbiter maintenance and checkout bays, from a nonredundant pool of nondedicated work stations. Significant alleviation of this problem, however, can be realized from the multifunction support capabilities conceived for the work stations. The capability to reconfigure (by program) any given work station to support any phase of checkout and test would make it possible to have the two Orbiters in exactly the same phase of turnaround. Personnel utilization under the same circumstances would depend, of course, on levels of "multipurpose" training provided or numbers of redundant (in responsibility) personnel deemed feasible.

The logistics impacts would, of course, be those involved with assuring availability of essentially "double" the normal spares and offline component maintenance and test facilities.

> *NOTE: Areas such as the LRU maintenance shops are referenced in the latter case above. It is recommended that such areas be configured with the same "automatic test" capabilities of online checkout stations in order to accommodate essentially doubled loads without requiring totally redundant hardware.*

4.5 TWO ORBITERS IN TURNAROUND (CONT'D)

In summary, the possibility of two Orbiters in turnaround enhances the need to consider the automated planning and scheduling support afforded by the previously defined operations management and work control concepts.

Support of dual Orbiters (or dual SSV elements) in turnaround without the need for redundant, dedicated checkout systems is greatly enhanced by the programmable, multifunction characteristics of the proposed work stations. The capability to dynamically reconfigure any functional work station position (e.g., console) will permit that given position to serve as the checkout control point for any of the various checkout phases; i.e., GN&C, SSME, Aerodynamic Stability Augmentation System (ASAS), etc. As a result two Orbiters, for example, could be processed either in simultaneously identical phases, if required, or in parallel with serially interleaved phases. Illustrative examples of the multifunction characteristic and a typical dual flow configuration are shown in figures 4-18 and 4-19, respectively. In the first figure, a given work station position (A) is shown reconfigured from "propellents" checkout to "propulsion system" checkout utilizing the same hardware, reconfiguring by program load from a CDE. Figure 4-19 shows two work station positions (A&B) configured simultaneously for GN&C checkout of two Orbiters, then reconfigured for simultaneous C&T checkout. This latter case (exact simultaneous checkout) represents the worst dual flow case envisioned.

> *NOTE: The example shown is for the maintenance and checkout function; similar capability will be available in the other turnaround control "sub-elements such as safing/deservicing, integration/mating.*

4.6 NASA LAUNCHES AT VAFB

The VAFB CCDS concept is applicable for NASA launches from VAFB with the following exceptions:

A. Security. There will be no special security requirements -- communications or physical -- involved in a NASA launch. All data involved will be black.

MULTIFUNCTION SUPPORT CAPABILITY

WORK STATION HARDWARE IS NON-DEDICATED (I.E., BLANK INDICATOR LEGENDS, ETC.)

CONFIGURATION/RECONFIGURATION IS BY SOFTWARE, RESIDENT IN STATION. MANUAL RECONFIGURATION IS NOT REQUIRED. TYPICAL EXAMPLE:

WORK STATION "A" IN PROPELLENTS LOADING CONTROL MODE

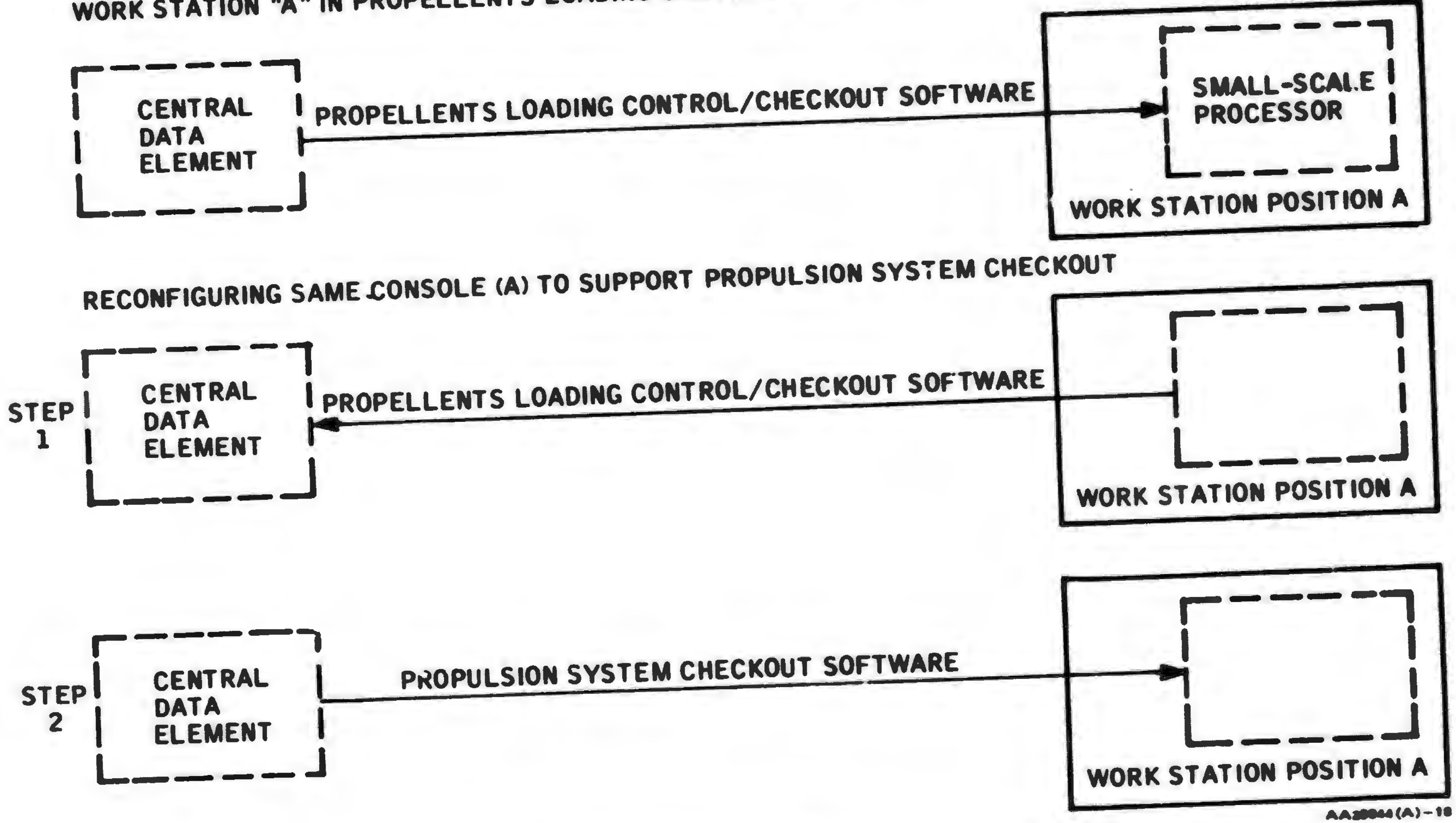


Figure 4-18 Multifunction Work Station Concept

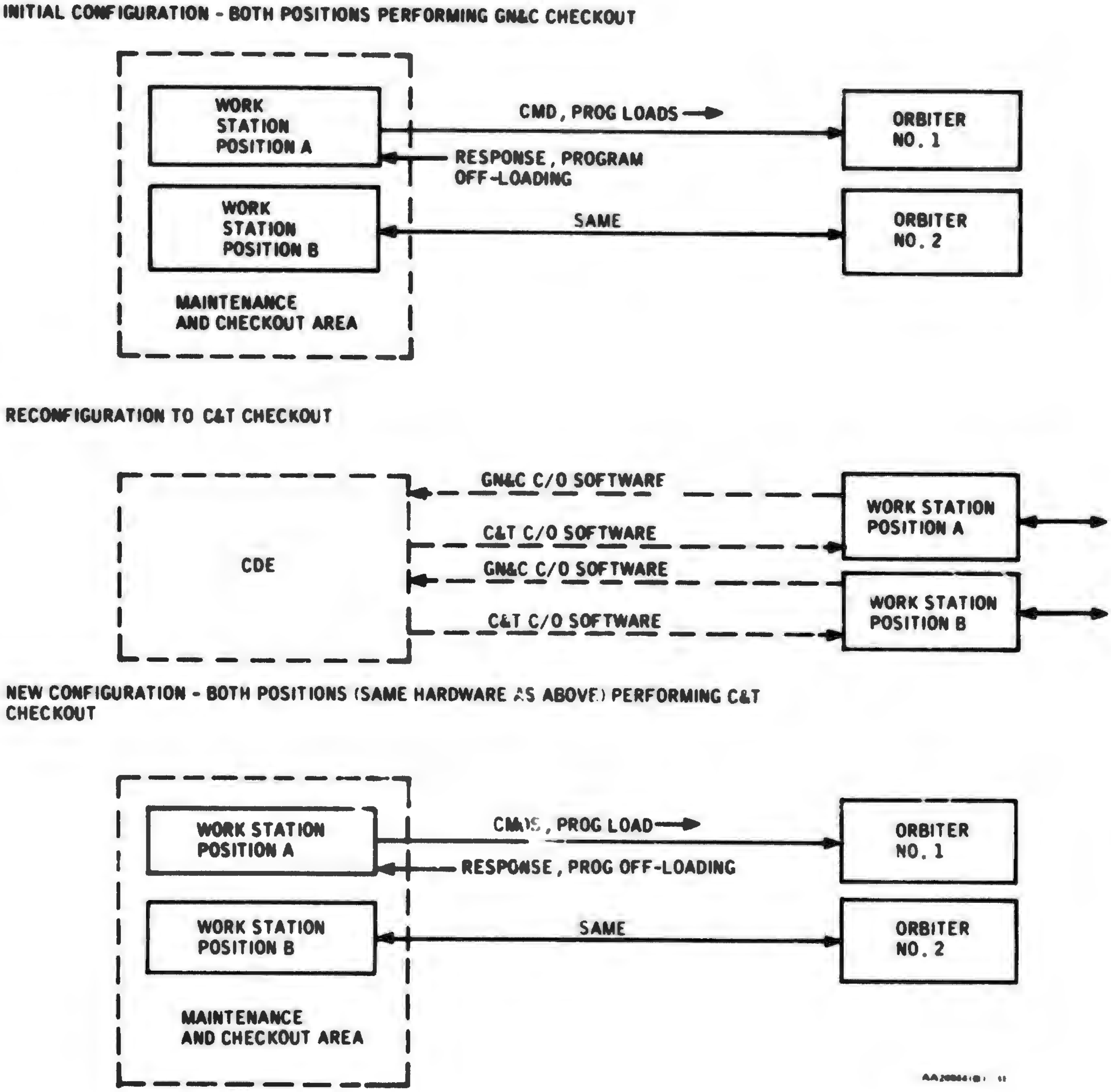


Figure 4-19 Simultaneous Dual Orbiter Checkout Operations

4.6 NASA LAUNCHES AT VAFB (CONT'D)

B. Payload Operations. NASA will be responsible for all NASA payload checkout and will provide the necessary personnel. A DOD/NASA team will mate the payload in the Orbiter and perform an integrated checkout of the interfaces and systems while the Orbiter is in maintenance and checkout operations rather than at the pad. The VAFB TAC will be required to provide the systems resources required to perform the integrated Orbiter/payload testing.

C. Data Routing. The CCDS will be responsible for processing, displaying and routing vehicle and payload data to the NASA payload agent and to the NASA JSC. Vehicle maintenance and checkout data will be handled by the standard method for vehicle operations except for the NASA interface requirement. Figure 4-20 indicates a typical NASA data flow for VAFB launch.

4.7 COMMUNICATION LINKS

The communications paths involved in the total Shuttle mission including prelaunch, launch, on-orbit, landing and turnaround operations are illustrated in figure 4-21. The location of COMSEC equipment required to provide secure communication is also indicated. The application of the communications network depicted will be discussed for each phase of the operation.

4.7.1 Turnaround Operations. The overall turnaround operation is broken down into landing, safing and purging, refurbishing, and prelaunch readiness checks. Each of these steps has unique implications in the communications operation.

4.7.1.1 Landing. The normal Orbiter Communication System remains operative from the end of blackout to rollout. Alternate operational communication for landing will be via ARTC VHF or UHF radio facilities supplemented by TACAN and MSBLS. Vehicle health and payload data will be encrypted onboard and transmitted to the local RTS (at KSC or VAFB) during this period. At the end of rollout, the payload data package will be removed and taken to a secure

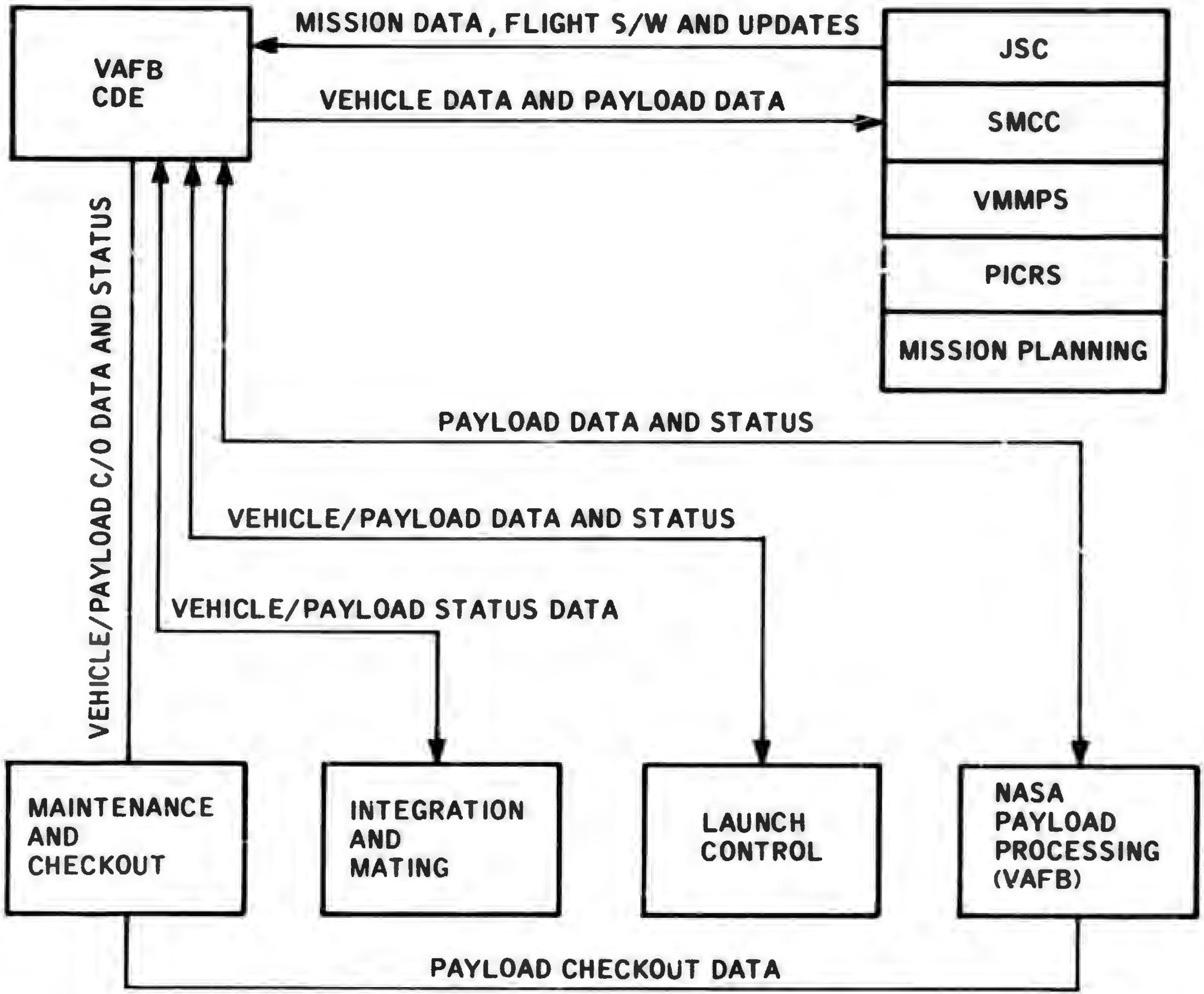
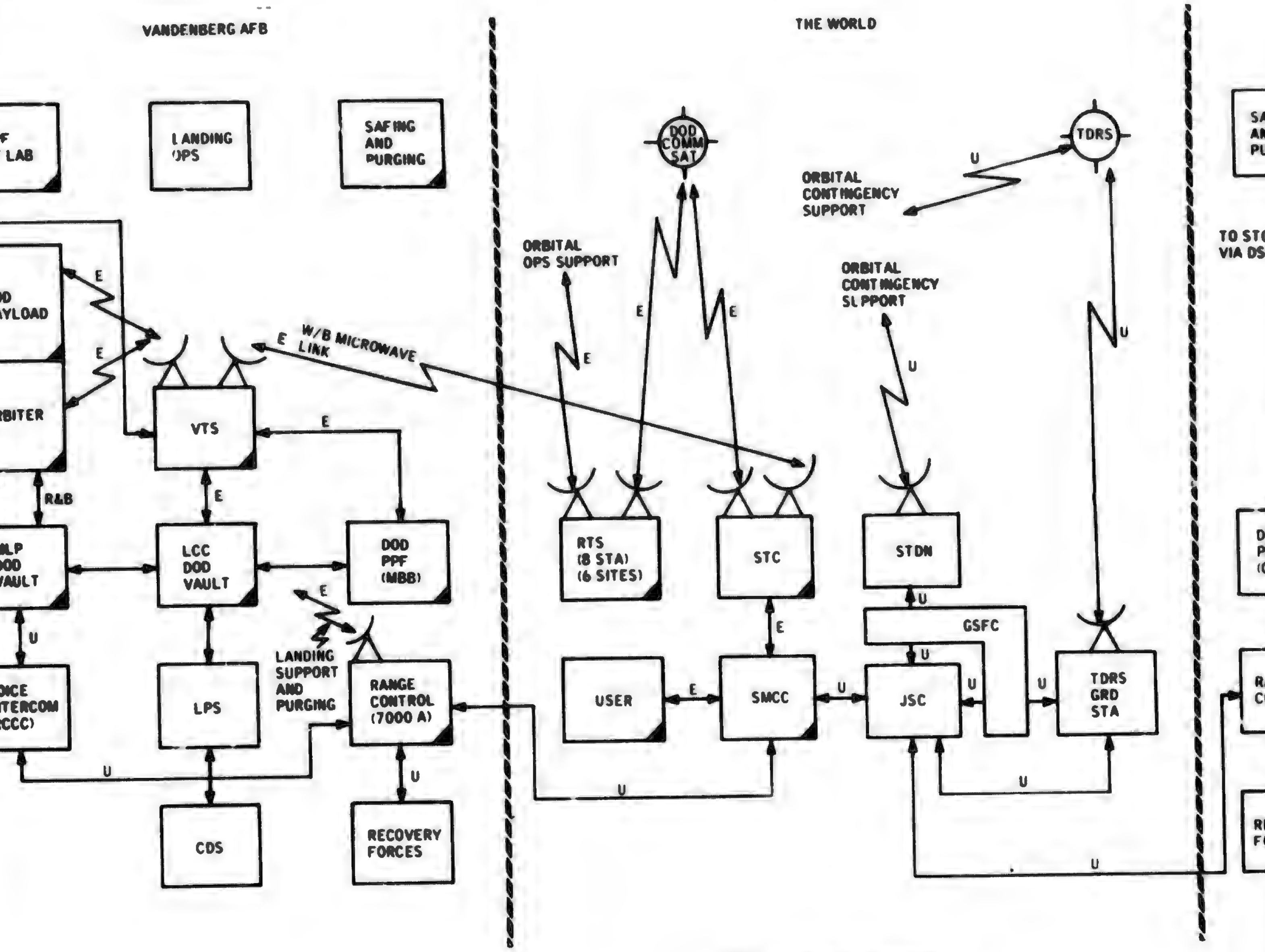


