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DOD SPACE TRANSPORTATION SYSTEM (STS) COMMAND AND CONTROL DATA SYSTEM STUDY. VOLUME I. STUDY SUMMARY

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

Volume I - Study Summary

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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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1.0 Introduction

1.1 DOD COMMAND AND CONTROL DATA SYSTEMS STUDY OVERVIEW

This study addressed the Department of Defense (DOD) Command and Control Data Systems (CCDS) required to support DOD operations of the Space Transportation System (STS). As used in the study, CCDS was a collective term since it comprised the total 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, and the personnel required for direct or near-real-time control of the STS and its mission.

The CCDS is neither a single nor a totally new system. Much of it currently exists in the USAF Satellite Control Facility (SCF) and Vandenberg Air Force Base (VAFB) data communications systems. NASA-operated systems and facilities are to be utilized where possible to avoid DOD/NASA duplication of resources (e.g., mission planning system, JSC computational and system expertise resources for support of some contingencies, etc.). In addition, where new systems are required by the DOD, maximum utilization is to be made of systems being developed by NASA [e.g., Launch Processing System (LPS)] for implementation at USAF facilities.

The objectives of the CCDS study were to define:

- A set of traceable requirements on the DOD CCDS
- Functional DOD CCDS concept required to support the DOD STS operations
- AFSCF and Shuttle Mission Control Center (SMCC) requirements for STS support
- Shuttle Mission Simulator (SMS) capability required by DOD for training of DOD flight crews and controllers.

DOD Command and Control Data Systems Study Overview

OBJECTIVES:

- DEVELOP CCDS FUNCTIONAL REQUIREMENTS WITH TRACEABILITY
- DEFINE DOD CCDS CONCEPT TO SUPPORT DOD STS OPERATIONS
- DEFINE AFSCF AND SMCC REQUIREMENTS
- DEFINE SMS CAPABILITY REQUIRED BY DOD

1.2 SCOPE OF EFFORT

To define the scope of the CCDS study, the boundaries described below were given in the Statement of Work, either explicitly or implied, and subsequently confirmed as proper boundaries.

The CCDS was to be defined as a group of functional control elements (e.g., Mission Control, Launch Control, etc.). CCDS functions were to be allocated to one or more of these elements and a set of functional requirements defined for each.

The functional interfaces between control elements were to be defined in terms of the type data that passed between the elements. Similarly, the CCDS interfaces to elements external to it were also to be defined.

The phases of operation to be considered were prelaunch, ascent, on-orbit, rendezvous, uocking, payload deployment, payload retrieval, de-orbit to entry, entry to terminal approach, terminal approach to landing, landing and rollout, ferry, and turnaround operations.

The Shuttle System elements to be considered were the solid rocket boosters (SRB), external tank (ET), Orbiter, and the interim upper stage (IUS).

Detailed support requirements were to be developed for the AFSCF and SMCC in support of Shuttle operations. These requirements were to be published in an initial edition of an Orbital Requirements Document (ORD).

SMS analysis and DOD requirements determination were to be extrapolated from previous work done by NASA.

Budgetary cost estimates and schedule considerations for the DOD SMS were to be adapted from costs and schedules of NASA.

Scope of Effort

- LEVEL OF CONCEPT DEFINITION - FUNCTIONAL REQUIREMENTS/CONTROL ELEMENT
- INTERFACE REQUIREMENTS - FUNCTIONAL BETWEEN CONTROL ELEMENTS
- PHASES OF OPERATIONS - PRELAUNCH THROUGH SUBSEQUENT TURNAROUND
- CONSIDER ORBITER, SRB, ET, AND IUS
- AFSCF/SMCC REQUIREMENTS - LEVEL SUITABLE FOR ORD
- SMS REQUIREMENTS - ADAPT FROM NASA
- IMPLEMENTATION CONSIDERATIONS/BUDGETARY COST ESTIMATES - FOR SMS ONLY

1.3 TASKS AND REPORTS

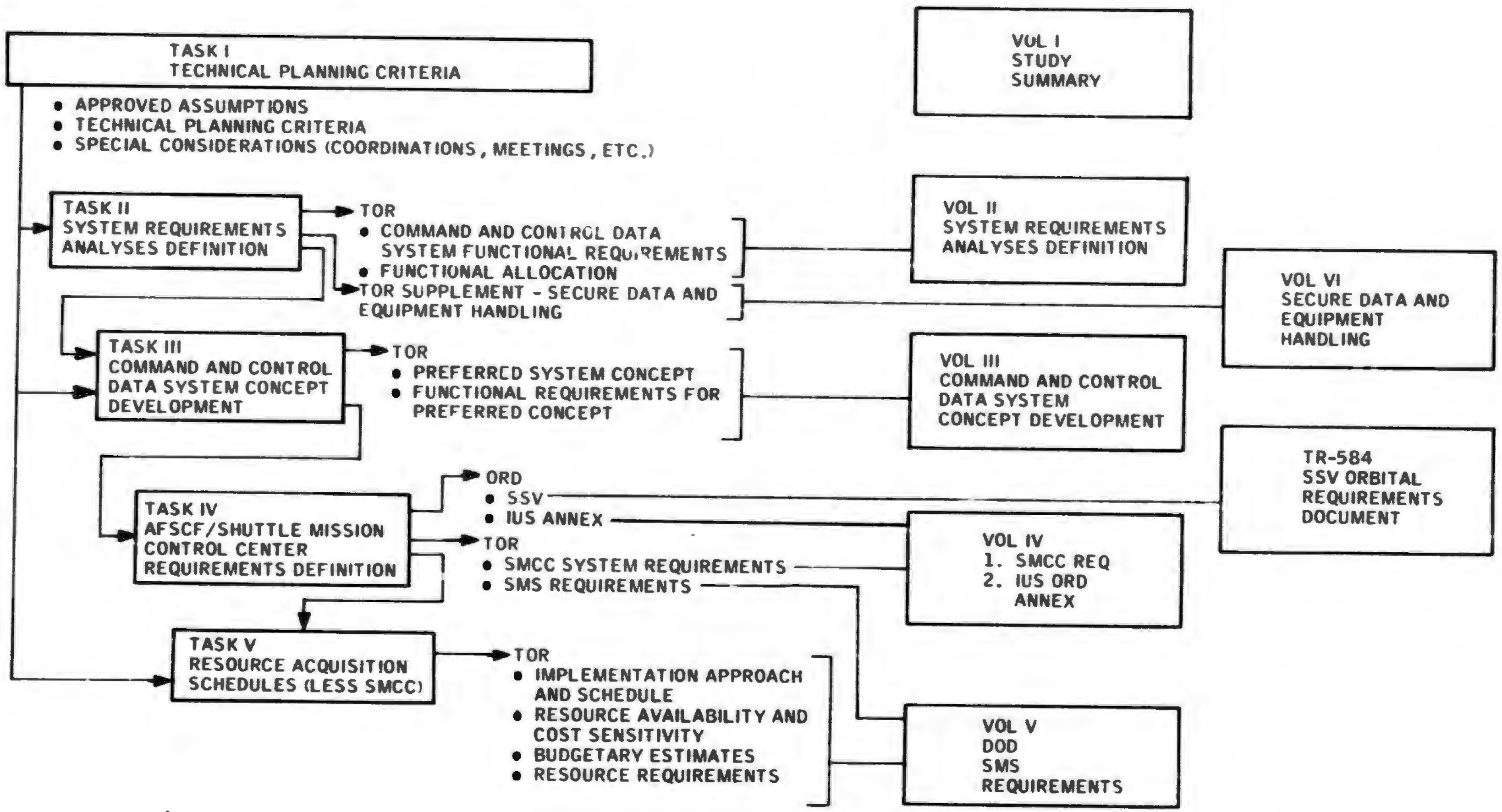
The attached chart indicates the tasks which comprised the total study and the reports generated during the study period. Volumes I-VI, shown on the right of the chart, indicate the volumes comprising the final report for this study. Task I, Technical Planning Criteria, developed the assumptions, guidelines, and STS system baselines to be used throughout the study. No specific report resulted from this task; however, the criteria established are reflected in reports resulting from subsequent tasks of the study. Task II resulted in two reports during the course of the study. These were a Technical Operating Report (TOR) which documented the CCDS functions and a supplement to the TOR which discussed secure data and equipment handling for DOD STS operations. These are also documented as volumes II and VI to this final report.

Task III developed the basic CCDS concept. It identified the control elements comprising the CCDS, identified their interfaces, and developed the functional requirements for each element. Volume III documents the results of this task.

Task IV investigated two separate STS areas: the SCF support requirements and the DOD SMS requirements. The support requirements for the Orbiter, ET, and SRB are documented in the *Orbital Requirements Document* (ORD), PHO-TR584, dated 15 October 1974; the support requirements for the IUS are in the form of a sample annex to the ORD, but because of the lack of IUS definition, it is documented as part II of volume IV of the final report. SMCC implementation approaches not contained in the ORD are documented as part I of volume IV.

DOD SMS requirements were defined in Task IV, and in Task V the budgetary costs and schedule estimates were developed. The results of both tasks are contained in volume V of the final report.

Tasks and Reports



1.4 STUDY PERFORMANCE SCHEDULE AND RESOURCE ALLOCATION

The percentages of the resources applied to each task and to the documentation are shown on the accompanying chart.

Task I - Technical Planning Criteria. Extended from the start of the study through 31 August and 9 percent of the total resources were devoted to it.

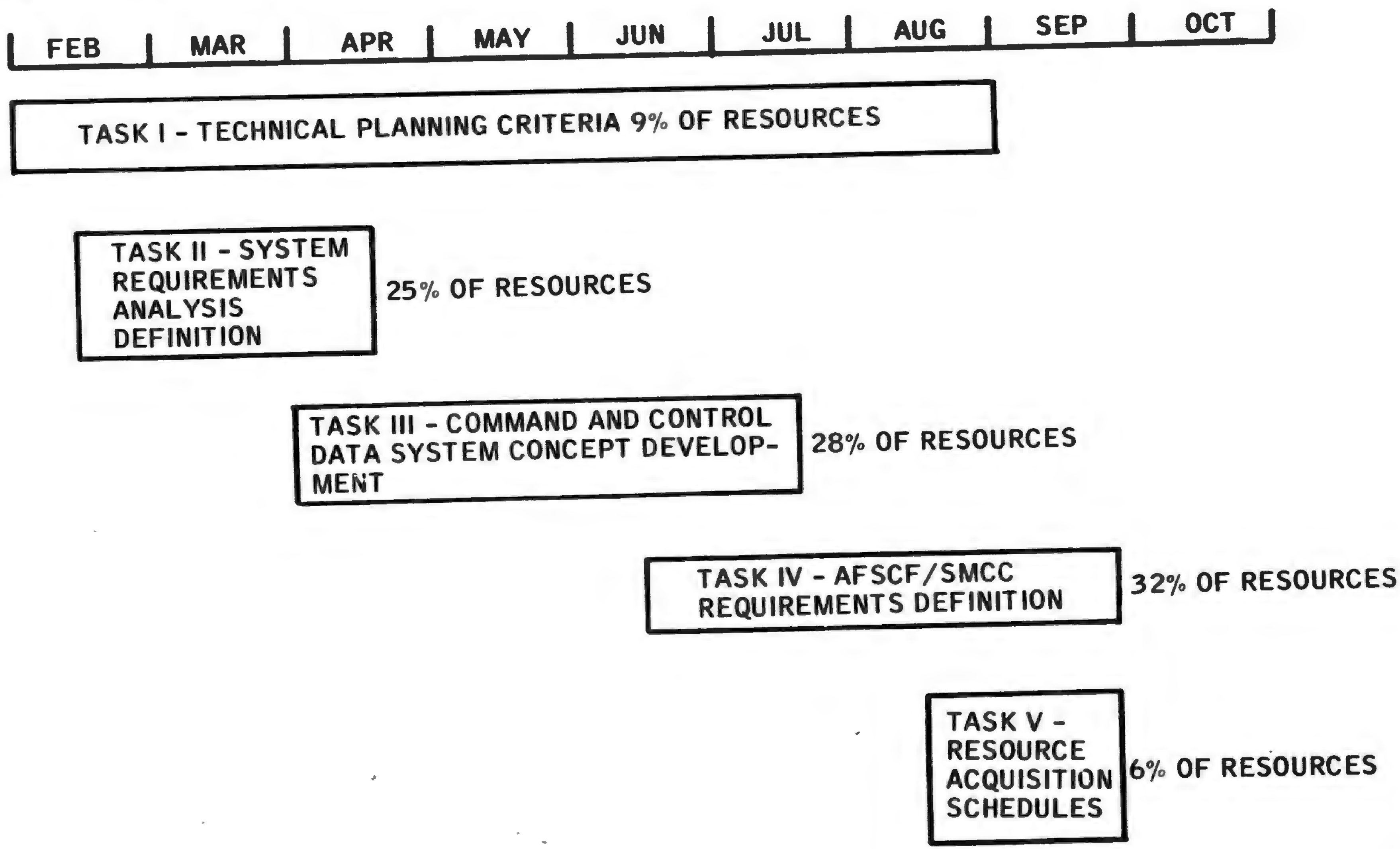
Task II - System Requirements Analysis Definition. Extended from approximately 15 February to 15 April and used 25 percent of the total resources.

Task III - CCDS Concept Development. Began about 1 April and extended through mid-July; approximately 28 percent of the total resources were expended on it.

Task IV - AFSCF/SMCC Requirements Definition. Began in mid-June and was completed the latter part of September; resources allocated to and expended on it were 31 percent.

Task V - Resource Acquistion Schedules. Was about a 1-month effort during August and September; 6 percent of the resource was expended on Task V.

Study Performance Schedule and Resource Allocation



2.0 Summary of Results

2.1 CCDS CONCEPT RESULTS

The CCDS concept resulted from Tasks II and III. These tasks, each of which will be discussed in more detail in subsequent sections of this volume, accomplished the following:

- Functions Determined. Criteria for allocating a function to either the CCDS or to the flight element were developed and applied to each STS function. This resulted in the set of functions required to be performed or supported by the CCDS.
- Control Elements Identified. It was determined that in support of mission operations and premission planning, a Mission Control Functional Element was required. In support of ground operations, the following functional elements were required: Turnaround Control, Launch Control, Operations Management, Central Data, Range, and Payload Control Elements. These were discussed as functional elements only and do not necessarily represent physical entities. For example, Turnaround Control and Launch Control could be combined in a single facility as could the functional elements of Operations Management and Central Data.
- Functions Allocated. CCDS functions identified were allocated to one or more of the functional control elements discussed above.
- Alternates Examined. Concept drivers were identified and alternatives to satisfy the drivers were developed. Recommendations on selected alternatives were made; i.e., the use of NASA resources for contingency/emergency support was identified as a driver, and the NASA and DOD divisions of responsibility for contingency support became alternatives for analysis.
- Interfaces Identified. Both the inter-element interfaces and the interfaces external to the CCDS were defined, and the information going through the interface was identified.
- Functional Requirements/Control Element. Functions allocated to each control element were examined further, and for each element, a set of functional requirements for personnel, data processing, display, command, control, and communications were developed.

Summarizing, Tasks II and III resulted in a CCDS concept defined in terms of its functional control elements, the functional requirements for each, and the inter-element and external interfaces.

CCDS Concept Results

- CCDS FUNCTIONS DETERMINED
- CCDS CONTROL ELEMENTS IDENTIFIED
- FUNCTIONS ALLOCATED TO CONTROL ELEMENTS
- ALTERNATE CONCEPTS EXAMINED
- INTERFACES IDENTIFIED
- FUNCTIONAL REQUIREMENTS/CONTROL ELEMENT DEVELOPED

2.2 AFSCF/SMCC REQUIREMENTS RESULTS

Subsequent to the start of the CCDS Study, the Air Force directed a change in the work to be done in Tasks IV and V. Pursuant to this change, the accomplishments summarized below resulted from the AFSCF/SMCC portion of Task IV. Each is discussed in more detail in later sections of this volume.

- Orbiter ORD. An ORD for the Orbiter, SRB's, and ET was published in October detailing the support requirements levied on the AFSCF for the STS. The ORD was prepared based on program detail currently available, program reference missions 1, 3A, and 3B, and DOD reference mission 2. Requirements that are specifically mission-dependent will be published in mission annexes to the basic ORD.
- IUS Annex. An ORD for the IUS was also developed. This was in the form of an annex to the Orbiter ORD; however, because of the lack of definitive detail available for the IUS, the annex was considered a sample only and is contained as part II of volume IV of the final report and not as an attachment to the SSV ORD.
- SMCC Operating Positions. Functions to be performed in the SMCC were examined and logically grouped in order to recommend the number of operating positions required. For nominal operations, involving an IUS, the number of operating positions recommended is seven.
- Position Requirements. Each function to be performed from an operating position was examined and the information display, control, and communications requirements to perform each function were determined.

AFSCF/SMCC Requirements Results

- ORD DEVELOPED FOR ORBITER
- SAMPLE IUS ANNEX DEVELOPED
- SMCC OPERATING POSITIONS RECOMMENDED
- OPERATING POSITION REQUIREMENTS DEVELOPED FOR:
  - -- INFORMATION DISPLAY
  - -- CONTROL
  - -- COMMUNICATIONS

2.3 SMS TASKS RESULTS

As part of the work change desired by the Air Force, the DOD requirements for an SMS were investigated. This resulted in the following accomplishments:

- Simulator Loading. It was determined that combined DOD/NASA utilization of the JSC SMS would result in simulator saturation.
- Saturation Dates. The SMS saturation for combined DOD/NASA utilization could occur as early as 1979.
- MCCS. A NASA-type Mission Control Center Simulator (MCCS) for use at the STC was recommended. A DOD MCCS would permit more realistic flight controller training and provide an increased checkout and validation capability.
- 2+4 SMS for STC. It was concluded that because of the saturation, a full capability-fixed base plus motion base-simulator was required by the DOD. This configuration is known as a "2+4" configuration. The 2 refers to the motion base crew station which has two crew positions; 4 refers to the fixed base crew station which has four crew stations. A 2+4 SMS consists of both the motion base and the fixed base crew stations.
- Cost and Schedule. Budgetary cost estimates for the SMS were provided for three separate configurations. These configurations were: 1) a 2+4 SMS at JSC; 2) a 2+4 SMS at JSC and one at the STC; and 3) a 2+4 SMS at JSC and a +4 SMS at STC. The cost estimates were based on cost figures provided to NASA by a simulator contractor and are subject to that accuracy. Schedule estimates were developed for the 2+4 SMS installed at the STC.

SMS Tasks Results

- DOD IMPACT ON JSC SIMULATOR LOADING DETERMINED
- SATURATION DATES FOR NASA JSC SMS DETERMINED
- A DOD NEED FOR MCCS DETERMINED
- DOD PROCUREMENT OF A FULL CAPABILITY SMS FOR STC RECOMMENDED
- BUDGETARY COST AND SCHEDULE ESTIMATES PROVIDED

3.0 CCDS Concept Development

3.1 Method

3.1.1 TECHNICAL PLANNING CRITERIA

As the first task in the study effort, technical planning criteria were established to serve as a guide to subsequent study tasks. Primarily, this study phase was oriented to provide:

- Definition of study terms and determination of references and general study guidelines.
- Rules or guidelines for allocation of functions; results were basically "ground vs. Orbiter" oriented.
- Definition of assumptions such as maximum loading (two Orbiters), contingencies, secure communications, and joint-use interface criteria.
- Requirements/source traceability; a listing was prepared to establish the correlation between a requirement and its source document.

Technical Planning Criteria

TECHNICAL PLANNING CRITERIA ESTABLISHED PROVIDED:

- DEFINITION OF STUDY TERMS
- GROUNDRULES AND GUIDELINES FOR ALLOCATION OF FUNCTIONS
- DEFINITION OF ASSUMPTIONS
- REQUIREMENTS/SOURCE TRACEABILITY

3.1.2 ALLOCATION CRITERIA

The key criterion for the functional allocation was that if the function could be done onboard; it would be done onboard. Considering this as the primary guideline, allocation criteria were established which provided that all functions involving the following would be allocated to the CCDS.

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

Allocation Criteria

ALL FUNCTIONS INVOLVING THE FOLLOWING WERE ALLOCATED TO THE CCDS:

- COMMAND AND/OR CONTROL WHICH CANNOT BE EXERCISED BY THE FLIGHT VEHICLE ELEMENTS
- OVERALL MANAGEMENT OR OPERATIONS
- MANAGEMENT OF DATA
- TELECOMMUNICATIONS/TELEPROCESSING
- MISSION DESIGN ACTIVITIES
- SIMULATIONS
- TRAINING
- CONTINGENCY REACTION/SUPPORT
- CONTROL AND MONITOR OF ONBOARD COMPUTATIONAL CAPABILITIES DURING GROUND CHECKOUT
- REMOTE CONTROL AND MONITORING FUNCTIONS FOR GSE AND FACILITIES

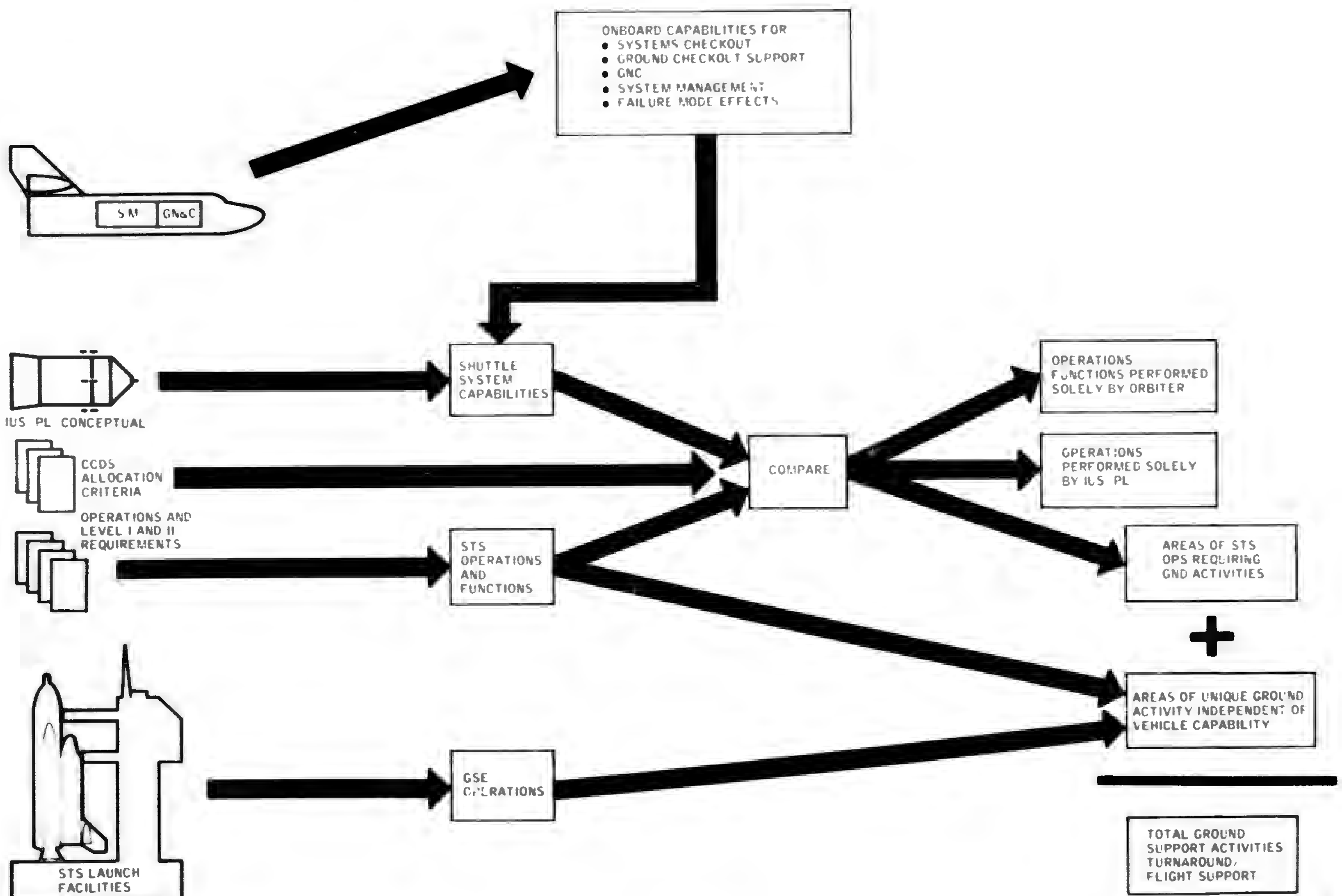
3.1.3 DETERMINATION OF CCDS FUNCTIONS

STS operations were examined to determine the functions required of the CCDS. These functions, or the support of these functions, were allocated to the ground or flight elements of the STS. The basis for this allocation was the functional capabilities of the baseline vehicles. Many of the allocations were recognized as preliminary due to developing design requirements on some of the vehicle systems. For example, the division of the on-pad checkout functions between onboard and ground computers remains a pacing item.

