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Vol. V



MARTIN
MARIETTA
CORPORATION

DENVER DIVISION

VOYAGER

CAPSULE

PRELIMINARY DESIGN (Phase B)

Contract Number 952001 FINAL REPORT

VOLUME V INTERFACE DESCRIPTIONS

AUGUST 31, 1967

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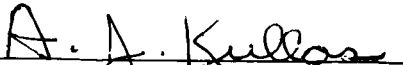
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Voyager Program Director

FOREWORD

This document is submitted in accordance with paragraph (a) (9) of Article 1, Statement of Work, to California Institute of Technology Contract No. 952001, which is a subcontract under NASA Contract NAS7-100. This document (→) is part of the Final Technical Report which consists of the following:

Vol I	Summary
CAPSULE BUS SYSTEM	
Vol II, Section I	Capsule Bus
Vol II, Section II	Preliminary Design for OSE
Vol II, Section III	Implementation Plan
Vol II, Section IV	Test Program
SURFACE LABORATORY SYSTEM	
Vol III, Section I	Surface Laboratory
Vol III, Section II	Preliminary Design for OSE
Vol III, Section III	Implementation Plan
Vol III, Section IV	Test Program
ENTRY SCIENCE PACKAGE	
Vol IV, Section I	Entry Science Package
Vol IV, Section II	Preliminary Design for OSE
Vol IV, Section III	Implementation Plan
Vol IV, Section IV	Test Program
Vol IV, Section V	Entry Science Package Interfaces
→ Vol V	Interface Descriptions
*Vol VI	RTG Report
*Vol VII	A Flight Capsule with RTG for 1973 Mission

*Limited distribution of Vol VI and VII has been made as directed by JPL.



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1. GENERAL APPROACH

Martin Marietta recognizes the importance of the systems integration of the Capsule Bus, the Entry Science Package and the Surface Laboratory. The task of systems integration begins with comprehensive definition of systems requirements at the interfaces. Only then can compatibility be achieved within the integrated system, and at the interfaces it presents to the other systems. Interfaces to be considered include hardware, software, and services as they are affected by physical, functional, environmental, test, and operational requirements plus the managerial relationships to be established.

1.1 Objectives

The objectives of the Voyager interface management program are to achieve compatible system interfaces by detailed interface definition and formal change management so that the task of systems integration can proceed. This document summarizes the contractor's recommendations for the interface management program with and within the Voyager Capsule systems as a result of the Phase B study. Section 2 identifies and provides preliminary definition of Voyager capsule systems interfaces and section 3 proposes methods for accomplishment of contractor-customer coordination, negotiation and control of interfaces.

2. SPECIFIC INTERFACES

The interfaces described in the following paragraphs are the recommendation of the contractor for identification, documentation, and configuration control. Interfaces exist between the Capsule Bus, the Entry Science Package, the Surface Laboratory, and between the combination of these and the Spacecraft. (Because the Capsule Bus supports the Entry Science Package and the Surface Laboratory in interfacing with the Spacecraft during interplanetary cruise, these interfaces are referenced to the Capsule Bus). Furthermore, the Capsule Bus, the Entry Science Package, and the Surface Laboratory each have independent interfaces with ground based systems. Interfacing systems are shown schematically in Fig. 1.

2.1 Capsule Bus Interfaces

2.1.1 Capsule Bus to Spacecraft

The physical and functional interfaces between the Capsule Bus and Spacecraft will be accommodated by the Sterilization Canister/Adapter, which performs the following functions:

- a) The encapsulating cover maintains the sterility of the Flight Capsule
- b) Provides the structural support and attachment points for adapting the Flight Capsule to the Spacecraft
- c) Provides for housing and installation of equipment required to support the Flight Capsule systems before separation
- d) Provides electrical connections between the Flight Capsule systems and the Spacecraft
- e) Provides energy storage devices, including safing and arming features, required for removing the encapsulating canister cover from the Flight Capsule
- f) Provides energy storage devices, including safing and arming features, required for removing the thermal barrier
- g) Provides energy storage devices, including safing and arming features, for separating the Flight Capsule from the Spacecraft
- h) Provides structural and electrical separation planes for Flight Capsule separation.

A block diagram of adapter-mounted equipment is shown in Fig. 2.

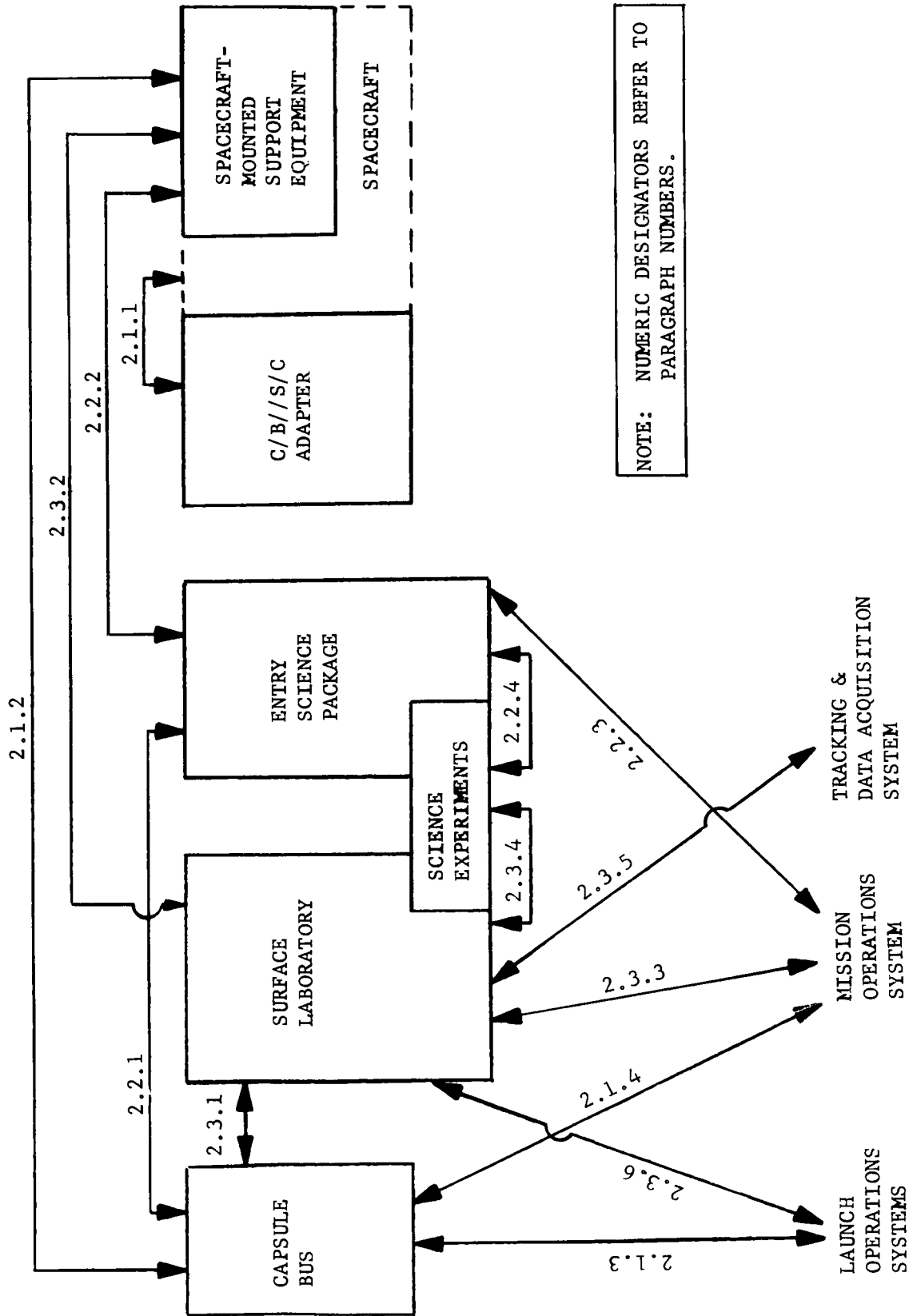
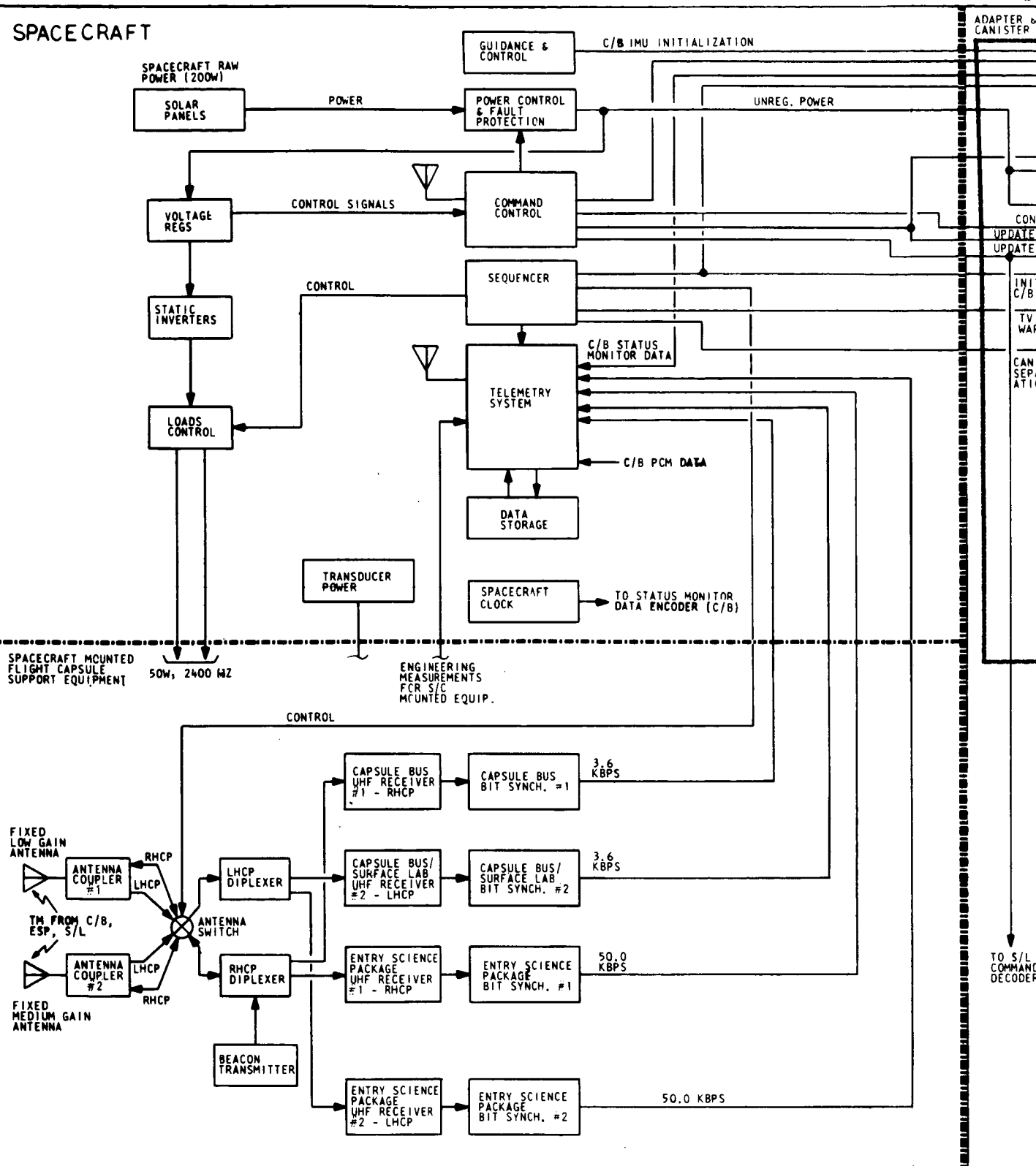