Figure 4-20 Typical Data Flow - NASA Launch at VAFB



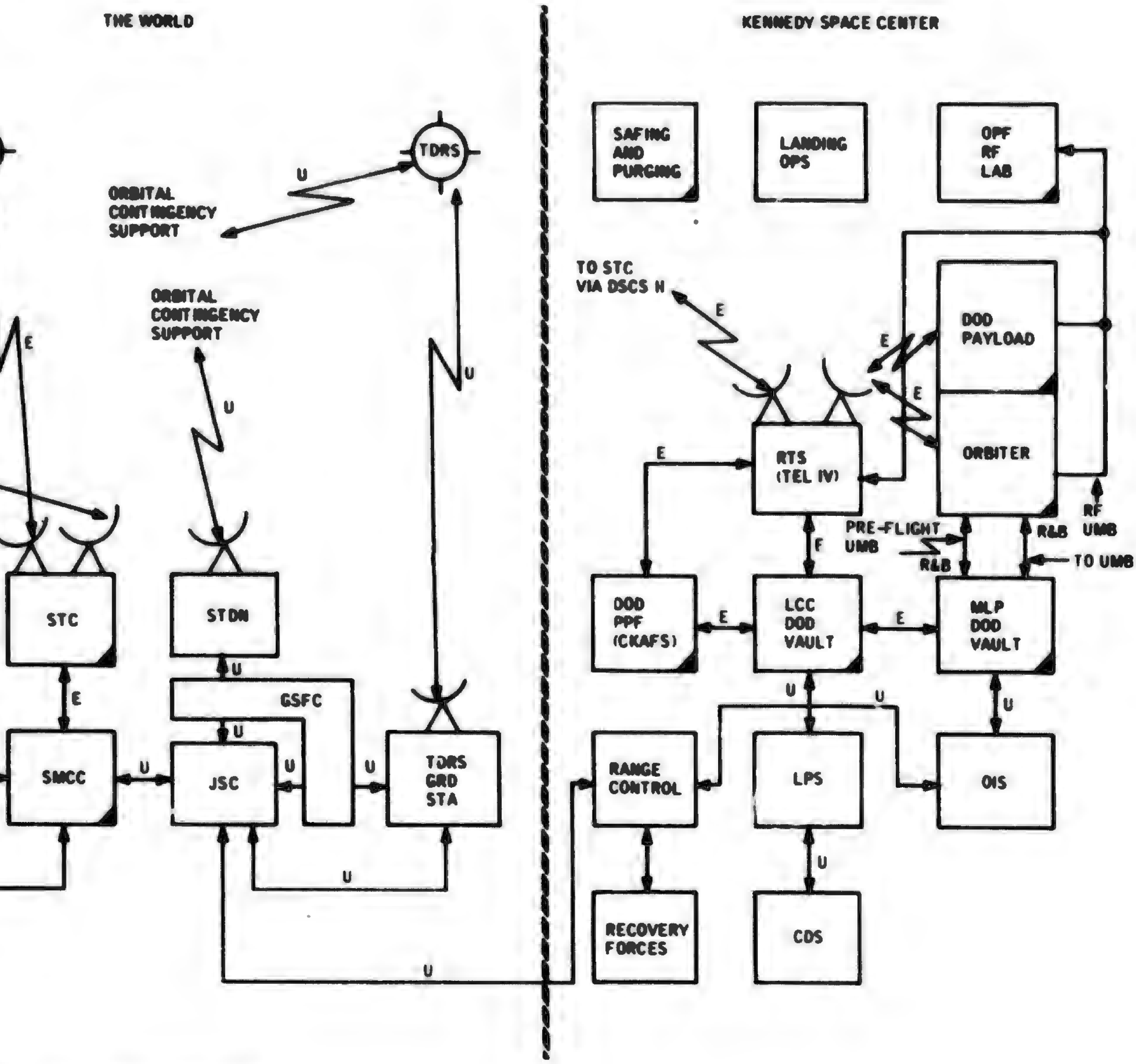
1. DENOTES AREA INCLUDING COMSEC EQUIPMENT

E - ENCRYPTED DATA
U - UNCLASSIFIED DATA
R - RED DATA
B - BLACK DATA

2. ALL RTS EXCEPT TELIV INCLUDE COMMAND ENCRYPTION AND DECRYPTION EQUIPMENT FOR SECURE COMMANDING AND VERIFICATION/ AUTHENTICATION

3. MEMORY READOUT PRIOR TO PURGING WILL BE HANDLED BY S-BAND FACILITY IN BLDG 7000A AT VAFB

4. I/F'S TO NASA FACILITIES MAY BE IMPLEMENTED DIFFERENTLY THAN SHOWN (E.G., DIRECT SMCC - GSFC INTERFACE).



DENOTES AREA INCLUDING COMSEC EQUIPMENT

- ENCRYPTED DATA
- UNCLASSIFIED DATA
- RED DATA
- BLACK DATA

L RTS EXCEPT TELIV INCLUDE COMMAND CRYPTION AND DECRYPTION EQUIPMENT R SECURE COMMANDING AND VERIFICATION/ THENTICATION

MORY READOUT PRIOR TO PURGING WILL HANDLED BY S-BAND FACILITY IN BLDG 00A AT VAFB

'S TO NASA FACILITIES MAY BE IMPLEMENTED FERENTLY THAN SHOWN (E.G., DIRECT SMCC - FC INTERFACE).

B

Figure 4-21 Overview of STS Communications

4.7.1.1 Landing (Cont'd)

area by an appropriately cleared escort. During this period, readout of the Orbiter mass memories will take place. This readout may be transmitted to the STC/SMCC/user via the SCF and DSCSII but will certainly be transmitted via the DOD vault for decryption and separation of classified and unclassified data. The unclassified data, which includes vehicle health, history, main engine performance history and unclassified mission parameters, is transmitted as clear text (Black) to the CDE for disposition and analysis by the turnaround authority. This mass memory, after readout, will be purged to prevent compromise of any classified data. The method of purging is covered in volume I of this report, "Secure Data and Equipment Handling."

4.7.1.2 Safing. At the safing area the payload package will be removed from the Orbiter in a secured manner and taken to the Payload Processing Facility (PPF) under appropriate escort. Any residual communication task is handled via the SCF RTS or an RF C&T facility in the safing area.

4.7.1.3 Refurbishment. In the refurbishing process, the Orbiter is resident in the Orbiter Maintenance Facility and the payload is in the PPF. An RF lab is provided in this facility for the checkout of Orbiter systems. This RF lab includes encryption/decryption equipment to work with the onboard encryption equipment. A link is provided to the SCF RTS for SCF compatibility checks. Control of checkout stimuli and responses may be exercised by the STC, SMCC or the LPS via the DOD vault. Encryption of this checkout link takes place at the controlling site. The payload is similarly checkout out in the PPF. The amount of checkout performed on the satellite is governed by the program and will be performed by satellite GSE or by the user via the SCF, STC and SMCC.

4.7.1.4 Integration. No checkout functions requiring the use of the communications network are performed during vehicle integration. All checkout operations related to the integration operation will be performed locally by the appropriate GSE.

4.7.1.5 Launch Pad Operations. The integrated vehicle after assembly on the mobile launch platform (MLP) is moved onto the launch pad, and flight readiness tests are performed. Unclassified orbital parameters and classified mission parameters are loaded and the payload is installed. Two umbilical connectors, the preflight and T_0 (flyaway) each contain both Red and Black data. The two categories are separated by appropriate isolation and the umbilical cables are run to a vault in the base of the MLP. Red data is encrypted in this vault for transmission to the LCC DOD vault. RF umbilicals with RF hats are provided for closed loop RF checkout. These umbilicals are run to the SCF RTS or the OMF RF lab for processing. The three voice circuits are brought out as clear analog signals to interface with the OIS or other launch complex voice network. The Orbiter is not considered to be Red until the DOD payload is installed and activated or until classified data has been loaded into the Oribter data processing system. Classified data is loaded into the system via a 72 kb/s uplink umbilical or via the RF uplink from the RTS. Prior to liftoff, the RF hats are removed from the antennas and open-loop checks are made with the SCF. At liftoff, only secure voice is used.

4.7.2 Orbiter Operations. After liftoff all nominal uplink and downlink transmissions are secured between the Orbiter and the STC. Additionally, transmissions to and from the payload are secured back to the user. Commands to the Orbiter and attached IUS and/or payload satellite are encrypted at the STC with the RTS acting as a "bent pipe." Handover from RTS to RTS will be coordinated from the STC. Contingency communications may be established from the Orbiter to the ground via the NASA STDN network or TDRS. In the event contingency support from NASA is required, up to 8 hours are required to man up the JSC MCC. Communications on the NASA network will not be secured.

SECTION 5

FUNCTIONAL REQUIREMENTS

5.1 GENERAL

This section delineates the functional requirements for each of the major functional elements of the Command and Control Data System (CCDS) and provides a level from which a detailed definition phase of the various elements can proceed. Purpose, major inputs and major outputs are presented for each element, and applicable functional requirements for personnel, data processing, display, command/control, and/or communications are listed.

5.2 OPERATIONS MANAGEMENT FUNCTIONS

The Operations Management Element (OME) will provide for overall management and control of Space Transportation System (STS) ground operations. As such, it will function as the focal point for other control elements for planning (premission ground operations scheduling, procedures development, etc.) and online operations support (task and schedule monitoring, problem reporting and resolution, etc.). All functions of the OME are traceable to paragraph 3.4.16.1 of Volume X, JSC-07700, *Space Shuttle Flight and Ground System Specification; KSC Launch Processing System, Station Set 84 Requirements Document;* and paragraph 7.1 of the *DOD Shuttle Systems Requirements*, 15 July 1973.

As shown in figures 4-2 and 4-3, the OME functions will be performed in a work station environment, with OME personnel interfacing the central data element (CDE) for callup of operations management programs (work control, etc.). The major distinction between work station utilization for OME functions as opposed to those in other ground operation elements (turnaround, launch) is that OME operations are purely schedule/planning/administration oriented and do not involve execution of any vehicle checkout software.

Inputs to the OME will include:

- Work control development programs for execution in OME work station processor

  NOTE: These programs are envisioned as small-scale (schedule display generation, procedure editing, history), working in conjunction with major work control programs (master schedule generators, master procedures file generators, etc.) executing in the CDE.

5.2 OPERATIONS MANAGEMENT FUNCTIONS (CONT'D)

- Voice from other CCDS control elements via CDE.
- Anomaly resolution data (historical data, trend analysis summary data, online turnaround/launch operations progress status).

Outputs from the OME will include:

- Keyboard inputs to master work control programs in CDE.
- Completed work control programs (those executed in OME work station) to CDE for maintenance in master program files.
- Voice to other CCDS control elements via CDE.

Turnaround control functions are traceable to paragraph 3.4 of Volume X, JSC-07700; *KSC Launch Processing System, Station Set 84 Requirements Document;* and paragraph 7.1 of the *DOD Shuttle System Requirements.*

The five major functions of the OME that levy requirements on the CCDS are personnel, data processing, display processing, command/control and communications. These functions are expanded in the following paragraphs.

5.2.1 Personnel Functions. Personnel functions to be performed in support of operations management will include performance of checkout/planning administrative functions in a work station (console-oriented) environment, such as:

A. Keyboard entry for callup of work control software from the CDE.

B. Keyboard entry of scheduling/procedures parameters (e.g., editing, updates) utilizing interactive communications between CDE, work station cathode ray tubes (CRT's) and the keyboards.

C. Control of anomaly resolutions (callup and evaluation of schedule conflicts, trend analysis summaries, historical data, etc.)

D. Monitoring and evaluating checkout program progress via CRT, indicator or hardcopy.

E. Maintaining voice communications with other major elements for planning, nominal status, or during checkout anomaly resolution.

5.2.2 Data Processing Functions. Data processing for operations management control will be required in two areas; the OME work stations, and the CDE. Specific requirements in each area are as follows.

5.2.2.1 OME Work Station Processing Functions. Three major functions will be required in the OME work stations for compatibility with the proposed distributive processing, CDE/work station concept:

A. Communications processing (work station-to-CDE)

B. Applications program execution (work control programs)

C. Work station peripherals support processing

- Manual entry device (keyboard)
- Mass memory (disk/cassette)
- Hardcopy interfaces (recorders, unit record, strip chart)
- Display interfaces (CRT, indicator).

5.2.2.1.1 Communications Processing. Work station/CDE interface communications will be computer-to-computer, requiring mulitplexing and demultiplexing of data onto or from shared data busses, message formatting/reformatting and error detection.

5.2.2.1.2 Applications Program Processing. Program execution in the work station processor will require nominal executive or supervisory support, permitting manual program interrupt (see paragraph 5.2.2.1.3,A), automatic interrupt for I/O and peripherals processing, etc. A multitask operating system is not envisioned in that execution will be performed one application at a time on a "rollout/rollin" basis from the CDE.

5.2.2.1.3 Work Station Peripherals Processing. Program execution will include processing of input/output (I/O) or peripherals interface transactions between the central processing unit (CPU) and manual entry devices, mass memory, hardcopy devices and display devices.

A. Manual Entry Processing. Program interrupts or initiation via manual entry (keyboard, pushbutton) should be provided. This will permit program callup from CDE, editing of schedule/procedures programs, interrupt for anomalies, checkpoint summary requests, etc.

B. Mass Memory Interface Processing. It is envisioned that some form of mass memory (disk/tape) will be provided at the OME work station(s) to provide backup storage for applications programs, work station executive storage and working memory areas. This concept would also permit loading of work station applications directly at the station in the event of CDE interface failures. Support of mass memory as such would require some form of disk operating system [Kennedy Space Center (KSC) Launch Processing System (LPS) concept] or tape cassette interface.

C. Hardcopy Interface Processing. Work station processing capabilities will include support of hardcopy requirements. This support will include primarily any required recorder or unit record (printer, card punch) processing.

D. Display Processing Function. Work station processing functions should include the capability to generate displays for presentation on CRT's or event indicators. The display processing function should include display generation from resident work control applications programs or as a result of dynamic updates from a CDE-generated display. Typical displays expected will include:

- Planning data
- Schedules
- Procedures
- Historical trend data (anomaly resolution)

5.2.2.2 CDE Processing Functions. Processing requirements levied on the CDE by the OME will include:

- CDE-to-work-station communications processing
- Data base management support for work control program retrieval/storage
- Work control applications processing (execution of work control programs in CDE in conjunction with those segments executing in work stations). These CDE applications would represent "summary" programs using work station processing results as inputs.
- Dynamic display generation. The CDE should be capable of generating and updating (in real-time) certain CRT displays for presentation at work station positions.

5.2.3 Display Functions. Display requirements levied on the CCDS by the OME include the display data communications routing and data processing defined in preceding paragraphs. In addition, they will include the following actual display end items:

- CRT (alphanumeric/graphic capability)
- Event indicators (e.g., console mounted)
- Hardcopy devices.

5.2.4 Command/Control Functions. Command/control functions include the manual input processing previously defined for the work stations in addition to the actual command/control end items necessary to initiate or monitor the processing, such as keyboards, pushbutton indicators, etc.

5.2.5 Communications Functions. OME communications functions are those defined in preceding paragraphs as CDE or work station (message routing, multiplexing/demultiplexing, error detection, voice communications). Associated communications functions will include any distribution processing required between the CDE and the work stations for both data and voice. Associated hardware impacts on the CCDS will be levied by the physical distribution networks and voice terminals in the work stations.

5.3 TURNAROUND CONTROL FUNCTIONS

The Turnaround Control Element (TCE) will provide the capabilities to receive, check out, refurbish and deliver to the pad those elements comprising the Space Shuttle Vehicle (SSV). In general, these functions are those provided by work station configurations within the various subelements of turnaround control (safing/deservicing, maintenance/checkout, etc.) including the work-station-resident processors and various data/voice distribution systems between the work stations, SSV elements and the CDE.

Major inputs to the TCE will include the following:

- Schedule and planning data from the CDE
- Checkout programs from the CDE, for residency in work station processors during execution.
- Downlinked response data from SSV systems during checkout.

5.3 TURNAROUND CONTROL FUNCTIONS (CONT'D)

- Voice from vehicle crews, operations management control personnel, range operations personnel and, during contingencies, launch control personnel [e.g., line replacement unit (LRU) fault isolation for on-pad anomaly beyond the scope of on-pad checkout software].

Outputs will include:

- Schedule and planning inputs to CDE for incorporation in work control (operations management) programs.
- Commands and test stimuli to SSV systems.
- Voice to personnel listed above (as inputs).
- Completed checkout programs to CDE (i.e., for return to CDE master files following work station execution).
- Keyboard entries to the CDE from work stations (e.g., program callup and interactive terminal communications with work control programs).

Five major functions are identified for the TCE in order to satisfy requirements levied upon it, as follows:

- Personnel
- Data processing
- Display
- Command/control
- Communications.

The following paragraphs expand these functions to indicate more detailed requirements which they, in turn, levy upon the CCDS.

5.3.1 Personnel Functions. Personnel functions to be performed in support of turnaround will include:

A. Performance of checkout/planning functions in a work station (console-oriented) environment, such as:

   - Keyboard entry for callup of checkout software from the CDE.

5.3.1 Personnel Functions (Cont'd)

- Keyboard entry of scheduling/procedures parameters utilizing near real-time interactive "prompting" techniques between CDE scheduling programs, work station CRT's and the keyboards.
- Input of commands at the work station for checkout program control (e.g., initiating program execution) or for subsequent uplinking of the command to the vehicle as a checkout stimuli.
- Monitoring and evaluation of checkout program progress via CRT, indicator (e.g., event light) or hardcopy
- Maintaining voice communications with other major elements for planning, nominal status or during checkout anomaly resolution.

B. Performance of technical support operations in the near vicinity of vehicle and ground support equipment (GSE) (versus work station positions) including verification of work-station/vehicle/GSF interface hookups prior to actual checkout, etc. These setup functions will be performed essentially using "checklist" techniques, with technical support personnel maintaining voice communications with checkout control personnel at the work stations.

5.3.2 Data Processing Functions. Data processing required for turnaround operations will occur in two areas: the work stations and the CDE. Specific requirements in each area are as follows.

5.3.2.1 Work Station Processing Functions. Three major processing functions will be required in the Vandenberg Launch Processing System (VLPS) work stations to support the distributive processing CDE/work station concept, as follows:

A. Communications processing

- Work station-to-CDE
- Work station-to-work station
- Work station-to-vehicle/GSE

5.3.2.1 Work Station Processing Functions (Cont'd)

B. Applications program execution

- Checkout programs
- Operations management (work control) programs.

C. Work station peripherals processing

- Manual entry device (keyboard)
- Mass memory (disk/cassette)
- Hardcopy interfaces (recorders, unit record, strip chart)
- Display interfaces (CRT, alarm/event indicator).

5.3.2.1.1 Communications Processing (See Figure 5-1). Work station/CDE interface communications will be computer-to-computer, requiring multiplexing and demultiplexing of data onto or from shared data busses, message formatting/reformatting and error detection (see figure 5-1).

Work station-to-work station communication processing functions will be to the same as for above, utilizing shared (multiplexed) distribution systems. This will be a computer-to-computer interface.

Work station-to-vehicle/GSE communications is envisioned to include a front end processing function to allow downlink data compression, preprocessing, and possibly a recorder interface. The associated processing functions (between front end processor and work station communications processor) will include multiplexing/demultiplexing for transfer through the shared distribution system, message formatting/reformatting and error detection.