Throughout the analysis, emphasis was placed on the online support for nominal missions, with the intent of comparing functions with vehicle capabilities. Only if a function had not been specified to be performed on the vehicle would it be allocated to the ground. This approach was used in order to minimize the ground support, which is a stated program objective of both NASA and the DOD. Many factors have potential impacts on the allocation of functions to the onboard systems and crew resources. The availability of time and resources for onboard processing tasks is a major consideration. Crew time has classically been at a premium in manned space flight to date. The management of onboard systems, the performance assessment of complex flight elements, and vehicle monitoring functions will require a highly trained crewman. Some of these factors may result in off loading of onboard tasks to ground systems for specific missions.

Functions allocated to the ground CCDS formed the basis for the subsequent development of the ground CCDS support concept.

Determination of CCDS Functions



3.1.4 SAMPLE ALLOCATION SHEET

All STS functions were investigated, the allocation criteria applied, and the results documented on allocation sheets as indicated on the sample sheet. In addition, the chart indicates the CCDS function required to support each vehicle function, a traceability reference to Level II for each CCDS function, and any explanatory remarks required.

Sample Allocation Sheet

POST LANDING & SECURING OPERATIONS

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

*MANUAL, FACILITIES, GSE AND SE

3.2 CCDS Concept Overview

3.2.1 CCDS DRIVERS

Program requirements, DOD requirements, and joint program plans were reviewed and items considered drivers on the CCDS were identified. These drivers include the following.

- Baseline Operations Commitments. The joint NASA/DOD program plan states responsibilities for the "agent" of the Shuttle Program. For example, the launch agent (NASA at KSC, DOD at VAFB) is to be responsible for the vehicle from rollout until liftoff; the mission agent (DOD for DOD payloads, NASA for non-DOD payloads) provides mission support from liftoff until rollout.

- Joint Use. A DOD requirement states that maximum use of GSE and procedures to be developed at KSC by NASA will be made by the DOD at VAFB. Level II requirements state that common mission planning, data bases, and software resources will be used.

- Orbiter Autonomy. A DOD requirement states the Orbiter shall be capable of performing its on-orbit operations independent of any dedicated ground support.

- NASA Contingency Support. The joint program plan states the other agency's SMCC will be made available, if requested by the mission agent, for support of on-orbit contingencies. Because of the extensive system expertise and computational capabilities expected to be present at the NASA SMCC, DOD will request NASA to provide any extensive support required for DOD Orbiter contingencies.

- 160 Hour Turnaround. A Level I requirement specifies the capability to prepare an Orbiter for launch in 160 hours within a 14-day period.

- Secure Data Handling. DOD requirements specify secure Orbiter-to-ground and ground-to-Orbiter communications.

- Dual Mission. An operational consideration is the probability that two Orbiters on a DOD mission may have to be supported simultaneously.

CCDS Drivers

- BASELINE OPERATIONS COMMITMENTS (JOINT PROGRAM PLAN)
- JOINT USE OF NASA DEVELOPED SYSTEMS/PROCEDURES (LEVEL II AND DOD REQUIREMENT)
- AUTONOMY OF ORBITER (DOD REQUIREMENT)
- NASA CONTINGENCY SUPPORT (JOINT PROGRAM PLAN)
- TURNAROUND GOAL OF 160 HOURS (LEVEL I REQUIREMENT)
- SECURE DATA HANDLING (DOD REQUIREMENT)
- DUAL MISSION CAPABILITY (OPERATIONAL CONSIDERATION)

3.2.2 CCDS Control Element Responsibilities

An overview of the CCDS in terms of its control elements and their top level functions is indicated on the attached chart. As presented here, the elements and functions represent DOD missions launched from either VAFB or KSC. For simplicity, the chart illustrates the time period during which the functional element is actively supporting a flight element(s) between liftoff and the subsequent liftoff of the same vehicle on its next mission. Obviously, the begin/end points are not as distinct as shown. For example, Mission Control is active during pre- and postmission phases, and is responsible for mission planning, design, analysis, flight crew and controller training, and postmission Orbiter data analysis. Turnaround Control must plan its operations for receipt of the next vehicle, receipt of the returned SRB's, and receipt of refurbished SRB's during periods not indicated on the chart. The elements of Turnaround Control, Launch Control, Operations Management, and Central Data can be considered as the VAFB or KSC LPS.

In summary, Mission Control is the active element supporting Shuttle from liftoff through rollout of the returned Orbiter. It must manage the mission and be prepared to react to any contingencies, either through direct support or through assistance provided by NASA. Mission Control is also involved in pre-liftoff verification tests and postmission data dumps.

Turnaround Control assumes control of the vehicle at rollout and maintains this control until delivery of the Orbiter (integrated or separate) to the launch pad. Its top-level function is maintenance and checkout.

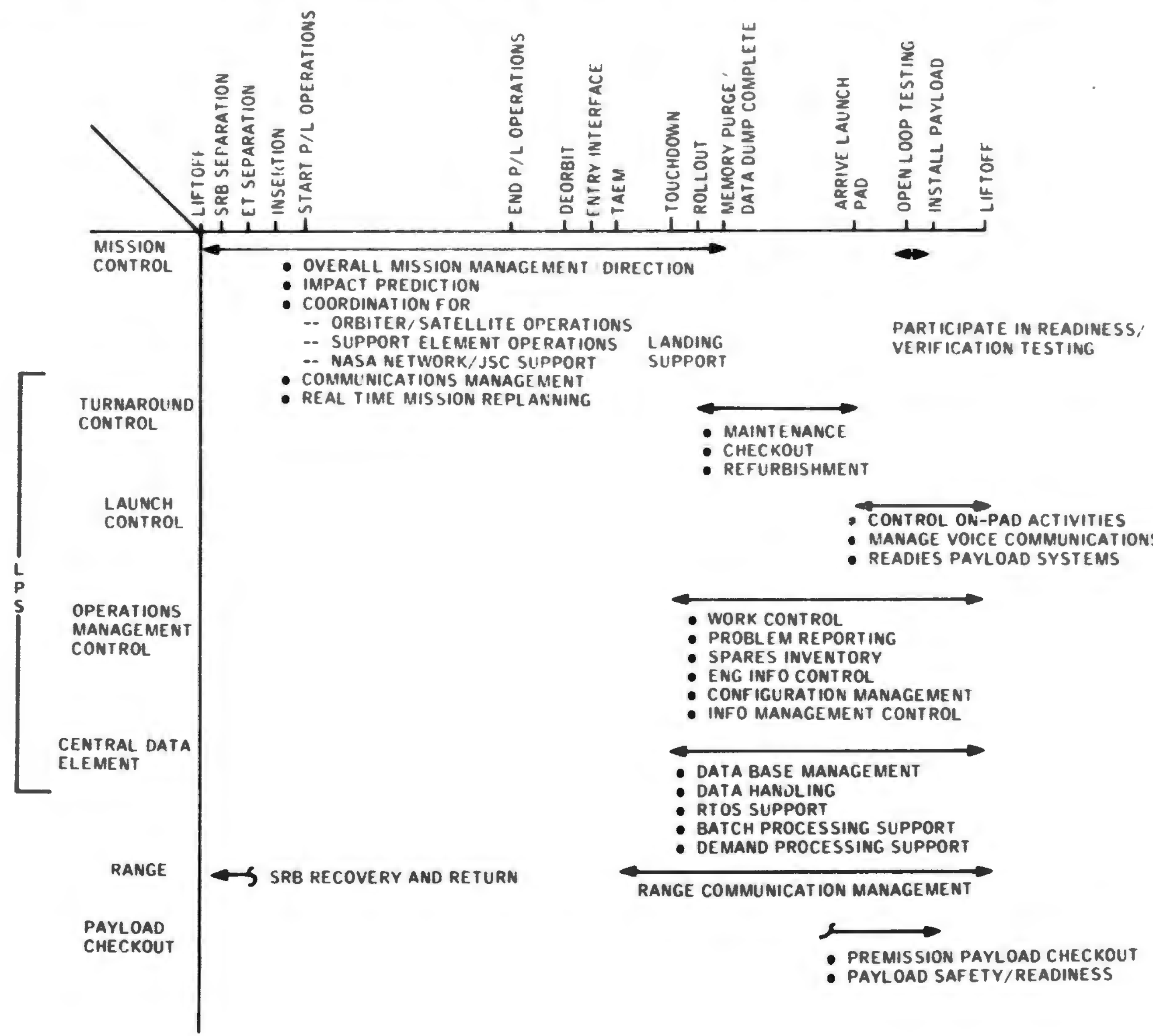
Launch Control is the primary element for support from arrival at the launch pad until liftoff. It is responsible for the on-pad activities.

Operations Management is responsible for the scheduling of launch site work, and for ensuring smooth operations between the turnaround and launch elements. A major resource used by Operations Management, Turnaround Control, and Launch Control is the Central Data element.

The Range element is resident at either launch site, and is responsible for SRB recovery and return, and for range communication management.

Payload Checkout is responsible for delivering a safe, fully checked out payload to the launch pad for installation into the Orbiter.

CCDS Control Element Responsibilities



3.2.3 KEY FEATURES

Key features of the CCDS concept include:

- Maximum utilization of NASA-developed systems for use at VAFB
- 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
- 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
- Real-time processing for mission evaluation decisions, contingency reaction, and anomaly resolution
- A vehicle processing scheme permitting multiple vehicle and vehicle elements to flow through the system

Key Features

PROVIDES/PERMITS

- MAXIMUM USE OF NASA DEVELOPED SYSTEMS (EQUIPMENT AND SOFTWARE) AT VAFB
- AUTOMATIC CHECKOUT
- CENTRAL DATA ELEMENT
- AUTOMATED WORK CONTROL
- MAXIMUM UTILIZATION OF NASA CAPABILITIES AND PLANNED RESOURCES
- REAL-TIME PROCESSING
- MULTIPLE VEHICLE PROCESSING

3.3 DOD Ground Operations (VAFB)

3.3.1 GROUND OPERATIONS CONCEPT DRIVERS

Partitioning of Checkout Responsibility (Ground vs. Orbiter). Assessment of this issue for concept development was directed towards the following three subissues: 1) defining partitioning guidelines, 2) defining a general checkout philosophy, 3) categorizing types of checkout software encountered.

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 dealt with the needs for and methods of manual intervention during checkout initialization, during normal processing sequences (e.g., key-entry branching to automated subroutines at prescribed points in the checkout sequence), and primarily during contingency situations.

Operations Management and Work Control. The concept assessment indicated that the 160-hour turnaround requirement will result in complex scheduling, procedural 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), 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. The major OMCE programs (systems) identified were: 1) work control; 2) problem reporting, reliability and QA; 3) engineering information; 4) spares inventory/logistics; 5) configuration control, and 6) information management support (data base management).

Baseline Operations Commitments. Another major concept driver was the baseline operations requirements defined in program level documentation. Primary considerations in this area (relative to ground operations) were launch-agent-to-mission-agent handover, onpad prelaunch support, control of mission/flight operations from an SMCC, dual turnaround operations, and KSC Launch Processing System concept applicability.

Secure Data Handling. Considerations for secure data handling include 1) location and function of secure areas at KSC and VAFB, 2) required distribution of classified and/or encrypted data both at KSC and VAFB, and 3) secure data link requirements between AFSCF and KSC.

Cost and Implementation Considerstions. 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.

Ground Operations Concept Drivers

COMPATIBILITY WITH 160-HOUR TURNAROUND GOAL

- PARTITIONING OF CHECKOUT RESPONSIBILITY (GROUND VS ORBITER)
- NEED FOR AUTOMATED CHECKOUT
- NEED FOR OPERATIONS MANAGEMENT ELEMENT

BASELINE OPERATIONS COMMITMENTS - LAUNCH/MISSION AGENT RESPONSIBILITY DIVISION

SECURE DATA HANDLING IMPACT - DOD AT KSC IN PARTICULAR

ECONOMY AND SCHEDULE COMMITMENTS

3.3.2 TURNAROUND OPERATIONS CONCEPT

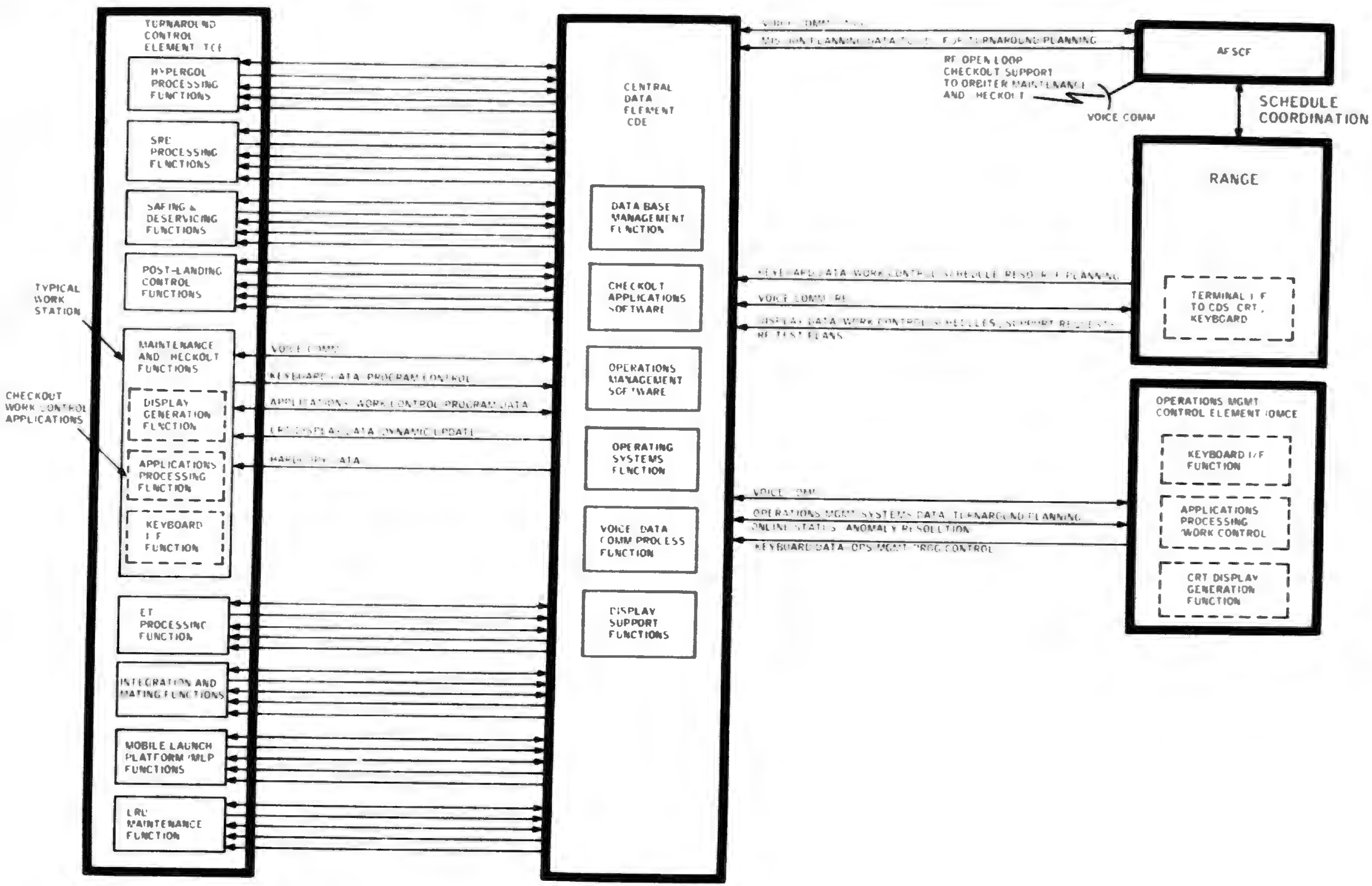
Turnaround operations begin at rollout of the returned Orbiter or receipt of an Orbiter via ferry. They end upon delivery of the Orbiter to the launch pad.

- Turnaround (Planning Phase). Prior to actual online turnaround, the development of procedures and schedules will be required. For these operations, the concept of work control is particularly applicable. The total planning phase envisioned includes 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 utilizing the work control station/CDE flow shown on the facing page, with keyboard interface to a CDE and display capability (CRT) being functional requirements of the system. Utilization for turnaround planning assumes the existence of an operations management control area, the personnel of which communicate with planning personnel in the subelements of the TCE; i.e., deservicing, Orbiter checkout, integration and mating, etc. (The concept of work control is presented in paragraph 3.3.5.)

- Online Turnaround (Operations Phase). The VLPS concept shown on the facing page will provide for automatic sequencing and control of vehicle and ground support systems/subsystems within each work station from applications programs resident within the work station processors. It permits initiation of all commands required to accomplish checkout software loading of both the work station and onboard processors, and permits discrete command generation (e.g., GSE stimulus). These functions will be accomplished through the use of application programs providing automatic and semi-automatic run modes, 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. (The automated checkout concept is presented in paragraph 3.3.6.)

Turnaround Operations Concept



3.3.3 ON-PAD OPERATIONS CONCEPT

The on-pad operations concept developed:

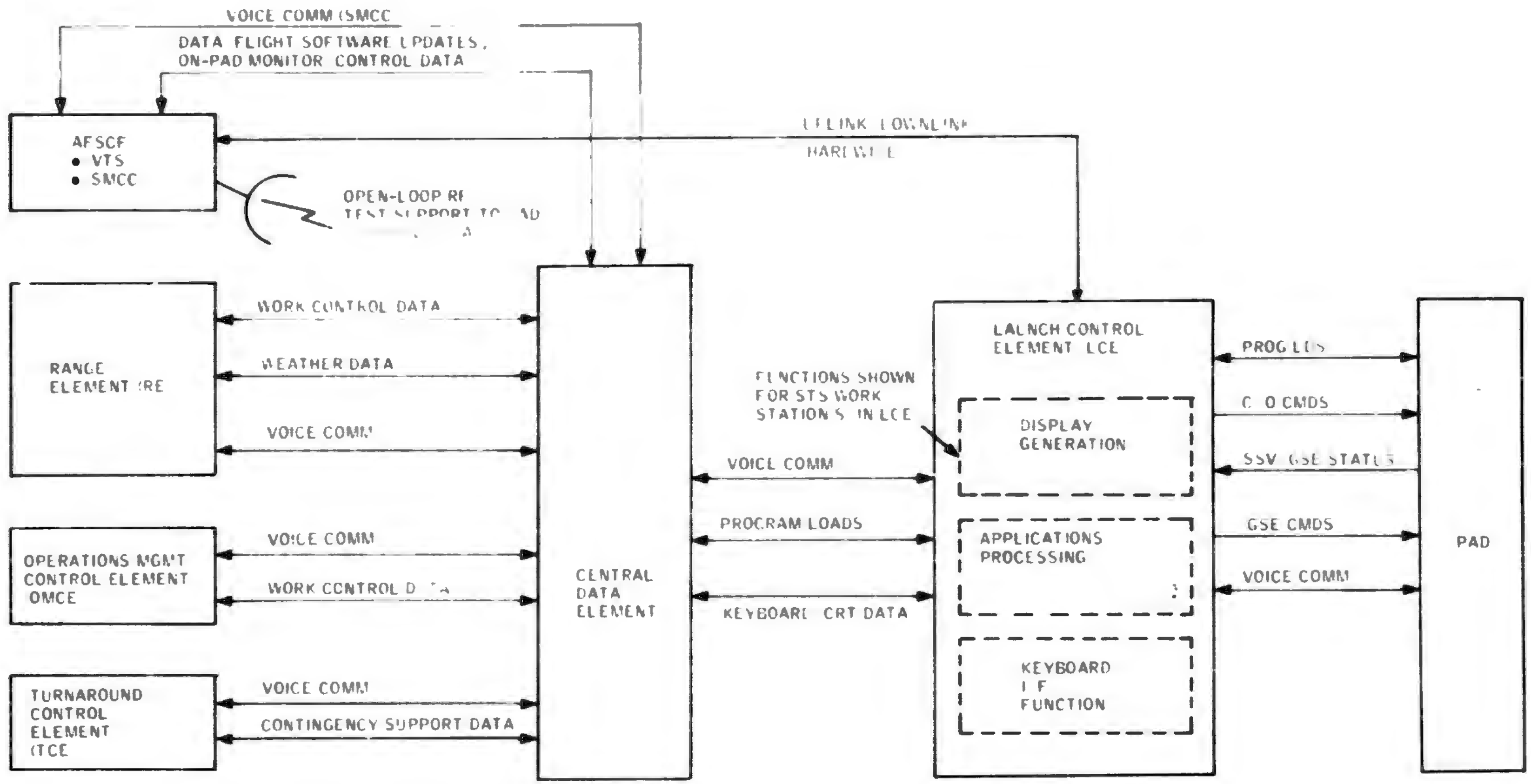
- Requires Range, Launch, Mission, Payload and Turnaround (in contingency) element support
- Employs Central Data element/Remote Work Station concept
- Maximizes use of onboard computers for vehicle checkout
- Is compatible with the 160-hour turnaround constraints of
  - -- Automated checkout
  - -- Interactive interface between central/remote processors
  - -- Automated work control compatibility.

