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INTEGRATED COMMAND, CONTROL,
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SYSTEM FUNCTIONAL ARCHITECTURE

Contract NAS5-26369

INTEGRATED COMMAND, CONTROL, COMMUNICATIONS AND COMPUTATION SYSTEM FUNCTIONAL ARCHITECTURE

Computer Technology Associates, Inc.
August 17, 1981

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FOREWORD

This Integrated Command, Control, Communications and Computation (IC^4) Functional Architecture document has been prepared by Computer Technology Associates, Inc., Denver, Colorado as a data requirement in the performance of the IC^4 system study contract NAS5-26369 for NASA Goddard Space Flight Center.

TABLE OF CONTENTS

		Page
	Foreword	ii
	Table of Contents	iii
1.0	INTRODUCTION	1
1.1	Purpose	1
1.2	Scope	3
1.3	Acronyms and Abbreviations	3
2.0	APPLICABLE DOCUMENTS	5
3.0	IC[4] FUNCTIONAL ARCHITECTURE DEFINITION	6
3.1	System Introduction	6
3.1.1	System Terminology	7
3.1.2	System Overview	9
3.1.3	Operations Overview	11
3.2	Functional Hierarchy	15
3.2.1	Science Experimenter Functional Hierarchy	17
3.2.1.1	Science Instrument Control	17
3.2.1.2	Instrument Data Acquisition and Utilization	20
3.2.2	Subsystem (Power, Thermal or Data Storage Management) Functional Hierarchy	21
3.2.2.1	Subsystem Mission Support	23
3.2.2.2	Subsystem Control	23
3.2.3	OBC or Command Memory Management Functional Hierarchy	24
3.2.3.1	Mission Support	24
3.2.3.2	Data Acquisition and Utilization	26
3.2.4	Subsystem (Communications) Functional Hierarchy	26
3.2.4.1	Subsystem Mission Support	28
3.2.5	Attitude Subsystem Functional Hierarchy	28
3.2.5.1	Mission Support	30
3.2.5.2	Attitude Subsystem Control	31

TABLE OF CONTENTS CONTINUED

3.2.6	Orbit Subsystem Functional Hierarchy	31
3.2.6.1	Mission Support	33
3.2.6.2	Orbit Subsystem Control	33
3.2.7	Mission Management Functional Hierarchy	34
3.2.7.1	Observatory Control	34
3.2.7.2	Ground Operations Control	36
3.2.8	Observatory Monitor and Control Functional Hierarchy	37
3.3	Key Features	40
3.3.1	Interactive User	40
3.3.1.1	Displays	41
3.3.1.2	Information Access	42
3.3.1.3	Procedure Access	42
3.3.2	Sequence Packages	43
3.3.3	Adaptive Update Capability	52
3.3.4	In-House Real-Time Operations	58
3.4	Operational Activity Threads	61
3.4.1	Long Range Planning Activities	61
3.4.2	Planning and Scheduling	62
3.4.2.1	Planning and Scheduling for a Period of Interest	62
3.4.2.2	User Update Capability to Observatory Sequence	65
3.4.3	Command Generation and Validation	68
3.4.3.1	CG&V for a Period of Interest	68
3.4.3.2	CG&V for a Command Period	76
3.4.3.3	CG&V with Completed Power, Thermal and Data Analysis	78
3.4.3.4	CG&V with Completed Uplink Plan	82
3.4.3.5	Parameter Update Capabilities	83
3.4.4	Real-Time Operations	86
3.4.4.1	Local Operations	86
3.4.4.2	In-House User Operations	91
3.5	Interfaces	93

FIGURES

			Page
Figure	3.1-1:	IC^4 System Overview	10
	3.1-2:	Operational Activity Overview	12
	3.2-1:	Functional Hierarchy Overview	16
	3.2-2:	Science Experimenter Functional Hierarchy	18
	3.2-3:	Subsystem (Power, Thermal or Data Storage Management) Functional Hierarchy	22
	3.2-4:	OBC (or Command Memory) Management Functional Hierarchy	25
	3.2-5:	Subsystem (Communications) Functional Hierarchy	27
	3.2-6:	Attitude Subsystem Functional Hierarchy	29
	3.2-7:	Orbit Subsystem Functional Hierarchy	32
	3.2-8:	Mission Management Functional Hierarchy	35
	3.2-9:	Observatory Monitor and Control Functional Hierarchy	38
	3.3-1:	Contents of a Sequence Package, Part I-Graphics	44
	3.3-2:	Contents of a Sequence Package, Part II-Graphics (1 of 2)	45
	3.3-2:	Contents of a Sequence Package, Part II-Graphics (continued, 2 of 2)	46
	3.3-3:	Sequence Generation Baseline Graphics	49
	3.3-4:	Adaptive Update Capability	56
	3.4-1:	Planning and Scheduling for Period of Interest	63
	3.4-2:	User Update Capability to Observatory Sequence	67
	3.4-3:	Command Generation and Validation (CG&V) Part I	69
	3.4-4:	Command Generation and Validation Part II	70
	3.4-5:	Command Generation and Validation Part III (Parameter Update Implementations)	84
	3.4-6:	Real-Time Operations (Pass Activities)	87
	3.5-1:	IC^4 System Interfaces	94

TABLES

		Page
Table 3.3-1:	Types of Adaptive Updates	54
3.5-1:	Subsystem (Power, Thermal, On-Board Data Storage Management) to Science Experimenter	96
3.5-2:	OBC (or Command Memory) Management to Science Experimenter	97
3.5-3:	Subsystem (Communications) to Science Experimenter	98
3.5-4A:	Science Experimenter to Attitude Subsystem	99
3.5-4B:	Attitude System to Science Experimenter	100
3.5-5A:	Science Experimenter to Orbit Subsystem	101
3.5-5B:	Orbit System to Science Experimenter	102
3.5-6A(1):	Science Experimenter to Mission Management	103
3.5-6A(2):	Science Experimenter to Mission Management (continued)	104
3.5-6B(1):	Mission Management to Science Experimenter	105
3.5-6B(2):	Mission Management to Science Experimenter (continued)	106
3.5-7A:	Science Experimenter to Observatory Monitor and Control	107
3.5-7B:	Observatory Monitor and Control to Science Experimenter	108
3.5-8A:	Subsystem (Power, Thermal, On-Board Data Storage Management) to OBC (or Command Memory)	109
3.5-8B:	OBC (or Command Memory) to Subsystem (Power, Thermal or Data Storage Management)	110
3.5-9A:	Subsystem (Power, Thermal, On-Board Data Storage Management) to Subsystem (Communications)	111
3.5-9B:	Subsystem (Communications) to Subsystem (Power, Thermal, On-Board Data Storage Management)	112
3.5-10A:	Subsystem (Power, Thermal, On-Board Data Storage Management) to Attitude Subsystem	113
3.5-10B:	Attitude System to Subsystem (Power, Thermal, On-Board Data Storage Management)	114
3.5-11A:	Subsystem (Power, Thermal, On-Board Data Storage Management) to Orbit Subsystem	115

TABLES CONTINUED

		Page
Table 3.5-11B:	Orbit Subsystem to Subsystem (Power, Thermal, On-Board Data Storage Management)	116
3.5-12A(1):	Subsystem (Power, Thermal, On-Board Data Storage Management) to Mission Management	117
3.5-12A(2):	Subsystem (Power, Thermal, On-Board Data Storage Management) to Mission Management (continued)	118
3.5-12B(1):	Mission Management to Subsystem (Power, Thermal, On-Board Data Storage Management)	119
3.5-12B(2):	Mission Management to Subsystem (Power, Thermal, On-Board Data Storage Management) (continued)	120
3.5-13A:	Subsystem (Power, Thermal, On-Board Data Storage Management) to Observatory Monitor and Control	121
3.5-13B:	Observatory Monitor and Control to Subsystem (Power, Thermal, On-Board Data Storage Management)	122
3.5-14A:	OBC (or Command Memory) Management to Subsystem (Communications)	123
3.5-14B:	Subsystem (Communications) to OBC (or Command Memory)	124
3.5-15:	OBC (or Command Memory) Management to Attitude Subsystem	125
3.5-16:	OBC (or Command Memory) Management to Orbit Subsystem	126
3.5-17A:	OBC (or Command Memory) Management to Mission Management	127
3.5-17B(1):	Mission Management to OBC (or Command Memory) Management	128
3.5-17B(2):	Mission Management to OBC (or Command Memory) Management (continued)	129
3.5-18A:	OBC (or Command Memory) to Observatory Monitor and Control	130
3.5-18B:	Observatory Monitor and Control to OBC (or Command Memory) Management	131

TABLES CONTINUED

Page

Table 3.5-19A: Subsystem (Communications) to Attitude Subsystem 132

3.5-19B: Attitude System to Subsystem (Communications) 133

3.5-20A: Subsystem (Communications) to Orbit Subsystem 134

3.5-20B: Orbit Subsystem to Subsystem (Communications) 135

3.5-21A(1): Subsystem (Communications) to Mission Management 136

3.5-21A(2): Subsystem (Communications) to Mission Management (continued) 137

3.5-21B(1): Mission Mangement to Subsystem (Communications) 138

3.5-21B(2): Mission Management to Subsystem (Communications) (continued) 139

3.5-21B(3): Mission Management to Subsystem (Communications) (continued) 140

3.5-22A: Subsystem (Communications) to Observatory Monitor and Control 141

3.5-22B: Observatory Monitor and Control to Subsystem (Communications) 142

3.5-23A: Attitude Subsystem to Mission Management 143

3.5-23B(1): Mission Management to Attitude Subsystem 144

3.5-23B(2): Mission Management to Attitude Subsystem (continued) 145

3.5-24A: Attitude Subsystem to Observatory Monitor and Control 146

3.5-24B: Observatory Monitor and Control to Attitude Subsystem 147

3.5-25A: Orbit Subsystem to Mission Management 148

3.5-25B: Mission Mangement to Orbit Subsystem 149

3.5-25B(2): Mission Management to Orbit Subsystem (continued) 150

3.5-26A: Orbit Subsystem to Observatory Monitor and Control 151

TABLES CONTINUED

		Page
Table 3.5-26B:	Observatory Monitor and Control to Orbit Subsystem	152
3.5-27A:	Mission Management to Observatory Monitor and Control	153
3.5-27B:	Observatory Monitor and Control to Mission Management	154
3.5-28A:	Mission Management to Ground-Space Link	155
3.5-28B:	Ground-Space Link to Mission Management	156
3.5-29A:	Observatory Monitor and Control to Ground-Space Link	157
3.5-29B:	Ground-Space Link to Observatory Monitor and Control	158
3.5-30A:	Ground-Space Link to Spacecraft	159
3.5-30B:	Spacecraft to Ground-Space Link	160

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to present a functional architecture for an Integrated Command, Control, Communications and Computation (IC^4) system which is applicable to spacecraft command and control during the TDRSS era from the 1980s to the early 1990s.

The IC^4 system study is concerned with the command and control portion of the NASA End-to-End Data System (NEEDS) program. The objectives of the total NEEDS program are to provide the systems concepts, techniques and technology which will increase the end-to-end data system responsiveness, reduce the relative cost of extracting information from space data and increase the degree of standardization throughout the system. (Reference 3) In meeting this objective the end-to-end process has been decomposed into the following functional areas:

a. Sensor
b. Sensor-unique processing
c. Ancillary Data Computing
d. Command and Control/Data System
e. Space-to-Ground Transport
f. Ground Transport (Downlink)
g. Data Staging
h. Support Computing (Ground)
i. Data Bases
j. Distribution Network
k. Data Bases (User)
l. End User
m. Mission Planning
n. Command and Control (Ground)
o. Ground Transport (Uplink)
p. Ground-to-Space Transport. (Reference 3)

The IC^4 functional architecture described in this document brings into focus the requirements for an integrated system which supports the command and control portions of the following NEEDS areas:

a. Command and Control (Ground)
b. Mission Planning
c. End User
d. Data Bases (User)
e. Distribution Network
f. Data Bases
g. Support Computing (Ground)
h. Data Staging
i. Command and Control/Data System (ground portions)
j. Sensor-unique Processing (ground portions).

The requirements which have driven this functional architecture are documented in the <u>IC^4 System Functional Requirements</u> (Reference 2). These requirements have been derived from analysis of the SMM, SME, UARS, and ERBE mission designs as well as knowledge of the Viking and Space Telescope requirements.

The IC^4 system described herein is a highly automated user-machine interactive system which allows multiple users the capability and flexibility to execute observatory command and control. All users (science experimenters, mission designers and spacecraft component engineers) are provided capabilities relative to requesting observatory responses, integrating these requests into a unified sequence of events, modifying these events in response to observatory data and ultimately commanding the vehicle. The IC^4 system emphasizes the utilization of standard interfaces, procedures and techniques which may be applied across a broad spectrum of GSFC missions during the TDRSS era. The system removes the requirement that all users be colocated by providing a common interface which may be remotely located at user facilities. The standard, common command and control capabilities comprise a basis set of mission requirements. The generation of a system design for both this basis IC4 system and the extension to a design for a specific mission model will be accomplished in subsequent efforts for NASA GSFC by Computer Technology Associates, Inc.

1.2 Scope

The functional architecture focuses exclusively on command and control activities. However, downlink data processing and analysis functions are included as required to support the uplink process. The functional architecture provides the functional characteristics and components of the IC4 system with a top-level allocation of resources (i.e., people and computers) to specific activities.

1.3 Acronyms and Abbreviations

CG&V	Command Generation and Validation
CRT	Cathode Ray Tube
D/L	Downlink
GSTDN	Goddard Space Tracking Data Network
H&S	Health and Safety
IC4	Integrated Command, Control, Communication, and Computation
IOS	Integrated Observatory Sequence
LRP	Long Rang Planning

NEEDS	NASA End-to-End Data System
OBC	On-Board Computer
P&S	Planning and Scheduling
POI	Period of Interest
R/T	Real-Time
TDRSS	Tracking and Data Relay Satellite System
TM	Telemetry
U/L	Uplink

2.0 APPLICABLE DOCUMENTS

1. IC⁴ Study Contract Monthly Reports
2. IC⁴ System Functional Requirements, Computer Technology Associates, Inc., March 31, 1981.
3. NEEDS System Concept, GSFC, February 28, 1979.
4. Mission Command and Control System Study Final Report, OAO Corporation, August 23, 1979.
5. Design Alternatives for a Modular Data Transport System, The Mitre Corporation, Report Number MTR-80W00026, April 1980.
6. NEEDS Archival Mass Memory Concept, MSFC, May 30, 1980.
7. NEEDS Modular Data Transport System Concept, Revision 1, JPL, July 7, 1980.
8. NEEDS Integrated Verification and Testing System Concept, LaRC, June 16, 1980.
9. Technology Requirements for NEEDS Phase 3 Program, October 31, 1980.
10. NEEDS Guidelines for Data Communications Standards - Packet Telemetry, GSFC, June 13, 1980.
11. NEEDS Information Adaptive System Concept, LaRC, May 30, 1980.
12. NEEDS Ancillary Data and Support Computing Concept, GSFC, June 27, 1980.
13. Execution Phase Project Plan for ERBE Mission, GSFC, July 1980.
14. NEEDS Data Base Management System Concept, MSFC, May 30, 1980.
15. Preliminary Execution Phase Project Plan for OPEN, GSFC, September 1979.
16. Mission Operations Plan for Solar Maximum Mission, GSFC, January 1980.
17. Flight Operations Requirements and Support System Description - SMM, Grumman Aerospace Corp., Bethpage, N.Y., December 1978.
18. Shuttle POCC Interface Facility Concepts and Requirements Document, GSFC, September 1979.
19. SME Project Launch Operation Support Circuit, JPL, April 1980.

3.0 IC4 FUNCTIONAL ARCHITECTURE DEFINITION

The purpose of this section is to define the IC4 system functional architecture. The following information provides this definition:

a. functional hierarchy
b. key system features
c. operational activity threads
d. interfaces.

The functional hierarchy provides the decomposition and allocation of command and control functions to the elements within the IC4 system. The key features summarize the major capabilities of the IC4 system. Operational activity threads illustrate the inter-relationship between the IC4 system elements, demonstrate the manner in which the key features are implemented and provide the order and timeliness in which the operations are performed. The interfaces illustrate those elements that originate or generate data and those elements that use the data. The interfaces also provide a description of the data and the data utilization and access techniques.

3.1 System Introduction

This section provides an overview of the IC4 system and operational activities. Key definitions are first presented to define major terms used to describe the IC4 system components. The overview then defines the system elements and summarizes the interactions between these elements. The operations overview summarizes the operational activities and capabilities of the IC4 system.

3.1.1 System Terminology

Key system terminology and definitions are as follows:

a. Observatory - The observatory is the total vehicle that supports a specific mission. It includes science instruments, on-board processors and spacecraft components required to support the science instruments or control vehicle operations.

b. Science Experimenter - The science experimenter is the initiator of science experimentation and the end-user of the on-board science instrument data. The functions performed by the science experimenter are as follows:

   1) Generation of sequences required to command and control the on-board science instrument
   2) Generation of commands for an instrument unique on-board processor
   3) Analysis and interpretation of science and instrument engineering data
   4) Dissemination and archival of science and instrument engineering data.

c. Subsystem Elements - The subsystem elements are responsible for the command and control of the following on-board subsystems: power, thermal, data storage management, communications (uplink and downlink), on-board computer (OBC) or command memory, attitude and orbit. Subsystem element functions include analysis and interpretation of subsystem data, generation of sequences required to command and control the specific on-board subsystems and support of all IC^4 elements to produce observatory sequences.

d. <u>Sequences</u> - A sequence is the definition of an instrument or subsystem activtiy which defines start time, duration and events within the activity. Inherent to a sequence is specific data which adds to the sequence definition (i.e., power and thermal profiles of the instrument or subsystem during the sequence, data and commanding requirements, etc.).

e. <u>Mission Management</u> - Mission management coordinates and integrates all other elements and activities within the IC^4 system. It provides the framework and mechanisms whereby a unified plan of action and observatory and ground sequences can be generated. The mission management element provides the capability to incorporate various mission objectives into a final usable form and directs the implementation of this detailed plan of action or sequence of events.

f. <u>User</u> - User refers to the elements that interact with the IC^4 system to control an instrument or subsystem. All science experimenters, subsystem elements and mission management are considered users of the IC^4 system.

g. <u>Local Operations</u> - Local operations refer to the standard, project-wide real-time observatory monitor and control functions which include transmitting command loads and monitoring real-time data to assure observatory health and safety.

h. In-House Operations - In-house operations refer to real-time functions unique to a specific science experimenter or subsystem user that are conducted at the user facility. The user facility may be at a location geographically dispersed from the local operations facility, or it may be at the same facility but residing in a separate room or building.

i. Ground-Space Link - The ground-space link primarily refers to the observatory communications (uplink and downlink) performed through TDRSS. It should be noted that other forms of ground-space communications could be applicable (i.e., GSTDN and mission unique facilities for communications). However, for the purpose of this document, TDRSS is assumed to provide the ground-space link.

3.1.2 System Overview

The IC^4 system provides the mechanism by which the users command and control the observatory. The IC^4 system is highly automated and provides the capability to perform the command and control activities in a timely manner via a computer based, man-machine interactive network.

Figure 3.1-1 defines the elements which comprise and utilize the IC^4 system. The elements are linked together by a computer and voice network which allows the elements to communicate with one another from separate and remote locations. Each user has available a CRT terminal through which the interaction with all system elements is conducted. Using computer graphic interactive techniques, each user

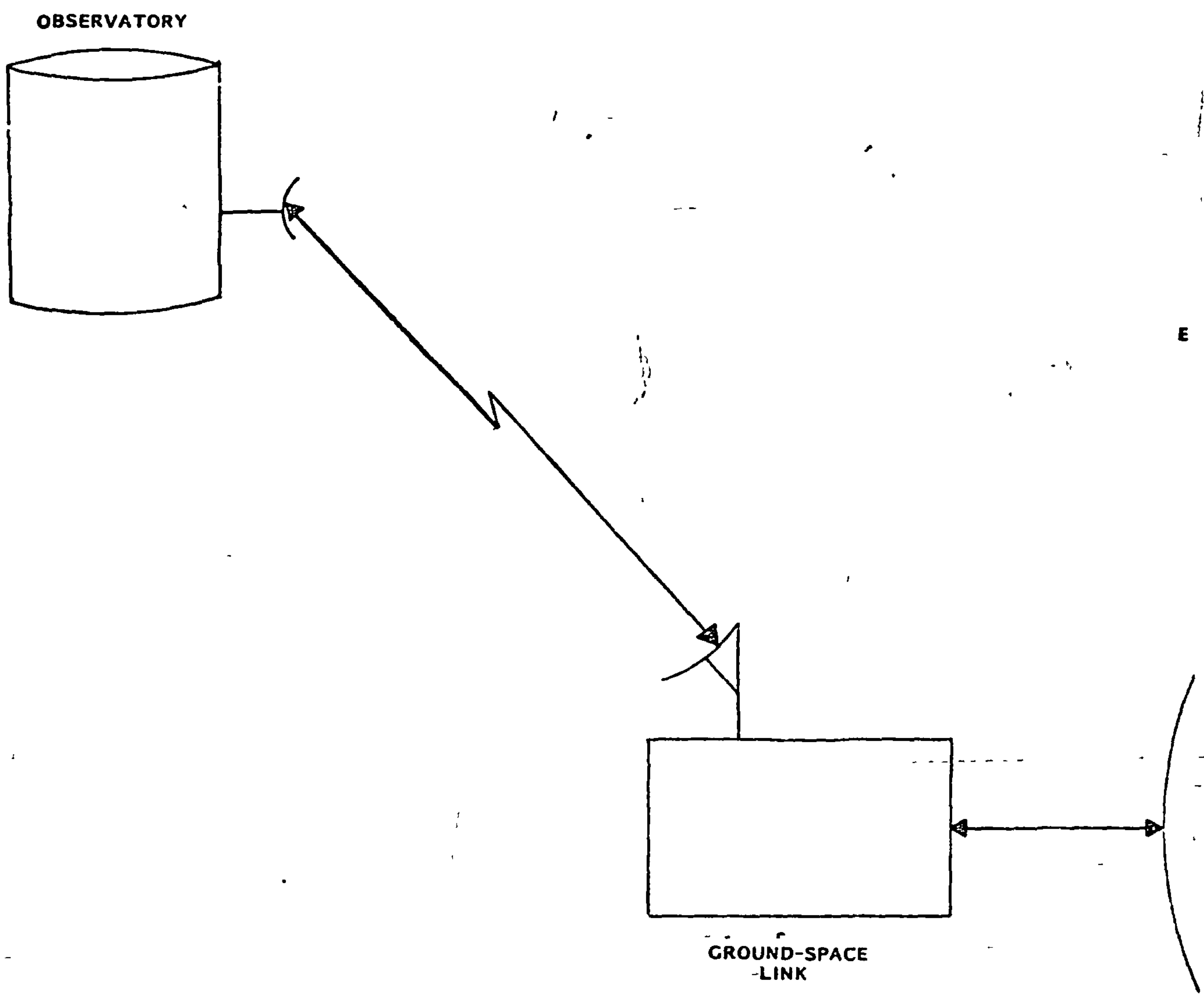

FIGURE 3.1-3. IC^4 SYSTEM OVERVIEW

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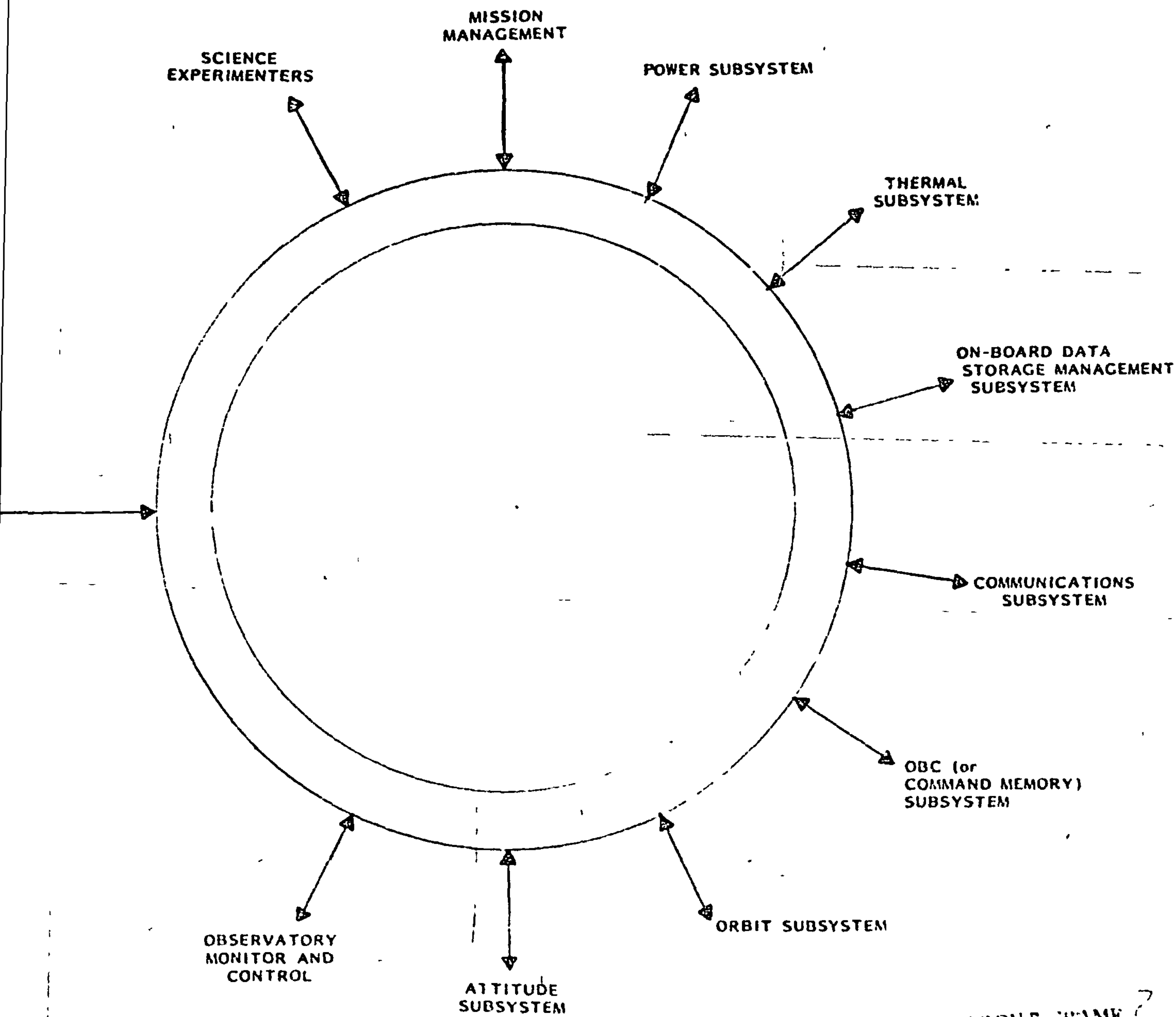

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has the capability to: a) participate in the planning and command generation activities; b) review uplink products; c) assist in conflict resolution; and d) modify observatory sequences (either in response to conflicts or adaptively in response to downlink data). Each element uses the interactive terminals to access system-wide data for display and support in creating command and control requirements. Additionally, each user uses the interactive terminals to access and monitor downlink data and to participate in the real-time uplink process.

3.1.3 Operations Overview

Figure 3.1-2 summarizes the operational activities and capabilities of the IC^4 system. Command and control activities are divided into four basic areas of concentration as follows:

a. Long-range planning
b. Planning and scheduling for a period of interest
c. Command generation and validation for the contacts within the period of interest
d. Real-time operations for each contact.

A brief description of these functions follows. Detailed activity threads are presented in Section 3.4 of this document.

Long-range planning is a highly manual, people interactive function that occurs as required throughout the lifetime of a mission. Long-range planning addresses the overall mission picture providing goals, objectives and plans for an extended period of time. The outputs of long-range planning provide a baseline for day-to-day mission operations.

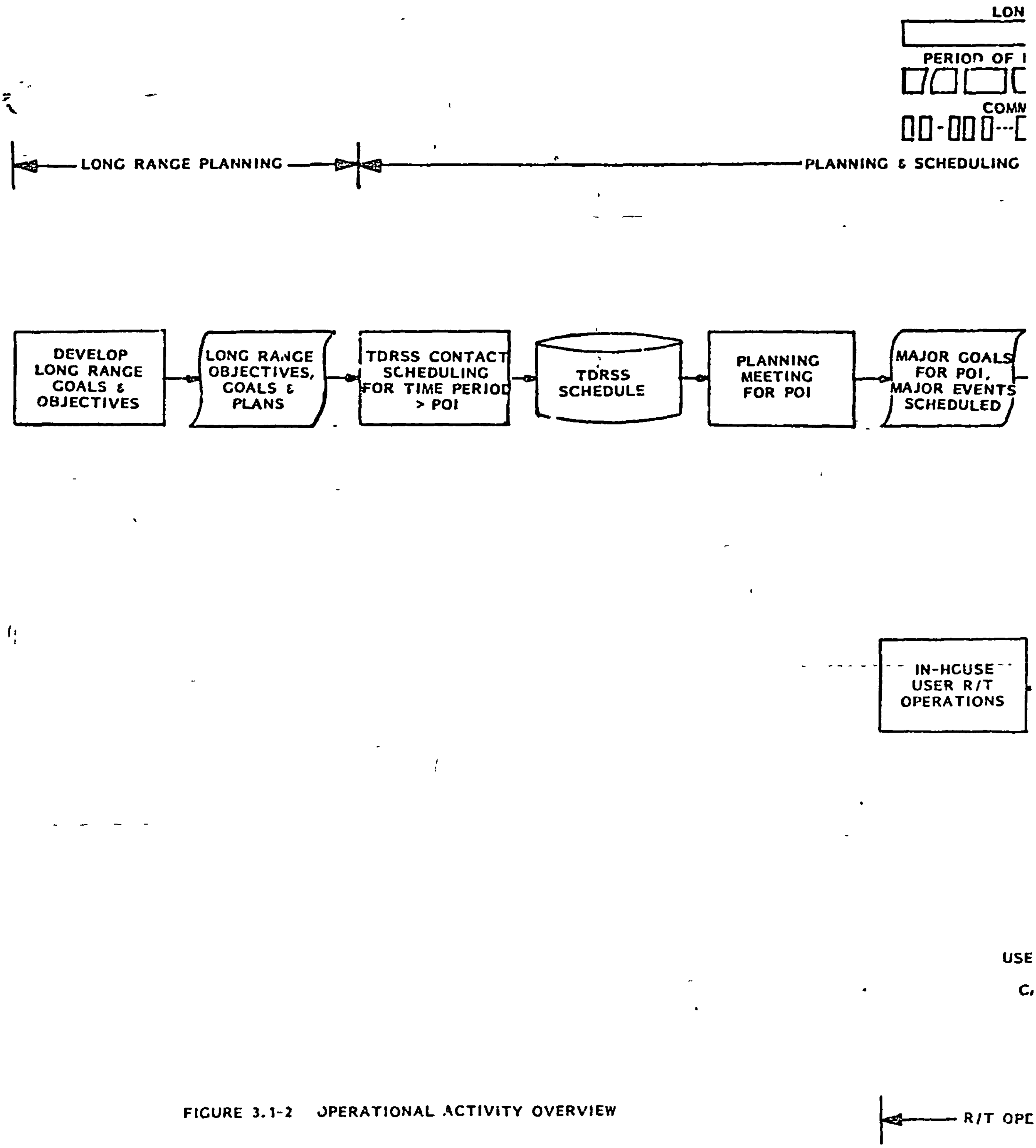

FIGURE 3.1-2 OPERATIONAL ACTIVITY OVERVIEW

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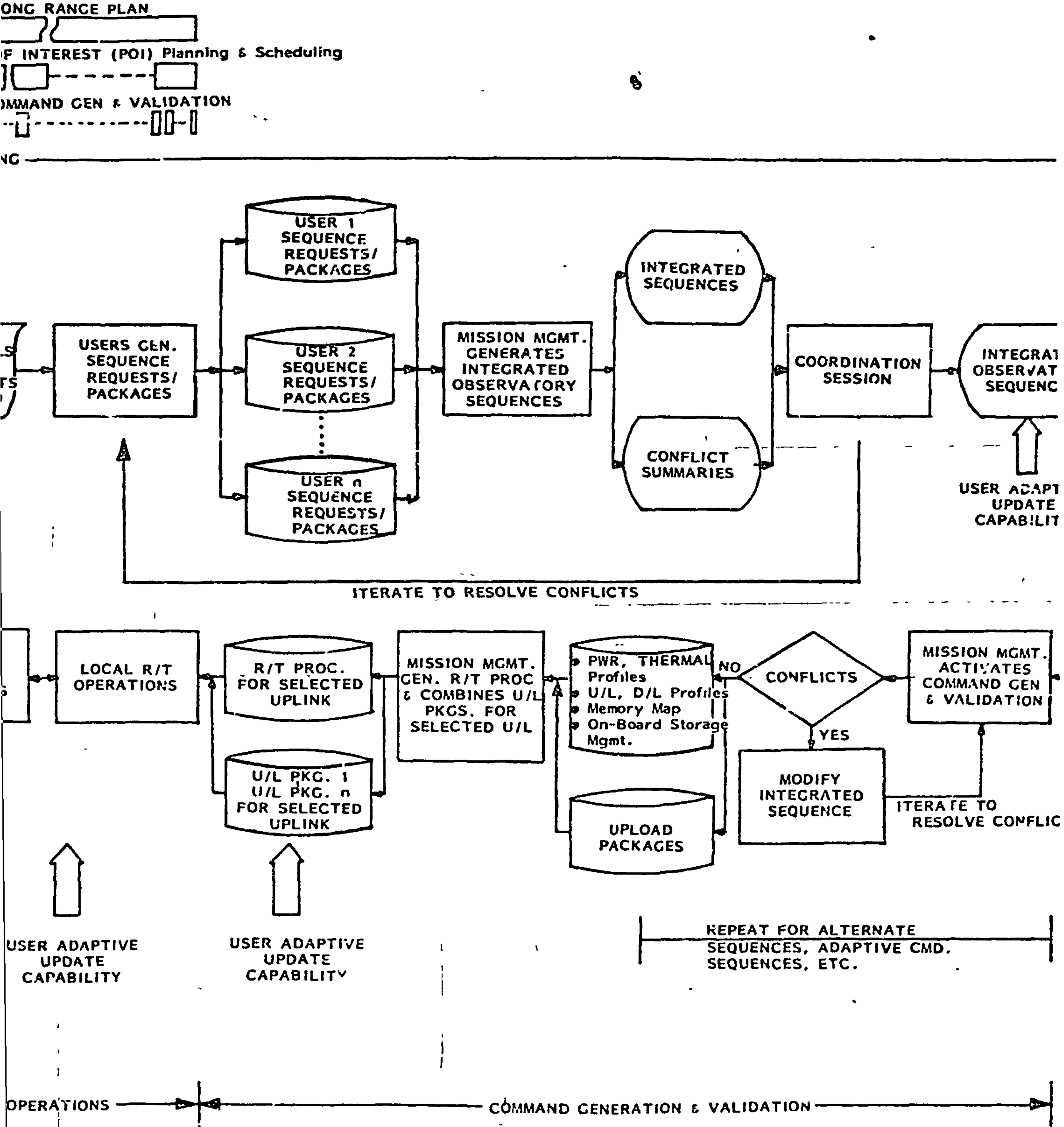

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Planning and scheduling (P&S) is an automated and man-machine interactive activity which addresses a fixed mission period of interest (POI) and which occurs on a regularly scheduled basis throughout the lifetime of the mission operations. The POI is a mission segment for which detailed scheduling and coordination of observatory activities are performed. The POI is typically on the order of one to two weeks. Within the POI, there are one or more contacts between the ground and observatory. Prior to the day-to-day planning and scheduling operations, the TDRSS schedule is established. The TDRSS schedule covers a time period greater than the POI and is finalized by the time actual planning begins for the POI. TDRSS scheduling is performed off-line to the normal POI P&S activities.