FIG. 1 VOYAGER CAPSULE SYSTEMS INTERFACES

SPACE CRAFT



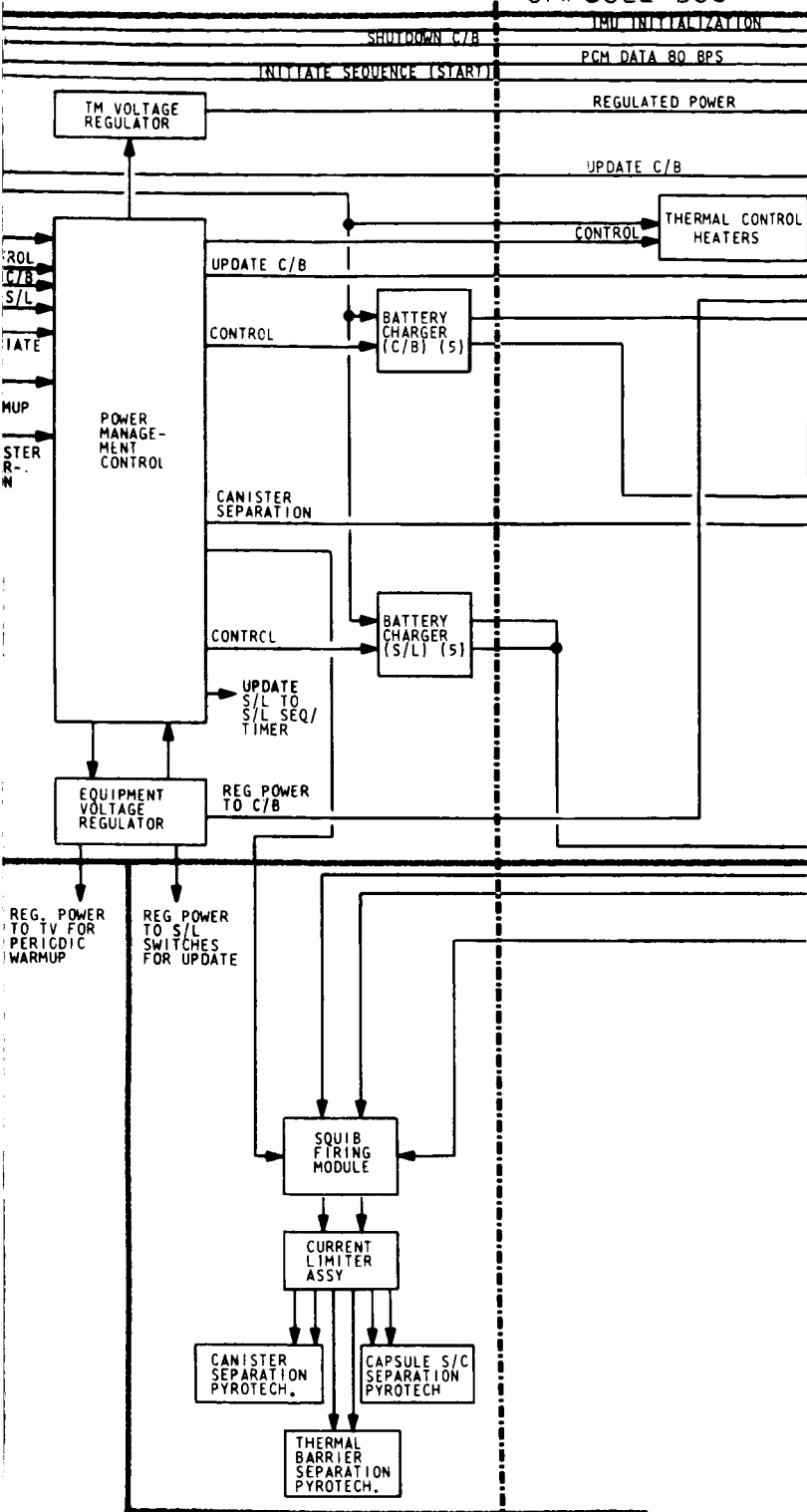


FIGURE 2-BLOCK DIAGRAM OF
FLIGHT CAPSULE/SPACECRAFT
INTERFACES

2.1.1.1 Structural Interfaces

The structural interface consists of a field joint of mating circular rings forming integral assemblies of the adapter and Spacecraft, respectively. The rings will have a nominal 163-inch diameter at the bolt-circle. Eight to twelve bolts will fasten the rings together. Longitudinal structural members rigidly attached to the rings at the bolted points will transmit longitudinal loads. Transverse loads will be transmitted through shear pins or sleeves in a manner finally negotiated with the Spacecraft contractor. Bolt-hole orientation will be maintained by offsetting at least one bolt to prevent misorientation. The exchange of a master gage to locate all holes for final drilling will provide bolt-circle control.

All mating surfaces at the interface will be propellant compatible, corrosion resistant, and electrically conductive.

Access to the interface bolts and electrical connectors will be provided for checkout of the electrical connectors and installation of the bolts.

Preseparation weight of all Flight Capsule equipment, including the adapter, will be not more than 5,000 pounds for the 1973 mission. The longitudinal center-of-gravity (cg) location (to be finalized in design) will not exceed the constraints of the Spacecraft control system. Lateral offset of the cg will be controlled within ± 0.25 inch.

The Sterilization Canister cover will be separated prior to Mars orbit injection and will be placed on a trajectory governed by the following constraints:

- a) No sterile surface shall be in line of sight of a contaminated surface at the time of separation
- b) Sterilization Canister separation shall not endanger the Flight Capsule or Spacecraft
- c) The predicted trajectory of the Sterilization Canister after separation shall not violate the planetary quarantine constraint

The maximum differential pressure at Sterilization Canister cover separation will not exceed 0.20 psi positive internal pressure. Post-separation weight of the adapter assembly and Sterilization Canister will not exceed 500 pounds.

2.1.1.2 Thermal

Thermal interface insulation material and thermal standoffs of the field joint will be provided by the Spacecraft contractor. Thermal interface design will be determined by analyses conducted jointly with the Spacecraft contractor. It is assumed that heat flow across the interface will be maintained below 50 watts, depending on Spacecraft temperature, while the Spacecraft is shading the Flight Capsule from solar radiation. Due to necessary placement in the Flight Capsule, the use of RTG (in the Surface Laboratory) for later missions will require special consideration.

2.1.1.3 Propulsion

The Capsule Bus deorbit propulsion system will be constrained from operation until the separation distance between the Flight Capsule and the Spacecraft is great enough that the Spacecraft will not lose its Sun-Canopus references. The separation distance will be at least 300 meters plus the margin required as determined by deorbit engine plume characteristics and the disturbing impulse acceptable to the Spacecraft.

2.1.1.4 Guidance and Control

The Spacecraft will ensure that pointing errors about the primary reference axes at the time of Flight Capsule separation do not exceed 20 milliradians (3σ) with a design goal of 10 milliradians (3σ).

Angular rates imparted to the Spacecraft, either at Flight Capsule separation or deorbit propulsion ignition, will be maintained within the recovery capability of the Spacecraft gyros (assumed less than 1 deg/sec).

After separation, attitude orientation of the Spacecraft will be controlled to facilitate communications during entry and landed operations.

The Spacecraft will provide discretes for initialization and referencing of the Capsule Bus guidance and control subsystem. Signal characteristics will be in accordance with Table 1.

Table 1 Discrete Signal Characteristics

Voltage	28 vdc nominal
Input impedance	10 k ohms minimum
Time	Momentary 100 ms minimum

2.1.1.5 Command and Sequencing

The Spacecraft command controller will provide a serial pulse-train uplink to the decoders of the Capsule Bus and Surface Laboratory command and sequencing subsystems. These interfaces will include a continuous discrete (receiver lock), coded commands in a series of binary signals (data line) and a series of pulses. Signal characteristics will be in accordance with Table 2.