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.

The LCE will interface with the CDE for loading work station computers with checkout software for interface testing for 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.

On-pad retargeting data will originate from the SMCC. Unclassified portions of retargeting programs may be transmitted over data links from the SMCC to the CDE for storage prior to uplinking to the vehicle. The LCE will be responsible for controlling the loading of retargeting data into the onboard computers and performing flight systems reverification. These activities will be performed utilizing the work station's program callup, display, monitoring, and command generation capabilities. Classified portions of the flight programs will be provided directly to the vehicle by the SMCC, either by the RF or by hardwire command and telemetry links.

On-Pad Operations Concept



3.3.4 ON-PAD PAYLOAD OPERATIONS

Three phases of on-pad payload operations were considered: the installation, launch readiness, and standby/countdown phases.

Guidelines for payload operations are the following. (1) Overall control and direction of on-pad payload activities reside with the launch agent. (2) The satellite agent is responsible for satellite monitoring and checkout under the overall direction of the launch agent. (3) The satellite agent is responsible for assuring the launch agent that Shuttle safety requirements are met by the satellite. (4) Payload installation and checkout is performed by a joint launch agent/satellite agent team.

These guidelines are reflected in the attached chart which indicates payload installation is monitored by the Payload Checkout element and directed by the Launch Control element. Payload integration/verification during launch readiness is a joint effort, but is under control of the launch agent. IUS integration and verification is a launch agent function. Satellite mission data (flight programs) is generated by the satellite agent; IUS mission data is generated by the SMCC.

On-Pad Payload Operations

PAYLOAD INSTALLATION

- PAYLOAD CHECKOUT ELEMENT MONITORS
- LAUNCH CONTROL DIRECTS AND MONITORS

PAYLOAD LAUNCH READINESS

- SATELLITE AND LAUNCH AGENTS RESPONSIBLE FOR INTEGRATION/VERIFICATION
- SATELLITE AGENT ACTIVATES, INITIALIZES, CONTROLS, AND MONITORS SATELLITE SYSTEMS, AND PROVIDES SATELLITE MISSION DATA
- LAUNCH AGENT ACTIVATES, INITIALIZES, AND CONTROLS IUS AND ORBITER SUPPORT SYSTEMS
- SMCC PROVIDES IUS MISSION DATA
- LAUNCH CONTROL HAS PRIMARY RESPONSIBILITY FOR SAFETY

STANDBY/COUNTDOWN

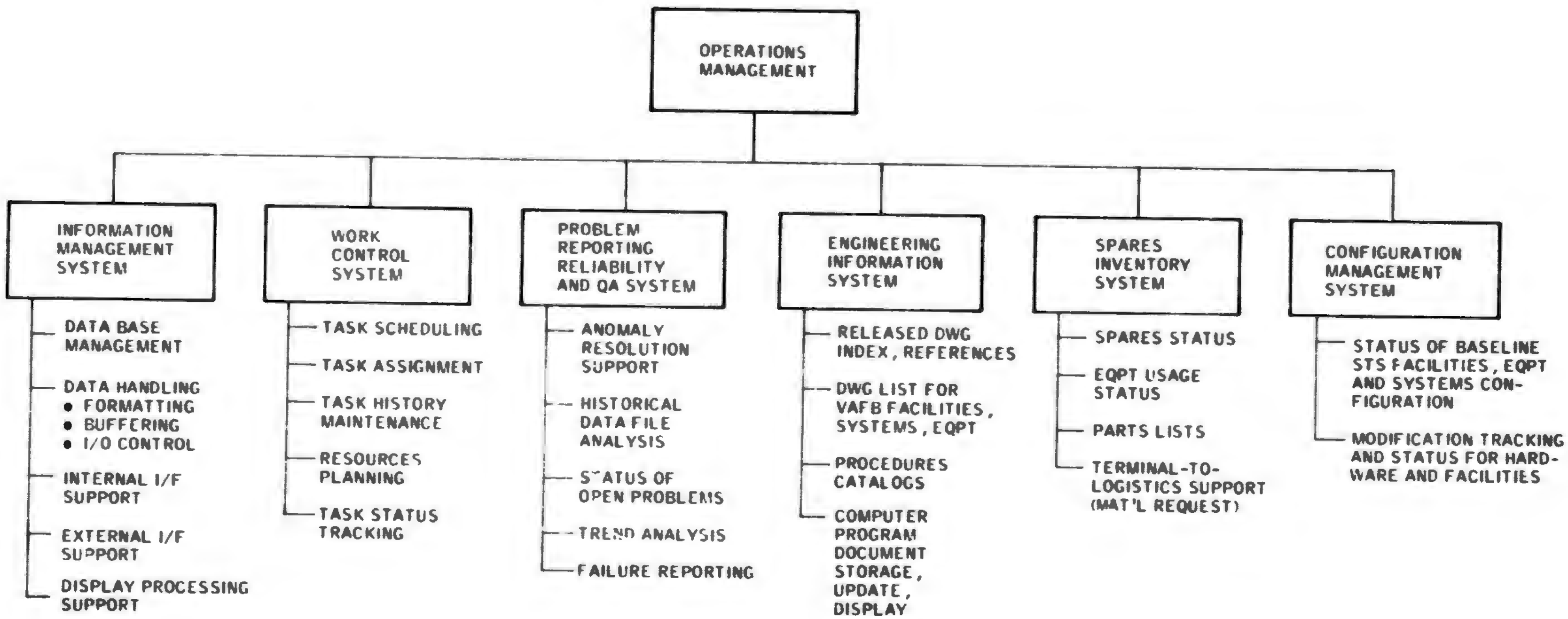
- CONTROL HANDOVER TO CREW
- LAUNCH CONTROL AND SATELLITE AGENT MONITOR SYSTEMS
- LAUNCH CONTROL RESPONSIBLE FOR INTEGRATED CONFIGURATION SAFETY

3.3.5 OPERATIONS MANAGEMENT CONTROL FUNCTIONS

Operations Management. 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. This 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.
- Work Control System. This 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.
- Problem Reporting, R&QA. The Problem-Reporting, Reliability and Quality Assurance System will provide a capability to track hardware problems, equipment failures and documentation anomalies; to status problem resolution; and to perform historical data analysis. This system interfaces terminals located at STS work sites throughout VAFB and executes in the CDE, maintaining data bases in mass storage.
- Engineering Information System. This 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 CDE, utilizing remote terminals for user interface and mass storage for data base storage.
- Spares Inventory System. This 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 CDE, utilizing remote terminals for user interface and mass storage for data base storage. Interfaces are identified with the Shuttle Inventory Management System and the AFLC.
- Configuration Management System. This system will provide a capability to identify and track the VAFB baseline facilities, systems, and equipment as they are developed, modified and utilized.

Operations Management Control Functions



3.3.6 STATION SET/CENTRAL DATA ELEMENT CONFIGURATION FOR AUTOMATED CHECKOUT

STATION SET FUNCTIONS:

Online Checkout Control. The VLPS concept 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 for both the work station and onboard processors, and 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 through the use of application programs 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 test, emergency procedures, real-time fault isolation, or troubleshooting.

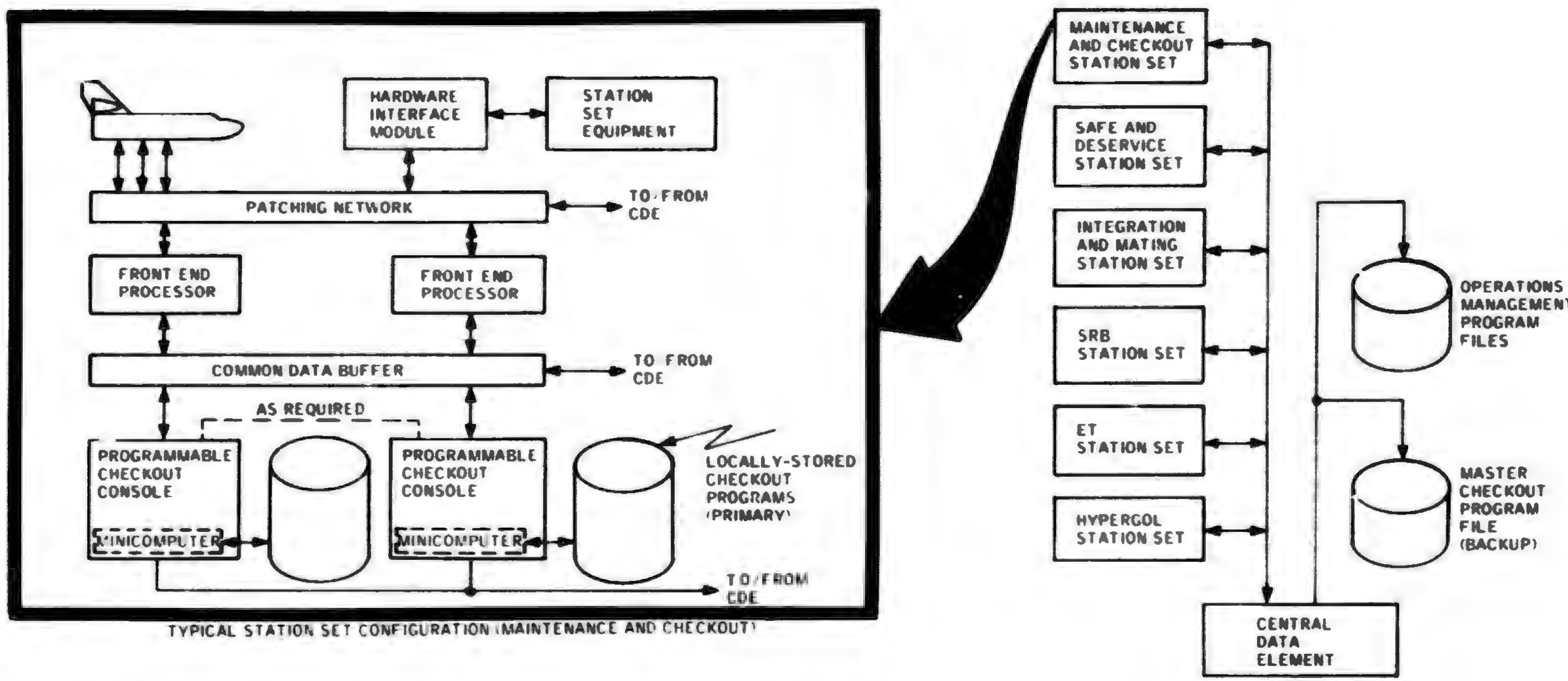
- Display Generation Functions. The VLPS will provide for display of the systems data maintenance and checkout work stations. Typical display devices anticipated include CRT's, event lights, meters/counters, and hardcopy devices. Display generation functions will be provided by work-station-resident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

- 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.

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, failure reporting, and program maintenance and execution.

Station Set/Central Data Element Configuration for Automated Checkout



TYPICAL STATION SET CONFIGURATION (MAINTENANCE AND CHECKOUT)

KEY FEATURES:

- CHECKOUT PROGRAMS RESIDE IN PROGRAMMABLE VLPS CONSOLES
- BACKUP CHECKOUT PROGRAMS (MASTER FILE) RESIDES IN CDE
- INTERACTIVE TERMINAL-TO-CDE INTERFACE EXISTS IN EACH STATION SET TO SUPPORT:
  - -- BACKUP CHECKOUT PROGRAM CALLUP
  - -- OPERATIONS MANAGEMENT FUNCTIONS (WORK CONTROL, PROBLEM REPORTING, ETC.)

3.3.7 TWO ORBITERS IN TURNAROUND

The major impact of dual Orbiter processing will be the significant increase in the complexity of scheduling, logistics support and resource allocation in the light of near-simultaneous dual checkout sequences. The ability to provide support to two Orbiters 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 a given position to serve as the checkout control point for any of the various checkout tasks. As a result, two Orbiters, for example, could be processed either in simultaneously identical tasks or in parallel with serially interleaved phases. Illustrative examples of the multifunction characteristics and a typical dual flow configuration are shown on the facing page.

Two Orbiters in Turnaround

- SCHEDULING OF GROUND RESOURCES
- DUAL ORBITER PROCESSING GREATLY ENHANCED BY PROGRAMMABLE WORK STATION CONCEPT
- FACILITY AND ORBITER TURNAROUND STATION CONCEPT NEEDED TO ASSESS TOTAL IMPACT. [DUAL MAINTENANCE BAYS, POOLING OF NONDEDICATED WORK STATIONS (CONSOLES), ETC.]

3.4 DOD Ground Operations (KSC)

3.4.1 DOD REQUIREMENTS AT KSC

TURNAROUND REQUIREMENTS:

- Landing Area Security

  -- Physical Security. A security guard is required from the end of rollout until the payload has been removed from the Orbiter and delivered to its appropriate area.

  -- 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; this will be done by the onboard system. The encrypted data will be dumped by RF means to the LCC secure vault where it will be decrypted and the classified data stripped out. The unclassified Orbiter data will be routed to the KSC LPS.

- 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.

ON-PAD REQUIREMENTS:

- LCC Secure Vault. The KSC LCC secure vault will contain equipment for the overall control of all DOD-unique classified data management functions involving the vehicle and payload. These functions will include receipt and decryption of data from the pad secure vault, stripout of the classified data, and routing of black data to the KSC LPS as required and classified data to the appropriate DOD areas; i.e., SMCC, Payload Checkout Control (PLCE).

- KSC Launch Pad Secure Vault (LPSV). All hardwire uplinks/downlinks containing classified data to/from the Orbiter and payload will be routed through this vault for decryption/encryption, respectively.

DOD Requirements at KSC

TURNAROUND REQUIREMENTS

- LANDING AREA SECURITY
  - -- PHYSICAL SECURITY - A SECURITY GUARD IS REQUIRED FROM THE END OF ROLLOUT UNTIL THE PAYLOAD HAS BEEN REMOVED FROM THE ORBITER AND DELIVERED TO ITS APPROPRIATE AREA
  - -- FLIGHT DATA DUMP - DATA ENCRYPTION WILL BE ACCOMPLISHED BY THE ONBOARD SYSTEM AND DUMPED BY RF
- SAFING AND DESERVICING - THIS WILL BE ACCOMPLISHED IN ACCORDANCE WITH STANDARD NASA PROCEDURES; DOD PROCEDURES WILL BE USED FOR SAFING AND DESERVICING OF THE PAYLOAD

ON-PAD REQUIREMENTS

- LCC SECURE VAULT - THE KSC LCC SECURE VAULT WILL PROVIDE EQUIPMENT FOR THE OVERALL CONTROL OF ALL DOD-UNIQUE CLASSIFIED DATA MANAGEMENT FUNCTIONS INVOLVING THE VEHICLE AND PAYLOAD
- KSC LAUNCH PAD SECURE VAULT (LPSV) - ALL HARDWIRE UPLINK/DOWNLINK DATA TO/FROM THE ORBITER AND PAYLOAD WILL BE ROUTED THROUGH THIS VAULT FOR DECRYPTION/ ENCRYPTION, RESPECTIVELY

3.5 Flight Operations

3.5.1 FLIGHT OPERATIONS AND OPERATIONS SUPPORT

Flight operations are defined as 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 to perform mission planning, analysis and design; mission software requirements development; and crew and ground personnel training.

The CCDS functions in support of flight operations were allocated to the MCE with other specific support required from other elements.

For the flight phase, the functions are summarized as follows.

- Provide overall mission direction and management
- Maintain an awareness of overall mission status; i.e., vehicle system status, vehicle orbital state, and mission plan vs. mission execution
- 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
- Manage communications and other program-shared resources
- Provide online mission/flight planning

In formulating the CCDS concept in support of flight operations, concept drivers were identified. Concepts were considered for each driver or subordinate issue where alternatives could be defined. These major drivers and subordinate issues are summarized on the facing page. As noted in the figure, each of the drivers considered affects one or more of the flight operations phases or mission activities considered in determining the CCDS concept.

Flight Operations and Operations Support

CONCEPT DRIVERS

- AUTONOMOUS ORBITER VEHICLE
  - -- SMCC OPERATIONS ENVIRONMENT
  - -- SMCC MANNING
- NASA SUPPORT TO DOD STS CONTINGENCIES
  - -- DIVISION OF RESPONSIBILITY
  - -- SMCC/JSC AND SMCC/STDN/TDRS INTERFACE
  - -- SECURITY CONSIDERATIONS
- DOD/NASA JOINT USE OF RESOURCES
- DUA'. MISSION CAPABILITY

ASCENT

ORBITAL

IUS AND SATELLITE OPERATIONS

CONTINGENCY FLIGHT OPERATIONS

ENTRY AND LANDING

DUAL MISSIONS

OPERATIONS SUPPORT

- MISSION PLANNING
- SOFTWARE DEVELOPMENT
- SIMULATIONS AND TRAINING

3.5.2 AUTONOMOUS ORBITER VEHICLE

The high degree of autonomy of the Orbiter vehicle minimizes the degree of real-time processing requirements for STS manned operations, and requires fewer ground support personnel than current manned operations. However, the CCDS must be capable of responding to contingency/emergency situations.

Concepts considered for the subordinate issues resulting from vehicle autonomy are summarized on the facing page. The selected concept is noted by an asterisk.

The preferred concept for the SMCC operations environment was to provide real-time processing and dynamic display capability at the SMCC. This concept was selected due to the requirement for the SMCC to respond to contingency situations.

The concept selected for SMCC manning provides a group of fixed consoles manned to the extent necessary to maintain mission progress and status awareness. In addition, a group of general-purpose consoles are provided to be manned as required for contingency support, or as mission requirements dictate. This concept was selected due to the low level of manning required for the nominal mission periods, and the inherent capability and flexibility provided at the multi-purpose consoles.

Autonomous Orbiter Vehicle

- MISSION CONTROL OPERATIONS ENVIRONMENT
  - -- CONCEPT 1* - REAL-TIME DATA PROCESSING AND DYNAMIC DISPLAY CAPABILITY
  - -- CONCEPT 2 - REAL-TIME COMMUNICATIONS PROCESSING AND DATA RECORDING; VEHICLE/MISSION STATUS MONITORING BY VOICE COMMUNICATIONS
- SMCC MANNING
  - -- CONCEPT 1 - FULL COMPLEMENT OF OPERATING POSITIONS WITH FULL TIME MANNING DURING MISSION EXECUTION
  - -- CONCEPT 2* - FIXED DEDICATED OPERATING POSITIONS. ADDITIONAL GENERAL PURPOSE POSITIONS MANNED AS REQUIRED FOR CONTINGENCY OPERATIONS OR UNIQUE MISSION SUPPORT REQUIREMENTS

* SELECTED CONCEPT

3.5.3 CONTINGENCY SUPPORT PROVIDED BY NASA

DOD may request support from NASA in contingency situations. This support would be in the form of vehicle systems expertise and computational/simulation facilities at JSC. The point at which DOD requests NASA support then becomes the driver on the capability limitations designed into the SMCC. In addition, network support may be requested from NASA by DOD without requiring JSC support. During periods when the NASA network is used, only non-secure voice and data may be provided by the NASA resources. DOD will make mission management decisions during all contingency situations. Data will be transferred to JSC by DOD as required for JSC support.

The joint use of NASA/DOD resources requires a voice and data interface among the SMCC, the STDN/TDRS and the JSC. Three methods to establish this interface were examined, with no specific implementation method recommended, since the final interface definition should be a joint NASA/DOD coordinated effort.

When the STDN/TDRS is used for Orbiter-to-SMCC communications, the data transmitted over this link is unencrypted. It may be possible to design one of the multiple downlink formats to provide unclassified voice and data to the SMCC via the STDN/TDRS during contingency periods. This format should be designed prior to the mission and selected onboard in contingency situations requiring NASA communications support.

Contingency Support Provided by NASA

- NASA/DOD DIVISION OF RESPONSIBILITY FOR CONTINGENCY
  - -- NASA FOR INDEPTH ENGINEERING SUPPORT
- SMCC/JSC AND SMCC/STDN/TDRS INTERFACES
  - -- CONCEPT 1 - INTERFACE SMCC TO JSC AND INTERFACE GSFC/TDRS/STDN VIA JSC
  - -- CONCEPT 2 - INTERFACE SMCC TO STDN/TDRS VIA GSFC AND TO JSC VIA GSFC
  - -- CONCEPT 3 - DIRECT SMCC TO GSFC AND SMCC TO JSC INTERFACE
- SECURITY CONSIDERATIONS - DOD COMMUNICATIONS THROUGH STDN/TDRS
  - -- COMMUNICATIONS MUST BE IN THE CLEAR
  - -- POTENTIAL FOR DESIGNATING ONE TELEMETRY FORMAT FOR CONTINGENCY OPERATIONS

3.5.4 UTILIZATION OF NASA RESOURCES

A program goal is to make maximum use of NASA resources for mission planning. During both nominal and contingency mission periods, there is a requirement for near-real-time mission planning. This planning system would perform such functions as optimizing flight/maneuver plans based on current status, determining effects of lengthening or shortening the mission, and selecting alternate landing sites.

Two concepts were considered in providing this capability, as outlined on the facing page. The one selected was to provide near-real-time mission planning capability at the SMCC. It 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 further study efforts of the total mission planning system indicates that such a VMMPS is required by DOD.

The use of the NASA PICRS and VMMPS were recognized and investigated, but the systems were not defined to the extent that their specific use by DOD could be identified.

Utilization of NASA Resources

- PROGRAM GOAL: MAKE MAXIMUM USE OF NASA RESOURCES FOR MISSION PLANNING
- TWO CONCEPTS CONSIDERED FOR NEAR-REAL-TIME MISSION PLANNING
  - -- CONCEPT 1 - USE VMMPS AT JSC WITH TERMINAL AT SMCC FOR NEAR-REAL-TIME MISSION PLANNING
  - -- CONCEPT 2 - PROVIDE NEAR-REAL-TIME MISSION PLANNING RESOURCES AT THE SMCC; SELECTED BECAUSE OF OPERATIONAL CONSIDERATIONS AND DOD MISSION SECURITY REQUIREMENTS
- PREMISSION PLANNING - POTENTIAL USE OF NASA PICRS AND VMMPS RECOGNIZED, BUT SPECIFIC DOD UTILITY NOT DEFINED

3.5.5 DUAL MISSION SUPPORT CAPABILITY

The CCDS may be required to support two Orbiters simultaneously. Guidelines used in developing the concept for SMCC support to two Orbiters were 1) one Orbiter is in a near polar orbit, launched from VAFB, and the second is in a low inclination orbit launched from KSC for an IUS/satellite mission; and 2) dual support will not be required until CY83.

Support of dual missions will require the duplication of certain mission and vehicle-oriented functions in order to provide simultaneous support. The overall SCF network coordination effort will need to be extended to include support to both STS missions.

Three mission control room concepts were considered for providing dual mission support capability for the SMCC, as outlined in the facing page. The concept selected (concept 1) provides 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.