Routine P&S operations begin with a planning meeting for the POI. At this meeting, science representatives, spacecraft elements and mission planning elements assess the observatory operations and schedule major observatory events for the POI (i.e., maneuvers, pointing agreements, high data rate operations). Based on the outputs of the planning meeting, all system users (science experimenters, subsystem engineers, attitude and orbit subsystem engineers) generate specific sequence packages/requests for the POI. The combined sequences are referred to as the Integrated Observatory Sequence (IOS). Associated with the IOS is a conflict summary defining inter-instrument, instrument-to-spacecraft and observatory-to-ground conflicts. To resolve conflicts between project elements, a coordination session is held and the user request process is iterated until all conflicts are resolved. The output of the coordination session is a conflict-free IOS. After the IOS is generated system users have the capability to adaptively modify their sequences within the IOS in response to spacecraft or science instrument data received during a POI.

Based on the IOS, mission management activates the command generation and validation (CG&V) process. CG&V is a highly automated process that generates the following products:

a. Upload packages (command loads) for each contact during the POI
b. Uplink (U/L) and downlink (D/L) profiles for each contact during the POI
c. Power/thermal profiles, on-board data storage management strategy and OBC (or command memory) map for the POI
d. Validated integrated sequence with respect to power, thermal, data storage, OBC (or command memory) and communications (U/L and D/L) capabilities.

When conflicts are detected within the validation process the integrated sequence is modified and the command generation and validation process is iterated until validation has been completed. This process is repeated as required by mission management to accommodate alternative observatory sequences (as part of the IOS) and potential adaptive commanding requirements.

To complete the CG&V process, mission management combines all upload packages into unique sets for each uplink and generates the real-time procedures for each contact period. These procedures are then used to drive automatic operations during contact with the observatory. Once integrated upload packages are prepared, the users have the capability to update adaptively the command loads prior to command transmission.

Real-time operations involve two distinct areas: local operations and in-house user operations. Local operations include the standard project-wide real-time operational facility and interface with TDRSS. In-house user real-time operations include facilities and activities unique to a user or user facility. Via in-house user operations, users have the capability to monitor real-time data and adaptively modify uploads based upon incoming downlink data.

3.2 Functional Hierarchy

Figure 3.2-1 identifies the IC^4 elements involved in the ground processes which command and control the observatory. Functional decompositions for each of the elements shown in the overview are contained in the hierarchy charts which are discussed in the following sections. The functional hierarchies define the detailed functions for each element. Each element has been decomposed into the component parts which are necessary to produce an IC^4 system.

For science experimenters and subsystems (power, thermal, attitude, orbit, data storage, OBC, communications), control and data acquisition/utilization are common components. The control component contains those functions necessary to plan and cause to be implemented on-board activities. The data acquisition and utilization component, which contains downlink-related functions, is included in this command and control analysis for completeness and to insure that the feedback of data to the command and control functions is considered in the total system design. In addition, the subsystem decompositions include a mission support component which contains those functions necessary to allow full utilization of observatory capabilities. These subsystems support the mission by supplying projections of capabilities, capacities and events. The power, thermal and on-board data storage management subsystems are shown in one hierarchy chart because their IC^4 components are similar. However, in implementation they are totally separate and distinct elements.

The mission management element serves as the focal point and controlling element for all activities. Mission management

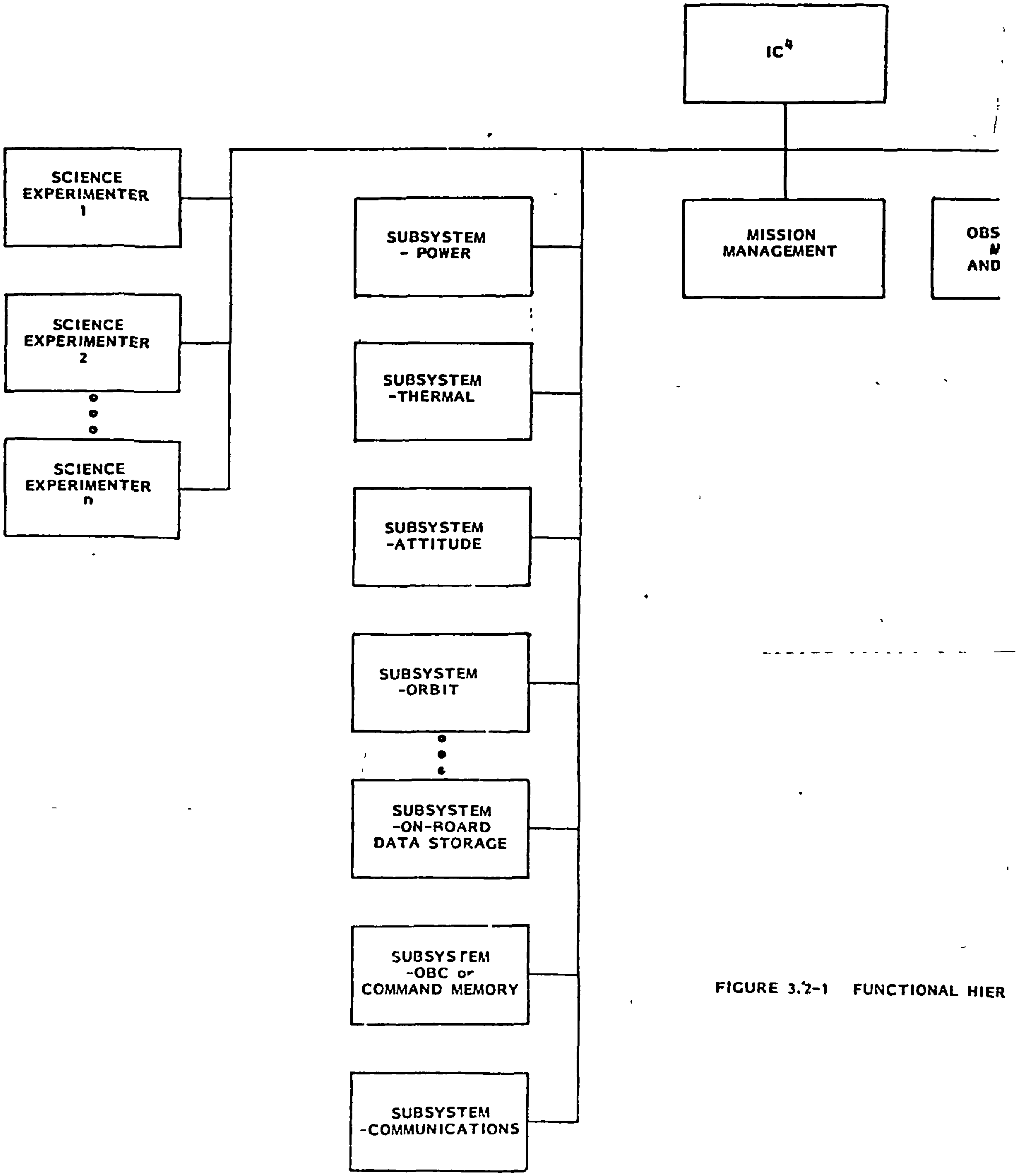

FIGURE 3.2-1 FUNCTIONAL HIER

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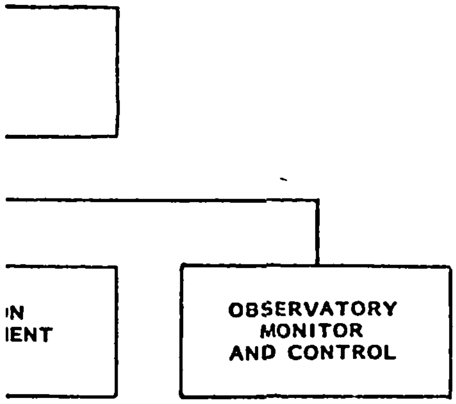

2-1. FUNCTIONAL HIERARCHY OVERVIEW

is divided into an observatory control component and a ground operations control component to reflect the two areas of responsibility. Finally, observatory monitor and control is decomposed into observatory control, ground control and data acquisition/utilization components.

These elements are discussed in the following paragraphs and fully described on the hierarchy charts.

3.2.1 Science Experimenter Functional Hierarchy

Figure 3.2-2 summarizes the functional hierarchy for the science experimenter element. The science experimenter element is divided into two distinct functions: 1) science instrument control and 2) instrument data acquisition and utilization. Science instrument control involves all activities necessary to generate instrument unique sequences and includes science experimenter real-time operations to transmit selected sets of commands for adaptive or anomalous situations. Instrument data acquisition and utilization encompasses all downlink data processing and analysis necessary to support science instrument control functions, real-time operations and science analysis. These two functions are addressed in greater detail below.

3.2.1.1 Science Instrument Control

Science instrument control involves the following functions:

a. all planning activities to determine integrated mission science requirements and to determine science instrument events for the POI
b. sequencing activities to schedule instrument events for the POI

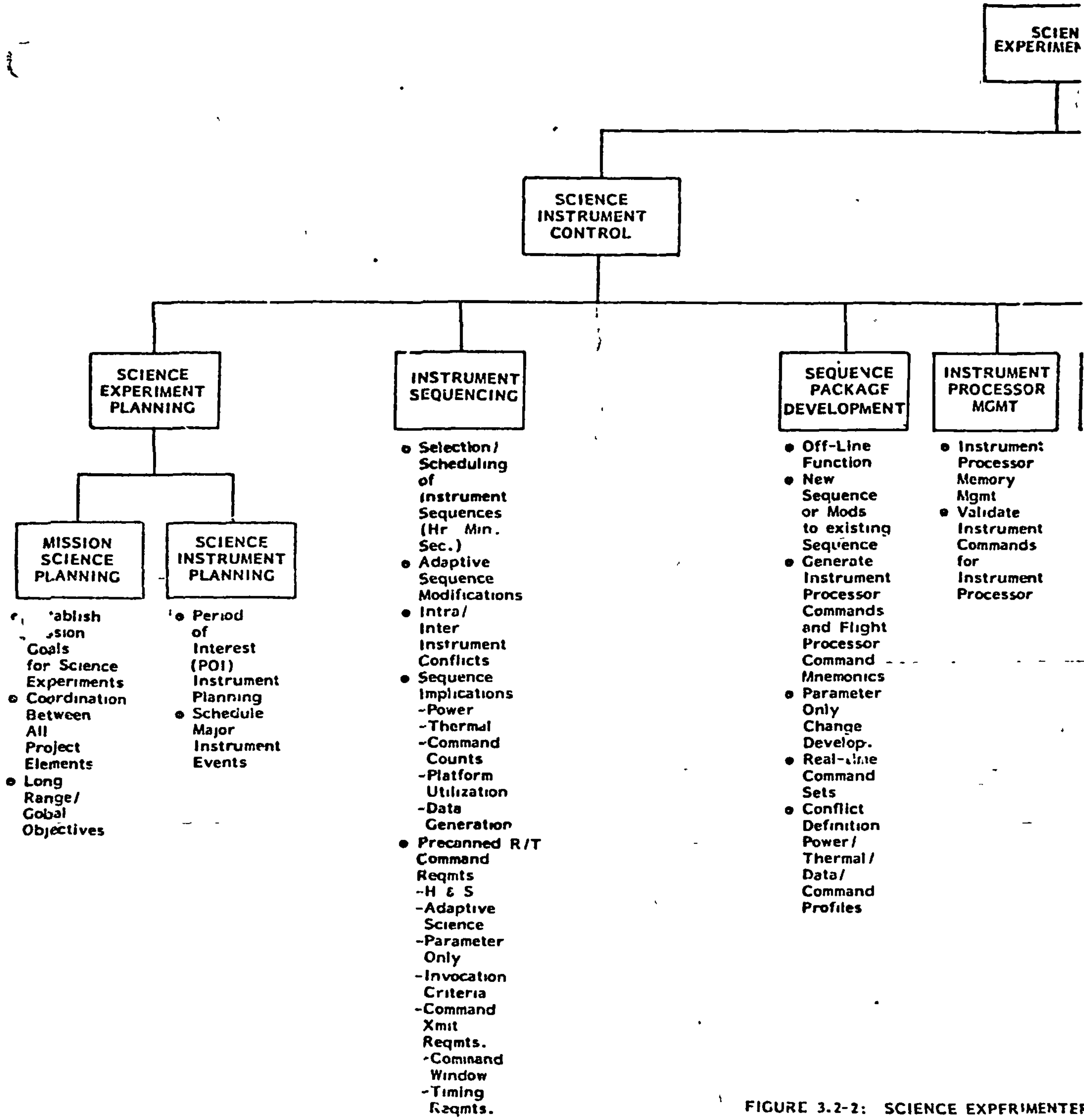

FIGURE 3.2-2: SCIENCE EXPERIMENTER

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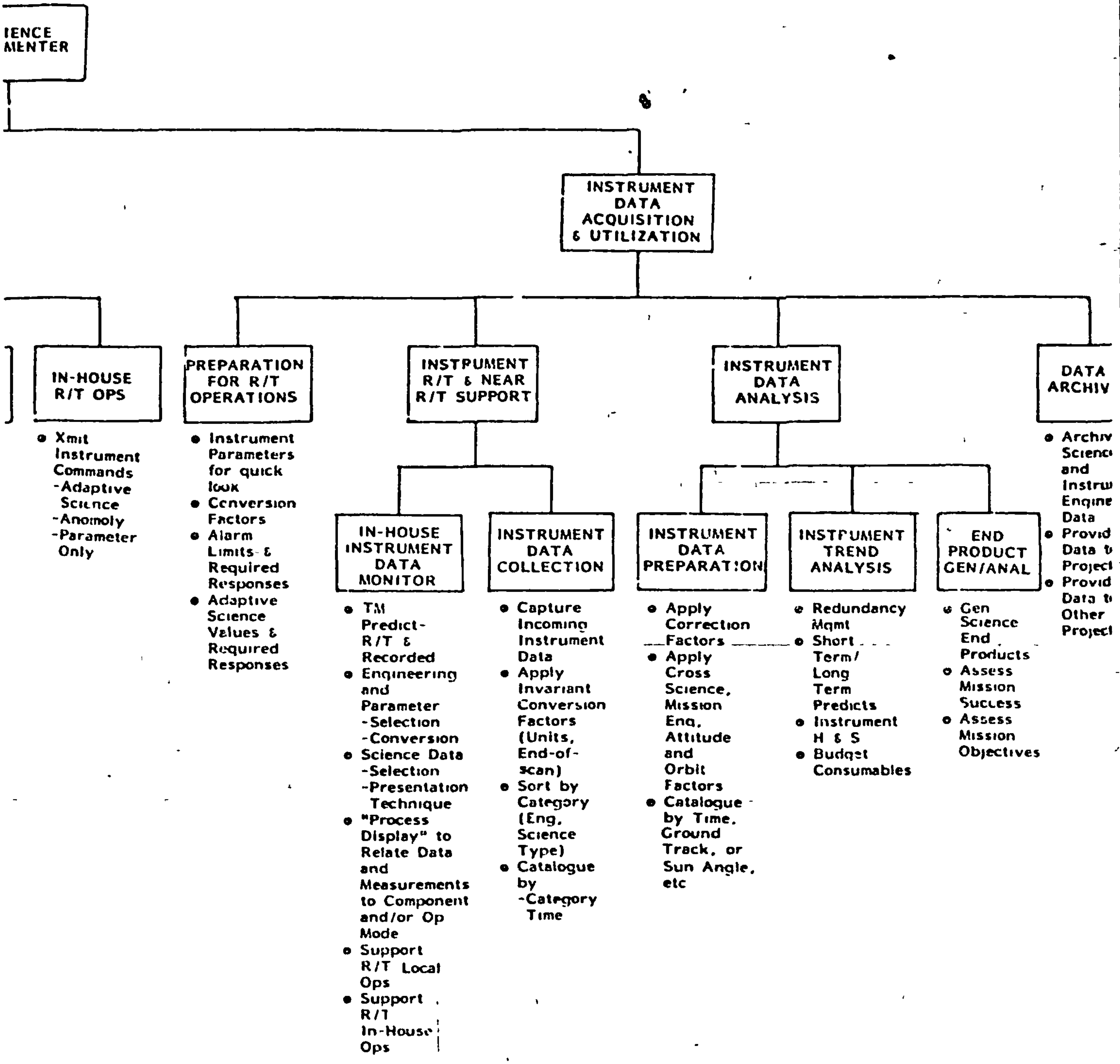

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c. sequence package development to support planning and scheduling activities
d. instrument processor management
e. user in-house real-time operations.

The science experiment planning function is divided into two areas mission science planning and science instrument planning. Mission science planning includes long-range science planning to establish mission goals and objectives. This function involves coordination between all project elements. Science instrument planning refers to the planning activities to support a specific science instrument. This function is responsible for specifying major instrument events during the planning POI and for coordinating these events with mission management.

Instrument sequencing includes the selection and scheduling of all instrument events during the POI. This function is responsible for definition of pre-defined adaptive responses and pre-canned commanding requirements. Instrument sequencing provides all sequencing inputs to mission management and participates in the review and conflict resolution process to generate the Integrated Observatory Sequence.

Sequence package development is an off-line process that generates individual sequence packages. (Refer to Section 3.3.2 for a description of the sequence packages.) The sequence packages are selected and scheduled by the instrument sequencing function.

Instrument processor management controls any instrument unique on-board processor by managing the processor memory and validating instrument commands sent to this processor.

The in-house [illegible]l-time operations function provides the real-time capability to request pre-canned instrument command responses during a contact with the observatory. This function interfaces with the observatory monitor and control function to request that commands be sent.

3.2.1.2 <u>Instrument Data Acquisition and Utilization</u>

Instrument data acquisition and utilization involves the following functions:

a. preparation for real-time operations
b. instrument real-time and near real-time activities to support in-house operations
c. instrument data analysis
d. archival of science data.

Preparation for real-time operations includes definition of data necessary to support the observatory monitor and control element to process and monitor real-time instrument data. This function defines instrument parameters to be displayed by observatory monitor and control and defines conversion factors, alarm limits and required responses for these parameters. Also, adaptive response parameters and associated responses are defined. The instrument real-time and near real-time support function is involved in in-house operations only. This function is responsible for processing raw data and generating in-house displays and is responsible for monitoring instrument data in-house. The in-house data monitor function monitors instrument data (either the raw data as processed by the instrument data collection function or the real-time displays from observatory monitor and control element). Also, the in-house data monitor function interfaces with observatory monitor and control to support real-time operations.

The instrument data analysis and data archive functions involve generation of science end products, analysis of these products and archival of the final data and products. These functions do not directly support science instrument control and are included for completeness only.

3.2.2 Subsystem (Power, Thermal, or Data Storage Management) Functional Hierarchy

Figure 3.2-3 summarizes the functional hierarchy for the power, thermal and data storage management subsystems. These three subsystems contain similar functions, and for the purposes of this document they are shown only once.

This subsystem element is divided into three distinct functions: 1) subsystem mission support, 2) subsystem control and 3) subsystem data acquisition and utilization. Subsystem mission support involves support for the planning and command generation and validation activities. Subsystem control involves those activities required to generate subsystem unique sequences and includes real-time operations to transmit selected sets of commands for anomalous situations. Subsystem data acquisition and utilization encompasses all downlink data processing and analysis necessary to support 1) the subsystem control function, 2) real-time operations and 3) subsystem data analysis. The data acquisition and utilization function is similar to the one for the science experimenter (section 3.2.1.2).

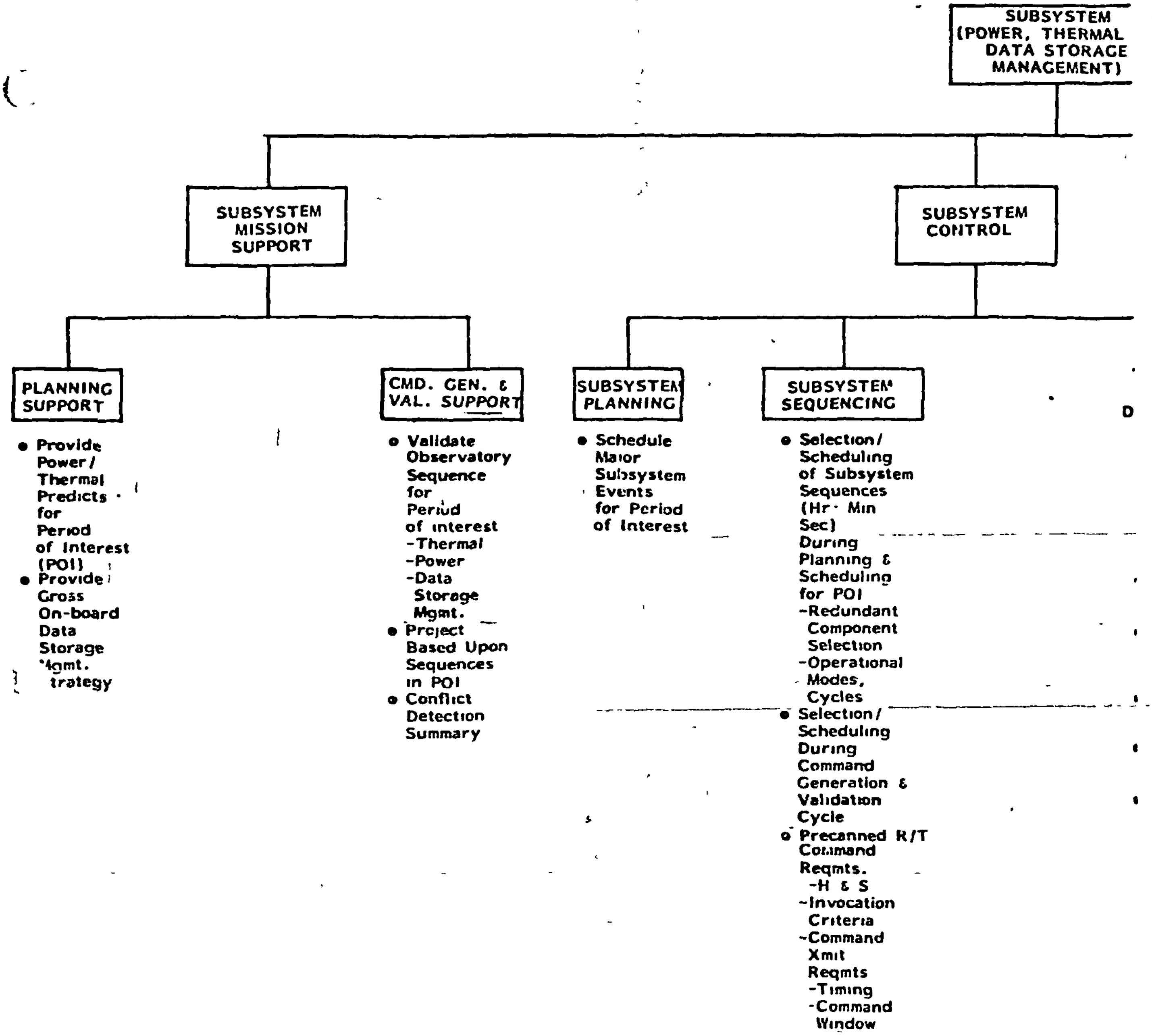

FIGURE 3.2-3. SUBSYSTEM (POWER, THERMAL, OR DATA STORAGE MANA

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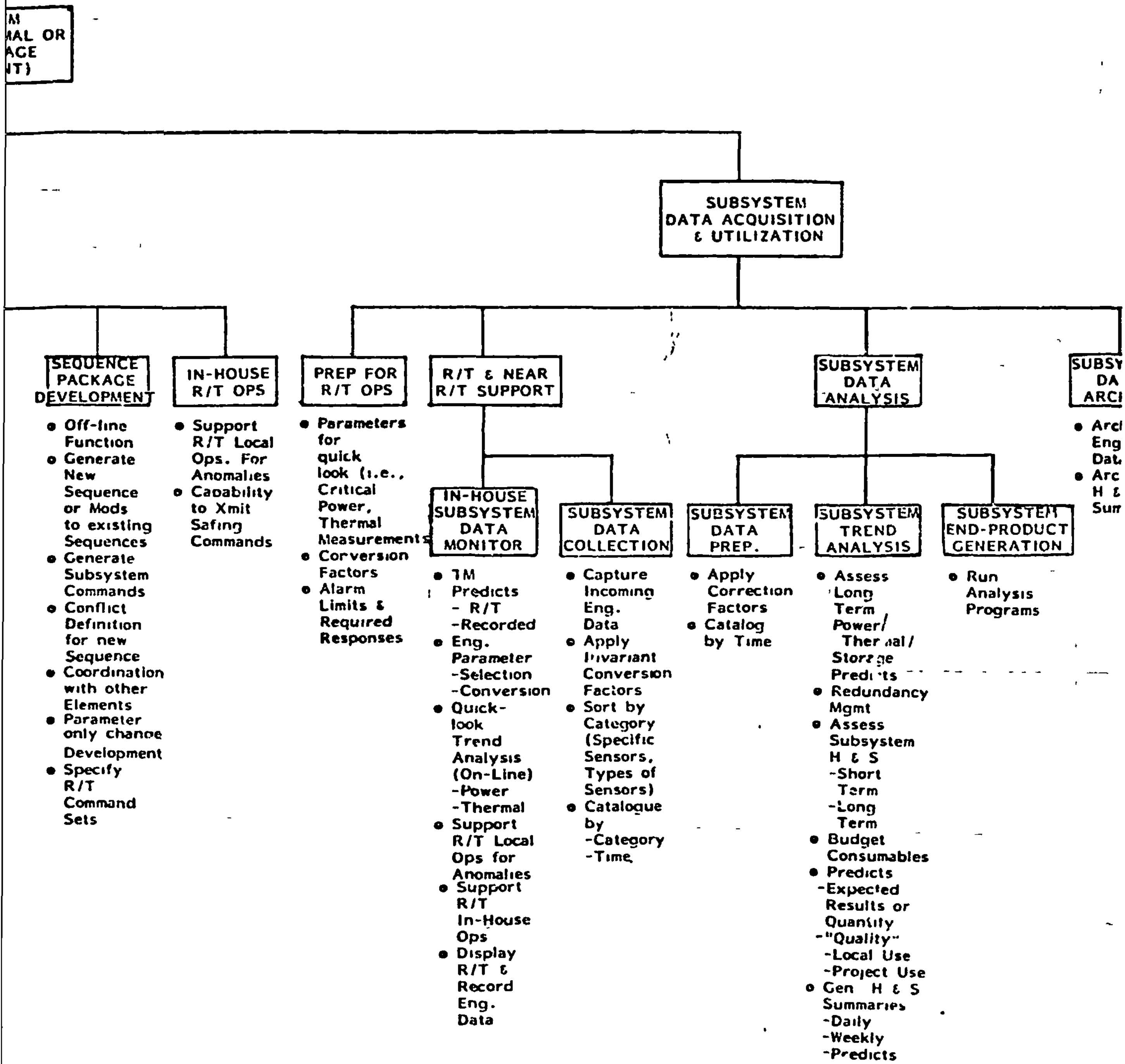

MANAGEMENT) FUNCTIONAL HIERARCHY

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Variations unique to the subsystem are covered on the hierarchy chart. The remaining two functions are addressed in greater detail below.

3.2.2.1 Subsystem Mission Support

Subsystem mission support involves the following functions:

a. support of observatory activities
b. support of the command generation and validation process.

The planning support function generates subsystem predicts (power, thermal and data storage management) for the POI. These predicts are used by all system elements as required during POI planning.

The command generation and validation support function is responsible for validating observatory sequences and assuring that no constraints are violated relative to power, thermal and on-board data storage. Also, this function generates power, thermal and data storage profiles based on the observatory sequence for POI.

3.2.2.2 Subsystem Control

The subsystem control functions are similar in practice to those for the science experimenter (section 3.2.1.1) with two exceptions. First, a mission science planning function is not included as this function is primarily science related. Second, a subsystem processor management function is not included as it is assumed that the systems use the flight processor (OBC or command memory) for commanding purposes.

3.2.3 OBC or Command Memory Management Functional Hierarchy

Figure 3.2-4 summarizes the functional decomposition for the OBC (or command memory) management subsystem. This element is divided into three distinct functions: 1) mission support, 2) subsystem control and 3) data acquisition and utilization. Mission support includes support of the planning and command generation and validation processes and generation of commands for those instruments or subsystems utilizing the OBC or command memory. The control function involves those activities required to generate sequences unique to this element and includes real-time operations to transmit selected sets of commands for anomalous conditions. Data acquisition and utilization encompasses all downlink data processing and analysis necessary to support 1) the control function, 2) real-time operations and 3) post-pass processing, analysis and data archival. The control function is similar to the one for the power, thermal and data storage subsystem (section 3.2.2.2). Variations unique to OBC or command memory are addressed in the hierarchy chart. The remaining functions are addressed in greater detail below.

3.2.3.1 Mission Support

Mission support is decomposed into the following functions:

a. planning support
b. command generation and validation support
c. command generation.