Table 2 Command Signal Characteristics

Discrete Commands	+28 vdc nominal
Coded Commands	serial, binary, NRZ
a. Data rate	1 bps
b. Synchronous pulses	1 pps
c. Data word	32 bits
d. Rise time	5 microsec nominal
e. Fall time	5 microsec nominal
f. Beginning of word discrete	+28 vdc
g. End of word discrete	+28 vdc
h. Binary one	+6 vdc
i. Binary zero	0 vdc

The Spacecraft command controller will provide signals for control of battery chargers in the adapter and for control of regulated power (from voltage regulators also in the adapter) to Flight Capsule systems.

The Spacecraft command controller will provide a signal to open the main power transfer switches of the Capsule Bus.

The Spacecraft sequencer will provide three signals to the power management controller in the adapter:

- a) Periodically (30 day intervals) activate TV cathode circuits
- b) Provide a signal for separation of the sterilization canister
- c) Provide a signal to initiate the sequencer of the Capsule Bus Command and Sequencing subsystem.

The maximum timing error for the Capsule Bus initiation signal will be no more than ± 25 sec (3σ) with a design goal of ± 10 sec (3σ).

2.1.1.6 Telemetry

These interfaces exist before separation. The Spacecraft will provide gate and clock signals to the status-monitor data encoder of the Capsule Bus to permit status monitoring of Flight Capsule Systems.

The Capsule Bus status monitor data encoder will provide a coded serial NRZ pulse train containing one data frame (896 bits) of status monitor data to the Spacecraft. Data frame transmission will occur as determined by the Spacecraft.

The Capsule Bus engineering measurement data encoder will provide a coded serial NRZ pulse train, containing engineering measurement data for checkout purposes, to the Spacecraft. The data rate will be 3584 bits per second.

Telemetry data will be required during the launch phase from three accelerometers installed on Capsule Bus structure and one differential pressure sensor installed on the sterilization canister. These transducers will directly interface with the Launch Vehicle telemetry subsystem via the Spacecraft. Data

recovery will be via the Launch Vehicle telemetry subsystem.

2.1.1.7 Communications

There are no interfacing communications subsystems between the Spacecraft and the Flight Capsule.

2.1.1.8 Power

During interplanetary cruise, the Spacecraft will provide 200 watts of raw dc power for Flight Capsule battery charging, status monitor telemetry, and thermal control. This power will be available except during periods of high spacecraft usage, assumed to be less than 3.5 hours per day. For a five minute period occurring once every 30 days, 40 watts (of the 200 watts available) will be applied to vidicons in the Surface Laboratory and the Entry Science Package to prevent cathode poisoning. The thermal control load will be reduced during these periods.

Preseparation checkout of the Flight Capsule will begin at separation minus 156 minutes and will continue on Spacecraft power until S-65 minutes when power transfer to Capsule Bus batteries will occur.

A two wire interface will supply power requirements from the Spacecraft. Fault protection will be provided by the Spacecraft; fuses will not be used. Power management control will be exercised through a unit provided for that purpose in the adapter.

2.1.1.9 Pyrotechnics

Pyrotechnics installed at the adapter/Flight Capsule interface will be forward of the adapter/Spacecraft interface and operated by Capsule Bus power for separation of the Sterilization Canister, separation of the thermal barrier, and separation of the Flight Capsule from the Spacecraft. No pyrotechnic circuits will cross the adapter interface with the Spacecraft. The maximum shock within one foot of any pyrotechnic shock source will be 2400 G peak with the peak level occurring at 4000 cps (equivalent to a 1500 G, 0.2 ms half-sine pulse input).

2.1.1.10 Cabling

Interfacing cables will be categorized and separately routed to minimize the possibility of circuit interactions. Separation distance between categories will be maintained at a minimum of four inches, except that it will be permissible to pass cables of different categories through connectors. Three categories of interfacing circuits have been identified:

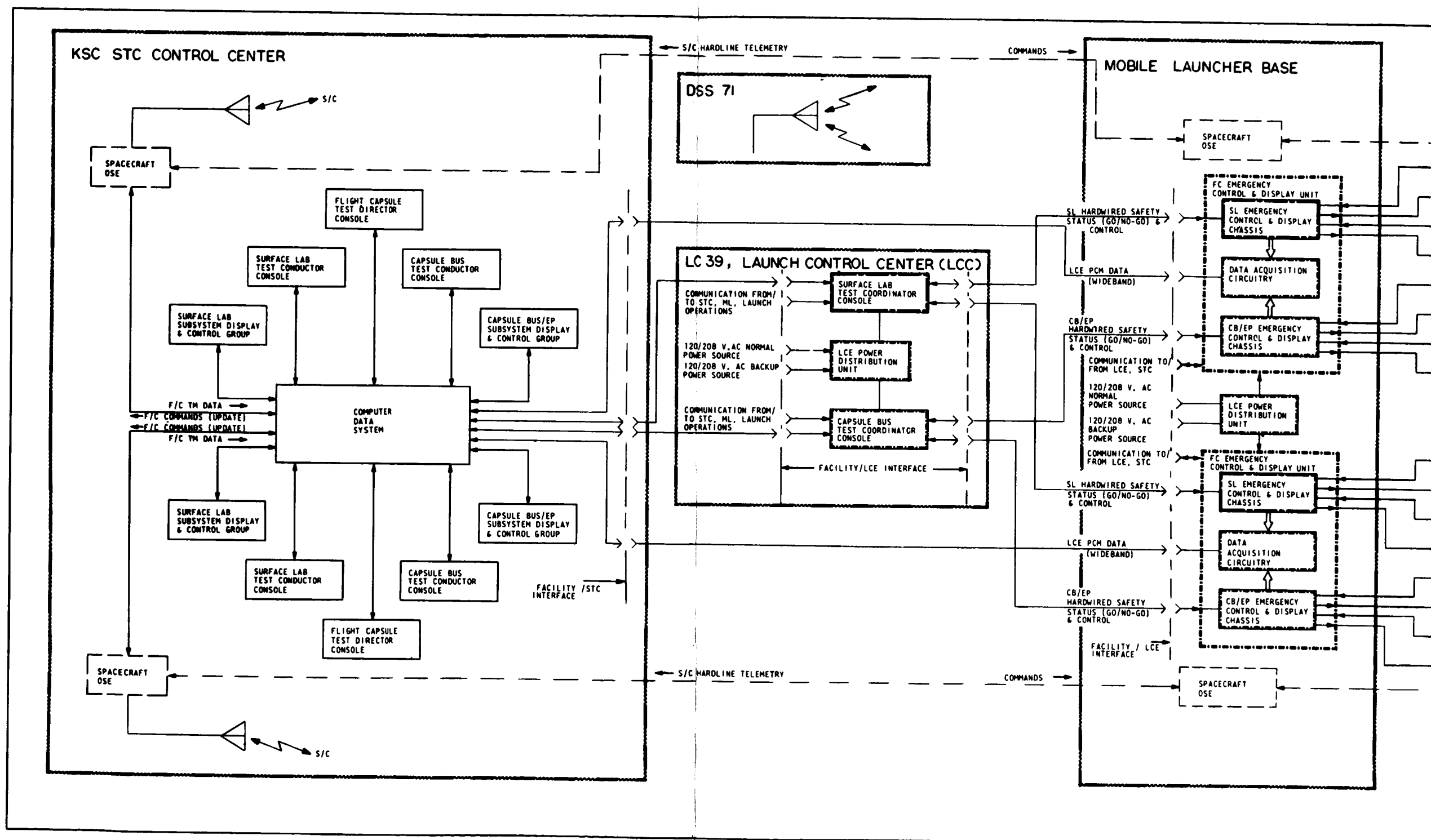
- a) Category A is the most susceptible to extraneous voltages and includes circuits with voltage levels less than 1 volt
- b) Category B is of medium susceptibility and includes circuits with voltage levels between 1 volt and 10 volts or between 1 volt and 20 volts depending on the signal characteristics
- c) Category C is of low susceptibility, but is most apt to induce voltages in neighboring circuits.

In addition to cable separation, protection against electromagnetic interference will be achieved by using twisted, shielded pairs; and in low-level circuits, double shielding may be required. Shielding will not be carried through interface connectors but will be grounded to Flight Capsule and Spacecraft structure on the respective sides of the interface. The grounding point may be at, or removed from, the interface as determined by analysis. Single-shielded circuits normally will be grounded at the receiving end with lengths of exposed wire and lengths of shield grounding straps held to minimum lengths. Double-shielded circuits will have the inner shield treated like single shields, and the outer shield will be grounded at intermediate points along the length of the cable as required.

Flight Capsule circuit-return leads will be grounded at a single point in the Capsule Bus, and Spacecraft circuit return leads will be grounded at a single point in the Spacecraft.

Table 3 amplifies the preceding requirements.