5.3.2.1.2 Applications Program Processing. Program execution in the work station processor will require nominal executive or supervisory support, permitting manual program interrupt (see paragraph 5.3.2.1.3,A), automatic interrupt for I/O and peripherals processing, etc. A multitask operating system is not envisioned in that execution will be performed one application at a time on a "rollout/rollin" basis from the CDE.

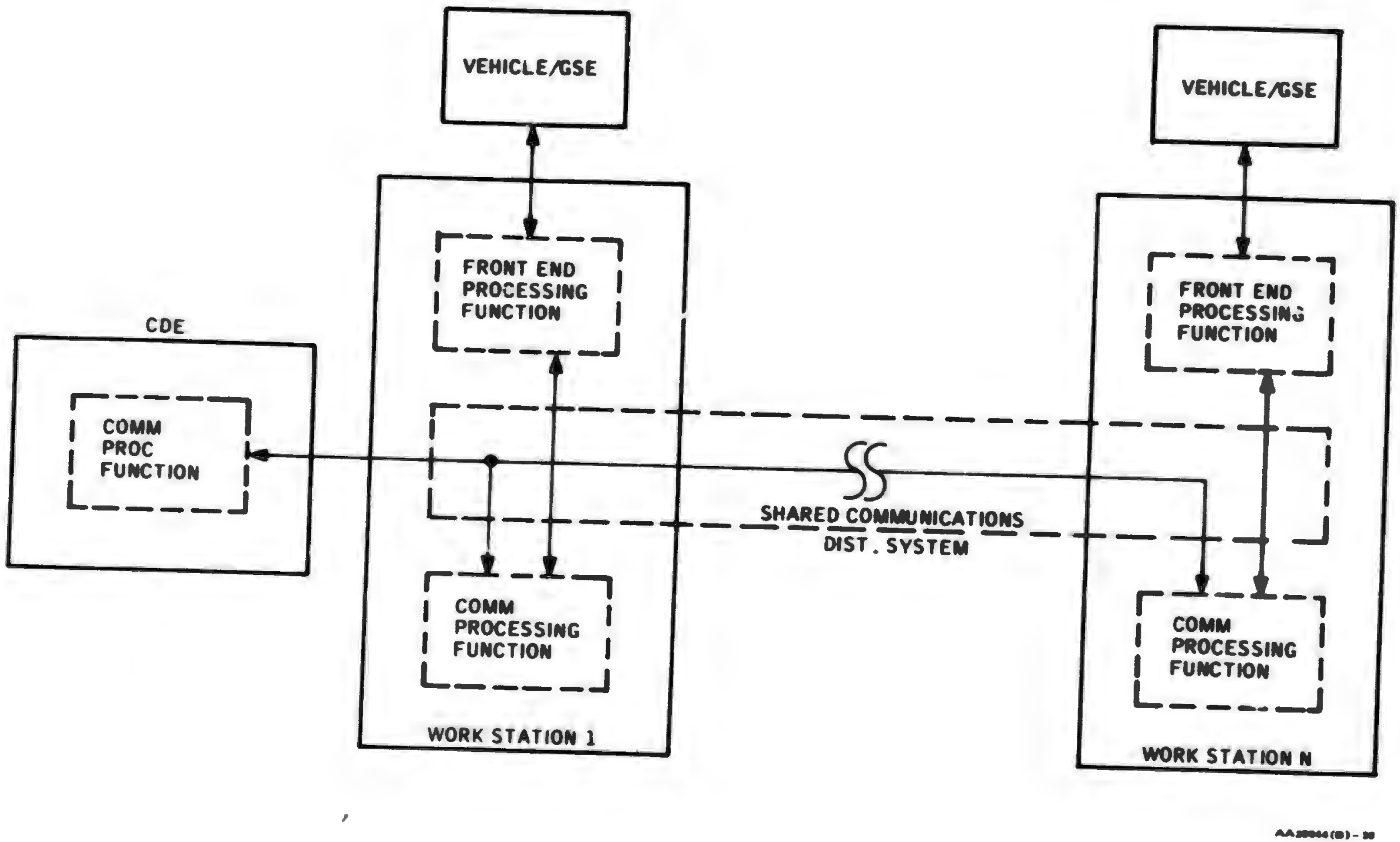


Figure 5-1 Work Station/CDE Communications Processing

5.3.2.1.3 Work Station Peripherals Processing. Program execution will include processing of I/O or peripherals interface transactions between CPU and manual entry devices, mass memory, hardcopy devices and display devices.

A. Manual Entry Processing. Program interrupt or initiation via manual entry (keyboard, pushbutton) should be provided. This will permit program callup from CDE, editing of schedule/procedures programs, interrupt for anomalies, checkpoint summary requests, etc.

B. Mass Memory Interface Processing. It is envisioned that some form of mass memory (disk/tape) will be provided at each work station, to provide backup storage of applications programs, work station executive storage and working memory areas (e.g., for checkout status summary tables). This concept would also permit loading of work station applications directly from the station in the event of CDE interface failures. Support of mass memory as such would require some form of disk operating system (KSC LPS concept) or tape cassette interface.

C. Hardcopy Interface Processing. Work station processing capabilities will include support of hardcopy requirements through recorder interface processing and possible analog stripchart and unit record (printer, card punch) processing.

D. Display Processing Function. Work station processing functions should include the capability to generate displays for presentation on CRT's or event indicators. The display processing function should include display generation from resident applications programs or that resulting from dynamic updates from a CDE-generated display. Typical displays expected will include:

1. Work control displays

- Planning data
- Schedules
- Procedures
- Historical trend data (anomaly resolution).

5.3.2.1.3 Work Station Peripherals Processing (Cont'd)

2. Checkout applications displays

- Procedures
- Anomaly alarms (CRT or event indicator)
- Vehicle/GSE checkout response data
- "Prompting" from applications program or CDE to request personnel intervention.

5.3.2.2 CDE Processing Functions. Processing requirements levied on the CDE by the TCE include:

- CDE-to-work-station communications processing
- Data base management support for checkout/work control program retrieval
- Work control applications processing (execution of work control programs in CDE in conjunction with those executing in work stations). These CDE applications would represent "summary" programs using work station processing results as inputs.
- Dynamic display generation. The CDE should be capable of generating and updating (in real-time) certain CRT displays for presentation at work station positions. Typical displays would include "prompting" of work station personnel for manual intervention and checkout test results involving other control elements [e.g., radio frequency (RF) open loop test results based on data received in the CDE from Vandenberg Tracking Station (VTS) data links].

5.3.3 Display Functions. Display requirements levied on CCDS by the TCE will include the display data communications routing and data processing defined in preceding paragraphs. In addition, they will include the following actual end items:

- CRT - alphanumeric/graphic capability
- Event indicators
- Hardcopy devices
- Analog recorders.

5.3.4 Command/Control Functions. Command/control functions will require the processing defined for the work stations (manual input processing, vehicle/GSE command stimulus generation) plus the actual command/control end items necessary to initiate or monitor the processing, such as keyboards and control prompting devices (e.g., event indicators).

5.3.5 Communications Functions. TCE communications processing functions which levy requirements on the CCDS will be those defined in preceding paragraph 5.3.2.1.1 (message routing, multiplexing/demultiplexing, error detection, voice communications). Additional communications functions will include any distribution processing required between the CDE and the work stations for both data and voice. Associated hardware impacts on the CCDS will include those levied by the physical distribution networks and voice terminals.

5.4 LAUNCH CONTROL ELEMENT

The Launch Control Element (LCE) will provide the capabilities to receive (on-pad) and perform the checkout, service, and launch of, the SSV and payload(s). The major functions performed by the LCE are installation of the SSV on the pad, interface verification, payload installation, SSV and payload flight verification, and countdown operations. In general, these functions are accomplished by work station configurations consisting of work-station-resident processors and various data/voice distribution systems between the work stations, SSV/payload, CDE, and other control elements [Shuttle Mission Control Center (SMCC), Operations Management Control (OMC), turnaround, and range].

Functions for the LCE are traceable to paragraph 3.4.6 of Volume X, JSC-07700; the *KSC Launch Processing System, Station Set 84 Requirements Document;* and paragraph 7.1 of the *DOD Shuttle Systems Requirements.*

Major inputs to the LCE will include the following:

- Schedule and planning data from CDE
- Checkout programs from CDE, for residency in work station processors during execution
- Mission/flight programs from CDE
- Downlink response data from the SSV/payload systems

- Voice from vehicle crews (when manned) and other control elements
- Mission/flight program updates during countdown (from CDE).

Major outputs from the LCE will include:

- Scheduling and planning inputs to CDE [for incorporation in work control (OME) programs]
- Commands and checkout stimuli to SSV and payload systems
- Mission/flight programs to the onboard computers (uplink from CDE)
- Mission/flight program updates to onboard computers (uplink from CDE)
- Voice to vehicle crews and other control elements
- Completed checkout programs to CDE
- Keyboard entries to CDE from work stations (e.g., program callup, interactive terminal communications with other control elements).

Five major functions are identified for the LCE in order to satisfy requirements levied upon it, as follows:

- Personnel
- Data processing
- Display
- Command/control
- Communications.

The following paragraphs expand these functions to indicate more detailed requirements which they, in turn, levy upon the CCDS.

5.4.1 Personnel Functions. Personnel functions to be performed in support of on-pad operations will include:

A. Performance of planning/checkout/launch functions in a work station (console-oriented) environment, such as:

- Keyboard entry for callup of checkout and launch software from CDE
- Keyboard entry of scheduling/procedures parameters utilizing real-time interactive "prompting" techniques between CDE scheduling programs, work station CRT's, and the keyboards.
- Input of commands at the work station for checkout and launch program control (e.g., initiating program execution) or for subsequent uplinking of the command as a checkout stimuli.
- Monitoring and evaluation of program progress via CRT, event indicator, or hardcopy
- Maintaining voice communication with vehicle crew and other control elements for planning, nominal status, and during anomaly resolution.

B. Performance of technical support operations in the near vicinity of the vehicle and GSE (versus work station positions) including verification of work station/vehicle/GSE interface hookups prior to actual checkout or launch operations. These functions will be performed essentially using "checklist" techniques, with technical support personnel maintaining voice communications with checkout/launch control personnel at the work stations.

5.4.2 Data Processing Functions. Data processing required for on-pad operations will occur in two areas: the work stations, and the CDE. Specific requirements in each area are as follows.

5.4.2.1 Work Station Processing Functions. Three major processing functions will be required in the VLPS work stations in support of the distributive processing, CDE/work station concept, as follows:

A. Communications processing

- Work station-to-CDE

5.4.2.1 Work Station Processing Functions (Cont'd)

- Work station-to-work station
- Work station-to-SSV/payload/GSE.

B. Applications program execution

- Checkout programs
- Mission/flight programs
- Operations management (work control) programs.

C. Work station peripherals processing

- Manual entry device (keyboard)
- Mass memory (disk/cassette)
- Hardcopy interfaces (recorders, unit record, strip chart)
- Display interface (CRT, indicator).

5.4.2.1.1 Communications Processing. Work station/CDE interface communications will be computer-to-computer, requiring multiplexing and demultiplexing of data onto or from shared data busses, message formatting/reformatting and error detection (see figure 5-1).

Work station-to-work station communication processing functions will be the same as for work station/CDE, utilizing shared (multiplexed) distribution systems. This will be a computer-to-computer interface.

Work station-to-SSV/payload/GSE communication processing functions are envisioned to include a front end processing function to allow downlink data compression and preprocessing. There may also be a recorder interface. The associated processing functions (between front end processor and work station communications processor) will include multiplexing/demultiplexing for transfer through the shared distribution system, message formatting/reformatting, and error detection.

5.4.2.1.2 Applications Program Processing. Program execution in the work station processor will require nominal executive or supervisory support, permitting manual program interrupt (see paragraph 5.4.2.1.3,A), automatic interrupt for I/O and peripherals processing, etc. A multitask operating system is not envisioned in that execution will be performed one application at a time on a "rollout/rollin" basis from the CDE.

5.4.2.1.3 Work Station Peripherals Processing. Program execution will include processing of I/O or peripherals interface transactions between CPU and manual entry devices, mass memory, hardcopy and display devices.

A. Manual Entry Processing. Program interrupt or initiation via manual entry (keyboard, pushbutton) should be provided and will permit program callup from CDE, editing of schedule/procedures programs, interrupt for anomalies, checkpoint summary requests, etc.

B. Mass Memory Interface Processing. It is envisioned that some form of mass memory (disk/tape) will be provided at each work station, to provide backup storage of checkout/flight programs, work station executive storage and working memory areas (e.g., for checkout/launch status summary tables). This concept would also permit loading of checkout/flight programs directly from the station in the event of CDE interface failures. Support of mass memory as such would require some form of disk operating system (KSC LPS concept) or tape cassette interface.

C. Hardcopy Interface Processing. Work station processing capabilities will include support of hardcopy requirements through recorder interface processing and possible analog stripchart and unit record (printer, card punch) processing.

D. Display Processing Function. Work station processing functions should include the capability to generate displays for presentation on CRT's or event indicators. The display processing function should include display generation from resident applications programs or that resulting from dynamic updates from a CDE-generated display. Typical displays expected will include:

1. Work control displays

   - Planning data
   - Schedules

5.4.2.1.3 Work Station Peripherals Processing (Cont'd)

- Procedures
- Historical trend data (anomaly resolution).

2. Checkout/flight program displays

   - Procedures
   - Anomaly alarms (CRT or event indicator)
   - Vehicle/GSE checkout response data
   - "Prompting" from applications program or CDE to request personnel intervention.

5.4.2.2 CDE Processing Functions. Processing requirements levied on the CDE by the LCE include:

- CDE-to-work-station communications processing
- Data base management support for work control/checkout/ flight program retrieval
- Work control applications processing (execution of work control programs in CDE in conjunction with those executing in work stations). These CDE applications would represent "summary" programs using work station processing results as inputs.
- Dynamic display generation. The CDE should be capable of generating and updating (in real-time) certain CRT displays for presentation at work station positions. Typical displays would include "prompting" of work station personnel for manual intervention and checkout test results involving other control elements (e.g., RF open loop test results based on data received in the CDE from VTS data links).

5.4.3 Display Functions. Display requirements levied on CCDS by the LCE include the display data communications routing and data processing defined in preceding paragraphs. In addition, they include the following actual end items:

- CRT - alphanumeric/graphic capability

5.4.3 Display Functions (Cont'd)

- Event indicators
- Hardcopy devices
- Analog recorders.

5.4.4 Command/Control Functions. Command control functions will require the processing defined for the work stations (manual input processing, SSV/payload/GSE command stimulus generation) plus the actual command/control end items necessary to initiate or monitor the processing, such as keyboards and control prompting devices (e.g., event indicators)

5.4.5 Communications Functions. LCE communications processing functions which levy requirements on the CCDS are those defined in paragraph 5.4.2.1.1 (message routing, multiplexing/demultiplexing, error detection, voice communications). Additional communications functions will include any distribution processing required between the CDE and the work stations for both data and voice. Associated hardware impacts on CCDS will be levied by the physical distribution networks and voice terminals.

5.5 RANGE

Range will support communications and tracking system checkout, support planning and scheduling of range resources, provide for SRB recovery and return to the launch site, and provide the necessary range communications management.

Inputs to the Range Element (RE) will consist of the following:

- Voice from the SMCC and recovery forces for solid rocket booster (SRB) recovery coordination.
- Planning and scheduling data from the CDE.
- Voice coordination from other CCDS elements.

5.5 RANGE (CONT'D)

Outputs from the RE will consist of the following:

- Voice and data to the SMCC and recovery forces for SRB recovery coordination.
- Planning and scheduling data to the CDE.
- Voice coordination to other CCDS elements.

The SRB functions are traceable to paragraph 3.4.9 of Volume X, JSC-07700 and the communications and tracking functions to paragraph 6.2.1 of the *DOD Shuttle System Requirements* (all systems operable at liftoff). The remaining two functions are based on engineering and operational judgment.

5.5.1 Personnel Subsystem. The personnel subsystem will perform the following functions in support of launch activities:

- Incorporate and compare SSV mission support scheduling data with existing range schedules.
- Coordinate planning and schedule updates.
- Resolve schedule conflicts.
- Advise recovery forces of SRB impact point coordinates.

In support of communications and tracking system checkout during turnaround operations, the Personnel Subsystem will:

- Schedule and issue clearance for RF open loop checkout for turnaround and on-pad operations.
- Resolve any associated schedule conflicts.

5.5.2 Communications Subsystem. The Communications Subsystem will provide the following capabilities:

- Data routing and switching
- Internal voice coordination links
- Line circuit quality monitoring
- Interface external data and voice lines with internal communication links. Major external interfaces will be with recovery forces, LCE, TCE, Mission Control Element, OME and CDE.

5.6 MISSION CONTROL

As stated in section 3 of this report, the Mission Control Element (MCE) performs those functions related to total mission management and support of STS flight elements and flight operations. This subsection discusses those functional subsystem requirements levied on the MCE for mission support.

Mission requirements are traceable to *DOD Shuttle System Requirements,* paragraph 7.4 and 3.2.1,a., and Volume X, JSC-07700, paragraph 3.3.1.1.3 (rendezvous coordinates from ground), and Volume XIV, JSC-07700, Rev. B, paragraph 5.3.2.4 (one-way doppler).

Inputs to the mission control element in performance of mission support activities include:

- Orbiter telemetry and voice via the remote tracking station (RTS)
- RTS tracking data (backup)
- Voice coordination from other CCDS elements
- Voice and data from the Lyndon B. Johnson Space Center (JSC) for both premission activities and inflight contingencies
- Voice and data from Orbiter via the Space Tracking and Data Network (STDN)/Tracking Data Relay Satellite (TDRS) during contingency operations
- Voice and data requests from User Mission Control Centers (UMCC's)
- Voice and data from National Oceanic and Atmospheric Administration (NOAA)
- Voice and data from North American Air Defense (NORAD)
- Voice and data from KSC for DOD launches from KSC.

Outputs from the MCE in performing mission support functions include:

- Vehicle commands, uplink data and voice via the RTS

5.6 MISSION CONTROL (CONT'D)

- Voice coordination to other CCDS elements
- Voice and data to JSC in support of premission planning and inflight contingencies.
- Voice, commands and uplink data to Orbiter via STDN/TDRS during contingency operations
- Voice and data to UMCC's
- Voice coordination to NOAA
- Voice and data to NORAD
- Voice coordination with other DOD agencies
- Voice and data to KSC for DOD launches from KSC.

5.6.1 Personnel Subsystem. The Personnel Subsystem will perform the following overall mission management functions:

- Communication coordination to include resources scheduling coordination, payload user coordination, and Orbiter co-ordination.
- Management of other SMCC subsystems
- Coordination of SMCC (Orbiter)/MCC (payload) operations handover
- Coordination of proposed flight plan changes with all STS disciplines to ensure no conflict
- Coordination with launch agency
- Release of landing site from once around abort standby status
- Coordination with NOAA and landing site to ascertain weather conditions pertinent to the landing approach route and landing site, and provide a GO/NO-GO decision for landing
- Coordination of corridor clearance for approach and landing with the Federal Aviation Administration (FAA) and landing site.

5.6.1 <u>Personnel Subsystem</u> (Cont'd)

In maintaining mission status awareness the Personnel Subsystem will perform the following functions:

- Participation in on-pad checkout, launch readiness, and countdown activities
- Maintaining of assurance of nominal mission profile
- Maintaining vehicle system status
- Maintaining vehicle trajectory status
- Maintaining status of mission events and flight plan variations
- Maintaining cognizance of data trends.