Planning support provides information to support planning activities for the POI. This information includes predicts

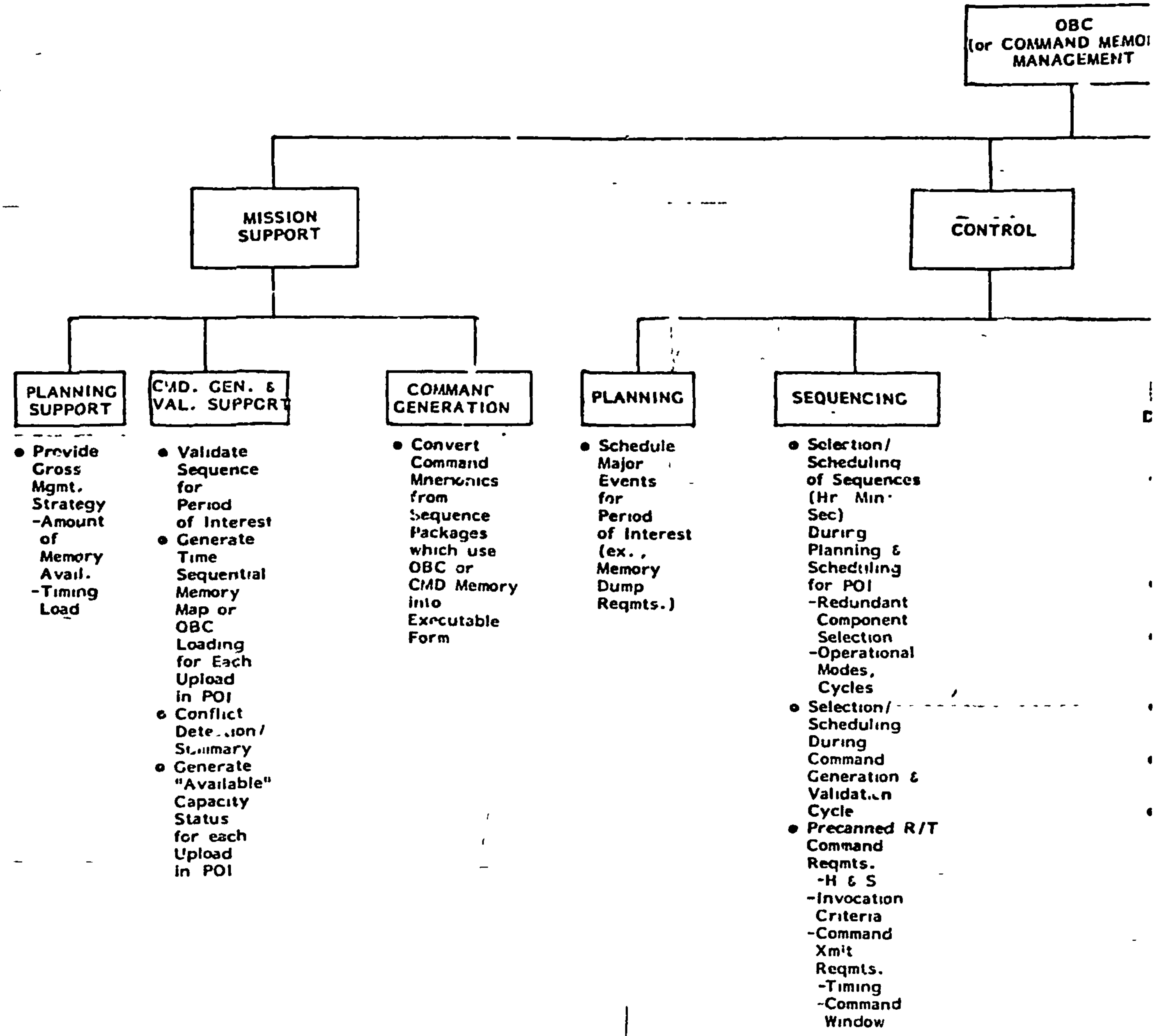

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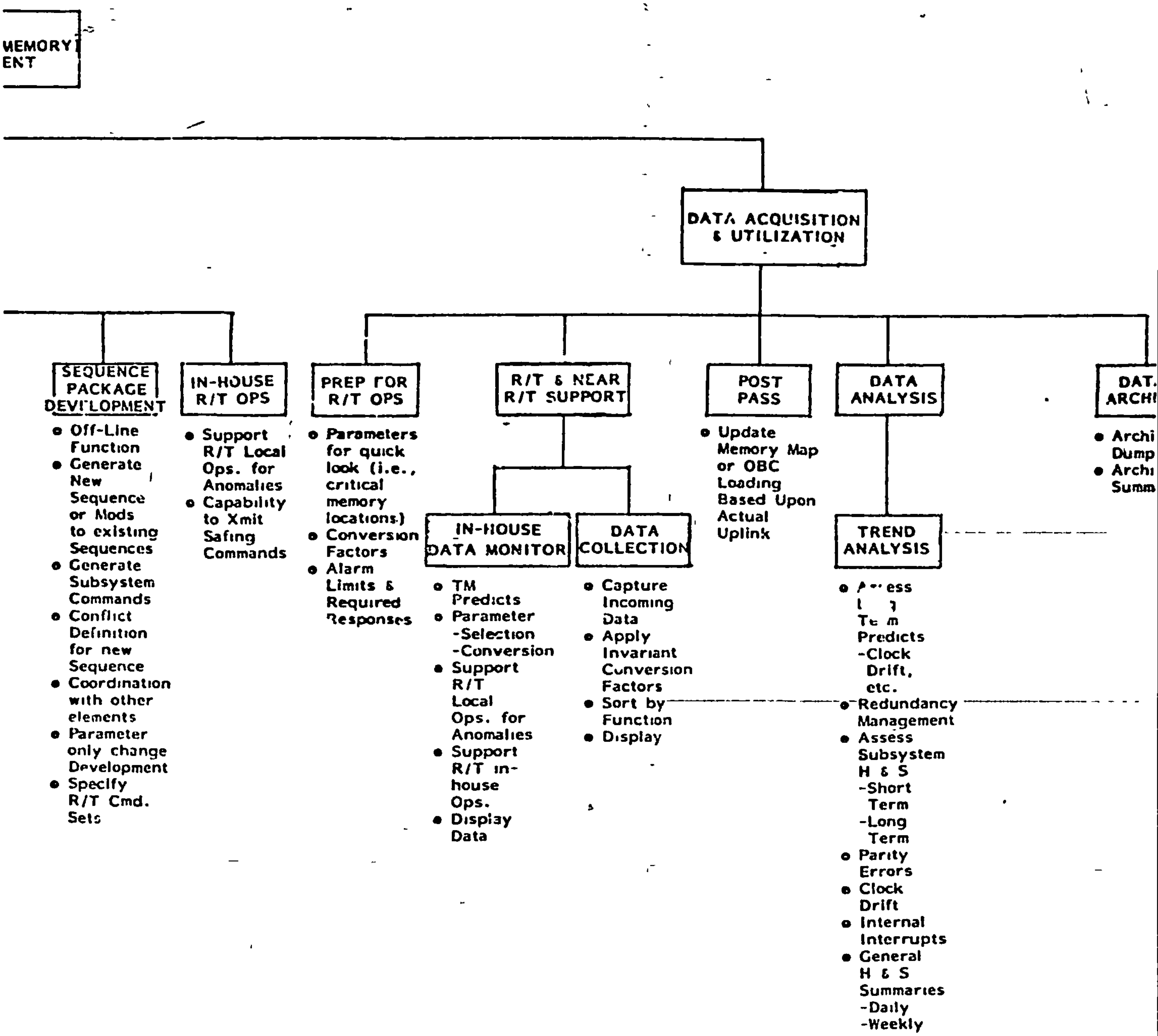
FIGURE 3.2-4 OBC (or COMMAND M... ORY



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relative to amount of memory available for POI and potential timing constraints for memory usage. Command generation and validation support provides a portion of the IOS validation. This function generates a memory map or OBC loading for each uplink within the POI and flags conflicts where constraints are violated. This function also summarizes available memory or OBC capacity following each upload in the POI. The command generation function generates commands (from command mnemonics) for those sequences utilizing the OBC or command memory.

3.2.3.2 Data Acquisition and Utilization

This function is similar to the one for the science experimenter element (section 3.2.1.2) with the following exceptions. A post-pass function is included to update the memory map or OBC loading post-contact. Also, the data analysis function is abbreviated to include trend analysis only.

3.2.4 Subsystem (Communications) Functional Hierarchy

Figure 3.2-5 summarizes the communications subsystem functional breakdown. The communications element is divided into three distinct functions: 1) subsystem mission support, 2) subsystem control and 3) subsystem data acquisition and utilization. Subsystem mission support involves support for the observatory planning and generation of observatory command files. Subsystem control includes those activities required to generate subsystem unique sequences and includes real-time operations to transmit selected sets of commands for anomalous situations. Subsystem data acquisition and utilization encompasses all downlink data processing and analysis necessary to support 1) the communication subsystem

SUBSYSTEM (COMMUNICATIONS

- **SUBSYSTEM MISSION SUPPORT**
  - **PLANNING SUPPORT**
    - Provide Gross Data Mgmt. Strategy Assuming Negotiated TDRSS Contacts (i.e., No. Bits Per D/L, No. Commands Per Contact, etc.)
  - **CMD. GEN. & VAL. SUPPORT**
    - Validate Sequence for Period of Interest
    - Project U/L and D/L Profiles Based upon Sequences in POI
    - Conflict Detection Summary
  - **COMMAND GENERATION**
    - Generate and Label Integrated Upload Packages
      - -Normal Command Gen Process
      - -Adaptive Command Gen Process
      - -Includes Command Blocking
    - Structure
    - Indexing
  - **POST PASS**
    - Update Uplink Profiles to Reflect Actual Uploads
- **SUBSYSTEM CONTROL**
  - **SUBSYSTEM PLANNING**
    - Schedule Major Subsystem Events for Period of Interest
  - **SUBSYSTEM SEQUENCING**
    - Selection/Scheduling of Subsystem Sequences (Hr. Min Sec) During Planning & Scheduling for POI
      - -Redundant Component Selection
      - -Operational Modes, Cycles
    - Selection/Scheduling During Command Generation & Validation Cycle
    - Antenna Pointing Parameters for On-board Use
    - Precanned R/T Command Reqmts.
      - -H & S
      - -Invocation Criteria
      - -Command Xmit Reqmts.
        - -Timing
        - -Command Window

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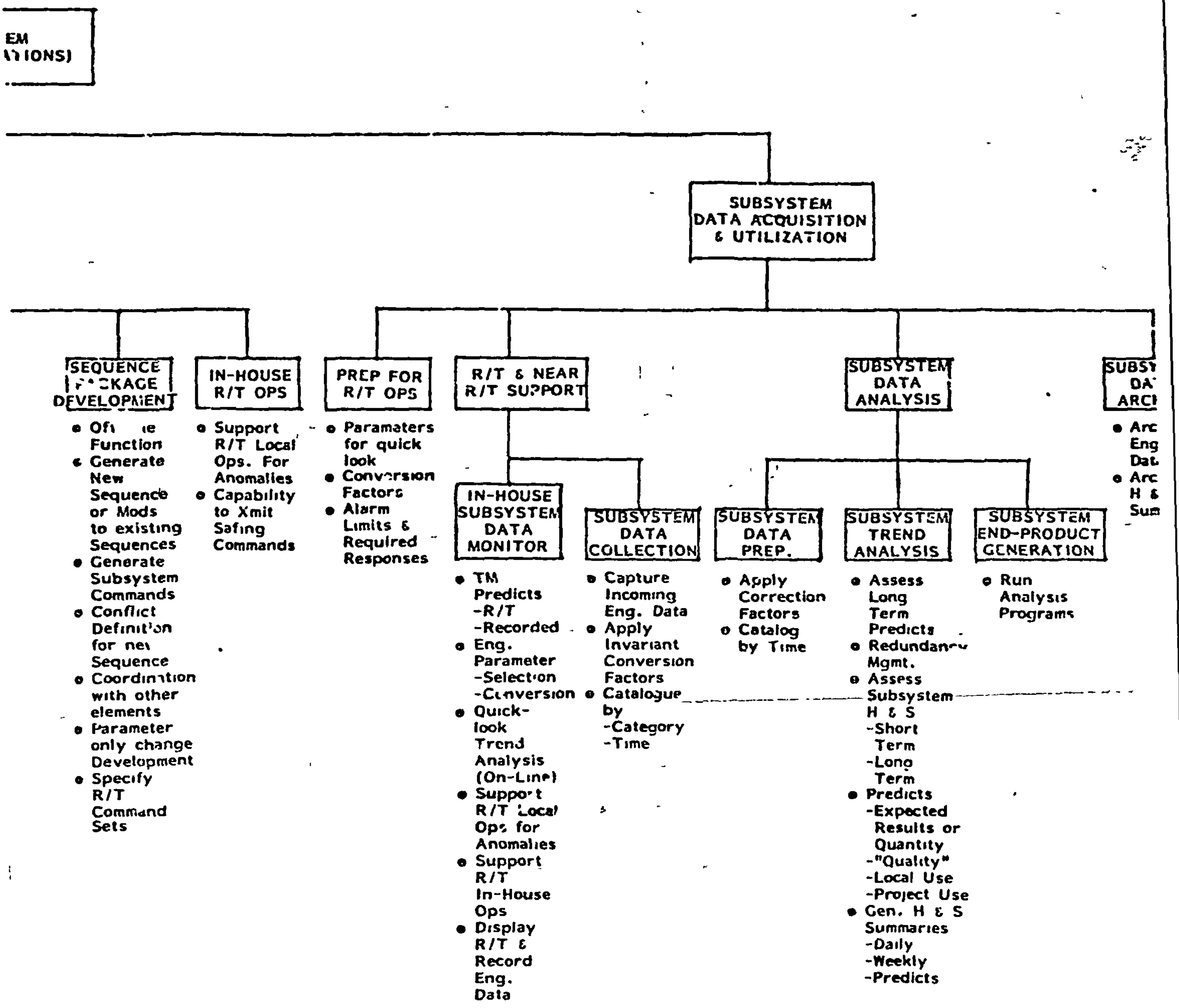
FIGURE 3.2-5 SUBSYSTEM (COMMUN



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control function, 2) real-time operations and 3) data analysis. The control and data acquisition/utilization functions are similar to those previously described (sections 3.2.2.2 and 3.2.1.2, respectively). The mission support function is summarized below.

3.2.4.1 Subsystem Mission Support

Subsystem mission support involves the following functions:

a. planning support
b. support of command generation and validation
c. command generation
d. post-pass activities.

The planning and command generation and validation support are similar to those functions for power, thermal and data storage subsystems (section 3.2.2.1). Variations unique to the communications element are covered on the hierarchy chart. The command generation function is responsible for generating the upload packages for transmittal to the observatory. The post-pass function updates the uplink profiles (as generated by the command generation and validation support function) based on actual real-time commanding.

3.2.5 Attitude Subsystem Functional Hierarchy

Figure 3.2-6 summarizes the functional decomposition for the attitude subsystem element. This element is divided into three distinct functions: 1) mission support, 2) attitude subsystem control and 3) data acquisition and utilization. The mission support involves support of the planning and sequencing activities and includes support of the off-line sequence development functions. Attitude subsystem

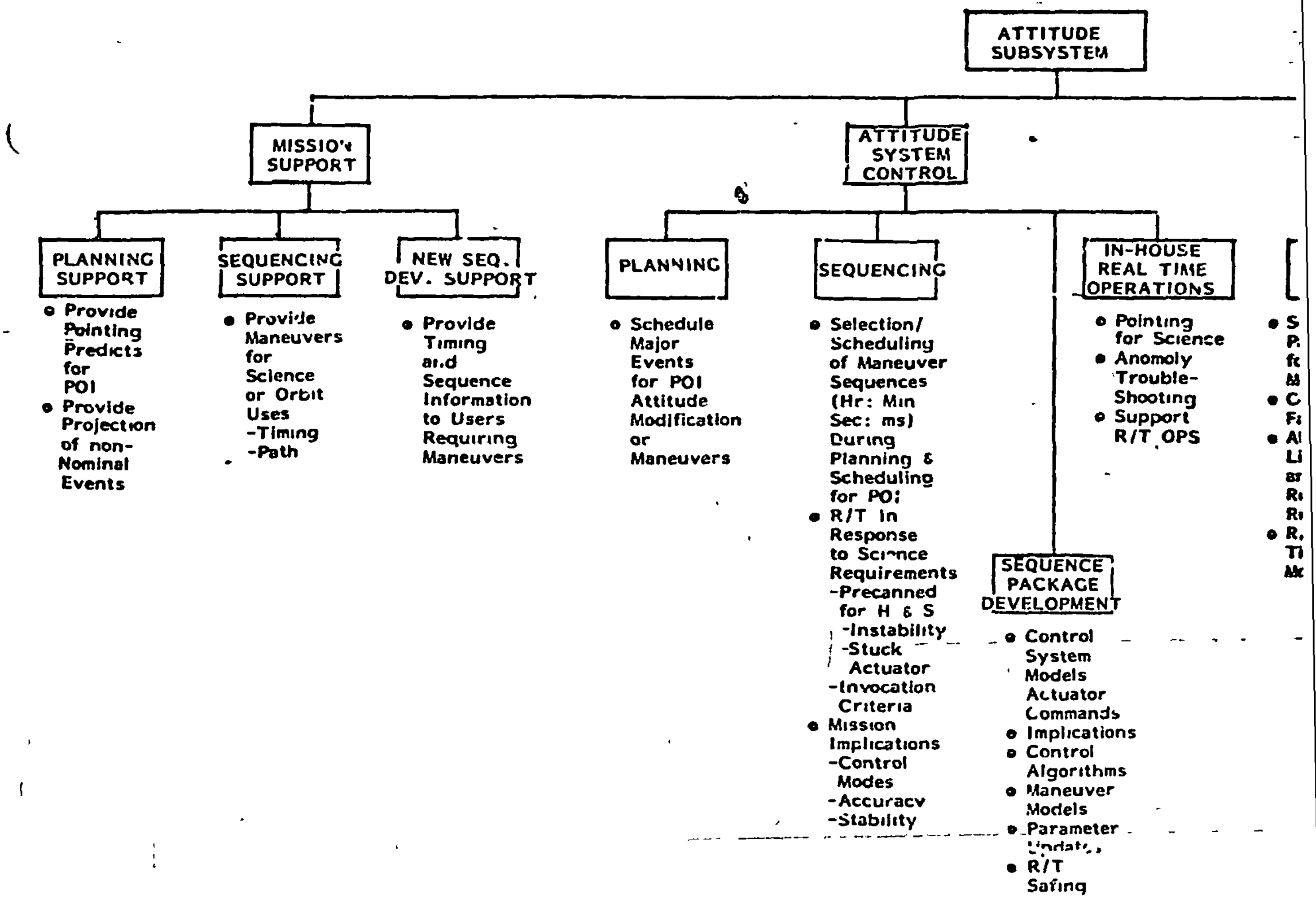

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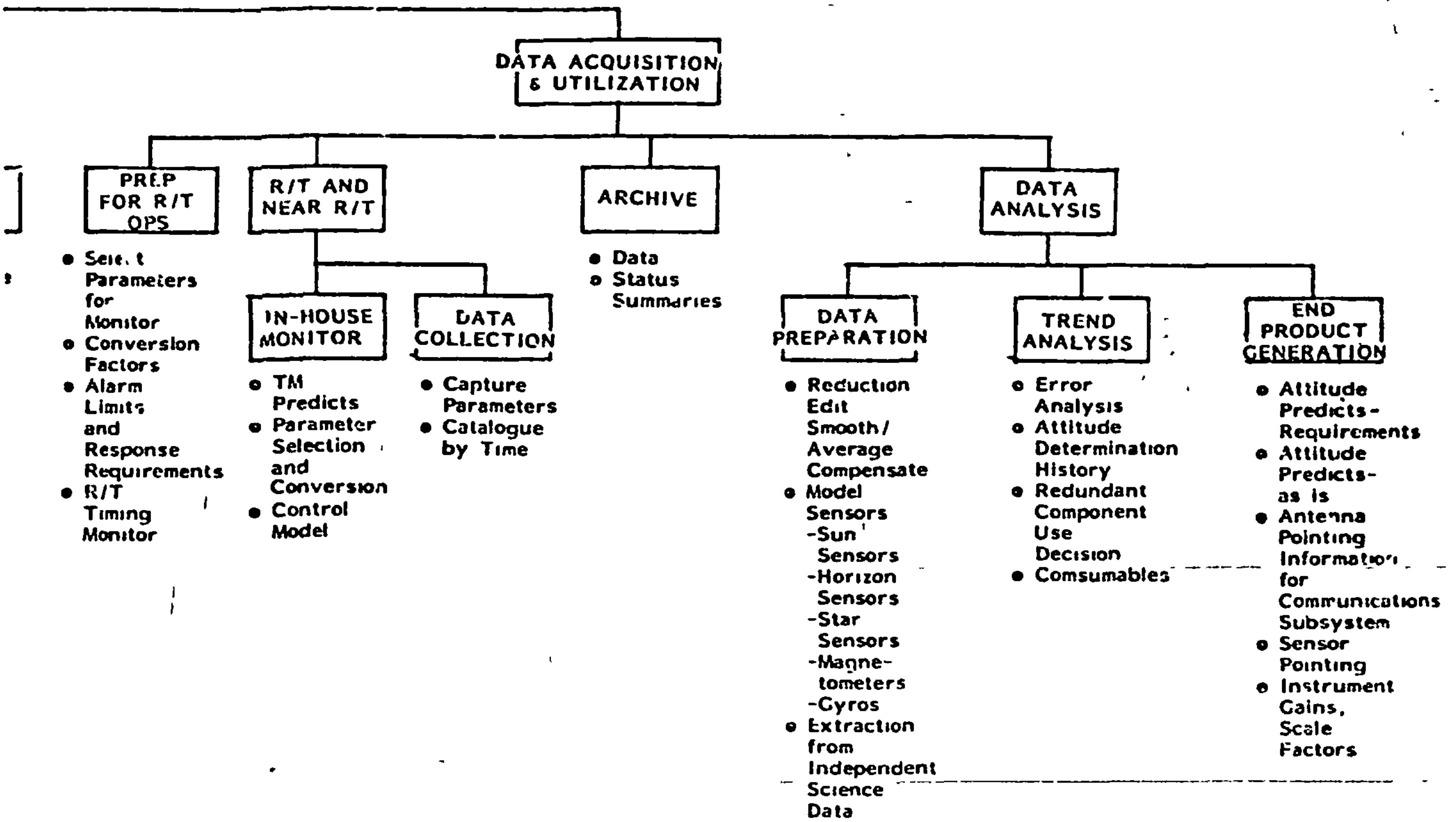
FIGURE 3.2-6 ATTITUDE SUBSYSTE



UBSYSTEM FUNCTIONAL HIERARCHY

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control involves those activities required to generate attitude system unique sequences and includes real-time operations to transmit selected sets of commands for anomalous situations. Data acquisition and utilization is identical in form to the science experimenter function (section 3.2.1.2). The details of data acquisition and utilization are shown in Figure 3.2-6 and are not repeated in the text. Mission support and attitude subsystem control are addressed in greater detail below.

3.2.5.1 Mission Support

Mission support includes the following functions:

a. planning support
b. sequencing support
c. new sequence development support.

Planning support provides attitude predicts for the POI in support of planning and scheduling activities. These predicts are used by all system elements for planning purposes during the POI preparation.

The sequencing support function provides the capability to design and schedule attitude maneuvers as required by science or orbit. This support supplies attitude profiles as required during the sequence preparation activities.

New sequence development support is responsible for the supply of detail timing and pointing information to users during their sequence development. This effort involves specification of such items as slew rates and durations in order that dependent activities can be fully coordinated.

Science examination of targets of opportunity or steering during burns for orbit adjust are thus achieved.

3.2.5.2 Attitude Subsystem Control

The subsystem control functions are similar to those for the science experimenter with two exceptions. First, a mission science planning function is not included as the attitude subsystem is a support function and not a mission driver. Second, a subsystem processor management function is not included as it is assumed that the central OBC or command memory is utilized. (Should this assumption be false a function such as subsystem processor management will be added.)

3.2.6 Orbit Subsystem Functional Hierarchy

Figure 3.2-7 summarizes the functional decomposition for the orbit subsystem element. This element is divided into three distinct functions: 1) mission support, 2) orbit subsystem control and 3) data acquisition and utilization. Mission support involves support of the planning and sequencing activities and includes support of the off-line sequence development functions. Orbit subsystem control involves those activities required to generate orbit unique events and to modify sequences. Data acquisition and utilization is identical in form to the science experimenter (section 3.2.1.2). The details of data acquisition and utilization are shown on Figure 3.2-7 and are not repeated in the text. Mission support and orbit subsystem control are addressed in greater detail below.

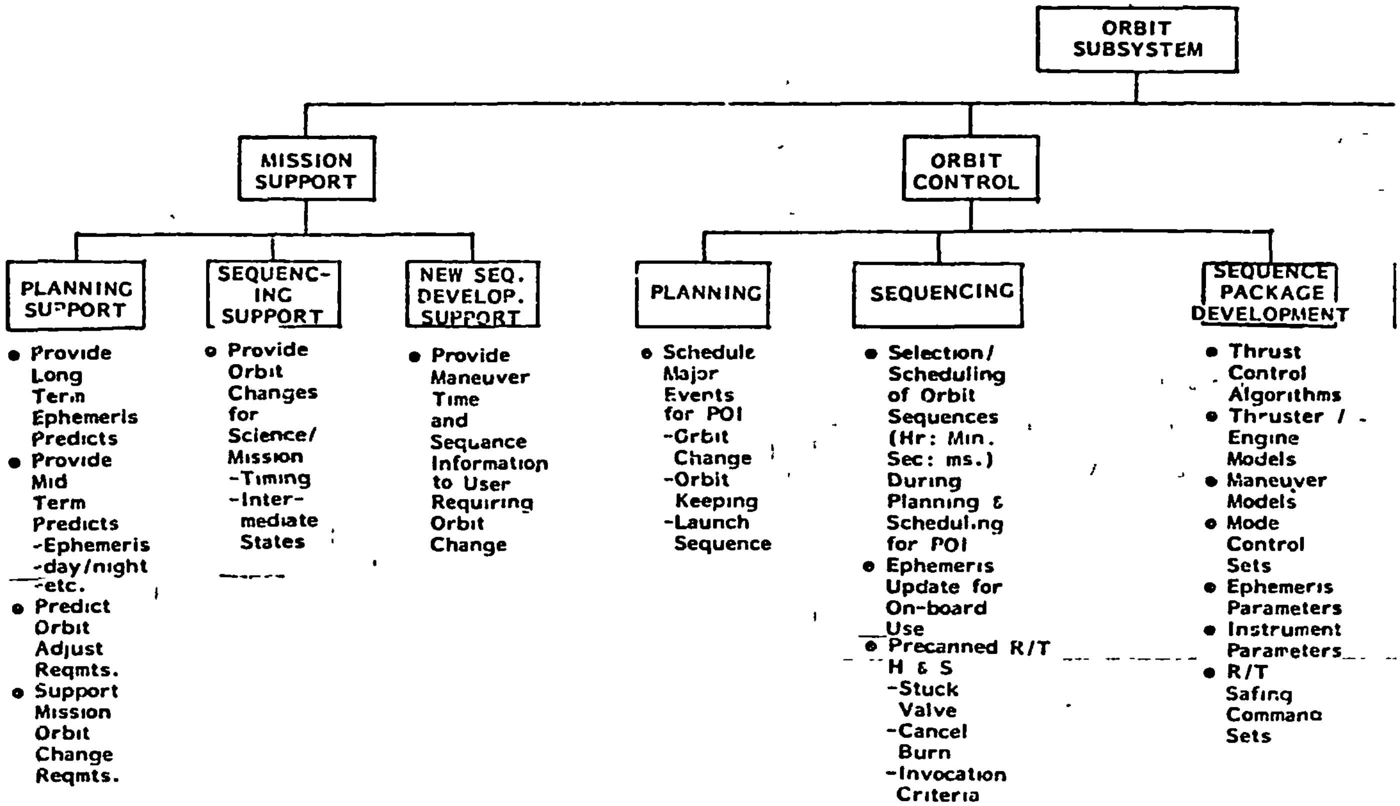

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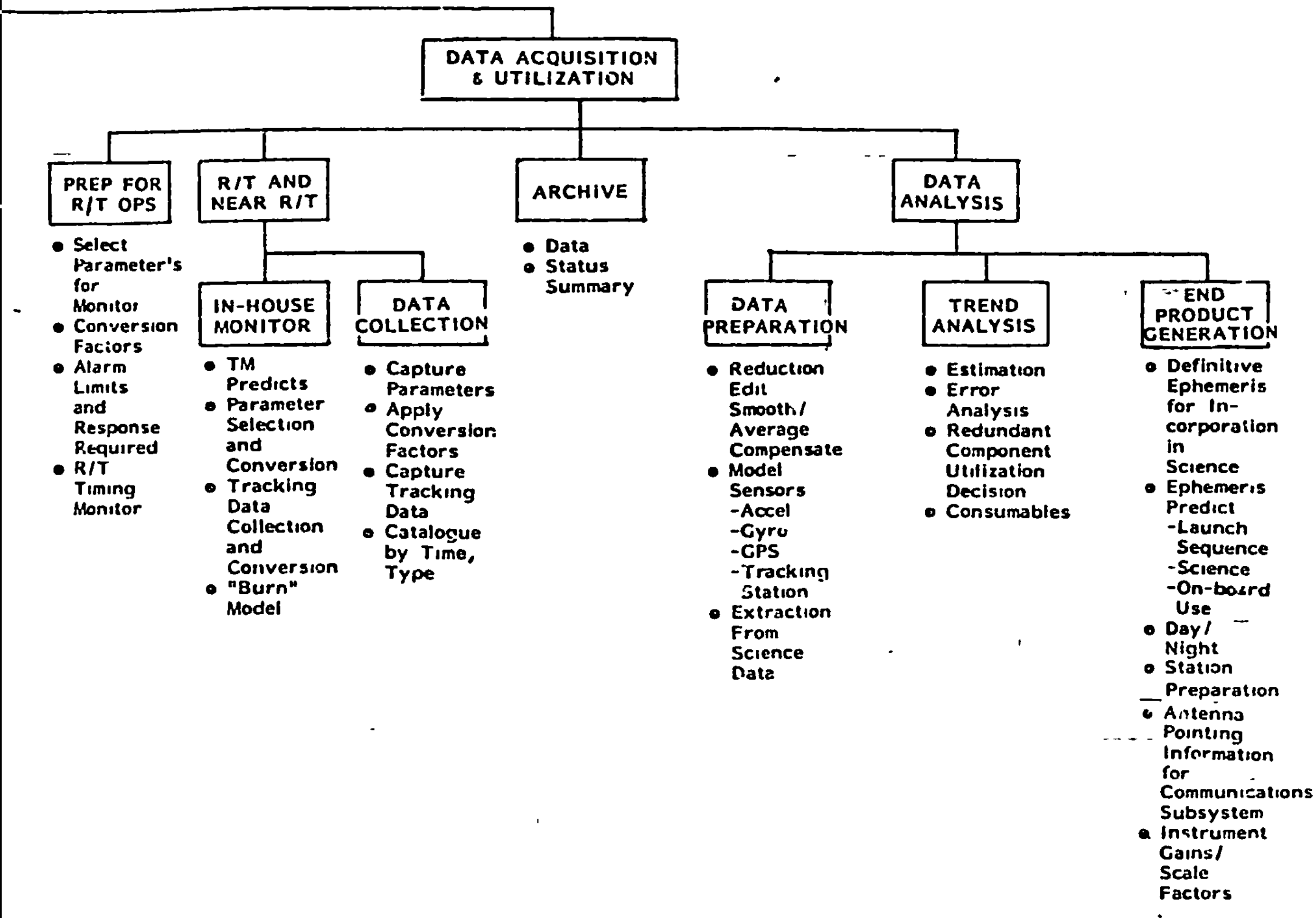
FIGURE 3 2-7· ORBIT SUBSYSTI



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SYSTEM FUNCTIONAL HIERARCHY

3.2.6.1 Mission Support

Mission support includes the following functions:

a. planning support
b. sequencing support
c. new sequence development support.

Planning support provides orbit predicts for the POI in support of planning and scheduling activities. These predicts are used by all system elements for planning purposes during the POI preparation.

The sequencing support function provides the capability to design and schedule orbit changes as required by mission specifications or activities. This support supplies orbit profiles and associated data such as ground track as required during the sequence preparation activities.

New sequence development support is responsible for the supply of detail timing and orbit information to users during their sequence development. This effort involves detail specification in order that dependent activities can be fully coordinated. Science examination of targets of opportunity and coordination with attitude for steering during burns for orbit adjust are thus achieved.

3.2.6.2 Orbit Subsystem Control

The subsystem control functions are similar to those for the science experimenter with three exceptions. First, a mission science planning function is not included as the orbit subsystem is a support function and not a mission driver. Second, a subsystem processor management function is not included as it is assumed that the central OBC or command memory is utilized. Third, orbit does not utilize in-house real-time operations as the launch process will be managed through independent facilities and, except for precanned shut down commands (which are generated under sequence package development), no real-time operations during nominal mission activities are anticipated.