14-2



14-3

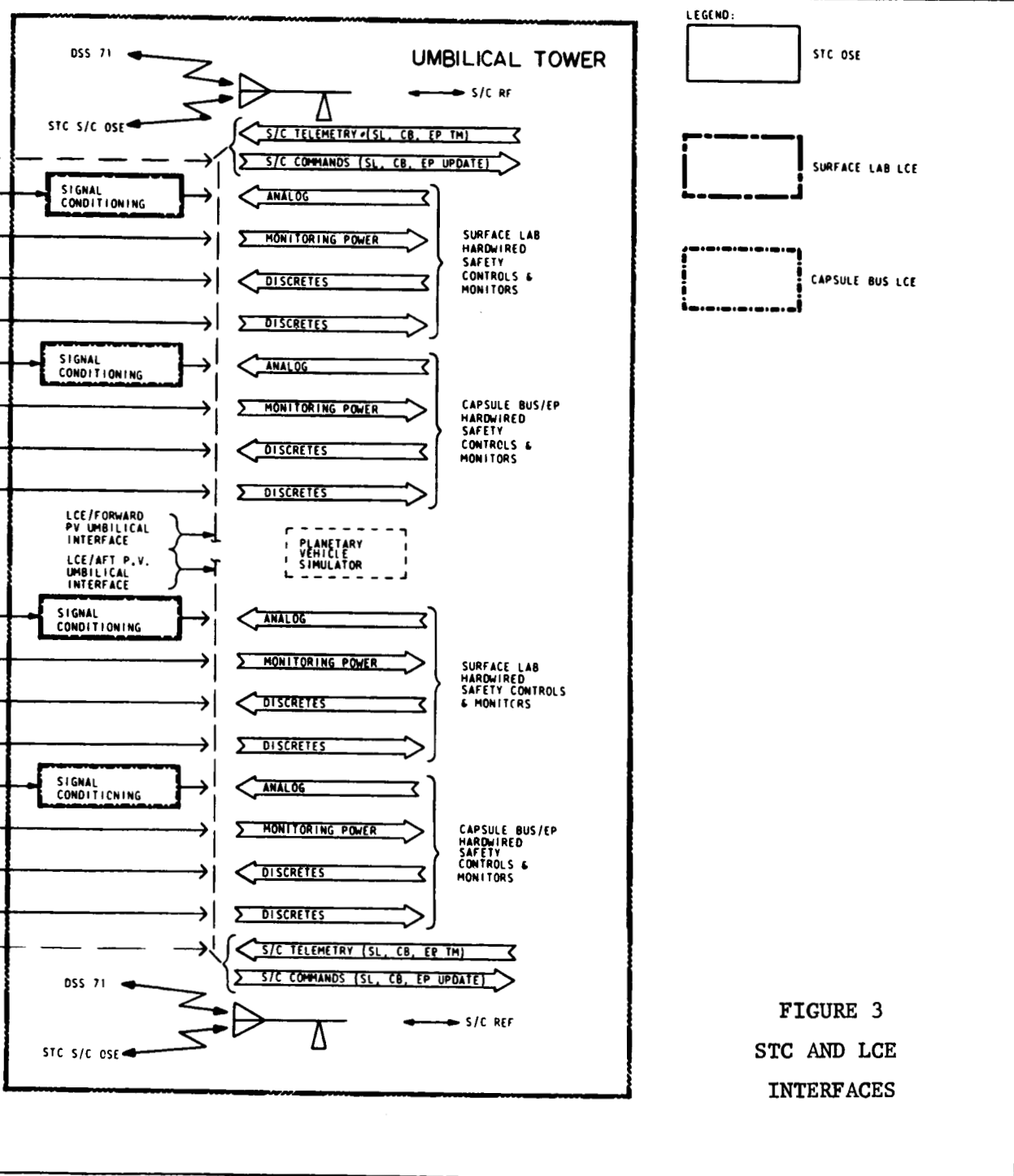


FIGURE 3
STC AND LCE
INTERFACES

Interface circuit connectors will be mounted to provide free contact engagement. The socket half of the power connector will be mounted on the Spacecraft side of the interface. Other connectors will have pin-socket mountings as determined by analysis.

The insulation resistance of interfacing cables will be a minimum of 100 megohms between each unshielded conductor and all other conductors and shields connected in parallel; a minimum of 20 megohms between shielded conductors and their associated shields; and a minimum of 100 megohms between each conductor and the connector shells, or any other point where continuity should not exist.

2.1.2 Capsule Bus to Spacecraft Mounted Support Equipment

The Capsule Bus will contain two transmitters operating at different frequencies in the 385 - 405 MHz band. Each transmitter will be on line for the transmission of data prior to entry and continuing through terminal descent and landing. A fixed low gain and a fixed medium gain receiving antenna mounted on the Spacecraft will be supplied as Spacecraft Mounted Support Equipment. An antenna switch will provide optimum utilization for each mission. Through control of Spacecraft orientation and attitude, this antenna will maintain proper aspect angles with respect to a fixed antenna on the Capsule Bus. In addition to frequency separation, the two channels will be of opposite circular polarization. Radiated power from each transmitter will be 10 watts.

2.1.3 Capsule Bus to Launch Operations System

Interfaces between the Capsule Bus and the Launch Operations System (LOS) will exist at the System Test Complex (STC) Control Center, the Saturn Launch Control Center, the Mobile Launcher Base,

and the umbilical tower. These Capsule Bus interfaces include the requirements of the Entry Science Package. The OSE interfaces described are relative to a single Flight Capsule. All functions must be provided for two Flight Capsules integrated into two Planetary Vehicles for each launch. See Figure 3.

2.1.3.1 STC Control Center Interfaces

It is assumed that all prelaunch functions of the Flight Capsule, including the Capsule Bus, the Entry Science package, and the Surface Laboratory, are under the direction of a Flight Capsule test director. With this assumption, the following equipment will be required, as shown in Fig. 3:

- a) Flight Capsule test director console
- b) Capsule Bus test conductor console
- c) Capsule Bus subsystem/Entry Science Package display and control group
- d) Computer data system.

Interfaces between these and the launch operations system will exist in the areas discussed in the following paragraphs.

2.1.3.1.1 Space

Space and provisions for installation, operation and maintenance of equipment will be required. Visibility and communications between consoles must be provided.

2.1.3.1.2 Power

Facility power (120/208 volt 60 cps) will be required.

2.1.3.1.3 Environmental

Equipment will be designed to operate in the controlled environment of the STC Control Center without special environmental demands on the facility.

2.1.3.1.4 Data Channels

Data channels among the STC Control Center, the Launch Control Center, and the Mobile Launcher Base will be provided by the LOS. A wide-band data transmission system (Western

Electric A2A) is assumed. Flight Capsule status data and digital commands will be transmitted over these channels.

2.1.3.1.5 Spacecraft Telemetry Interfaces

It is assumed that Spacecraft OSE in the STC Control Center will provide RF links to receive Spacecraft telemetry data and transmit Spacecraft commands to/from the umbilical tower. These signals will interface with the Capsule Bus computer data system.

2.1.3.1.6 Communications Interfaces

Means for communications with other elements of the Launch Operations System (LOS) will be required at the Capsule Bus test conductor console.

2.1.3.2 Launch Control Center Interfaces

A Capsule Bus Test Coordinator Console will be required in the Launch Control Center LC 39. This console will provide data readout ability from the wide-band data transmission system and will provide emergency control of Flight Capsule OSE in the Mobile Launcher Base. The control-circuit lines will be provided by the Launch Operations System, hardwired to the Mobile Launcher Base. Facility power (120/208V 60 cps) will be distributed to the Capsule Bus test coordinator console by a power distribution unit provided by the Capsule Bus contractor. Space and environmental interfaces will be compatible to those in the STC Launch Center.

2.1.3.3 Mobile Launcher Base Interfaces

Equipment required for support of the Capsule Bus and Entry Science Package in the Mobile Launcher Base will include the following:

- a) Data acquisition circuitry (shared with Surface Laboratory)
- b) Capsule Bus/Entry Science Package emergency display and control chassis.

The above items will be installed in the Flight Capsule emergency display and control unit.

2.1.3.3.1 Space

Space and provisions for installation, servicing, and maintenance of the equipment listed in paragraph 2.1.3.3 will be required in the Mobile Launcher Base.

2.1.3.3.2 Power

Facility power (120/208 V 60 cps) will be required from a normal and from a backup source.

2.1.3.3.3 Environment

Equipment will be packaged to operate in the environments of the Mobile Launcher Base. In general, design will be the same as for the STC Control Center, but modified for use in the Mobile Launcher Base as required.

2.1.3.3.4 Data and Control Channels

The Flight Capsule emergency display and control unit will have hardwire interfaces with the Capsule Bus test coordinator console in the Launch Control Center, and the umbilical tower J-box.

2.1.3.4 Umbilical Tower Interfaces

Junction boxes and cables on the umbilical tower will be required for the termination of cables interfacing with Mobile Launcher Base equipment and for routing of these cable circuits up the umbilical tower to the Spacecraft.

Air conditioning of Flight Capsule systems will be required on the umbilical tower.

Interface requirements between the launch vehicle shroud and the umbilical tower will be the responsibility of the Launch Vehicle Contractor and the Launch Operations System.

The Capsule Bus Contractor will integrate all Flight Capsule (Capsule Bus, Entry Science Package, and Surface Laboratory) umbilical requirements and negotiate these with the Launch Vehicle Contractor.

2.1.4 Capsule Bus to Mission Operations System

The Mission Operations System (MOS) consists of the hardware,

software and personnel required to direct the mission from injection to the end of Mars orbital and landed operations. The hardware consists of Mission Independent Equipment (MIE) and Mission Dependent Equipment (MDE). The MIE consists of the Deep Space Instrumentation Facility (DSIF), the Space Flight Operations Facility (SFOF), and the Ground Communications System. Software consists of planning and implementation documentation and computer programs or routines. Personnel are those provided by the contractor to plan the mission and to man the Flight Capsule flight operations team, which forms part of the overall MOS project organization.

2.1.4.1 MIE/MDE Interfaces

There are no Capsule Bus MDE interfaces with the MIE.

2.1.4.2 Software

2.1.4.2.1 Documentation

The contractor will supply chapters relating to the Capsule Bus for the following documentation:

Support Instrumentation Document

MOS Requirements Document

Space Flight Operations Plan

Space Flight Operations Test Plan.

In addition, the following planning documents relating to the Capsule Bus will be prepared:

MOS Policy and Guidelines

MOS Plans

Personnel and Documentation - Functional Specification and Development Plan

Personnel and Documentation Specification

Computer Programs - Functional Specification and Development Plan

Computer Programs Specification

Computer Programs Acceptance Procedure

Detailed Operating Procedures.