In providing for response to contingency situations, the Personnel Subsystem will perform the following functions:

- Response to alarm conditions by 1) internal correction, 2) requesting assistance from additional SMCC personnel, or 3) requesting assistance from external agency
- Determination of degree of support required for contingency situations
- Coordination with NASA to secure required STDN/TDRS coverage or JSC computational facility support
- Response to caution and warning alarms to find cause and determine appropriate action
- Analysis of contingency situations to determine if support is required from additional personnel
- Determination of contingency support required from NASA or other external agencies.

The Personnel Subsystem will provide the following near-real-time mission planning functions:

- Determination of need for mission plan alterations in real-time based upon evaluation of data trends or mission anomalies

5.6.1 Personnel Subsystem (Cont'd)

- Coordination of near-real-time mission plan changes with all STS disciplines to ensure no conflicts
- Provision of a central control point for internal and external agency coordination
- Response to any alarm condition and determination of need for additional support personnel or for NASA or other agency contingency support.

During the Orbiter/satellite coordination phase, the Personnel Subsystem will perform the following functions:

- Coordinate Orbiter/MCC operations handovers
- Coordinate RTS scheduling and configuration to meet Orbiter/payload support requirements
- Provide SMCC/MCC/Orbiter voice coordination during payload deployment and retrieval
- Ensure voice and data circuit security and integrity during Orbiter/payload operations.

- Coordination of RTS scheduling
- Verification of RTS status and configuration
- Monitoring of voice and data line circuit quality
- Central control of SMCC/MCC/Orbiter voice uplink and downlink
- Verification of payload user voice and data integrity during payload activity
- Coordination with all Orbiter system disciplines to assure compatibility of communication plans.

5.6.2 Data Processing Subsystem Functional Requirements. The Data Processing Subsystem will provide for the following:

A. Input Processing

- Perform message routing, data interpretation, error checking and formatting of RTS and flight controller inputs
- Determine source and destination of incoming data.

B. Computational Processing

- Demultiplex, decommutate and reformat telemetry inputs from the RTS
- Process trajectory data to generate site acquisition information
- Strip payload data from incoming telemetry: provide payload status data to SMCC Display Subsystem; and format payload data for routing to UMCC
- Record data for historical purposes
- Time tag all data unless otherwise time tagged
- Maintain updated ephemeris of Orbiter and rendezvous targets
- Generate acquisition data for RTS contract
- Monitor and/or analyze selected telemetry data points and generate alarms
- Process specific display requests to generate, format and output required data
- Format commands and uplink data for transmission to RTS for uplink to Orbiter and payload
- Provide data reformatting to permit exchange of data between the SMCC and STDN/TDRS or between SMCC and JSC for contingency support
- Maintain data base for real-time mission planning

5.6.2 Data Processing Subsystem Functional Requirements (Cont'd)

- Perform computations necessary for the performance of flight plan updates, revised station contacts, trajectory replanning, rendezvous replanning, targeting updates, deorbit replanning and alternate landing site selection

- Format mission planning updates for transmission to RTS for uplink to Orbiter.

C. Output Processing

- Convert display data to suitable display format and route to Display Subsystem

- Initiate alarm input to Display Subsystem if parameters are out-of-limits

- Format data for output to RTS to include site address and message overhead information.

5.6.3 Display Subsystem. The Display Subsystem will provide the capabilities to:

A. Receive converted parameters from the Data Processing Subsystem.

B. Process data for display on end display devices. Types of data to be displayed include bilevels (events and status), discretes (alphanumerics, digitals) and analogs.

C. Accept alarm input signals and provide audible and visual alarms.

D. Route permanent records (hardcopies) of requested non-permanent displays.

E. Route selected parameters to end display instruments.

Displays for mission support will include:

- Time of day, mission time, estimated time of acquisition (ETA), estimated time to track (ETT), and general purpose countup and countdown clocks

- Vehicle status data

5.6.3 Display Subsystem (Cont'd)

- Indication of network (RTS) status
- Predicted site acquisition tables and next station contact tables
- Outgoing command data and Orbiter response to the uplink (accept, reject, etc.)
- Mission planning data required for flight plan updates, revised station contacts, trajectory replanning, rendezvous replanning, targeting updates, deorbit replanning and alternate landing site selection.

5.6.4 Command/Control Subsystem. The Command/Control Subsystem will provide the following capabilities:

- Encoding, routing, and multiplexing for flight control entry device inputs to data processing subsystem
- Control of computer operations to include program control, format selection, processing and outputting of logged data, and system tests
- Transfer of command execute data to Data Processing Subsystem for subsequent output to network
- Command load generation for navigation updates and general purpose updates to Orbiter and interim upper stage (IUS).

5.6.5 Communications Subsystem. The Communications Subsystem will provide the following capabilities:

- Interface external data lines with Data Processing Subsystem
- Air/ground voice communications uplink and downlink capability
- Voice and data routing and switching
- Internal voice coordination links
- Line circuit quality monitoring
- Interface with external agencies and support computational facilities

5.6.5 Communications Subsystem (Cont'd)

- Recording and subsequent retrieval of incoming and outgoing data
- Voice coordination interface with landing support facilities to include FAA, primary and alternate landing sites, and NOAA
- Voice coordination and data interfaces with NASA for STDN/TDRS support
- Voice coordination and data interfaces with launch site and SRB recovery forces
- Detecting, shaping, decrypting and inputting of payload and Orbiter telemetry data
- Output, encryption and transmittal of payload mission data, commands and uplink data
- Routing and distribution of payload status, environmental and telemetry (TLM) data to user and SMCC.

5.7 LANDING AREA

The landing area is not considered a functional element. It will maintain the navigation and landing aids, and it will provide landing site weather information to the SMCC for relay to the Orbiter. Voice communications between the SMCC and the landing area are required. These functions are traceable to paragraph 3.2.1, *DOD Shuttle System Requirements*, and paragraph 4.2.2 of the *Joint NASA/DOD STS Program Plan*.

5.8 CENTRAL DATA ELEMENT FUNCTIONAL REQUIREMENTS

The Central Data Element (CDE) will provide real-time work control and checkout data storage and retrieval, technical data management functions, and support services such as command logging, program loading, and initialization for the work station processors.

The master library for Vandenberg Air Force Base (VAFB) ground operations software programs will reside in the CDE, with checkout and monitoring subsystems configured on a request basis by shipping the requested data from the CDE to the work stations via a communications processing interface.

5.8 CENTRAL DATA ELEMENT FUNCTIONAL REQUIREMENTS (CONT'D)

Functions for the Central Data Element are traceable to paragraph 3.4.16.2.11 of Volume X, JSC-07700; *KSC Launch Processing System, Station Set 84 Requirements Document;* and paragraph 7.1 of the *DOD Shuttle System Requirements.*

5.8.1 General Checkout/Test Processing Functions. The CDE will provide direct and dedicated vehicle and test area support to the VLPS work station network. By means of a software transaction processor in a multitask environment, application programs will be called into service as needed to provide functions such as:

- Real-time data recording and display, including telemetry data, GSE systems data, command data, event logs, and work station computer parameters
- Historical data recall with trends, analysis, etc., for direct display to the CRT's at the work stations
- Linkage from the work station CRT's to the data base information and programs
- Program loading and initialization of VLPS work station computer and front end processors
- Application program development support
- Support of demand (terminal) and batch programming for data base file development and modification, together with engineering and management analysis
- Support of stand-alone terminals in utilities areas, labs, and LRU refurbishment areas, etc. as required
- Data transfer to/from other centers and contractor sites.

5.8.2 Operations Management Support Functions. The CDE will provide the capability for an automated information management system for the collection of inputs; arranging, sorting and formatting of data for reports; and dissemination of tasks and pertinent management data.

The management systems envisioned (refer also to figure 4-2) include:

A. Work Authorization and Control. A system dealing with tasks to be performed, skills and resources necessary to support, and scheduling of same.

5.8.2 Operations Management Support Functions (Cont'd)

B. Configuration Management. A system for controlling vehicle and GSE hardware configurations and modifications.

C. Problem and Failure Reporting. A system of documenting detected failures, causes, and cures.

D. Spares Inventory Management. A system of recording and maintaining spare parts.

E. Engineering Information Management.

F. Information Management (data base management processing).

Access will be provided to the CDE for program retrieval from VLPS work station CRT/keyboard units and office-type terminals as required.

Data base management techniques will be employed for data filing to minimize redundant storage and the maintenance of "current" data. Both online and batch processing should be accommodated.

The man/machine interface will allow reports generation and trend selection needed for problem resolution. Work station personnel will be provided current status information from any of the management systems (as necessary) included in the operations management data base.

The operations management systems developed for VLPS applications should give consideration to automation principles such as defining the data elements, field lengths, access requirements, security controls, reports requirements, etc., and utilization of standard terminology and system design.

5.8.3 Data Base Processing Functions. Direct access storage devices serving as the storage mediums for programs and data will typically include the following:

- Operating system software
- Compilers, utility routines, and a library of CDE application programs
- Source copies of all VLPS work station application programs

5.8.3 Data Base Processing Functions (Cont'd)

- A library of simulation models and model driving programs
- Real-time vehicle and GSE data available for historical data recall, trend analysis, etc.
- Integrated data files for engineering and management support.

General data base management processing functions will include:

- Data structuring on files for classification, categorization, and logical structuring
- Access control processing for access by logical relationships, and mass storage interface communications processing (control signal generation, etc.).

5.8.4 Communications Processing. Communications processors will provide communications and data transfer between the CDE and the work stations to be driven by the CDE. These processors will use standard available software and should be switchable under operating system or manual control to backup CDE processing should the "primary" CDE processor fail. These communications processors should provide an isolated path to the work stations driven by the CDE; i.e., failure of a work station computer should have no effect on CCDS support to the other stations.

5.8.4.1 Terminal Communications Processing. This processing function should operate under standard software and accommodate dialup-type phone lines to provide office-type terminal support, standalone VLPS work station support, and block transfer between other centers (JSC, KSC, SMCC). This function should also be compatible with communications and data transfer to a "secondary" CDE computer if required, for data base buildup and modification, engineering and management analysis, report generation, and file and program development work.

5.8.4.2 Real-Time Front End Preprocessing Functions. Real-time preprocessors will accept raw data from the VLPS work station network and perform the low level maniuplations such as decommutation, limit checks, compression, application of calibration curves, and reformatting. This preprocessed data will then be transmitted to the primary CDE computer. The real-time preprocessor will be capable of two-way file transfers for transmission of source programs to the "primary" computer and receipt of object programs from the "primary" computer.

5.8.5 CDE Operating System Software. The CDE operating systems will be capable of supporting real-time data storage/retrieval, simulation, remote interactive processing, batch processing, and time-sharing within a multiprogramming environment. The operating supervisor will provide scheduling, loading, allocation, dispatching, and input/output functions for programs and software executives within the system. The supervisor will permit communication with direct access storage devices shared by more than one computer, automatic switching of support when there is computer failure, CPU program access by priority, and system monitoring/accounting capability. The operating system should include executives for functions such as time-sharing and remote processing, real-time data storage, graphics processing, data base management, and transaction processing.

5.8.6 CDE Data Security. Data security within the CDE should provide data protection from unauthorized use or purposeful change or destruction. This requires the identification of the authorized users of the system and provision of protective mechanisms to prevent illegal entry to the system or access to the files and programs. User identification and the protective mechanisms will be through computer software.

5.8.7 CDE Data Integrity. Data integrity within the CDE should include features providing safeguards from inadvertent destruction or alterations, and data base recovery.

5.9 PAYLOAD CHECKOUT FUNCTIONAL ELEMENT

During the study, it was assumed a checked out payload (IUS and/or satellite) would be delivered to the KSC or VAFB launch pad for integration into the Orbiters. The payload checkout functional element then was considered only for its activities during the period from payload delivery to the pad to ascent. Within this limitation, the payload checkout element functional requirements are as follows:

A. Personnel

- Assist in the installation and integration of the payload into the Orbiter
- Monitor the installation and integration through voice communications with the LCE
- Assist the launch control personnel in the in-vehicle checkout and validation of payload readiness.

B. Communications. Voice to mission control, launch control, and Orbiter.

SECTION 6

FUNCTIONAL INTERFACE CONTROL DEFINITION

6.1 INTRODUCTION

This section describes the functional interfaces between the major systems elements delineated in the preferred Command and Control Data System (CCDS) concept (reference Statement of Work III). This description is functional only and must be considered as preliminary since the specific intra-Vandenberg Air Force Base (VAFB) interfaces can only be defined based on a specific VAFB system, facility, and siting plan. Many of the functional interfaces identified in this section will become official interface control points as the Space Transportation System (STS) program evolves and will be subjected to rigid interface control and documentation procedures.

The following paragraphs describe the functional data interfaces between major CCDS control elements. Figures 6-1 through 6-3 show the major interfaces for turnaround, launch, and flight operations, respectively. Tables 6-1 through 6-3 relate to the drawings by interface line number and describe the functional requirements for the interface, the data type or interface type, and the physical and electrical characteristics where available. In those cases where a reference is needed to another table to completely describe the interface (e.g., interface required during turnaround and launch operations), such a reference is made in each applicable table. Table 6-4 indicates the dedicated voice lines required between the elements of the CCDS.

6.2 TURNAROUND OPERATIONS FUNCTIONAL INTERFACES

Figure 6-1 and table 6-1 illustrate and describe the VAFB functional data interfaces required for turnaround operations of a DOD or NASA mission to be launched from VAFB or DOD missions to be launched from KSC.

6.3 LAUNCH PAD OPERATIONS FUNCTIONAL INTERFACES

Figure 6-2 and table 6-2 illustrate and describe the functional data interface required by DOD for STS missions launched from either VAFB or KSC.

6.4 FLIGHT OPERATIONS FUNCTIONAL INTERFACES

Figure 6-3 and table 6-3 illustrate and describe the SMCC functional data interfaces required for DOD missions to conduct the flight operations (liftoff through rollout).

6.5 VOICE LINKS

Table 6-4 indicates the voice links required between the various elements of the CCDS for DOD missions launched from either KSC or VAFB. These are only the dedicated voice links and do not include those voice links capable of being served by normal telephone circuits.

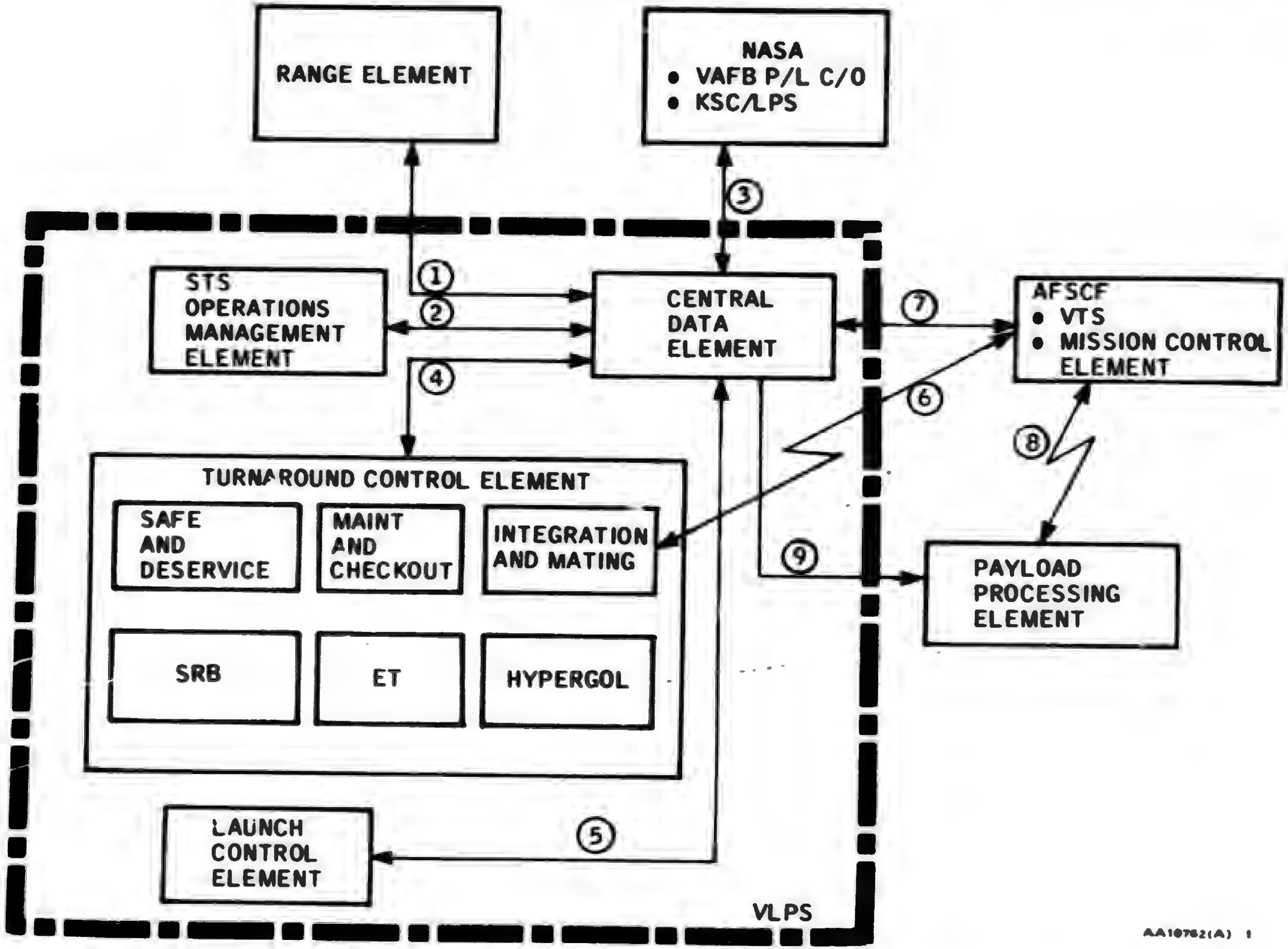


Figure 6-1 Turnaround Operations Functional Interfaces (Data)