3.2.7 Mission Management Functional Hierarchy

Figure 3.2-8 summarizes the functional decomposition for the mission management element. This element is divided into two distinct functions: 1) observatory control and 2) ground operations control. The observatory control function is responsible for integrating all user requirements for commanding the observatory from conception of science desires through final command package preparation. The ground operations control provides schedules, procedures and constraints for performing all ground operations.

3.2.7.1 Observatory Control

Observatory control is divided into the following functions:

a. planning
b. sequencing
c. command generation.

The planning function supports mission science planning activities by generating long range schedules based upon science integration of mission goals and objectives.

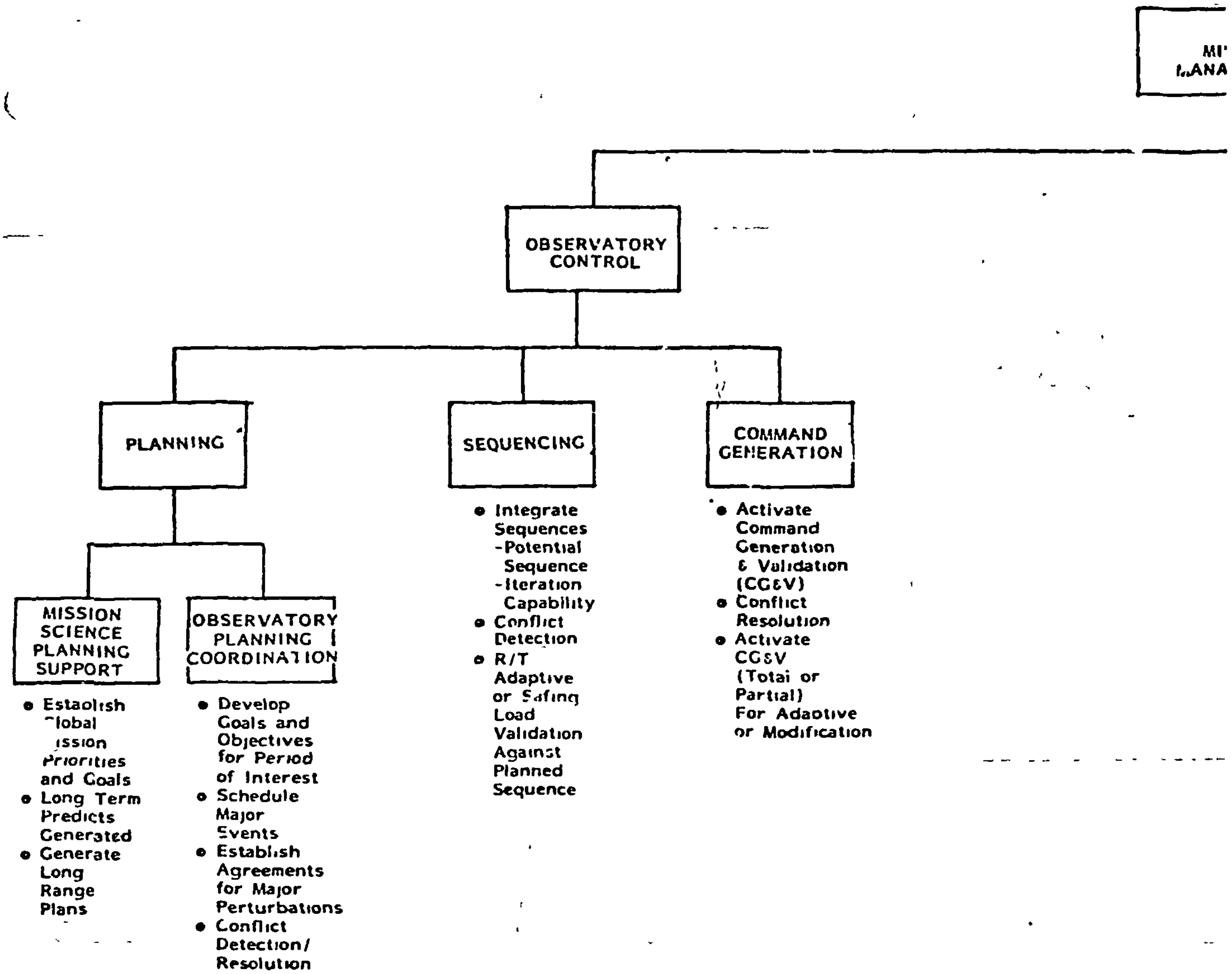

FIGURE 3.2-8 MISSION MANAGE IENT I

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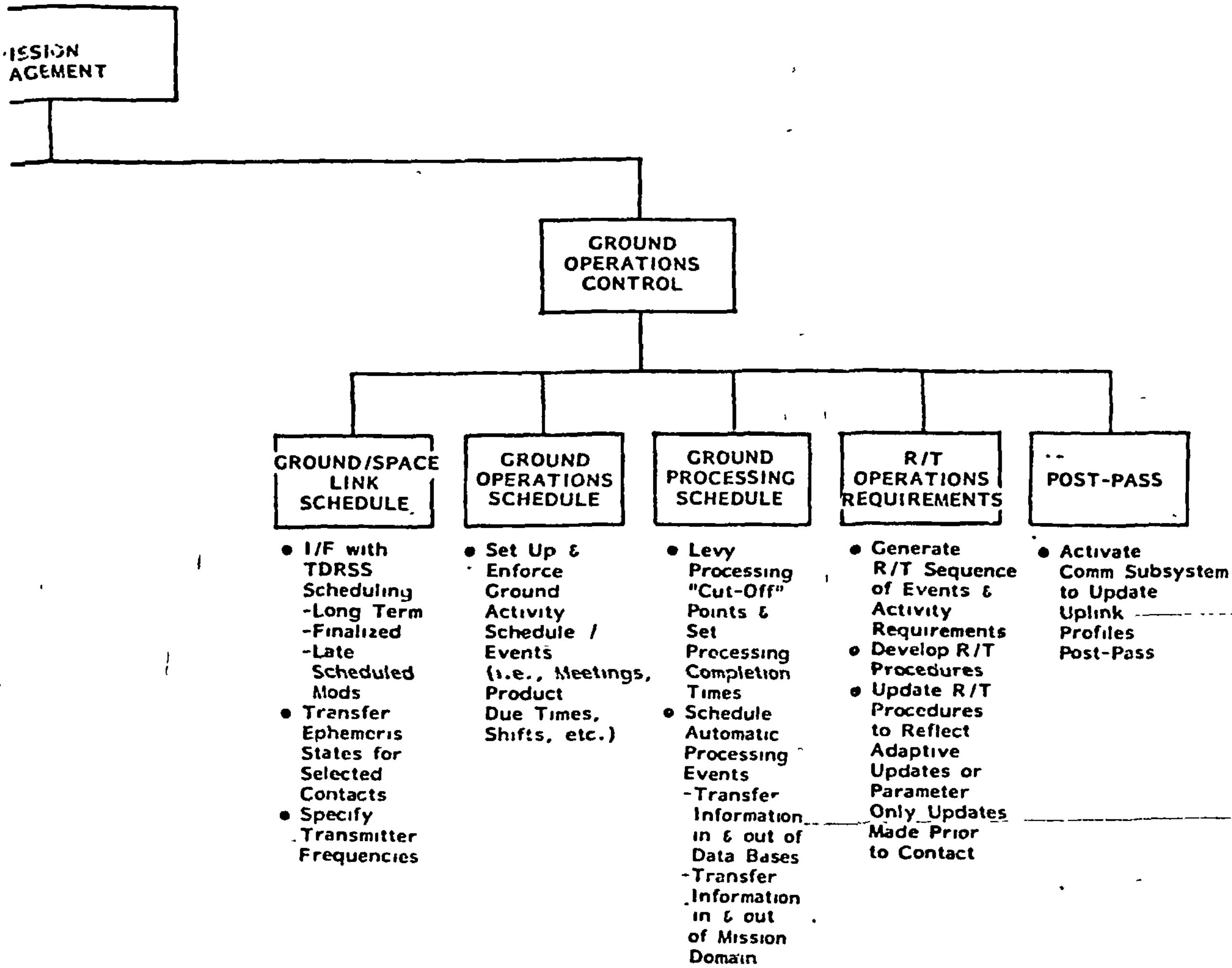

FUNCTIONAL HIERARCHY

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The function also coordinates the observatory planning activity by integrating user requests for major events during the POI and conducting meetings/reviews to resolve conflicts between the users. The sequencing function integrates all user sequencing requests thereby generating the IOS. Conflict detection is performed relative to the IOS. This function conducts the iteration process to resolve conflicts and generate the IOS. The command generation function activates the subsystem elements to perform command generation and validation. Detected conflicts are reported to this function for subsequent resolution.

3.2.7.2 Ground Operations Control

The ground operations control function is divided as follows:

a. ground/space link schedule
b. ground operations schedule
c. ground processing schedule
d. real-time operations requirements
e. post-pass.

The ground/space link schedule specifies TDRSS support requirements and coordinates these requirements directly with the ground/space link (TDRSS). This function provides all inputs to TDRSS including observatory ephemeris states for all contacts and transmitter frequencies as appropriate.

The ground operations schedule function provides ground/personnel activity schedules for meetings, shifts, product due times, etc. The schedule produced provides the framework by which all mission operations are performed.

The ground processing schedule function schedules ground events that are to occur or to be controlled automatically. Examples include 1) cut-off points which dictate times by which selected events are to be completed (i.e., command file generation), 2) software programs to run at specified times and 3) transfer of data between data bases based on time.

The real-time operations function coordinates all real-time events that are to occur during each contact. This function develops real-time procedures which schedule and control real-time operations. These procedures may be general for many contacts or may contain events unique to a specific pass (i.e., adaptive science uplinks for a given contact).

The post-pass function activates the communication system to update profiles based on actual real-time operations.

3.2.8 Observatory Monitor and Control Functional Hierarchy

Figure 3.2-9 summarizes observatory monitor and control decomposition. This element is divided into three distinct functions: 1) real-time observatory control, 2) ground control and 3) data acquisition and utilization. The observatory control function implements the real-time procedure to transmit command loads, monitor the uplink process, cause safing or adaptive commands to be transmitted and incorporate command requests from user in-house facilities during real-time operations. The ground control function assures equipment, software and personnel

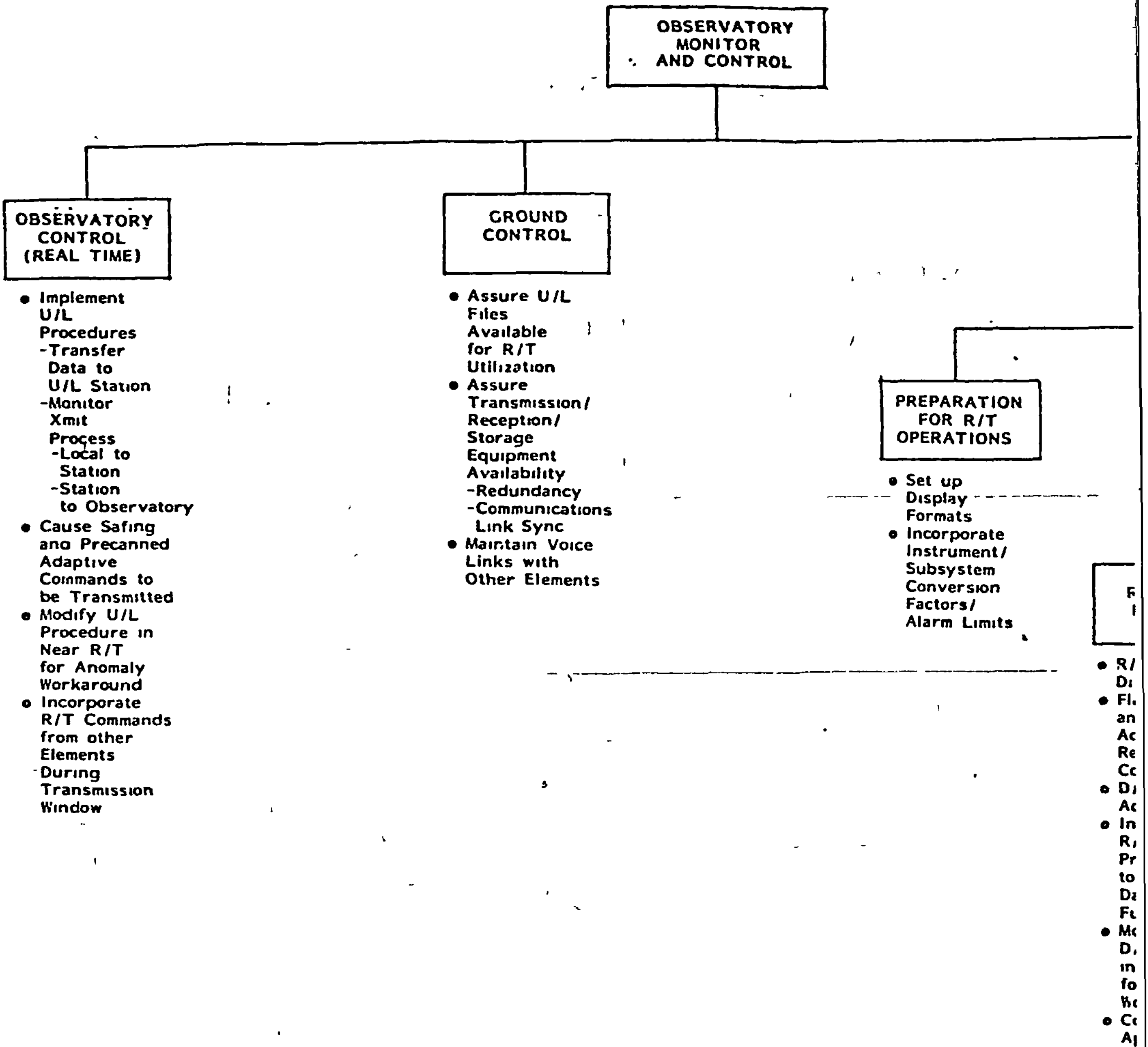

FIGURE 3.2-9 OBSERVATORY MONITOR AND CONTROL FUNCTIONAL HIERARCHY

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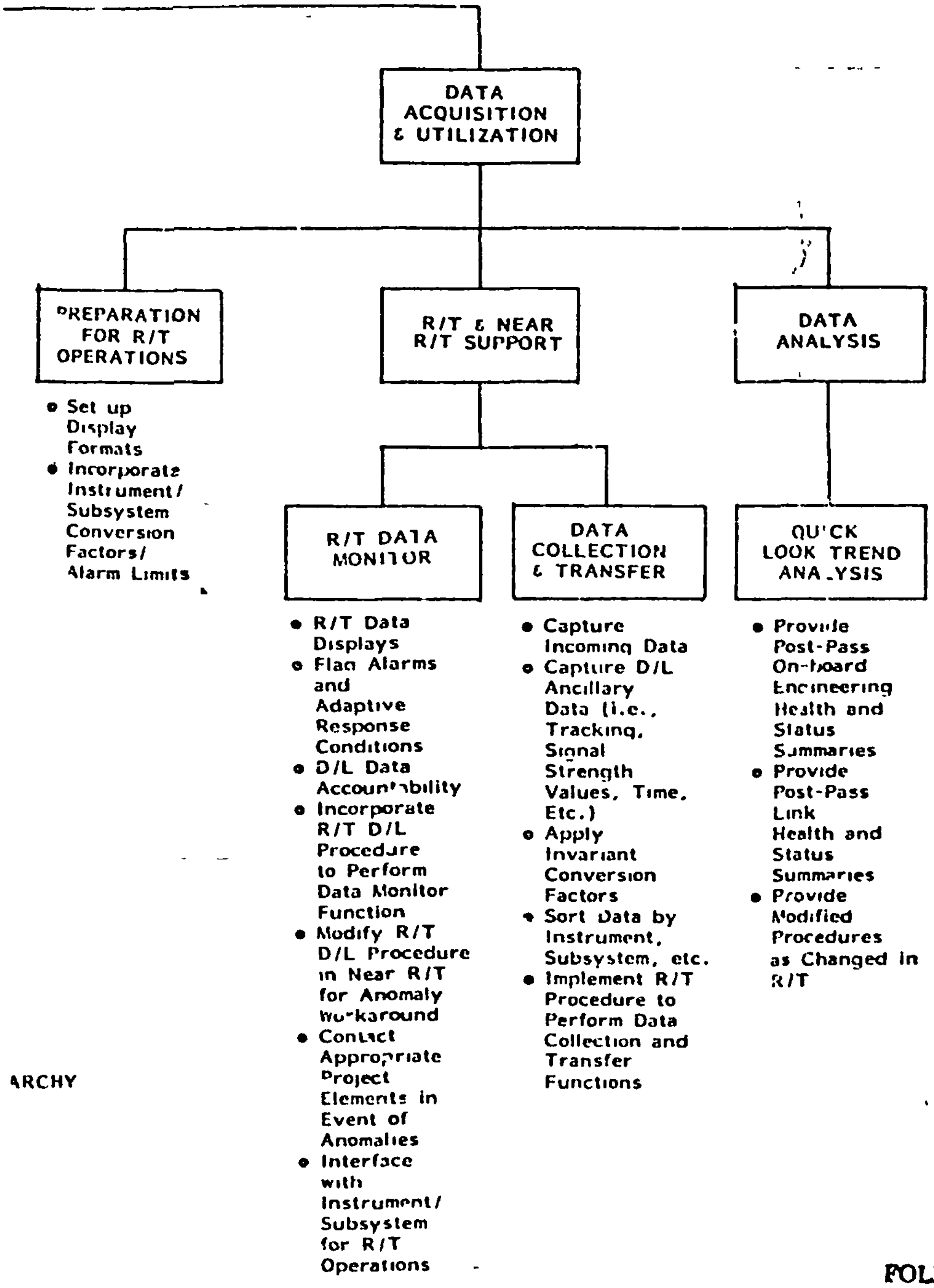

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availability to support real-time operations.

The data acquisition and utilization function is divided as follows:

a. preparation for real-time operations
b. real-time and near-real-time support: real-time data monitor and data collection/transfer
c. quick look trend analysis.

Preparation for real-time operations is responsible for display format generation and for incorporation of user requirements into the downlink processing events (i.e., instrument/subsystem data conversion factors, alarm limits and adaptive response limits). The real-time data monitor function is responsible for displaying the data, checking for pre-specified alarm or adaptive conditions in the ata and monitoring all data as displayed. This function coordinates downlink events with the instrument or subsystem in-house operations in event of anomalies or special observatory operations. The data collection and transfer function collects all incoming data, performs data conversion, sorts the data and transfers the data to other system elements per the real-time procedures. The quick look trend analysis function performs a quick-look analysis of the displayed data and provides a post-pass health and safety status of the observatory and of the uplink and downlink process.

3.3 Key Features

The following subsections describe the key features of the IC^4 system. These features provide underlying capabilities which allow the system elements to perform the required activities. These key features are the outstanding characteristics of the IC^4 system. The interactive user and the facilities available to him, the sequences packages, the adaptive update capabilities and the user specific in-house real-time operations are as follows.

3.3.1 Interactive User

The IC^4 system users have the capability to interact directly with other operational elements of the system. Users have the capability to independently develop instrument or subsystem operational scenarios and then present the control requirements necessary to achieve the desired activities to the system in the form of sequence packages. The IC^4 system combines the sequence packages into an IOS. The user can interactively review and modify the IOS at many points during the operations cycle. The user may direct the system to check newly developed sequence packages against the IOS to detect conflicts or excessive use of observatory capacity. The interactive user has the capability to modify, add or remove sequence packages at any time from the initial generation of an IOS through the actual real-time uplink period.

To achieve this interactive capability, the IC^4 system provides the following related services:

a. graphic and textual displays
b. information access
c. procedure access.

General purpose hardware/software subsystems provide these services and enforce common interfaces between users. These services are described in the following paragraphs.

3.3.1.1 Displays

The primary means of generating and presenting data within the IC^4 system is through graphic and textual displays which are maintained by underlying computer systems. Utilizing CTRs (or equivalent devices), sequences of events, schedules, command files and subsystem data can be displayed by all users. Each user has the capability to generate new displays at the user interactive terminal using keyboard for textual input and light pens, joysticks or digitizing tablets (as appropriate) for graphical input. Interactive display software and hardware allow the users, both local and remote, to access and generate displays which are maintained in standard interface formats.

Display access is provided via menu selection. A user selects first from a master menu and then from selective menus until the desired information is obtained. The technique used to obtain a display defining uplink schedules and the technique used to obtain a sequence package display is the same. Different menus lead to different data sets, but the operation is identical. Similarly, standard development skeletons are available to users which provide a common format for generating displays while allowing each user to tailor the actual content of the display to his needs. (For a detailed example, refer to Section 3.3.2, Sequence Packages.)

Each display in the IC^4 system is stored in a standard format thereby allowing every user to view all internal IC^4 data. The capability to partition a display into totally independent areas (i.e., define "windows") is provided such that a user may display information from several different data sources simultaneously. An example of the use of this interactive capability arises during interscience coordination. When several science users located at remote sites wish to develop a joint experiment, they each display portions of the others' sequence packages on their terminal while communicating via a voice network. Utilizing a light pen to highlight specific items of interest or move timelines about on the display, they generate a coordinated plan.

3.3.1.2 Information Access

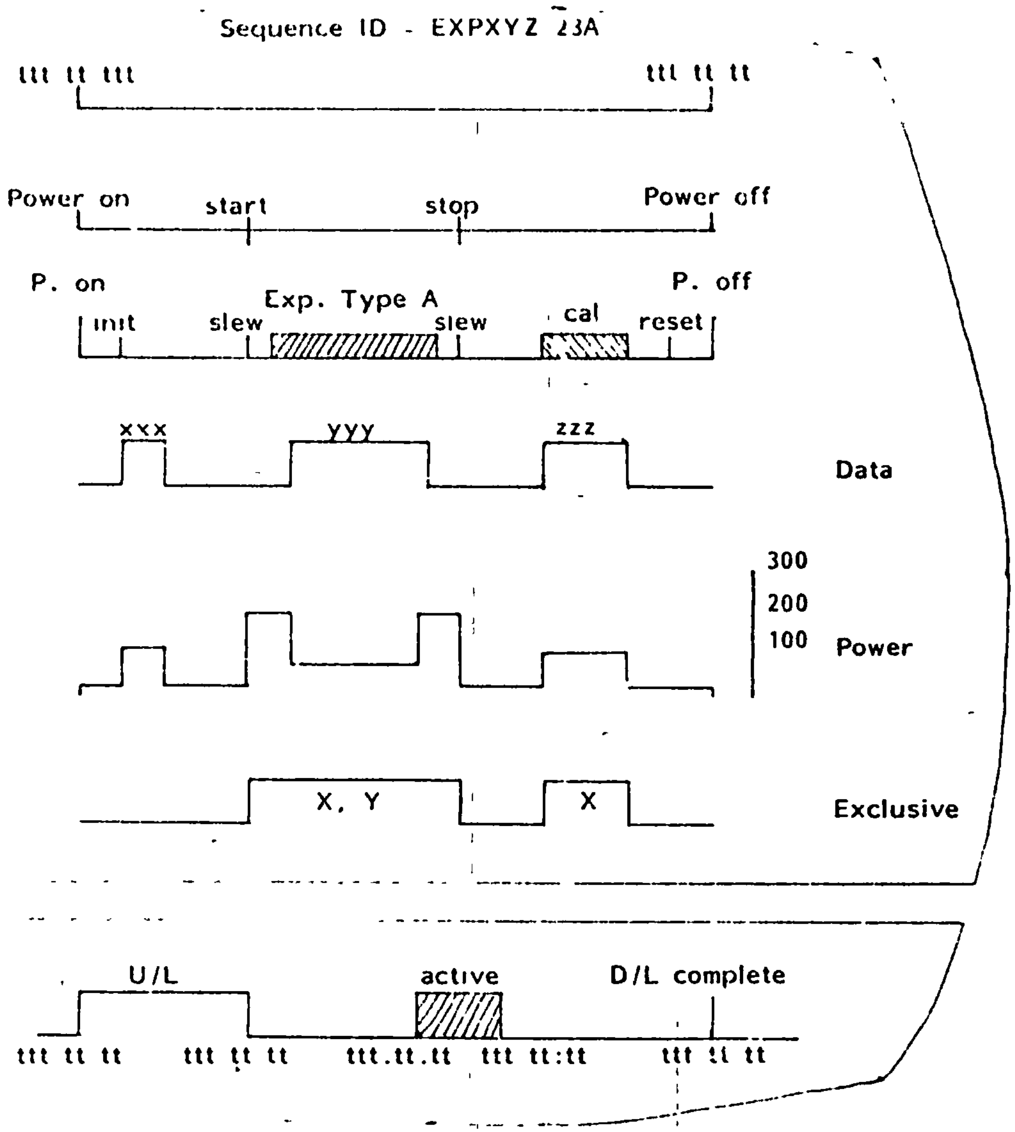
The IC^4 system allows all users to access system-wide data. By maintaining data in a standard interface format and orienting this format toward the interactive user, common access is provided. Each user develops several different types of data during the operations cycle; i.e., sequence packages, telemetry data display packages (providing information such as conversion factors) and parameter packets (for adaptive use in real-time commanding). Additional examples of system data are the IOS, command packages and indexes and real-time procedures. The IC^4 system allows each user to access the various data for display and to modify or replace the content of user data packages.

3.3.1.3 Procedure Access

The IC^4 system provides various developmental and validation procedures. Included in these are the capabilities to combine individual user sequences into an integrated sequence and to validate the combined sequence. (See Section 3.4 Operational Activity Threads). The individual users have the capability to modify the observatory sequence and to trigger appropriate validation procedures. Thus, a user may produce a potential sequence, request selective or complete validation (as necessary) and determine the implications of this potential modification without disrupting the normal overall flow of events. The IC^4 system is capable of recognizing a potential change which has successfully met all acceptance criteria (via validation procedures) and incorporating the new sequence upon user request.

3.3.2 Sequence Packages

The standard method of defining observatory requirements and activities is via sequence packages. A sequence package contains information in two forms: graphical and tabular. The graphical representation is used in the design of a new activity profile for an experiment or subsystem and in the illustration of desired or actual activities or observatory events (Figure 3.3-1). The tabular data is used to communicate detailed instructions from the user to (ultimately) the observatory (Figure 3.3-2). Sequence packages are generated using standard interactive terminals which provide the support required. The user interactive terminal with support software provides skeletons for sequence packages, standard storage techniques and standard interfaces. Each user specifies the detail content of a sequence package within the confines of the skeleton to match the needs of the experiment or subsystem.



DESCRIPTION

Time (granularity selectable)
(May be absolute or relative)

Major Event Timeline

Detailed Timeline

Periods of Data Transfer to Central Storage
(xxx,etc = Subtotal, not always displayed)
(Similar for R/T Data Transfer)

Power Profile (Standard Scale)
(Similar for Thermal)

Mutually Exclusive Profile
(X,Y, etc. = Standard Designators)
(Similar for Required Spacecraft Activity Profile)

Command Window, Data Receipt Deadline (Note different time scale. Times would not be shown on high level graphic with common time line.)

FIGURE 3.3 1. Contents of a Sequence Package, Part I - Graphics

SEQUENCE PACKAGE
SUMMARY VALUES

ITEM	NAME	VALUE	DESCRIPTION
1	Sequence ID	EXPXYZ-23A	Identification of Sequence Package
2	Uplink Total	XXXX	Total Command Load for this Sequence
3	Rec'ed Downlink Total	YYYY	Schedulable Data Downlink
4	R/T Downlink Total	ZZ	Real-Time Downlink
5	Central Storage Total	XXXX	Data to be stored in Central Storage Facility
6	OBC Commands Total	YY	Number of Commands to be Executed by OBC (or Command Memory)
7	R/T Commands Total	0	Number of Commands to be Executed during the Command Window
8	Power Consumed Total	XX	
9	Thermal Load Total	YY	
10	Exclusive Periods	Yes/No	

FIGURE 3.3-2: Contents of a Sequence Package, Part II - Graphics (1 of 2)

SEQUENCE ID = EXPXYZ-23A

ITEM	NAME	TIME	COMMAND		DESCRIPTION
11	OBC Command Exec.	P. on + 0	XYZCMD 1		Mnemonics for OBC (or Command Memory) -similar for R/T
		P. on + XX XX	XYZCMD 2		
12	XYZ Processor Exec.	P. on + XX XX	STRT A		Mnemonics (or actual processor commands) for instrument or subsystem dedicated processor
		P. on + ZZ ZZ	EXEC 3		
		P. on + YY YY	SLEW Z		
		o	o		
		o	o		
		o	o		
		EARLIEST/START	**LATEST/STOP**		
13	U/L Window	X XX.XX XXX	Y YY.YY.YYY		Defines when commands may be transmitted
14	D/L Window-Rec	N/A	Z ZZ ZZ.ZZZ		Defines when data must be collected on-ground
15	D/L Window R/T	X XX XX XXX	Z ZZ ZZ ZZZ		Defines when data will be transmitted
		TIME	**WATTS**		
16	Power Consumed	P. on + XX X	0.05		Describes Power Consumed - similar for Thermal, etc. (May be generated automatically from graphic or vice versa)
		P. on + YY Y	1.25		
		o	o		
		o	o		
		o	o		
		TIME	**AZ**	**EL**	
17	Pointing Req.	P. on + XX X	0°	90°	Coordinated with attitude control -similar for other S/C-wide req's or exclusive use. (May be a tabular or graphic copy of controlling subsystem's sequence package.)
		P. on + YY Y	+60°	+80°	
		o	o	o	
		o	o	o	
		o	o	o	

FIGURE 3.3 2 (continued, 2 of 2)

A sequence package is the total and only description of an on-board activity performed by an experiment or subsystem. All control over the observatory results from utilization of data contained in the sequence packages. Each sequence package is a self contained item which defines a unique activity. Thus, if an experimenter has several experiments to run during a POI, there is a corresponding number of sequence packages. Similarly, if the same experiment is to run several times within a POI, there are several sequence packages each containing the time associated with the reoccurance of the experiment.

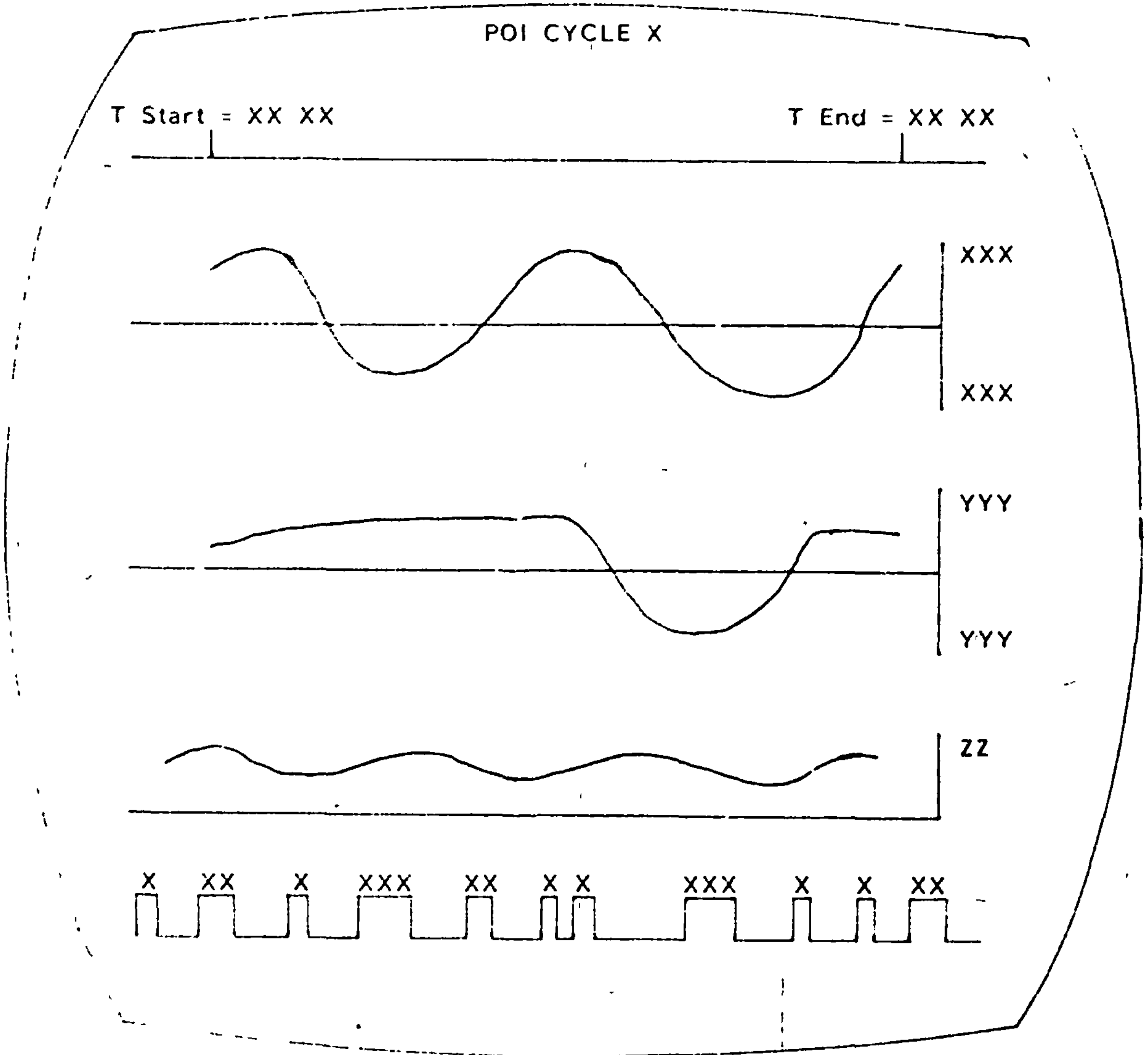
The IC^4 system is designed such that mission management calls for specific inputs to the operational cycle at various times. The users comply by supplying sequence packages. This activity is done via machine-to-machine (or data base-to-data base) interaction with appropriate checks made by the mission management software.

