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Vol. IV Sect. II

Copy No. 34

MARTIN MARIETTA CORPORATION

DENVER DIVISION

VOYAGER

CAPSULE

PRELIMINARY DESIGN (Phase B)

Contract Number 952001 FINAL REPORT

VOLUME IV ENTRY SCIENCE PACKAGE

Section II Preliminary Design for OSE

AUGUST 31, 1967

A. J. Kullas

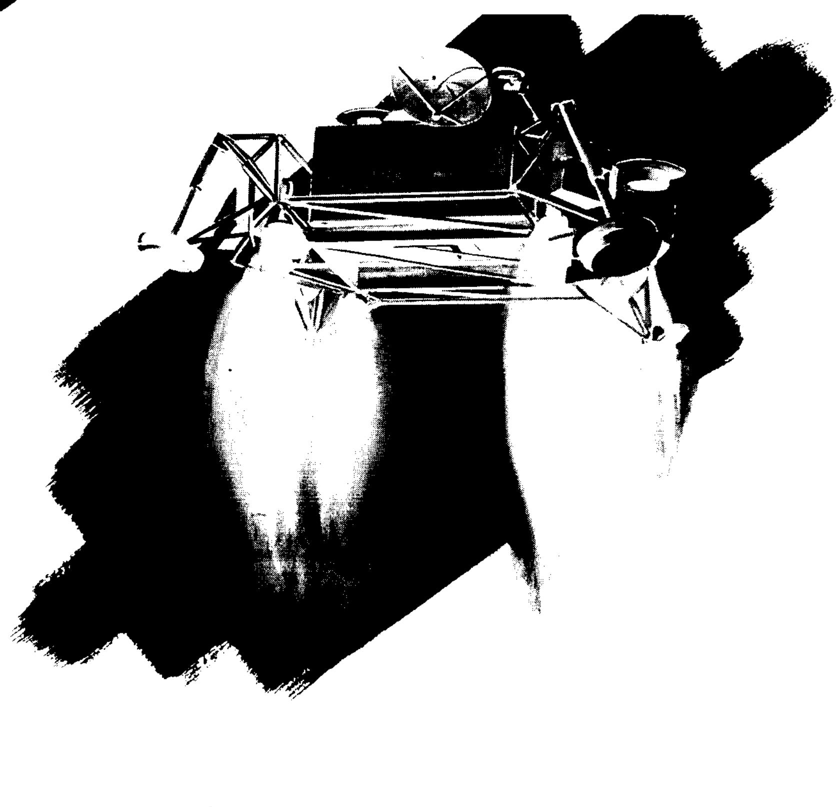
Voyager Program Director

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.



MARTIN MARIETTA CORPORATION
DENVER DIVISION

PREFACE

This volume of the Martin Marietta Corporation's Voyager Capsule Systems Final Report provides the results of the Entry Science Package preliminary design studies. In the performance of this Phase B study effort, Martin Marietta was assisted by RCA Astro-Electronics Division in the communications subsystem area, and by the following group of consultants in the Entry Science area.

	Fields of Specialty
Institute for Aerospace Science University of Toronto (J. deLeeuw, J. French)	Free Molecular Flows and Molecular Beams
Cornell Aeronautical Laboratory, Inc. (G. Hall, C. Treanor)	Hypersonic and Supersonic Flow
High Altitude Engineering Laboratory Dept. of Aerospace Engineering University of Michigan (L. Jones, E. Schaefer)	High Altitude Atmospheric Structure and Measurements

This volume consists of five sections: Section I, Entry Science Package; Section II, Preliminary Design for OSE; Section III, Implementation Plan; Section IV, Test Program; and Section V, Interfaces.

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1. GENERAL REQUIREMENTS AND CONCEPTS

This section describes the requirements and conceptual implementation of the Operational Support Equipment (OSE) and Mission-Dependent Equipment (MDE) for the Entry Science Package (ESP) portion of the Voyager Flight Capsule System. Descriptions for OSE include subsystem OSE, System Test Complex (STC), Launch Complex Equipment (LCE), and Assembly, Handling, and Shipping Equipment (AHSE).

Requirements and constraints specified in the following NASA/JPL documents are the basis for OSE and MDE definitions provided here:

1) SE002BB001-1B21, Performance and Design Requirements for the 1973 Voyager Mission, General Specification for, dated January 1, 1967
2) SE003BB002-2A21, Voyager Capsule Systems Constraints and Requirements Document, dated June 1967
3) EPD No. 283 (Rev 2) - Planned Capabilities of the DSN for Voyager 1973.

In addition to the above documented requirements, the flight subsystem configuration described in Volume IV, Section I of this document, and integrated test requirements and supporting analyses and trade studies performed during the Phase B contract period, provide further requirements for the OSE and MDE descriptions contained here.

1.1 OSE/MDE Concepts

Flexibility, commonality, standardization, subsystem OSE and STC use of computers are some of the significant features incorporated in Voyager OSE designs because of Entry Science Package requirements and constraints. These and other significant features are summarized below.

Flexibility - Flexibility is incorporated to permit support of all missions.

Commonality of Equipment Designs - The commonality of equipment designs among subsystem OSE, STC, and LCE is stressed to assure correlation of data from one test to another. Common equipment designs are used extensively for stimuli and monitoring equipment that directly interface with the flight equipment.

Standardization - Standardization is emphasized to permit maximum common usage of equipment. Modular packaging techniques permit flexibility and efficiency of use.

Reliability, Maintainability, Human Engineering, and Safety Provisions - These provisions are included to assure system effectiveness.

Cost/Effectiveness - Cost/effectiveness is achieved by sharing the Capsule Bus subsystem OSE computer system and subsystem test sets for testing similar Entry Science Package subsystems, by standardized design, and by integrating Entry Science Package STC and LCE requirements with Capsule Bus OSE designs.

Transportability - Provisions are included to facilitate expeditious relocation and reinstallation of OSE. These provisions are particularly emphasized for Capsule-vicinity OSE that is normally assigned to a flight article. This OSE remains with the flight article throughout all system test phases.

Simulation of Interfaces - Simulated interfaces are provided for all levels of testing to assure complete and realistic testing.

Self-Test of OSE - To assure that flight equipment is not damaged by improper sequencing or OSE failure, OSE contains a self-test capability.

Computer Use - Computer use by both subsystem OSE and the STC is featured to permit early development of computer software programs, and maximum common usage of software between subsystem OSE and STC.

MDE Recommendations - MDE recommendations are based on the planned operational characteristics and capabilities of the Deep Space Network (DSN), Mission-Independent Equipment (MIE) so that duplicate capability is avoided.

MDE and MDS Designs - These designs are proved by use in the STC.

1.2 Summary OSE Descriptions

1.2.1 Subsystem OSE

Subsystem OSE required to support flight subsystem and replacement level testing is illustrated in Fig. 1.2-1. Subsystem OSE test sets provide subsystem test capability while operating under control of a general-purpose digital computer system shared with the Capsule Bus subsystems. The subsystem OSE computer system consists of a computer central processor (compatible with the type selected for STC), input/output equipment, and control and display equipment. The computer system provides test sequence control, and acquisition, storage, processing and display of data for the various test sets. In addition to standard computer-controlled stimuli and monitoring equipment, the subsystem test sets include manual control, unique stimuli, monitoring and display equipment. Standard computer test stations are permanently located at designated test areas and are used with the various test sets to perform flight subsystem testing. The computer system and the subsystem test sets perform tests in real-time and on a time-sharing basis between the various test stations. The subsystem test sets are briefly described in the following paragraphs.

Power and Pyrotechnic Test Set - This set consists of two electronic equipment racks and is shared with the Capsule Bus. One rack contains the computer data acquisition equipment and built-in manual test equipment; the other contains power supplies, loads, command generator and the computer interfacing equipment for test control. Capability is provided for testing the power distribution, control, and pyrotechnic circuits.

Communications Test Set (UHF) - This set consists of two and one-half electronic equipment racks and is shared with the Capsule Bus. It contains standard commercial and special test equipment required to test the UHF communications equipment. Standard equipment is also included for computer control and data acquisition interfaces.

Structures, Mechanisms, and Thermal Control Test Set - This set consists of one electronic equipment rack and is shared with the Capsule Bus. It contains power supplies, controls, displays, and standard computer-controlled stimuli and monitoring equipment. It provides the capability for testing the Entry Science Package thermal control heaters and thermostats.

Entry Science Test Sets - Five unique test sets are required for testing the Entry Science subsystem. Each of these sets are capable of independently testing its flight article and can be moved individually to computer test stations for parallel testing. These sets are described in the following paragraphs.

Visual Imaging (TV) Test Set - This set consists of two electronic equipment racks that can reconstruct, display, and record TV pictures on file. It includes a test pattern generator, power supplies, CRT display and associated control, and conditioning and processing equipment. This set interfaces with the subsystem OSE computer.

Accelerometer Test Set - This set consists of one electronic equipment rack and a rate table required for checkout of the accelerometer triad. It includes a stimulus generator, power, switching, standard test equipment, and computer interfacing equipment.

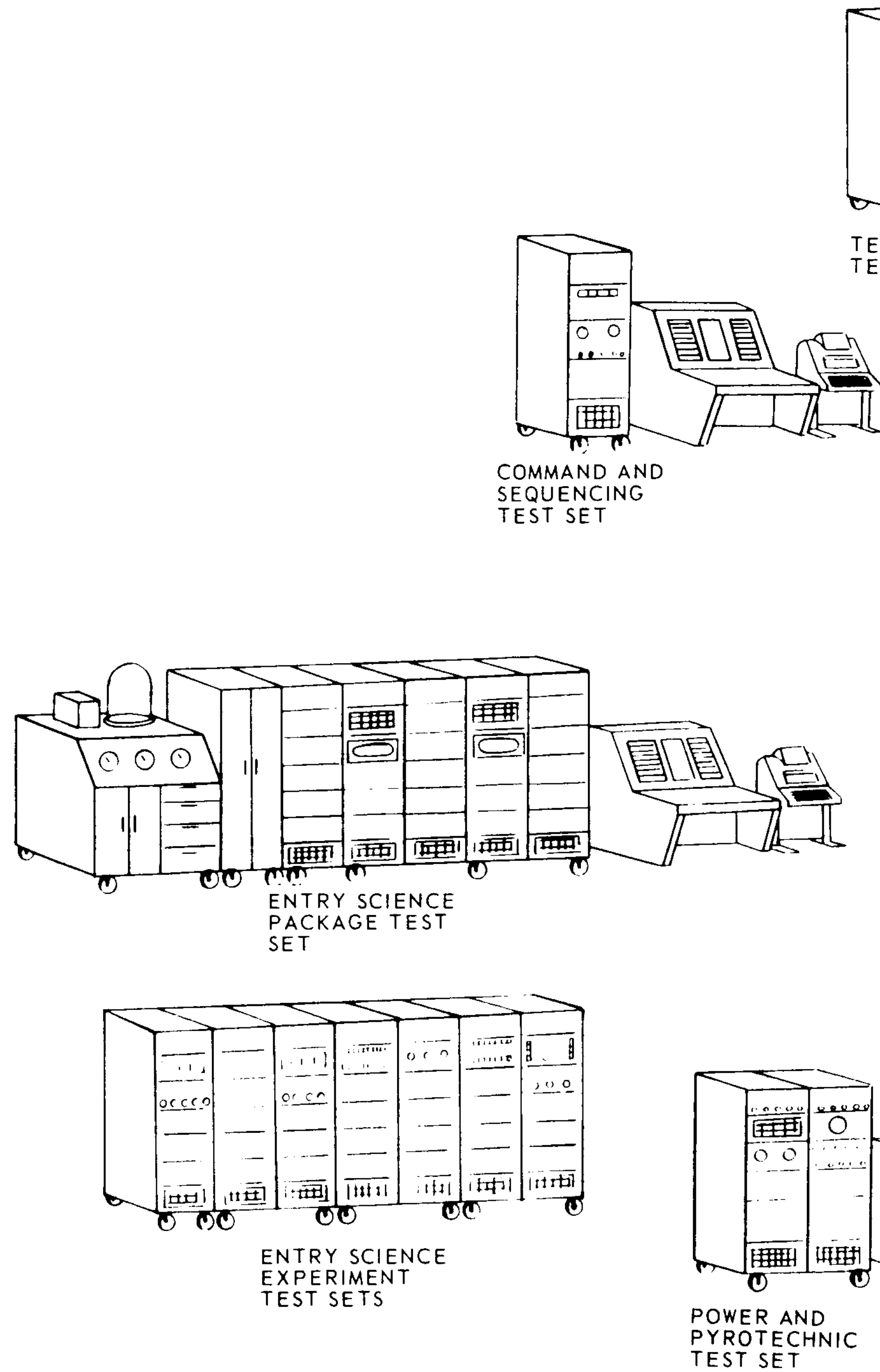
Atmospheric Instruments Test Set - This set consists of one electronic equipment rack and a separately packaged vacuum and thermal control chamber. The electronic rack contains power supply, standard test equipment, and computer interfacing equipment.

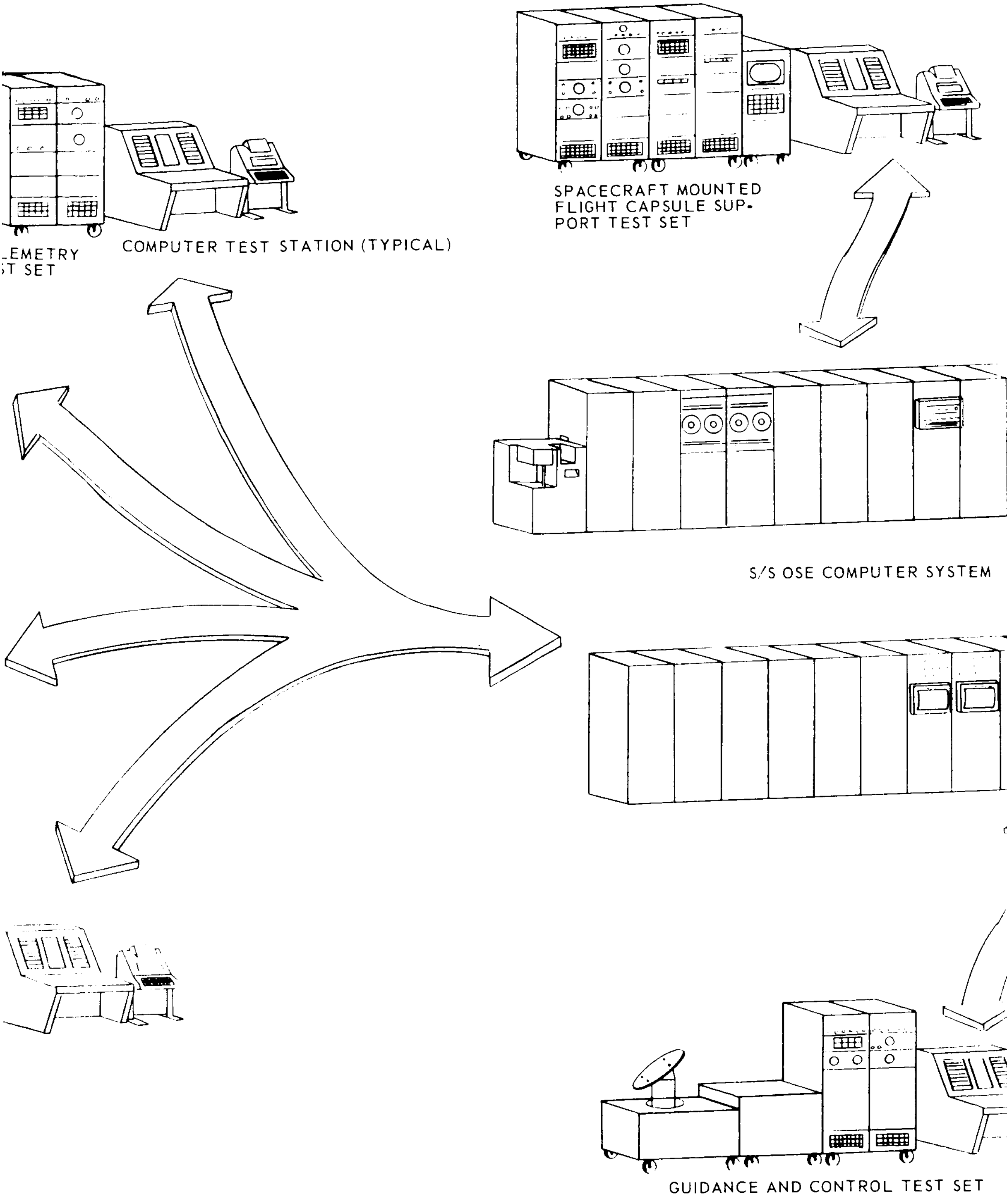
Mass Spectrometer Test Set - This set consists of two electronic equipment racks for testing the Entry Science spectrometers. It contains a power supply, switching, standard test equipment, and computer interfacing equipment.

Science Data Subsystem - This item is tested by the Entry Science Package test complex described in paragraph 1.2.2.

1.2.2 System Test Complex (STC)

Two system levels of test capability are provided for the Entry Science Package. The first level is performed by an Entry Science Package test complex, which provides complete functional test of the Entry Science Package before integration with the Capsule Bus. The second level of testing by the Capsule Bus STC provides integrated testing of the Entry Science Package and Capsule Bus. The following paragraphs describe these test complexes.