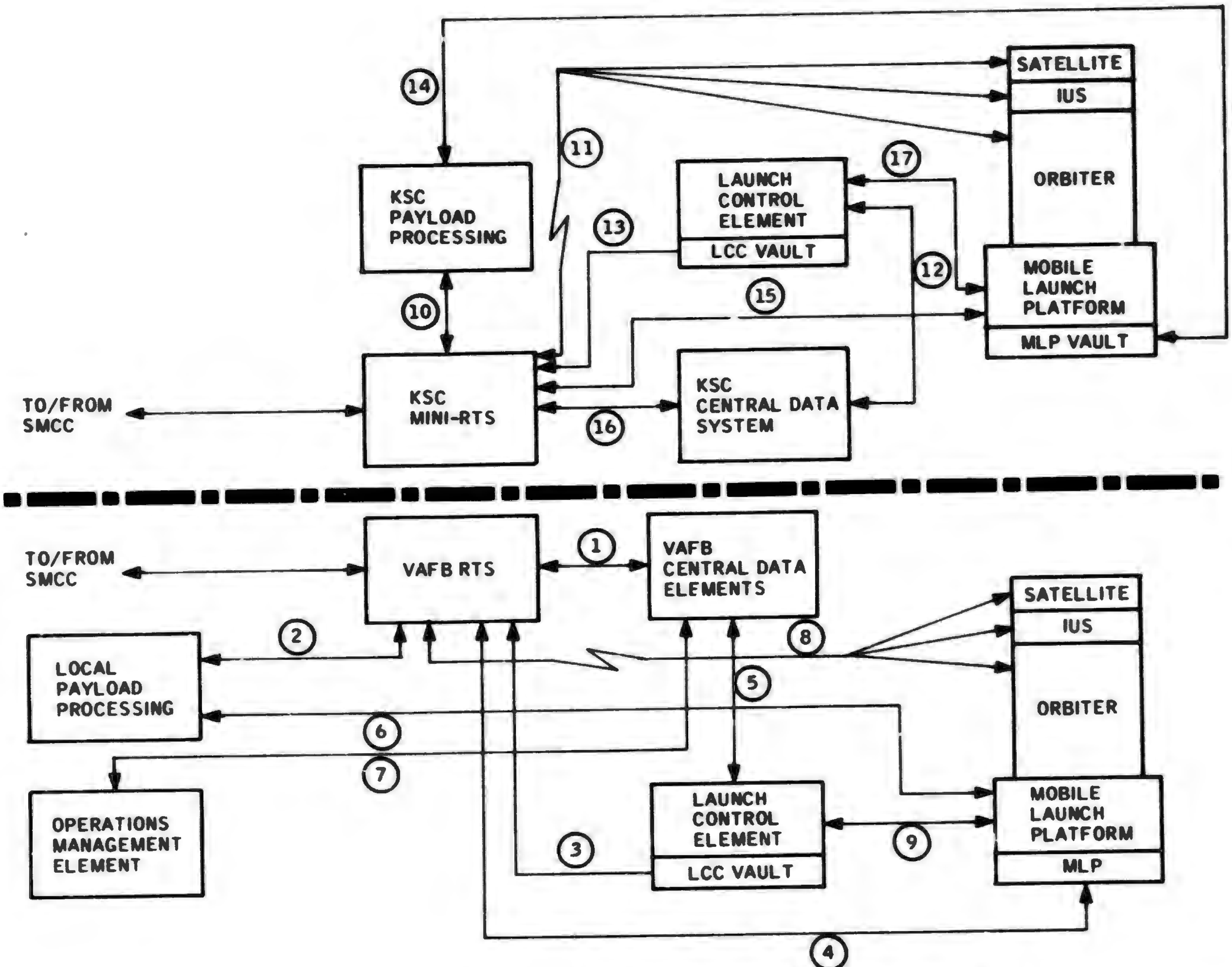
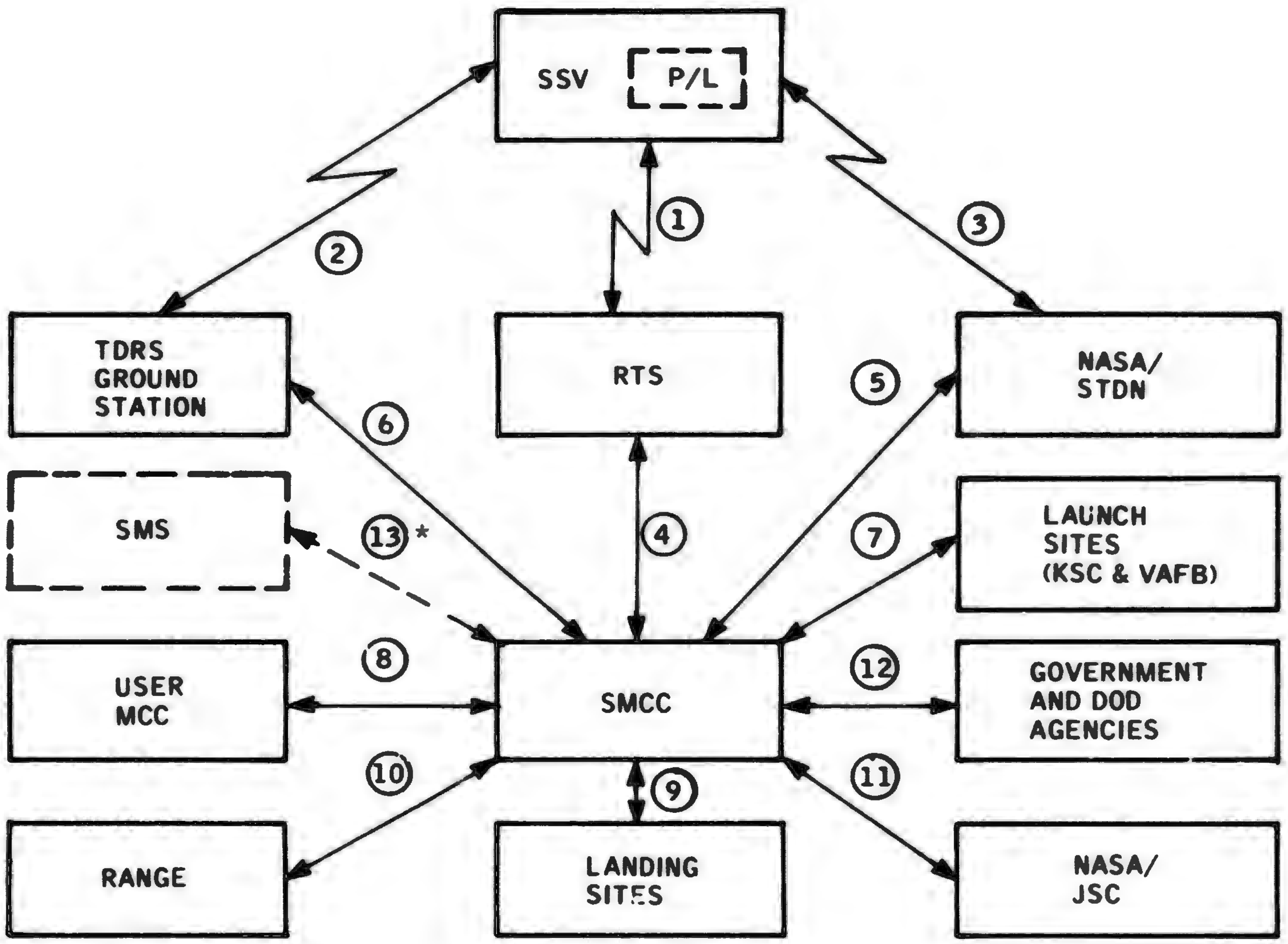


Figure 6-2 Launch Pad Operations Functional Interfaces (Data)



*INTERFACE TO BE DEFINED IN TASK IV

Figure 6-3 Operations Functional Interfaces (Data)

TABLE 6-1

TURNAROUND OPERATIONS FUNCTIONAL INTERFACES

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
1) RE-CDE	• TO CDE - SCHEDULE DATA, WEATHER DATA	• HARDWIRE, TERMINAL-TO-COMPUTER	TBD
	• FROM CDE - SCHEDULE AND STATUS DATA RETRIEVED FROM CDE	• SAME AS ABOVE	TBD
2) OMCE-CDE (SEE ALSO TABLE 6-2, REF. 7)	• TO CDE - REQUESTS FOR WORK PROGRAMS, WORK PROGRAM UPDATES, STATUS/SCHEDULE DATA	• BIDIRECTIONAL HARDWIRE, TERMINAL-TO/FROM-COMPUTER. UNIDIRECTIONAL COMPUTER-TO-CRT.	TBD
	• FROM CDE - WORK PROGRAMS, SCHEDULE/STATUS DATA, CRT/EVENT LIGHT DISPLAY UPDATES, DISPLAY USER PROMPTING	• SAME AS ABOVE	TBD
3) NASA-CDE	• TO CDE - DATA BANK TRANSFERS FROM KSC CDE • TO CDE - WORK CONTROL/CHECKOUT PROGRAM CALLUP FROM KEYBOARDS IN NASA PLCE AREA AT VAFB	• BIDIRECTIONAL MICROWAVE, COMPUTER-TO-COMPUTER (KSC-TO-VAFB). BIDIRECTIONAL HARDWIRE, TERMINAL-TO/FROM COMPUTER (NASA'S VAFB PLCE AREA-TO-VAFB CDE)	TBD
	• FROM CDE - DATA BANK TRANSFER FROM VAFB TO KSC	• MICROWAVE, COMPUTER-TO-COMPUTER	TBD

TABLE 6-1 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
3) (CONT'D)	• FROM CDE - WORK CONTROL/ CHECKOUT PROGRAMS AND UPDATES; DYNAMIC CRT DISPLAY UPDATES. FOR NASA PLCE	• HARDWIRE, COMPUTER-TO-COMPUTER (CDE-TO-WORK STATION MINIPROCESSOR). HARDWIRE COMPUTER-TO-CRT	TBD
4) TCE-CDE	• TO CDE - KEYBOARD REQUESTS FOR WORK CONTROL/ CHECKOUT PROGRAMS, PROGRAM UPDATES • FROM CDE - WORK CONTROL/ CHECKOUT PROGRAMS, CRT DISPLAYS	• HARDWIRE, COMPUTER-TO-COMPUTER (CDE-TO-WORK STATION MINIPROCESSOR); HARDWIRE COMPUTER-TO-CRT • SAME AS ABOVE	TBD TBD
5) LCE-CDE (SEE ALSO TABLE 6-2, REF. 5)	• TO CDE - KEYBOARD REQUESTS FOR WORK CONTROL/ CHECKOUT PROGRAMS; REQUESTS FOR FLIGHT SOFTWARE UPDATES (E.G., RETARGETING) • FROM CDE - WORK CONTROL/ CHECKOUT PROGRAMS; CRT UPDATES	• HARDWIRE, COMPUTER-TO-COMPUTER (CDE-TO-WORK STATION MINIPROCESSOR). HARDWIRE COMPUTER-TO-CRT; "BENT-PIPE" TRANSFER OF FLIGHT SOFTWARE FROM CDE TO ORBITER WHILE ON PAD	TBD

TABLE 6-1 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
6) TCE-AFSCF	• RF CHECKOUT (OPEN-LOOP) BETWEEN ORBITER AND VTS	• S-BAND	TBD
7) AFSCF-CDE (SEE ALSO TABLE 6-2, REF. 1)	• ORBITER/TUG MISSION FLIGHT SOFTWARE AND SOFTWARE UPDATES	• MICROWAVE, BIDIRECTIONAL DATA LINK	TBD
8) VAFB RTS-P/L PROCESSING	• SPACECRAFT RF COMMUNICATIONS SYSTEM COMPATIBILITY CHECKS	• RF OPEN LOOP	• 1.76-1.84 GHZ (UP) • 2.2-2.3 GHZ (DOWN) S-BAND
9) CDE-PPE	• WORK SCHEDULE STATUS DATA	• BIDIRECTIONAL HARDWIRE, TERMINAL-TO-COMPUTER; UNIDIRECTIONAL HARDWIRE, COMPUTER-TO-CRT	TBD

TABLE 6-2

LAUNCH PAD OPERATIONS FUNCTIONAL INTERFACES (DATA)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
1) CDE VAFB RTS (SEE ALSO TABLE 6-3, REF. 7)	• UNCLASSIFIED OR CLASSIFIED MISSION/FLIGHT TRAJECTORY DATA LOADS FOR SUBSEQUENT TRANSFER TO LCE AND LOADING INTO ORBITER/PAYLOAD	• W/B, HARDWIRE	TBD
	• ORBITER TEST DATA (UNCLASSIFIED, RECEIVED FROM KSC VIA SMCC/STC FOR DOD/KSC LAUNCHES)	• W/B, HARDWIRE	TBD
	• HISTORY, TREND, STATUS DATA FOR ON-PAD OPERATIONS MANAGEMENT (ANOMALY RESOLUTION IN PARTICULAR	• W/B, HARDWIRE	TBD
2) AFSCF-P/L	• DOD SPACECRAFT CHECKOUT DATA, COMMANDS TO SPACECRAFT FROM SMC, TLM TO SMCC --IUS AND/OR SATELLITE AT KSC --SATELLITE AT VAFB	• TBD	16 KB/S C/O DATA (DN) 256 KB/S (DN) 8 KB/S COMMANDS (UP)
3) VAFB RTS-LAUNCH CONTROL ELEMENT (LCC VAULT)	• REDUNDANT TLM AND VOICE DOWNLINK FROM ORBITER TO RTS	• HARDWIRE UNIDIRECTIONAL (LCC VAULT-TO-RTS) DOWNLINK; 192 KB/S ENCRYPTED	• 192 KB/S (DETAILED CHARACTERISTICS TBD)

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
4) VAFB RTS MLP (MLP VAULT)	• REDUNDANT VOICE AND COMMAND UPLINK FROM RTS TO ORBITER • P/L AND MAINTENANCE DATA DOWNLINK FROM ORBITER TO RTS	• HARDWIRE, UNIDIRECTIONAL (RTS-TO-MLP VAULT) UPLINK; 72 KB/S ENCRYPTED • HARDWIRE, UNIDIRECTIONAL (MLP VAULT-TO-RTS) DOWNLINK; 256 KB/S EITHER ENCRYPTED OR UNCLASSIFIED	• 72 KB/S (DETAILED CHARACTERISTICS TBD) • 256 KB/S (PAYLOAD) • 128 KB/S OR 1.024 MB/S (MAINTENANCE) • DETAILED CHARACTERISTICS TBD
5) CDE-LCE (SEE ALSO TABLE 6-1, REF. 5)	• TO CDE - WORK CONTROL AND CHECKOUT PROGRAM CALLUP FROM KEYBOARD, SCHEDULE UPDATES FROM LCE PERSONNEL • FROM CDE - WORK CONTROL PROGRAMS, CHECKOUT PROGRAMS, DYNAMIC CRT UPDATES	• HARDWIRE, BIDIRECTIONAL COMPUTER-TO-COMPUTER (CDE-TO-STATION SET MINIPROCESSOR) UNDER TERMINAL KEYBOARD CONTROL. UNIDIRECTIONAL CDE-TO-CRT	TBD
	• FROM CDE - UNCLASSIFIED FLIGHT SOFTWARE AND UPDATES RECEIVED FROM STC FOR SUBSEQUENT UPLINK TO ONBOARD COMPUTERS	• HARDWIRE, UNIDIRECTIONAL COMPUTER-TO-COMPUTER (CDE-TO-ORBITER); BENT-PIPE THROUGH LCE	TBD
6) LCE-PPF	• SPACECRAFT DOWNLINK	• WBTS/MICROWAVE	• 256 KB/S (FROM PAYLOAD UMBILICAL)

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
7) CDE-OMCE (SEE ALSO TABLE 6-1, REF. 1)	• TO CDE - KEYBOARD REQUESTS FOR WORK CONTROL/PROCEDURES/SCHEDULING PROGRAMS AND/OR DISPLAY DATA • FROM CDE - PROGRAM DATA (WORK CONTROL, SCHEDULING, PROCEDURES, ANOMALY DATA HISTORY FILES, TREND ANALYSES); DYNAMIC CRT UPDATES	• BIDIRECTIONAL, HARDWIRE COMPUTER-TO-COMPUTER (OMCE STATION SET MINI-PROCESSOR TO CDE) UNDER TERMINAL CONTROL. UNI-DIRECTIONAL CDE-TO-CRT • SAME AS ABOVE	TBD
8) VAFB RTS-SATELLITE/IUS	• RF COMMUNICATIONS COMPATIBILITY CHECKS FOR SGLS; FM TRANSMITTER (S-BAND); PAYLOAD SUPPORT (S-BAND) • UPLINK FOR LOAD OF CLASSIFIED DOD MISSION/FLIGHT TRAJECTORY DATA • SECURE VOICE	• RF OPEN LOOP • RF (WBTS/MICROWAVE) • DIGITAL DUPLEX	TBD
9) MLP-LCE	• CHECKOUT PROGRAM AND MISSION DATA LOADING	• 1 MB/S HARDWIRE UP/DOWNLINK, WBTS UNCLASSIFIED (2 EACH UP, 2 EACH DOWN)	TBD

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
9) (CONT'D)	• SSME CONTROLLER MEMORY LOADING	• 3 EACH HARDWIRE UP/DOWNLINKS, 60 KB/S, WBTS	TBD
	• TV, MAINTENANCE/LOOP RECORDER, P/L RECORDER, P/L DATA, SSME DATA	• 2.2-2.3 GHZ FM DOWNLINK, INCLUDING 256 KB/S P/L DATA	TBD
	• DETACHED P/L CMD	• WBTS (PREFLIGHT UNBILICAL); 8 KB (UNMANNED P/L)	TBD
	• DETACHED P/L DOWNLINK	• WBTS (PREFLIGHT UMBILICAL); 16 KB (UNMANNED P/L)	TBD
	• C&T DOWNLINK	• WBTS, 192 KB/S (138 KB PCM AND 2-32 KB VOICE; 128 KB INCLUDES 16 KB P/L DATA)	TBD
	• PCM DOWNLINK	• WBTS, 128 KB, INCLUDING 16 KB P/L DATA	TBD
	• DATA UPLINK (BLACK)	• 72 KB/S WBTS (8 KB CMD AND 2-32 KB VOICE)	TBD
	• DATA UPLINK (RED)	• SAME AS ABOVE	TBD
	• CCTV FROM ORBITER TO LCC FOR MONITORING	• WBTS; 30-4.5 MHZ VIDEO	TBD
10) KSC/MRTS-KSC PPF	• SPACECRAFT RF COMMUNICATIONS SYSTEM COMPATIBILITY CHECKS	• RF OPEN LOOP	• 1.76-1.84 GHZ (UP) • 2.2-2.3 GHZ (DOWN) S-BAND

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
11) KSC/MRTS-SATELLITE/IUS (DOD AT KSC)	• RF COMMUNICATIONS COMPATIBILITY CHECKS FOR SGLS, FM TRANSMITTER (S-BAND), P/L SUPPORT (S-BAND)	• RF OPEN LOOP	TBD
	• UPLINK FOR LOAD OF CLASSIFIED DOD MISSION/FLIGHT TRAJ DATA	• RF (WBTS/MICROWAVE)	TBD
	• SECURE VOICE	• DIGITAL DUPLEX	TBD
12) LCE-KSC CDE (DOD AT KSC)	• TO CDE - WORK CONTROL AND CHECKOUT PROGRAM CALLUP FROM KEYBOARD. SCHEDULE UPDATES FROM LCE PERSONNEL • FROM CDE - WORK CONTROL PROGRAMS, CHECKOUT PROGRAMS, DYNAMIC CRT UPDATES	• HARDWIRE, BIDIRECTIONAL COMPUTER-TO-COMPUTER (CDE-TO-STATION SET MINIPROCESSOR) UNDER TERMINAL KEYBOARD CONTROL; UNIDIRECTIONAL CDE-TO-CRT	TBD
	• FROM CDE - UNCLASSIFIED FLIGHT SOFTWARE AND UPDATES RECEIVED FROM STC FOR SUBSEQUENT UPLINK TO ONBOARD COMPUTERS	• HARDWIRE, UNIDIRECTIONAL COMPUTER-TO-COMPUTER (CDE-TO-ORBITER); BENT-PIPE THROUGH LCE	TBD

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
13) KSC/MRTS-KSC LCC VAULT (DOD AT KSC)	• REDUNDANT DOWNLINK VOICE AND TLM FROM ORBITER TO RTS	• HARDWIRE UNIDIRECTIONAL (LCC VAULT-TO-RTS) DOWN-LINK; 192 KB/S ENCRYPTED	• 192 KB/S (DETAILED CHARACTERISTICS TBD)
14) MLP-KSC P/L PROCESSING AT KSC	• SPACECRAFT DOWNLINK	• WBTS/MICROWAVE	• 256 KB/S (FROM PAYLOAD UMBILICAL)
15) KSC/MRTS-MLP (DOD AT KSC)	• REDUNDANT UPLINK TO OR-BITER FOR VOICE AND CMD DATA • P/L AND MAINTENANCE DATA DOWNLINK FROM ORBITER TO RTS	• HARDWIRE, UNIDIRECTIONAL (RTS-TO-MLP VAULT); 72 KB/S ENCRYPTED • HARDWIRE, UNIDIRECTIONAL (MLP VAULT-TO-RTS); 256 KB/S EITHER ENCRYPTED OR UNCLASSIFIED	• 72 KB/S (DETAILED CHARACTERISTICS TBD) • 256 KB/S (PAYLOAD) • 128 KB/S OR 1.024 MB/S (MAINTENANCE) • DETAILED CHARACTERISTICS TBD
16) KSC/MRTS-KSC CDS (DOD AT KSC)	• UNCLASSIFIED OR CLASSI-MISSION/FLIGHT TRAJ DATA LOADS FOR SUBSEQUENT TRANSFER TO LCE AND LOAD-ING INTO ORBITER/PAYLOAD	• W/B, HARDWIRE	TBD