A user develops sequence packages off-line from the day-to-day operational activities. In fact, for many activities, sequence packages are developed before the observatory is launched. A predefined sequence package can then be selected by the user during the P&S cycle and the actual start times inserted to define placement within the POI and to replace the relative times used during sequence package development.

Figure 3.3-1 illustrates the graphic contents of a typical sequence package as it would be viewed on a user interactive terminal. The capability to present selectively any portion of the sequence package allows more information (graphic or tabular) to be held in a sequence package than can be displayed at one time. Thus, while generating a new sequence, each line of the graphic may be developed while showing only other relevant data. Similarly, portions of mission support information (Figure 3.3-3) may be displayed while developing, modifying or comparing sequences. The graphic displays are developed using a light pen, joystick and/or digitizing tablet and keyboard supported by software which presents features of a sequence which the user selects, modifies or moves about to complete each portion of the picture. Additionally, software is provided to take tabular data (Part II of a sequence package) and generate equivalent graphics or vice versa. For a standard item such as an instrument or subsystem power profile, the user may draw the graphic which then generates the tabular data, or the user may enter the tabular data and have the graphic support package draw the picture.

Standard designators are used by all sequence package generators such that the integrating software may detect conflicts. For example, in Figure 3.3-1 under the exclusive profile, graphic "X" might be an indicator that this experiment cannot execute while experiment "X" is active. Similarly, "Y" might indicate that there is a requirement for the entire observatory to be pointed at specific targets during the indicated time periods. Note that in a pointing situation, the design process is supported by the attitude control subsystem to generate required attitude profiles and by mission management to assure inter-science coordination.

The attitude control subsystem and the experimenter may transfer the pointing portion of their sequence packages back and forth between themselves while generating the desired attitude profile. The attitude control subsystem sequence package and the experiment sequence package are, in this way,



DESCRIPTION

Definition of Period of Interest

Earth track latitude (similar for other measures)

Projected Azimuth with respect to mission target (typical of a mission unique graphic)

Projected power available (similar for other parameters)

Scheduled U/L windows with quantity shown (similar for D/L)

FIGURE 3.3-3 Sequence Generation Baseline Graphics

Note User may select to display any (or none) of the graphics while defining, modifying, or positioning a sequence package developed in parallel. Support functions such as attitude, orbit or communications will, in addition, develop long range projections within the sequence package format.

The user has the capability to modify or combine existing sequences. Therefore, if an experimenter has already developed a basic sequence, he will modify that sequence to produce a sequence package for a special situation. The graphic and tabular data associated with the basic sequence are modified and the new sequence package generated by adding, deleting or modifying items. Thus, as the mission matures, the sequence generation process becomes one of selecting the sequence most closely resembling that desired and modifying as required.

The tabular data given in Part II of a sequence package is used by support subsystems to determine power, thermal, data storage, data transmission and command requirements. Each user fills in the appropriate values while designing or modifying a sequence. The sequence development support software prompts the user to fill in each item of the tabular data which is not directly obtainable from a graphic. Using the prompting technique, the completeness of a sequence package is determined. For example, if a previously developed sequence package is being modified, the user must verify each tabular item via interaction with the sequence development software before the new sequence package item is marked "complete".

The bottom graphic on Figure 3.3-1 shows the total time line of an experiment from upload of the commands to receipt of data. This graphic (and supporting tabular data) defines critical times for each activity within a POI. If, for example, the hardware for an experiment is designed such that it can only execute in one manner, there would be one basic sequence package required during the entire mission, except possibly for the selection of redundant components. The experimenter presents the same sequence package every time he wishes to be active and only changes the times associated with the experiment for the appropriate POI.

The user has the capability to designate a sequence package as a potential sequence (as compared to a package which is being utilized in the nominal POI activities by mission management). This potential sequence may be submitted to the validation software to determine if it is an acceptable substitute for an existing package or addition to a POI. If all validation shows the potential sequence package acceptable, the user may update the actual IOS with the potential sequence package to produce a new observatory sequence. The IC^4 system allows only one user to update the IOS at a time. Requests to modify the IOS are accommodated on a priority or first-come-first-serve basis as mission requirements specify. The IC^4 system notifies all active users when an IOS update is in progress. Alternatively, the potential sequence package may be an adaptive sequence which is trasmitted only under adaptive situations.

The sequence package is used in the following situations.

a. Long-range planning:
    1. Illustrate observatory ground track or other mission unique items of interest such as star fields and solar disks viewability
    2. Define long range predictions for conditions such as power and thermal
    3. Show major observatory events

b. Planning and scheduling:
   1. Define the POI
   2. Illustrate observatory ground track
   3. Show power and thermal projections
   4. Show communications windows
   5. Show experiment and subsystem events
   6. Provide data which is used to determine conflicts and gross capacity overloads.

c. Command generation and validation:
   1. Provide all data necessary to validate the integrated observatory sequence
   2. Provide all data necessary to produce integrated command loads, on-board storage plans, OBC (or command memory) management and downlink plans.

3.3.3 Adaptive Update Capability

Adaptive updates are modifications made to the on-going observatory events or to the planned observatory sequences and command loads. Adaptive updates may be incorporated into the IOS or command loads prior to command transmission, or they may be command sets transmitted in response to real-time data during actual contact with the observatory. For the first case, the IOS is routinely planned and generated and command loads are prepared. During this process, downlink data analysis may cause a science experimenter or subsystem to require a change to the planned IOS or command loads. The IC^4 system allows for adaptive updates to be incorporated into the IOS and command loads generated and validated accordingly. In the latter case, real-time downlink data may cause a science experimenter or subsystem to require an update to the on-going observatory sequence and commands to be uplinked during that contact. The IC^4 system allows for precanned commands to be transmitted to affect the required update.

The types of adaptive updates accommodated by the IC^4 system are summarized by Table 3.3-1. Sequence modifications are made to the IOS and have the potential for impacting any observatory event. Parameter only modifications have little or no impact to other observatory events. Parameter only updates are made to the IOS or may be incorporated after command files are generated. A parameter change update is a change to a parameter sequence that is currently scheduled in the IOS. Parameter change updates have no impact to any observatory events. A parameter remove update involves deleting a parameter sequence that is currently scheduled in the IOS. Parameter remove updates may impact the OBC (or command memory) if the commands reside in the OBC (or command memory). However, the change requires only the replacement of the command with a no-operation code in the command load and is considered a minimum change. A parameter add update involves addition of a parameter sequence to the IOS. Parameter add updates may impact the OBC (or command memory) if the commands reside in the OBC (or command memory) and not the instrument/subsystem processor. Also, since additional commands are to be uplinked, it is necessary to verify that uplink capacity exists (i.e., the total number of commands to be transmitted does not exceed time available to transmit)

Precanned commands are generated prior to a contact and are available for transmission during real-time operations. All precanned commands are to be transmitted within the available uplink capacity. Precanned adaptive commands

TABLE 3.3 I TYPES OF ADAPTIVE UPDATES

ADAPTIVE UPDATE	IMPACT TO OBSERVATORY SEQUENCE
SEQUENCE MODIFICATION	POTENTIAL IMPACT TO ALL OBSERVATORY EVENTS (IOS)
PARAMETER CHANGE	NO IMPACT
PARAMETER REMOVE	POTENTIAL IMPACT TO OBC OR COMMAND MEMORY
PARAMETER ADD	• POTENTIAL IMPACT TO OBC OR COMMAND MEMORY - Add if Enough Memory - Update Map Post Contact • REQUIRES U/L CAPACITY
PRECANNED ADAPTIVE COMMANDS	• POTENTIAL IMPACT TO IOS - Validated Prior to Contact • REQUIRES U/L CAPACITY
PRECANNED PARAMETER ADD COMMANDS	• POTENTIAL IMPACT TO OBC OR COMMAND MEMORY - Add if Enough Memory - Update Map Post Contact • REQUIRES U/L CAPACITY
PRECANNED HEALTH AND SAFETY	• POTENTIAL IMPACT TO IOS

are sequence modifications that potentially impact observatory events. The commands are generated prior to a contact and are validated by the P&S and CG&V processes. Precanned adaptive commands are validated for all possible contacts that they are considered for transmission. Precanned parameter updates are treated as parameter additions and may be transmitted at any time provided uplink capacity and OBC (or command memory) capacity exist. Precanned health and safety commands are transmitted in event of instrument or subsystem anomalies.

Figure 3.3-4 provides an overview of the adaptive update capabilities provided by the IC^4 system. The major events to generate the IOS, generate and validate command loads and transmit the commands are shown in the order in which they occur operationally. The dashed lines indicate that the events are not conducted consecutively and that some period of time exists between them. Cut-off points are identified which are used to define update capabilities up to the specific point in time.

Once the IOS is generated, it is available for some period of time prior to starting the CG&V process (cut-off point 1). During this interval, each user may modify the IOS for any type of adaptive update. The user has the capability to display the current IOS at the user interactive terminal. Using the IOS as a baseline, the user inputs IOS update requests (e.g., add, delete, reschedule instrument/subsystem sequences). The user is restricted from altering sequences of other instruments/subsystems. The user has the capability

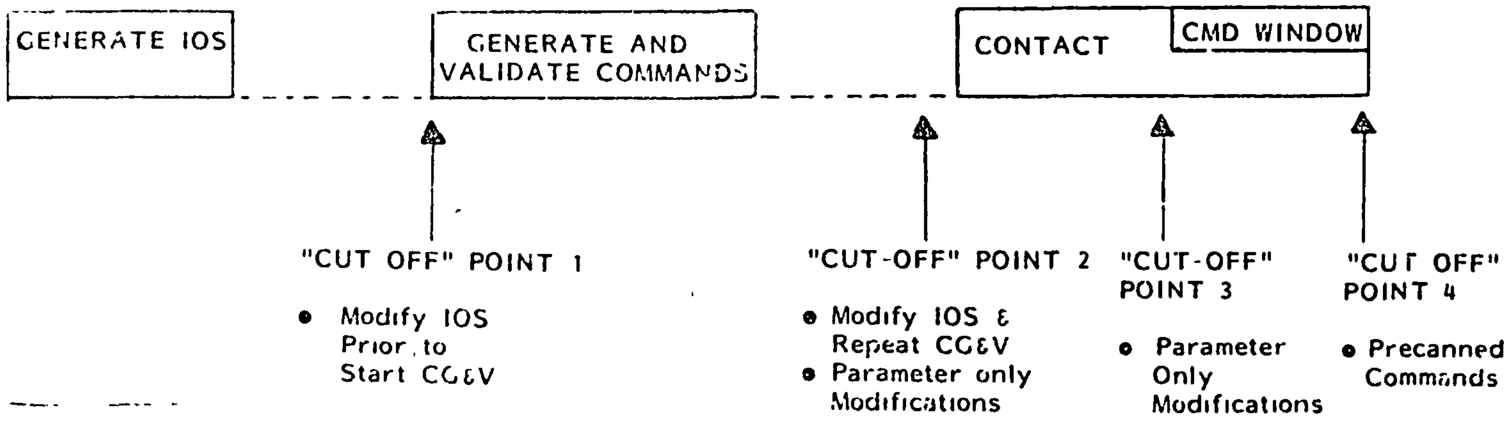


FIGURE 3.3 4 ADAPTIVE UPDATE CAPABILITY

to activate the IOS generation software from the interactive terminal using the input update requests thereby generating a potential IOS. If no conflicts occur, the user requests that the potential IOS become the current IOS. If conflicts occur, the IC^4 system does not allow the user to update the IOS. In a conflict condition, the user must edit the new inputs or coordinate with other users in order to affect modifications to remove the conflicts. The IC^4 system provides displays which inform the user of the time available prior to the CG&V process. If time runs out, the user is restricted from generating a new current IOS until CG&V has been completed for the contact of interest.

After the CG&V process has been performed for a selected contact, the command loads are available for a time period prior to the contact (cut-off point 2). If sufficient time exists to make the change, the user has the capability to modify the appropriate portion of the IOS and re-perform the CG&V process or to make parameter only modifications via CG&V. To modify the IOS, the user has the same capabilities as defined above. However, since CG&V has been performed, the potential IOS does not become current until CG&V has been repeated. Once the IOS is conflict free, the user activates CG&V providing the potential IOS as input. If no conflicts occur, the user is allowed to upgrade the potential IOS to current. However, if conflicts occur, it is the user's responsibility to make changes accordingly. The IC^4 system informs the user of the time available prior to cut-off point 2. If the cut-off point is exceeded, the user is restricted from making the IOS modifications and is limited to parameter only updates.

Prior to the command window, the user may elect to make parameter only modifications provided sufficient time exists to implement the change (cut-off point 3). The user has the capability to interactively input the requests to add, remove or change parameters. The user then activates a portion of the CG&V process (refer to Section 3.4.3) in order to update the specific command load. If time runs out, the IC^4 system restricts the user from updating the command loads.

During the contact, the user has the capability to select precanned adaptive command loads from a list of commands. Each precanned load is identified relative to the contact for which it can be transmitted. For the case of precanned adaptive commands, the commands may be validated for transmission during only one contact. For precanned parameter only commands, the loads may be transmitted during any contact. Precanned commands, as interactively selected by the user, are transmitted within the available command window (cut-off point 4).

3.3.4 In-House Real-Time Operations

The IC^4 system provides all users the capability to directly perform selected real-time functions within the physical confines of the user in-house facility. The user's in-house facility may be either at a physically remote site or the same physical location as the local operations.

Identical in-house capabilities are available to each user where these capabilities involve real-time monitoring of data and real-time instrument or subsystem control. However, it should be noted that selected users may not have a specific requirement to conduct real-time functions (monitor, control or both) from their in-house facility. The functional hierarchy charts presented in Section 3.2 identify the in-house real-time responsibilities for specific users. The real-time operations activity threads of Section 3.4.4 describe the operational techniques.

To perform the in-house real-time operations, the user interactive terminal is employed in a manner which allows the user to interface with the local real-time operations functions. Continuous voice communications during a contact exist between the in-house user (at the interactive terminal) and local operations personnel to allow discussions concerning science instrument/subsystem status or special observatory activities.

The user has the capability to select any or all of the raw instrument/subsystem data as the data is available to the local operations functions. The user may select real-time and/or recorded observatory data. Prior to or during a contact, the user has the capability to input the required data options (e.g. instrument data selections and measurement IDs) to local operations. The requests are input via man-machine interactions with the user in-house terminal. As the data is received at the local operations facility, the requested user data is stripped out and passed to the user in-house facility. It is the user's responsibility to convert and process the raw data for possible display and analysis. The capability exists to restrict the user from selecting any data pre-defined as sensitive.

The user has the capability to select and display any of the local operations standard real-time data displays. Display requests are input to the interactive terminal via keyboard entry or menu select. The user sees the displays as the local operations personnel do. This is the standard in-house monitoring mode and the user is not required to process raw data or generate additional displays.

The user has the capability to select for transmission precanned command loads that have been validated for a specific uplink or for multiple uplinks. Precanned command loads include:

a. health and safety commands in event of anomalies
b. adaptive science sequence commands
c. parameter only modifications

The user selects the desired command load from a menu. Upon user request (via terminal entry) the selection is passed to local operations for implementation. During real-time operations, either the user in-house operations or the local operations have the capability to select the command loads but not both. However, local operations are always responsible for the routinely planned commanding and have the capability to override or ignore the in-house user in event of anomalies.

3.4 Operational Activity Threads

Section 3.1.2 of this document provides an overview of the IC^4 operational activities and defines four major command and control areas: long range planning, planning and scheduling, command generation and validation and real-time operations. Activity flows of each of these areas are provided below. The activity threads define the inter-relationships between the IC^4 system elements, illustrate the manner in which the system key features are utilized and provide the order and timeliness in which the operations are performed. It should be noticed that downlink data analysis is not included in the activity threads as it is not considered a command and control function.

3.4.1 Long Range Planning Activities

Long range planning (LRP) provides the "big picture" or synopsis of observatory operations. Long-range plans and objectives typically address major mission events such as launch dates, science interactions between mission observatories and major spacecraft/science instrument events which significantly impact observatory operations for some extended period of time. Depending upon mission needs, requirements and complexities, LRP covers varying durations from the entire length of the mission to a time period greater than the P&S POI. For some missions it may be necessary to perform LRP on a regularly scheduled basis due to the complexity of spacecraft and science instrument operations; whereas for other missions LRP is performed primarily prior to launch with infrequent updates during mission operations.

LRP is a manual operation, whereby science and project representatives meet to address mission requirements. Consequently, LRP is not considered a driving factor to the command and control system and is not presented in greater detail in this document.

3.4.2 Planning and Scheduling (P&S)

3.4.2.1 Planning and Scheduling for a Period of Interest (POI)

Figure 3.4-1 summarizes the P&S activity thread. The detailed activities and capabilities are as follows:

a. Generate projection data to support POI P&S - Initial conditions are available to start the P&S process. These include: the LRP, the IOS from previous POIs, any known event carried over from the previous POI and the TDRSS schedule. The TDRSS schedule covers a time period greater than the POI and is finalized by the time actual planning begins for the POI. The TDRSS schedule is generated off-line to the normal P&S operations. Minor perturbations may arise during P&S, but the TDRSS schedule is coordinated in advance and available for P&S of the current POI.

   Each of the subsystems generates projection data for the POI using as input the previous POI and projecting forward. The subsystem data to be available include power and thermal profiles, uplink capacity for each contact (number of commands that can be transmitted), downlink capacity (gross downlink data estimates), preliminary data storage management strategy and attitude and orbit predicts. Also,

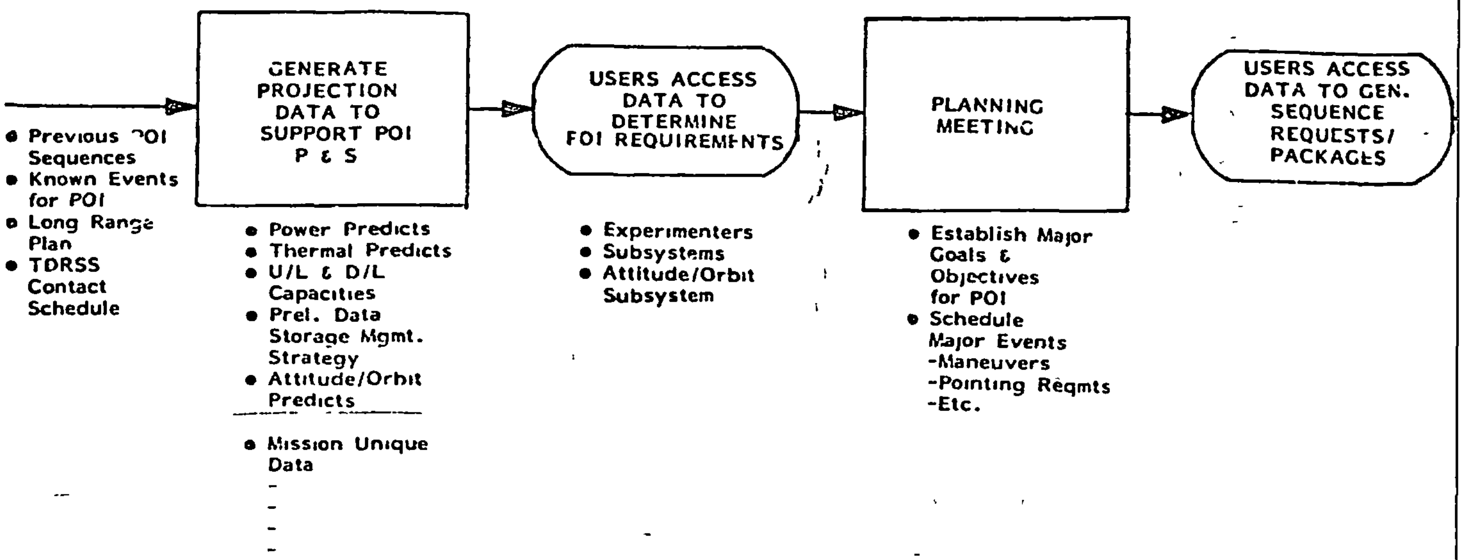


FIGURE 3.4-1 PLANNING AND SCHEDULING FOR PERIOD OF

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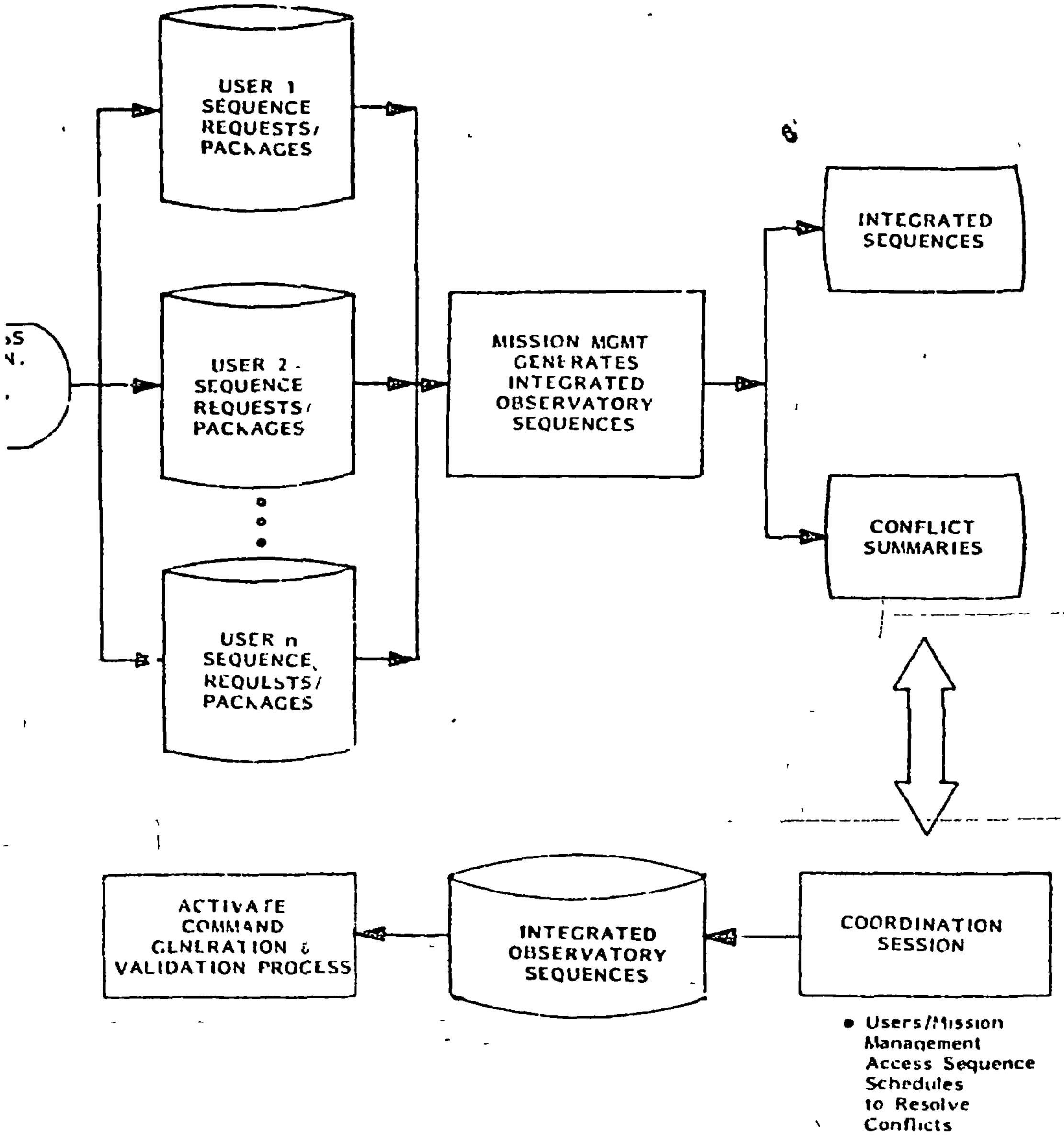

OD OF INTEREST.

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mission management provides mission unique data for reference (e.g. star fields as function of attitude/orbit, orbit day and night and South Atlantic Anomaly times). The projection data are available for access by all users.

b. <u>Users access data to determine POI requirements</u> - Each of the users accesses the projection data (via user interactive terminals) to aid in determining individual POI requirements. Standardized data displays containing the projection data are available.

c. <u>Planning meeting</u> - The purpose of the planning meeting is to establish major goals and objectives for the POI and to schedule observatory events that may cause major conflicts or perturbations on the observatory or the ground. Mission management is responsible for organizing and running the meeting.

The users attend the meeting in person or "attend" from the user interactive terminals employing voice communications. Remote users input requirements and display other user requirements via interactive terminals. Mission management and all users have the capability to interactively build timeline displays for use during the meeting. The output of the planning meeting is summarized by mission management and is available for display to all users.

d. <u>Users access data to generate sequence requests/packages</u> - Each user generates individual sequence package requests consistent with the planning meeting agreements. These requests schedule the user sequences for the POI. The data from each user are available for automatic access by mission management.

e. Mission management generates integrated observatory sequence - Mission management automatically accesses the user sequence requests/packages and combines the data into the IOS. The outputs of this function are the preliminary IOS and associated conflict summaries. The mission management software checks for major conflicts between observatory events and compliance with uplink and downlink capacities.

f. Coordination session - A coordination session is held to review the IOS and resolve conflicts. Mission management is responsible for organizing and running the session.

The users attend the meeting in person or "attend" from the remote user interactive terminals employing voice communications. The users have the capability to display the preliminary IOS and conflict summary. The users modify their original inputs per the coordination session, and mission management re-runs the IOS generation software.

The output of the coordination session is the conflict free IOS. With the IOS as input, mission management activates the command generation and validation process.

3.4.2.2 User Update Capability to Observatory Sequence

Once the IOS is generated, the capability exists for the users to adaptively update the sequences as described in

Section 3.3.3. This process is conducted by the user from the user interactive terminal. Figure 3.4-2 summarizes the process whereby the user modifies the IOS. The detailed activities are as follows:

a. <u>User access observatory sequences</u> - From analysis of received observatory data, the user derives a requirement to change the originally generated and coordinated IOS. The user displays the IOS to determine the necessary instrument or subsystem changes.

b. <u>User inputs requests to add, remove, reschedule sequences</u> - The user has the capability to reschedule, add and delete any user unique sequences and to activate the mission management software to generate a potential IOS based on the inputs. This activity is performed from the user interactive terminal.

c. <u>Conflicts</u> - If conflicts occur in the potential IOS, the mission management function notifies the user with a displayed message and restricts the user from continuing. If no conflicts are detected by the mission management function, step d is performed.

d. <u>Command generation and validation started check</u> - The user requests a status of CG&V to determine if the CG&V has started for any contact in the POI or if CG&V has started for the portion of the IOS affected by the proposed updates.

e. <u>User requests implementation of sequence update</u> - If CG&V has not started, the user requests that the potential IOS be made the current IOS. For this case, the user has modified the IOS on a success oriented basis without involvement of mission management or other instrument/subsystem personnel

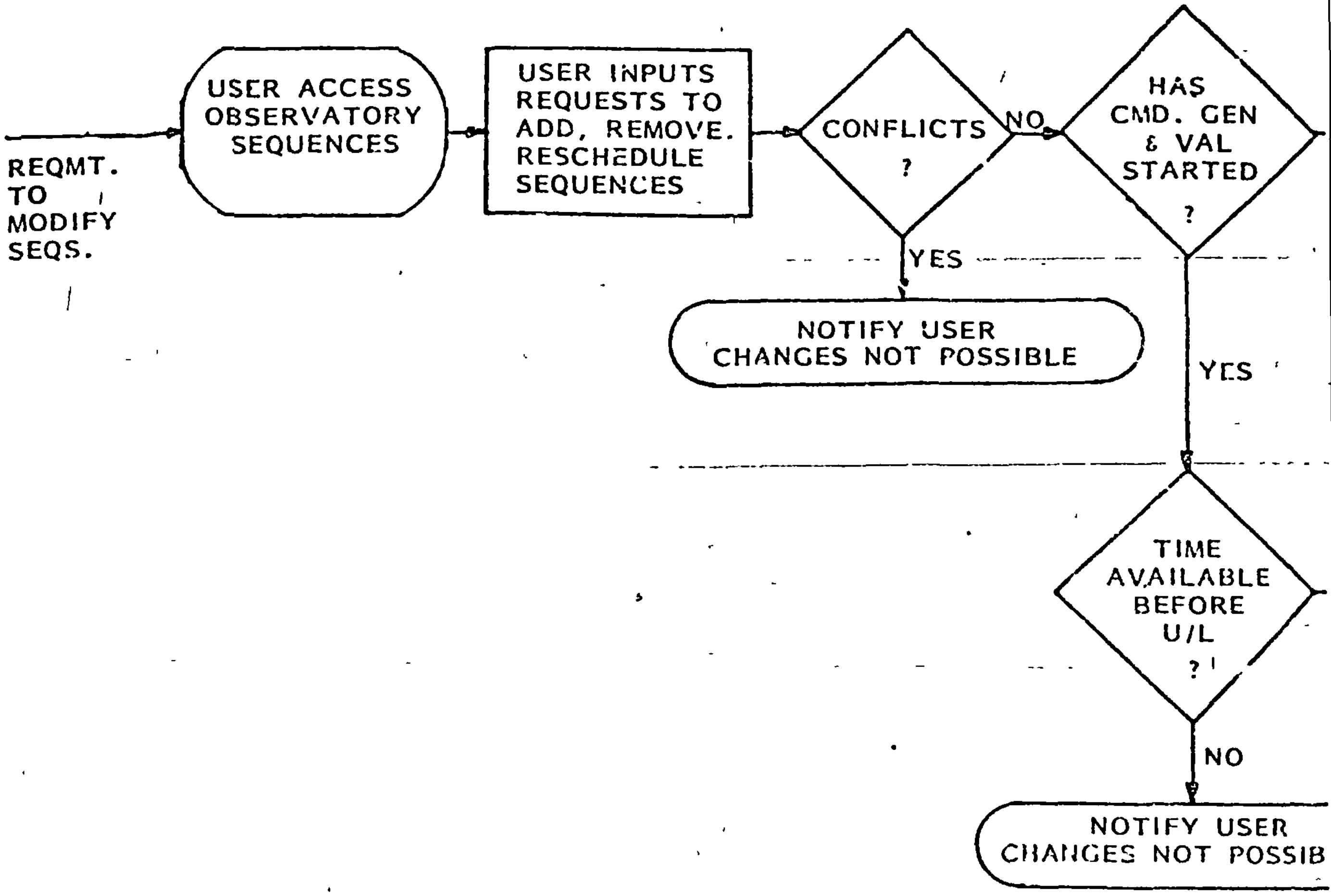

FIGURE 3.4-2. USER UPDATE CAPABILITY TO OBSER

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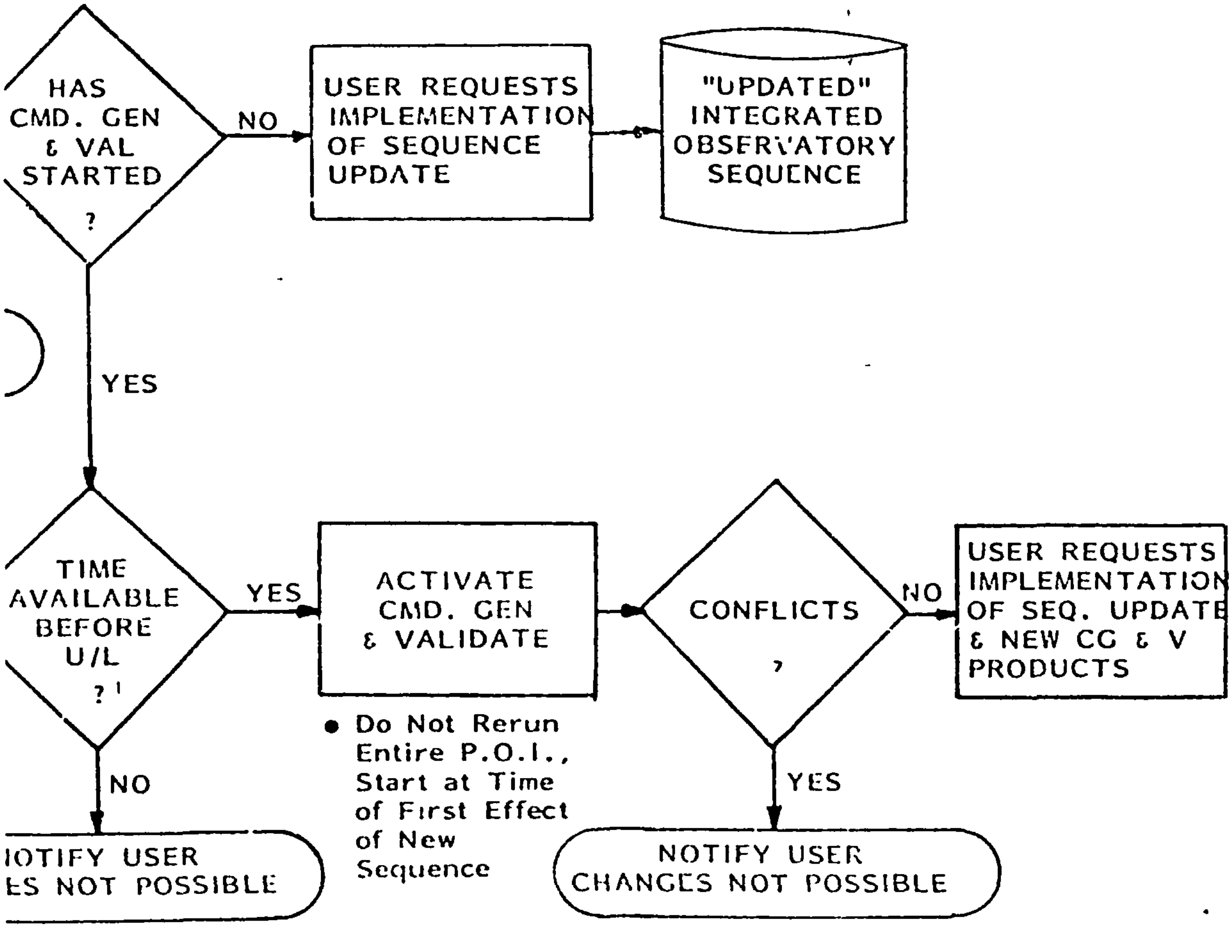

LITY TO OBSERVATORY SEQUENCES

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f. Time available before uplink check - If CG&V has started or been completed for the contact in question, the user requests status relative to time available to update the IOS (refer to Section 3.3.3). If time is not available, the mission management function restricts the user from continuing and the user receives a displayed message.

g. Activate command generation and validation - If time is available, the user activates the CG&V process using the potential IOS as input.

h. Conflict check - If conflicts are detected, the mission management function notifies the user with a displayed message and restricts the user from continuing.

i. User requests implementation of sequence update and new CG&V products - If no conflicts occur, the user requests that the potential IOS and new CG&V products be made the current products.