COMMAND AND
SEQUENCING
TEST SET
ENTRY SCIENCE
PACKAGE TEST
SET
ENTRY SCIENCE
EXPERIMENT
TEST SETS
POWER AND
PYROTECHNIC
TEST SET



SPACECRAFT MOUNTED FLIGHT CAPSULE SUPPORT TEST SET
COMPUTER TEST STATION (TYPICAL)
LEMETRY
T SET
S/S OSE COMPUTER SYSTEM
GUIDANCE AND CONTROL TEST SET

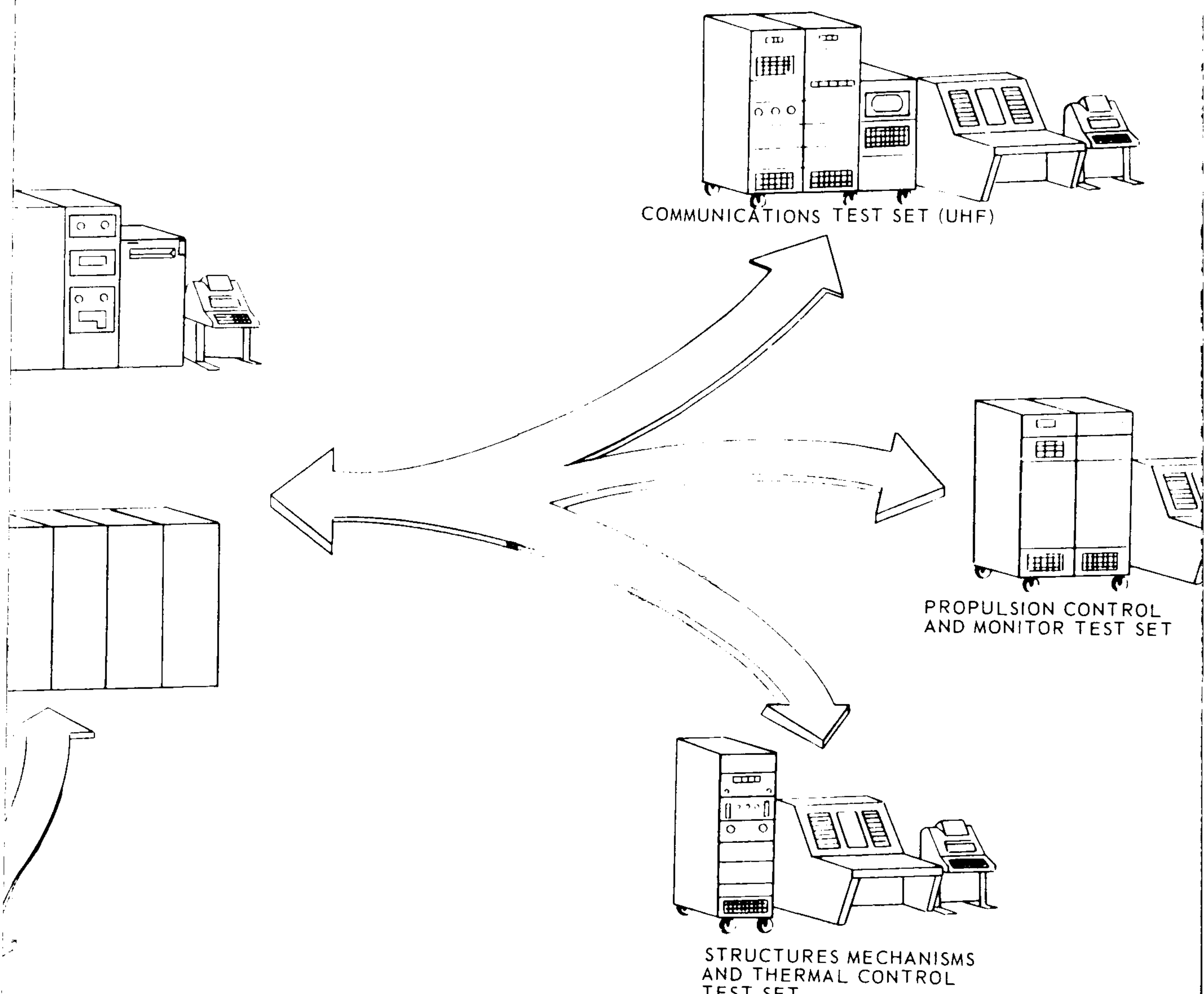
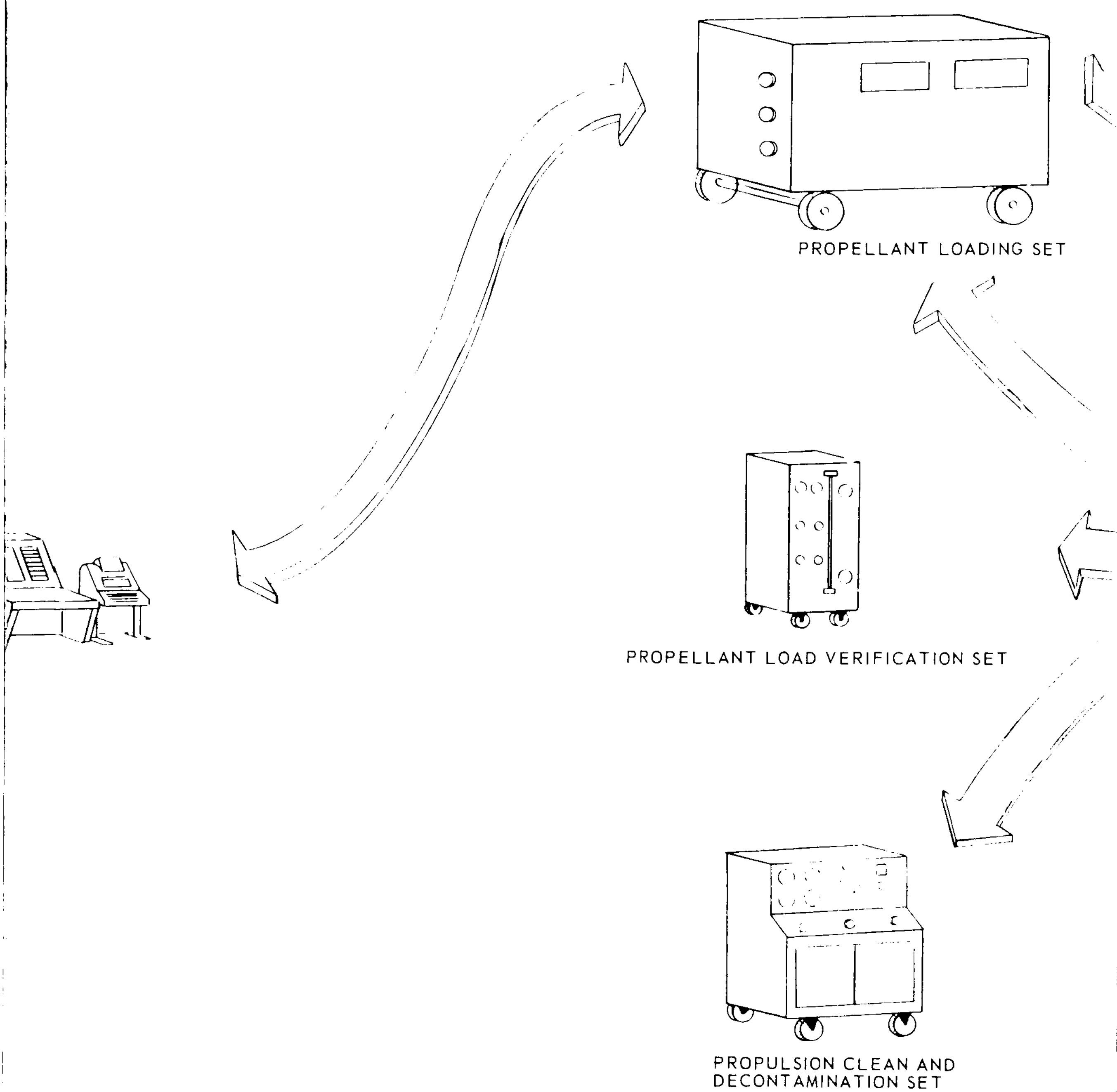
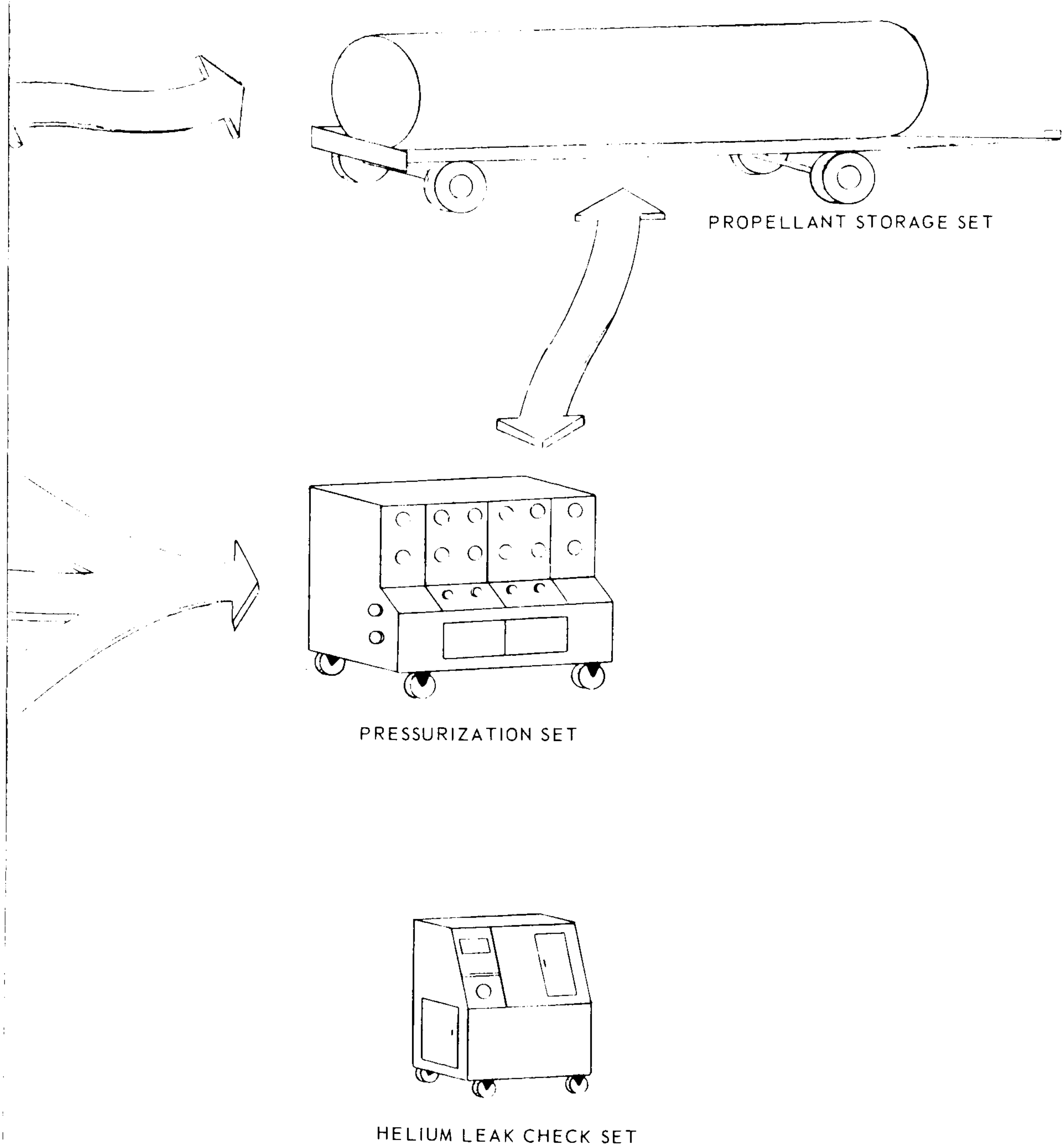


Fig. 1.2-1 Capsule Bus/Entry Science Package Subsystem OSE


PROPELLANT LOADING SET
PROPELLANT LOAD VERIFICATION SET
PROPULSION CLEAN AND
DECONTAMINATION SET


PROPELLANT STORAGE SET
PRESSURIZATION SET
HELIUM LEAK CHECK SET

Entry Science Package Test Complex - The Entry Science Package test complex is illustrated in Fig. 1.2-1. It consists of the subsystem OSE computer system and an Entry Science Package test set that uses selected portions of subsystem OSE designs to provide an integrated Entry Science Package test capability. The test set also can test the science data subsystem. It consists of selected portions of power, pyrotechnic, and communications subsystem OSE, general-purpose computer interfacing equipment, and special calibration equipment.

Flight Capsule System Test Complexes - System Test Complexes required to support development, qualification, and acceptance testing of Flight Capsule systems are illustrated in Fig. 1.2-2. Each STC is divided into the following functional equipment groups -- control and display, capsule-vicinity OSE, and computer data system.

Control and Display - This grouping includes the various consoles and other equipment required for man-machine interface with the computer data system (CDS) for test control and data display. The equipment in this grouping is located in the control center and generally remains fixed at a test facility location.

Capsule-Vicinity OSE (CV OSE) - This grouping includes all of the computer-controlled command, stimuli, and digital data acquisition and conversion equipment that interfaces with the flight systems. It also includes any unique subsystem OSE required for testing of the flight system. The equipment in this grouping is located near the Capsule and generally moves with the flight system from test area to test area.

Computer Data System (CDS) - This grouping includes the general-purpose digital computer and its associated input/output and peripheral equipment. This group of equipment is located in the control center and generally remains fixed at a test facility location. The CDS is shared with more than one set of control and display and capsule-vicinity OSE.

After the Entry Science Package is tested by its test complex, it is married to the Capsule Bus and integrated testing is performed with the Capsule Bus STC. Selected portions of Entry Science Package subsystem OSE are included in the Capsule Bus STC. The Capsule Bus CDS is shared between the Capsule Bus and Entry Science Package for this configuration.

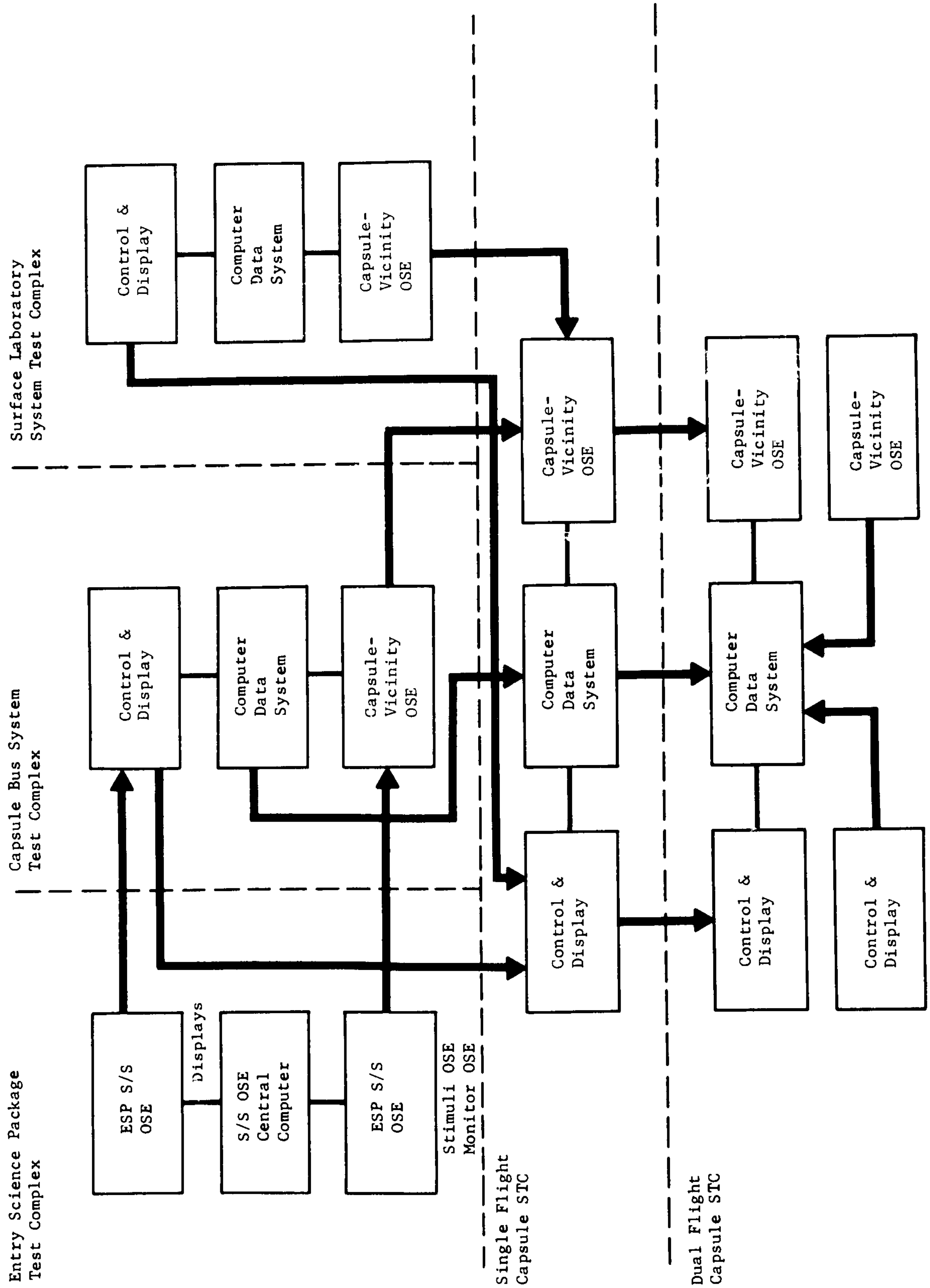


Fig. 1.2-2 Flight Capsule STC Configurations

After testing of the Surface Laboratory system is completed by its STC, it is integrated with the Capsule Bus and Entry Science Package into a Flight Capsule configuration. Selected portions of Surface Laboratory Capsule-Vicinity and control and display OSE are included in the Capsule Bus STC to test the complete Flight Capsule. The Capsule Bus CDS is shared with the Capsule Bus, Entry Science Package, and Surface Laboratory for this STC configuration, which provides a single Flight Capsule system test capability. Figure 1.2-3 illustrates a typical Flight Capsule STC.

The Capsule Bus CDS is sized to handle two complete Flight Capsules. Therefore, a dual Flight Capsule STC configuration is provided by including another complete set of Capsule-vicinity and control and display OSE for the Entry Science Package, Capsule Bus, and Surface Laboratory. This configuration permits real-time testing of two integrated Flight Capsules on a time-shared basis.

Two dual Flight Capsule STC configurations are provided at the Capsule Bus contractor's facilities to support testing of the four Capsules required for the Voyager mission.

Two dual Flight Capsule STC configurations are also provided at KSC to support prelaunch and launch test operations for the four Capsules. Each dual Flight Capsule STC configuration comprises a single CDS and two sets of Capsule-vicinity and control and display OSE moved from the Capsule Bus contractor's facility. (The CDSs remain at the Capsule Bus contractor's facility to support later missions.) These two STCs are used initially to support test of the Flight Capsules before marriage with the Spacecraft. One dual Flight Capsule STC is used to support later Planetary Vehicle tests. The other is available for continued support of the two spare Capsules, in addition to providing backup capability for Planetary Vehicle testing.

1.2.3 Launch Complex Equipment (LCE)

Capsule Bus LCE includes provisions to support the Entry Science Package prelaunch and launch activities at Launch Complex 39. The LCE configuration, shown in Fig. 1.2-4, makes use of the STC. Basically, it is a dual Flight Capsule STC configuration, augmented by A2A transmission lines and remote display and control equipment located at the Launch Control Center and launch pad.