The selected concept has:

- Growth capability for dual mission support (permitted by guideline 2).
- Provision for real-time contingency support to one Orbiter while continuing 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 nominal support for two Orbiters to contingency support for one.

Dual Mission Support Capability

- CCDS MAY BE REQUIRED TO SUPPORT TWO ORBITERS SIMULTANEOUSLY
- CERTAIN MISSION- AND VEHICLE-ORIENTED FUNCTIONS MUST BE DUPLICATED
- MISSION CONTROL ROOM CONCEPTS
  - -- CONCEPT 1 - DUAL SET OF FIXED OPERATING POSITIONS WITH SINGLE SET OF GENERAL PURPOSE OPERATING POSITIONS; SELECTED BECAUSE OF ITS GROWTH CAPABILITY, REAL-TIME CONTINGENCY SUPPORT FOR ONE ORBITER AND NOMINAL SUPPORT TO SECOND ORBITER, RAPID RECONFIGURATION CAPABILITY
  - -- CONCEPT 2 - SAME AS CONCEPT 1 EXCEPT GENERAL PURPOSE OPERATING POSITIONS ARE FIXED AND NOT RECONFIGURABLE
  - -- CONCEPT 3 - SINGLE SET OF OPERATING POSITIONS TIME-SHARED BETWEEN MISSIONS

3.5.6 ASCENT OPERATIONS

Ascent operations extend from liftoff of the integrated STS vehicle and payload until orbital insertion, or until the Orbiter's entry into any of the defined ascent abort modes. STS vehicle design provides complete autonomy in the execution of this mission phase.

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.

During ascent (until RTS loss of signal), selected Orbiter and payload telemetry and trajectory data will be 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.

SRB inpact predictions will be calculated by the MCE for all DOD missions launched from either KSC or the VAFB site. Computations will be based on the Orbiter state vector at SRB staging. SRB impact coordinates are provided by the MCE to recovery forces for subsequent pickup and return of the SRB's to the launch site.

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 orbital operations.

Ascent Operations

- MAJOR SUPPORT PERFORMED BY MCE TO INCLUDE:
  - -- MAINTENANCE OF COMMUNICATIONS BETWEEN ORBITER AND CCDS
  - -- DETERMINE IMPACT POINT FOR SRB'S
  - -- VOICE COORDINATION WITH LANDING SITE
- MAINTENANCE DATA STRIPPED FROM ORBITER TELEMETRY AT MCE AND PROVIDED TO TCE
- RANGE PROVIDING FOR RECOVERY OF SRB'S

3.5.7 ORBITAL OPERATIONS

The CCDS functions in support of orbital operations are performed totally by the MCE. These MCE functions are summarized on the facing page. For single-revolution missions or missions which may occur without any station contact, the MCE's function is to be prepared to respond to an onboard emergency situation.

The nominal mode of operation of the STS vehicle places no unique event- or phase-related requirements on the MCE to support that event or 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 which direct that certain events be accomplished only when ground monitoring is possible. For these events, station contact may 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, or cause orbit adjustment, cancellation of a deployment, or return to an alternate landing site.

SMCC personnel will interface the central processing with display and control equipment in the SMCC. The STC/SMCC will provide for data received from the RTS processing to extract tracking (backup for Orbiter, primary for deployed IUS), onboard telemetry, payload telemetry, and voice. Processing will be provided to generate commands and transfer command and voice data to the Orbiter via the RTS. Orbiter acquisition lists will be provided to the RTS from the STC/SMCC.

Orbital Operations

- MISSION SUPPORT PROVIDED BY MCE
- MAJOR SUPPORT FUNCTIONS AS RESULT OF MULTIORBIT MISSIONS AND INCLUDE:
  - -- OVERALL MISSION MANAGEMENT
  - -- MONITORING IN PREPARATION FOR CONTINGENCY RESPONSE
  - -- COMMUNICATIONS MANAGEMENT
  - -- CONTROL/MONITORING OF DEPLOYED IUS/SATELLITE
  - -- HANDOVER OF SATELLITE TO PAYLOAD USER
  - -- PROVISION OF STABLE FREQUENCY FOR ONE-WAY DOPPLER UPDATES
  - -- NEAR-REAL-TIME MISSION PLANNING FOR FLIGHT PLAN CHANGES
- DATA PROCESSING PROVIDED BY SMCC FOR TRACKING, ONBOARD TELEMETRY, PAYLOAD TELEMETRY AND VOICE
- COMMANDS AND VOICE DATA PROVIDED BY SMCC
- ACQUISITION DATA TO RTS

3.5.8 IUS AND SATELLITE OPERATIONS

The primary role of the SMCC-RTS for nominal IUS/satellite operations is to: 1) coordinate IUS/satellite operations; 2) track the IUS/satellite for orbit computation; 3) receive, record, process and distribute telemetry; and 4) initiate, format, and uplink IUS commands.

The figure on the facing page shows five periods of IUS/satellite on-orbit operations. These are IUS/satellite in Orbiter payload bay, IUS/satellite predeployment checkout, IUS/satellite pre-ignition, IUS/satellite post-ignition, and post-satellite deployment.

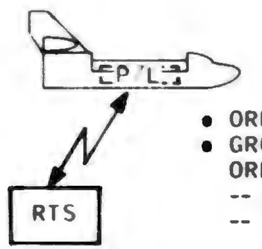
The IUS/satellite is controlled from the Orbiter during periods when the payload is in the Orbiter bay, during predeployment checkout, and during pre-ignition. During these periods, the SMCC and user MCC monitor the IUS and satellite, respectively, via the Orbiter-to-RTS telemetry link. Pre-ignition checkout command and telemetry data is transferred between the Orbiter and either the IUS or satellite. This assumes that some communication is possible with the satellite in its predeployment state, and that the satellite communications link is not via the IUS.

After ignition, control of the IUS/satellite is from the SMCC with mission status and/or mission data provided to the user MCC. A command and telemetry link is provided between the RTS and either the IUS or the satellite for a single RTS. For a dual site, communication may be possible to both the IUS and satellite, providing that this is operationally and technically feasible. The same assumptions are applicable during this phase as during pre-ignition checkout.

Upon satellite deployment, the IUS is controlled from the SMCC and the satellite is controlled from the user MCC. Satellite checkout is from the user MCC after handover. Satellite checkout and the transfer of satellite control will require coordination between the SMCC and the user MCC. Communication with the RTS during this period may be with a single RTS, simultaneous communications with two RTS's, or with a dual RTS.

IUS and Satellite Operations

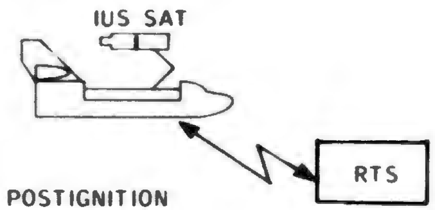
① IUS/SATELLITE IN BAY



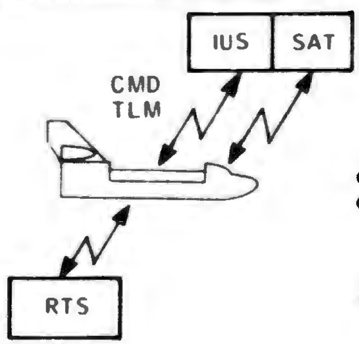
- ORBITER CONTROL
- GROUND MONITOR VIA ORBITER AS REQUIRED
  -- SMCC (IUS)
  -- USER MCC (SATELLITE)

② IUS/SATELLITE PREDEPLOYMENT CHECKOUT

- ORBITER CONTROL
- GROUND MONITOR VIA ORBITER AS REQUIRED
  -- SMCC (IUS)
  -- USER MCC (SATELLITE)

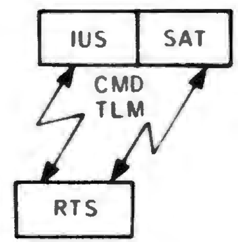


③ IUS/SATELLITE PREIGNITION



- ORBITER CONTROL
- GROUND MONITOR VIA ORBITER AS REQUIRED
  -- SMCC (IUS)
  -- USER MCC
- COMMAND AND TELEMETRY LINK TO IUS OR SATELLITE

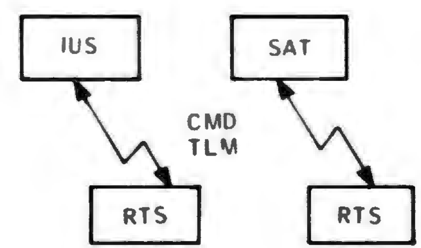
④ IUS/SATELLITE POSTIGNITION



- CONTROL FROM SMCC (IUS)
- MISSION STATUS AND/OR DATA TO USER MCC
- COMMAND AND TELEMETRY LINK TO IUS OR SATELLITE FOR SINGLE STATION

⑤ POST-SATELLITE DEPLOYMENT

- IUS CONTROL FROM SMCC
- SATELLITE CONTROL FROM USER MCC



3.5.9 INFLIGHT CONTINGENCY OPERATIONS

The autonomous Orbiter design, with redundant critical systems operating in a "fail operational/fail safe" mode, and crew response to the C&W system will provide for onboard correction to most problems. However, resolution of and reaction to many contingencies may 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 of these functions requires one or more of the following: near-real-time mission planning, mission management decisions, anomaly resolution, and/or 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.

SMCC key personnel performing nonoperational 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 affected by the contingency.

In all cases, 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-anomalous condition has occurred, 2) voice link from the Orbiter advising 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.

Inflight Contingency Operations

- CONTINGENCIES INVESTIGATED INCLUDE:
  - -- ABORTS TO ALTERNATE MISSION
  - -- DEPLOYED PAYLOAD ANOMALIES
  - -- MANIPULATOR MALFUNCTION
  - -- FAILURES IN REDUNDANT CRITICAL SYSTEMS
- ONBOARD CORRECTIONS FOR MOST PROBLEMS
- RESOLUTION/REACTION TO CONTINGENCY REQUIRES COORDINATION WITH GROUND
- MAJOR GROUND FUNCTIONS INCLUDE:
  - -- MISSION MANAGEMENT
  - -- SYSTEMS MANAGEMENT
  - -- SYSTEMS ANALYSIS
- SMCC SUPPORT REQUIRES ONE OR MORE OF THE FOLLOWING:
  - -- NEAR-REAL-TIME MISSION PLANNING
  - -- MISSION MANAGEMENT DECISIONS
  - -- ANOMALY RESOLUTION
  - -- COORDINATION WITH NASA
- NASA ASSISTANCE DETERMINED BY:
  - -- DEGREE OF FAILURE
  - -- EFFECT ON MISSION SUCCESS
  - -- CREW SAFETY
- DATA PROVIDED TO NASA AS REQUIRED FOR MALFUNCTION ANALYSIS

3.5.10 ENTRY AND LANDING

The major functions performed by the CCDS in support of the Orbiter entry and landing are performed by the SMCC, and are summarized on the facing page. Throughout the entry and landing phase, data handling functions are similar to on-orbit operations.

Other support elements also assist the SMCC during Orbiter entry and landing operations. The FAA is continuously advised of Shuttle progress during this phase of flight so that it can ensure air corridor clearances and reroute other aircraft in the vicinity of the Shuttle corridor. The landing site provides weather information and navigation and landing aid status to the SMCC for relay to the Orbiter.

Entry and Landing

- PRIMARY SUPPORT PROVIDED BY SMCC
- SUPPORT PERSONNEL WILL:
  - -- ESTABLISH AND MAINTAIN COMMUNICATIONS LINK TO ORBITER
  - -- MAINTAIN CONTACT WITH LANDING AREA FOR LANDING SITE STATUS ADVISORIES
  - -- COORDINATE WITH FAA FOR AIR CORRIDOR CLEARANCE
  - -- RELAY LANDING SITE WEATHER DATA TO ORBITER
  - -- RECORD TELEMETRY FOR POSTMISSION ANALYSIS
- NAVIGATION AND LANDING AID STATUS MAINTAINED BY LANDING SITE; STATUS RELAYED TO SMCC

3.5.11 OPERATIONS SUPPORT

Operations support functions include mission planning, software development, and simulations and training. Although not within the scope of the study, these were examined briefly and allocated to the Mission Control element.

These functions levy significant resource requirements on the ground systems, but also lend themselves to implementation in joint-use resources. Many of these are being developed by NASA; e.g., the VMMPS, PICRS, SMS, etc.

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. Premission planning functions involve mission definition design and analysis. The joint use of the JSC VMMPS and PICRS appears attractive; however, factors which may affect this and may require consideration prior to implementation decisions 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 VMMPS for DOD planning
- Capability of the real-time mission planning system located at the SMCC.

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. Facilities of the JSC SDL and the STC will be used in performing these functions. The JSC SDL will perform development of new software and/or the modification of existing software under joint NASA/DOD configuration control. The incorporation of mission specific parameters into flight programs will be performed using DOD facilities.

Simulations and training are also major tasks for both flight control and flight crew training. Simulations are discussed in section 7 of this volume to the extent of determining the DOD SMS requirement.

Operations Support

- FUNCTIONS IMPACT OVERALL GROUND SYSTEMS BUT MAY BE IMPLEMENTED BY JOINT USE OF RESOURCES
- FUNCTIONS RELATE TO MISSION PLANNING, SOFTWARE DEVELOPMENT AND VERIFICATION, SIMULATIONS, AND TRAINING
- VMMPS BEING DEVELOPED BY NASA WILL:
  - -- MAKE ACCESS POSSIBLE BY MCC TERMINAL SYSTEM
  - -- PROVIDE PROGRAMS THAT MAY BE APPLICABLE FOR STC/SMCC COMPUTERS
- NASA DEVELOPING FLIGHT SOFTWARE TO INCLUDE:
  - -- UNIQUE SOFTWARE REQUIRED BY DOD
  - -- SOFTWARE MODIFICATIONS DEFINED BY DOD
- FLIGHT-CRITICAL PARAMETERS PROVIDED BY DOD
- SIMULATIONS AND TRAINING - A MAJOR TASK FOR FLIGHT CONTROLLERS AND FLIGHT CREWS

3.5.12 STC/SMCC DATA HANDLING FUNCTIONAL CONFIGURATION

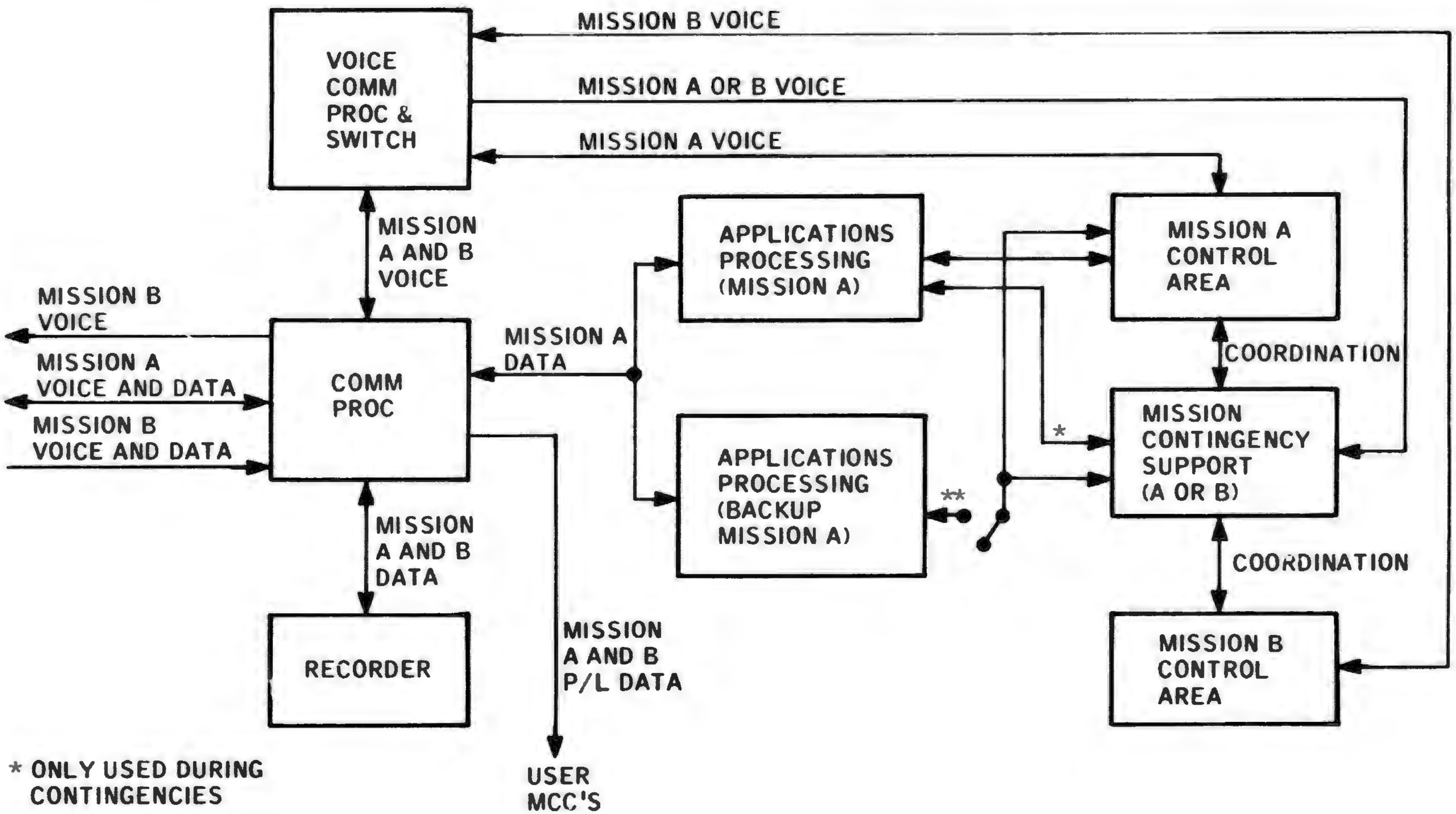
Two functional concepts for the STC/SMCC data handling in support of STS missions are presented on the next two pages. Both concepts assume a dual mission support capability.

The facing figure presents one STC/SMCC functional configuration for support of DOD missions. For convenience in defining the support configuration, missions are designated as missions A and B. In this configuration, mission A is the primary mission and mission B is the secondary mission. As applied to this configuration, "primary" refers to the mission for which applications processing is provided as a result of high activity, contingency support, or nominal processing. "Secondary" pertains to the mission for which only voice is being processed and the telemetry data is recorded.

Inputs to the SMCC consist of Orbiter and payload telemetry and voice for both missions. For this configuration, the capability is provided for receiving and processing both downlinks simultaneously. Processing consists of receiving A and B mission inputs, verifying data quality, communications processing, data recording, and stripping out of the digital voice data. Applications processing is provided for the prime mission. Both a prime and backup applications processor are provided only during contingency support periods. In addition, payload data from both the prime and secondary mission is routed to the user MCC's. Digital voice is processed and routed to the appropriate mission control areas. The capability is provided for voice transmission to/from the separate control areas for both missions. Selective voice monitoring capability of the air-to-ground voice link for either mission from the contingency support area is provided.

Two Orbiters may have simultaneous contact with an RTS (dual). During these periods, however, only one mission control area would receive real-time TLM data.

STC/SMCC Data Handling Functional Configuration



* ONLY USED DURING CONTINGENCIES

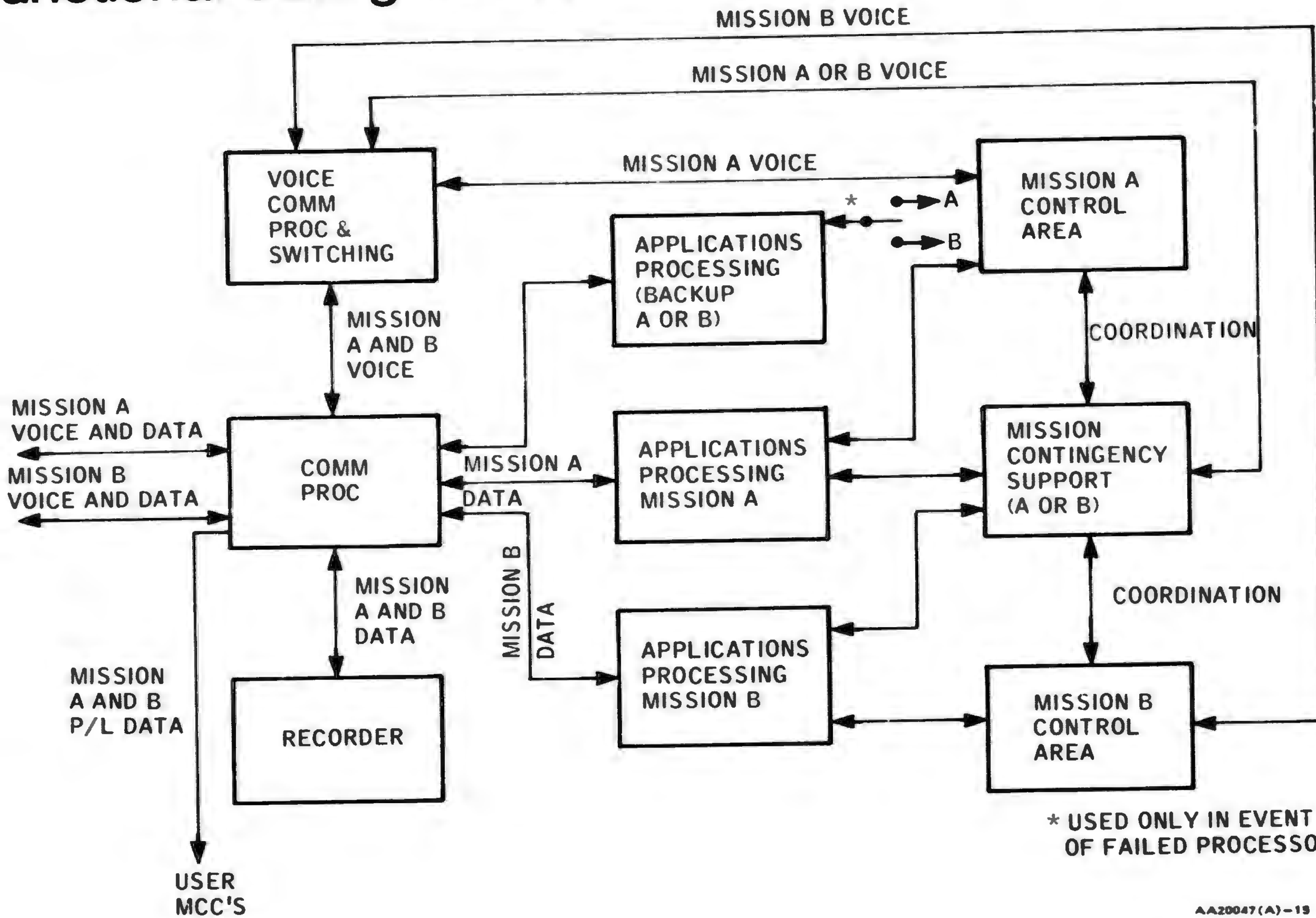
** BACKUP PROCESSOR SWITCHED ONLINE IN EVENT OF FAILED APPLICATIONS PROCESSOR

3.5.13 ALTERNATE STC/SMCC DATA HANDLING FUNCTIONAL CONFIGURATION

The facing figure presents a second STC/SMCC functional configuration for support of DOD missions. The addition of a second applications processor in this configuration provides the following additional capabilities:

- Simultaneous applications processing for mission A and B telemetry inputs to the STC/SMCC, and command outputs from the STC/SMCC
- A backup processor for support of either mission A or B; the backup processor would be online only during contingency situations
- Mission data provided to each mission control area simultaneously in support of its respective mission.