2.1.4.2.2 Computer Programs

The Capsule Bus contractor will functionally specify Capsule Bus-oriented computer programs and routines for processing data, Capsule Bus simulation, target analyses, and generating commands.

2.1.4.3 Personnel

Contractor personnel will be assigned to the Capsule Bus flight operations team at SFOF. This will require that desks, and work space and telephone service be provided by SFOF.

2.2 Entry Science Package Interfaces

2.2.1 Entry Science Package to Capsule Bus

2.2.1.1 Structures and Mechanisms

One equipment module of the Entry Science Package will be located in the nose of the aeroshell behind a quartz window provided for TV. The other modules will be located in an equipment bay in the +X, -Y quadrant. Other requirements include:

- a) Proper field of view for instruments
- b) Locating the communication subsystem antenna on the roll axis to maintain proper aspect angles to view the orbiting Spacecraft during entry
- c) Mounting the antenna so that discontinuities in the effective RF ground plane are not exaggerated
- d) Maintenance of structural references for the entry science instruments so that significant uncertainties are not contributed to entry measurement data
- e) Use of existing structure to shield interconnecting cables from radiated RF energy, wherever possible
- f) Providing structural mounting points for modules that are corrosion resistant, propellant compatible, and electrically conductive
- g) Passive thermal control of science instruments.

2.2.1.2 Command and Sequencing

Checkout of the Entry Science Package will be accomplished

by the sequencer timer and command decoder in the Capsule Bus prior to Flight Capsule separation from the Spacecraft. The Entry Science Package will receive the following discretes from the sequencer timer of the Capsule Bus after Flight Capsule separation from the Spacecraft:

- a) Five primary discretes in the interval between T-1800 sec and T+502 sec where T = 0 is the beginning of entry (800,000 ft). These discretes will initiate primary sequences in the ESP sequencer timer. In addition, power will be interrupted at T+622
- b) Discretes to provide backup for operating and data transmission mode changes initiated by the ESP sequencer timer.

These discrete signals will have the following characteristics:

Voltage	28 vdc nominal
Input impedance	10 K ohms minimum
Time	momentary, 100 ms minimum

2.2.1.3 Science Data (Telemetry)

A two-wire (twisted and shielded) interface will be provided between each status monitoring measurement in the Entry Science Package and the Capsule Bus. Signals having the following characteristics will interface with the status monitor data encoder in the Capsule Bus:

Analog signals

Voltage	0-50 mv dc
Source Impedance	500 ohms max

Bilevel signals

Binary one	5 vdc
	5 k source impedance
Binary zero	0.4 vdc $\pm$ 0.4
	1 ma current

Signals not having these characteristics will be conditioned in the Capsule Bus.

Analog signals will be provided from atmospheric-science data sensors in the Entry Science Package to the data encoders of the Capsule Bus. This interface will allow real-time and back-up transmission of entry data to the Spacecraft.

2.2.1.4 Power

The Entry Science Package will receive power from the Load Control Assembly in the Capsule Bus beginning 30 minutes prior to entry and ending two minutes after landing, when the Entry Science Package and Capsule Bus subsystems are shut down. Redundant two-wire circuits will cross the interface to the load control assembly of the Entry Science Package. Voltage will be 24 v to 33 v. Power will be provided from the Capsule Bus transducer power supply for Entry Science Package status monitor measurements and from the equipment voltage regulator to periodically activate Entry Science Package vidicon cathodes to prevent cathode poisoning.

2.2.1.5 Cabling

Interface cabling will be designed in accordance with the requirements of paragraph 2.1.1.10.

2.2.1.6 Pyrotechnics

Pyrotechnics in the Entry Science Package required for deployment of the total temperature probe, and for calibration of the gas chromatograph, will be operated by power from the pyrotechnic power supply of the Capsule Bus. Safe/Arm assemblies, squib firing circuits, and current limiter assemblies will be provided in the Entry Science Package.

2.2.2 Entry Science Package to Spacecraft-Mounted Support Equipment

The Entry Science Package will have RF communications interfaces with the Spacecraft-mounted support equipment for data transmission.

2.2.2.1 RF Communications

The Entry Science Package will contain two transmitters operating at different frequencies in the 385 to 405 MHz band. Each transmitter will be on line for the transmission of data during entry. A fixed medium gain and a fixed low gain receiving antenna mounted on the Spacecraft will be supplied as Spacecraft mounted support equipment. An antenna switch will provide optimum utilization for each mission. Through control of Spacecraft orientation and attitude, this antenna will maintain proper aspect angles with respect to a fixed antenna provided as part of the Entry Science Package and mounted on the Capsule Bus structure. The orientation and attitude of the Entry Science Package antenna will be under the control of the Capsule Bus guidance and control subsystem. In addition to frequency separation, the two channels will be of opposite circular polarization. Radiated power from each transmitter will be 30 watts.

The two transmitter frequency channels will interface with two receiving channels that are part of the Spacecraft-mounted support equipment.

2.2.2.2 Data Rate

Two channels will be separately provided to the Spacecraft at a data rate of 50 kbps on a frequency of 380 to 420 MHz. The Spacecraft will provide temporary storage for these data streams and will relay the streams separately to earth after completion of transmission from the Entry Science Package.

2.2.3 Entry Science Package to Mission Operations System

The Mission Operations System (MOS) consists of the hardware, software and personnel required to direct the mission from injection to the end of Mars orbital and landed operations. The hardware consists of Mission Independent Equipment (MIE) and Mission Dependent Equipment (MDE). The MIE consists of the Deep Space Instrumentation Facility (DSIF), the Space Flight Operations

Facility (SFOF), and the Ground Communications System. Software consists of planning implementation documentation and computer programs or routines. Personnel are those provided by the contractor to plan the mission and to man the Capsule Bus flight operations team, which forms part of the overall MOS project organization.

2.2.3.1 MIE/MDE Interfaces

An Entry Science Package TV data processor and display will require space at the SFOF. This piece of MDE will physically interface with the data processing system, will require power (115 vac, 60 cps) and an air-conditioned environment.

2.2.3.2 Software

2.2.3.2.1 Documentation

The contractor will supply chapters relating to the Entry Science Package for the following planning documentation:

Support Instrumentation Document
 MOS Requirements Document
 Space Flight Operations Plan
 Space Flight Operations Test Plan
 Space Flight Operations Memorandum

In addition, the contractor will prepare the following planning documents relative to the Entry Science Package:

MOS Policy and Guidelines	Personnel and Documentation Design Requirements
MOS Plan	
MDE Development Plan	Computer Program Development Plan
MDE Performance Requirements	Computer Program Performance Requirements
MDE Design Requirements	
MDE Acceptance Requirements	Computer Program Design Requirements
Personnel and Documentation Development Plan	Computer Program Acceptance Requirements
Personnel and Documentation Performance Requirements	Detailed Operating Procedures
	DSN Failure Problem Report

2.2.3.2.2 Computer Programs

The contractor will functionally specify Entry Science Package-oriented computer programs and routines for data processing, Entry Science Package simulation, and generating commands.

2.2.3.3 Personnel

Contractor personnel will be assigned to the flight operations team at SFOF. This will require that desk, and work space and telephone service be provided by SFOF.

2.2.4 Entry Science Package to Experiments

The purpose of the entry science experiments is to (a) obtain static and stagnation pressures and temperatures, density and composition of the Martian atmosphere as functions of altitude during descent to the Martian surface; (b) obtain entry flight-path velocity and acceleration as functions of altitude, and (c) obtain TV pictures of the Martian surface during terminal descent. To obtain these data, various sensors are provided by the Entry Science Package subsystem.

2.2.5 Entry Science Package to Launch Operations System

Interfaces between the Entry Science Package and the Launch Operations System are accommodated through the Capsule Bus. See paragraph 2.1.3.

2.3 Surface Laboratory Interfaces

2.3.1 Surface Laboratory to Capsule Bus

Direct interfaces will exist between the Surface Laboratory and the Capsule Bus during all mission phases from final assembly to the start of landed operations on the Martian surface.

2.3.1.1 Structural Interfaces

Capsule Bus structure will support the Surface Laboratory. The physical interface will consist of a volumetric envelope and a field joint secured by mounting bolts. Mating surfaces will be corrosion resistant, propellant compatible, and electrically conductive.

Capsule Bus structure will maintain a relatively stable reference for the Surface Laboratory during landed operations.

This requirement comes primarily from the high-gain antenna of the Surface Laboratory communications subsystem. Total pointing-error limits due to structural deflections of the order of ± 2 degrees will be required.

Capsule Bus structure will be compatible with the 1973 Surface Laboratory weight (900 lb) and compatible with later missions (1500 lb) without major redesign.

2.3.1.2 Thermal

Thermal interfaces between the Capsule Bus and the Surface Laboratory will consist of a combination of component placement and the use of thermal barriers to minimize the radiative and conductive transfer of heat. In particular, the field joint will be adiabatic to the fullest extent practicable.

2.3.1.3 Propulsion (Capsule Bus Subsystem)

The propulsion system of the Capsule Bus will be constrained from unduly contaminating the Martian surface with vernier-engine exhaust products or charred debris dislodged from the engines on landing impact. A total contamination limit of not more than one percent of any sample required for landed science experiments will be established as a design goal. Possible sources and concentrations of contaminant products will be identified.