The Capsule Bus LCE consists of the Launch Control Center and mobile launcher (ML) equipment groups. The Launch Control Center group consists of the Capsule Bus test coordinator console and supporting power distribution unit. The ML equipment group consists of an emergency control and display unit and a power distribution unit.

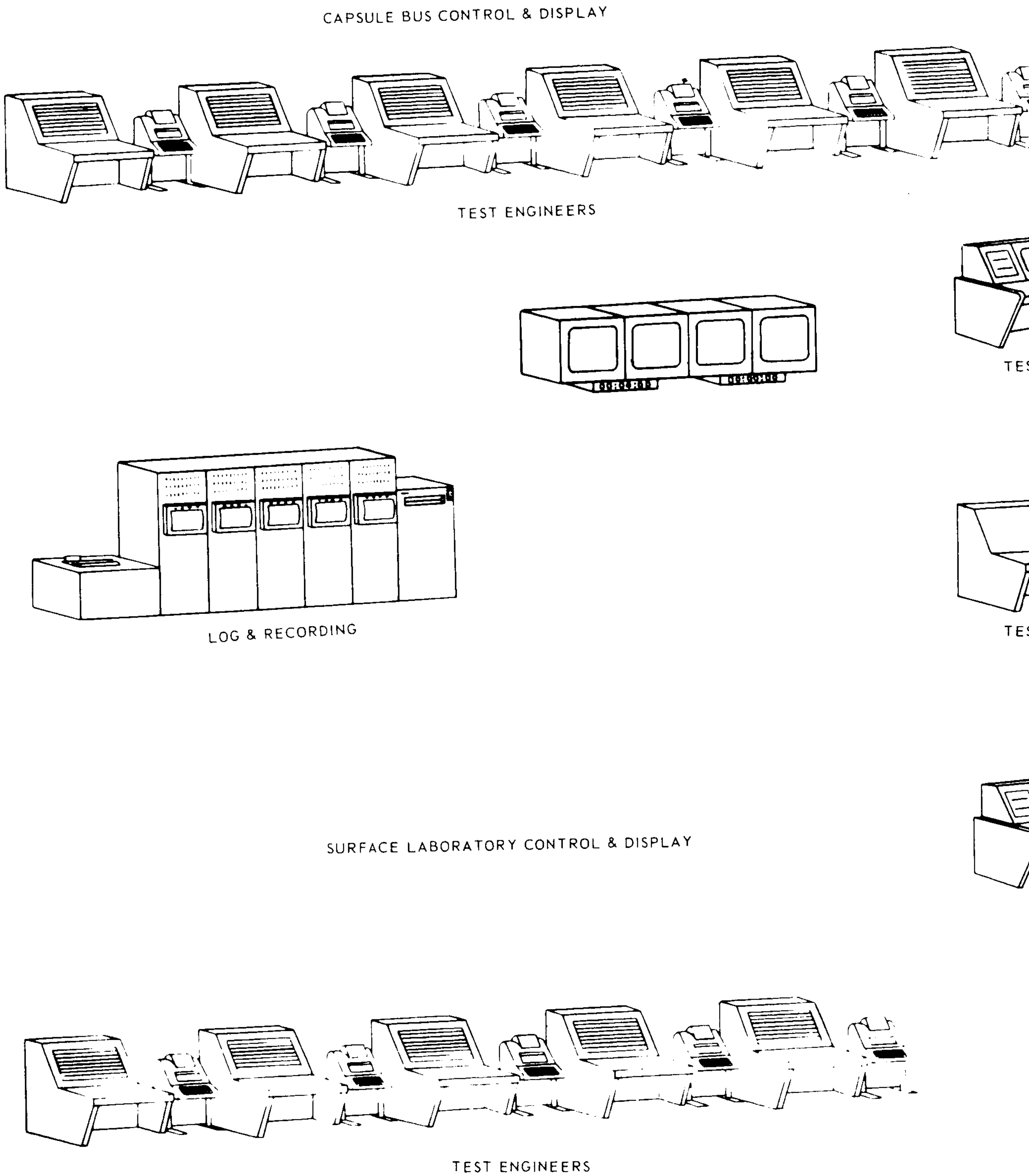
LCE checkout capability is based on command capability via the Spacecraft to the onboard sequencing equipment, telemetry data available through the Spacecraft data links, and hardwired safety controls and monitors available through the Planetary Vehicle umbilical. With the exception of safety control and monitoring, all Flight Capsule system testing is performed in cooperation with the Spacecraft contractor.

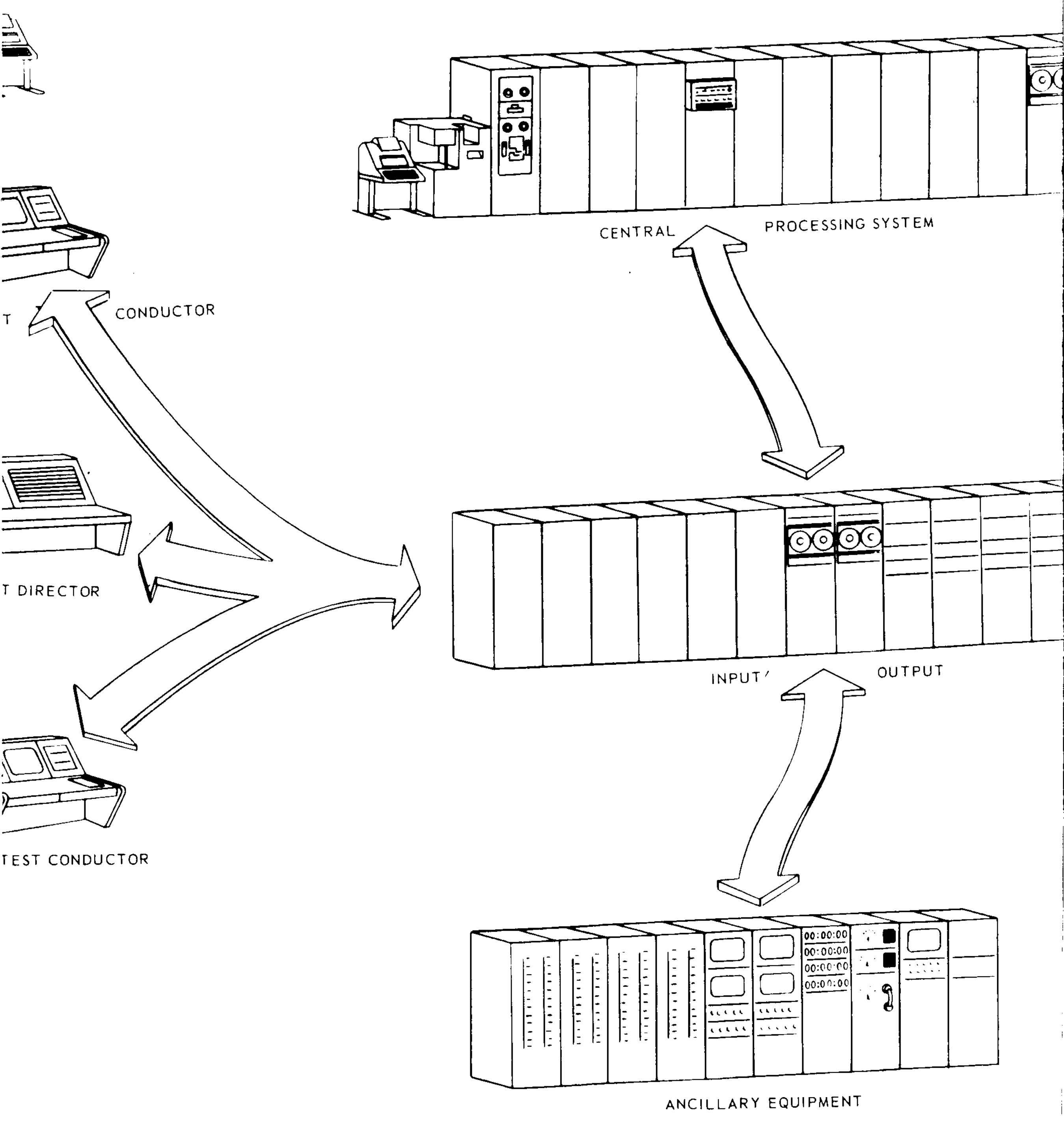
1.2.4 Mission-Dependent Equipment (MDE)

Figure 1.2-5 illustrates the overall implementation of MDE for the Entry Science Package. MDE is not required at the Deep Space Instrumentation Facility (DSIF) because there are no direct radio interfaces between the Entry Science Package and the Deep Space Network MIE receiver-transmitters. All ESP command and telemetry data modes during the Voyager mission are via the Spacecraft. Television MDE is provided at the Space Flight Operations Facility (SFOF). This equipment consists of two electronic equipment racks and a console capable of reconstructing TV pictures from video data stored on SFOF magnetic tapes. Pictures are displayed on a cathode-ray tube (CRT) used as an exposure source for recording the pictures on film. A film processor is also included to provide film negatives for photographic enlargement. The Entry Science Package TV MDE is shared with the Surface Laboratory. Mission-dependent software is also provided for use with the SFOF data processing system.

1.2.5 Assembly, Handling, and Shipping Equipment (AHSE)

AHSE required for the Entry Science Package are illustrated in Fig. 1.2-6.


CAPSULE BUS CONTROL & DISPLAY
TEST ENGINEERS
LOG & RECORDING
SURFACE LABORATORY CONTROL & DISPLAY
TEST ENGINEERS


CENTRAL PROCESSING SYSTEM
T CONDUCTOR
T DIRECTOR
TEST CONDUCTOR
INPUT/ OUTPUT
ANCILLARY EQUIPMENT

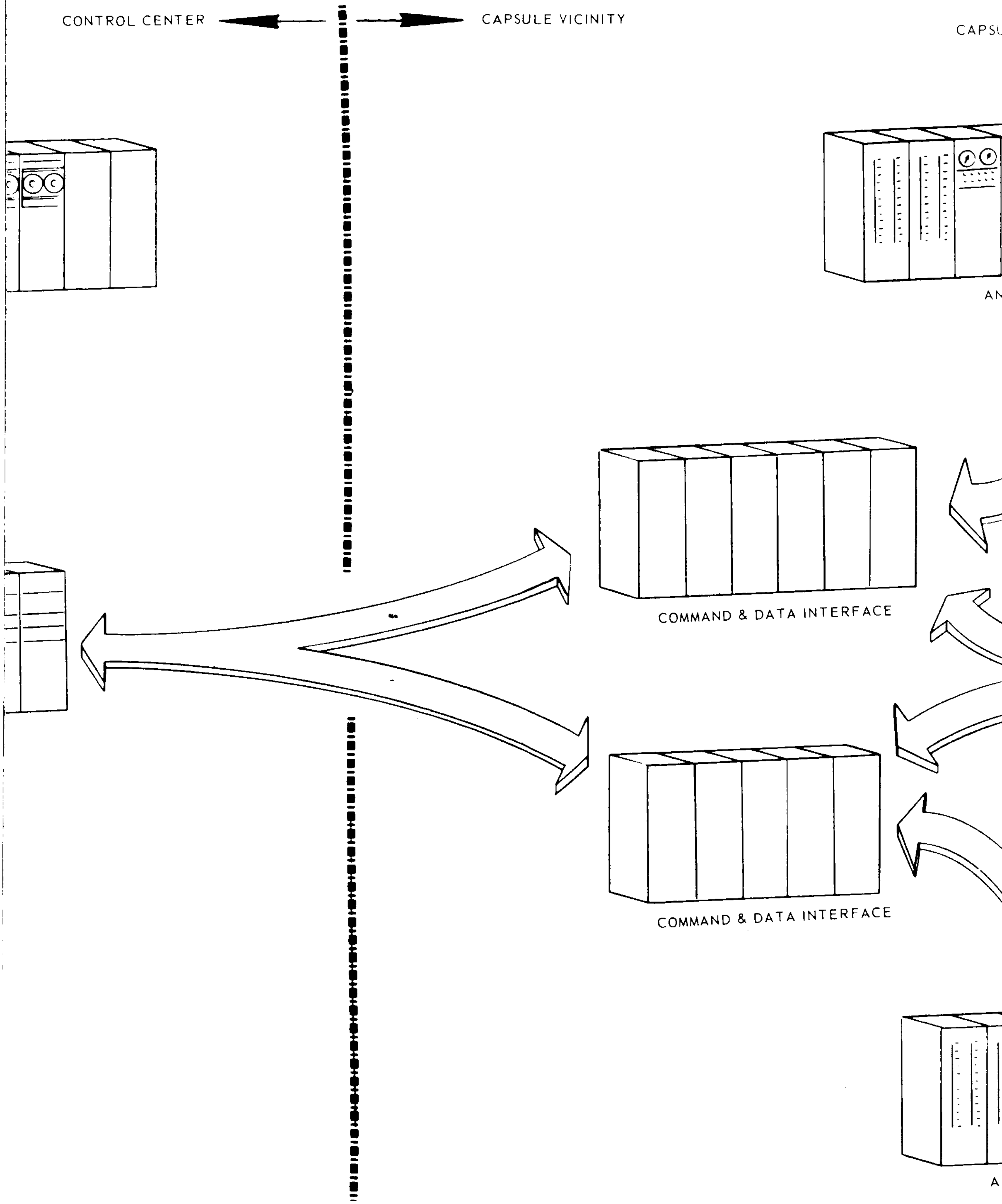


Fig. 1.2-3 Typical Flight Capsule STC

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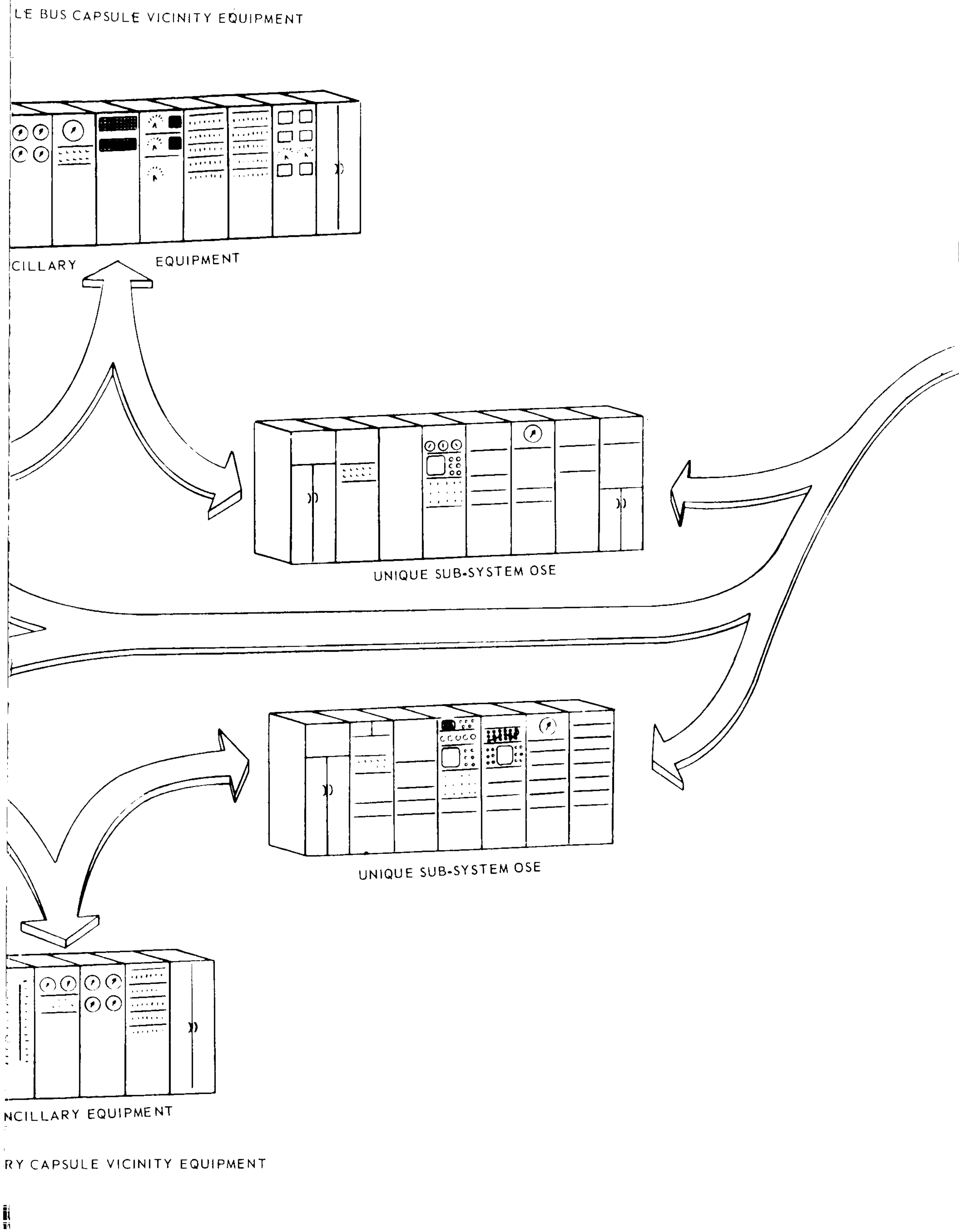
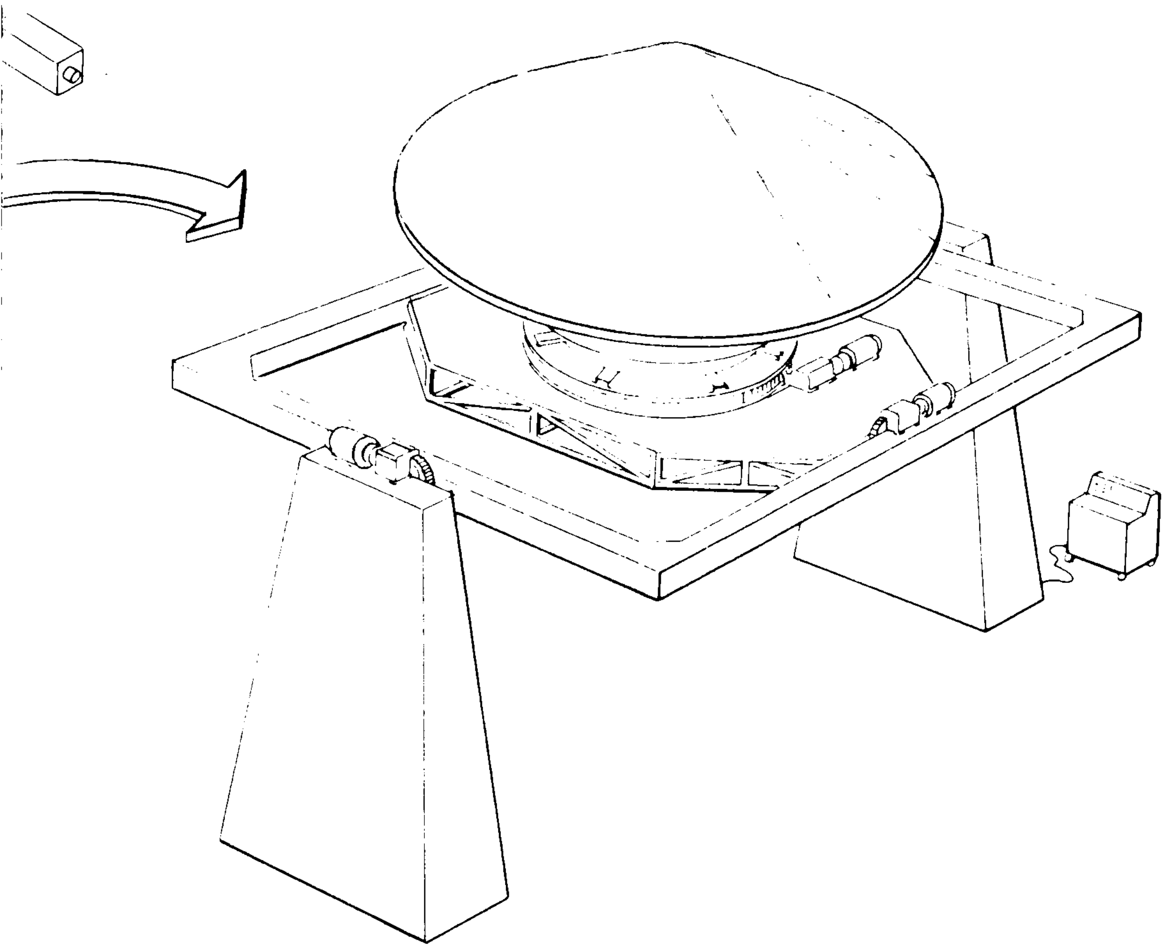