TABLE 6-2 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
16) (CONT'D)	• ORBITER TEST DATA (UNCLASSIFIED, RECEIVED FROM KSC VIA SMCC/STC FOR DOD/KSC LAUNCHES)	• W/B, HARDWIRE	TBD
	• HISTORY, TREND, STATUS DATA FOR ON-PAD OPERATIONS MANAGEMENT (ANOMALY RESOLUTION IN PARTICULAR)	• W/B, HARDWIRE	TBD
17) MLP-LCE (DOD AT KSC)	• SAME AS (9) ABOVE	• SAME AS (9) ABOVE	TBD

TABLE 6-3

FLIGHT OPERATIONS FUNCTIONAL INTERFACES (DATA)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
1) SSV-RTS	• DOWNLINK TLM AND VOICE FROM SSV TO RTS	• 192 KB/S ENCRYPTED RF DOWNLINK	• TLM DOWNLINK A. SGLS CHANNELS: 4 OR 18 B. RF BANDWIDTH: 384 KHZ C. MODULATION FORMAT: SPLIT PHASE PCM/PM D. MODULATION INDEX: 1:1 RAD NOTE: CHANNEL (4), 2217.500 MHZ CHANNEL (18), 2287.500 MHZ
	• DOWNLINK P/L CR MAINTENANCE DATA DUMP	• 256 KB/S OR 1024 KB/S RF DOWNLINK	• TLM DOWNLINK A. SGLS CHANNEL: (BETWEEN 10 AND 11) B. MODULATION FORMAT: PCM/FM C. MODULATION INDEX: 0.36 NOTE: f_{ONE} TO, f_{ZERO} = f_{CAR} ± 0.36 (BIT RATE) CHANNEL (10), 2247.500 MHZ CHANNEL (11) 2252.500 MHZ

TABLE 6-3 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
	• UPLINK CMD AND VOICE FROM RTS TO SSV TO INCLUDE ONE-WAY DOPPLER STABLE FREQUENCY FOR ONBOARD STATE VECTOR UPDATE	• 72 KB/S ENCRYPTED RF UPLINK	• CMD UPLINK A. SGLS CHANNELS: 4 OR 18 B. RF BANDWIDTH: 144 KHZ C. MODULATION FORMAT: SPLIT PHASE PCM/PSK D. MODULATION INDEX: $\pi/2$ RAD NOTE: CHANNEL (4), 1775.732 MHZ CHANNEL (18), 1831.787 MHZ
2) SSV-TDRS GROUND STATION (CONTINGENCY ONLY)	• DOWNLINK TLM AND VOICE FROM SSV TO TDRS GROUND STATION • UPLINK CMD AND VOICE FROM TDRS GROUND STATION TO SSV	• 576 KB/S RF DOWNLINK VIA NASA TDRS • 216 KB/S RF UPLINK VIA NASA TDRS	TBD TBD
3) SSV-NASA/ STDN (CONTINGENCY ONLY)	• DOWNLINK TLM AND VOICE FROM SSV TO NASA/STDN • DOWNLINK P/L OR MAINTENANCE DATA DUMP	• SAME AS REFERENCE 1) EXCEPT UNENCRYPTED • SAME AS REFERENCE 1) EXCEPT UNENCRYPTED	TBD TBD
4) RTS-SMCC	• ORBITER AND P/L TLM AND VOICE FROM RTS TO SMCC	• 192 KB/S ENCRYPTED RF LINK	TBD

TABLE 6-3 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
	• P/L OR MAINTENANCE DATA DUMP FROM RTS TO SMCC	• 256 KB/S OR 1024 KB/S RF LINK	TBD
	• CMD AND VOICE FROM SMCC TO RTS	• 72 KB/S ENCRYPTED RF LINK	TBD
5) NASA/STDN-SMCC (CONTINGENCY ONLY)	• NONSECURE VOICE AND DATA COMMUNICATIONS FROM NASA/STDN TO SMCC DURING CONTINGENCY PERIODS REQUIRING GREATER STATION CONTACT	• TBD WB DATA AND VOICE LINK	TBD
	• ORBITER ACQUISITION DATA TO NASA/STDN FROM SMCC	• TBD WB DATA AND VOICE LINK	TBD
6) TDRS GROUND STATION SMCC (CONTINGENCY ONLY)	• ORBITER AND P/L TLM AND VOICE	• 576 KB/S UNENCRYPTED	TBD
	• ORBITER CMD AND VOICE	• 216 KB/S UNENCRYPTED	TBD
7) SMCC-LAUNCH SITES (KSC AND VAFB)	• MAINTENANCE DATA TO EITHER KSC OR VAFB CDE; DATA TERMINATION DEPENDENT ON PLANNED ORBITER LANDING SITE AND TURNAROUND OPERATIONS	• VAFB INTERFACE VIA SMCC TO VTS MICROWAVE LINK	TBD
		• KSC INTERFACE TBD	TBD
8) SMCC-USER	• P/L TLM DATA ROUTED TO SATELLITE MCC'S	TBD	TBD

TABLE 6-3 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
9) SMCC-LANDING SITE (OTHER THAN ORBITER UPLINK AND DOWNLINK) (KSC, VAFB)	• ORBITER STATUS FOR DE-ORBIT AND LANDING AND CONDITION OF ORBITER SYSTEMS	• VAFB VOICE AND DATA INTERFACE VIA SMCC TO VRTS MICROWAVE LINK	TBD
	• SAFE ORBIT CONDITION TO LANDING SITE AND RELEASE OF LANDING SITE FROM ABORT STATUS	• SMCC TO KSC INTERFACE TBD	TBD
		• SMCC TO EDWARDS AFB INTERFACE TBD	TBD
	• LANDING AND NAVAID STATUS FROM LANDING SITE TO SMCC		
	• LANDING SITE WEATHER STATUS		
10) SMCC-RANGE (NASA OR DOD)	• SRB IMPACT POINT DATA FOR RECOVERY OF SRB'S TO EITHER NASA OR DOD RECOVERY FORCES. TERMINATION OF INTERFACE DEPENDENT ON AGENCY RESPONSIBLE FOR SRB RECOVERY (I.E., NASA OR DOD)	TBD	TBD
11) SMCC-NASA/JSC	• ORBITER HISTORY DATA TO JSC FOR CONTINGENCY SUPPORT	• TBD WB DATA LINK	TBD
	• MISSION MANAGEMENT COORDINATION BETWEEN SMCC AND JSC	• VOICE LINK	TBD

TABLE 6-3 (CONT'D)

REFERENCE NUMBER	FUNCTION	TYPE OF INTERFACE	PHYSICAL & ELECTRICAL CHARACTERISTICS
	• PREMISSION MISSION PLANNING DATA FROM JSC TO SMCC	• TBD WB DATA LINK	TBD
12) SMCC-GOVERNMENT AND DOD AGENCIES	• WEATHER AND SOLAR FLARE DATA FROM NOAA TO SMCC	• TBD DATA LINK	TBD
	• ORBITER AND IUS TRAJ DATA FROM SMCC TO NORAD	• TBD DATA LINK	TBD
	• ORBITER FLIGHT PATH DATA TO FAA FOR AIR SPACE CLEARANCE FROM PRIOR TO DEORBIT TO LANDING	• TBD VOICE AND DATA LINK	TBD
	• COORDINATION WITH STATE DEPARTMENT OF ORBITER LANDINGS IN FOREIGN COUNTRIES FOR CONTINGENCY LANDINGS	• VOICE LINK	TBD
13) SMC-SMS	• TO BE SPECIFIED IN TASK IV		

TABLE 6-4
DEDICATED VOICE LINK CONFIGURATIONS

FROM \ TO	RANGE	CDE	OME	TCE	LCE	VTS	P/L PROC	MCE	MLP	SSV	MRTS	KSC P/L PROC	KSC CDE	KSC LC	RTS	TDRS STATION	NASA/STDN	USER MCC	LANDING AREA	JSC	SMS	NASA P/L AT VAFB
RANGE																						
CDE																						
OME		X																				
TCE		X																				
LCE	X	X																				
VTS	X	X			X																	
P/L PROC					X																	
MCE	X	X			X	X	X															
MLP	X				X																	
SSV					X		X	X	X													
MRTS					X			X														
KSC P/L PROC								X		X												
KSC CDE																						
KSC LC								X		X[1]	X	X	X									
RTS								X														
TDRS STATION								X														
NASA/STDN								X														
USER MCC							X	X				X		X								
LANDING AREA								X														
JSC					X		X	X	X										X			
SMS								X												X		
NASA P/L AT VAFB										X										X		

[1] DOD MISSIONS FROM KSC

APPENDIX A

TURNAROUND AND COMMUNICATIONS SUPPORT CONSIDERATIONS

A.1 CONTROL OF TURNAROUND ALTERNATIVES

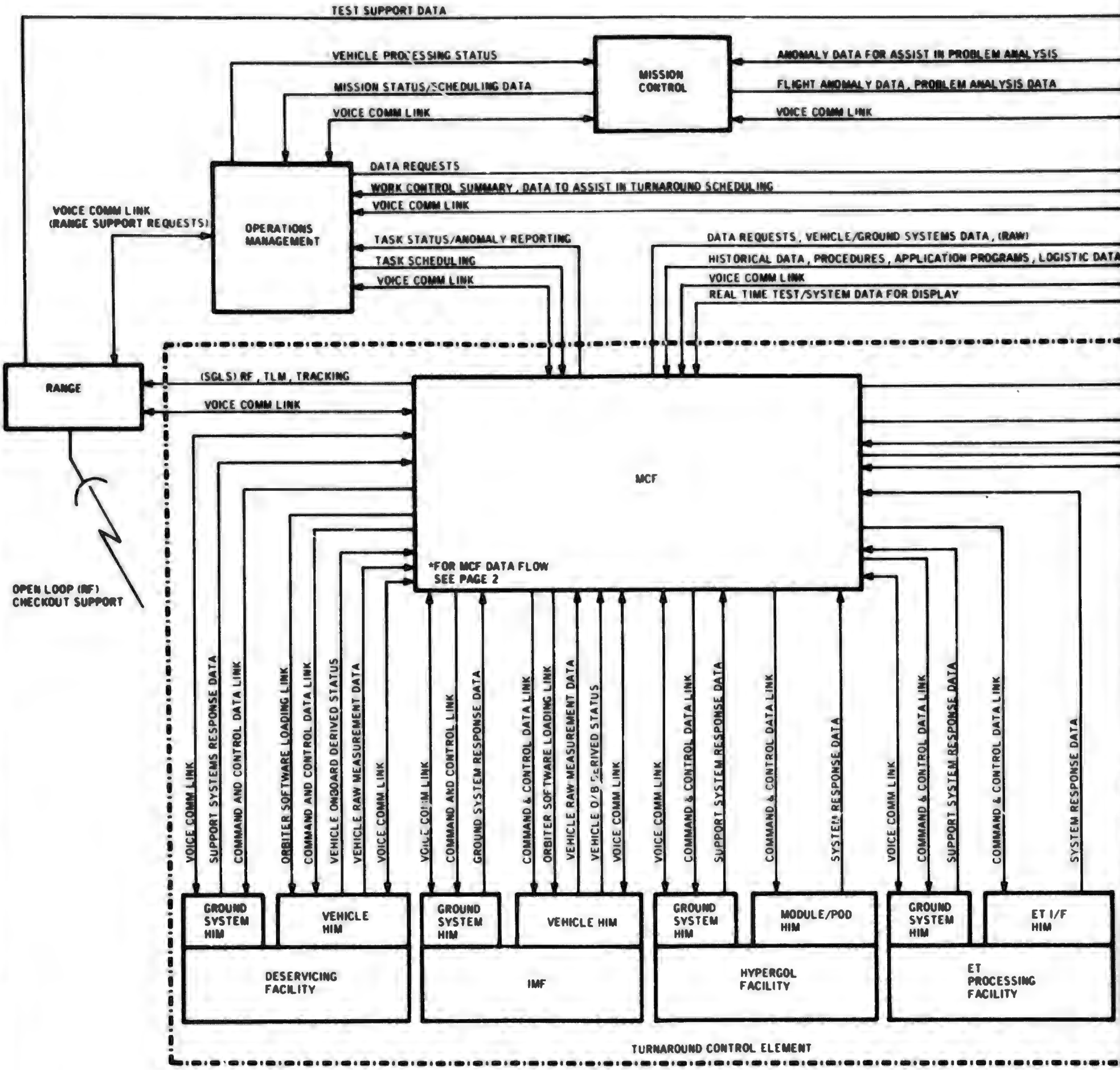
Turnaround control will be the element responsible for performing the CCDS functions required to process the Space Transportation System (STS) flight elements during ground turnaround. Three concepts for the control of turnaround are presented; however, since these are methods of implementing requirements, they are presented only for consideration when developing methods for implementing the turnaround functions at VAFB. The three concepts presented are: 1) control of turnaround from the Maintenance and Checkout Facility (MCF), 2) control of turnaround from individual station sets, and 3) control of turnaround from the launch control.

In developing these concepts, the following assumptions were made:

- Period of control for the Orbiter will be from the end of rollout after landing until rollout from the Integration and Mating Facility (IMF)
- Period of control for the external tank (ET) and solid rocket boosters (SRB's) will be from receipt through rollout from the IMF
- Control will include those offline functions applicable to this phase of turnaround operations.

A.1.1 Concept 1: MCF Control. In concept 1, control of turnaround is exercised from the MCF. Figure A-1 illustrates the data flow for the MCF control concept. Key features of this concept are:

- Personnel will be based at the MCF and dispatched to the various facilities as required
- Checkout will be accomplished by a central station located in the MCF


TEST SUPPORT DATA
VEHICLE PROCESSING STATUS
MISSION STATUS/SCHEDULING DATA
VOICE COMM LINK
MISSION CONTROL
ANOMALY DATA FOR ASSIST IN PROBLEM ANALYSIS
FLIGHT ANOMALY DATA, PROBLEM ANALYSIS DATA
VOICE COMM LINK
DATA REQUESTS
WORK CONTROL SUMMARY, DATA TO ASSIST IN TURNAROUND SCHEDULING
VOICE COMM LINK
VOICE COMM LINK (RANGE SUPPORT REQUESTS)
OPERATIONS MANAGEMENT
TASK STATUS/ANOMALY REPORTING
TASK SCHEDULING
VOICE COMM LINK
DATA REQUESTS, VEHICLE/GROUND SYSTEMS DATA, (RAW)
HISTORICAL DATA, PROCEDURES, APPLICATION PROGRAMS, LOGISTIC DATA
VOICE COMM LINK
REAL TIME TEST/SYSTEM DATA FOR DISPLAY
RANGE
(SGLS) RF, TLM, TRACKING
VOICE COMM LINK
MCF
OPEN LOOP (RF) CHECKOUT SUPPORT
*FOR MCF DATA FLOW SEE PAGE 2
VOICE COMM LINK
SUPPORT SYSTEMS RESPONSE DATA
COMMAND AND CONTROL DATA LINK
ORBITER SOFTWARE LOADING LINK
COMMAND AND CONTROL DATA LINK
VEHICLE ONBOARD DERIVED STATUS
VEHICLE RAW MEASUREMENT DATA
VOICE COMM LINK
VOICE COMM LINK
COMMAND AND CONTROL LINK
GROUND SYSTEM RESPONSE DATA
COMMAND & CONTROL DATA LINK
ORBITER SOFTWARE LOADING LINK
VEHICLE RAW MEASUREMENT DATA
VEHICLE O/B DERIVED STATUS
VOICE COMM LINK
VOICE COMM LINK
COMMAND & CONTROL DATA LINK
SUPPORT SYSTEM RESPONSE DATA
COMMAND & CONTROL DATA LINK
SYSTEM RESPONSE DATA
VOICE COMM LINK
COMMAND & CONTROL DATA LINK
SUPPORT SYSTEM RESPONSE DATA
COMMAND & CONTROL DATA LINK
SYSTEM RESPONSE DATA
GROUND SYSTEM HIM
VEHICLE HIM
DESERVICING FACILITY
GROUND SYSTEM HIM
VEHICLE HIM
IMF
GROUND SYSTEM HIM
MODULE/POD HIM
HYPERGOL FACILITY
GROUND SYSTEM HIM
ET I/F HIM
ET PROCESSING FACILITY
TURNAROUND CONTROL ELEMENT