2.3.1.4 Command and Sequencing

Before separation, a three-wire interface (originating in the Spacecraft but passing through the Capsule Bus adapter) will exist between the Capsule Bus to the command decoder of the Surface Laboratory. The three wires will provide a serial pulse-train up-link for updating the Surface Laboratory. The interface will consist of a continuous discrete (receiver lock), coded commands in a series of binary signals (data line), and a series of pulses (sync line). The characteristics of this three-wire interface will be:

Discrete Commands	+28 vdc nominal
Coded Commands	serial, binary, NRZ
a) Data rate	1 bps
b) Synchronous pulses	1 pps
c) Data word	32 bits
d) Rise time	5 microsec nominal
e) Fall time	5 microsec nominal
f) Beginning of word discrete	+28 vdc
g) End of word discrete	+28 vdc
h) Binary one	+6 vdc
i) Binary zero	0 vdc

During terminal descent and at the time of vernier engine ignition (approximately 3,000-ft alt) the Capsule Bus will provide a signal to operate the power transfer switches in the Surface Laboratory. At the time of vernier engine shutdown (approximately 15-ft alt) the Capsule Bus will provide a signal to initiate the sequencer of the Surface Laboratory.

2.3.1.5 Telemetry

A two-wire (twisted and shielded) interface will be provided between each status monitoring measurement in the Surface Laboratory and the Capsule Bus. These interfaces will transmit analog and bilevel signals. If the signals have the following characteristics, they will interface with the status monitor data encoder in the Capsule Bus.

Analog signals

Voltage	0 - 40 mv dc
Source impedance	500 ohms max

Bilevel Signals

Binary one	5 vdc
	5 k source impedance
Binary zero	0.4 vdc $\pm$ 0.4
	1 ma current.

If the signals do not have the above characteristics, they will be conditioned in the Capsule Bus.

The data encoder in the Surface Laboratory will provide a PCM checkout circuit to the Capsule Bus. This wire goes to an umbilical in the Capsule Bus adapter. This interface will consist of a coded serial digital NRZ pulse train.

2.3.1.6 Power

A Surface Laboratory battery charger in the Capsule Bus adapter will charge the equipment batteries (via a diode isolation assembly) in the Surface Laboratory. The Surface Laboratory battery charger in the Capsule Bus adapter will charge the pyrotechnic batteries (via a diode isolation assembly) in the Surface Laboratory. Regulated power (28 vdc nominal) from the power management controller in the Capsule Bus adapter will be provided to the equipment-power transfer switch in the Surface Laboratory by a two-wire interface. Electrical power from the status-monitor transducer power supply in the Capsule Bus will be provided to the Surface Laboratory status monitor transducers. An interface consisting of one wire from a Surface Laboratory multiplexer to an umbilical on the Capsule Bus adapter is required to transmit battery cell status during formation charging after terminal sterilization. Heat sterilization measurement status will also be multiplexed to a Capsule Bus adapter umbilical.

A power interface from the Capsule Bus to the Surface Laboratory TV system is needed to periodically energize the vidicon cameras to prevent cathode tube poisoning.

2.3.2 Surface Laboratory to Spacecraft-Mounted Support Equipment

With the initiation of landed operations on Mars, the Surface Laboratory interfaces with the Spacecraft-mounted support equipment over the relay communications system.

2.3.2.1 RF Communications

One transmitter in the Surface Laboratory operating in the 380- to 405 MHz band at 30 watts will transmit landed television, landed science, and engineering data on Surface Laboratory systems operation to the Spacecraft. This signal will be received by an antenna, antenna coupler, and receiver in the Spacecraft, completing one of the links used for Surface Laboratory communications. Operation of this relay circuit will be activated by receipt, at the Surface Laboratory, of a signal from a 3 watt UHF beacon transmitter that is part of the Spacecraft-mounted support equipment. Receipt of the beacon signal will indicate that the Spacecraft is in view and the relay link can be operated.

2.3.3 Surface Laboratory to Mission Operations System

The Mission Operations System consists of MIE, MDE, software and personnel as described in Section 2.1.4 above. For this study it is assumed that the Flight Capsule contractor will be the integrator for the Surface Laboratory, and will, with inputs from the Surface Laboratory contractor, define Surface Laboratory MOS requirements.

2.3.3.1 MIE/MDE Interfaces

2.3.3.1.1 TV Processor

A TV data processor and display will be located in the SFOF. This piece of MDE will physically interface with MIE SFOF electrical power (115 vac 60 cps) and the data processing system, and will be installed in an air-conditioned environment.

2.3.3.1.2 Surface Laboratory Simulator

A simulator will be located at each DSIF (KSC, Madrid, Woomera, and Goldstone). This piece of MDE will physically interface with the DSIF receiver and computer and will simulate the S-Band radio link, the telemetry data stream, and the commands. The MDE will also interface with MIE power (115 vac 60 cps) and

will be installed in an air-conditioned environment.

2.3.3.1.3 M'ary Demodulator/Decoder

A low-gain demodulator/decoder will be located at each DSIF. This MDE will interface with the DSIF receiver and telemetry command processor, and will be used in the low-gain mode for the direct S-Band link with the Surface Laboratory. This MDE will also interface with MIE power (115 vac 60 cps) and will be installed in an air conditioned environment.

2.3.3.2 Software

2.3.3.2.1 Documentation

The Capsule Bus contractor, with inputs from the Surface Laboratory contractor relating to the Science Subsystem, will submit combined Flight Capsule inputs to the following MOS planning documentation:

- Support Instrumentation Document
- MOS Requirements Document
- Space Flight Operation Plan
- Space Flight Operations Test Plan
- Space Flight Operations Memorandum

In addition, the following planning documents will be prepared by the Flight Capsule Contractor:

- MOS Policy and Guidelines
- MOS Plan
- MDE Development Plan
- MDE Performance Requirements
- MDE Design Requirements
- MDE Acceptance Requirements
- Personnel and Documentation Development Plan
- Personnel and Documentation Performance Requirements
- Personnel and Documentation Design Requirements
- Computer Program Development Plan

Computer Program Performance Requirements
Computer Program Design Requirements
Computer Program Acceptance Requirements
Detailed Operating Procedures
DSN Failure Problem Report.

2.3.3.2.2 Computer Programs

The Flight Capsule contractor, with science subsystem inputs from the Surface Laboratory contractor, will functionally specify computer programs and routines for data processing, simulation, and generating commands.

2.3.3.3 Personnel

Both the Capsule Bus contractor and the Surface Laboratory contractor will provide personnel to man the Flight Capsule operation team at SFOF. This requires that desk, and work space and telephone service be provided by the SFOF.

2.3.4 Surface Laboratory to Experiments

The purpose of landed science experiments in the Surface Laboratory is to gather scientific data relating to Martian surface phenomena for one diurnal cycle. The following types of data will be obtained:

- a) Photographs of local topography
- b) Atmospheric data including pressure, temperature, humidity, wind velocity and direction
- c) Atmospheric and surface material composition, particularly organic compounds
- d) Subsurface temperature and subsurface gas samples for presence of organic compounds
- e) Specific life detection with simple culture experiments
- f) Solar and UV flux incident on the Martian surface.

To obtain these data, various sensors are employed in the landed science subsystem, and the following interfaces exist between those sensors and the above data.

2.3.4.1 Local Topography

A television instrument will be used to provide panoramic images of the landscape in the vicinity of the landing spot. High-resolution images will also be provided of the area from which samples are collected.

2.3.4.2 Atmospheric Data

Data sensors will be mounted on a common boom and consist of the following:

<u>Parameter(s)</u>	<u>Sensor</u>
Wind velocity and direction	Sonic anemometer
Atmospheric pressure	Diaphragm pressure sensor
Atmospheric temperature	Platinum resistance temperature sensor
Humidity	Aluminum oxide hygrometer

2.3.4.3 Subsurface Temperature and Gas Sampling

A gas chromatograph-mass spectrometer will be used to detect the presence of organic material in the Martian soil and to measure subsurface temperatures. Means will be provided to gather samples of subsurface material and process them for these experiments.

2.3.4.4 Surface Composition

An alpha-scattering spectrometer will be used to determine surface and subsurface composition of the Martian soil. Means will be provided to gather and process samples of soil to be analyzed.

2.3.4.5 Life Detection

A biochemical analyzer will be used to detect the presence of organic macromolecules in the Martian soil due to either molecular absorption in the UV region, or detection of optical polarization activity. A culture experiment will also be used to detect metabolic processes.

2.3.4.6 Solar and UV Flux

A two-channel dc radiometer will be used to measure radiation in the range of 0.2 to 15 microns.

2.3.5 Surface Laboratory to Tracking and Data Acquisition System

The Surface Laboratory will have a communications (S-Band) subsystem interface with the tracking and data acquisition system. In addition, Surface Laboratory MDE will interface with TDAS stations.

2.3.5.1 Communications

The Surface Laboratory direct-link communications subsystem will use a dual-section S-Band transponder with the receiver portions coupled to a low-gain omnidirectional fixed antenna. Update commands will be received from the earth over this uplink. The transmitter portion of the transponder feeds either of two selectable TWT amplifiers. Either transmitter can be selected to feed a high-gain steerable antenna, or the low gain (0 db) antenna through a directional coupler.

The RF interface with the TDAS consists of achieving compatibility in system design with the planned capabilities of the deep space network. Detailed discussion of design compatibility is contained in Volume III, Section I. Major characteristics are summarized below:

Downlink

TWT amplifier power	20 watts
Transmitting frequency band	2290 - 2300 MHz
Steerable antenna gain	22.7 db
Steerable antenna beamwidth	4.2°
Steerable antenna pointing accuracy	4.5°

Uplink

Transmitting Frequency Band 2110 - 2120 MHz

DSN Stations Planned for Voyager Support

<u>Location</u>	<u>Station</u>	<u>DSS Designation</u>	<u>Antenna Size (ft)</u>
Goldstone	Echo	12	85
	Mars	14	210
Canberra	Tidbinbilla	42	85
	Booroomba	43	210
Madrid	Cebreros	62	85
	Rio Cofio	63	210

Antenna Polarization

Right-hand circular

Downlink/Uplink Frequency Coherency Ratio

240/221

2.3.5.2 MDE Interfaces

The Surface Laboratory MDE at the DSIF will consist of a Surface Laboratory S-Band simulator and telemetry demodulators.