LE BUS CAPSULE VICINITY EQUIPMENT
CILLARY EQUIPMENT
UNIQUE SUB-SYSTEM OSE
UNIQUE SUB-SYSTEM OSE
NCILLARY EQUIPMENT
RY CAPSULE VICINITY EQUIPMENT



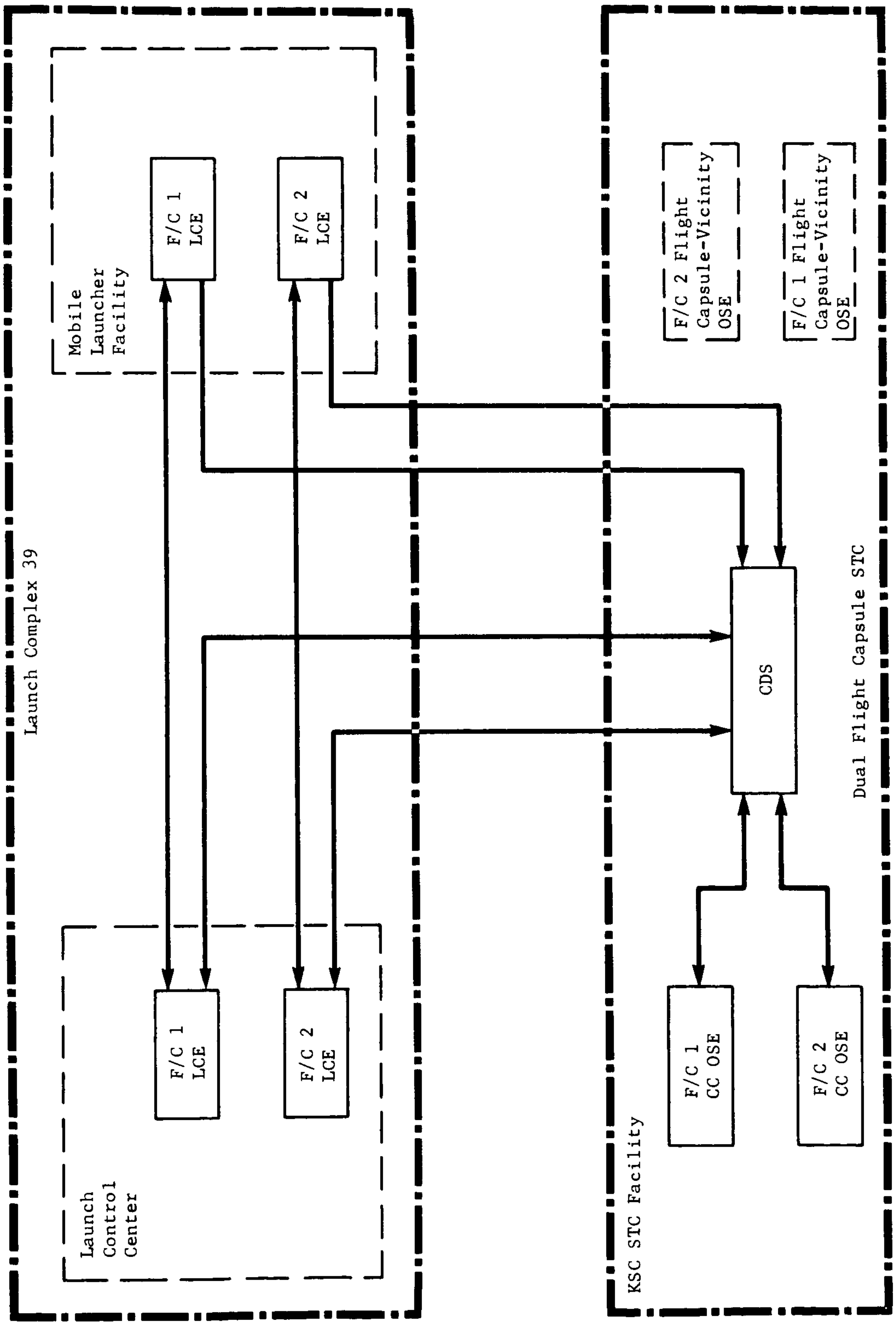


Fig. 1.2-4 LCE Configuration

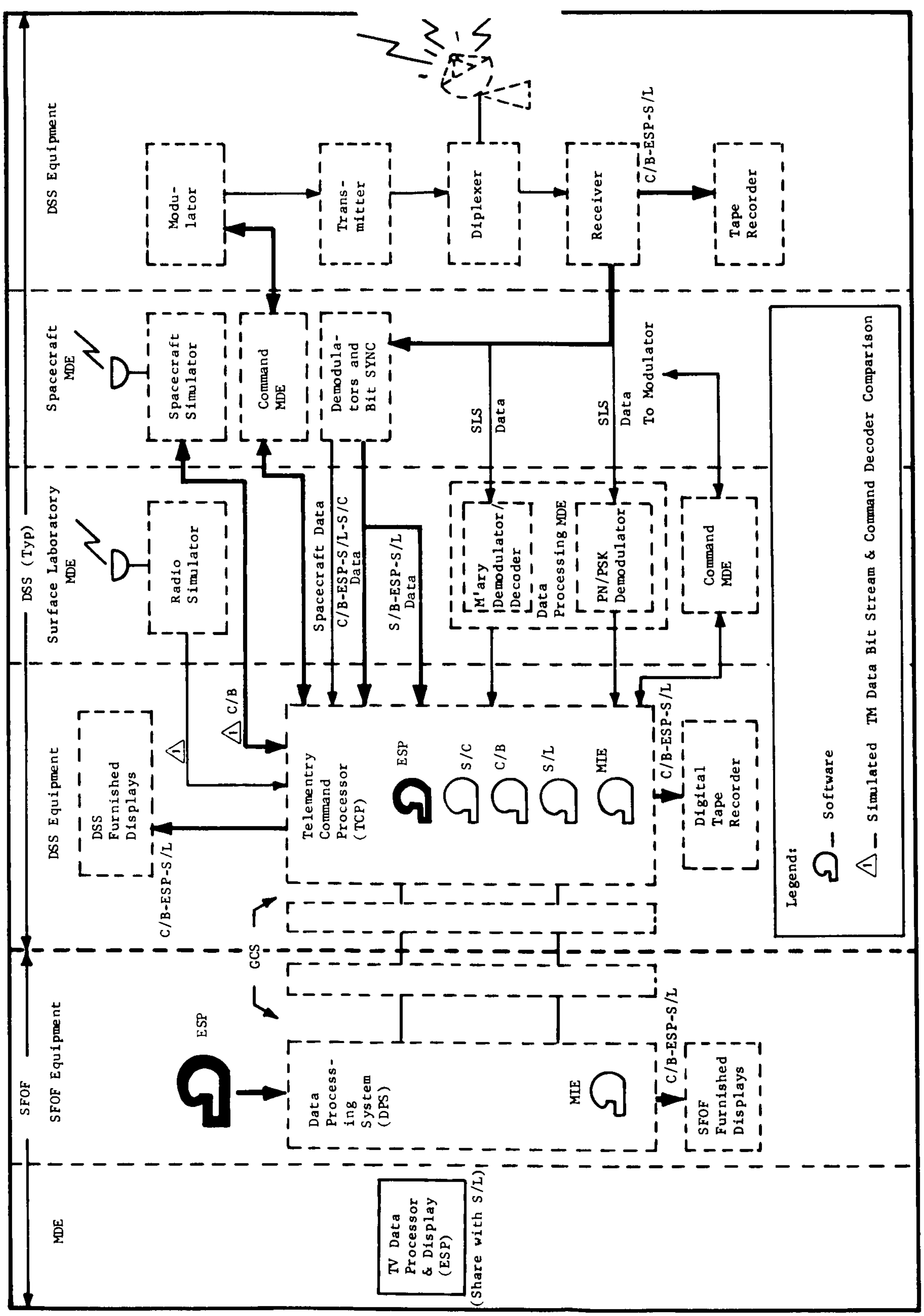


Fig. 1.2-5 Entry Science Package MDE Implementation

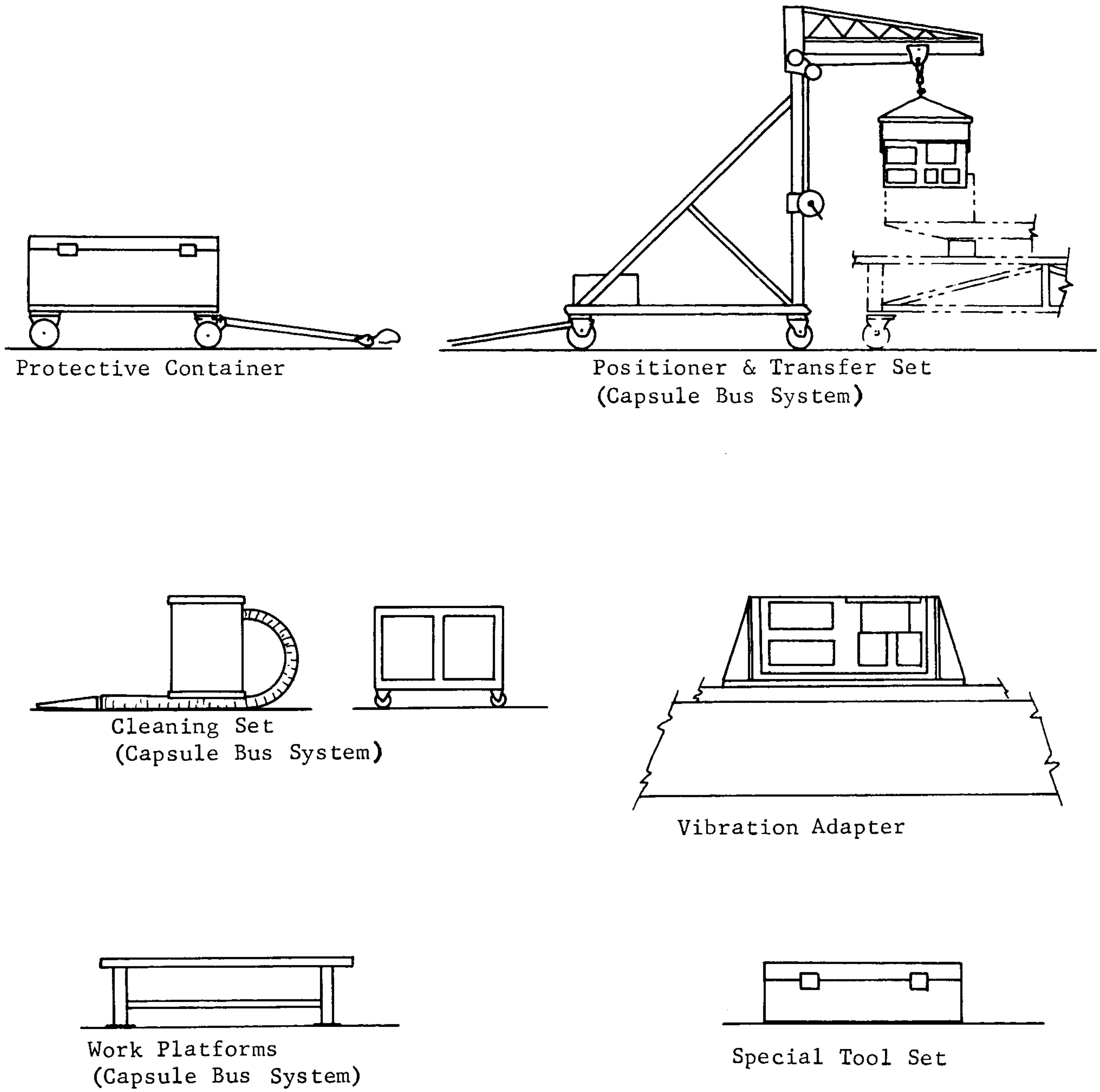


Fig. 1.2-6 Entry Science Package Assembly, Handling, and Shipping Equipment

1.3 Requirements and Analysis

1.3.1 OSE System Analysis

During Phase B, Voyager Program requirements were evaluated to determine those factors that significantly effect OSE selection and preliminary design. The following paragraphs identify the analyses performed to establish configuration selections.

1.3.1.1 Flight System Requirements

The primary requirement imposed on OSE is for support of the flight systems and subsystems during the development, qualification, and operational phases of the program. Support includes tasks necessary to service, test, operate, monitor, maintain, and handle flight equipment safely and effectively. Flight system and subsystem requirements fall into two categories: those that impose functional requirements on OSE; and those that constrain OSE because of physical characteristics.

Functional Requirements - Analysis of flight system requirements imposes the following general requirements on OSE:

1) OSE must support flight subsystem and system development, qualification, and acceptance tests
2) OSE must provide capability for acquiring, processing, distributing and displaying all flight subsystem data links. This includes a variety of telemetry data links, each with variable formats and bit rates, and various analog, discrete, and digital signals available via direct access and umbilical connections
3) OSE must support isolation of malfunctions to the replacement assembly level
4) All alternative modes must be verified in simulated mission sequences
5) Integrated assembly tests are required to verify interfaces
6) Planetary Vehicle-Deep Space Network compatibility tests are required
7) Flight telemetry data must provide the primary data channels for monitoring of flight system performance. Direct access and umbilical monitoring is required where telemetry channels are lacking or sampling rates are insufficient to provide the necessary performance data

8) Since the Capsule Bus flight sequencer provides the basic stimuli for Entry Science Package/Capsule Bus flight system testing, OSE must include provisions for loading and verification of time-compressed simulated mission test sequences, special checkout routines, and actual flight mission programs

9) Monitors and safing controls are provided as hardlines for all critical functions that are hazardous to equipment or personnel.

Physical Constraints - The physical configuration of the Flight Capsule design imposes many constraints on the OSE. One of the most significant constraints is due to the requirement to encapsulate the entire Flight Capsule in a sterilization canister. This encapsulation severely restricts access to the flight subsystems by limiting the number of canister penetrations to only those that are absolutely mandatory. Access provisions are further limited by the number of separation planes required for segmentation of the Capsule during the various mission modes. Separation planes constrain access by limiting the number and types of functions carried across the interface because of reliability considerations.

Prior to encapsulation of the Capsule, no significant constraints on access exist. However, some tests, such as thermal vacuum, require direct access restriction because of canister implacement and thermal isolation factors.

Access to the Capsule is achieved by direct access and umbilical access. Direct access for OSE interfaces is achieved through connectors provided by flight subsystems. In most instances, these connectors are lost when the canister is installed. However, some direct access is provided for the more critical functions by routing them across the canister-adapter separation planes. This permits some degree of functional access even after encapsulation. The total post-encapsulation interface, consequently, consists of critical function monitors and controls, command hardlines, telemetry hardlines, multiplexer control and data lines, and ground power supply lines.

After post-sterilization testing, umbilical provisions are used for Flight Capsule-Spacecraft marriage tests. Only critical hazard monitor and controls are routed via the Spacecraft to the umbilicals on the Planetary Vehicle shroud. This is the total extent of the Flight Capsule umbilical access requirements with command, telemetry, and power interfaces provided by the Spacecraft through umbilical interfaces and normal flight circuitry.