Alternate STC/SMCC Data Handling Functional Configuration



* USED ONLY IN EVENT OF FAILED PROCESSOR

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3.6 Secure Data and Equipment Handling Requirements

3.6.1 SECURE DATA AND EQUIPMENT HANDLING

Objectives of the Analysis. A major subtask of the Philco-Ford CCDS study was defining the requirements on the CCDS imposed by the DOD mission and equipment security requirements. Based on these requirements, Philco-Ford developed candidate approaches to the application of COMSEC/TEMPEST techniques and procedures to areas of the CCDS which handled secure data or required equipment that must be safeguarded.

The NASA-defined LPS at KSC is considered a nonsecure element. A major emphasis of this study was, therefore, to define support areas and systems which must be isolated to conduct DOD operations at KSC. Interfaces with LPS from red to black areas were also a major concern.

Objectives of the Analysis

- TO DEFINE FUNCTIONAL REQUIREMENTS ON THE CCDS IMPOSED BY DOD MISSION SECURITY REQUIREMENTS
- TO INVESTIGATE POTENTIAL APPLICATIONS OF COMSEC/TEMPEST TECHNIQUES AND PROCEDURES TO AREAS OF THE CCDS
- TO EMPHASIZE THE REQUIREMENTS THAT AFFECT THE KSC LAUNCH PROCESS CONCEPT

3.6.2 RESULTS

It was recognized early in the study that many areas concerning secure data and equipment handling would require resolution and concurrence by other agencies of the Government. At the direction of the AF, Philco-Ford withheld final publication of the analysis results until near the end of the study. This allowed Philco-Ford to participate at the working group level with representatives from these other agencies.

The final report (volume VI) contains the results of this effort and contains resolutions and guidelines from the COMSEC Working Group meetings held in September 1974. The document contains the statement of requirements, major guidelines from the working group meetings, and candidate approaches for meeting these requirements at each stage of operations.

Results

EXTENSIVE PARTICIPATION IN COMSEC WORKING GROUP MEETINGS

SEPARATELY DOCUMENTED RESULTS OF ANALYSIS (STAND-ALONE DOCUMENT)

- STATEMENT OF REQUIREMENTS
- CANDIDATE APPROACHES IDENTIFIED FOR IMPLEMENTATION
  - -- CHECKOUT INTERFACES (ORBITER, IUS, SATELLITE)
  - -- INTEGRATED CHECKOUT (ON-PAD)
  - -- POSTLANDING DATA RETRIEVAL AND MEMORY PURGING
  - -- COMSEC EQUIPMENT HANDLING
  - -- FLIGHT PHASES OF OPERATIONS
- MAJOR AREAS AFFECTED
  - -- LAUNCH PAD
  - -- LAUNCH CONTROL
  - -- SAFING AND DESERVICING
  - -- INTERFACES BETWEEN RED AND BLACK AREAS

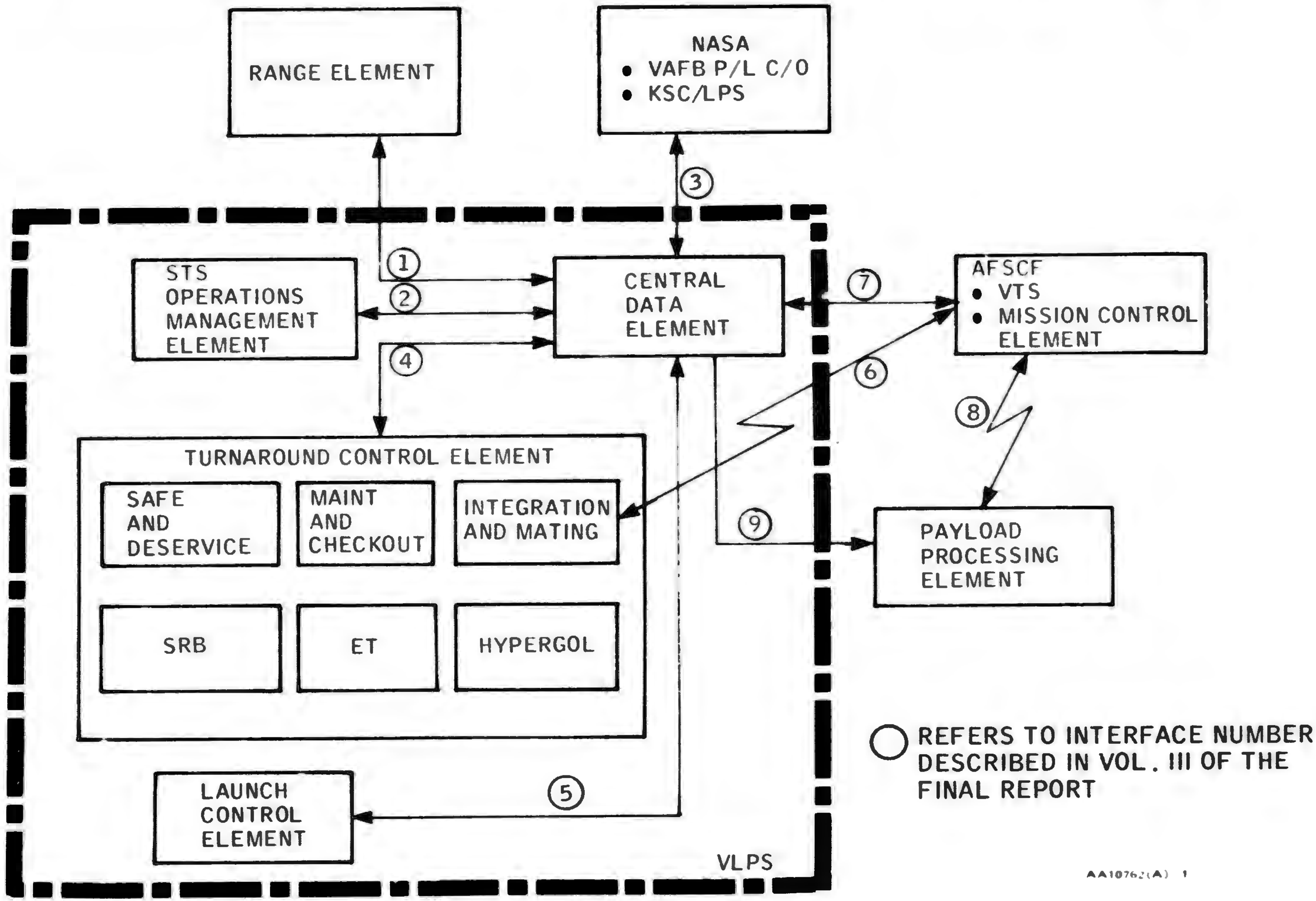
3.7 CCDS Functional Interfaces

3.7.1 TURNAROUND OPERATIONS FUNCTIONAL DATA INTERFACE

The facing figure illustrates the elements/agencies requiring data interfaces to support STS Turnaround Operations from VAFB. The figure and the two following are functional only, and must be considered as preliminary since the specific interfaces can only be defined based on specific system, facility, and siting plans. Many of the functional interfaces identified in these drawings are expected to become official interface control points as the STS program evolves, and will be subjected to rigid interface control and documentation procedures. The numbers shown on the drawings are used in volume 3 of this report as a reference for identifying and describing the interface.

Of significance in this drawing is the use of the Central Data element as the functional element assigned the central communications switching function. In addition, the interface with NASA, used for data bank transfers, is important as a joint use of a program resource.

Turnaround Operations Functional Interfaces (Data)



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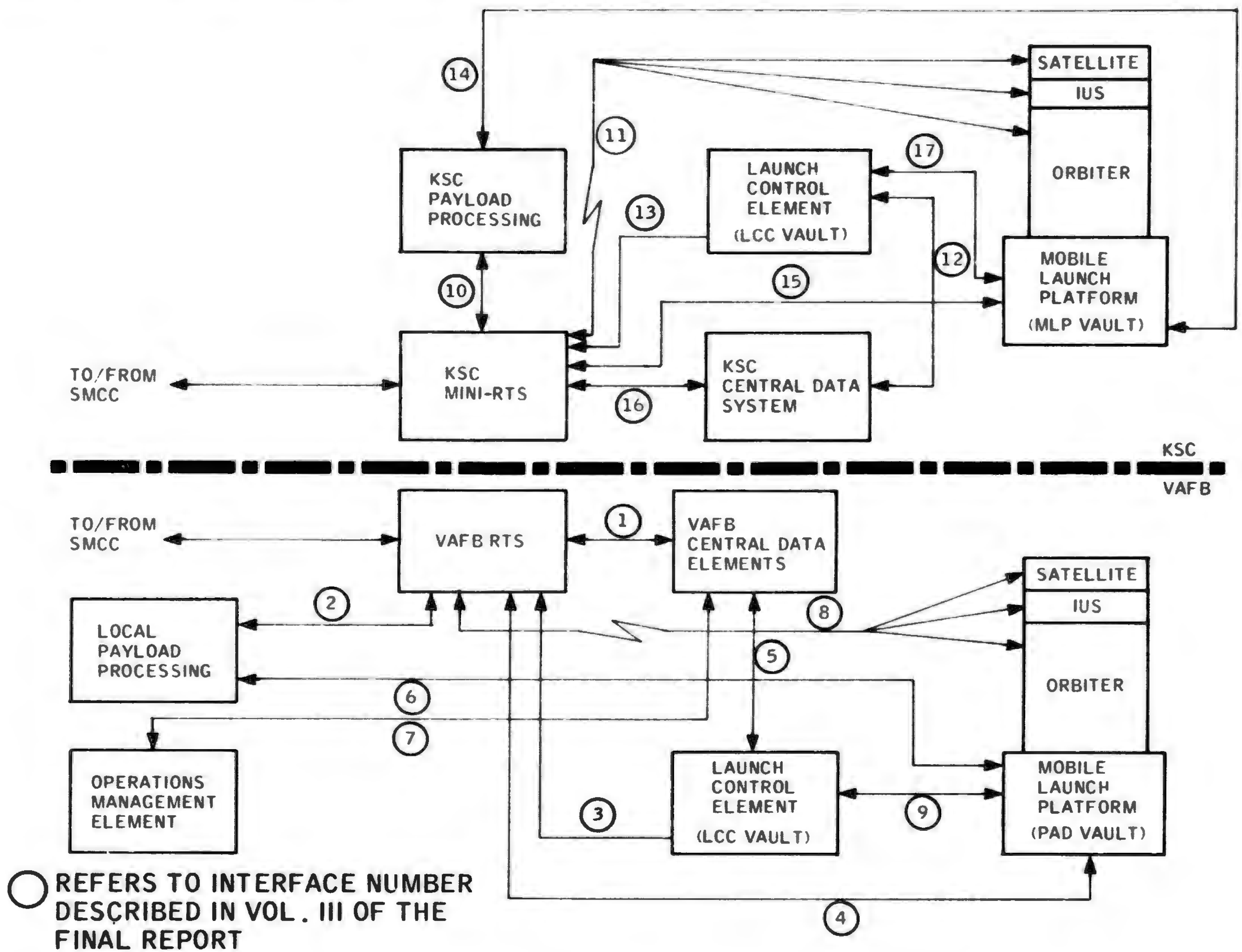
3.7.2 LAUNCH PAD OPERATIONS FUNCTIONAL DATA INTERFACES

The functional interfaces required for DOD launch pad operations are shown for a mission launched either from KSC (top) or VAFB (lower).

Note that the launch pad interface to the SMCC is through SCF resources -- the mini-RTS at KSC and the VAFB RTS from VAFB. Interfaces 8 and 11 are RF interfaces between the integrated SSV and the RTS facility.

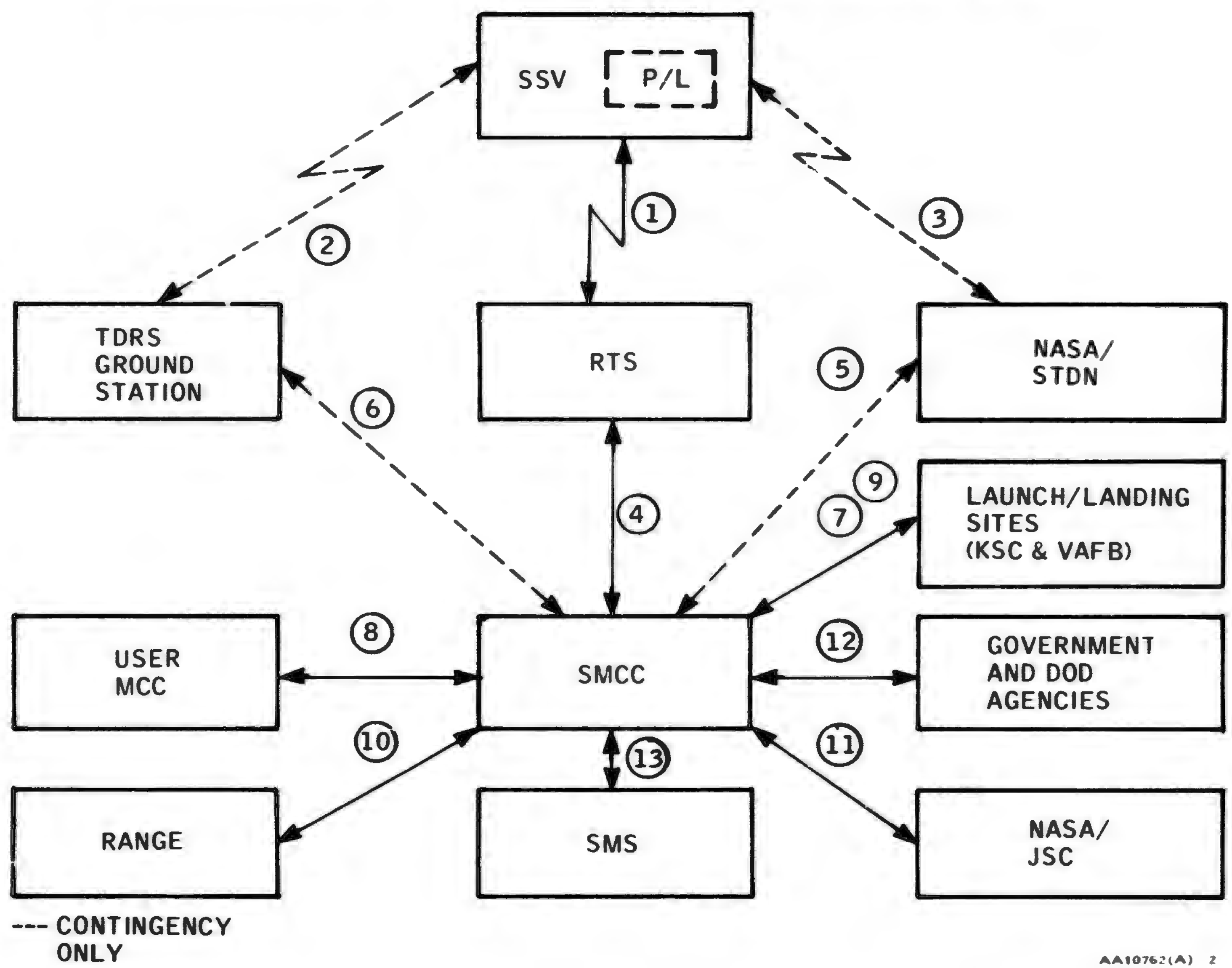
Launch Pad Operations Functional Interfaces



3.7.3 FLIGHT OPERATION FUNCTIONAL DATA INTERFACES

Functional interfa[illegible] required for DOD flight operations are shown on the facing figure. SMCC interface with the [illegible] is normally through the SCF RTS; only for contingencies is the interface through the NASA [illegible]N or TDRS ground station. An interface with the SMS is shown for flight crew/flight controller training. Range receives the SRB impact point prediction, and the User MCC receives payload telemetry data. The JSC interface is for both contingency support assistance and premission planning data from a shared DOD/NASA mission planning resource. Other Government agencies include FAA, NORAD and NOAA for air route clearance, trajectory data, and weather and solar flare data. Launch and landing site interfaces are required for coordination of these operations with the SMCC, and to provide positive handover at launch and at rollout.

Flight Operations Functional Interfaces (Data)



3.8 Conclusions

3.8.1 RESULTS AND CONCLUSIONS

Conclusions reached during the performance of this portion of the CCDS study are:

- Operations Management. An OMCE is required at the launch site to perform administration and control of scheduling, resource allocation, and similar functions to coordinate the operations of the CCDS ground elements.
- Work Station Checkout/Test Environment. Utilization of work stations capable of performing automated checkout, with applications software executing in the work stations themselves, will provide rapid turnaround operations.
- Central Data Element. A CDE was established as a resource shared by the several elements for providing data access and processing support.
- Landing Control. Control of the Orbiter remains with the mission agent until rollout is complete; therefore, landing control was deleted as a functional control element.
- Recovery Element. No need for a recovery control element (RCE) could be substantiated; SRB impact coordinates will be provided to the range by mission control for SRB pickup and return.
- On-Pad Payload Operations. Primary launch-pad payload activities for STS missions should be restricted to installing and integrating the payload, and to verifying and maintaining its operational integrity once installed.
- Payload C&W Functions. Control of the payload's C&W parameters should be exercised from the LCE to provide greater assurance of payload safety to the launch agency.

Results/Conclusions

- OPERATIONS MANAGEMENT - AN OMCE IS REQUIRED AT THE LAUNCH SITE
- WORK STATION CHECKOUT/TEST ENVIRONMENT - REQUIRED FOR AUTOMATED CHECKOUT
- CENTRAL DATA ELEMENT - REQUIRED AS A SHARED RESOURCE
- LANDING CONTROL - DELETED AS A FUNCTIONAL CONTROL ELEMENT
- RECOVERY ELEMENT - NO NEED FOR A RECOVERY CONTROL ELEMENT (RCE) SRB IMPACT COORDINATES WILL BE PROVIDED TO THE RANGE FOR SRB PICKUP AND RETURN
- ON-PAD PAYLOAD OPERATIONS - LAUNCH PAD PAYLOAD ACTIVITIES SHOULD BE RESTRICTED
- PAYLOAD C&W FUNCTIONS - CONTROL EXERCISED FROM THE LCE

3.8.1 RESULTS AND CONCLUSIONS (CONT'D)

- On-Orbit Support. Because of vehicle autonomy, the requirements for on-orbit support of the nominal mission are limited.

- Real-Time Processing Requirements for the SMCC. Due to the SMCC requirement to provide support in contingency situations, a real-time processing and dynamic display capability is required for the SMCC.

- JSC/DOD Division of Responsibility. 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, and any in-depth engineering support required for on-orbit contingencies will be requested from NASA.

- Near-Real-Time Mission Planning. 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.

- NASA Interfaces. Because of the incompletely defined role of NASA's VMMPS and PICRS, DOD's potential use of these resources is recognized, but its extent cannot be defined.

- IUS Control. To prevent duplication of IUS management operating consoles and personnel, IUS operations will be directed from the SMCC as opposed to the satellite MCC.

- Dual Mission Support. Since there is a probability that two DOD missions will be in orbit 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.

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

Results and Conclusions

- REQUIREMENTS FOR ON-ORBIT SUPPORT TO NOMINAL MISSIONS LIMITED
- REAL-TIME PROCESSING AND DYNAMIC DISPLAY CAPABILITY REQUIRED FOR SMCC
- INDEPTH ENGINEERING SUPPORT FOR CONTINGENCIES PROVIDED BY NASA
- NEAR-REAL-TIME MISSION PLANNING LOCATED AT THE SMCC
- DOD USES OF PICRS AND VMMPS RECOGNIZED BUT EXTENT CANNOT BE DEFINED
- IUS OPERATIONS DIRECTED FROM SMCC
- CCDS MUST BE SIZED FOR DUAL MISSION SUPPORT
- NOMINAL ONE-PER-ORBIT STATION CONTACT SHOULD BE SCHEDULED WITH THE SCF FOR ORBITER STATUS

4.0 SMCC Candidate Operating Positions

4.1 SMCC CANDIDATE OPERATING POSITIONS (NOMINAL ACTIVITY LEVEL)

In order to determine the candidate operating positions required in the SMCC to support DOD missions, STS flight operations were reviewed to determine the ground functions required to be performed from the SMCC. Using as a baseline the functional organization contained in *DOD STS Operations Concept Document* (Draft), dated 6 August 1974, the SMCC support functions were assigned to one or more of the functional groups described in that document. If additional functional groups were required, such groups were added. Analysis of the functions assigned was then accomplished to determine if any functional groups could be combined and to recommend the number of operating positions required within each group.

The results of those analyses are presented in the next two charts.