The S-Band simulator will be capable of the following:

- a) Accept telemetry signals of post-landing nature generated by the MIE telemetry command processor
- b) Modulate or encode the telemetry signals onto an S-Band carrier and provide for transmitting the modulation and the modulated or encoded carrier to selected test points in the DSS
- c) Provide for receiving command signals on a modulated S-Band carrier from selected test points in the DSS
- d) Present to the telemetry command processor, a detected command identical to that detected by the SLS command detector
- e) Convert detected signals to the general-purpose computer into the logic level and format required.

Telemetry MDE will consist of two units with functions as follows:

S-Band High Gain Demodulator - Accepting the S-Band (High-Gain) telemetry data signal from the MIE receiver, demodulating the data, establishing bit-sync, and conditioning the data stream for entry into the telemetry command processor.

Many Demodulator/Decoder - Accepting the S-Band (low-gain) telemetry data signal from the MIE receiver, demodulating the data, establishing bit sync, and conditioning the data stream for entry into the telemetry command processor.

2.3.6 Surface Laboratory to Launch Operations System

Interfaces between the Surface Laboratory and the Launch Operations System (LOS) will exist at the System Test Complex (STC) Control Center, the Saturn Launch Control Center, the Mobile Launcher Base and the umbilical tower. The following subparagraphs contain minimum requirements that are foreseen. The OSE interfaces described are relative to a single Surface Laboratory. All functions must be provided for two Surface Laboratories integrated into two planetary vehicles for each launch.

2.3.6.1 STC Control Center Interfaces

It is assumed that all prelaunch functions of the Flight Capsule, including the Capsule Bus, the Entry Science Package, and the Surface Laboratory, are under the direction of a Flight Capsule test director. Under this assumption, the following equipment will be required as shown in Fig. 3:

- a) Flight Capsule test director console
- b) Surface Laboratory test conductor console
- c) Surface Laboratory subsystem display and control group
- d) Computer data system.

Interfaces between these items and the Launch Operations System will exist in the areas discussed in the following paragraphs.

2.3.6.1.1 Space

Space and provisions for installation, operation, and maintenance of equipment will be required. Visibility and communications between consoles must be provided.

2.3.6.1.2 Power

Facility power (120/208 volt ac 60 cps) will be required.

2.3.6.1.3 Environment

Equipment will be designed to operate in the controlled environment of the STC Control Center without special environmental demands being made on the facility.

2.3.6.1.4 Data Channels

Data channels between the STC Control Center, the Launch Control Center, and the Mobile Launcher Base will be provided by the LOS. A wide-band data transmission system (Western Electric A2A) is assumed. Flight Capsule status data and digital commands will be conveyed over these channels.

2.3.6.1.5 Spacecraft Telemetry Interfaces

It is assumed that Spacecraft OSE in the STC Control Center will provide RF links receiving Spacecraft telemetry data and transmitting Spacecraft command to/from the umbilical tower. These signals will interface with the computer data system.

2.3.6.1.6 Communications Interfaces

Means for communications with other elements of the Launch Operations System will be required at the Surface Laboratory conductor console.

2.3.6.2 Saturn Launch Control Center Interfaces

A Surface Laboratory test coordinator console will be required in the Saturn Launch Control Center LC 39. This console will provide data readout capability from the wide-band data transmission system and will provide emergency control of Surface Laboratory OSE in the Mobile Launcher Base. The control circuit lines will be provided by the Launch Operations System, hard-wired to the Mobile Launcher Base. Facility power (120/208vac 60 cps) will be distributed to the Surface Laboratory test coordinator console by a power distribution unit provided by the Capsule Bus contractor. Space and environmental interfaces will be comparable to those in the STC Launch Control Center.

2.3.6.3 Mobile Launcher Base Interfaces

Surface Laboratory equipment installed in the Mobile Launcher Base will include the following items:

- a) Data Acquisition Circuitry (shared with Capsule Bus)
- b) Surface Laboratory emergency display and control unit

The above items will be installed in the Flight Capsule emergency display and control unit.

2.3.6.3.1 Space

Space and provisions for installation, servicing and maintenance of the equipment listed in paragraph 2.3.6.3 will be required in the Mobile Launcher Base.

2.3.6.3.2 Power

Facility power (120/208 vac 60 cps) will be required from a normal and from a backup source.

2.3.6.3.3 Environmental

Equipment will be packaged to operate in the environments of the Mobile Launcher Base. In general, the design will be the same as for the STC Control Center, but modified for use in the Mobile Launcher Base as required.

2.3.6.3.4 Data and Control Channels

The Flight Capsule emergency display and control unit will have hardwire interfaces with Surface Laboratory test coordinator console in the Launch Control Center, and the umbilical tower J-box.

2.3.6.4 Umbilical Tower Interfaces

Junction boxes and cables on the umbilical tower will be required for the termination of cables interfacing with Mobile Launcher Base equipment and for routing of these cable circuits up the umbilical tower to the Spacecraft. See paragraph 2.1.3.4.

2.4 Spacecraft Mounted Support Equipment to Spacecraft Interfaces

Spacecraft-mounted support equipment is provided by the

Capsule Bus contractor and mounted in the Spacecraft to support the Capsule Bus, Entry Science Package, and Surface Laboratory after Spacecraft/Capsule Bus separation. The primary functions of this equipment are to:

- a) Receive RF signals transmitted from the Flight Capsule systems in the 380 to 420 MHz band
- b) Demodulate the RF signals
- c) Provide bit synchronization and detection
- d) Route the detected signals to the Spacecraft
- e) Frequency modulate an RF beacon signal to the Surface laboratory.

Spacecraft-mounted support equipment will consist of:

- 2 fixed antennas
- 2 antenna couplers
- 1 antenna switch
- 2 diplexers
- 4 receivers
- 4 bit synchronizers
- 1 beacon transmitter

interconnecting cabling and connectors

Summary operation modes - Two receivers connected to a single antenna will receive data from the two Capsule Bus transmitters. Separate data from the two channels will be provided to the Spacecraft at a rate of 3584 bps. The Spacecraft will relay these data to the earth in real time.

The other two receivers connected to the other antenna will receive entry science data from the two Entry Science Package transmitters. The two channels will be separately provided to the Spacecraft at a data rate of 50 kbps. The Spacecraft will provide temporary storage for these data streams and will relay the streams separately to earth after completion of transmission from the Entry Science Package.

After the Capsule Bus has completed its mission and the Surface Laboratory is in operation, one of the Capsule Bus receivers will receive signals transmitted by the Surface Laboratory. The data rate on this channel will be 3584 bps. The Spacecraft will accept this data stream for relay to earth. Transmission over this channel will occur whenever the Surface Laboratory is operating and is receiving a signal from the beacon transmitter, indicating the Spacecraft is in view. Subsystem interfaces are defined below.

2.4.1 Structural Interfaces

The structural interfaces consist of bolts and/or bolted clamps to attach the Spacecraft-mounted support equipment to the Spacecraft structure and trusses. Bolt-hole control will be exercised by the exchange of templates for locating all holes for final drilling. All structural interfaces will be propellant compatible, corrosion resistant, and electrically conductive. Access to the equipment and electrical connector will be provided. Spacecraft-mounted support equipment will weigh no more than 50 pounds. Installation in the Spacecraft will be subject to the following constraints:

- a) Antennas will be positioned to maintain unobstructed and adequate view angles during entry and landed operations
- b) Equipment will be mounted so that RF cables are minimized in length
- c) Mounting surfaces will provide good electrical grounding contact.

2.4.2 Thermal

Thermal control of Spacecraft-mounted support equipment will be provided by the Spacecraft within the limits of -40°C to $+70^{\circ}\text{C}$ while non-operating and 0°C to $+40^{\circ}\text{C}$ while operating.

2.4.3 Command and Sequencing

On/off control of Spacecraft-mounted support equipment will

be provided through the Spacecraft sequencer. During landed operations, the equipment will be turned on 30 minutes prior to the time the Spacecraft is in view of the Surface Laboratory.

2.4.4 Power

An interface is provided between the spacecraft static inverters to provide square-wave ac power to Spacecraft-mounted support equipment. The characteristics of this power are:

50 watts maximum

47.5 to 51.5 volts (RMS)

2400 Hz nominal

Power (28 vdc) from the transducer power supply in the spacecraft is provided for the engineering measurement transducers provided in Spacecraft-mounted support equipment.

2.4.5 Telemetry

The Spacecraft will accept data at 50 kbps from two channels for real-time relay to earth. The Spacecraft will accept data at 3584 bps from two channels for temporary storage and relay to earth. The Spacecraft will accept analog signals from engineering measurement transducers provided in Spacecraft-mounted support equipment for transmission over Spacecraft telemetry channels.

2.4.6 Cabling

Interface cabling will consist of cables carrying telemetry data stream discretes, and power as described above. Cabling design requirements applicable also to this interface are in paragraph 2.1.1.10. The socket half of the interface connector will be mounted on the Spacecraft side of the interface.

3. PROGRAM IMPLEMENTATION

Following customer evaluation of the information in this report, and direction to continue program effort, Martin Marietta Corporation will implement the interface management program proposed in this section. A functional flow diagram of this control program is shown in Fig. 4.

3.1 Interface Identification and Definition

3.1.1 Selection of Controlled Interfaces

All Voyager capsule systems areas of effort which might possibly impact another contractor or government agency will be reviewed and evaluated for consideration as a formal interface. Things to be considered in performing this selection are:

3.1.1.1 Systems Requirements and Constraints

Basic system requirements, such as the majority of the interfaces between the Flight Capsule and the flight spacecraft are readily definable. While these interfaces may have severe effects on either or both of the interfacing systems, they provide design parameters against which both independent and jointly conducted trade studies can be completed. Most interfaces discussed in Section 2. are in this category. Detailed effort in interface development can be expected to result in a recommendation for modification of some parameters or criteria from those values initially given.