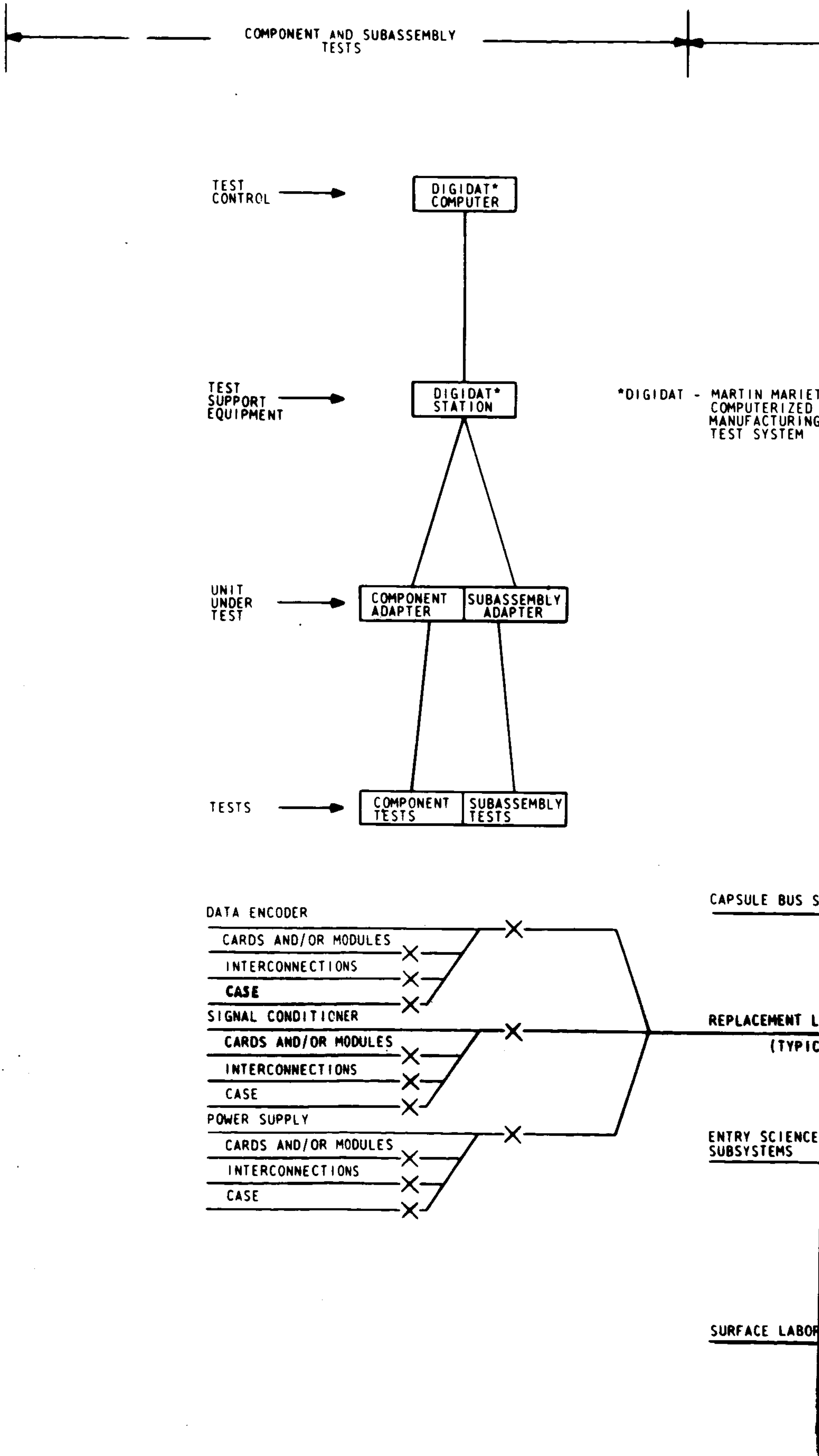
The above considerations are directly responsible for the use of onboard sequencing and telemetry as the primary test mode and impose the following additional requirements on OSE:

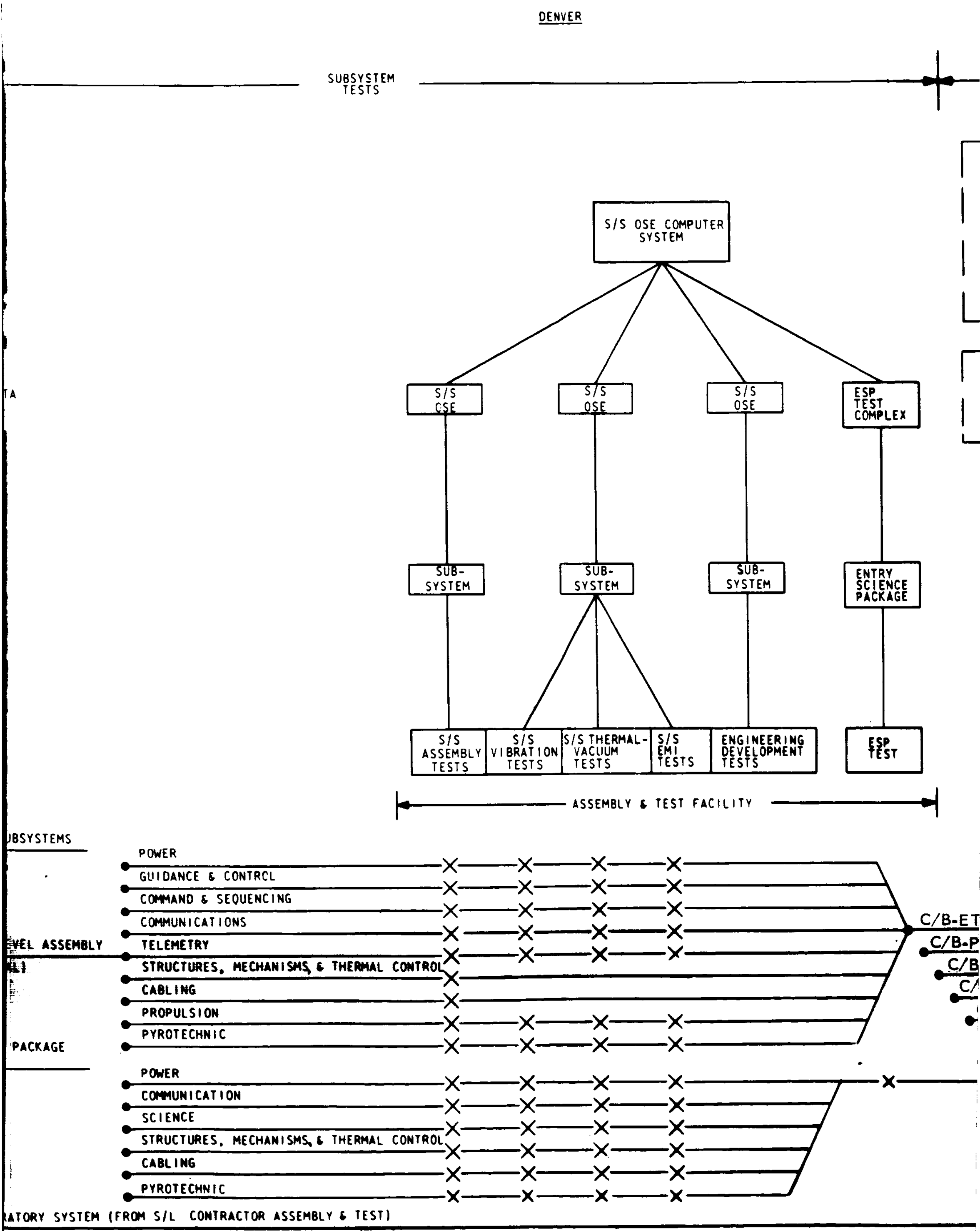
1) Preencapsulation tests use direct access provisions for functional interfaces between OSE and flight subsystems
2) Post-encapsulation tests only use direct access provisions and umbilicals available at the adapter
3) During and after Planetary Vehicle marriage tests only umbilicals are used
4) RF radiation after encapsulation is limited to radiation at reduced power levels, or radiation into dummy loads
5) No mechanisms are deployed while encapsulated
6) Such nonreversible functions as pyrotechnics are not actuated after encapsulation.

1.3.1.2 Test and Operations Flow

Analysis of the OSE test and operations support requirements is significant to the functional and physical implementation of OSE. These requirements constrain the physical and functional design of OSE configurations because support is required at a variety of facilities and at a number of different test levels. Figure 1.3-1 illustrates OSE relationships to the various test facilities and test functions. The chart flows from left to right and shows the progression of test activities for the Entry Science Package from subassembly levels through assembly as a complete Entry Science Package. It also illustrates the integration of the Entry Science Package with the Capsule Bus and the subsequent test flow through mission operations. The lower portion of the diagram shows an Entry Science Package-Flight Capsule assembly flow with the test exposures for each assembly indicated under the appropriate test blocks. OSE relationships to the unit under test and to the test blocks are shown on the upper portion of the diagram.

Starting at the left of the diagram, the first operations encountered are the manufacturing, assembly, and test operations. Tests conducted in this area are accomplished using manufacturing test tools and are confined to the component-subassembly levels.


COMPONENT AND SUBASSEMBLY TESTS
TEST CONTROL
DIGIDAT* COMPUTER
TEST SUPPORT EQUIPMENT
DIGIDAT* STATION
*DIGIDAT - MARTIN MARIET
COMPUTERIZED
MANUFACTURING
TEST SYSTEM
UNIT UNDER TEST
COMPONENT ADAPTER
SUBASSEMBLY ADAPTER
TESTS
COMPONENT TESTS
SUBASSEMBLY TESTS
DATA ENCODER
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
SIGNAL CONDITICNER
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
POWER SUPPLY
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
CAPSULE BUS S
REPLACEMENT L
(TYPIC
ENTRY SCIENCE
SUBSYSTEMS
SURFACE LABOR



DENVER
SUBSYSTEM TESTS
S/S OSE COMPUTER SYSTEM
S/S CSE
S/S OSE
S/S OSE
ESP TEST COMPLEX
SUB-SYSTEM
SUB-SYSTEM
SUB-SYSTEM
ENTRY SCIENCE PACKAGE
S/S ASSEMBLY TESTS
S/S VIBRATION TESTS
S/S THERMAL-VACUUM TESTS
S/S EMI TESTS
ENGINEERING DEVELOPMENT TESTS
ESP TEST
ASSEMBLY & TEST FACILITY
TA
JBSYSTEMS
POWER
GUIDANCE & CONTROL
COMMAND & SEQUENCING
COMMUNICATIONS
TELEMETRY
STRUCTURES, MECHANISMS, & THERMAL CONTROL
CABLING
PROPULSION
PYROTECHNIC
EVEL ASSEMBLY
PACKAGE
POWER
COMMUNICATION
SCIENCE
STRUCTURES, MECHANISMS, & THERMAL CONTROL
CABLING
PYROTECHNIC
C/B-ET
C/B-P
C/B
C/
ATORY SYSTEM (FROM S/L CONTRACTOR ASSEMBLY & TEST)

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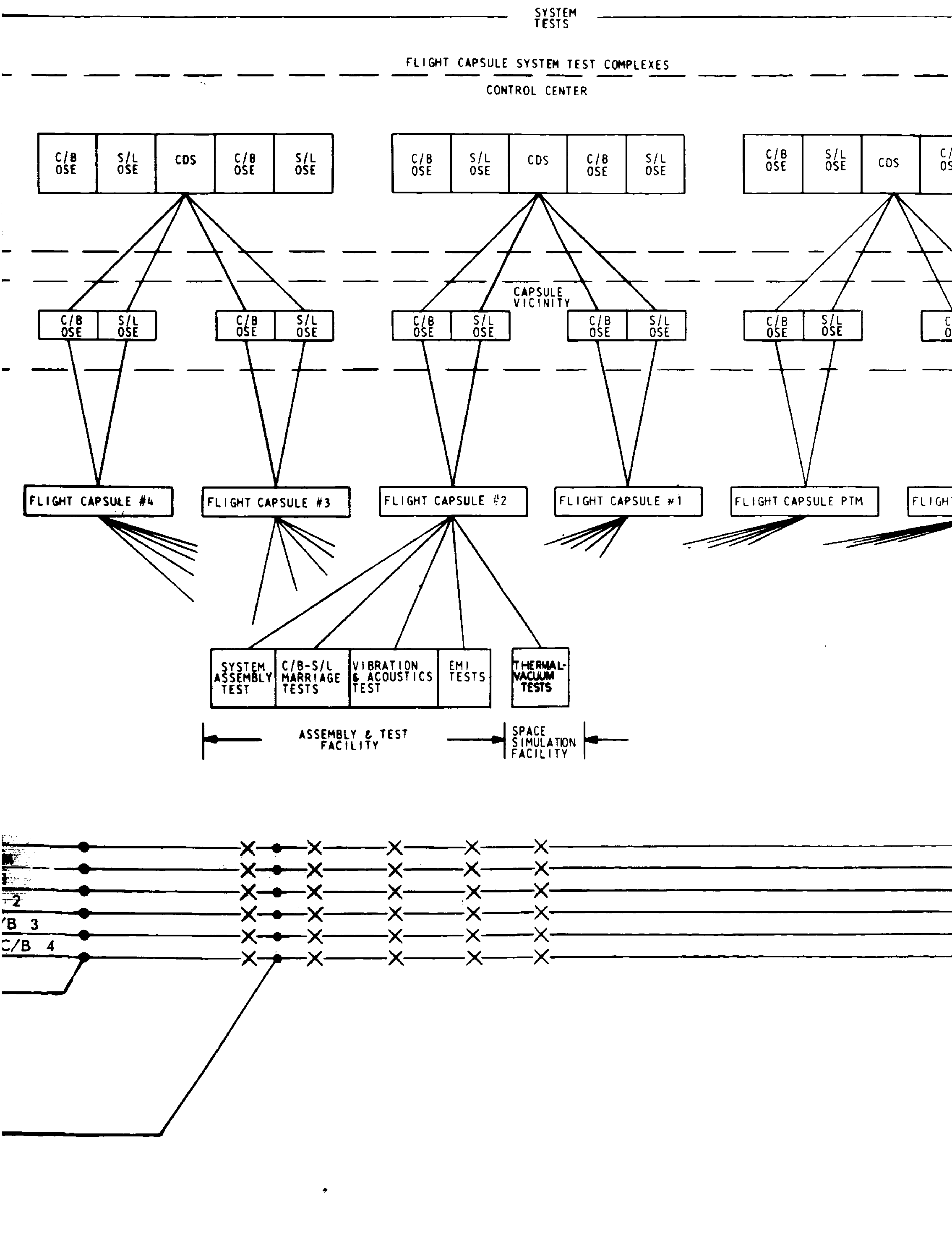


SYSTEM TESTS
FLIGHT CAPSULE SYSTEM TEST COMPLEXES
CONTROL CENTER
C/B OSE
S/L OSE
CDS
CAPSULE VICINITY
FLIGHT CAPSULE #4
FLIGHT CAPSULE #3
FLIGHT CAPSULE #2
FLIGHT CAPSULE #1
FLIGHT CAPSULE PTM
SYSTEM ASSEMBLY TEST
C/B-S/L MARRIAGE TESTS
VIBRATION & ACOUSTICS TEST
EMI TESTS
THERMAL-VACUUM TESTS
ASSEMBLY & TEST FACILITY
SPACE SIMULATION FACILITY
C/B 3
C/B 4