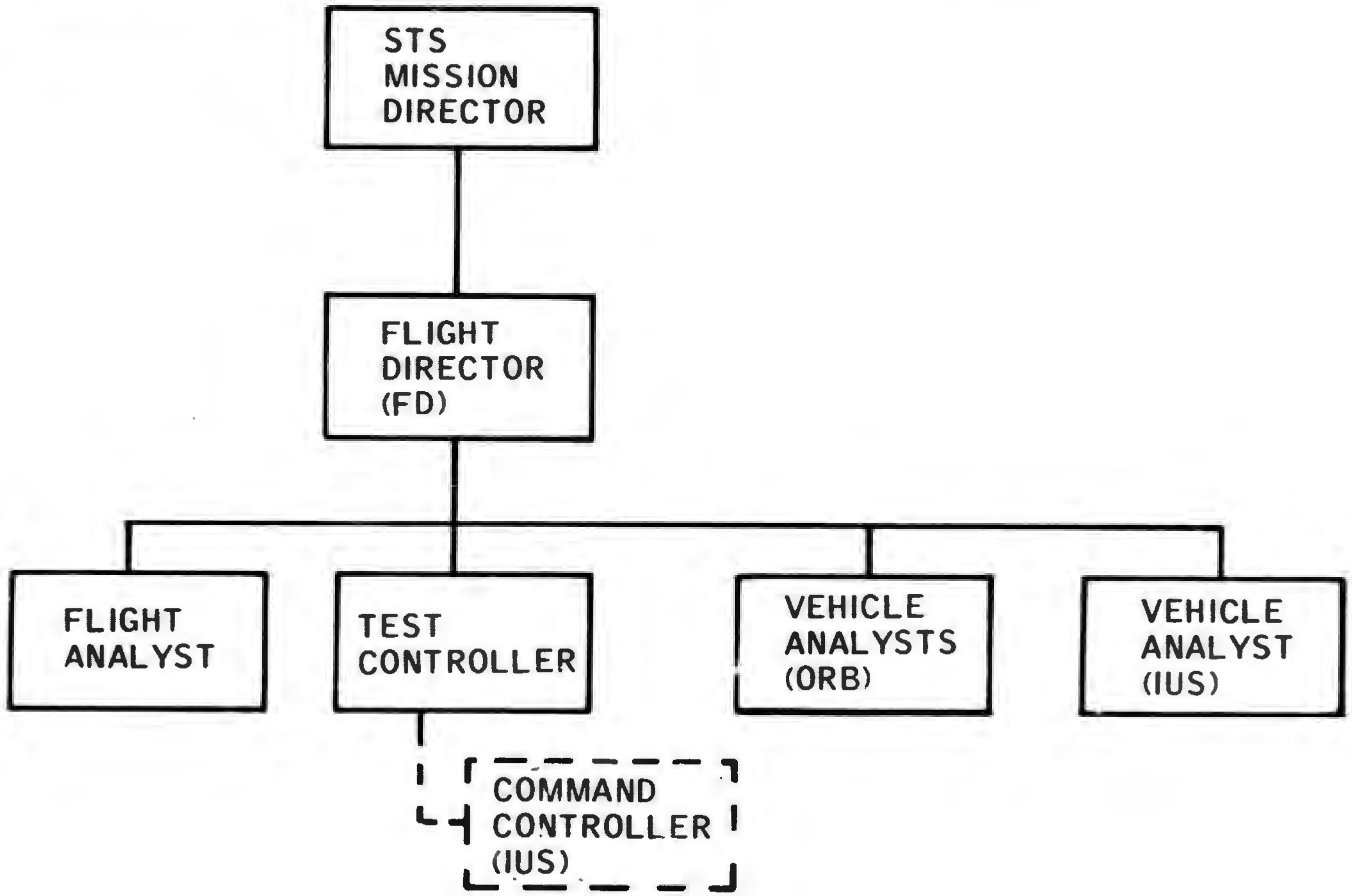
The facing chart indicates the candidate SMCC positions recommended for nominal support periods.

Functions performed during these periods are summarized as follows:

- STS Mission Director. Responsible for overall control and direction of all STS flights supported from the SMCC
- Flight Director. Responsible to the STSMD for mission support of a specific Shuttle flight. He performs normal duties associated with overall coordination and supervision of mission operations to ensure satisfactory accomplishment of mission objectives.
- Test Controller. Responsible to the FD for the overall command and control coordination between the SMCC and the RTS; he also maintains the primary secure voice communications link between the SMCC and the Orbiter crew.
- Flight Analyst. Responsible for the trajectory analysis activities during all phases of the mission for both the Orbiter and IUS. Trajectory status data will be provided to other SMCC and user MCC positions. In addition, he will coordinate RTS prepass, pass and postpass activities.
- Vehicle Analyst (Orbiter). Maintains top level status of Orbiter systems and Orbiter configuration during nominal mission activities. Significant changes in system status will be reported to the FD. The VAO will also support prepass and analyze data resulting from pass activities.
- Vehicle Analyst (IUS). Maintains system status of the IUS during free-flight or provides assistance during periods when the IUS is stowed in the payload bay.
- Command Controller (IUS). Responsible to the Test Controller for the SCF command capability for the IUS when it is in free-flight (only manned during IUS free-flight periods).

SMCC Candidate Operating Positions

Nominal Activity Level



4.2 SMCC CANDIDATE OPERATING POSITIONS (CONTINGENCY ACTIVITY LEVEL)

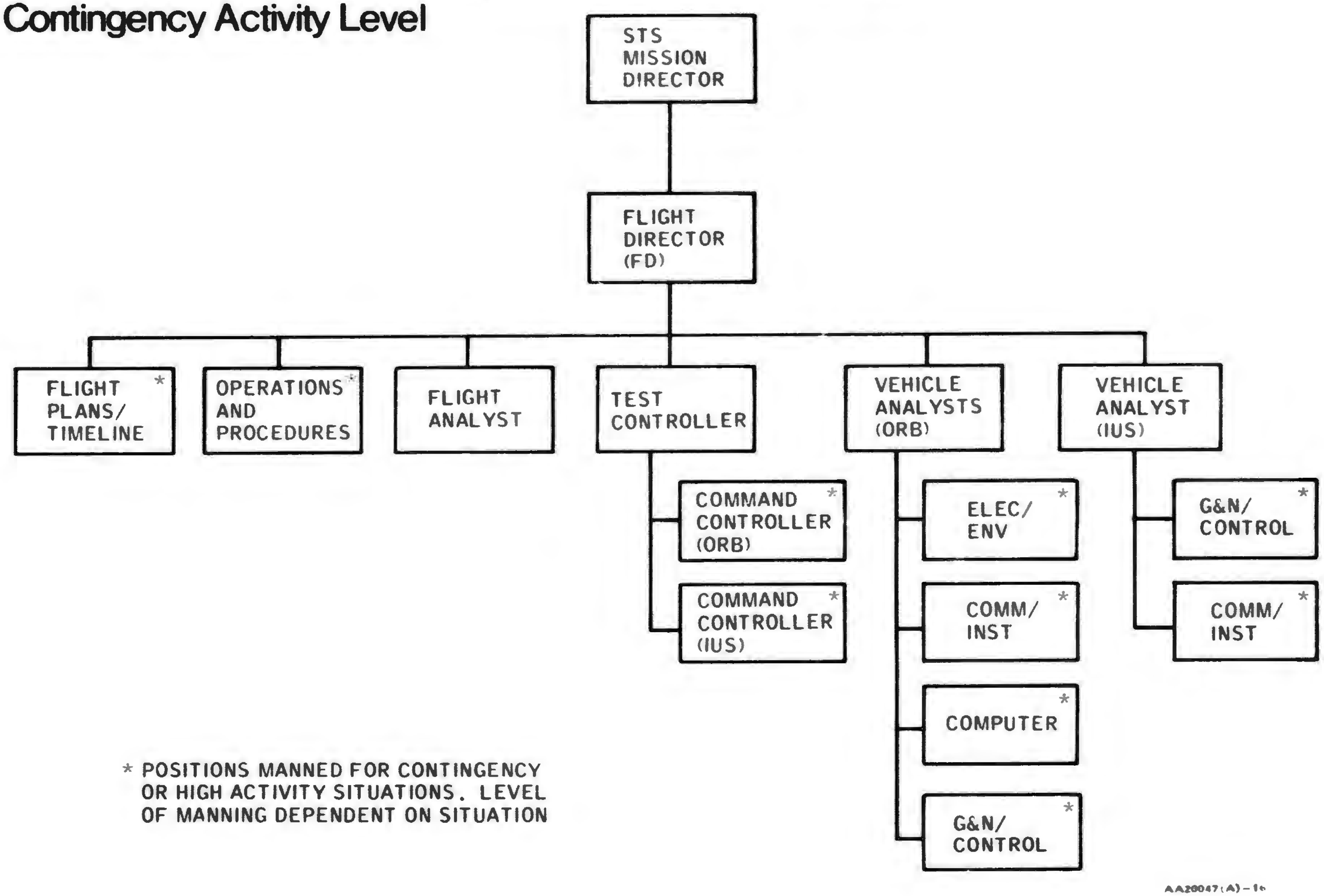
The SMCC candidate operating positions recommended for contingency activity levels are presented in the facing figure.

Functions performed by the candidate operating positions in support of Orbiter and/or IUS contingencies are as follows:

- STSMD. Evaluates contingency situations and initiates mission operational redirection such as flight termination, flight plan changes, and additional SCF and/or NASA resources
- FD. Redirects STC elements as required to accomplish mission objectives such as implementation of alternate command plans, procedures, and contingency manning
- Test Controller. Overall contingency coordination of network support activities and updates to network pass plan
- Flight Analyst. Performs analysis required for trajectory or maneuver planning activities, evaluates trajectory acceptability, and performs replanning associated with defining alternate mission
- Flight Plans/Timeline. Monitors and updates the mission flight plan during contingency support periods
- Operations and Procedures. Coordinates implementation of contingency mission procedures and data management timelines
- Vehicle Analyst (Orbiter). Maintains status of Orbiter systems and directs subsystem personnel in contingency Orbiter system analysis activities
- Command Controller (Orbiter). Maintains overall status of SCF command capability for Orbiter and coordinates RTS support during pass
- Subsystem Personnel (Orbiter). Evaluate Orbiter subsystem status and perform system analysis activities as required druing contingency situations
- Vehicle Analyst (IUS). Maintains status of IUS systems and directs subsystem personnel in contingency IUS system analysis activities
- Command Controller (IUS). Maintains overall status of SCF command capability for IUS and coordinates RTS support activities
- Subsystem Personnel (IUS). Evaluate IUS subsystem status and perform system analysis activities as required during contingency situations.

SMCC Candidate Operating Positions

Contingency Activity Level



* POSITIONS MANNED FOR CONTINGENCY OR HIGH ACTIVITY SITUATIONS. LEVEL OF MANNING DEPENDENT ON SITUATION

5.0 Orbital Requirements Document

Orbiter, External Tank, Solid Rocket Boosters

5.1 ORBITAL REQUIREMENTS DOCUMENT

The Orbital Requirements Document (ORD) defines the requirements for SCF support of the STS. It furnishes the SCF a basis for planning and implementing changes in equipment, software, facilities, operational procedures, and manpower needed to support the program.

The flight elements of the STS include the Orbiter, Solid Rocket Boosters (SRB's) and the External Tank (ET). Both the Orbiter and the SRB's are recoverable and reusable which imposes new support requirements on the SCF. The STS operations concept will add to the SCF's normal orbital support role the support for ascent, entry, landing and turnaround operations of a manned vehicle. STS missions will vary with each satellite program user requiring different orbits, mission durations and execution sequences. For the purpose of the definition or the basic SSV ORD, four reference applications missions were analyzed:

- A 7-day mission launched from the John F. Kennedy Space Center (KSC)
- A second mission launched from Vandenberg Air Force Base (VAFB) to deploy a satellite
- A third mission launched from VAFB to retrieve a satellite.
- A fourth mission launched from VAFB to deploy a satellite into a polar orbit, then retrieve a different satellite which has been commanded from the ground into the retrieval orbit.

As specific STS missions are defined, the description of each mission and the specific requirements it levies on the SCF will be defined in an annex to the ORD.

The format and information content of the ORD are as specified in Exhibit 61-98, *Space and Missile Systems Organization (SAMSO)*, Rev. B, October 1967.

Orbital Requirements Document

- DEFINES BASIC REQUIREMENTS ON THE AFSCF TO SUPPORT STS OPERATIONS
- BASIC REQUIREMENTS ARE REPETITIVE FROM MISSION TO MISSION
- FOUR REFERENCE APPLICATIONS MISSIONS WERE CONSIDERED
- MISSION AND SATELLITE PROGRAM UNIQUE REQUIREMENTS WILL BE DOCUMENTED AS ANNEXES TO THE BASIC ORD
- PREPARED AS SPECIFIED IN EXHIBIT 61-98, REVISION B, OCTOBER 1967

5.2 MISSION AND ORBITER VEHICLE PHASES

STS operations were analyzed to determine SCF detailed support requirements. This analysis indicated SCF support is required during the premission, real-time support, and postmission phases. These requirements were documented in an initial edition of an STS Orbital Requirements Document.

Premission activities involve premission preparation, SCF readiness testing, and launch site support. Premission preparation consists of mission planning, mission unique software development, mission support planning, SSV/AFSCF compatibility testing, training, simulations data base preparation, scheduling, and ephemeris data operation. Readiness testing includes validation and verification tests of specific hardware, software, and personnel as specified in the mission annex. Direct support will be provided by the SCF to the launch site and includes participation in open-loop compatibility testing and provision of flight software to the Launch Control Element.

The real-time support phase includes the Orbiter vehicle phases of prelaunch, ascent, on-orbit operations, entry, and approach and landing.

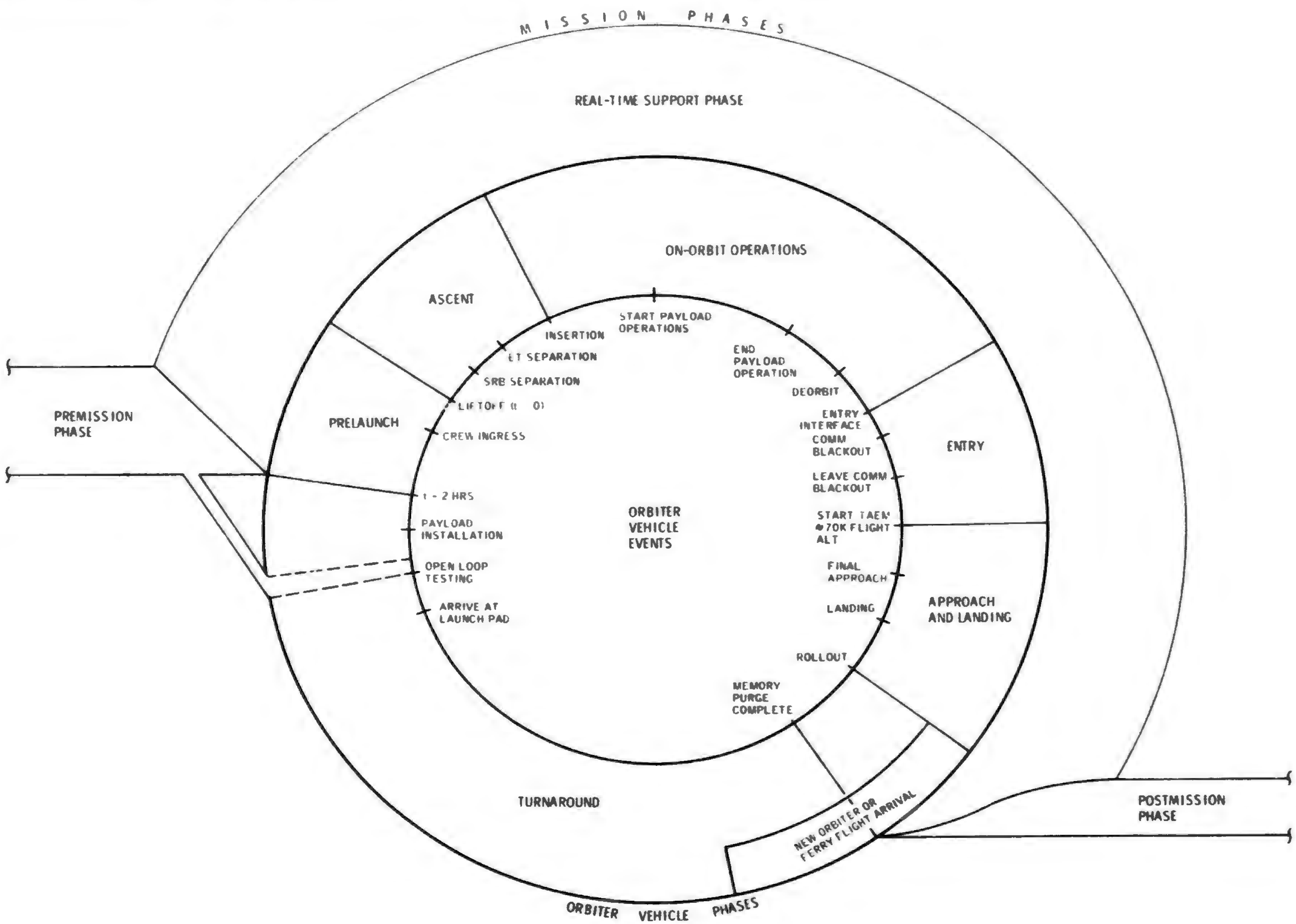
SCF prelaunch support requirements include mission updates, confirmation of support element readiness, and participation in countdown activities.

During ascent the SCF will maintain vehicle status data for possible abort support, coordinate ground support, and predict SRB impact point for SRB recovery.

On-orbit support requirements result from multirevolution missions and for contingency situations. Generally, on-orbit support requirements are related to requiring the SMCC to: 1) perform overall mission management and direction; 2) maintain mission status awareness; 3) respond to emergency/contingency situations; 4) perform near-real-time mission planning; 5) coordinate Orbiter/satellite operations, and 6) manage communications between ground and flight elements. These requirements result from SCF support of mission activities to include postinsertion status determination, orbit determination, maneuver targeting, Orbiter systems management, communications management, payload checkout and deployment, rendezvous and stationkeeping, retrieval, satellite handover, deorbit planning, entry and contingency support.

Postmission support is required to receive data dumps and participate in memory purging. Postmission analysis will be performed to determine the degree to which success criteria have been met for mission objectives, and to evaluate the performance of total systems, personnel, ground equipment, and vehicle equipment.

Mission and Orbiter Vehicle Phases



5.3 REQUIREMENTS BY SUPPORT SYSTEM FUNCTION

The SCF requirements contained in the ORD were based on program reference missions, and, by extension, are the general requirements for all STS missions launched from VAFB or KSC. Annexes will be provided to the basic ORD detailing the unique support required by individual missions.

Support system functional requirement categories considered were: tracking, ephemeris generation, telemetry processing, control and display, commands, data handling and distribution, computer program development, timing, communications and facilities.

Tracking requirements include uplink of reference signals for 1-way doppler orbit determination onboard and the provision of a backup capability for ground-based tracking using 2-way doppler.

Orbiter ephermeris will be generated for mission progress evaluation, data reduction, and correlation during nominal and contingency support periods.

Telemetry processing will be provided by the SMCC for real-time and dumped telemetry data. This processing will include validation, decommutation, limit sensing, EU conversion/calibration, and command verification.

The STC/SMCC display and control system performing in conjunction with its data processing system will provide mission and support personnel with the capability to request and observe data displays.

Two basic command types will be utilized by the Orbiter: real-time and vehicle update commands. The command repertoire is divided into fixed and variable commands. The fixed commands will remain constant from mission to mission, while the variable commands may be peculiar to each mission.

The required STC/SMCC data handling requirements are those which perform standard operations and support the handling of data for applications. They will include data formatting, data buffering, data routing, and input/output control.

Computer program development requirements pertain to software for data base management, limit sensing/alarm generation, command generation, peripheral processors, special applications, front-end software, simulation/training, mission planning, and targeting.

Accurate timing information to both equipment and time displays will be provided by the SCF timing system.

Facilities will be required for mission control, mission design and development, software development, classroom training, SMS, and a general administrative area for support of the STS program.

Requirements By Support System Function

- TRACKING
- EPHEMERIS GENERATION
- TELEMETRY PROCESSING
- CONTROL AND DISPLAY
- COMMANDS
- DATA HANDLING AND DISTRIBUTION
- COMPUTER PROGRAM DEVELOPMENT
- TIMING
- COMMUNICATIONS
- FACILITIES

6.0 IUS Orbital Requirements

6.1 IUS ANNEX

A "sample" IUS annex was prepared to illustrate the format and data type to be provided in specific mission annexes. Due to lack of IUS vehicle definition at this time it was concluded that this annex not be considered as part of the basic SSV ORD. This annex is contained in Vol. IV of the final report.

IUS Annex

- SAMPLE ANNEX
- INSUFFICIENT VEHICLE SYSTEM DEFINITION TO STATE SPECIFIC REQUIREMENTS
- USEFUL AS AN ANNEX GUIDE
- PUBLISHED IN VOLUME IV

7.0 Shuttle Mission Simulator

7.1 SHUTTLE MISSION SIMULATOR TASKS

As part of the efforts in CCDS Tasks IV and V, the DOD requirement for a Shuttle Mission Simulator (SMS) was investigated. The purpose was to define the SMS capability required for the conduct of DOD SMS operations and to determine the time-phased events, tasks, and funds required for subsequent SMS definition/procurement activities.

The SMS is a full mission simulator which is planned to be used to train upper deck crews for both NASA and DOD missions. The current concept for the SMS consists of one central computer facility driving two crew stations - a motion base crew station (MBCS) and a fixed base crew station (FBCS). The MBCS comprises the commander and pilot stations on a motion base with 7 degrees of freedom [three translational, three rotational, and an extended pitch] for full simulation. The MBCS has a full forward visual simulation. The FBCS comprises the entire upper flight deck with commander, pilot, mission specialist, and payload specialist stations on a fixed base. It will have both a forward and aft visual simulation system. It will be used for full fidelity simulation of payload operations and manipulation. The SMS configuration is referred to as the "2+4," where 2 refers to the MBCS, 4 refers to the FBCS, and 2+4 is an SMS with both the MBCS and FBCS.

These SMS analyses had the following objectives:

- Review the NASA training requirements and curriculum for applicability to the DOD
- Determine the approximate date(s) for which the JSC simulator usage rate becomes saturated (saturation was assumed to occur at 2000 machine hours/year for the MBCS and 2500 machine hours/year for the FBCS)
- Determine the DOD need for a "stand-alone" Mission Control Center Simulation System (MCCSS)
- Analyze and recommend one of these SMS deployment concepts: one 2+4 SMS at JSC, one 2+4 SMS each at JSC and STC, or one 2+4 SMS at JSC and one +4 SMS at STC
- Develop budgetary cost and schedule estimates for subsequent SMS definition, procurement, and implementation activities.

Shuttle Mission Simulator Tasks

PURPOSE: DETERMINE DOD SMS CAPABILITY REQUIREMENTS, COST, AND SCHEDULE ESTIMATES

DEFINITIONS: SHUTTLE MISSION SIMULATOR (SMS)

- MOTION BASE CREW STATION (MBCS)
- FIXED BASE CREW STATION (FBCS)
- 2+4 (MBCS + FBCS)

OBJECTIVES:

- REVIEW NASA TRAINING REQUIREMENTS/CURRICULUM
- DETERMINE JSC SIMULATOR SATURATION DATES
  - -- MBCS - 2000 MACHINE HOURS
  - -- FBCS - 2500 MACHINE HOURS
- DETERMINE DOD NEED FOR MCCSS
- ANALYZE THREE SMS DEPLOYMENT CONCEPTS
- DEVELOP COST AND SCHEDULE ESTIMATES

7.2 SMS TRAINING INITIAL CHECKOUT HOURS

The training requirements and curriculum proposed for NASA are applicable to the DOD. Most modifications required are in the area of the training of payload specialists; however, in subsequent SMS results to be discussed, the DOD crew is the commander, pilot, and the mission specialist (DOD-provided study guideline). The payload specialist is not considered.

Initial checkout hours on the SMS are 220 hours for the commander, 180 hours for the pilot, and 150 hours for the mission specialist. This is further broken down into 125 hours MBCS and 95 hours FBCS for the commander; 55 hours MBCS and 125 hours FBCS for the pilot; and all 150 hours for the mission specialist on the FBCS.

It is assumed that the initial commanders and pilots selected will have had previous astronaut training and will require only the 220 hours SMS as part of the commander qualification and only the 180 hours as part of the pilot qualification. Subsequent upgrading of mission specialist to pilot will require the 150 SMS hours plus the 180 SMS hours for pilot; likewise, pilots upgrading to commander will require the entire 220 SMS hours listed, in addition to those already received.