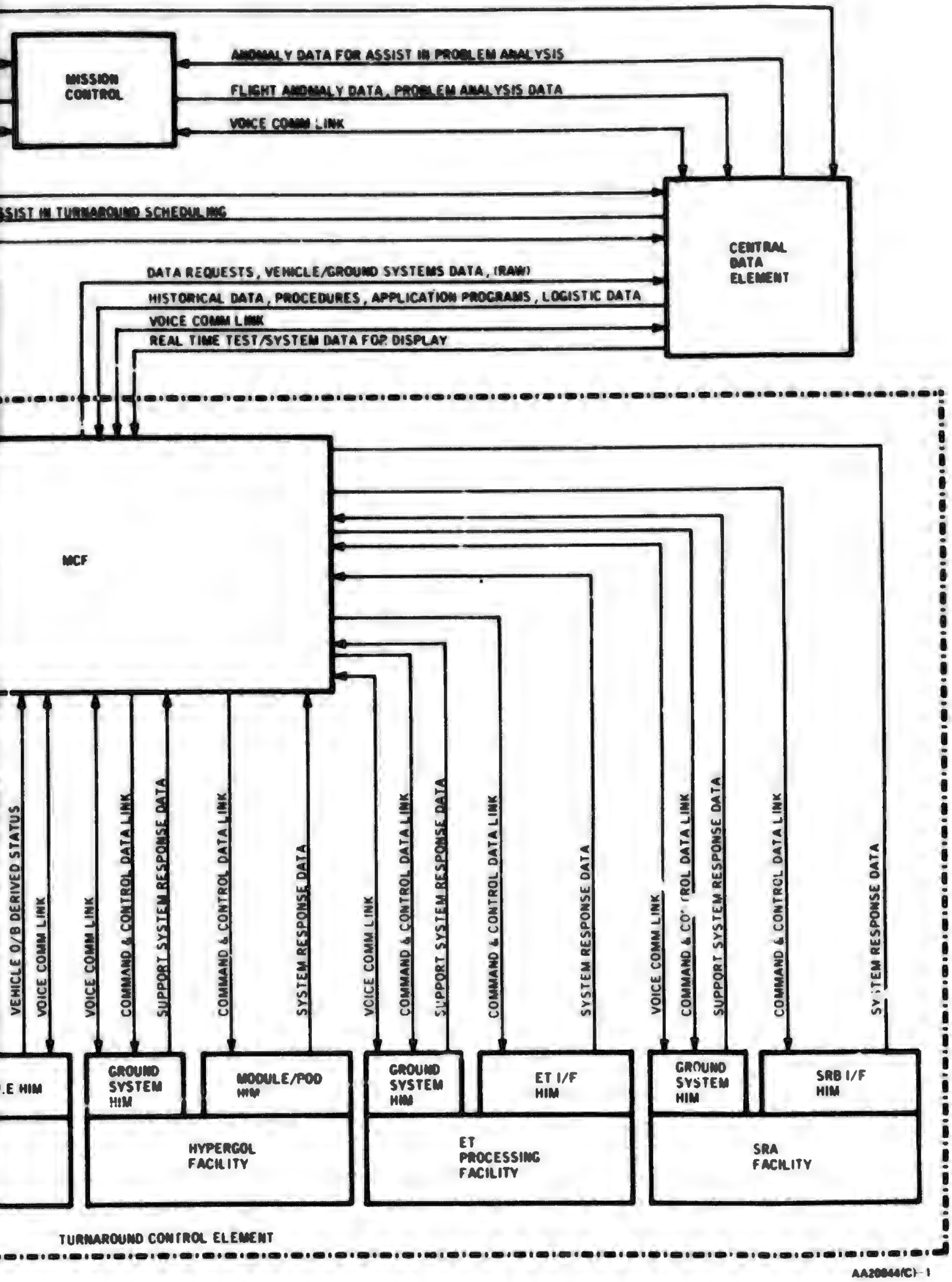


Figure A-1 Alternate Concept for Turnaround Operation

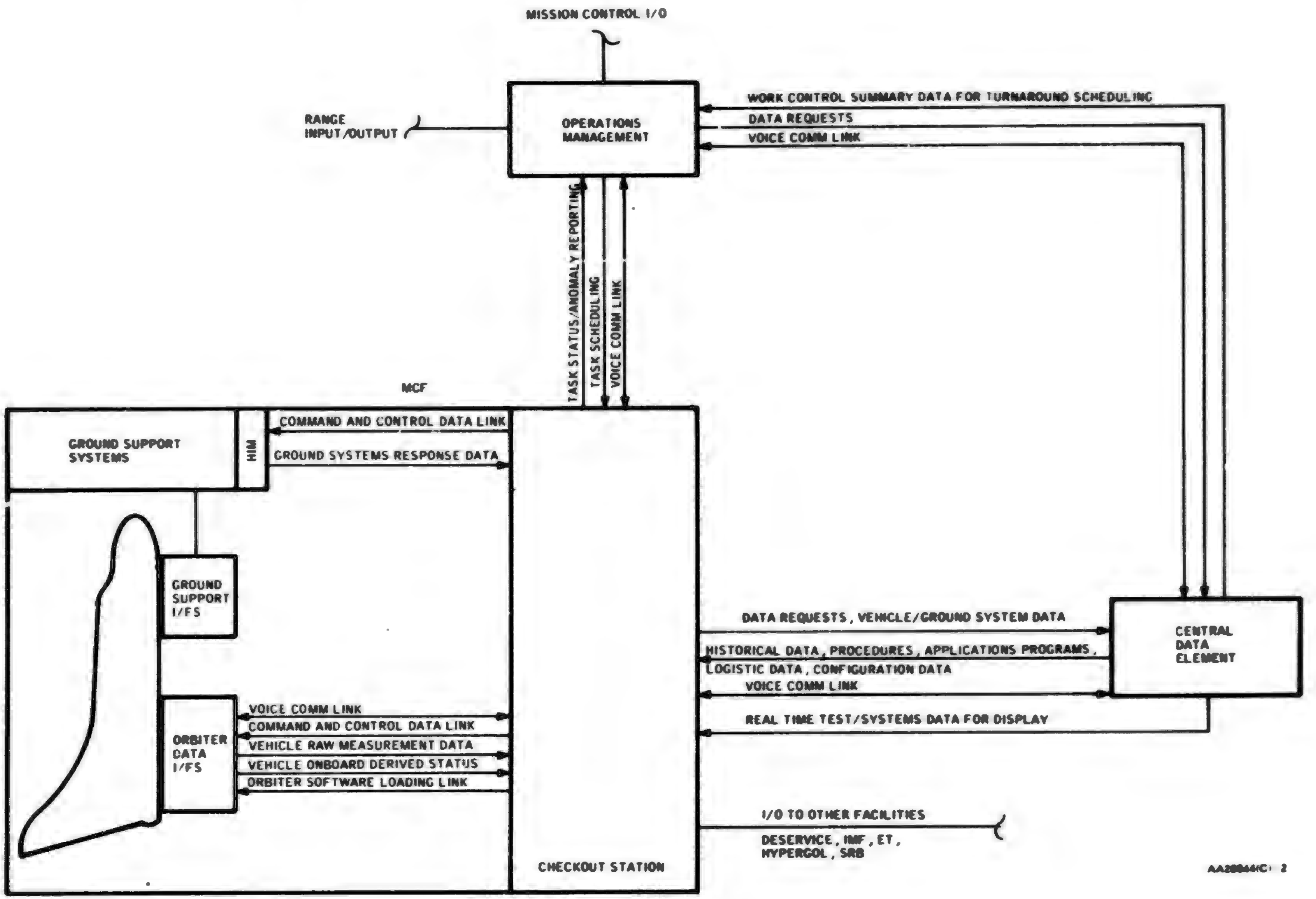


Figure A-1 (Cont'd)

A.1.1 Concept 1: MCF Control. (Cont'd)

- Interface with other facilities will be accomplished through hardware interface modules (HIM's)
- MCF station set will initiate all commands (manually or through application program) required to accomplish functions, control all operations and provide required displays
- Centralized control of equipment and personnel is provided.

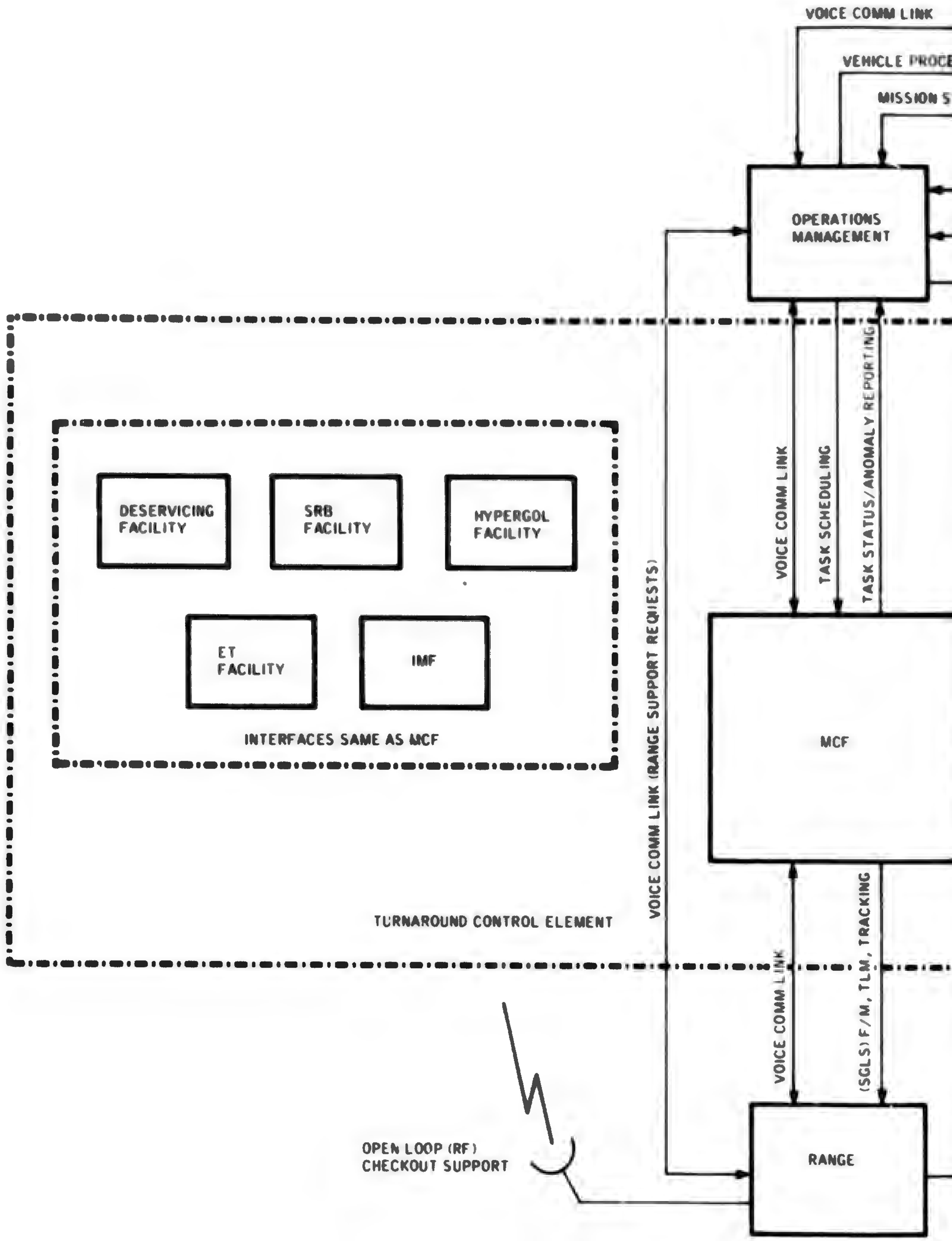
Control of turnaround from the MCF offers the following advantages:

- Cost Savings: one station set (MCF) versus six (MCF, IMF, SRB, ET, hypergol, and deservicing)
- Better utilization of equipment and personnel
- Less equipment to be maintained
- Centralized operations
- Divided workload between MCF and launch control center (LCC) during total operations
- Capability to support multi-vehicles in same stage of turnaround
- Greater redundancy capability
- Fewer personnel (assuming personnel are cross-trained) in multi-checkout functions.

Disadvantages of control from MCF are remoteness of the checkout personnel from the test article, necessary travel of personnel between facilities, and increased amount of hardware interfaces due to centralization.

A.1.2 Concept 2: Multiple Station Set Control. Individual station sets are used for turnaround control in concept 2. Figure A-2 illustrates the data flow for this concept. Its key features are:

- Facility station set will initiate all commands (manually or through application programs) required to accomplish its



VOICE COMM LINK
VEHICLE PROCE
MISSION S
OPERATIONS MANAGEMENT
DESERVICING FACILITY
SRB FACILITY
HYPERGOL FACILITY
ET FACILITY
IMF
INTERFACES SAME AS MCF
TURNAROUND CONTROL ELEMENT
VOICE COMM LINK (RANGE SUPPORT REQUESTS)
VOICE COMM LINK
TASK SCHEDULING
TASK STATUS/ANOMALY REPORTING
MCF
VOICE COMM LINK
(SGLS) F/M, TLM, TRACKING
OPEN LOOP (RF) CHECKOUT SUPPORT
RANGE

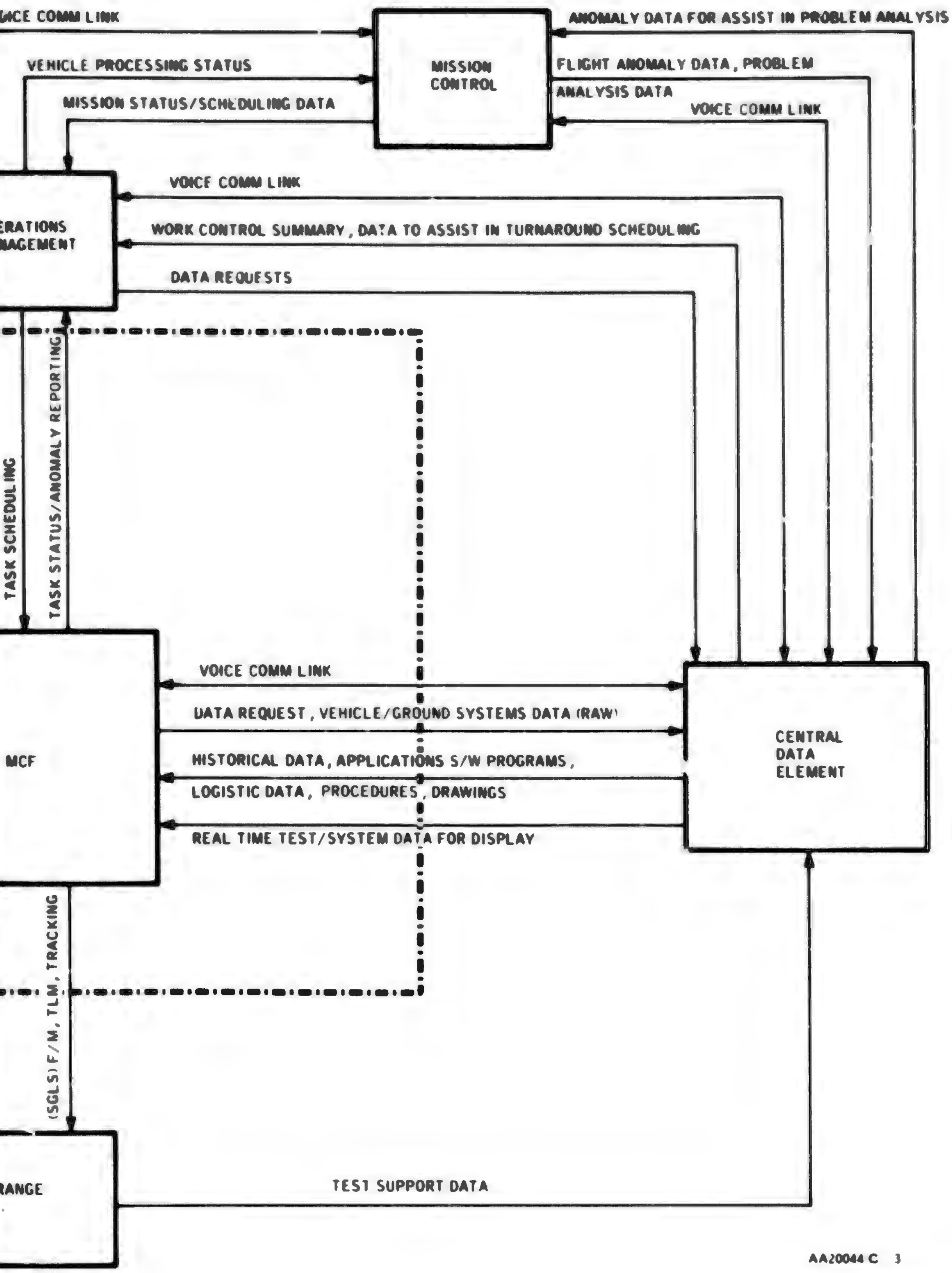


Figure A-2 Preferred Concept for Turnaround Operations (Refer also to Figure 4-4)

A.1.2 Concept 2: Multiple Station Set Control (Cont'd)

functions, control all operations conducted at that facility, and provide displays required at the facility

- Station sets will have autonomous capability
- Each facility will contain a checkout station and will operate independently from other facilities
- Personnel will be assigned to each facility. The vehicle will move; the crew remains at the facility.

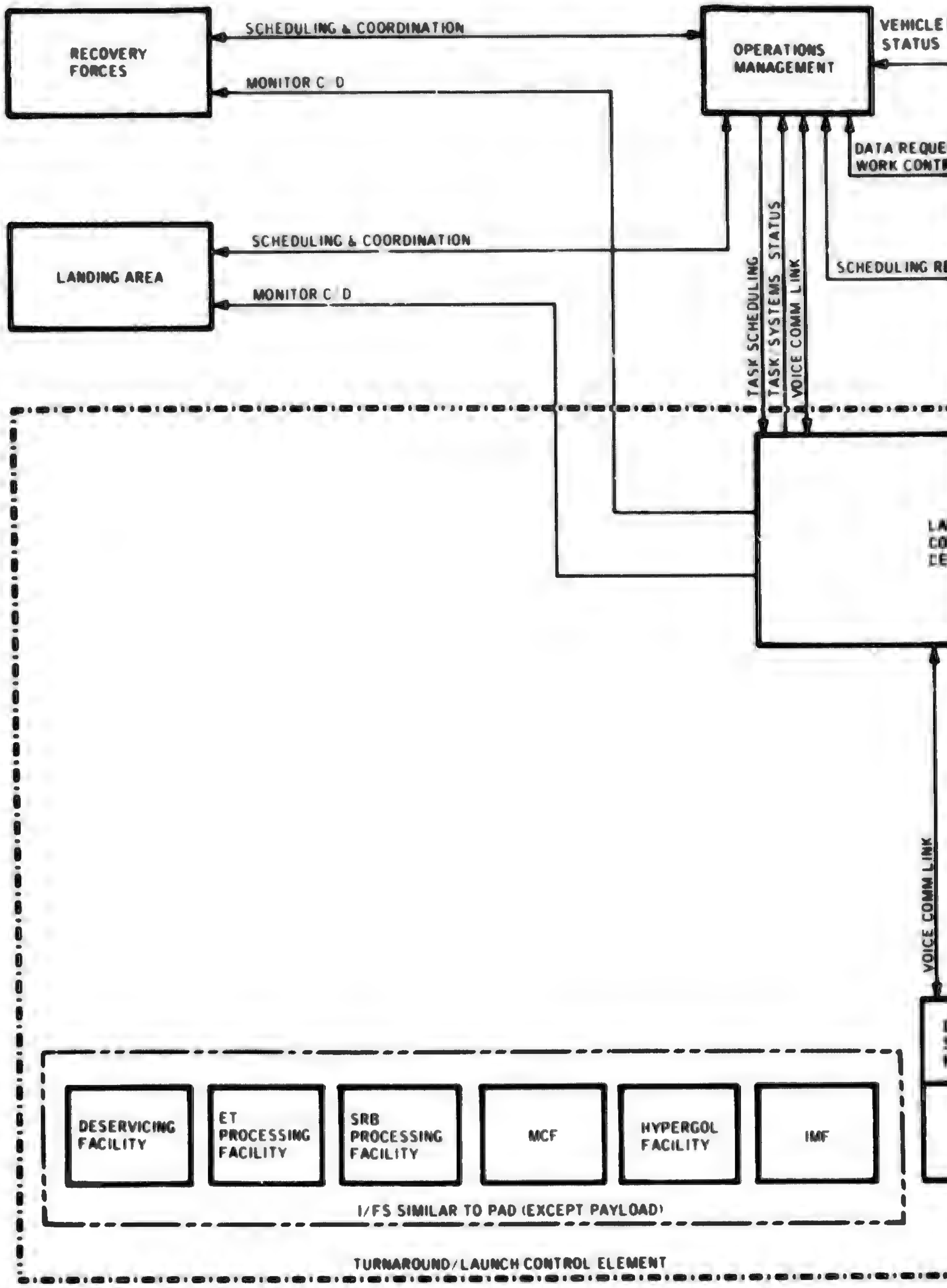
Concept 2 advantages are that it operates independently of other station sets, which presents no scheduling conflicts.

The disadvantages of multiple station set control include higher cost due to number of station sets required, poorer utilization of equipment and personnel, more equipment to be maintained, lack of centralized operations, and more personnel.