1-20-3

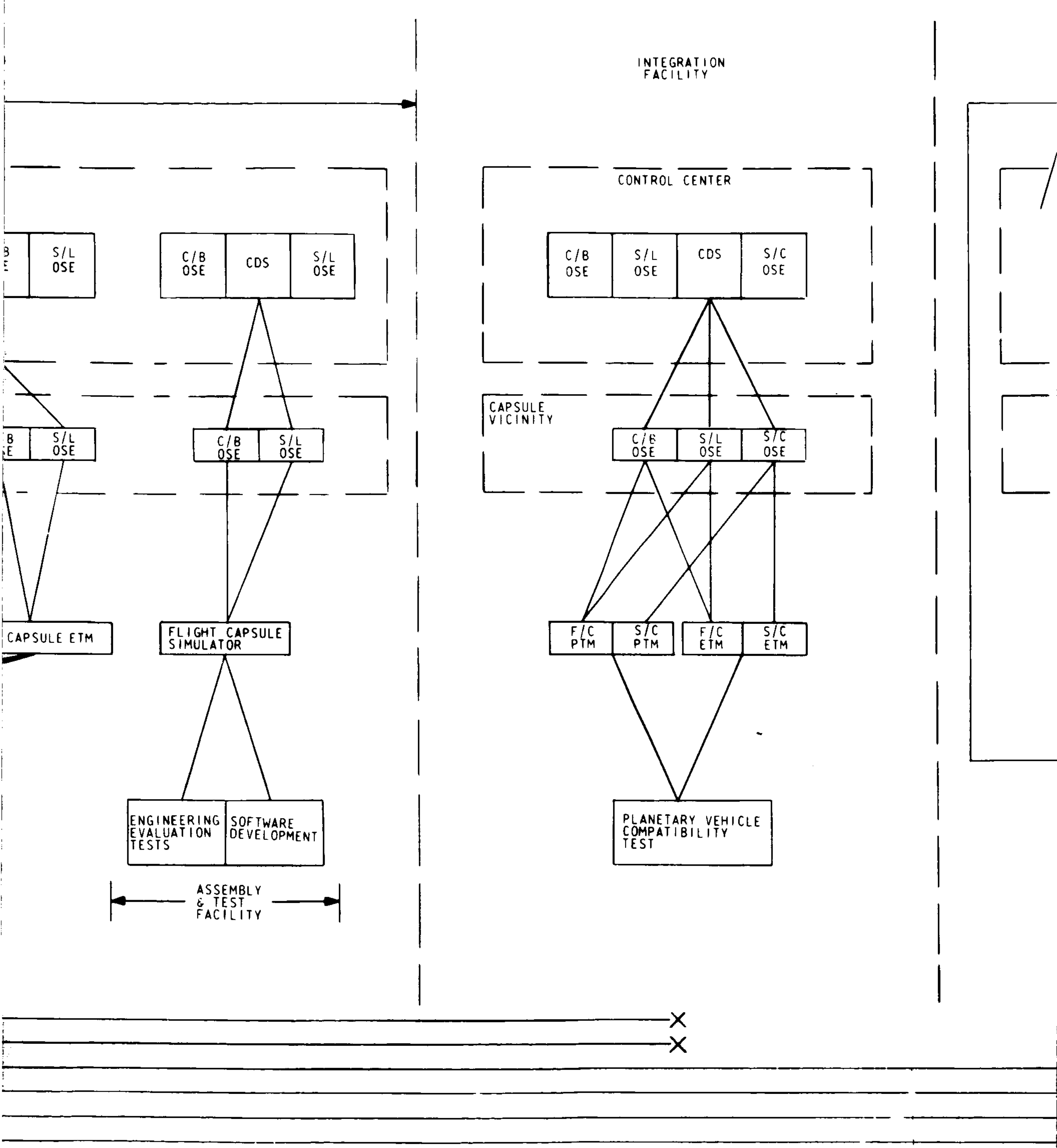
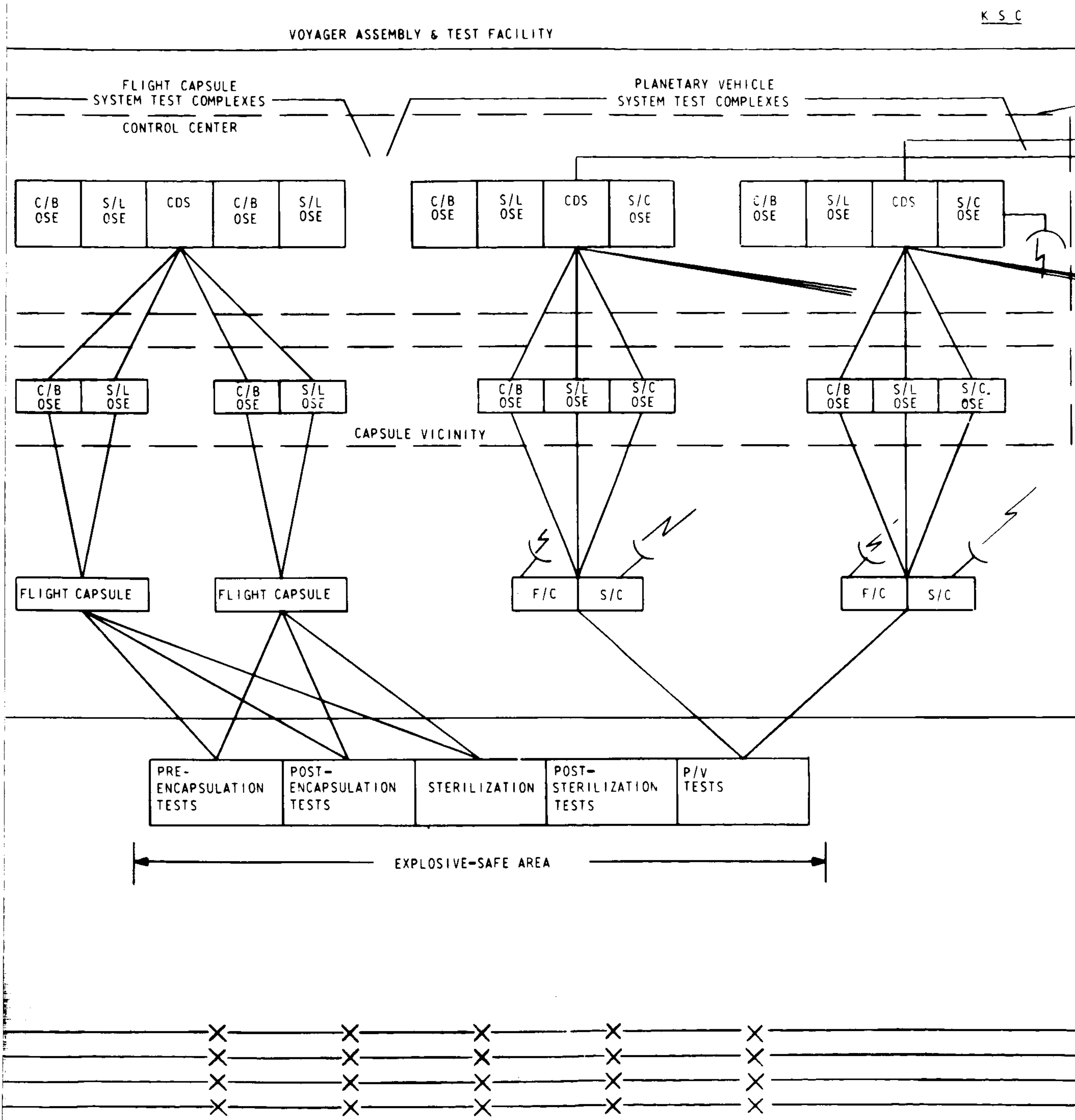
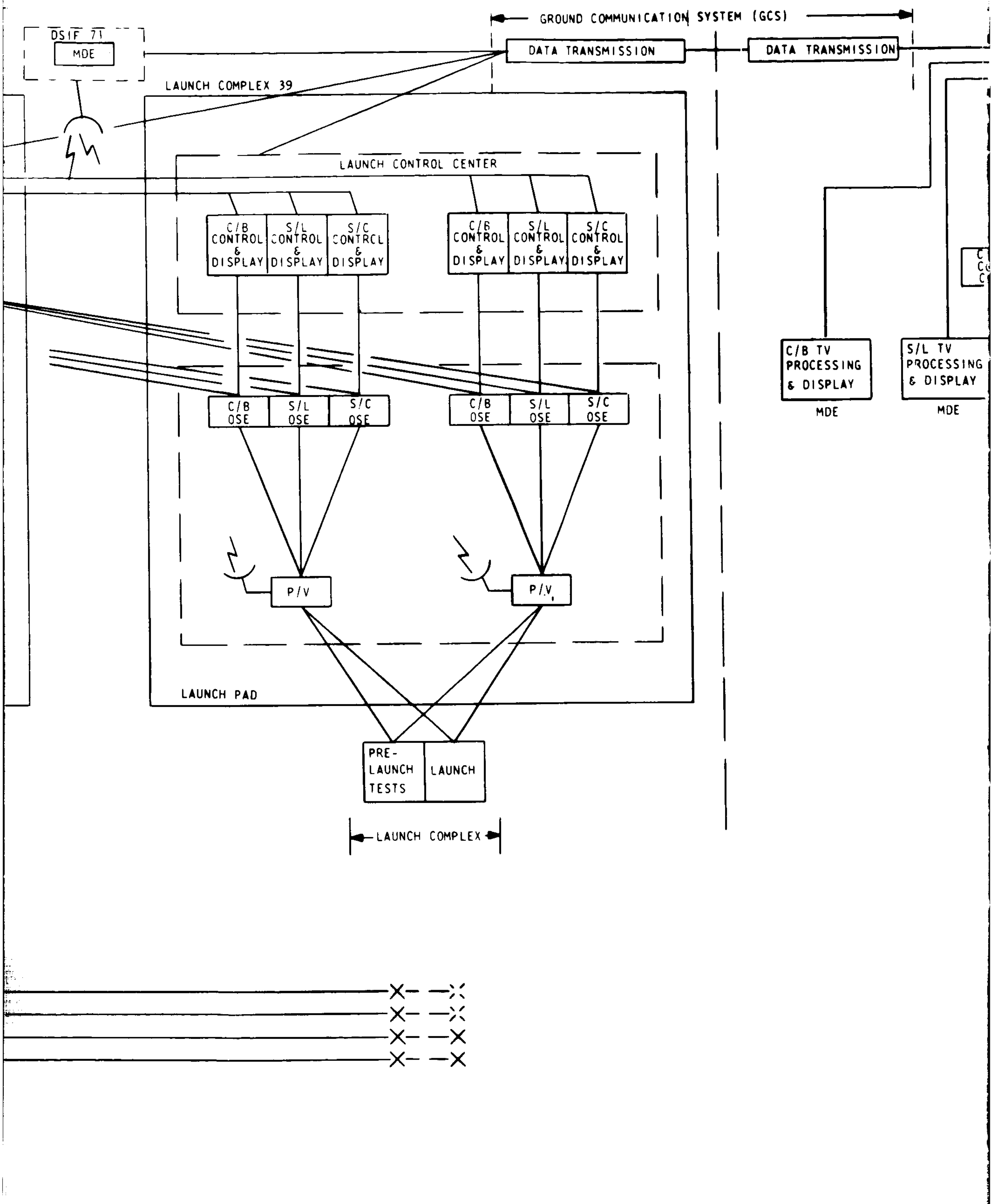


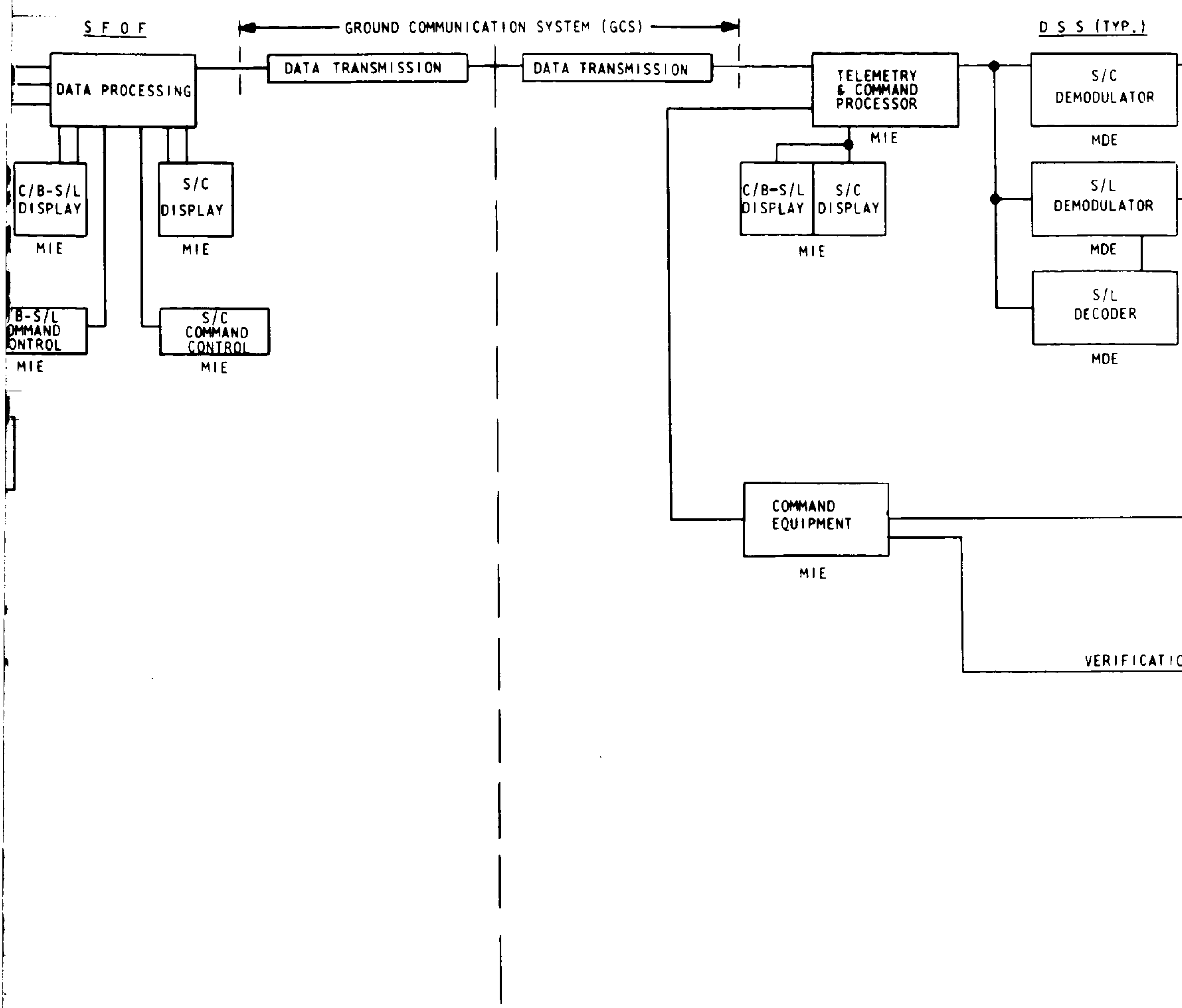
Fig. 1.3-1 Capsule Bus/



'Flight Capsule Test Flow Diagram

1-20-5


GROUND COMMUNICATION SYSTEM (GCS)
DSIF 71
MDE
DATA TRANSMISSION
DATA TRANSMISSION
LAUNCH COMPLEX 39
LAUNCH CONTROL CENTER
C/B CONTROL & DISPLAY
S/L CONTROL & DISPLAY
S/C CONTROL & DISPLAY
C/B CONTROL & DISPLAY
S/L CONTROL & DISPLAY
S/C CONTROL & DISPLAY
C/B TV PROCESSING & DISPLAY
MDE
S/L TV PROCESSING & DISPLAY
MDE
C/B OSE
S/L OSE
S/C OSE
C/B OSE
S/L OSE
S/C OSE
P/V
P/V
LAUNCH PAD
PRE-LAUNCH TESTS
LAUNCH
LAUNCH COMPLEX


S F O F
GROUND COMMUNICATION SYSTEM (GCS)
D S S (TYP.)
DATA PROCESSING
DATA TRANSMISSION
DATA TRANSMISSION
TELEMETRY & COMMAND PROCESSOR
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S/C DEMODULATOR
MDE
C/B-S/L DISPLAY
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S/C DISPLAY
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C/B-S/L DISPLAY
S/C DISPLAY
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S/L DEMODULATOR
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S/L DECODER
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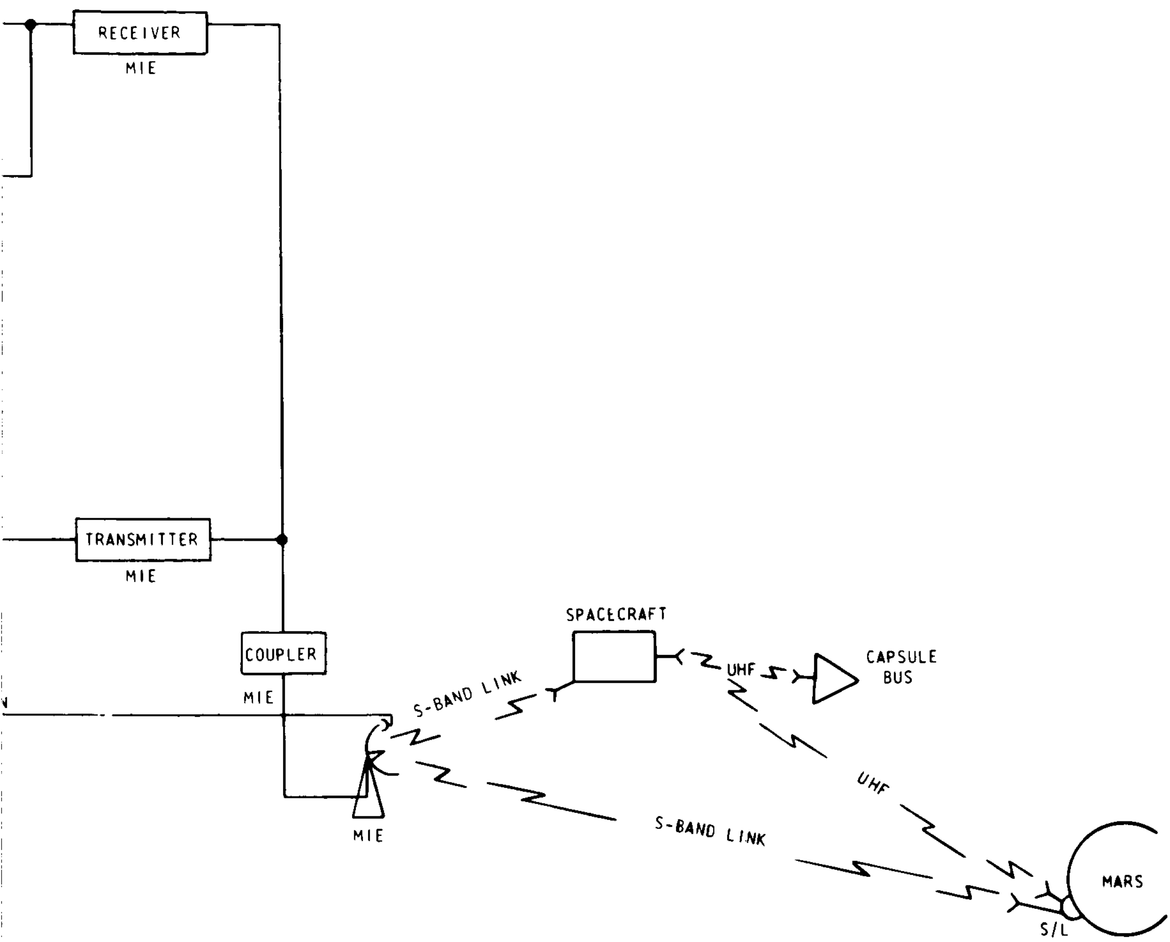
RECEIVER
MIE
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MIE
SPACECRAFT
S-BAND LINK
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CAPSULE
BUS
UHF
S-BAND LINK
MARS
S/L

Components and subassemblies from the manufacturing area, or from outside vendors, are next assembled into assembly/replacement level packages. These packages are, wherever possible, subsystem peculiar. They undergo a series of tests at this level that are designed to assure complete functional and environmental compatibility before assembly as an Entry Science Package. Should there be more than one replacement level assembly per subsystem, each replacement level assembly is environmentally tested individually, with integrated subsystem functional tests conducted before and after the environmental tests. It is the task of the subsystem OSE to support these tests and the additional engineering development and evaluation tests.

When subsystem tests are complete the Entry Science Package subsystems are married and Entry Science Package system tests performed. When tests at this level are complete, the Entry Science Package is integrated with the Capsule Bus for further testing at the Flight Capsule level using the Capsule Bus STC. The Flight Capsule tests are conducted in several distinct areas. Assembly, ambient system, EMI, and vibration tests are conducted in the Spacecraft Assembly and Test Building. Space simulation thermal-vacuum tests are conducted in the Space Simulation Facility. The first flight systems through this flow are the engineering test model (ETM) and proof test model (PTM). These vehicles provide development and qualification assurance testing to more stringent levels than required for flight systems.

In addition to the flight system tests, OSE engineering evaluation tests are conducted using a flight system simulator. These tests verify OSE designs and flight system compatibility. With these tests, and as a continuing follow-on activity, computer programing is developed and verified for the STC computer systems. These activities are supported by System Test Complexes.

After completion of Denver ETM and PTM tests, these vehicles are transported to an integration facility for Planetary Vehicle compatibility tests with the Spacecraft system. These tests are also supported by System Test Complexes.

After completion of Denver test activities, Flight Capsule systems are shipped to Kennedy Space Center (KSC) for prelaunch operations. These operations, supported with System Test Complexes, include encapsulation, sterilization, and Planetary Vehicle marriage. These test activities also include open-loop RF radiation tests to assure compatibility between Planetary Vehicle communication systems and DSIF-71 and verify compatibility with the Deep Space Network.

The final portion of Fig. 1.3-1 portrays overall relationships between the flight systems and the ground monitoring facilities. These facilities provide command, tracking, and data acquisition services for mission operations. The Deep Space Stations (DSS) provide the RF communication links with the flight systems while mission control is exercised from the Space Flight Operations Facility (SFOF). The Ground Communication System (GCS) provides the communication channels to link these facilities together on a common network. MDE is supplied, if required, to supplement MIE capabilities existing at these facilities to satisfy the Voyager mission-peculiar functions.