Shuttle Mission Simulator Training
Summary Initial Checkout Hours

	COMMANDER	PILOT	MISSION SPECIALIST	PAYLOAD SPECIALIST	STATION M OR F
BASIC SYSTEMS	30	30	50		F
LAUNCH AND ABORT	30 10	10 10			M F
RENDEZVOUS AND DOCKING	30 10	10 10			M F
REMOTE MANEUVERING SYSTEM	20	40	10		F
ENTRY	15 5	5 5			M F
APPROACH AND LANDING	40 10	20 10			M F
PAYLOAD - SYSTEMS	10	10	40	20	F
- OPERATIONS		10	50	30	F
FERRY	10	10	—	—	M
TOTALS	220	180	150	50	

NOTES:
1. INTEGRATED SIMS INCORPORATED IN TOTAL HOURS
2. HOURS BASED ON A CREW CAPABILITY FOR ALL MISSIONS EXCEPT EVA
3. M = MOVING BASE; F = FIXED BASE
4. DURING INTEGRATED SIMS IT IS ASSUMED THAT THE COMMANDER AND PILOT WILL PRIMARILY TRAIN IN THE FIXED BASE CREW STATION (THUS THE DOUBLE ENTRIES UNDER CERTAIN MISSION PHASES)

7.3 SMS TRAINING RECURRING HOURS

Recurring SMS training hours for Shuttle crewmen are 115 MBCS hours and 35 FBCS hours for the commander; 45 MBCS hours and 85 FBCS hours for the pilot, and 100 FBCS hours for the mission specialist. Training for specific missions is included in the recurring training requirements.

Shuttle Mission Simulator Training Summary Recurring Hours Per Annum

	COMMANDER	PILOT	MISSION SPECIALIST	PAYLOAD SPECIALIST	STATION M OR F
BASIC SYSTEMS			10		F
LAUNCH AND ABORT	30 10	10 10			M F
RENDEZVOUS AND DOCKING	30 10	10 10			M F
REMOTE MANEUVERING SYSTEM		40	20		F
ENTRY	15 5	5 5			M F
APPROACH AND LANDING	40 10	20 10			M F
PAYLOAD - SYSTEMS			20	20	F
- OPERATIONS		10	50	30	F
FERRY					M
TOTALS	150	130	100	50	

NOTES:
1. PAYLOAD SPECIALIST OR EXPERIMENTS ASSUMED DIFFERENT FOR EACH MISSION AND ONE PAYLOAD SPECIALIST ONBOARD FOR EACH TWO MISSIONS
2. DURING INTEGRATED SIMS IT IS ASSUMED THAT THE COMMANDER AND PILOT WILL PRIMARILY TRAIN IN THE FIXED BASED CREW STATION (THUS THE DOUBLE ENTRIES UNDER CERTAIN MISSION PHASES)
3. M = MOTION BASE CREW STATION; F = FIXED BASE CREW STATION

7.4 DOD SHUTTLE FLIGHT CREW MEMBERS

It was a DOD-provided study groundrule that a flight crew could consist of a commander, pilot, and a mission specialist. In developing the annual manning required for career astronauts, the following items were considered: 1) six flights per year per crew, 2) one reserve crew and one additional reserve mission specialist required (some missions may require more than one mission specialist), and 3) a peak of 17 DOD launches per year. This resulted in a requirement for four commanders, four pilots, and five mission specialists.

The number of crew members in training was developed based on a buildup to the crew size referred to above, an assumed attrition of two commanders per year (an approximate rate of 20 percent of the entire crew population), and an upgrading of pilots to commanders, mission specialists to pilots, and an entry level of mission specialists. This philosophy results in a fixed annual initial training rate for the SMS of two members in each career category (commander, pilot, and mission specialist) based solely on the attrition of two commanders. Other members in initial training are as a result of crew buildup.

DOD Shuttle Flight Crew Members

	CALENDAR YEAR													
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
NUMBER OF MISSIONS	-	-	3	5	5	13	16	17	16	16	15	16	17	17
<u>CREW CATEGORY REQUIRED</u>														
COMMANDERS	-	3	4	4	4	4	4	4	4	4	4	4	4	4
PILOTS	-	3	3	3	3	3	4	4	4	4	4	4	4	4
MISSION SPECIALIST	-	3	3	3	4	5	5	5	5	5	5	5	5	5
<u>CREW MEMBERS IN TRAINING</u> (A)														
COMMANDERS (B)	3	3	2	2	2	2	2	2	2	2	2	2	2	2
PILOTS (C)	3	3	2	2	2	3	2	2	2	2	2	2	2	2
MISSION SPECIALISTS (D)	3	3	2	3	3	3	2	2	2	2	2	2	2	2

ASSUMPTIONS:
(A) ATTRITION OF 2 COMMANDERS PER YEAR (~20% ATTRITION)
(B) PILOTS UPRATING TO COMMANDER - 220 HOURS IN SMS
(C) MISSION SPECIALIST UPRATING TO PILOT - 180 HOURS IN SMS
(D) NEW MISSION SPECIALIST TRAINING - 150 HOURS IN SMS

7.5 DOD ANNUAL SMS REQUIREMENTS

The annual DOD SMS requirements estimates are derived by multiplying the number of crew members in training by the SMS hours required for each career category (i.e., commander - 220 hours, pilot - 180 hours, and mission specialist - 150 hours), and adding to that figure the product of the number in each crew category by the annual SMS hours previously indicated as required (commander - 150 hours, pilot - 130 hours, and mission specialist - 100 hours). This results in an annual SMS requirement of 1650 hours initially, peaking at 2920 hours in 1983, and a constant level of 2720 hours from 1984 through 1991. These figures list the hours required for independent training and do not consider parallel or joint training of crew members. This will be discussed on the next page.

These figures, as stated, assume an attrition of two commanders annually. Assuming an attrition of only one commander (an approximate 10 percent attrition of the total crew size per year), the annual proficiency hours required per year are the same but the initial checkout hours required as a result of attrition are halved. This results in a total annual SMS requirement initially of 1650 hours; the peak is 2520 hours in 1983, with a leveling-off at 2170 hours from 1984 through 1991.

DOD Annual Simulator Requirements
Initial Checkout, Operational and Crew Uprating

	CALENDAR YEAR													
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
INITIAL CHECKOUT AND CREW UPRATING (SIMULATOR HOURS)														
COMMANDERS	660	660	440	440	440	440	440	440	440	440	440	440	440	440
PILOTS	540	540	360	360	360	540	360	360	360	360	360	360	360	360
MISSION SPECIALISTS	450	450	300	450	450	450	300	300	300	300	300	300	300	300
SUBTOTAL (HOURS)	1650	1650	1100	1250	1250	1430	1100	1100	1100	1100	1100	1100	1100	1100
OPERATIONAL (PROFICIENCY TRAINING)														
COMMANDERS	-	450	600	600	600	600	600	600	600	600	600	600	600	600
PILOTS	-	390	390	390	390	390	520	520	520	520	520	520	520	520
MISSION SPECIALISTS	-	300	300	300	400	500	500	500	500	500	500	500	500	500
SUBTOTAL (HOURS)	-	1140	1290	1290	1390	1490	1620	1620	1620	1620	1620	1620	1620	1620
TOTAL ANNUAL SMS HOURS	1650	2790	2390	2540	2640	2920	2720	2720	2720	2720	2720	2720	2720	2720

7.6 DOD/NASA MBCS SIMULATOR HOURS/CALENDAR YEAR

The attached chart is a graphic representation of the NASA and DOD requirements for the MBCS for both initial and recurring training. Hours required are shown as maximum, probable, and minimum. These levels were derived by the following method:

- Maximum - assumes all crew members are trained independently; therefore, the hours are the sum of the hours required for the commander plus the pilot plus the mission specialist.

- Minimum - assumes all crew member training is accomplished within the time period of the crew member requiring the maximum simulator time (i.e., command requires 240 hours on the MBCS, pilot requires 1C0 hours; total SMS hours required are 240).

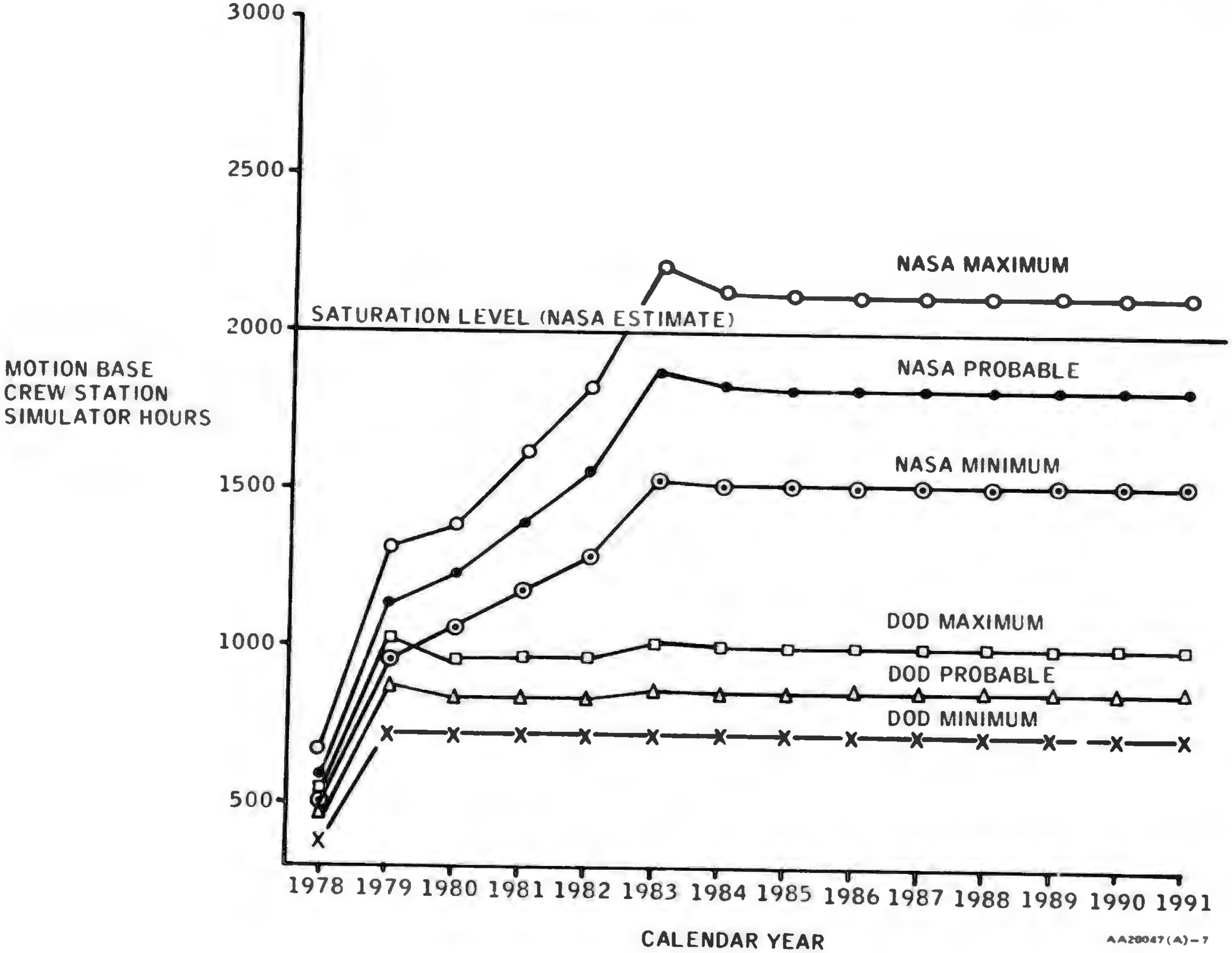
- Probable - assumes all crew members are trained within the MBCS hours required by the commander plus one-half of the pilot requirement (i.e., commander requires 240 MBCS hours; pilot requires 100 MBCS; total required is 290 hours).

On the probable curves, it is shown that the DOD requirements for the MBCS begin with 457 hours in 1978, peak at 870 hours in 1979, and taper off to 832 hours in 1980-82, 860 hours in 1983, and 855 hours from 1984 through 1991.

Similarly NASA's MBCS hours in 1978 are 1125; they peak at 1870 hours in 1983 and level off at 1817 hours from 1985 through 1991.

The totals for NASA are based on a crew size that reaches 11 each commanders, pilots, and mission specialists, with an annual attrition of two of each crew member category. For the initial training required, however, NASA figures reflect hours as if two commanders, two pilots, and two mission specialists are replaced, as opposed to the upgrading of crew members. As a result, NASA and DOD figures for initial training as a result of attrition are identical instead of NASA's being three times as great.

DOD/NASA MBCS Simulator Hours vs Calendar Year

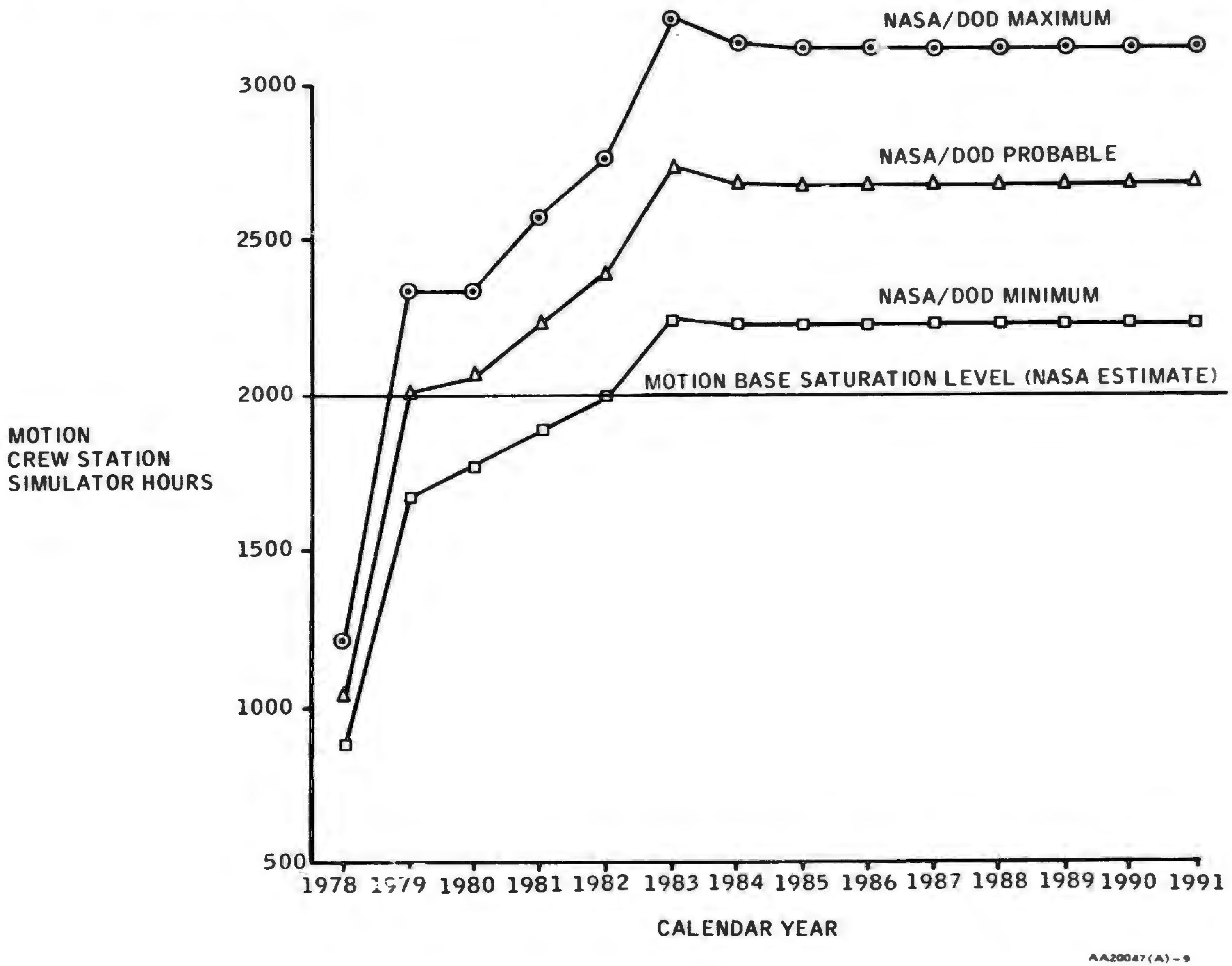


7.7 TOTAL MBCS SIMULATOR HOURS/CALENDAR YEAR

The NASA and DOD requirements for the MBCS are summed and presented graphically in the following chart. Assuming the MBCS saturates at 2000 hours, it is evident that saturation occurs in 1979 for both the maximum and probable curves and in 1983 for the minimum curves.

On a 10 percent attrition for both NASA and DOD, saturation is extended slightly. For the maximum, saturation still occurs in 1979, but the probable is 1981, and the minimum levels off at 1975 hours or 25 hours below saturation.

Total MBCS Simulator Hours vs Calendar Year

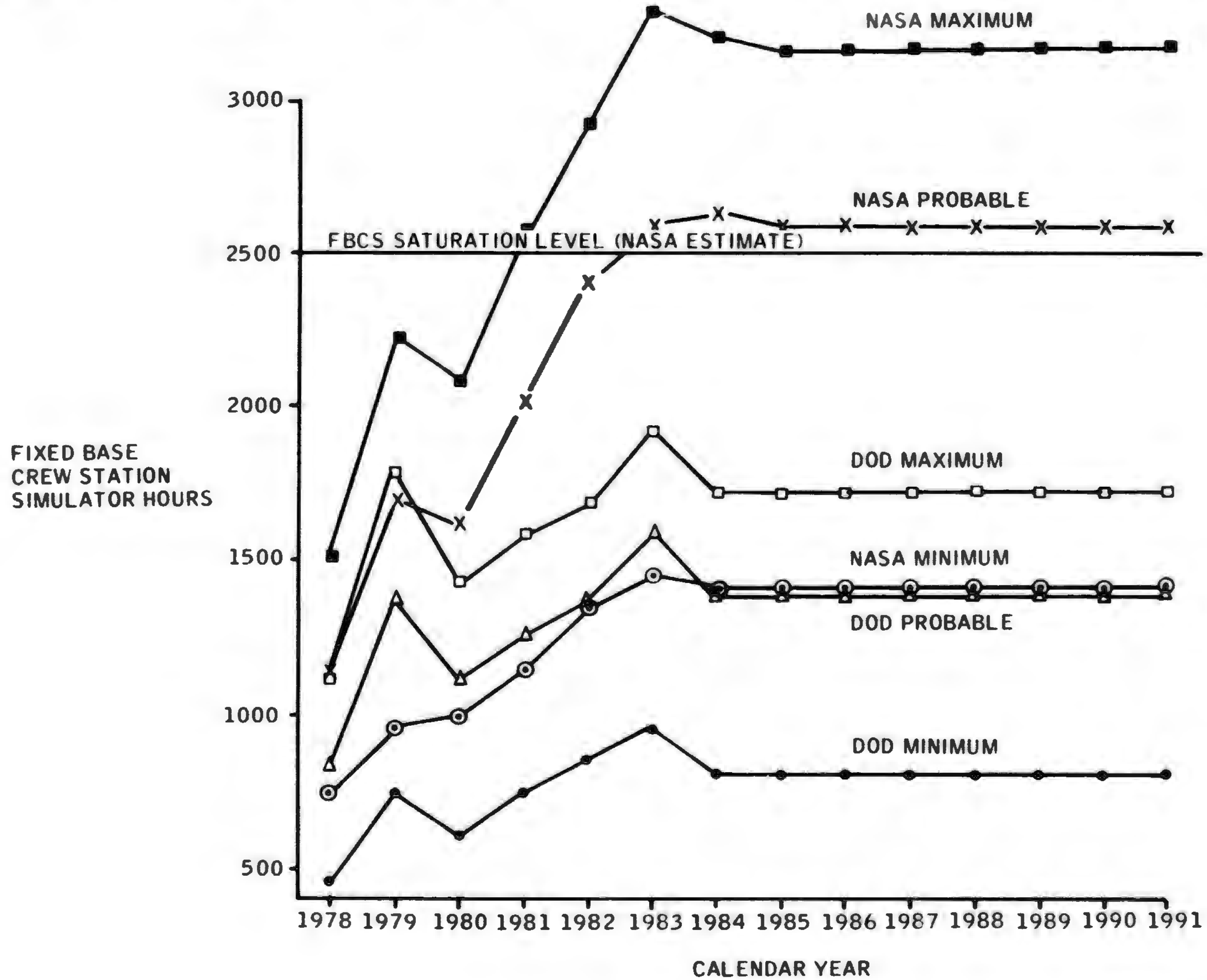


7.8 DOD/NASA FBCS SIMULATOR HOURS/CALENDAR YEAR

Both DOD and NASA requirements for the FBCS are presented on the accompanying chart, shown as maximum, probable, and minimum hours required. These are defined similarly to those for the MBCS with one exception; i.e., probable consists of the mission specialist hours plus the pilot hours.

Using these guidelines, DOD probable hours for the FBCS begin with 835 hours in 1978, peak at 1580 hours in 1983, then remain steady at 1390 hours from 1984 through 1991.