3.4.3 Command Generation and Validation

3.4.3.1 CG&V for a POI

The CG&V process is a fully automated activity which is shown in Figure 3.4-3 and 3.4-4.

a. Initiation of CG&V - An IOS is presented to the CG&V process after having completed the P&S activity. The IOS contains sequence packages from all IC[1] elements which are active during the time period to be validated.

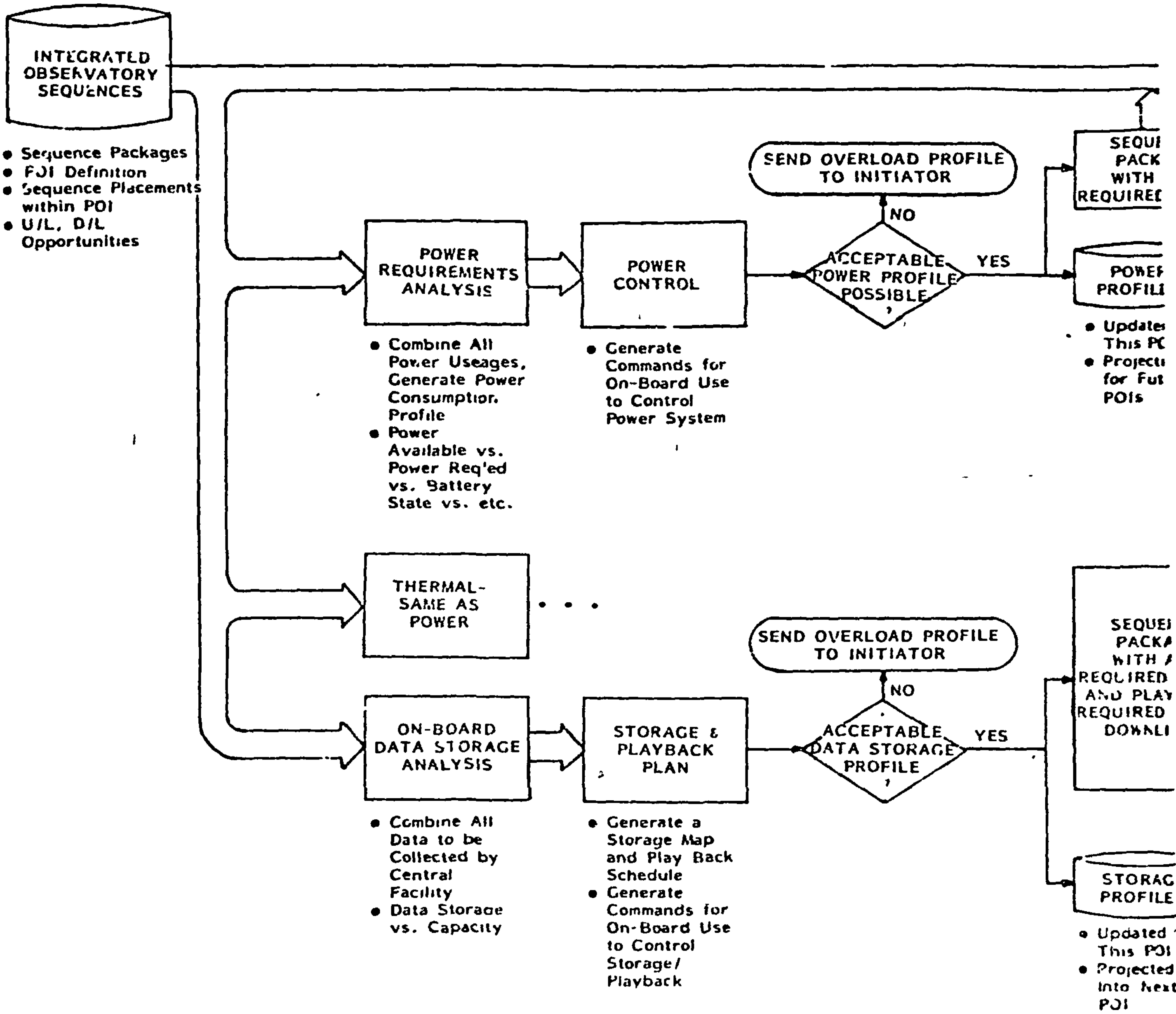

FIGURE 3 4-3 COMMAND GENERATION

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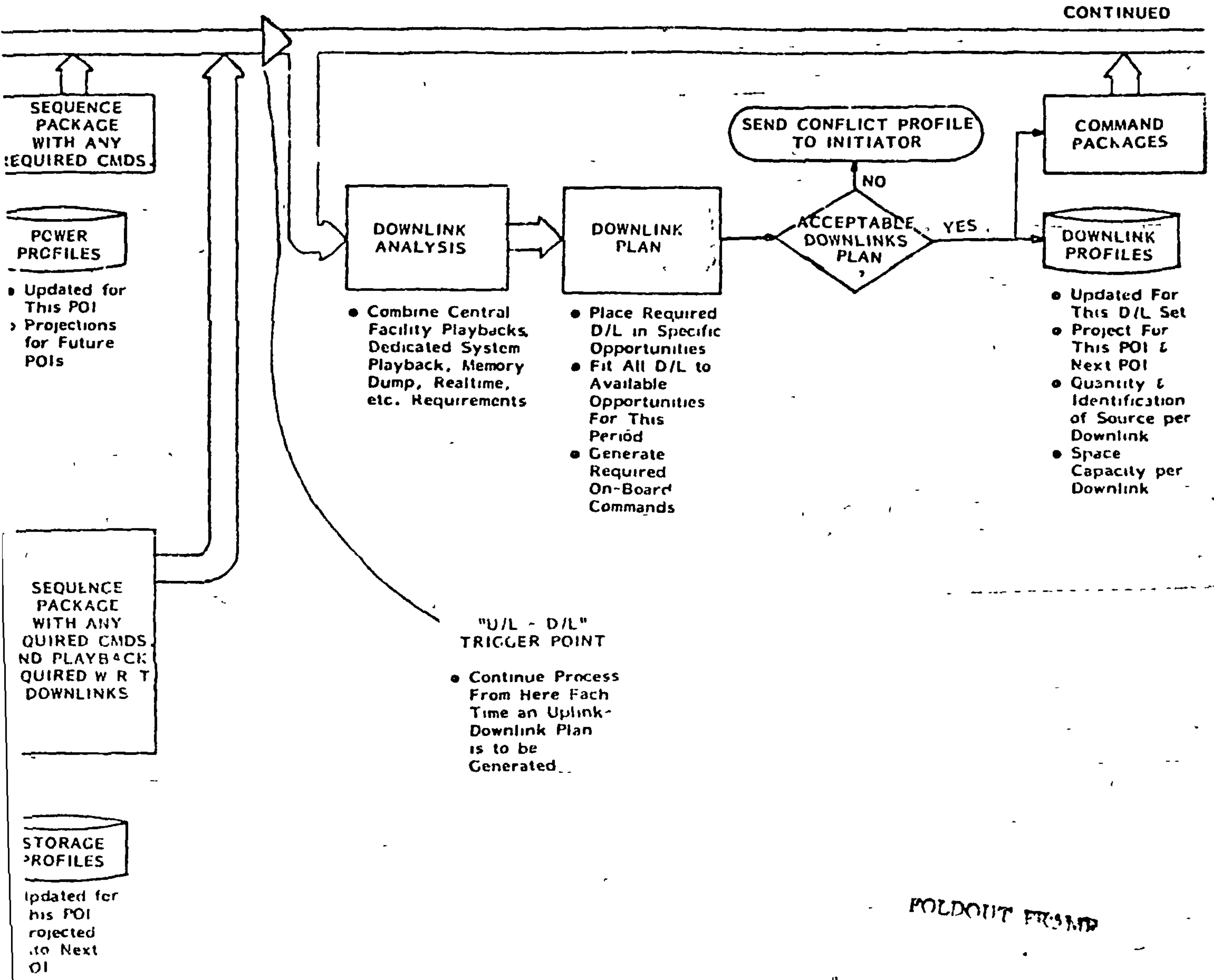

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RATION AND VALIDATION (CG&V) PART I

(CONTINUED FROM PART I)

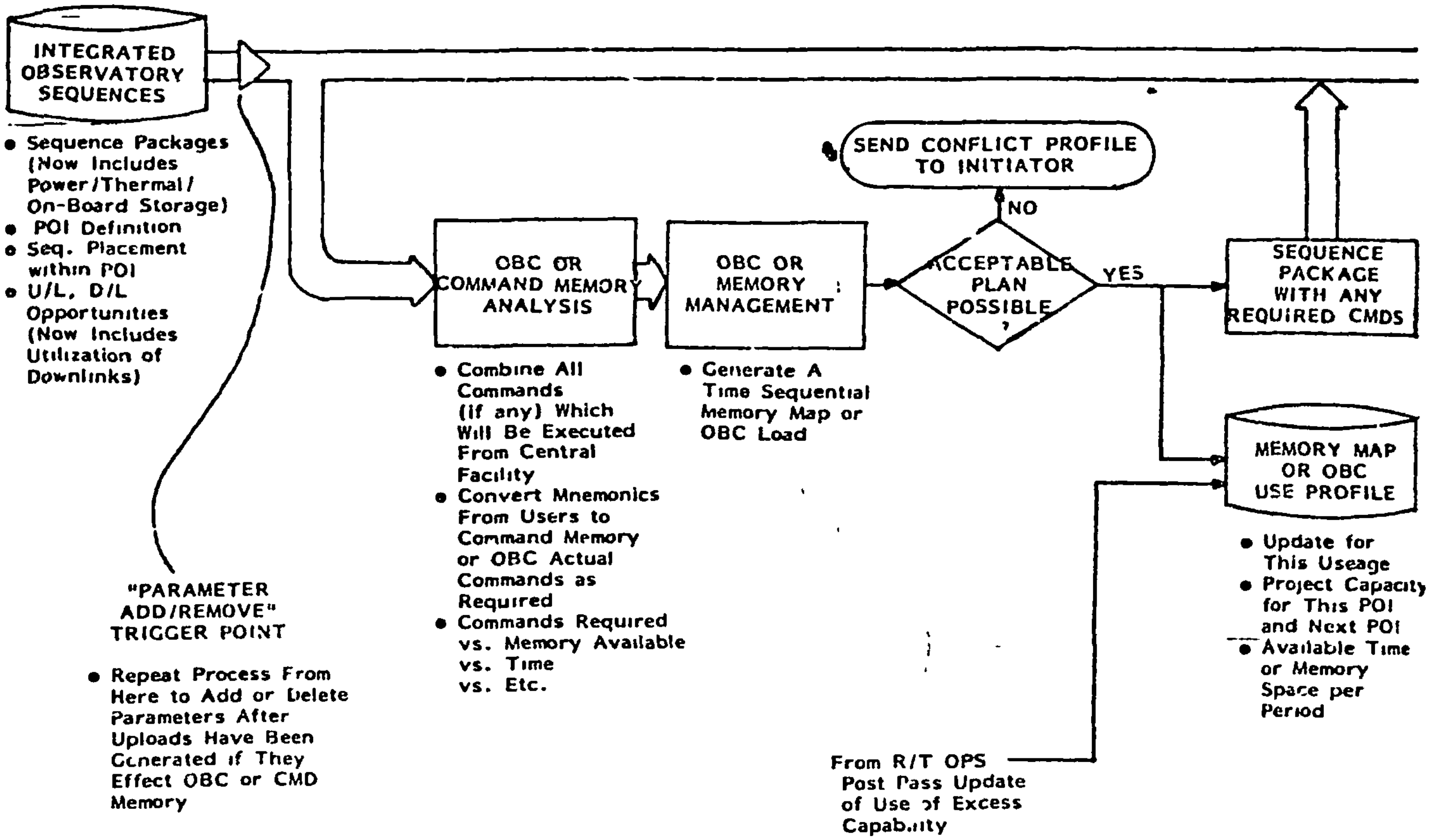

FIGURE 3 4-4 COMMAND GENERATION AND VAL

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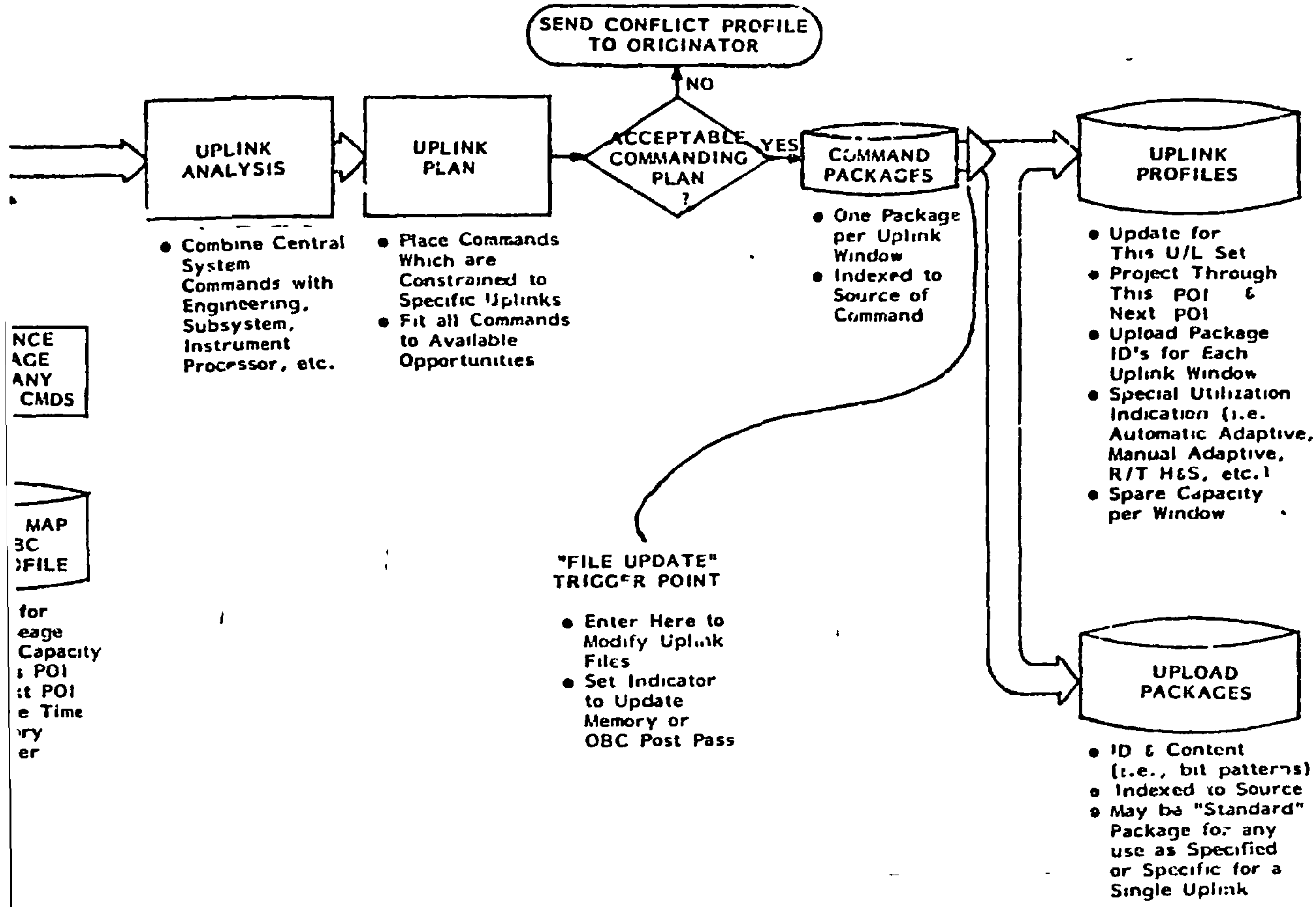

AND VALIDATION PART II

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The time period over which the IOS is to be validated is given as an input to the CG&V initiation. Under normal cycle activities the period is identical to the POI. It is possible, however, to run the CG&V process for other periods. A potential sequence modification may be presented to the CG&V process for validation. In this case, the period may be shorter than a POI, as some of the POI may be before any effect of the modification or may have already transpired.

Additionally, health and safety or adaptive sequence packages may be presented to the CG&V process to be validated against an existing IOS. Then, should the need arise, the sequences are available as prepackaged upload segments.

Mission management software schedules and controls the activities of the CG&V. Where several activities are shown to run in parallel (i.e., power, thermal and on-board data storage analysis programs), the actual execution depends upon the physical configuration. If all programs run in the same small computer, then they are run sequentially. If all programs run in a large computer, they are started at once and the operating system multiplexes between them. If any program is executed in a computer other than the mission management computer, then the mission management software is able to initiate the execution as well as transfer the necessary information to and from the remote computer.

b. Power requirements analysis - The power requirements analysis program is automatically invoked at the initiation of CG&V unless specifically commanded otherwise. This program combines all power consumption values from the sequence packages to produce a required power profile for the observatory. Utilizing attitude and orbit information contained in the attitude and orbit subsystem sequences if necessary for solar panel output analysis, the program determines if enough power is available throughout the POI.

c. Power control - The power control program generates any power subsystem commands necessary to produce an acceptable power profile. Such items as battery charging commands and shunt resister selections are generated at this time.

d. Profile check - If an acceptable power profile cannot be generated. a message is sent to the mission management software to be forwarded to the originator of the CG&V run. (The originator is mission management for normal cycle activities.) The power subsystem sequence package is marked incomplete and the CG&V process is not allowed to continue to further stages. If this is a test of a potential new sequence, note that this failure does not effect the on-going POI. Included in the notification of an unacceptable power profile is the required power profile with the time period(s) of over capacity highlighted.

e. Sequence incorporation - When an acceptable power profile is achieved, the actual profile is logged into the system (as either actual or potential) and a projection is updated for future POIs. The power subsystem sequence package which was received with the IOS - which may have been null except for the projected

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power profile - is updated to reflect the actual profile and any commanding necessary (i.e., commands, time of execution and uplink requirements). The updated power subsystem sequence package is now part of the IOS.

f. Thermal requirements analysis - The thermal requirements analysis program is automatically initiated in parallel to the power programs (step b above). This program combines all thermal load values from the sequence packages to produce a required thermal profile for the observatory. Utilizing orbit and attitude information contained in the orbit and attitude subsystem sequence packages to determine thermal loading values, the program determines if an acceptable thermal-profile can be achieved throughout the POI.

g. Thermal control - The thermal control program generates any thermal subsystem commands necessary to produce an acceptable thermal profile. Such items as louver control commands and heater cycling commands are generated at this time.

h. Profile check - If an acceptable thermal profile cannot be generated, a message is sent to the mission management software to be forwarded to the originator of the CG&V run. (The originator is mission management for normal cycle activities.) The thermal subsystem sequence package is marked incomplete and the CG&V process is not allowed to continue to further stages. Included in the notification of an unacceptable thermal profile is the required thermal profile with the time period(s) of overcapacity highlighted.

i. Sequence incorporation - When an acceptable thermal profile is achieved, the actual profile is logged into the system (as either actual or potential) and a projection is updated for future POIs. The thermal subsystem sequence package which was received with the IOS - which may have been null except for the projected thermal profile - is updated to reflect the actual profile and any commanding necessary. The updated thermal subsystem sequence package is now part of the IOS.

j. On-board data storage analysis - The on-board data storage analysis program is automatically initiated in parallel to the power and thermal programs (steps b and f above). This program combines all requirements for data storage in the common on-board storage (i.e., tape or bubble data storage device(s)) from the sequence packages to produce a required common data storage profile for the observatory. The program determines the amount of data being stored and the times at which data is to be stored.

k. Storage control - The storage and playback planning software generates a storage map and playback plan. Events from prior POIs are carried forward by the planning software. If storage control is performed on-board the observatory, this program duplicates the on-board technique. The program develops a playback plan which takes into account the data receipt time requirements in the sequence packages. This program causes the data storage management sequence package to reflect the required downlink timing for all data stored on-board. An index is generated which coordinates the originating users' sequence package to the downlink periods. The commands utilized to control storage management and playback are generated by this program.

l. <u>Profile check</u> - If an acceptable on-board data storage profile cannot be generated, a message is sent to the mission management software to be forwarded to the originator of the CG&V run. (The originator is mission management for normal cycle activities.) The on-board data storage management sequence package is marked incomplete and the CG&V process is not allowed to continue to further stages. Included in the notification of an unacceptable storage profile is the required storage profile with the areas of conflict or overcapacity highlighted. The profile may be unacceptable because of too much data, multiple users exceeding the data acceptance rate of the storage device or an unachievable data receipt time. Except for the gross excess data problem (which normally would be detected during P&S) most problems can be corrected by moving sequences slightly or relieving a too-soon data receipt requirement.

m. <u>Sequence incorporation</u> - When an acceptable on-board data storage profile is achieved, the actual profile is logged onto the system (as actual or potential) and a projection for carry-over use into the next POI is generated. The data storage management sequence package which was received with the IOS - which may have contained only those items carried over from the previous POI - is updated to reflect the actual profile and the commands necessary to achieve storage management and playback. (The playback commands may be for on-board use, ground real-time use or a combination depending upon the mission and observatory design.) The updated data storage management sequence package is now part of the IOS.

3.4.3.2 CG&V for a Command Period

a. Initiation of CG&V - At this point in the CG&V process, the IOS contains all information necessary to generate uplink and downlink schedules. This "U/L - D/L" trigger point is a mid-term holding point. The CG&V process may automatically continue from here to generate the communications plan for the entire POI or may be triggered periodically throughout the POI to generate communications events for a subperiod such as a day or some number of orbits. The choice as to which technique to use is mission unique and controlled by mission management. (The CG&V process may be continued to validate a full POI as a potential to detect any incompatabilities and then returned to the "U/L - D/L" trigger point for incremental execution to allow late changes to occur during the POI.)

b. Downlink analysis - The downlink analysis program (a support function of the communications subsystem) is initiated when a communications plan is required. The program is given a time period over which to operate which may be the entire POI or a subset of the POI. The downlink analysis combines the recorded playback requirements from the data storage management sequence package, recorded playback requirements from experiment controlled storage devices, memory dump requirements from OBC (or command memory) sequence package and any real-time downlink requirements from all sources. This program generates an integrated, detail observatory required downlink profile.

c. Downlink plan - The downlink planning software, using the knowledge of the downlink windows contained in the communications subsystem sequence package, first fits uniquely specified downlink requirements into the specified windows. Next, all downlinks are fit into downlink opportunities and a total downlink plan is produced. The downlink plan includes an index which relates user sequence packages to selected downlink windows such that all downlink content can be traced back to the originating sequence. Any on-board or ground commands necessary to achieve this schedule are generated at this time.

d. Downlink plan check - If an acceptable downlink plan cannot be generated, a message is sent to mission management software to be forwarded to the originator of the CG&V run. (The originator is mission management for normal cycle activities.) The communications subsystem sequence package is marked incomplete and the CG&V process is halted. Included in the notification of an unacceptable condition is the required downlink profile with areas of incompatibility highlighted.

e. Sequence incorporation - When an acceptable downlink plan is achieved, the actual downlink profile is logged onto the system (as actual or potential) and a projection for carry-over use into the next POI or subset of a POI is generated. The communications subsystem package which was received with the IOS - which may have contained only those items carried over from a previous POI or subset of POI - is updated to reflect the actual profile and the commands necessary to achieve the desired downlinks. (The downlink commands may be for on-board use, ground real-time use or a combination depending upon the mission and observatory design.) The updated communications subsystem sequence package is now part of the IOS.

3.4.3.3 <u>CG&V with completed power, thermal and data analysis</u>

a. <u>Initiation of CG&V</u> - At this point in the CG&V process (Figure 3.4-4), the IOS contains all information necessary to operate and receive data from the observatory. This is called the "Parameter Add/Remove" trigger point because past this point, only parameter changes which do not affect power, thermal or data quantity can be made without redoing previous CG&V steps. Under normal CG&V activities, processing does not stop at this step and therefore no specific initiation is required.

The significance of the "Parameter Add/Remove" trigger point is that users may develop sequence packages which specify only parameter values for use in adapting instrument gains, scale factors, pointing, field of view, etc. to observed phenomenon. These parameters are constrained such that they do not affect power, thermal or data generation on-board the observatory. Such parameters can be incorporated into the IOS directly by the user. Utilizing an interactive terminal, the user presents to the CG&V process a sequence package which contains the parameter(s) and desired uplink time frame. The

CG&V software informs the user whether or not an uplink window is available and if there is enough time before the uplink to incorporate the new sequence package. If conditions are favorable, the CG&V process is executed from this trigger point on.

b. <u>OBC or command memory analysis</u> - The OBC (or command memory) analysis program is automatically initiated after the downlink CG&V function is complete or upon command when a parameter change is to be validated. The anlysis program extracts all OBC (or command memory) commands from the IOS. These commands are in the form of mnemonics which are specified in user sequence packages for execution on-board the observatory. These commands are combined with those already on-board (held in a memory map or equivalent) and analyzed to verify that enough memory and time are available to execute the total command set.

c. <u>OBC or command memory management</u> - The management software converts mnemonics to actual commands and generates a time-sequential memory map or OBC activity profile which contains the projection of activity (and memory content) for the period of analysis. The period may be for the entire POI across several command periods or it may be for a subset of a POI. If the analysis period covers only one uplink, then only one memory map or OBC profile is generated. If over multiple uplinks, then sequential maps or profiles are generated.

d. <u>Plan check</u> - If an acceptable OBC (or command memory) usage cannot be generated, a message is sent to mission management software to be forwarded to the originator of the CG&V run. (The originator is mission management for normal cycle activities; however, any user could have entered a sequence package containing a simple parameter change.) The OBC (or command memory) management sequence package is marked incomplete, the CG&V process is halted and no outputs of this CG&V run are carried forward. The attempted map/plan is included in the failure message with the area(s) of incompatability highlighted.

e. Sequence incorporation - When an acceptable OBC (or command memory) usage plan is achieved, the memory map(s) or OBC activity profile(s) are updated to reflect current usage. The map/profile is projected into future time periods to reflect known usages. Additionally, the program calculates critical resource availability (such as memory available and computer time available) for ready access during real-time contingency or adaptive commanding activities. This program also updates the map/profile post-pass to reflect any real-time utilization of the available resources. The OBC (or command memory) management sequence package is updated to contain all commands which are to be executed. (This is the summation of user specified as well as OBC (or command memory) subsystem specified commands.) Where required, these commands are grouped together into sets which must be transmitted contiguously.

f. Uplink analysis - The uplink analysis program combines all commands which are to be sent to the observatory: OBC (or command memory) commands, commands to experiment or subsystem processors and real-time commands as defined by the IOS. This program generates an integrated detail observatory required uplink profile.

g. Uplink plan - The uplink planning software, using the knowledge of the uplink windows contained in the communications subsystem sequence package, first fits uniquely specified uplinks into specified windows. Next, all uplinks are fit into uplink opportunities and a total uplink plan is produced. An index is generated which relates uplinks to the originating sequence packages such that the uplink which contains commands from any sequence can be determined.

h. Commanding plan check - If an acceptable uplink plan cannot be generated, a message is sent to mission management software to be forwarded to the originator of the CG&V run. The communications sequence package is marked incomplete, the CG&V process is halted, and no outputs of this CG&V run are carried forward. The required uplink profile with areas of incompatibility highlighted is included in the error message.

i. Sequence incorporation - When an acceptable uplink plan is achieved, the actual uplink profile is logged on the system (as actual or potential). Command packages are produced which contain all uplink values for a given uplink. The uplink content is indexed to the originating sequence such that given the sequence package identification, the uplink which contains the resulting commands can be determined. The command package specifies the order of transmission, which items must be sent within a single upload sement and which are to be sent only upon external stimuli, such as real-time or adaptive uploads.

3.4.3.4 CG&V with Completed Uplink Plan

a. Initiation of CG&V - At this point in the CG&V process, the IOS reflects the total activity of the observatory and the commanding plan for a period of time. This is called the "File Update" trigger point as no changes can take place past this point except modification of the upload packages. (See paragraph 3.4.3.5 for a description of such modifications.) Depending upon mission unique considerations, the CG&V process may automatically continue its activities at this time, or the process may halt at this point and be restarted shortly before the real-time uplink activities commence.

b. Uplink File Generation - The command package for a single uplink window is prepared for use by the real-time operations and the expected usage is logged onto the system. The command package is converted into individual upload packages (segments) which conform to the format and length conventions used by the real-time processes. Each segment is assigned an ID. Each segment is indexed such that given a sequence package, the upload segment which contains resultant commands can be determined. Normally a segment is to be transmitted in a specific uplink to achieve the desired activity for a POI; however, a segment may be the result of a health and safety or adaptive sequence in which case it is kept on file until it is required. The uplink profile for a command period is generated. This may be for a single uplink window or a set of windows depending upon mission requirements. (The period may be varied within a mission depending upon such factors as the day of the week o scientific interest in a transient phenomenon.) The profile is generated defining current upload window utilization, and projections for any upload segments that utilize subsequent windows are produced. For each uplink window the segments which are to be transmitted are identified and ordered. If there are segments which are to be transmitted only upon special command or because of health and safety or adaptive science reasons, such segments are identified. The final step is to analyze the uplink window to produce a spare capacity measure to indicate the amount of adaptive commanding that can be performed by real-time operations.