The test and operations flow imposes the following requirements on OSE:

1) Subsystem OSE is required to support all development and qualification tests for the flight subsystems. To perform this task, the subsystem OSE must be designed with sufficient versatility and flexibility to accomplish -
   a) Flight acceptance testing of replacement level subsystem assemblies
   b) Flight acceptance testing of assembled subsystems
   c) Development and qualification (type assurance) testing at each of the above levels
   d) Testing at various locations. This requires that OSE be capable of being readily relocated from test area to test area
2) A test complex is required to support tests at the Entry Science Package level
3) The Capsule Bus STC is required to support testing of the Entry Science Package at the Flight Capsule level. To accomplish this, the integrated Entry Science Package/Capsule Bus STC design must include provisions for -
   a) Centralization of STC control center equipment (including the computer data system) to limit the number of intrafacility relocations of this equipment
   b) Digital data transmission links between STC control center OSE and Capsule-vicinity OSE
   c) Transportability of all STC equipment between test facilities such as Denver and KSC
   d) Transportability for intrafacility relocations of Capsule-vicinity STC equipment
   e) Test or facility-imposed unique functional differences between test locations

4) Launch Complex Equipment (LCE) is required to support all test operations and monitoring activities at the launch complex. The Capsule Bus LCE and STC is required to support Entry Science Package launch operations

5) Capsule Bus Assembly, Handling, and Shipping Equipment (AHSE) is required to -

   a) Transport and handle the Entry Science Package elements within and between test facility locations

   b) Transport and handle OSE within and between test facility locations.

1.3.1.3 Facility Considerations

Two facilities of interest for the Entry Science Package and Flight Capsule System are Denver and KSC.

The physical locations of Denver facilities are as shown in Fig. 1.3-2. The facilities planned for assembly and test of the Entry Science Package and Flight Capsule include the Electronic Manufacturing Facility, the Manufacturing Assembly Building, the Spacecraft Assembly and Test Building, and the Space Simulation Facility.

OSE functional support is required in the last two facilities where subsystem and system assembly and test operations are conducted. The Spacecraft Assembly and Test Building contains assembly and test capabilities within one integrated facility. This arrangement permits the permanent installation of most OSE in this building. Only STC Capsule-vicinity OSE is required to support Flight Capsule tests at the Space Simulation Facility since digital data links provide the necessary data channel interfaces between these facilities.

The locations of existing and planned KSC facilities are illustrated in Fig. 1.3-3. These facilities include the Launch Complex 39 launch pads and Launch Control Center areas, Voyager Assembly and Test Facility, and DSIF-71.

The location for the Voyager Assembly and Test Facility is assumed to be in the NASA Merritt Island Industrial Area, which appears to offer significant advantages in terms of the available support that can be derived from within the existing complex. It is assumed further that this building provides an integrated facility for both Spacecraft and Flight Capsule operations and includes space provisions for the Systems Test Complexes.

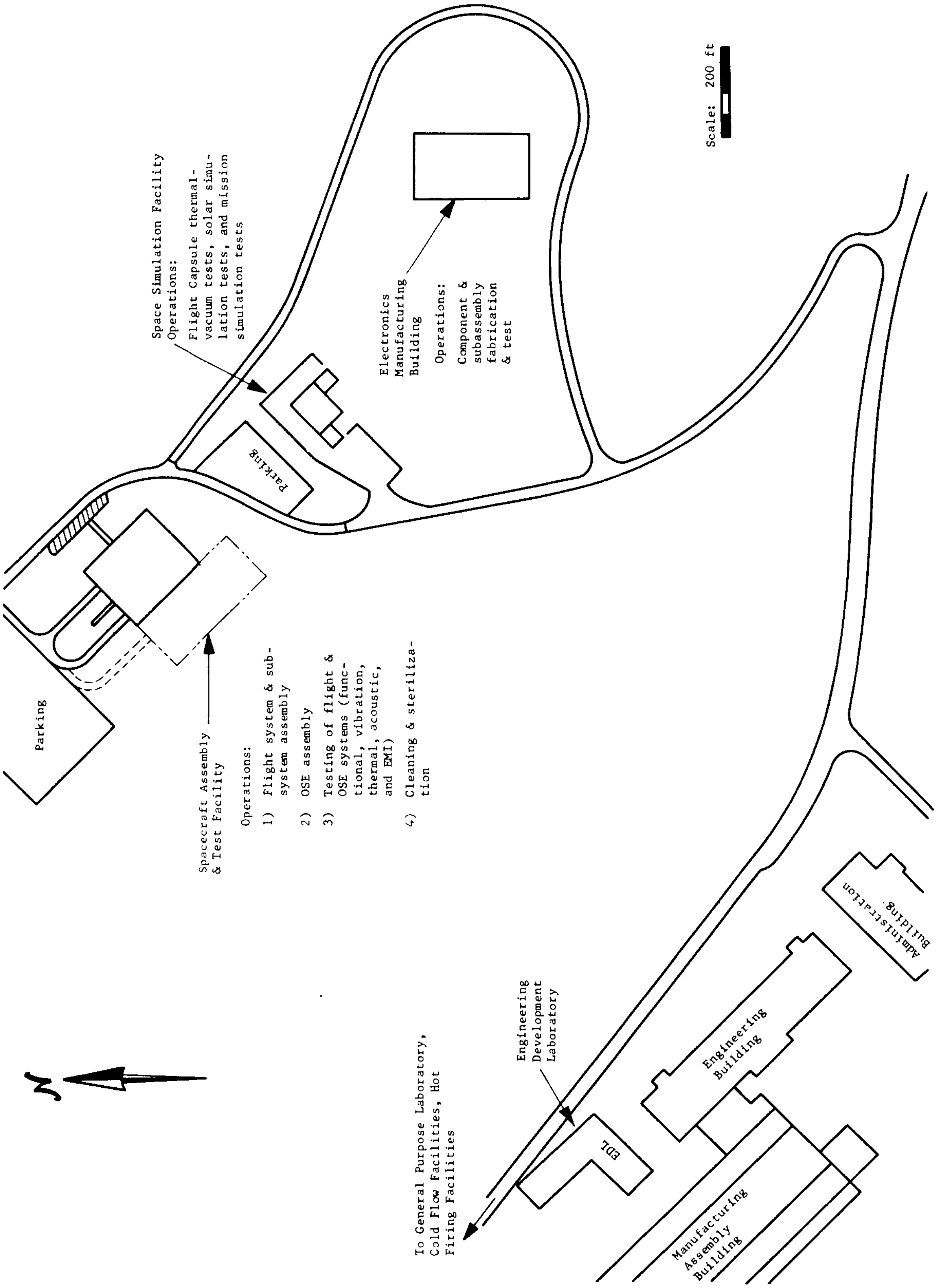


Fig. 1.3-2 Voyager Program Denver Facilities

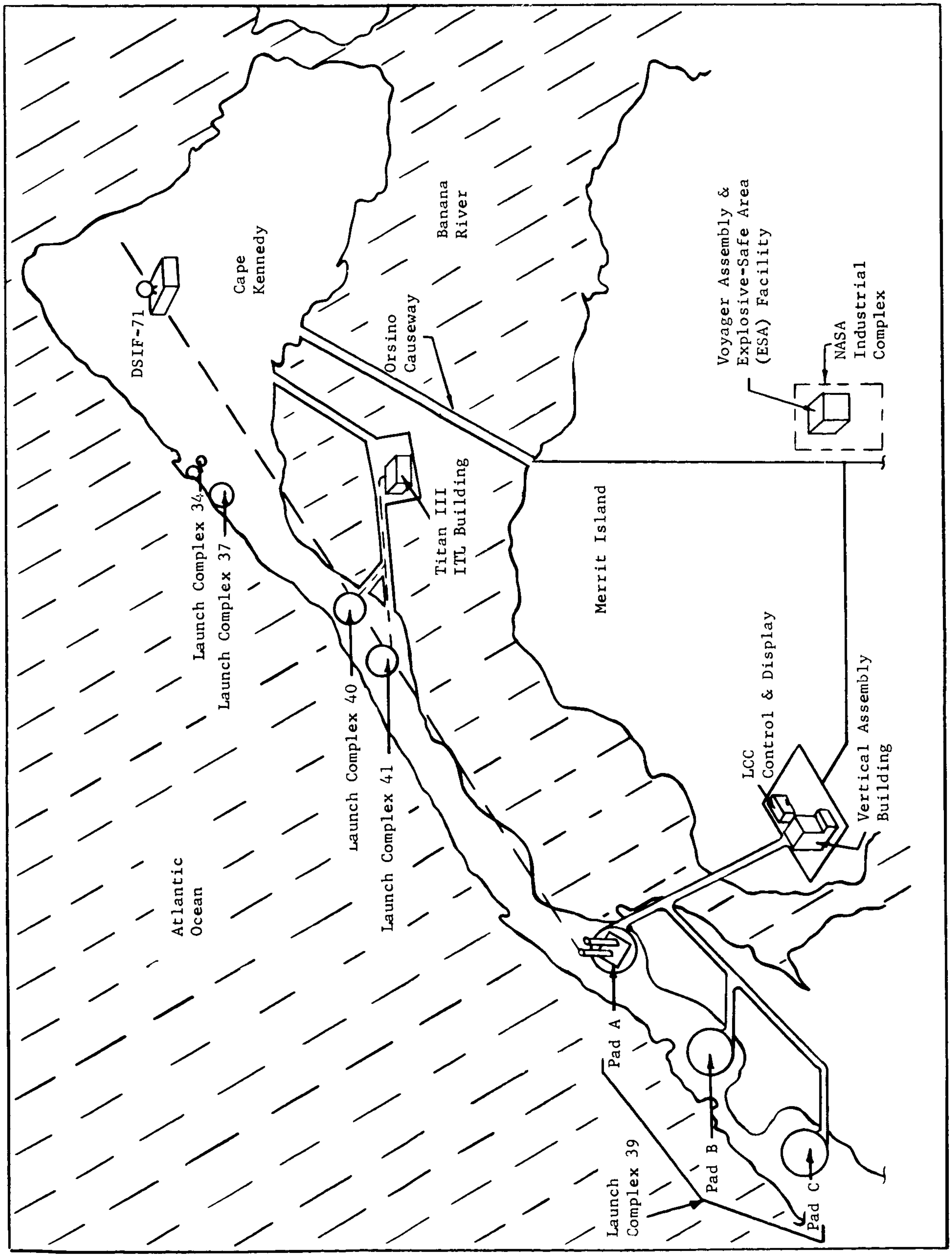


Fig. 1.3-3 Voyager Program KSC Facilities

The Launch Complex 39 launch pad and Launch Control Center areas are used for Voyager prelaunch and launch operations. Because of the amount of Saturn equipment located in each of these areas, space is assumed to be a constraining factor. Therefore, the use of A2A data links between these areas and the STC and an integrated Entry Science Package/Capsule Bus LCE design must be considered to reduce the amount of LCE.

The Deep Space Station (DSIF-71) provides command, tracking, and data acquisition and processing functions during the initial phases of mission operations. The interface between this and other KSC Voyager facilities is by open-loop RF radiation. Prelaunch activities requiring open-loop transmission from both the Voyager Assembly and Test Building and the launch pad are necessary. Line-of-sight provisions are therefore required between these areas. Based on these facility considerations, the following additional requirements are imposed on OSE:

1) Transportability of OSE is required to support relocations between Denver and KSC and to a lesser extent to support operations within these facilities
2) Digital data links are required to connect remote areas
3) Line of sight between DSIF-71 and the Planetary Vehicle is required for open-loop RF tests from the Voyager Assembly and Test Building and the launch pad
4) The amount of LCE must be minimized because of limited space provisions.

1.3.2 Trade Studies

Several of the more important design features were selected for additional detailed analysis and evaluation of tradeoff alternatives. These design features pertained primarily to various configuration selections and were formalized in trade study reports identified in subsequent sections of this document.

1.3.3 Problem Areas

DSN capabilities for the Voyager mission must be clearly defined before MDE can be realistically specified. Areas of potential functional integration must be examined in detail after selection of Voyager system configurations and contractors. Coordination of contractor designs will establish the required DSN interfaces that can then be evaluated in terms of proposed capabilities. The areas that must be examined are signal demodulation, data decommutation and decoding, command generation and verification, display, and recording.

2. SUBSYSTEM OSE

2.1 General Requirements and Concepts

Functional requirements for subsystem OSE are specified in the Voyager Capsule Systems Constraints and Requirements Document, SE003BB002-2A21. Additional requirements are specified here.

2.1.1 Subsystem OSE Configurations

Subsystem OSE configurations defined in this subsection are based on the following considerations:

1) Flight subsystem definitions and functional test requirements
2) Flight subsystem replacement levels
3) Flight subsystem spares levels.

2.1.1.1 Flight Subsystems

The Entry Science Package includes power; pyrotechnics; entry science; communications (UHF); structures, mechanisms, and thermal control; and cabling functional subsystems. Subsystem OSE is provided to support development, qualification, and acceptance testing of each of these subsystems.

2.1.1.2 Flight Subsystem Replacement Levels

Replacement levels are defined as the operational spares level for the ESP. They represent the packaged assembly level at which acceptance tests are conducted and at which installation assembly and malfunction isolation and replacement are implemented for the Entry Science Package. The STC is required to isolate malfunctions to the replacement level during system testing. Subsystem OSE test sets are required to support development, qualification, and acceptance tests at the replacement level. If more than one replacement assembly is required for an individual flight subsystem, the test sets support these replacement levels both separately and together as a complete subsystem.

2.1.1.3 Flight Subsystem Spares Level

Flight subsystem spares levels are defined essentially as the depot or factory repair level of spares. They are those subassembly spares that are provided to support repair of the replacement level assemblies. These spares are acceptance tested in dummy replacement level assemblies. Subsystem test sets to support acceptance testing at replacement levels are also required to support acceptance tests at the spares level. These same test sets are capable of isolating malfunctions to the spares level during test of replacement assemblies.

2.1.2 Subsystem OSE Use of Computers

2.1.2.1 General Requirements

The concept of testing all flight subsystems by using general purpose computers imposes the following general requirements on subsystem OSE:

1) Time-sharing of larger centrally located computer systems by subsystem test sets is necessary to minimize the total number of computer systems required
2) Computer central processors identical to or compatible with the type selected for STC are necessary to provide maximum compatibility of software design for subsystem OSE and STC tests. This permits maximum flexibility of computers since STC computer systems may also be used to support flight subsystem testing during peak testing periods
3) Computer support is provided for various subsystem test operations at the Entry Science Package/Capsule Bus contractor and subcontractor facilities
4) "Minimum" computer systems are used by subcontractors in the interest of reducing costs. Minimum system is defined as minimum computer memory, input/output, and peripheral equipment required to support subsystem test activities.

2.1.2.2 Functional Requirements

Flight subsystem development, qualification, and acceptance tests are performed by subsystem OSE test sets under control of a general-purpose digital computer system. The subsystem OSE computer system provides test sequence control, and data acquisition, processing, and display functions for the subsystem OSE test sets. The subsystem test sets include the necessary interfacing equipment to perform the above functions by the computer system. To assure maximum cost effectiveness and correlation of data for all subsystem and system level tests, standard equipment is used by all subsystem OSE test sets for flight subsystem and computer interfaces.

Standard computer test stations are permanently located at designated test areas and are used with the various test sets to test flight subsystems. Testing is performed by the computer system and the subsystem test sets in real-time and on a time-sharing basis between the various test stations. The overall concept is illustrated in Fig. 1.2-1.

2.1.3 Subsystem OSE Test Set Mobility

Subsystem OSE test sets are designed for mobility to facilitate relocation from one computer test station to another.

2.1.4 Unique Subsystem OSE Stimulus and Data Acquisition Equipment

Subsystem OSE designs include unique computer data acquisition and stimulus generation equipment required in the STC to perform automated testing. Unique computer data acquisition and stimulus generation functions are defined as those functions that cannot be performed by standard equipment.

2.1.5 Subsystem OSE Packaging

Unique portions of subsystem OSE (e.g., RF signal generators and receivers) required in the STC are packaged in modules so that these modular units can be readily incorporated in the STC on a selective basis. Modular units may include chassis and even complete rack assemblies, if an efficient and cost-effective packaging approach is permitted for the STC.

2.1.6 Subsystem OSE Displays

Subsystem OSE test set displays are provided in a manner best suited to their individual needs, except that displays of common design are used for those functions that must also be displayed in the STC.

2.2 Subsystem OSE Computer Systems

2.2.1 Requirements and Constraints

The subsystem OSE computer system provides:

1) Complete functional testing of the various flight subsystems when used with appropriate subsystem test sets
2) Central control of the various subsystem test sets invididually or simultaneously through complete or selected portions of a subsystem test. Simultaneous testing of flight subsystems of the same or different designs is provided
3) Safeguards to prevent damage to subsystems because of improper sequencing of test steps
4) Capability for issuing coded commands to the subsystem test sets for varying subsystem test parameters for performance testing
5) Man/machine interfaces with the computer to effect command/control and intervention of tests as required
6) Man/machine interfaces with the computer for call-up of subsystem test programs stored in computer memory
7) Acquisition, processing, distribution, and display of flight subsystem and subsystem OSE data for real-time and nonreal-time analysis
8) Man/machine interface with the computer for display of data and call-up of stored data
9) Hard copy printouts of data restricted to only necessary information required for real-time evaluation of the subsystem under test. Data display suppression, data averaging, and alarm monitoring are provided
10) Capability for playing back previously recorded data for post-test analysis and evaluation
11) A central test recording and test log which includes -
    a) Identification of the flight subsystem under test and accumulated operating times
    b) Identification of tests performed, procedures in use, and step numbers
    c) Identification of data and time of tests
    d) A complete record of test data
    e) Capability for recording subsystem test data
12) Automatic detection alarm and interruption for abnormal subsystem behavior during environmental tests (e.g., temperature, vacuum)

13) Self-check capabilities

14) Decommutation of serially coded data streams

15) Central electric power and distribution to the various elements of the computer system.

2.2.2 Preferred Preliminary Design

2.2.2.1 Subsystem OSE Computer System Definition

Analysis of requirements outlined in paragraph 2.2.1 together with analyses conducted in Phase B concluded that subsystem OSE computer systems can be shared for the Capsule Bus and Entry Science Package. The computer systems required to support the Capsule Bus and Entry Science Package are illustrated in Fig. 2.2-1 and 2.2-2. Figure 2.2-1 illustrates the system required for the Entry Science Package/Capsule Bus contractor and Fig. 2.2-2 the system required for the Entry Science Package/Capsule Bus communication (and TV) subcontractor.

The subsystem OSE computer configurations operate in a similar manner. The differences between the configurations are in the amount of bulk and core storage required, the number of test stations required, the amount and types of input/output and peripheral equipment provided, and the actual computer central processor selected. Flight subsystem complexities, quantities, and different types that must be tested at the various areas are factored into the selected configurations. For example, considerations for subcontractors indicate that generally only one or two flight subsystem types need to be supported, consequently fewer test stations, less bulk and core storage, and less pheripheral and input/output equipment are required.