3.1.1.2 System Susceptibilities

Interfaces that have not yet been explored are those resulting from specific hardware designs. Many of these interfaces cannot be defined until interface coordination between contractors is underway. Most of the Phase C effort should be devoted to this area to permit early interface definitization. The classic example is that of electromagnetic interference between systems. The fairly stringent restrictions on interface cabling in paragraph 2.1.1.10 of the Capsule Bus/Flight Spacecraft interface

represent the best technical approach to reducing the effects of EMI on a gross basis, but it may develop that radiated fields or switching transients can cross the interface with detrimental effect on sensitive components. The possible existence of these interfaces can only be determined with the exchange of design data between contractors.

3.1.1.3 Program Organizations and Schedules

These interface requirements result from such sources as program philosophy, criteria, and schedules. Examples in this category are the level of simulation, and the realism of simulation requirements, that will be determined necessary at the interfaces before actual mating of flight hardware or ground based OSE. In this particular case, the philosophy to be recommended is that the contractor responsible for one side of an operational interface should also assume responsibility for simulators to be used by the other contractor for interface verification and validation tests. This responsibility should extend to stipulating that, under specified conditions of use, the simulator does represent the operational interfacing equipment within limits specified for each subsystem involved. This requirement should not necessarily be extended to the area of development testing where the operational interfaces have not been formally defined.

The boundaries of certain interfaces can be expected to be fixed by such things as program organization, or structural characteristics, in addition to the boundaries fixed by technical requirements. The possible use of RTG in the Surface Laboratory for future missions seems to have several implications in this respect.

3.1.2 Interface Definition

Once selected, all aspects of the interface recognized by the contractor will be documented in specification format in a preliminary interface control document (ICD).

It is proposed that this ICD be completed with a reasonable depth of detail during the Phase C program, thus increasing the understanding and ability to scope and control the phase D program. These ICDs will then be coordinated with the affected contractors through the interface control working group.

3.2 Interface Coordinations

Experience has shown that the most effective approach to an interface coordination program between contractors has been to hold interface discussions on working group basis with representation in depth from both sides. As the detail features of the interfacing systems are understood, a continuing attempt should be made to reduce the discussions and to relegate true interfaces to smaller groups. This may be accomplished through an interface control working group (ICWG) co-chaired by the Capsule systems integrating contractor and JPL or the NASA center of principal interest. This group to consist of representatives from each affected contractor with authority to commit their company technically and representation from the customer with technical approval authority. This group will review the ICD submitted by the affected contractors, assign action items and dates for working off differences and identify items which require arbitration by the customer. The schedule for the ICDs, their coordination, action items and the eventual delivery of hardware, software or services by all affected contractors will be accomplished on the Schedule Interface Logs (SIL) maintained by the Capsule integrating contractor and approved by the customer.

Once the ICWG has agreed on one ICD for each intercontractor interface this ICD will be placed under configuration management by the customer and the integrating contractor and the ICD included as an applicable document for design and production on each affected contractor's contract.

3.3 Contractor Implementation of Customer-Approved Interfaces

The release of engineering drawings and procurement documents containing requirements that reflect interface agreements necessarily depends on customer approval of the interface agreements at the time of release. This approval will be reflected in appropriate changes to the basic contract.

3.4 Interface Control -

The control of interfaces, whether functional, physical, environmental, test or managerial, requires the participation of the procuring agency, the integrating contractor, and those contractors or agencies whose systems are being integrated by the integrating contractor. For the Voyager Capsule Systems effort, Martin Marietta Corporation proposes to be the integrator and will integrate the flight capsule interfaces with the spacecraft, the Surface Laboratory, the Voyager MOS, and the LOS. The functions of the integrator, affected contractors and the procuring agency for an effective interface control program, are proposed in the following paragraphs.

3.4.1 Role of the Procuring Agency

- a) Designate Martin Marietta as integrating contractor and custodian of Interface Control Documents (ICD)
- b) Co-chair interface control working group meetings and act as arbitrator in all cases where the contractors cannot resolve an interface problem
- c) Provide technical direction as necessary to permit an orderly discussion of problems between interfacing contractors
- d) Approve interface control documents after they have been signed by the interfacing contractors, indicating concurrence, after the document has been submitted for formal approval

- e) Contractually implement the approved interface control documents and changes on the applicable contracts
- f) Implement formal configuration management of the approved interface control documents through the integrating contractor's configuration management office.

3.4.2 Role of the Integrating Contractor

- a) Act as Voyager Capsule Systems integrating contractor and be responsible for determining systems effect of interface agreements and changes
- b) Prepare and maintain interface control documents
- c) Co-Chair interface control working group (ICWG)
- d) Present the interface control documents at the ICWG for coordination and approval
- e) Establish, coordinate, and schedule interface control working group meetings
- f) Maintain and distribute schedule interface log (SIL) scheduling all interfacing activities
- g) Prepare and distribute coordinated formal agenda and minutes for the ICWG to all participants
- h) Review all interfacing contractor's Class I changes for impact on Voyager Capsule Systems interfaces
- i) Publish, bind, and distribute approved ICDs, and their revisions, and maintain an interface document file.

3.4.3 Role of Affected Contractors -

Each affected contractor or agency involved in an interface control program will:

- a) Prepare data pertinent to that interface and submit the data as required to the integrator
- b) By signature, indicate concurrence with his affected ICD as prepared by the integrator for formal submittal to the procuring agency

- c) Participate in interface control meetings, submit agenda items for the meetings, and request meetings when necessary
- d) Provide integrator with copies of Class I changes affecting interfaces.

3.4.4 Interface Change Approval

Following preparation and coordination of interface change documentation by the ICWG, signature approvals will be obtained by the integrator. Authorized signatures of the integrator and affected contractors on the title block or cover sheet of the ICD constitute concurrence with the agreements contained in the ICD. The customer representative will then either approve or disapprove the document. Following approval by the customer, the ICDs will be contractually implemented on the appropriate contracts.

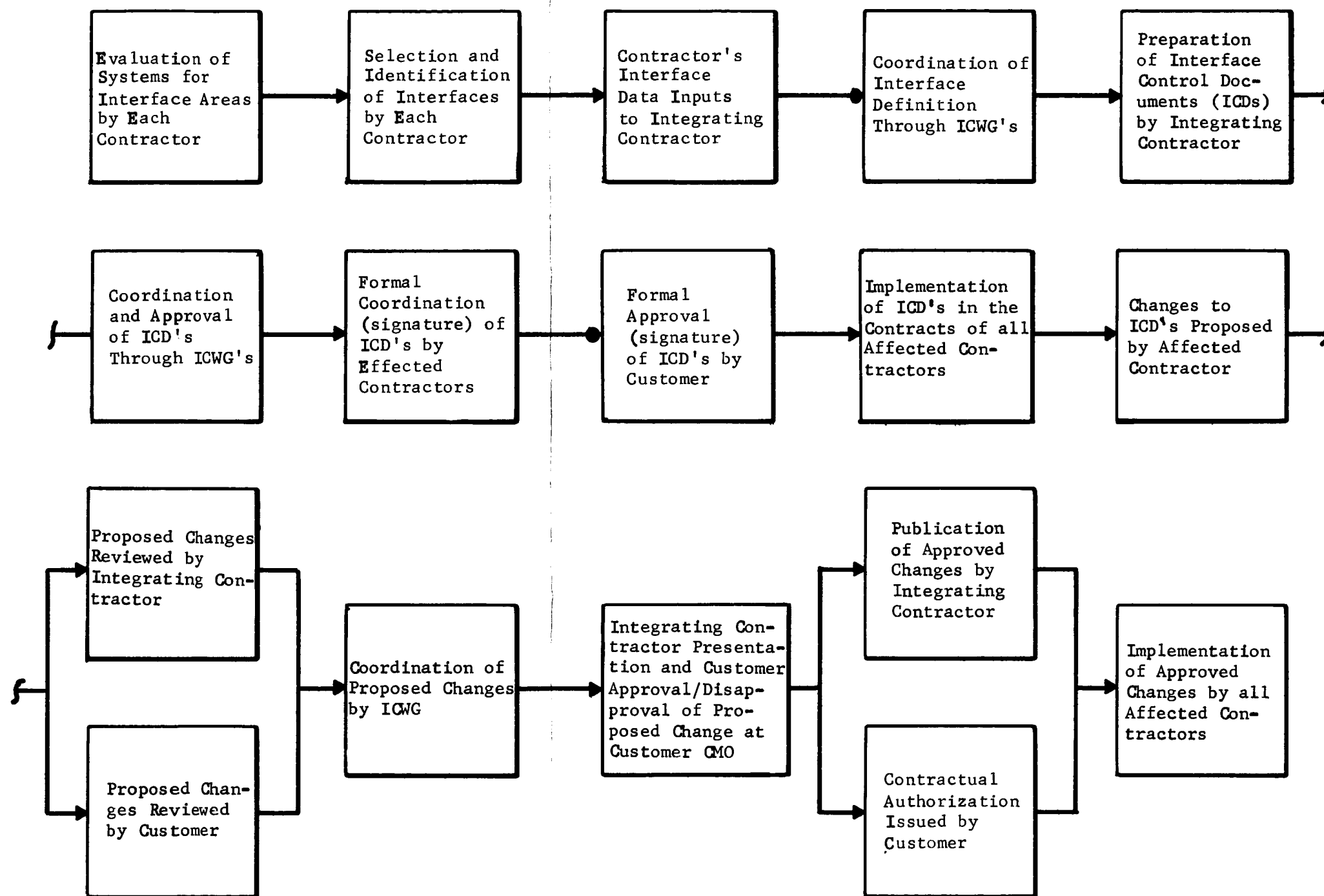


Fig. 4 Interface Control Program