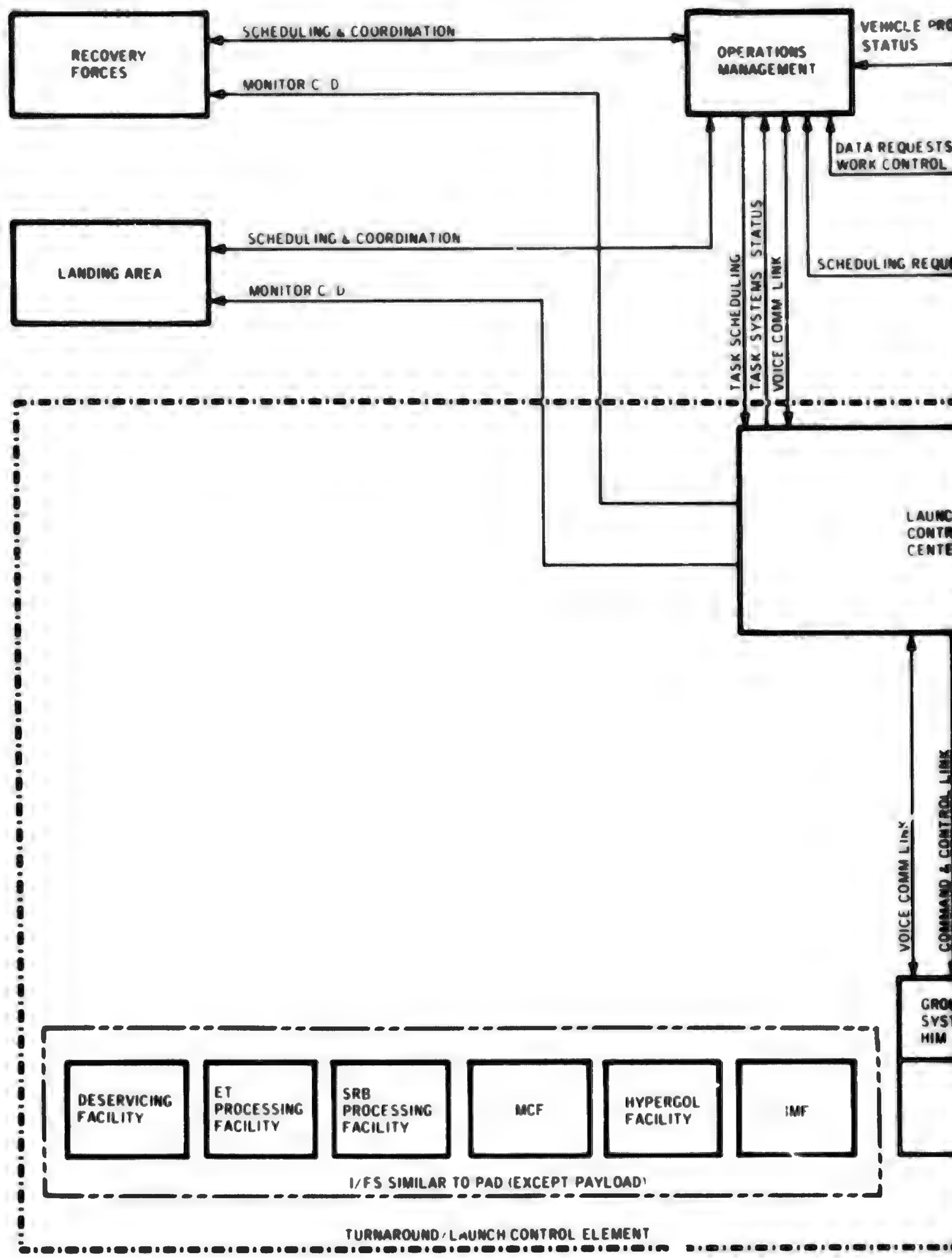
A.1.3 Concept 3: Control of Turnaround from Launch Control. In concept 3, turnaround control responsibility is merged with launch control. Figure A-3 illustrates the data flow for this concept. Concept 3 assumes there will be two firing rooms in the LC element.

Its key features are:

- Firing Room station set will initiate all commands (manually or application programs) required to accomplish functions, control all operations, and provide required displays
- Personnel will be based at the MCF and LCC and will be dispatched to the various facilities as required
- Checkout will be accomplished by one of the two stations located in Firing Rooms 1 and 2
- Interface with the other facilities will be accomplished through HIM's
- Centralized control of operations, equipment and personnel.



RECOVERY FORCES
SCHEDULING & COORDINATION
MONITOR C/D
OPERATIONS MANAGEMENT
VEHICLE STATUS
DATA REQUE
WORK CONTR
LANDING AREA
SCHEDULING & COORDINATION
MONITOR C/D
TASK SCHEDULING
TASK/SYSTEMS STATUS
VOICE COMM LINK
SCHEDULING RE
VOICE COMM LINK
DESERVICING FACILITY
ET PROCESSING FACILITY
SRB PROCESSING FACILITY
MCF
HYPERGOL FACILITY
IMF
I/FS SIMILAR TO PAD (EXCEPT PAYLOAD)
TURNAROUND/LAUNCH CONTROL ELEMENT


RECOVERY FORCES
SCHEDULING & COORDINATION
MONITOR C D
OPERATIONS MANAGEMENT
VEHICLE
STATUS
DATA REQUESTS
WORK CONTROL
LANDING AREA
SCHEDULING & COORDINATION
MONITOR C D
TASK SCHEDULING
TASK SYSTEMS STATUS
VOICE COMM LINK
VOICE COMM LINK
COMMAND & CONTROL LINK
DESERVICING FACILITY
ET PROCESSING FACILITY
SRB PROCESSING FACILITY
MCF
HYPERGOL FACILITY
IMF
I/FS SIMILAR TO PAD (EXCEPT PAYLOAD)
TURNAROUND/LAUNCH CONTROL ELEMENT

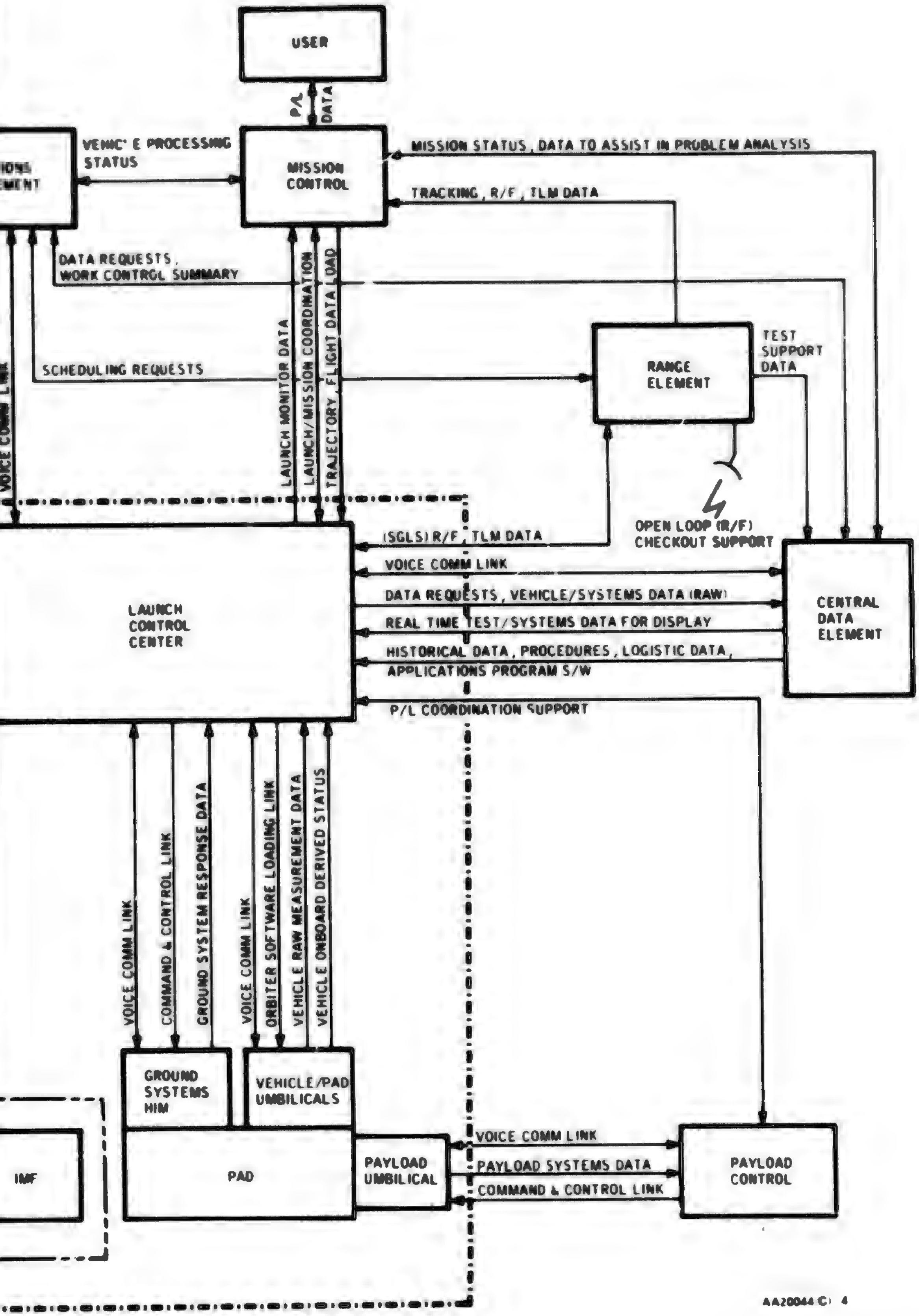


Figure A-3 Turnaround Control Responsibility (Concept 3)

A.1.3 Concept 3: Control of Turnaround from Launch Control. (Cont'd)

Concept 3 offers the following advantages:

- Cost Savings (over Concept 2): one station set (LCC) versus eight (MCF, I'4F, ET, SRB, hypergol, deservicing, pad, and LCC)
- Less equipment to be maintained
- Better utilization of equipment and personnel
- Centralized operations
- Fewer personnel.

Concept 3 has the following disadvantages:

- Cannot support more than two vehicles (two firing rooms)
- Possible scheduling conflicts
- Large workload in one area
- Lack of backup capability if one line fails with two vehicles in turnaround and launch
- Personnel required to travel between facilities
- Different working environments (launch-oriented personnel and hanger (maintenance)-oriented personnel working from same firing room).

A.2 COMMUNICATIONS SUPPORT OF SPACE VEHICLES

In a typical high-altitude deployment mission three vehicles are involved, i.e., the Orbiter, the interim upper stage (IUS), and the satellite. Baseline communications between these vehicles, or between a single vehicle and a remote tracking station (RTS), is via Space Ground Link Subsystem (SGLS) RF links.

A.2 COMMUNICATIONS SUPPORT OF SPACE VEHICLES (Cont'd)

The SGLS frequency band (2200-2300 MHz) is subdivided into 20 channels, each 5 MHz wide. The Satellite Control Facility (SCF) RTS's are currently configured with high-gain S-band antennas, having half-power beam width typically in the range of 0.5 to 0.7 degrees. Also, the current RTS receivers are capable of supporting downlink communications on only a single channel at a time, and the overall station channel changeover time is approximately 10 minutes.

A representative SGLS satellite contains a communications receiver which is preset to a single SGLS channel. Although the receiver front end contains an RF filter which acts to reject out-of-channel interference and there is further IF filtering, the satellite receivers are in no sense of the word narrow band; signals 10 or 20 MHz away from a given channel are capable of producing interference.

A.2.1 Simultaneous Communication. The considerations above complicate the problem of communications support to the vehicles after the IUS/satellite combination is deployed from the Orbiter, and result in the mission constraint that simultaneous communication to two vehicles will be scheduled only during dual station contact. This problem is evident regarding simultaneous communications to two or more of the vehicles from a given RTS, or from the Orbiter to two vehicles.

Consider for example the matter of RF links between a mated IUS/satellite, and an RTS. A first consideration is that, because of the beam-width of the SCF/RTS antennas (roughly 0.6 degrees), the antenna must be pointed very nearly dead at the mated pair before any communications can occur. Thus, the antenna must be prescheduled to make the link possible. From the point of view of the antenna, the pointing error cannot exceed 0.3°; from the spacecraft point of view the position error for spacecraft 110 nautical miles (nmi) high cannot exceed 0.58 nmi.

On the other hand, if the antenna is pointed at the IUS, then it is also pointed at the mated satellite. No repointing is needed to establish both communications links.

A.2.1 Simultaneous Communication. (Cont'd)

Now, if the IUS SGLS transmitter is on, radiating a few watts for communications to the ground, the matter of interference with, or damage to, the satellite SGLS receiver must be examined. For example, if the IUS transmitter is on the same channel, or even a closely adjacent channel, as the satellite receiver, there is the possibility of damage to the receiver front end. The situation is similar if the satellite transmits while the IUS is quiescent.

Alternatively, if the IUS and satellite channels are well removed, either can transmit while the other is quiet, with minimal risk of receiver damage. This type of operation, however, requires channel switching on the ground, or simultaneous operation of two ground stations (possible at only the three SCF dual stations), which at the very least doubles the RTS work load. Rapid channel switching at the RTS is currently not possible, and there are no outstanding plans to provide this capability.

Simultanous communications between the mated IUS/satellite spacecraft and an RTS (or the Orbiter) on the same SGLS channel creates the problem of each spacecraft transmitter jamming, or damaging, the other receiver. Furthermore, the current RTS receivers will not receive two SGLS signals simultaneously, either on the same channel or on separate channels. Additionally, the RTS transmitters can transmit on only one channel at a time [for commanding, data uploading, or psuedo-random noise (PRN) ranging]. RTS channel changeover time can represent a serious operations limitation for low-altitude spacecraft, since a changeover time of 10 minutes considerably exceeds the duration of many passes over an RTS.

Communications between an RTS and a mated IUS/satellite thus can be established by any of the various alternates:

A. Non-simultaneous communications on the same SGLS channel, but only after tests have been made to guarantee the safety of the spacecraft receiver.

B. Non-simultaneous communications on well-separated SGLS channels, but only if the RTS changeover time is reduced sufficiently for this mode of operation to provide effective support of DOD missions.

A.2.1 Simultaneous Communication. (Cont'd)

C. Simultaneous communications on well-separated SGLS channels, sufficient to avoid spacecraft receiver interference. This mode of operation requires new RTS receiving equipment.

D. Constraints on the mission that communications to two vehicles simultaneously or near-simultaneously will occur only when in contact with a dual SGLS site.

Obviously, the problem is further complicated by the addition of communications to the Orbiter when the Orbiter, the IUS and the satellite are all within an RTS antenna lobe at the same time. The problem is even more complex if the Orbiter is more than about 0.6 nmi from the mated IUS satellite, i.e., immediately following deployment of the mated spacecraft. In this case the RTS antenna must be repointed, or dual antennas must be used (only three SCF stations have this capability), or new antennas with broader main lobes (and hence lower gain) will be required.

A.2.2 Emergency Alert Initiation. A second major consideration is that, because of the narrow lobe width of the current SCF/RTS antennas, and because of the one-channel-at-a-time capability of the receivers, it is extremely unlikely that the Orbiter would be able to initiate an alert to an RTS in the event of an emergency. Unless the RTS is configured on a pre-scheduled channel, with its antenna pointed at the Orbiter during a pass, the Orbiter simply could not call into the RTS. There are two possible solutions to this problem, as follows:

A. In the event of an Orbiter contingency, the Orbiter could alert the SCF through the Tracking Data Relay Satellite (TDRS), then establish communications on an SGLS channel.

B. Each RTS could be augmented with emergency alarm receiving equipment, using a standard SGLS channel, an alarm receiver, and a low-gain, broad-lobe receiving antenna. Following the alarm the main communications would be established with the high-gain antenna and its associated (SGLS) receiver and transmitter.

A.2.2 Emergency Alert Initiation. (Cont'd)

Both these approaches of course must allow for enough time to configure the RTS and re-point the high-gain antenna. The required time could easily exceed the duration of the in-view time to any particular RTS. Both approaches also imply that the appropriate RTS's would provide emergency communications support to the Orbiter at a higher priority level than any other RTS activity.

APPENDIX B

LIST OF ACRONYMS AND ABBREVIATIONS

A

ACQ	acquisition
AFSCF	Air Force Satellite Control Facility
A/G	air to ground
APU	auxiliary power unit
ARTC	Air Route Traffic Control
ASAS	Aerodynamic Stability Augmentation System
ATC	Air Traffic Control

B

C

CCDS	Command and Control Data System
CDE	Central Data Element
CMD	command
COMSEC	communication security
CPU	central processing unit
CRT	cathode ray tube
C/T	crawler/transporter
C&T	Communication and Tracking
C&W	Caution and Warning
CY	calendar year

D

DISP	display
D/L	downlink
DOD	Department of Defense
D/R	display request
DSCS	defense support communication satellite

E

EOS	Earth-to-orbit Shuttle
ET	external tank
ETA	estimated time of acquisition
ETT	estimated time of track

F

FAA	Federal Aviation Administration
FM	frequency modulated

G

G&N	Guidance and Navigation
GN&C	Guidance, Navigation, and Control
GSE	ground support equipment
GSFC	Goddard Space Flight Center

H

HIM(s)	hardware interface module(s)

I

ICD	Interface Control Document
ID	identification
I/F	interface
IMF	Integration and Mating Facility
ILS	Instrument Landing System
I/O	input/output
IUS	Interium Upper Stage

J

JSC	Lyndon B. Johnson Space Center (Texas)

K

kb/s	kilo bits per second
KSC	Kennedy Space Center (Florida)

L

LC	Launch Control
LCC	Launch Control Center
LCE	Launch Control Element

L (Cont'd)

LCCSV	Launch Control Center Secure Vault
LEC	Lockheed Electronics Corporation
LOS	Loss of signal; line-of-sight
LP	launch pad
LPS	Launch Processing System
LPSV	Launch Pad Secure Vault
LRU	line replacement unit

M

MC	Mission Control
MCC	Mission Control Center
MCE	Mission Control Element
MCF	Maintenance and Checkout Facility
ME	main engine
MET	Mission Elapsed Time
MHz	megahertz
MLP	Mobile Launch Platform
MOD	Mission Operations Directorate
MRTS	Mini Remote Tracking Station

N

NASA	National Aeronautics and Space Administration
NAVAID	Navigation Aid
nmi	nautical mile(s)
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Air Defense

O

O/B	onboard
OIS	Operational Intercommunication System
O&M	Operations and Maintenance
OME	Operations Management Element
OMCC	Operations Management Control Center
OMCE	Operations Management Control Element
OMF	Orbiter Maintenance Facility
OMS	Orbiter Maneuvering Subsystem
OPF	Orbiter Processing Facility
ORD	Orbiter Requirements Document

P

PCE	Payload Control Element
PCM	pulse code modulated
PICRS	Program Information Control d Retrieval System
P/L	Payload
PLCC	Payload Control Center
PLCE	Payload Checkout Control Element
PMS	Performance Monitoring System
PPF	Payload Processing Facility

Q

Q	dynamic pressure

R

RC	Range Control
RCS	Reaction Control Subsystem
RE	Range Element
RF	radio frequency
RFCF	Radio Frequency Checkout Facility
RTS	remote tracking station
RVCE	Recovery Control Element
RVCF	Remote Vehicle Checkout Facility
R&QA	Reliability and Quality Control

S

SAIL	Shuttle Avionics Integration Laboratory
SAMSO	Space and Missile Systems Organization
SCF	Satellite Control Facility
SDL	Software Development Laboratory
SGLS	Space Ground Link Subsystem
SMCC	Shuttle Mission Control Center
SMS	Shuttle Mission Simulator
SRB	solid rocket booster
SSME	Space Shuttle main engine
SSV	Space Shuttle Vehicle
STC	Satellite Test Center
STDN	Space Tracking and Data Network
STS	Space Transportation System
SOW	Statement of Work
SW	software

T

TAC	Turnaround Control
TACAN	Tactical Air Navigation
TAEM	terminal area energy management
TBD	to be determined
TCE	Turnaround Control Element
TDM	time division multiplexed
TDRS	Tracking Data Relay Satellite
TLM	telemetry
TOR	Technical Operating Report
TRAJ	trajectory
TRK	tracking

U

Uhf	Ultra high frequency
U/L	Uplink
UMCC	User Mission Control Center
USAF	United States Air Force
USB	Unified S-Band

V

VAFB	Vandenberg Air Force Base
Vhf	Very high frequency
VLPS	Vandenberg Launch Processing System
VMMPS	Vehicle Management and Mission Planning System
VTS	Vandenberg Tracking Station

W

W/B	Wide Band
WTR	Western Test Range

X

Y

Z