3.4.3.5 Parameter Update Capabilities

The CG&V late update activities and capabilities are shown in Figure 3.4-5.

a. Initiation of CG&V parameter update - Each user may define parameters which are used to modify the operation of their instrument or subsystem which do not affect the overall activities during a POI. These parameters are to be utilized to react quickly to situations when a new sequence is not called for or time is not available to generate a new sequence. Such parameters as redundant component selectors, reset commands (if they do not effect data generated, power or thermal), gains and scale factors are examples. The IC^4 system provides the capability for the user to have such parameters incorporated into uplinks from his terminal via a menu select activity. In order to add, remove or change such a parameter, the user commands the CG&V process to generate a file update. This activity occurs after

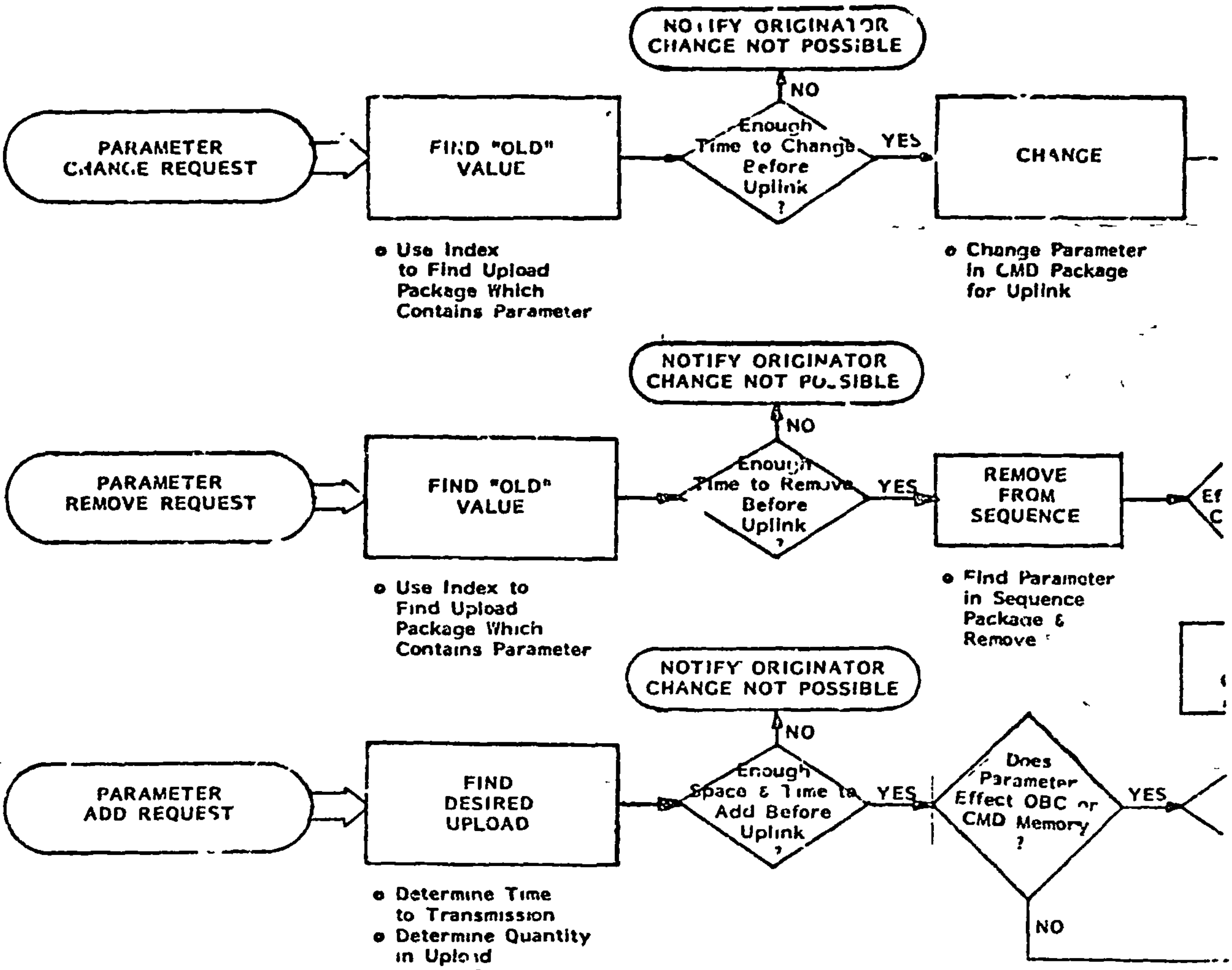

FIGURE 3.4-5 COMMAND GENERATION AND VALIDATION PART III (PARAMETER UPDATE IMPLEMENTATIONS)

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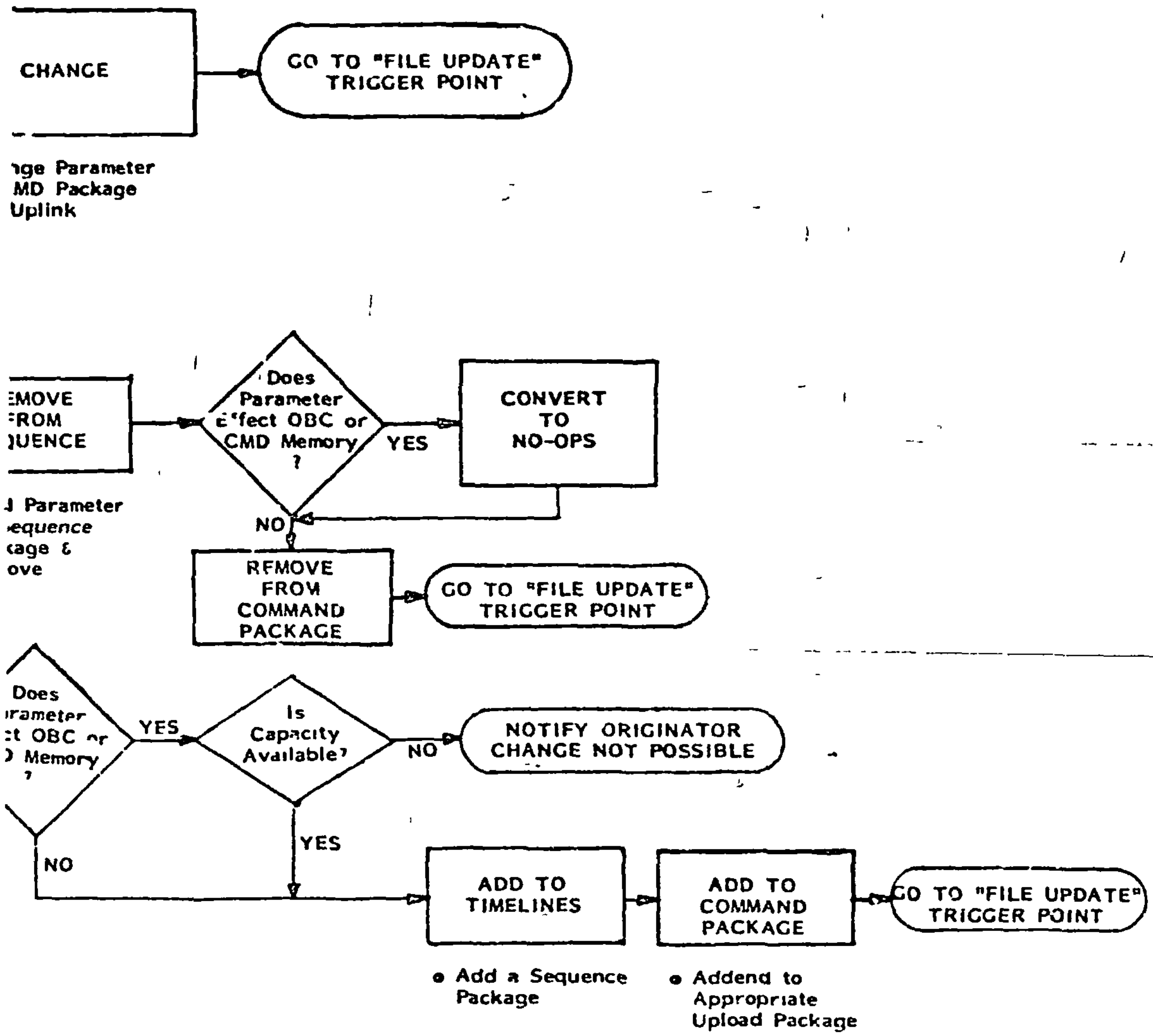

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the upload segments have been generated for an uplink window.

b. Parameter change - To command the CG&V process to change a parameter, the user inputs to the system the sequence package ID which contained the original parameter(s), an image of the original parameter and the new parameter. The CG&V process determines which upload segment contains the old parameter and determines if there is enough time to change the upload. (That is, has real-time operations already accessed the segment in question.) If the segment has already been transmitted, the user is informed of this fact; otherwise, the old parameter value(s) are replaced with the new values in the command package and the IOS version of the sequence package is updated. The change is treated as a post-pass modification for later incorporation by OBC (or command memory) management. The CG&V process then executes from the file update trigger point as was described previously. The originating user is notified that the change has been completed.

c. Parameter remove - This activity is essentially the same as the parameter change process except for the following point. The parameter to be removed is tested by CG&V software to determine if it affects OBC (or command memory). If it does, then it is converted into a no-op rather than being removed from the command package. (Note that changes at this point- change, add or remove- are treated as real-time changes and are reflected in memory management post-pass.)

d. Parameter add - To command the CG&V process to add a parameter the user inputs to the system a desired uplink window and the parameter to be added. The CG&V process determines if the uplink has not yet occured, if there is sufficient time to modify the upload before transmission and if there is sufficient space in the uplink window to add the new parameter. If the add is not possible, the user is so notified. If the change is executed by OBC (or command memory), the available resource file generated during the normal CG&V process is accessed to determine if capacity exists. If the add is possible, a dummy sequence package is automatically generated and associated with the IOS. The command package is updated to reflect the additional parameter(s). The CG&V process then executes from the file update trigger point and the originating user is notified that the addition has been made. The add is treated as a real-time activity and the memory map updated post-pass.

3.4.4 Real-Time Operations

Figure 3.4-6 provides a synopsis of the real-time activities which outlines the local and in-house user operations and the interactions between each. These activities are described below.

3.4.4.1 Local Operations

The local operations are the focal point for all real-time downlink and uplink activities. Local operations are automatically controlled by the real-time procedure which is generated off-line to the operations and is tailored to a specific contact. The real-time procedure drives

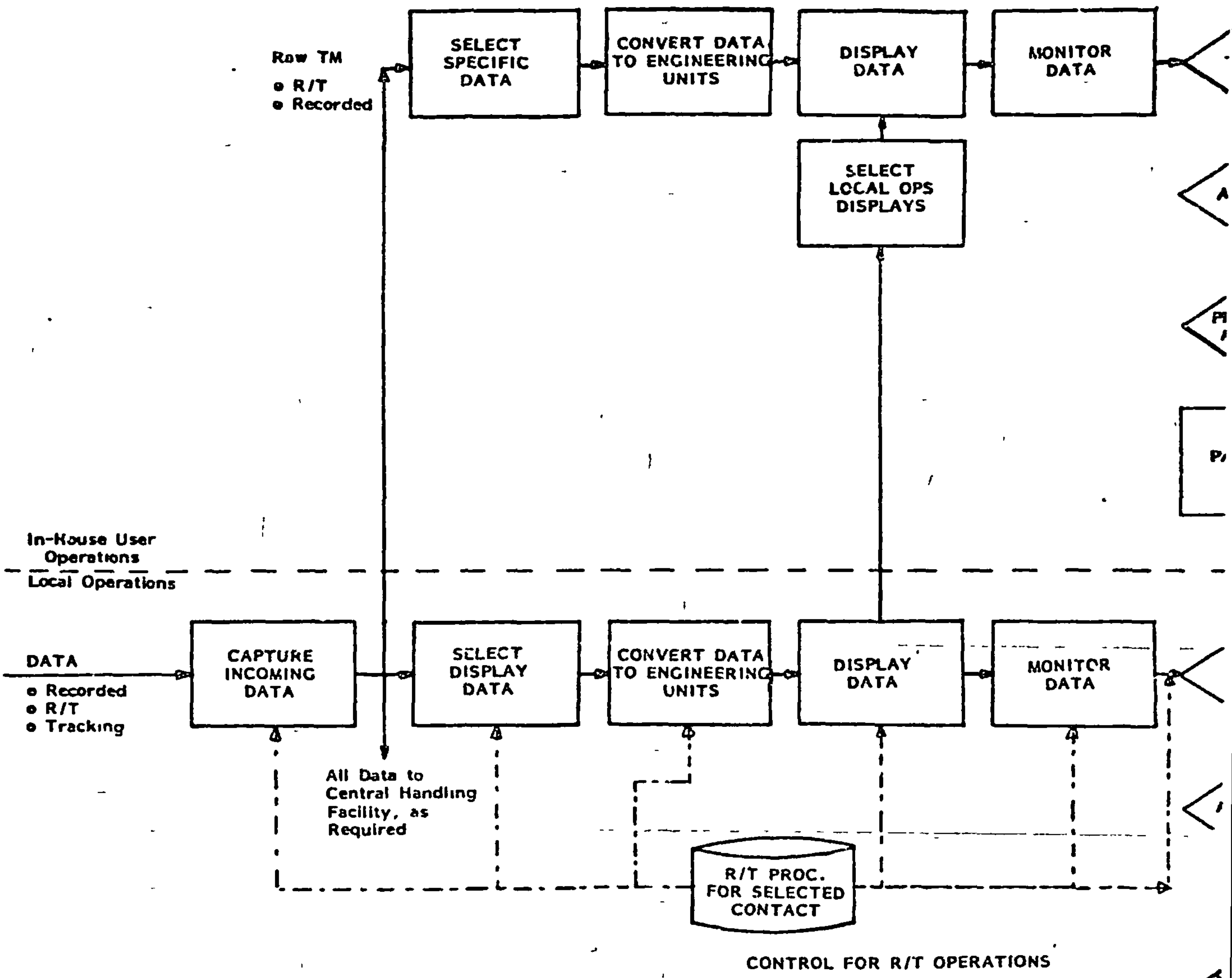

FIGURE 3.4-6· REAL TIME OPERATIONS (PASS ACTIVITIES)

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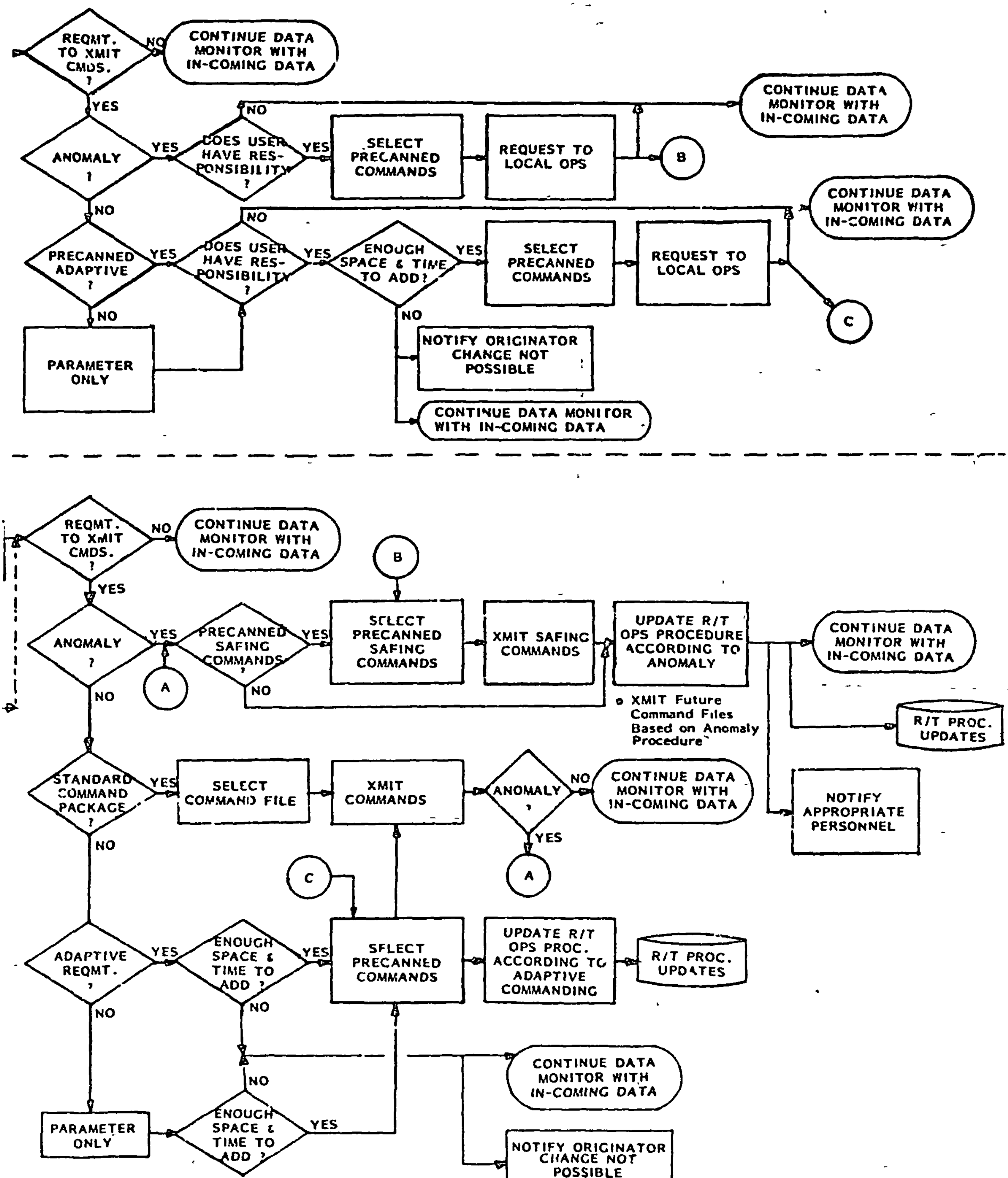

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data selection for display, data conversion, data monitoring and command transmission. With these procedures manual intervention is required primarily to support anomalies. However, the capability exists for the operator to control manually many of the real-time functions.

The local operations activities are as follows:

a. <u>Capture incoming data</u> - All downlink observatory data enter the local operations facility. For real-time command and control activities, the prime data is the real-time data (data accumulated and transmitted real-time from the observatory). However, recorded and tracking data are also received at the local operations facility.

b. <u>Select display data</u> - The data for display is typically real-time data. However, the capability exists to display and monitor recorded observatory data. It may not be required or possible to display all of the data. This function automatically selects the appropriate data based on the real-time procedure. The operator has the capability to manually request additional data parameters for display.

c. <u>Convert data to engineering units</u> - The data for display is converted automatically to engineering units according to conversion factors supplied by the system users.

d. <u>Display data</u> - Standardized data display formats are prepared and displayed upon operator request.

e. Monitor data - The data monitor function is automatically controlled by the real-time procedure, but the capability exists for operator monitoring of the data. For the automatic monitor function, the downlink data is compared to alarm limits or adaptive response limits as defined in the real-time procedure. Alarm conditions and adaptive response conditions are flagged and, depending upon the procedure, a requirement may be derived to transmit commands.

f. Requirement to transmit commands check - Based on the real-time procedure there may be a requirement to command the observatory. If there is no such requirement, the downlink functions continue until the contact ends.

One of the following types of commands may be required: 1) precanned anomaly commands in response to alarm conditions flagged by the data monitor function; 2) standard command loads as defined by the real-time procedure; 3) precanned adaptive commands as defined by the procedure and detected by the data monitor function; 4) precanned parameter only commands as defined by the procedure and detected by the data monitor function.

g. Anomaly check - An anomaly is flagged by the data monitor function, and the anomaly condition is automatically displayed to the operator. The real-time procedure (or the operator) determines if precanned safing commands are available for this condition. If commands are available, the procedure (or operator) causes the transmission to occur. The procedure (or operator) updates the real-time procedure (if required) in response to the anomaly and the downlink/uplink functions continue accordingly. Also, the operator notifies the appropriate off-line personnel of the anomaly.

h. Standard command package check - The real-time procedure dictates the time(s) to transmit the normal upload packages that were planned for the specific contact. The procedure (or operator) causes the appropriate command files to be selected and transmitted. Anomaly procedures as described above are applicable if an anomaly occurs. The downlink data functions continue throughout the contact.

i. Adaptive requirement check - The capability exists to define in the real-time procedure specific downlink data conditions which, if occur, cause precanned adaptive commands to be transmitted. These command loads are verified during the normal planning cycle as possible sequences to be commanded during a specific contact. The adaptive response requirement is flagged by the data monitor function, and this condition is automatically displayed to the operator. The real-time procedure (or operator) determines if sufficient OBC command or memory exists to accomodate the adaptive update. The operator requests a display of the OBC command or memory status to make this assessment. If there is sufficient time during the command window and the sufficient uplink capacity, the procedure (or operator) selects the appropriate commands and causes the commands to be transmitted. The real-time procedure (or operator) causes the procedure to be updated accordingly, and the normal operation continues. If the adaptive commands are not transmitted according to the procedure, the operator notifies the user.

j. Parameter only - Parameter only commands are similar to the adaptive commands with the exceptions that parameter only commands cause minimum or no impact to observatory events and can be applicable for all contacts. However, the process from the operations point of view is identical to the adaptive commanding technique.

3.4.4.2 In-House User Operations

The real-time in-house user activities parallel the local operations. The in-house user operations and activities are as follows:

a. Select specific data - The user has the capability to select the raw telemetry data (real-time and/or recorded) for use during operations. The user inputs this request from the user interactive terminal, and the data is passed to the in-house facility.

b. Convert data to engineering data - If the user selects the raw data, it is the user's responsibility to decommutate and convert the data to engineering units.

c. Display data - If the user selects the raw data, it is the user's responsibility to generate the data displays. The user has the option to request the local operations displays via the user interactive terminal. The user has a menu of display formats available and selects the displays from the menu.

d. Requirement to transmit command check - The user monitors the data displays to determine command transmission requirements. The user has the capability to request that the following types of commands be transmitted: 1) precanned anomaly commands, 2) precanned adaptive commands, 3) precanned parameter only commands. If no commands are to be transmitted, the user continues the data monitoring functions.

f. Anomaly check - The prime responsibility for anomaly commanding resides with local operations. However, isolated instances may arise where the user has responsibility to trigger anomaly commanding (i.e., back-up to local operations or user instrument anomalies that occur while user is requesting adaptive commands). If the IC^4 system recognizes the user responsibility, the user may select the appropriate precanned commands from a menu of responses and input the request to local operations.

g. Precanned adaptive and parameter only check - The user has the capability to trigger adaptive and/or parameter only commanding provided the IC^4 system recognizes this responsibility. The user has available a menu of precanned adaptive and parameter only command loads. Where required, these loads are restricted for specific contacts. The IC^4 system accepts the command requests provided OBC (or command memory) and uplink capacity are available and provided the command window exists. The user selects the precanned commands, and the request to local operations is input via the user interactive terminal. If the IC^4 system does not accept the command request, the user is notified via an automatic display. The user continues to monitor the data throughout the contact.

3.5 Interfaces

Figure 3.5-1 summarizes the data interfaces between the major IC^4 system elements. These functional interfaces show the elements that develop data and that utilize the data. Figure 3.5-1 shows generators and users of data and is not intended to define the actual manner in which data are transferred within the system. It should be noted that only those interfaces to support command and control activity are shown.

The IC^4 interfaces are defined in detail in Tables 3.5-1 through 3.5-30B. For each interface, the originating and receiving functions are identified where the functions are referenced to the functional hierarchy charts (Section 3.2). The type of interface (or functional architecture technique) is defined as one of the following categories of interfaces:

a. person-to-person
b. man-machine
c. machine-machine.

Person-to-person interfaces address information passed between people. These interfaces consist of:

a. face-to-face interfaces (i.e. meetings)
b. voice communications (via mechanisms)
c. notes and memos.

Man-machine interfaces include those interfaces where man interacts with an automated device (i.e., terminal and CRT) to input or receive information. The following types

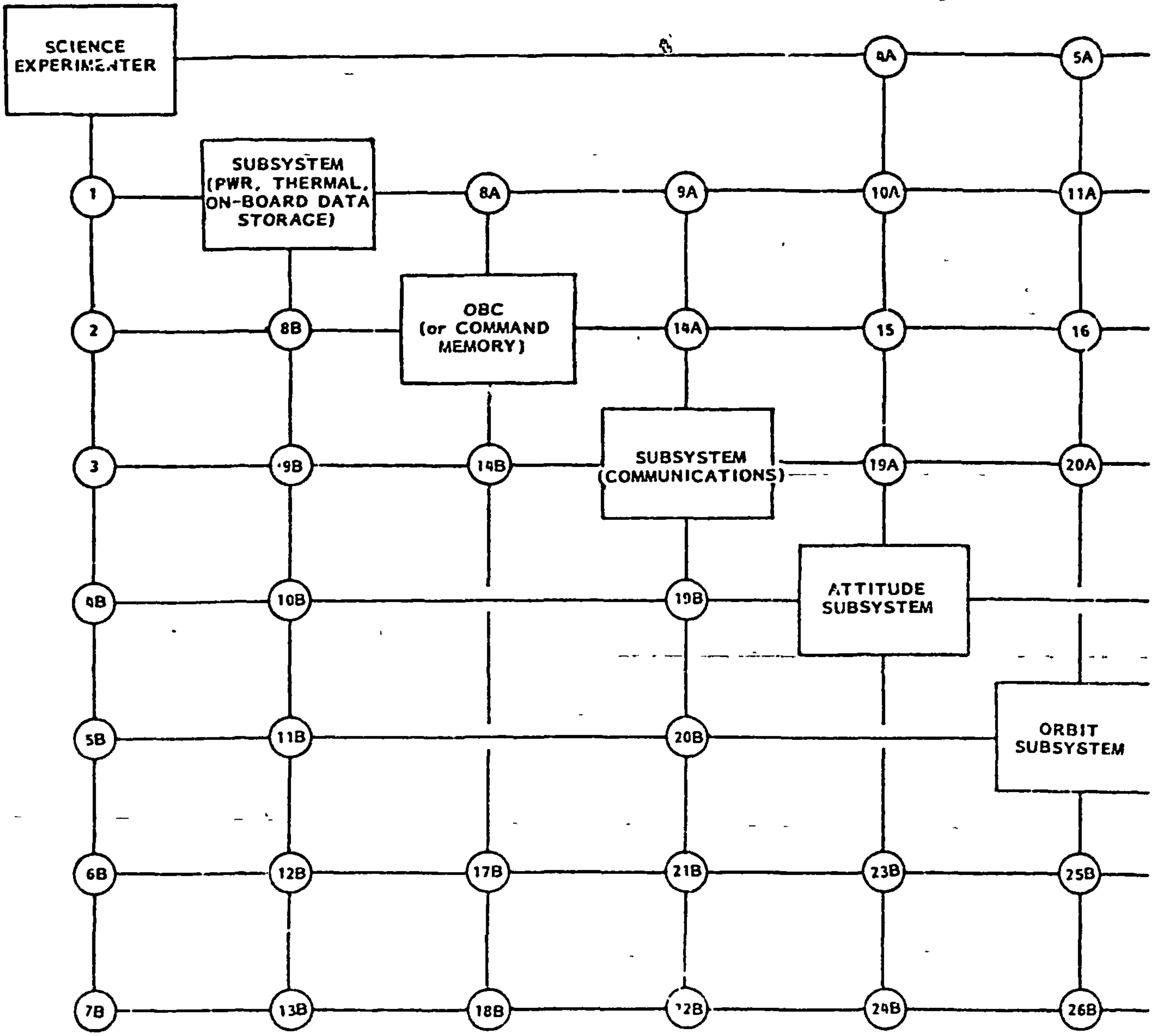

FIGURE 3 5-1. IC[4] SYSTEM INTERFACES

Note Interface numbers refer to Table numbers in text.

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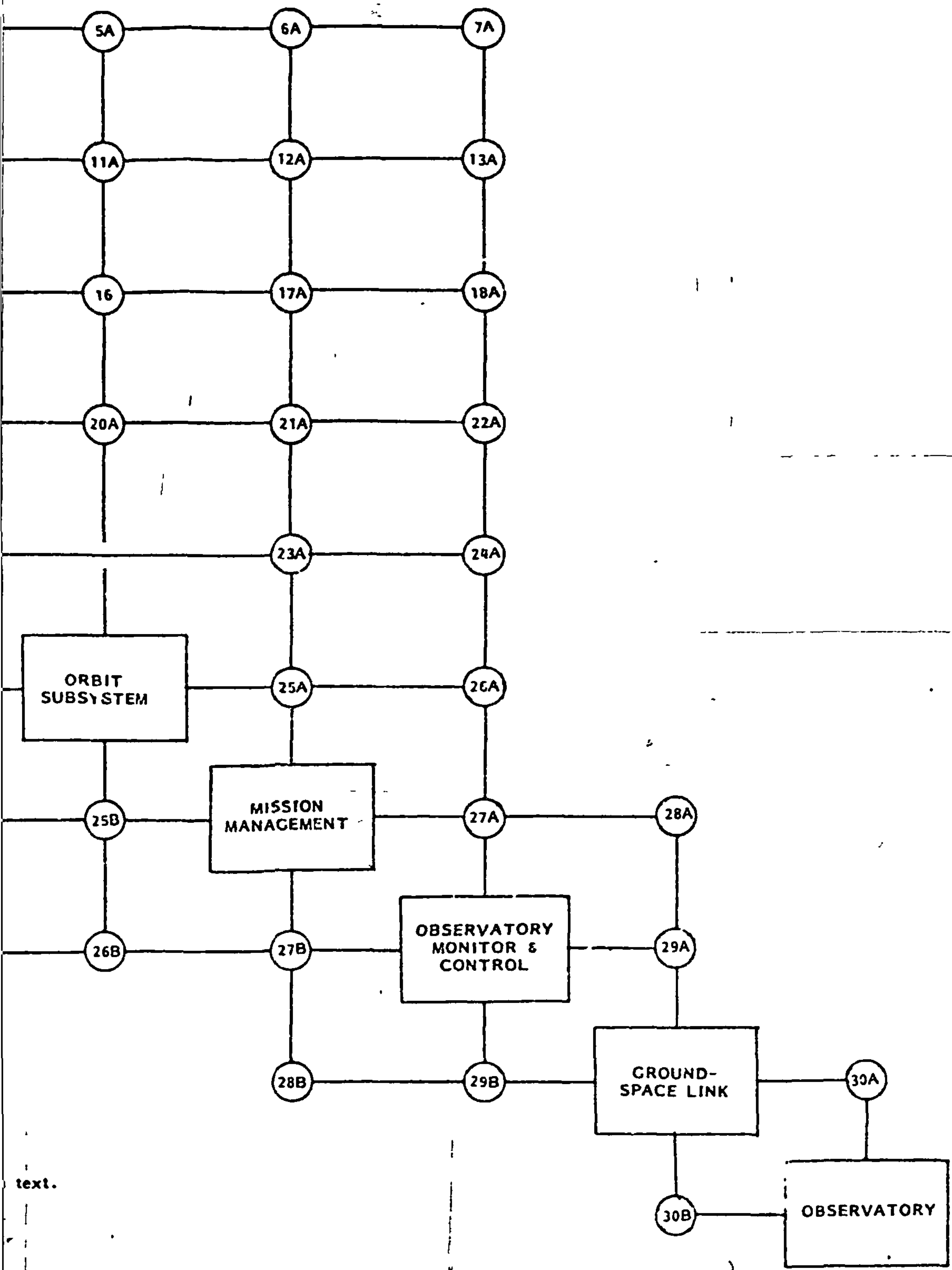
text.



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of man-machine interfaces are considered:

a. man directs activity of the machine (i.e., man activates programs, man replaces data sets, man requests data displays)
b. data display (data is visually presented to the man)
c. data entry (man inputs data/information in response to program requirements/prompts, man originates data sets).

Machine-machine interfaces address automatic interfaces (no man-in-the-loop) that occur between programs and machines. These include:

a. automatic triggers (machine triggers execution of an activity/program based on time, availability of data or successful completion of a previous activity)
b. data access (machine/program access defined data from another program or interface).