DOD/NASA FBCS Simulator Hours vs Calendar Year

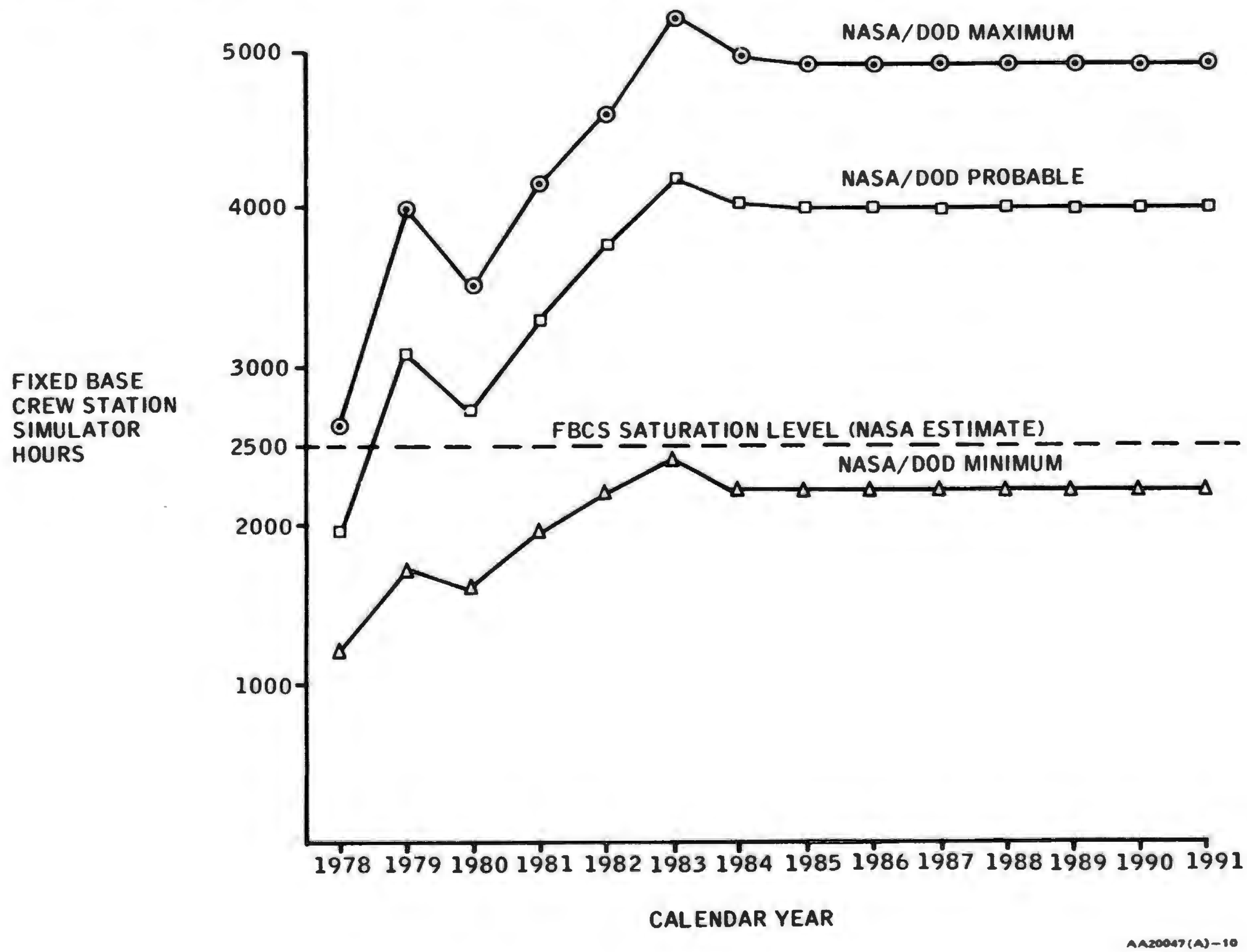


7.9 TOTAL FBCS SIMULATOR HOURS/CALENDAR YEAR

The combined DOD/NASA FBCS requirements are presented on the attached chart. Assuming the FBCS is saturated at 2500 hours, the maximum hour requirement indicates saturation in 1978; the probable requirement shows saturation in 1979; the minimum peaks at 2400 hours, levels off at 2200 hours, and remains below saturation.

Assuming only an annual attrition of 10 percent, the saturation date in the maximum case remains 1978; for the probable case the saturation date is encountered in 1979; 1980 is below saturation, and saturation is sustained from 1981 through 1931. The minimum does not exceed 2250 hours and remains below saturation.

Total FBCS Simulator Hours vs Calendar Year



7.10 SMS DEPLOYMENT CONCEPTS

DOD has a requirement for SMS training of the DOD flight crews. An analysis was made of three SMS deployment concepts to determine their applicability to the DOD requirements. Deployment concept 1 eliminates any SMS at the STC and DOD training is accomplished on the JSC 2+4 SMS. Concept 2 provides a 2+4 SMS at both the STC and JSC, and concept 3 deploys a 2+4 SMS at JSC and a +4 SMS at the STC.

Concept 1 provides the lowest cost method of providing the DOD SMS training. However, it requires total DOD dependency on NASA for training; travel and TDY costs for personnel in training would be high; DOD is not provided with an onsite simulator for use in real-time trajectory change analysis, work-around procedures, malfunction analyses, etc. Because of projected JSC SMS saturation in 1979, concept 1 cannot provide all the required DOD SMS training.

Concept 2 provides DOD with a complete SMS capability, but at a higher cost for equipment and operations. However, it reduces the dependency on NASA facilities, eliminates SMS saturation, provides increased capability for contingency support and analysis, provides a backup for NASA training, permits increased DOD visibility in crew selection/proficiency, and reduces costs associated with expansion from a +4 capability.

Concept 3 provides DOD the capability to perform all FBCS simulation at the STC and MBCS simulation on the NASA 2+4 SMS at JSC. It has a lower cost than concept 2; however, if later expansion to a 2+4 capability is accomplished, it becomes the highest cost option. Its other advantages are similar to those of concept 2 as effected by the FBCS only. Its major disadvantage is that the MBCS at JSC saturates in 1979.

Concept 2 is the deployment concept recommended. It is the only concept satisfying the DOD/NASA training requirements for either the 10 or 20 percent attrition rates.

SMS Deployment Concepts

REQUIREMENT: SMS FOR DOD FLIGHT CREW TRAINING

DEPLOYMENT CONCEPTS:

	JSC	STC
CONCEPT 1	2+4	0
CONCEPT 2	2+4	2+4
CONCEPT 3	2+4	+4

COMPARISONS:

CONCEPT 1 - MINIMAL COST
TOTAL DEPENDENCY ON NASA
JSC SMS SATURATION IN 1979

CONCEPT 2 - HIGH COST
ELIMINATES SATURATION AND DEPENDENCY
IMPROVED DOD VISIBILITY IN CREW PROMOTION/TRAINING
INCREASED CONTINGENCY SUPPORT CAPABILITY

CONCEPT 3 - LOWER COST (HIGHEST IF EXPANSION REQUIRED)
JSC MBCS SATURATION IN 1979
PREVENTS FBCS SATURATION
INCREASED CONTINGENCY SUPPORT CAPABILITY

CONCLUSION: CONCEPT 2 - ONLY ONE CAPABLE OF SATISFYING REQUIREMENT

7.11 MISSION CONTROL CENTER SIMULATION SYSTEM VS TAPES

Training of flight controllers includes mission simulation exercises in both an integrated mode (involving both the SMCC and the SMS) and in an SMCC stand-alone mode. In addition, verification and checkout are essential requirements for the implementation and sustaining operation of the DOD SMCC.

These requirements can be met by using canned data tapes processed tnrough SMCC Front End Processor (FEP) computers to the various consoles of the SMCC, or through a DOD unique Mission Control Center Simulation System (MCCSS). The MCCSS is a simulator capable of interfacing with the SMCC to provide realistic simulations for flight controller training and with both the SMCC and the SMS for integrated flight crew/controller training.

The use of canned tapes provides only limited flight controller training capability and does not provide the total realism obtained through real-time fault insertion, crew reaction, vehicle reaction, etc. A DOD MCCSS, however, provides extremely flexible verification and checkout capabilities and the following desirable features for flight controller training:

- Development and verification of unique mission plans, checklists, etc.
- Stand-alone training capability easily modified to test the design of unique DOD missions
- Malfunction analysis training
- Contingency support training
- Trajectory analysis and modification
- Handling of secure data
- Training in the proper DOD environment.

Because of these features, a DOD MCCSS is recommended for deployment at the STC.

Mission Control Center Simulation System vs Tapes

REQUIREMENT: TRAINING OF FLIGHT CONTROLLERS
VERIFICATION AND CHECKOUT OF SMCC

METHODS:

- CANNED TAPES
- MCCSS

COMPARISON:

- TAPES LIMITED - PROVIDES NO REAL-TIME DYNAMIC CAPABILITY
- MCCSS PERMITS
  - -- DEVELOPMENT/VERIFICATION OF MISSION PLANS, CHECKLISTS, ETC.
  - -- STAND-ALONE FLIGHT CONTROLLER TRAINING (GENERAL AND UNIQUE MISSION)
  - -- MALFUNCTION ANALYSIS TRAINING
  - -- CONTINGENCY SUPPORT TRAINING
  - -- MODIFICATION AND ANALYSIS OF TRAJECTORIES
  - -- SECURE DATA HANDLING
  - -- TRAINING IN PROPER ENVIRONMENT

RECOMMENDATION: MCCSS DEPLOYED AT STC

7.12 STC MISSION CONTROL CENTER SIMULATION SYSTEM

The STC MCCSS should have total capability of training mission operations personnel, developing and validating operational concepts and procedures, and validating SMCC capabilities. The MCCSS comprises a math model computer; a trajectory simulation function; simulation consoles; and for interfacing, a network simulation computer and an SMS interface.

The math model computer is primarily responsible for providing vehicle and groundtrack math models for the Shuttle systems, flight elements, and payloads. These models are interfaced to the simulation consoles for time-tagging and real-time fault insertion. Ephemeris computations are provided through an interface with the trajectory simulation element.

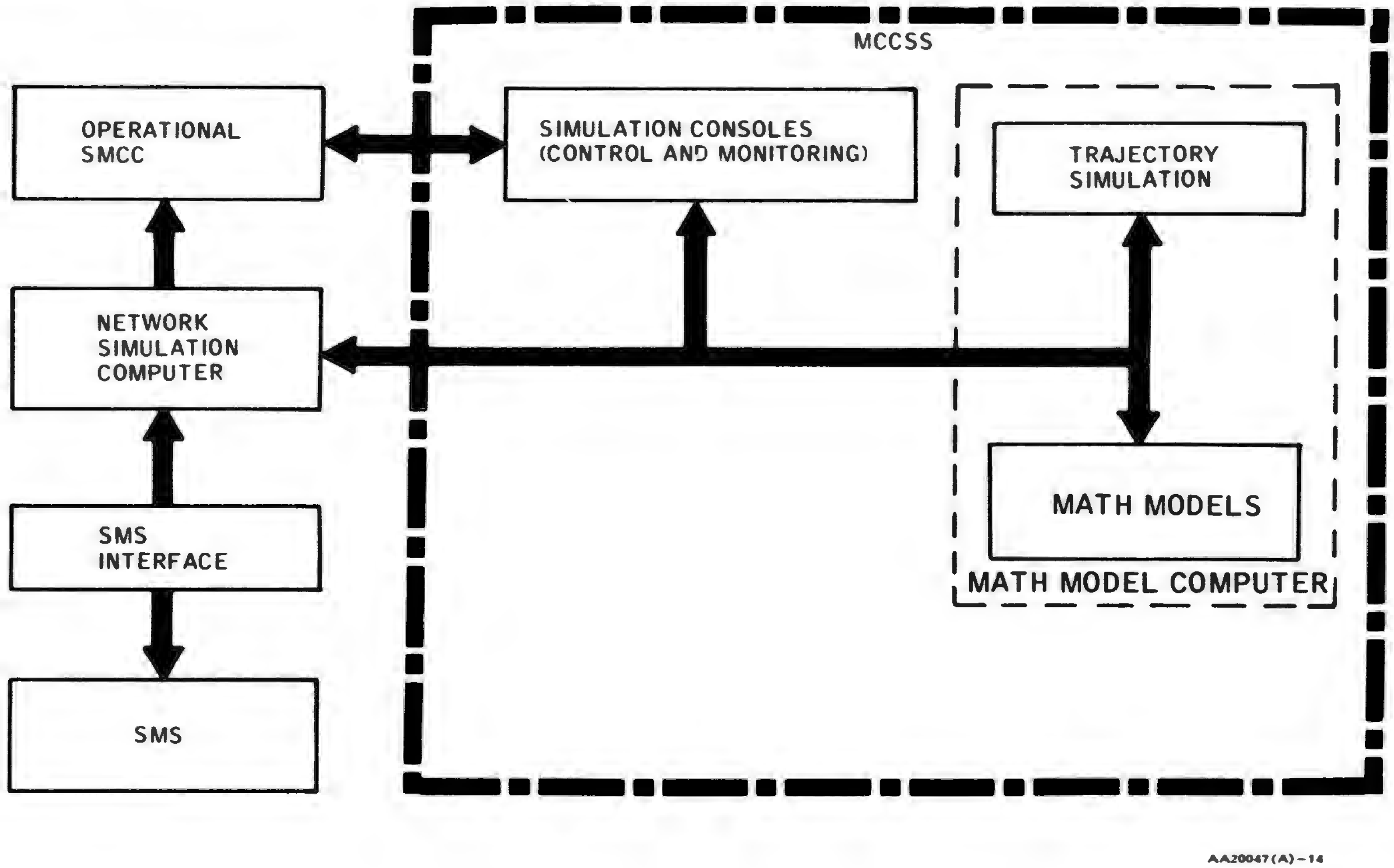
The math model computer contains the trajectory simulation element which provides ephemeris and trajectory information (as a function of the vehicle math model systems or from velocity data from the SMS during integrated simulations). Data is displayed on the simulation consoles from the trajectory simulation element.

The simulation consoles provide the display and control interfaces with the MCCSS functional elements. Displays and voice loops from the SMCC are paralleled to the simulation consoles to permit monitoring the simulation progress.

The network simulation computer is responsible for the simulation of the SMCC operational interfaces with the RTS's and the NASA networks. Faults may be inserted into the simulated network elements from the MCCSS consoles.

The SMS interface is used to interface the SMS to the MCCSS and SMCC during integrated simulations. It, in conjunction with the network simulation computer, provides the air/ground link, simulator data interchange, and voice coordination required during SMS-SMCC simulations.

STC Mission Control Center Simulation System



7.13 <u>FUNCTIONAL DOD SMCC INTERFACE DEVELOPMENT</u>

The attached figure illustrates an incremental approach to the functional interfaces required by DOD for SMCC and SMS simulation exercises.

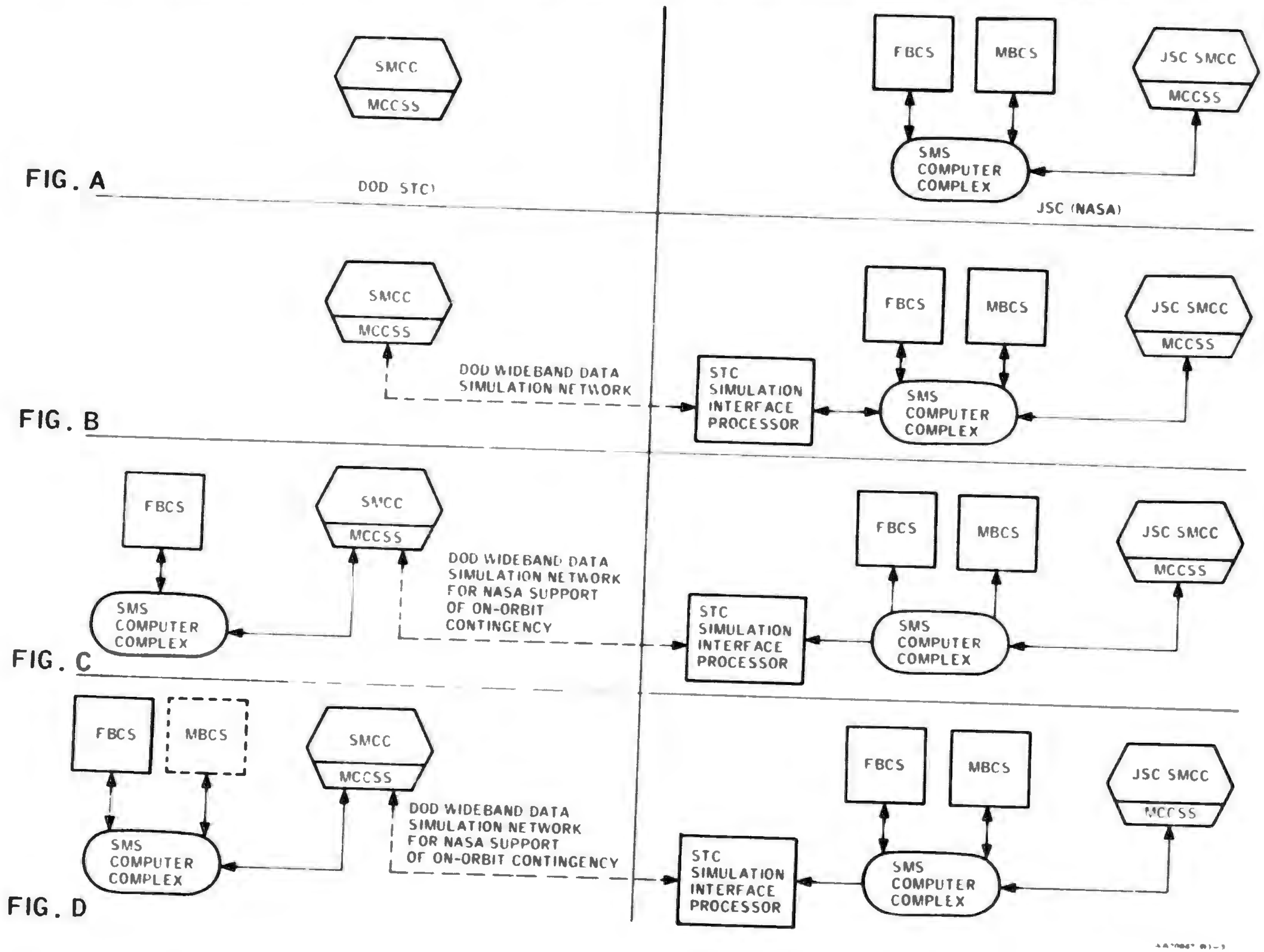
Figure A illustrates the initial DOD simulator capability required for the early development phase. During this period the SMCC can be developed, verified, and checked out. Flight crew/controller training could start at the JSC facilities.

Prior to OFT-integrated training, DOD would provide a wideband data simulation network between the STC and the JSC SMS through a simulation interface processor. This interface provides DOD with an integrated SMCC-SMS simulation capability. (See figure B.)

Prior to JSC FBCS saturation, DOD would have procured an FBCS and associated computer complex and no longer be dependent on NASA for FBCS or integrated SMCC-SMS training. The wideband interface would remain intact, however, for use in the event NASA contingency support was requested by the DOD. (See figure C.)

Figure D indicates the addition of the MBCS to the STC SMS. This added capability is required prior to saturation of the JSC MBCS.

Functional DOD SMCC Interface Development



7.14 BUDGETARY COST ESTIMATES

Deployment concept 1 (2+4 SMS at JSC) results in a total cost to NASA of $34,040,000. These figures are based on estimates made to NASA as a result of other studies.

Cost estimates for deployment concept 2 (2+4 SMS at JSC and STC) were based on the following assumptions: 1) initial developmental and engineering costs will be born by NASA, and 2) an average savings of 30 percent will be realized due to reduced development and engineering costs. The attached chart indicates NASA's cost remains at $34,040,000 and the cost to DOD is $23,827,000.

Concept 3 (2+4 at JSC and a +4 at STC) cost estimates assume that the single FBCS does not benefit from engineering and development reduction as did concept 2 since the difference in simulator configuration represents a different prototype design and requirement. Total ROM cost to DOD for the FBCS and computer complex facilities is $16,363,000.

In each estimate, costs of facilities, GFE, and external interfaces are not included. Among the items considered to be GFE by NASA were the onboard computers (nine for a 2+4), flight software, and certain crew items (e.g., crew seats and hand controllers). These items must also be provided by DOD for the SMS and the estimates increased to reflect their acquisition.

Because of different source data for different components of the SMS, cost figures shown are a mix of FY73 and FY74 dollars.

Budgetary Cost Estimates

	NASA(1) (CONCEPT 1, 2, & 3)	DOD (CONCEPT 2)	DOD (CONCEPT 3)
MOTION BASE CREW STATION(2)	$18,250,000	$12,775,000	----
FIXED BASE CREW STATION(3)	11,854,000	8,297,000	12,896,000
HOST COMPUTER COMPLEX	3,936,000	2,755,000	3,467,000
TOTAL(4)	$34,040,000	$23,827,000	$16,363,000

(1) NASA HAS A FULL CAPABILITY SMS IN EACH CONCEPT

(2) DOES NOT INCLUDE COST OF 4 FLIGHT COMPUTERS

(3) DOES NOT INCLUDE COST OF 5 FLIGHT COMPUTERS

(4) TOTALS DO NOT INCLUDE FACILITY COSTS, ITEM IDENTIFIED AS GFE BY NASA, OR SMS EXTERNAL INTERFACES

7.15 SMS DEVELOPMENT AND PROCUREMENT MILESTONES (ESTIMATED)

Development and procurement milestones for the SMS are shown for both NASA and the DOD. Milestones are shown for the SMS computer complex, the crew stations, and the start of training in each. DOD training start dates were based on DOD SMS completion prior to the saturation dates for the NASA SMS. Saturation for NASA's FBCS was December 1978 and assumed to be December 1979 for the MBCS.

SMS Development and Procurement Milestones (Estimated)

	NASA	DOD
COMPUTER SYSTEM RFP	JUN 74	FEB 76
CONTRACT AWARD	NOV 74	JUL 76
COMPUTER DELIVERY	MAR 76	MAY 77
SMS RFP	JAN 75	APR 76
CONTRACT AWARD	JUN 75	SEP 76
MBCS COMPLETE/TRAINING BEGINS	NOV 77	JUN 79
FLIGHT HARDWARE DELIVERIES COMPLETE	FEB 78	JUL 78
FBCS COMPLETE/TRAINING BEGINS	JUN 78	DEC 78

7.16 SUMMARY CONCLUSIONS AND RECOMMENDATIONS

NASA training requirements, curriculum, and crew selection criteria were reviewed and are applicable to DOD.

For joint DOD/NASA use, the JSC SMS will saturate. Considering the probable SMS usage, both the MBCS and the FBCS will become saturated in 1979 based on a 20 percent crew attrition. Based on a 10 percent crew attrition, both the MBCS and the FBCS will sustain saturation in 1981.

A DOD MCCSS deployed at the STC is recommended for verification and checkout of the SMCC, for flight controller training, and for integrated SMCC-STS simulations.

Because of the saturation of the JSC SMS when used to provide DOD flight crew training, a 2+4 SMS deployed at STC is recommended. This is the only deployment concept given that will satisfy the anticipated DOD simulation requirements.

The ROM cost estimate to DOD for deployment of a full capability SMS at the STC is $23.7 million, excluding facilities, external interfaces, and items identified as GFE by NASA.

To satisfy DOD requirements, implementation of the FBCS at STC is required by 1 December 1978; implementation of the STC MBCS is required by 1 June 1979.

Summary Conclusions and Recommendations

- NASA TRAINING REQUIREMENTS, CURRICULUM AND CREW SELECTION CRITERIA APPLICABLE TO DOD
- FOR JOINT DOD/NASA USE, JSC SMS SATURATION OCCURS IN:
  - -- 1979 FOR MBCS (20% ATTRITION)
  - -- 1981 FOR MBCS (10% ATTRITION)
  - -- 1979 FOR FBCS (20% ATTRITION)
  - -- 1981 FOR FBCS (10% ATTRITION)
- AN STC MCCSS IS RECOMMENDED FOR TRAINING, SMCC VERIFICATION, AND INTEGRATED SMCC-SMS SIMULATIONS
- BECAUSE OF SATURATION OF THE JSC SMS, AN STC 2+4 SMS IS RECOMMENDED
- ROM COST FOR THIS IS $23.7 MILLION
- IMPLEMENTATION IS REQUIRED BY:
  - -- 1 DECEMBER 1978 FOR THE FBCS
  - -- 1 JUNE 1979 FOR THE MBCS