TABLE 3 5-1
SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem profiles for POI (as projected based on previous POI and known events for current POI) - power - thermal - preliminary Data Storage strategy	Man-machine interface (Data Display)	Science Instrument Planning
Sequencing Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H & S sequence) - power - thermal - Data Storage strategy	Man-machine interface (Data Display)	Instrument Sequencing

TABLE 3.5-2
[illegible] COMMAND MEMORY MANAGEMENT TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
[illegible]	Profiles [illegible] percent loading [illegible] and/or space for POI (as [illegible] POI based upon previous POI and [illegible] for current POI)	Man-machine interface (Data Display)	Science Instrument Planning
[illegible]	Profiles indicating available loading [illegible] and/or space for selected observatory sequence ([illegible] POI [illegible], adaptive/HGS sequence)	Man-machine interface (Data Display)	Instrument Sequencing

TABLE 5-3

SUBSYSTEM (COMMUNICATIONS) TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for the POI (as projected for POI based on TDRSS schedule) - number of bits per downlink - number of commands per uplink	Man-machine interface (Data Display)	Science Instrument Planning
Sequencing Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive or H&S sequence)	Man-machine interface (Data Display)	Instrument Sequencing

TABLE 3 5-4A

SCIENCE EXPERIMENTER TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequence Package Development	Request for attitude deltas due to science requirements giving desired time and desired attitudes	Person to Person via direct if colocated or Voice Communication if remote from each other. (Science Sequence Package may be accessed by Attitude via Man-Machine Interface.)	New Sequence Development Support

TABLE 3 5-4B

ATTITUDE SYSTEM TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing Support	Profiles indicating attitude states during POI which may be used to support sequence selection	Man-machine interface is used by Experimenters to view attitude profiles Machine-machine interface is used to provide data to experiment specific pointing programs.	Science Experiment Planning and Instrument Sequencing

TABLE 3 5-5A

SCIENCE EXPERIMENTER TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequence [illegible] Development	Request for orbit deltas to science requirements giving desired time and desired orbit modifications	Person to Person via direct if colocated or Voice Communication if remote from each other (Science Sequence Package may be accessed by Orbit via Man-Machine Interface.)	New Sequence Development Support

TABLE : 5-5B

ORBIT SYSTEM TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing support	Profiles indicating orbit ephemeris during POI which may be used to support sequence selection.	Man-machine interface is used by Experimenters to view orbit profiles. Machine-machine interface is used to provide data to experiment specific pointing programs.	Science Experiment Planning and Instrument Sequencing

TABLE 3.5-6A(1)

SCIENCE EXPERIMENTER TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning	o Science Experiment requirements/ desires for long range o Modified requirements based on conflicts	Person-Person (face-to-face/meeting)	Mission Science Planning Support
Science Instrument Planning	Instrument requirements for POI - major instrument events - data/commanding requirements - etc	o Person-Person (Voice Communication) or o Man-machine (Exp creates data set containing requirements)	Observatory Planning Coordination
	Modified instrument requirements based on discussions during Planning Meeting	o Person-Person (Voice Communication) or o Man-machine (Experimenter creates data set modifying requirements)	Observatory Planning Coordination
Instrument Sequencing	Instrument sequence requests for POI or H&S or adaptive sequence	Machine-machine (Data access)	Sequencing
	Sequence package (per seq. requests)	Machine-machine (Data access)	
	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication)	
	Request to activate Mission Management to generate "potential" observatory/ sequence using modified sequence requests	Man-machine (Man directs activity; data entry)	

TABLE 3.5-6A(2)

SCIENCE EXPERIMENTER TO MISSION MANAGEMENT (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Instrument Sequencing (continued)	Request to activate Mission Management to (in-turn) activate the command generation & validation process using modified observatory sequence or parameter only updates.	Man-machine (Man directs activity, data entry)	Command Generation
	Request Mission Management to implement modified sequence or parameter only update	Man-machine (Man directs activity)	

TABLE 3.5-6B(1)

MISSION MANAGEMENT TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning Support	Long Range Products and Notes of Agreements	Person-Person (Notes & Memos) or Man-machine (Data Display)	Mission Science Planning
Observatory Planning Coordination	TDRSS contact schedule	Man-machine (Data Display)	Science Instrument Planning
	Integrated observatory sequence from previous POIs	Man-machine (Data Display)	
	Known events for current POI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication)	
	Summation of major observatory events and schedules	Man-machine (Data Display)	
Sequencing	Integrated observatory sequence nominal/planned sequence - in response to sequence/parameter mods	Man-machine (Data Display)	Instrument Sequencing
	Conflict summary for integrated observatory sequence	Man-machine (Data Display)	
	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication)	

TABLE 3.5-6B(2)

MISSION MANAGEMENT TO SCIENCE EXPERIMENTER (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Acknowledgement of implementation of sequence or parameter modification	Man-machine (Data display: automatically occurs per implementation request)	Instrument Sequencing (continued)
Command Generation	Conflict summaries from command generation and validation process	Man-machine (Data Display)	
Ground Processing Schedule	Time available to perform selected operations. i.e., modify observatory sequence prior to initiating command generation process for POI	Man-machine (Data Display)	All Functions
	Message to experimenter that "cut-off" point has been exceeded	Man-machine (Data display: automatically occurs if "cut-off" point passes)	

TABLE 3 5-7A

SCIENCE EXPERIMENTER TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
In-House R/T Operations	Selection of precanned commands (upload packages) - P&S - adaptive sequence - parameter only changes	Machine-machine (Data Access) or Man-machine (Man directs activity)	Observatory Control
	Discussions relative to R/T commanding	Person-Person (Voice communication)	
Preparation for R/T Operations	Instrument parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for instrument data and required responses		
	Adaptive science value/limits and required responses		
In-House Instrument Data Monitor	Discussions concerning instrument operations	Person-Person (Voice communication)	R/T Data Monitor

TABLE 3.5-7B

OBSERVATORY MONITOR AND CONTROL TO SCIENCE EXPERIMENTER

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control (Real-Time)	Discussions relative to R/T commanding - verification of command transmission	Person-Person (Voice communication)	In-House R/T Operations
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Instrument Data Monitor
	Discussions concerning instrument operations	Person-Person (Voice communication)	
Data Collection and Transfer	Raw instrument data in R/T, near R/T or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3 5-8A
SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO OBC (or COMMAND MEMORY)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem profiles for POI (as projected based on previous POI and known events for current POI) - power - thermal - preliminary Data Storage strategy	Man-machine interface (Data Display)	Planning
Sequencing Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence) - power - thermal - Data Storage strategy	Man-machine interface (Data Display)	Sequencing

TABLE 3 5-38
OBC (or COMMAND MEMORY) TO SUBSYSTEM (POWER, THERMAL OR DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating percent loading of time and/or space for POI (as projected for POI based upon previous POI and known events for current POI)	Man-machine interface (Data Display)	Subsystem Planning
Sequencing Support	Profiles indicating available loading of time and/or space for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Subsystem Sequencing

TABLE 3.5-9A

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem profiles for POI (as projected based on previous POI and known events for current POI) - power - thermal - preliminary/ Data Storage strategy	Man-machine interface (Data Display)	Subsystem Planning
Sequencing Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence) - power - thermal - Data Storage strategy	Man-machine interface (Data Display)	Subsystem Sequencing

TABLE 3 5-9B

SUBSYSTEM (COMMUNICATIONS) TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for the POI (as projected for POI based on TDRSS schedule - number of bits per downlink - number of commands per uplink	Man-machine interface (Data Display)	Subsystem Planning
Sequencing Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive or H&S sequence)	Man-machine interface (Data Display)	Subsystem Sequencing

TABLE 3.5-10A

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem profiles for POI (as projected based on previous POI and known events for current POI) - power - thermal - preliminary Data Storage Management strategy	Man-machine interface (Data Display)	Planning
Sequencing Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence), - power - thermal - Data Storage Management strategy	Man-machine interface (Data Display)	Sequencing

TABLE 5-10B

ATTITUDE SYSTEM TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing Support	Profiles indicating attitude states during FOI which may be used to generate power generation and thermal profiles	Machine-machine interface. Man-machine interface may be used by power or thermal to view attitude profiles.	Planning Support and Subsystem Planning and Subsystem Sequencing

TABLE 3 5-11A

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem profiles for POI (as projected based on previous PCs and known events for current POI) - power - thermal - preliminary Data Storage strategy	Man-machine interface (Data Display)	Planning
Sequencing Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence) - power - thermal - Data Storage strategy	Man-machine Interface (Data Display)	Sequencing

TABLE 3 5-11B

ORBIT SUBSYSTEM TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing Support	Profiles indicating orbit ephemeris during POI which may be used to generate power generation and thermal profiles	Machine-machine interface. Man-machine interface may be used by Power or Thermal to view orbit profiles	Planning Support and Subsystem Planning and Subsystem Sequencing

TABLE 3.5-12A(1)

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Subsystem Profiles for POI (as projected based on previous POI and known events for current POI) - power - thermal - preliminary data storage strategy	Man-machine (Data Display) and Machine-machine (Data access)	Observatory Planning Coordination
Command Generation and Validation Support	Subsystem profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine (Data Display) and Machine-machine (Data Access)	Command Generation
	Conflict summaries from command generation and validation process	Man-machine (Data Display) and Machine-machine (Data Access)	
Subsystem Planning	Subsystem requirements for POI - major events - data/commanding requirements - etc	Person-Person (Voice communication if subsystems are remote; face-to-face meeting if co-located) or Man-machine (Subsystem creates data set containing requirements)	Observatory Planning Coordination
Subsystem Sequencing	Subsystem sequence requests and sequence package for POI or H&S sequence request	Machine-machine (Data Access)	Sequencing
	Coordination agreements concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	
	Request to activate Mission Management to generate "potential" observatory sequence using modified sequence requests	Man-machine (Man directs activity, data entry)	

TABLE 3 5-12A(2)

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO MISSION MANAGEMENT (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Subsystem Sequencing (continued)	Request to activate Mission Management to (in-turn) activate the command generation and validation process using modified sequence or parameter only updates	Man-machine (Man directs activity, data entry)	Command Generation
	Request Mission Management to implement modified sequence or parameter only update	Man-machine (Man directs activity)	
	Sequence requests and sequence packages due to command generation and validation process - sequences/commands required to control subsystem as function of integrated observatory sequence - sequences/commands required to control storage/playback of observatory data (as function of integrated observatory sequence)	Machine-machine (Data Access)	

TABLE 3 5-12B(1)

MISSION MANAGEMENT TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning Support	Long range products and notes of agreement	Person-Person (Notes and Memos) or Man-machine (Data Display)	Planning Support and Subsystem Planning
Observatory Planning Coordination	TDRSS Contact Schedule	Man-Machine (Data Display)	
	Integrated observatory sequence from previous POIs	Man-machine (Data Display) and Machine-machine (Data Access)	
	Known events for current POI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication or face-to-face)	Planning Support and Subsystem Planning
Sequencing	Integrated observatory sequence - nominal - in response to sequence/parameter mods - H&S and adaptive	Man-machine (Data Display)	Subsystem Sequencing
	Conflict summary for integrated observatory sequence	Man-machine (Data Display)	
	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	

TABLE 3 5-12B(2)

MISSION MANAGEMENT TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Acknowledgement of implementation of sequence or parameter modification	Man-machine (Data display: automatically occurs per implementation request)	Subsystem Sequencing (continued)
Command Generation	Integrated observatory sequence - nominal/planned sequence - in response to sequence/ parameter mods	Man-machine (Data Display) and Machine-machine (Data Access)	Sequencing Support
	Sequence packages associated with integrated observatory sequence	Machine-machine (Data Access)	
	Request to activate power, thermal, and on-board data storage management to perform their portion of command generation and validation	Man-machine (Man directs activity) and Machine-machine (start execution upon successful completion of validation activities)	
	Conflict summaries from command generation and validation process	Man-machine (Data Display)	Subsystem Sequencing
Ground Processing Schedule	Time available to perform selected operations i e , modify observatory sequence prior to initiating command generation process for POI	Man-machine (Data Display)	All Functions
	Message to subsystem that "cut-off" point has been exceeded	Man-machine (Data display: automatically occurs if "cut-off" point passes)	

TABLE 3.5-13A

SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT) TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
In-House R/T Operations	Selection of precanned commands (upload packages) - H&S - Parameter only changes	Machine-machine (Data Access) or Man-machine (Man directs activity)	Observatory Control
	Discussions relative to R/T commanding	Person-Person (Voice communication)	
Preparation for R/T Operations	Subsystem parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for subsystem data and required responses		
In-House Subsystem Data Monitor	Discussions concerning subsystem operations	Person-Person (Voice communication)	R/T Data Monitor

TABLE 3.5-13B

OBSERVATORY MONITOR AND CONTROL TO SUBSYSTEM (POWER, THERMAL, ON-BOARD DATA STORAGE MANAGEMENT)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory control (Real-time)	Discussions relative to R/T commanding - Verification of command transmission	Person-Person (Voice communication)	In-House R/T Operations
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Subsystem Data Monitor
	Discussion concerning subsystem operations	Person-Person (Voice communication)	
Data Collection and Transfer	Raw subsystem data in R/T, near R/T or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3.5-14A

OBC (or COMMAND MEMORY) MANAGEMENT TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning support	Profiles indicating percent loading of time and/or space for POI (as projected for POI based upon previous POI and known events for current POI)	Man-machine interface (Data Display)	Subsystem Planning
Sequencing support	Profiles indicating available loading of time and/or space for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Subsystem Sequencing

TABLE 3 5-14B

SUBSYSTEM (COMMUNICATIONS) TO OBC (or COMMAND MEMORY)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for the POI (as projected for POI based on TDRSS schedule - number of bits per downlink - number of commands per uplink	Man-machine interface (Data Display)	Planning
Sequencing Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive or H&S sequence)	Man-machine interface (Data Display)	Sequencing

TABLE 3.5-15

OBC (or COMMAND MEMORY) MANAGEMENT TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating percent loading of time and/or space for POI (as projected for POI based upon previous POI and known events for current POI)	Man-machine interface (Data Display)	Planning
Sequencing Support	Profiles indicating available loading of time and/or space for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Sequencing

TABLE 3.5-16

OBC (or COMMAND MEMORY) MANAGEMENT TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating percent loading of time and/or space for POI (as projected for POI based upon previous POI and known events for current POI)	Man-machine interface (Data Display)	Planning
Sequencing Support	Profiles indicating available loading of time and/or space for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Sequencing

TABLE 5-17A

OBC (or COMMAND MEMORY) MANAGEMENT TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating percent loading of time and/or space for POI (as projected for POI based upon previous POI and known events for current POI)	Man-machine (Data Display) Machine-machine (Data Access)	Observatory Planning Coordination
Planning	Requirements indicating major events which are to occur in POI	Man-machine (Data Display) Person-Person (Voice communication if remote)	Observatory Sequencing Coordination
Sequencing	Coordination agreements with respect to integrated sequences	Person-Person (Voice communication if remote)	Sequencing
	Sequence requests and sequence packages which indicate events (memory dump, subsystem adjustments, etc.) for POI	Machine-machine for integration (Data Access) Man-machine interface may be used by Mission Management to view Sequence Packages	Sequencing and Command Generation
Command Generation and Command Generation and Validation Support	Conflict and availability profiles generated during sequence validation	Man-machine (Data Display) Machine-machine status information	Command Generation
Command Generation	Sequence Packages which include command loads required for each uplink.	Machine-machine for integration (Data Access)	Command Generation

TABLE 3.5-17B(1)

MISSION MANAGEMENT TO OBC (or COMMAND MEMORY) MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning Support	Long Range products and notes of agreement	Person-Person (Notes and Memos) or Man-machine (Data Display)	Planning Support and Control-Planning
Observatory Planning Coordination	TDRSS Contact Schedule	Man-machine (Data Display)	
	Integrated observatory sequence from previous POIs	Man-machine (Data Display) and Machine-machine (Data Access)	
	Known events for current POI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication or face-to-face)	Planning Support and Planning
	Summation of major observatory events and schedules	Man-machine (Data Display)	
Sequencing	Integrated observatory sequence - nominal - in response to sequence/parameter mods - H&S and adaptive	Man-machine (Data Display)	Sequencing
	Conflict summary for integrated observatory sequence	Man-machine (Data Display)	

TABLE 3-. 17B(2)

MISSION MANAGEMENT TO OBC (or COMMAND MEMORY) MANAGEMENT (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	Sequencing (continued)
	Acknowledgement of implementation of sequence or parameter modification	Man-machine (Data Display: automatically occurs per implementation request)	
Command Generation	Conflict summaries from command generation and validation process	Man-machine (Data Display)	
	Integrated observatory sequence - nominal/planned sequence - in response to sequence/ parameter mods	Man-machine (Data Display) and Machine-machine (Data Access)	Command Generation and Validation Support
	Sequence packages associated with integrated observatory sequence	Machine-machine (Data Access)	
	Request to activate OBC-Command Memory to perform its protion of command generation and valiation	Man-machine (Man directs activity) and Machine-machine (start execution upon successful completion of validation activities)	
Ground Processing Schedule	Time available to perform selected operations i.e., modify observatory sequence prior to initiating command generation process for POI	Man-machine (Data Display)	All Functions
	Message to subsystem that "cut-off" point has been exceeded	Man-machine (Data Display: automatically occurs if "cut-off" point passes)	

TABLE 3.5-18A

OBC (or COMMAND MEMORY) TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
In-House R/T Operations	Selection of precanned commands (upload packages) - H&S - parameter only changes	Machine-machine (Data Access) or Man-machine (Man directs activity)	Observatory Control
	Discussions relative to R/T commanding	Person-Person (Voice communication)	
Preparation for R/T Operations	OBC (or Command Memory) parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for data and required responses		
In-House Data Monitor	Discussions concerning OBC (Command Memory) operations	Person-Person (Voice communication)	R/t Data Monitor

TABLE 3 5-18B

OBSERVATORY MONITOR AND CONTROL TO OBC (or COMMAND MEMORY) MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control (Real-time)	Discussions relative to R/T commanding - verification of command transmission	Person-Person (Voice communication)	In-House R/T Operations
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Data Monitor
	Discussions concerning OBC (Command Memory) operations	Person-Person (Voice communication)	
Data Collection and Transfer	Raw data in R/T, near R/T, or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3 5-19A

SUBSYSTEM (COMMUNICATIONS) TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for the POI (as projected for POI based on TDRSS schedule) - number of bits per downlink - number of commands per uplink	Man-machine interface (Data Display)	Planning
Sequencing Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Sequencing

TABLE 3.5-19B

ATTITUDE SYSTEM TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing Support	Profiles indicating attitude states during POI which may be used to generate antenna pointing commands.	Machine-machine interface. Man-machine interface is used by Communications to view attitude profiles.	Subsystem Sequencing

TABLE 3 5-20A

SUBSYSTEM (COMMUNICATIONS) TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for the POI (as projected for POI based on TDRSS schedule) - number of bits per downlink - number of commands per uplink	Man-machine interface (Data Display)	Planning
Sequencing Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine interface (Data Display)	Sequencing

TABLE 3 5-20B

ORBIT SUBSYSTEM TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing Support	Profiles indicating orbit ephemeris during POI which may be used to generate antenna pointing commands	Machine-machine interface. Man-machine interface may be used by Communications to view orbit profiles	Subsystem Sequencing

TABLE 3.5-21A(1)
SUBSYSTEM (COMMUNICATIONS) TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Uplink/downlink predicts for POI (as projected based on TDRSS schedule - number of bits per downlink - number of commands per uplink	Man-machine (Data Display) and Machine-machine (Data Access)	Observatory Planning Coordination
Command Generation and Validation Support	Uplink/downlink profiles for selected observatory sequence (nominal POI sequence, adaptive/H&S sequence)	Man-machine (Data Display) and Machine-machine (Data Access)	Command Generation
	Conflict summaries from command generation and validation process	Man-machine (Data Display) and Machine-machine (Data Access)	
Command Generation	Upload packages (command loads per uplink)	Machine-machine (Data Access)	
Subsystem Planning	Communications requirements for POI	Person-Person (Voice communication if remote; face-to-face meeting if co-located)	Observatory Planning Coordination
Subsystem Sequencing	Sequence requests and packages for POI	Machine-machine (Data Access)	Sequencing
	Coordination agreements concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	
	Request to activate Mission Management to generate "potential" observatory sequence using modified sequence requests	Man-machine (Man directs activity, data entry)	

TABLE 3.5-21A(2)
SUBSYSTEM (COMMUNICATIONS) TO MISSION MANAGEMENT (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planned (Subsystem Sequencing)	Request to activate Mission Management to (in-turn) activate Command Generation and Validation process using modified integrated sequence or parameter only updates	Man-machine (Man directs activity, data entry)	Command Generation
	Request Mission Management to implement modified sequence or parameter only update	Man-machine (Man directs activity)	
	Sequence requests/sequence packages due to command generation and validation process - commands/sequences required to control subsystem as function of integrated observatory sequence	Machine-machine (Data Access)	

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TABLE 3 5-21B(1)

MISSION MANAGEMENT TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Guidance Planning Support	Long range products and notes of agreement	Person-Person (Notes & Memos) or Man-machine (Data Display)	Planning Support and Subsystem Planning
Observatory Planning Coordination	TDRSS Contact Schedule	Man-Machine (Data Display)	
	Integrated observatory sequence from previous POIs	Man-machine (Data Display) and Machine-machine (Data Access)	
	Known events for current POI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication or face-to-face)	Planning Support and Subsystem Planning
	Summation of major observatory events and schedules	Man-machine (Data Display	
Sequencing	Integrated observatory sequence - nominal - in response to sequence/ parameter mods - H&S and adaptive	Man-machine (Data Display)	Subsystem Sequencing
	Conflict summary for integrated observatory sequence	Man machine (Data Display)	

TABLE 3 5-21B(2)

MISSION MANAGEMENT TO SUBSYSTEM (COMMUNICATIONS) (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Discussions concerning observatory/sequence conflicts	Person-person (Voice communication or face-to-face)	Subsystem Sequencing (continued)
	Acknowledgement of implementation of sequence or parameter modification	Man-machine (Data Display, automatically occurs per implementation request)	
Command Generation	Conflict summaries from command generation and validation process	Man-machine (Data Display)	
	Integrated observatory sequence - nominal/planned sequence - in response to sequence/parameter mods	Man-machine (Data Display) and Machine-machine (Data Access)	Command Generation and Validation Support
	Sequence packages associated with integrated observatory sequence	Machine-machine (Data Access)	
	Request to activate communications to perform it's portion of command generation and validation (except upload package generation)	Man-machine (Man directs activity) and Machine-machine (start execution upon successful completion of validation activities)	
	Request to activate uplink portion of communications to generate upload packages	Man-machine (Man directs activity) and Machine-machine (start execution upon successful completion of validation activities)	Command Generation
Ground Processing Schedule	Time available to perform selected operations i e , modify observatory sequence prior to initiating command generation process for IOI	Man-machine (Data Display)	All Functions

TABLE 3 5-21B(3)

MISSION MANAGEMENT TO SUBSYSTEM (COMMUNICATIONS) (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
[illegible] (continued)	Message to subsystem that "cut-off" point has been exceeded	Man-machine (Data Display: automatically occurs if "cut-off" point passes)	All Functions (continued)

TABLE 3.5-22A

SUBSYSTEM (COMMUNICATIONS) TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
In-House R/T Operations	Selection of precanned commands (upload packages) - [illegible] - parameter only changes	Machine-machine (Data Access) or Man-machine (Man directs activity)	Observatory Control
	Discussions relative to R/T commanding	Person-Person (Voice communication)	
Preparation for R/T Operations	Subsystem parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for instrument data and required responses		
	Adaptive science value/limits and required responses		
In-House Subsystem Data Monitor	Discussions concerning subsystem operations	Person-Person (Voice communication)	R/T Data Monitor

TABLE 3.5-22B

OBSERVATORY MONITOR AND CONTROL TO SUBSYSTEM (COMMUNICATIONS)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control (Real-time)	Discussions relative to R/T commanding - verification of command transmission	Person-Person (Voice communications)	In-House R/T Operations
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Subsystem Data Monitor
	Discussions concerning subsystem operations	Person-Person (Voice communications)	
Data Collection and Transfer	raw data in R/T, near R/T or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3.5-23A
ATTITUDE SUBSYSTEM TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating attitude states for POI (as projected based upon previous POI and known events for current POI)	Man-machine interface (Data Display)	Observatory Planning Coordination
Sequencing Support	Profiles indicating attitude states during POI (nominal POI sequences, adaptive/H&S sequences)	Machine-machine interface Man-machine interface (Mission Management may view profiles)	Sequencing
Sequencing	Sequence requests and command requirements in the form of Sequence Package to cause maneuvers required during POI and/or update on-board parameters	Machine-machine interface for integration Man-machine interface may be used by Mission Management to view Sequence Packages	Sequencing and Command Generation

TABLE 3.5-23B(1)

MISSION MANAGEMENT TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning Support	Long range products and notes of agreement	Person-Person (Notes and Memos) or Man-machine (Data Display)	Planning Support and Attitude System Control-Planning
Observatory Planning Coordination	TDRSS Contact Schedule	Man-machine (Data Display)	
	Integrated observatory sequence from previous POIs	Man-machine (Data Display) and Machine-machine (Data Access)	
	Known events for current POI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication or face-to-face)	Planning Support and Planning
	Summation of major observatory events and schedules	Man-machine (Data Display)	
Sequencing	Integrated observatory sequence - nominal - in response to sequence/parameter mods - H&S and adaptive	Man-machine (Data Display)	Attitude System Control-Sequencing
	Conflict summary for integrated observatory sequence	Man-machine (Data Display)	

TABLE 3.5-23B(2)

MISSION MANAGEMENT TO ATTITUDE SUBSYSTEM (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	Attitude System Control-Sequencing (continued)
	Acknowledgement of implementation of sequence or parameter modification	Man-machine (Data Display: automatically occurs per implementation request)	
Command Generation	Conflict summaries from command generation and validation process	Man-machine (Data Display)	Sequencing
Ground Processing Schedule	Time available to perform selected operations. i.e., modify observatory sequence prior to initiating command generation process for POI	Man-machine (Data Display)	All Functions
	Message to subsystem that "cut-off" point has been exceeded	Man-machine (Data-Display: automatically occurs if "cut-off" point passes)	

TABLE 3.5-24A

ATTITUDE SUBSYSTEM TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
In-House R/T Operation	Selection of precanned commands (upload packages) - H&S - parameter only changes	Machine-machine (Data Access) or Man-machine (Man directs activity)	Observatory Control
	Discussions relative to R/T commanding	Person-Person (Voice communication)	
Preparation for R/T Operations	Attitude system parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for attitude data and required responses		
In-House Monitor	Discussions concerning attitude system operations	Person-Person (Voice communication)	R/T Data Monitor

TABLE 3.5-24B

OBSERVATORY MONITOR AND CONTROL TO ATTITUDE SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control (Real-time)	Discussions relative to R/T commanding - verification of command transmission	Person-Person (Voice communication)	In-House R/T Operations
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Monitor
	Discussions concerning attitude system operations	Person-Person (Voice communication)	
Data Collection and Transfer	Raw Data in R/T, near R/T or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3 5-25A

ORBIT SUBSYSTEM TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Planning Support	Profiles indicating orbit ephemeris for POI (as projected based upon previous POI and known events for current POI)	Man-machine interface (Data Display) Machine-machine interface to provide long term predicts of ephemeris which may be used to select communications windows	Observatory Planning Coordination and Ground/Space Link Schedule
Sequencing Support	Profiles indicating orbit ephemeris for POI (nominal POI sequences, adaptive/H&S sequences)	Machine-machine interface used to provide data which may be forwarded by Mission Management to Ground-Space link Man-machine interface (Data Display)	Sequencing and Ground/Space Link Schedule
Sequencing	Sequence requests and Command requirements in the form of a Sequence Package to cause orbit events required during POI and/or update on-board parameters	Machine-machine interface for integration Man-machine interface may be used by Mission Management to view Sequence Packages	Sequencing and Command Generation

TABLE 3.5-25B(1)

MISSION MANAGEMENT TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Mission Science Planning Support	Long range products and notes of agreement	Person-Person (Notes and Memos) or Man-machine (Data Display)	Planning Support and Orbit Control-Planning
Observatory Planning Coordination	TDRSS Contact Schedule	Man-machine (Data Display)	
	Integrated observatory sequence from previous POIs	Man-machine (Data Display) and Machine-machine (Data Access)	
	Known events for current IOI (as carried over from previous planning cycle)	Man-machine (Data Display)	
	Discussions during Planning Meeting	Person-Person (Voice communication or face-to-face)	Planning Support and Planning
	Summation of major observatory events and schedules	Man-machine (Data Display)	
Sequencing	Integrated observatory sequence - nominal - in response to sequence/ parameter mods - H&S and adaptive	Man-machine (Data Display)	Orbit Control-Sequencing
	Conflict summary for integrated observatory sequence	Man-machine (Data Display)	

TABLE 3 5-25B(2)

MISSION MANAGEMENT TO ORBIT SUBSYSTEM (continued)

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Sequencing (continued)	Discussions concerning observatory sequence conflicts	Person-Person (Voice communication or face-to-face)	Orbit Control-Sequencing (continued)
	A knowledgement of implementation of sequence or parameter modification	Man-machine (Data Display: automatically occurs per implementation request)	
Command Generation	Conflict summaries from command generation and validation process	Man-machine (Data Display)	Sequencing
Ground Processing Schedule	Time available to perform selected operations i.e., modify observatory sequence prior to initiating command generation process for POI	Man-machine (Data Display)	All Functions
	Message to subsystem that "cut-off" point has been exceeded	Man-machine (Data Display: automatically occurs if "cut-off" point passes)	

TABLE 3 5-26A

ORBIT SUBSYSTEM TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Preparation for R/T Operations	Orbit subsystem parameters for quick look	Machine-machine (Data Access)	Preparation for R/T Operations
	Conversion factors for local operations display parameters		
	Alarm values/limits for orbit data and required responses		
In-house Instrument Data Monitor	Discussions concerning orbit subsystem operations	Person-Person (Voice communication)	R/T Data Monitor

TABLE 3.5-26B

OBSERVATORY MONITOR AND CONTROL TO ORBIT SUBSYSTEM

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
R/T Data Monitor	R/T Display Data	Man-machine (Data Display)	In-House Monitor
	Discussions concerning orbit system operations	Person-Person (Voice communication)	
Data Collection and Transfer	Raw Data in R/T, near R/T or delayed - real-time data - recorded data	Machine-machine (Data Access)	

TABLE 3.5-27A

MISSION MANAGEMENT TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Command Generation	Upload packages for each uplink - normal upload packages - Ibs uploads - potential adaptive science uploads - potential parameter only uploads	Machine-machine (Data Access)	Observatory Control
R/T Operations Requirements	R/T Procedures	Machine-machine (Data Access)	Observatory Control, R/T Data Monitor; Data Collection and Transfer, Ground Control

TABLE 3.5-27B

OBSERVATORY MONITOR AND CONTROL TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control, P/L Data Monitor	P/L Procedure Updates	Machine-machine (Data Access)	R/T Operations Requirements

TABLE 3 5-28A

MISSION MANAGEMENT TO GROUND-SPACE LINK

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Ground/Space Link Schedule	Long term command/data acquisition planning	Person-Person (Voice communication and notes of agreement)	Operations
	Near term command/data acquisition schedules	Machine-machine (Data Access) and Man-machine (Data Display)	
	Ephemeris States, Frequency, etc	Machine-machine (Data Access)	

TABLE 3 5-28B

GROUND-SPACE LINK TO MISSION MANAGEMENT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Operations	Command and data acquisition window schedules (TDRSS schedules)	Machine-machine (Data Access) Man-machine (Data Display)	Ground/space Link Schedule

TABLE 3 5-29A

OBSERVATORY MONITOR AND CONTROL TO GROUND-SPACE LINK

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Observatory Control (Real-time)	Bit stream which identifies and contains the physical uplink	Machine-machine data transmission	Operations
Ground Control	Status and operations modifications	Person-Person (Voice communication)	

TABLE 3.5-29B

GROUND-SPACE LINK TO OBSERVATORY MONITOR AND CONTROL

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Operations	Bit stream which identifies and contains the physical downlink	Machine-machine data transmission	Data Acquisition and Utilization
	Tracking data and status data	Machine-machine (Data Access)	
	Status and operations modifications	Person-Person (Voice communication)	

TABLE 3.5-30A

GROUND SPACE LINK TO SPACECRAFT

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
Real time operations, [illegible]	Bit stream which is the physical uplink	Machine-machine data transmission	Spacecraft Telemetry Receivers and On-Board Data Distribution

TABLE 3.5-39B

SPACECRAFT TO GROUND-SPACE LINK

ORIGINATING FUNCTION	INFORMATION REQUIREMENT	FUNCTIONAL ARCHITECTURE TECHNIQUE	RECEIVING FUNCTION
On-board Data Access and Transmission	Bit stream which is the physical downlink and ranging signal	Machine-machine data transmission	Real-time Operations (ex. TDRSS)