The subsystem OSE computer system that supports testing of the Entry Science Package/Capsule Bus subsystems (Fig. 2.2-1) uses a computer central processor identical to the one selected for STC. This selection is made to provide software compatibility with STC and to permit the use of STC computer systems to supplement the subsystem OSE computer system during peak subsystem test periods.

The subsystem OSE computer system required for the Entry Science Package/ Capsule Bus communications (and TV) subcontractor (Fig. 2.2-2) uses a computer central processor compatible with the type selected for STC. This selection is made to provide software compatibility between subsystem OSE and STC computer systems. An STC compatible (but less expensive) processor is selected for this system rather than one identical to STC since subsystem test loads are significantly less than for the Entry Science Package/Capsule Bus contractor.

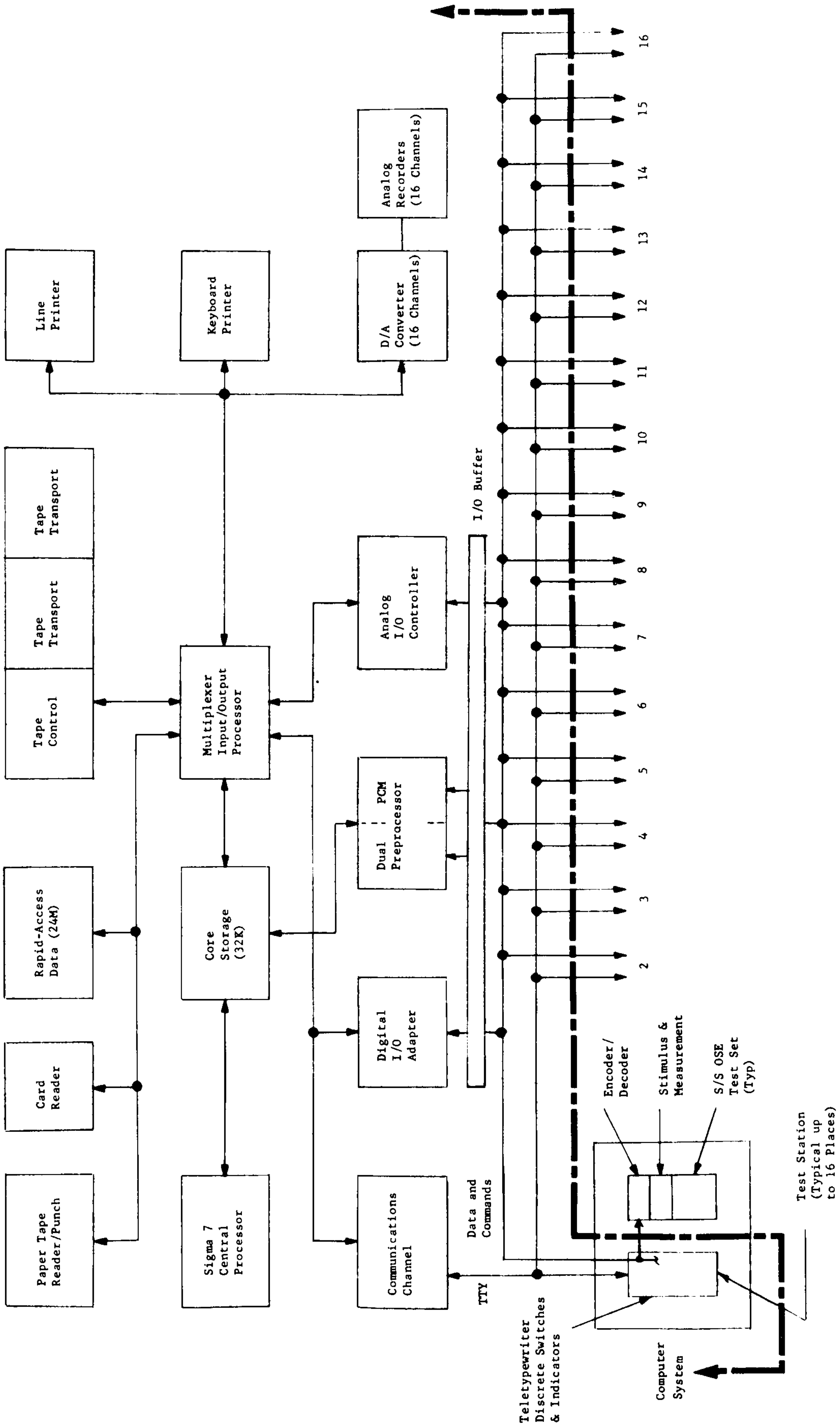


Fig. 2.2-1 Subsystem OSE Computer System Configuration

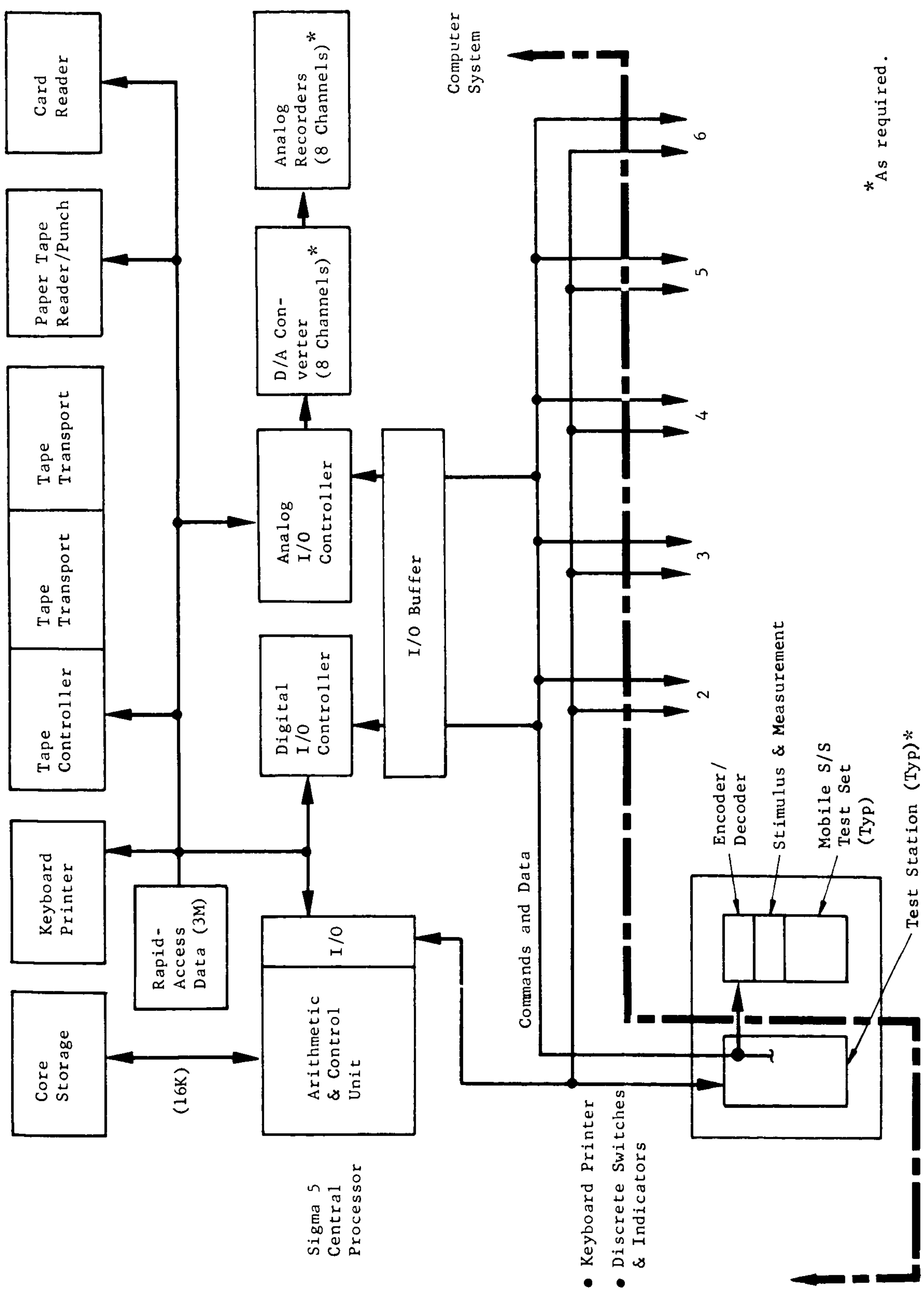


Fig. 2.2-2 Typical Subcontractor Subsystem OSE Computer System Configuration

Functional Description - The functional description in the following paragraphs is typical of the computer systems discussed above.

The subsystem OSE computer system uses a general-purpose digital computer with subsystem test sets to provide the required capability for testing various flight subsystems. The computer system provides test sequence control, data acquisition, storage, processing, and display functions for the various test sets. The test sets include all the standard and unique computer interfacing equipment for generation of stimuli and commands, and conversion of data to digital form for processing by the computer. The test set standard computer interfacing equipment includes the necessary address decoding and encoding equipment.

Testing under computer program control is performed from any of the remote test stations on operator request. Testing is in real time and on a time-sharing basis between the various stations. Off-line post-test evaluation of data can also be performed.

A time-sharing system monitor program is provided with test programs written in a test-oriented language. A translator program converts the test program language statements from punched cards or tape into computer code and stores the coded programs in bulk storage. The test programs are transferred from bulk storage to core storage from any of the test stations on operator request. The test programs are executed on operator command resulting in the issuance of commands and evaluation and display of data as appropriate. Priority interrupts are used to notify the computer system when test station data require processing by the computer. The computer system responds to the priority interrupt in accordance with the system monitor program provisions and commands the subsystem test sets located at that particular station to dump data stored in their registers into core storage. The computer then processes the data and sends results back to the test station.

Provisions are included in each computer system remote test station for command/control and intervention of tests. Discrete switches are provided for manually issuing commands to the computer systems and discrete light indicators are also included for displays. A teletypewriter is provided for each remote station for call-up of test programs, and display of anomaly data or requested data, alarm message, and instructions issued by the computer.

2.2.2.2 Physical Characteristics

A typical subsystem OSE computer system is illustrated in Fig. 2.2-3. It can be divided into three functional groups. Since these equipment groups are similar to STC, descriptions may be found in paragraph 3.2.2.1. The three groups are input/output group, central processing group, and control and display group.

The input/output group buffers and conditions the signals between the computer system and the test stations and includes the following items: communications channel, digital input/output adapter, analog input/output controller, digital-to-analog converters, and PCM preprocessor.

The central processing group operates on the incoming data after proper formatting by the input/output equipment. The central processing equipment analyzes the data, stores the results, and drives peripheral display units. The central processing equipment includes the central processor, core storage, disc storage, keyboard printer, tape control and transports, paper tape reader/punch, multiplexer input/output processor, and card reader.

The control and display group provides the man-machine interface with the computer system. It includes the line printer and analog recorders similar to those used in STC. Also included in this group is the test station control and display equipment, which consists of a teletypewriter and a standard single-bay console. The console contains discrete switches for command/control and intervention and discrete light indicators for test status as required.

2.2.2.3 Description of Interfaces

The following paragraphs identify physical and functional interfaces for the subsystem OSE computer system.

Facility Interfaces - Facility interfaces fall into three categories:

1) Space - Space provisions are required for the central computer equipment and the remote test stations
2) Environmental - A controlled environment is required for the central computer system and remote test stations
3) Power - 120/208 vac, 60 Hz, three phase and single phase for the central computer system. 120 vac, 60 Hz, single phase at each remote test station.

Subsystem OSE Test Set Interfaces - Standard provisions are included at each computer system remote test station for connection of subsystem test sets. The standard interface provisions are for routing commands from the computer system to the subsystem test set and data from the test set to the computer system.

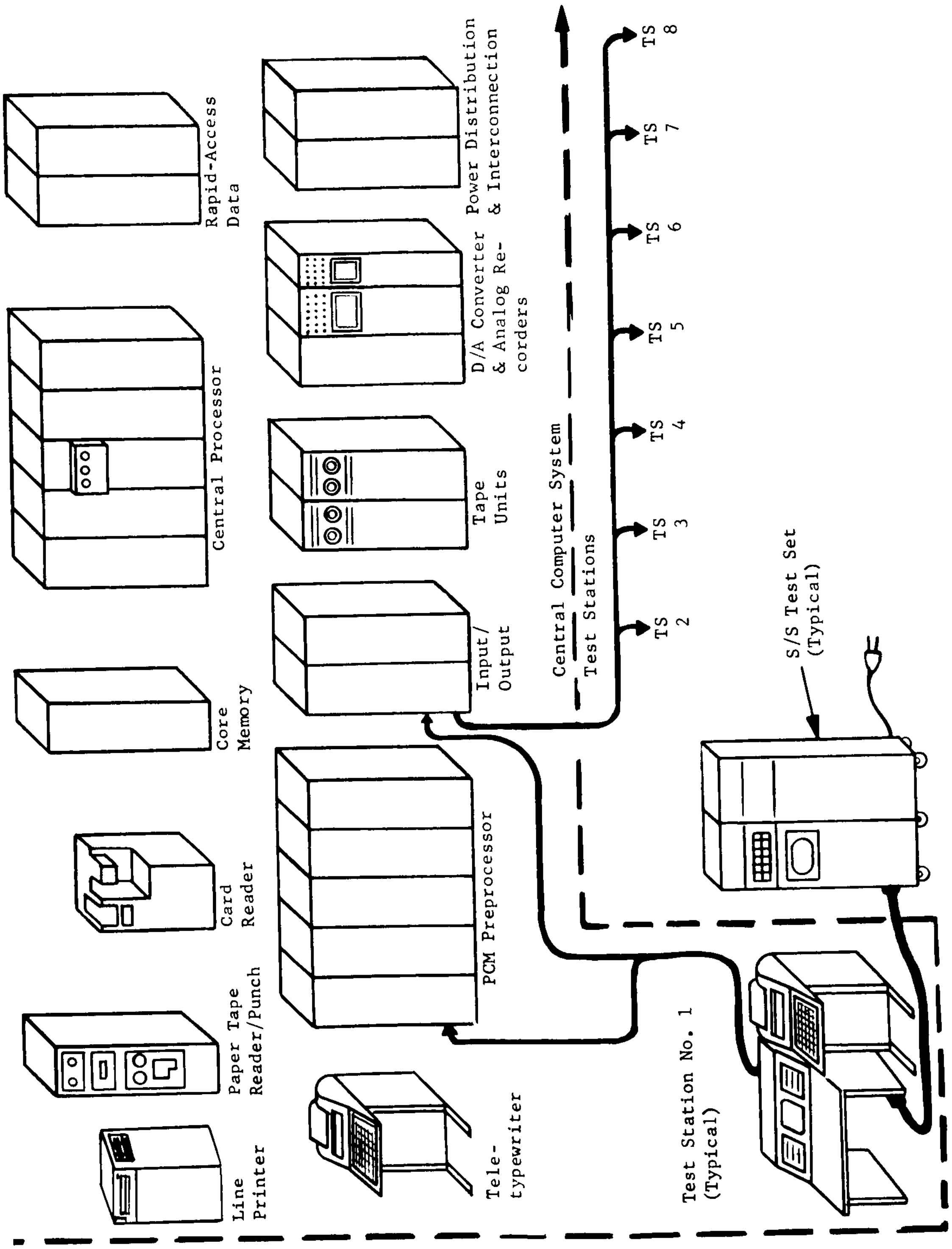


Fig. 2.2-3 Subsystem OSE Computer System

2.2.3 Subsystem Analysis and Trade Studies

The following paragraphs summarize the analyses conducted during Phase B.

The following customer-imposed requirements established the basis for evaluating the feasibility of general-purpose computer usage by subsystem OSE:

1) S/S OSE shall be capable of -
   a) "Performing all test routines expeditiously, correctly, and repeatedly."
   b) "Interfacing with a general-purpose computer system for test sequence control or direction and data acquisition and display."
2) STC shall be capable of "centrally controlling or directing the Capsule or any of its subsystems individually or in combination through a complete or selected portion of a system test by use of a general-purpose computer system."

Requirement 1)a) above implies that some form of automatic test control and evaluation of flight subsystems may be required for the more complicated subsystem OSE test sets. Since many of the subsystems are fairly complex in nature, alternative methods of automated testing were considered. The use of general-purpose computers warranted consideration as one of the alternative approaches, in light of requirements 1)b) and 2) above. Consequently, the following alternative methods of implementing test control and evaluation for the more complicated test sets were considered on an individual basis:

1) Use of small general-purpose computers as an integral part of the test sets
2) Use of tape programers and associated logic and control circuits.

The use of small computers was recommended for telemetry, science, and communications (and TV) subsystem OSE. These recommendations were based on the large quantity and variety of digital and other data that required processing.

2.2.3.1 Subsystem OSE Use of Central Computer Systems

Based on the above recommendations, the feasibility of test sets time-sharing central general-purpose computer systems was considered. This approach was considered attractive because of potential hardware and software cost savings and because it offered possibilities for testing essentially all flight subsystems with general-purpose computers. Therefore, the following alternatives were evaluated:

1) Use of STC computer systems on a shared basis (noninterference with STC)

2) Use of a number of smaller, individual STC-compatible computer systems. (A small computer system would be provided for each major subsystem and would be time-shared by a number of test sets of the same or different designs.)

3) Use of small individual computers in subsystem test sets.

Real time-sharing of STC computer systems with subsystem OSE was considered as a fourth alternative. This alternative provided the capability of simultaneous testing of Capsule systems and flight subsystems. However, it was dropped from serious consideration because of schedule problems, high cost, and risks involved in developing the more complicated software.

To maintain a consistent policy relative to use of computers for flight subsystem testing, subcontractor-furnished equipment was also considered. The recommendation resulting from this consideration provides a "minimum" STC-compatible computer system for each subcontractor. Based upon this recommendation, each of the primary alternatives identified above assumed that smaller STC-compatible computers are used by subcontractors to permit continuity of this concept.

Although alternative 1) (sharing of STC computers) is the most cost-effective approach, it was not selected because of the apparent inability to support projected test schedules for both system and flight subsystem tests. The requirement for concurrent test capability for system and subsystems, in addition to the requirement for maintaining subsystem test capability throughout the life of the program, precluded its selection.

Alternative 2) was eventually selected over alternative 3) because it is less costly, it permits the use of common software between subsystem OSE and STC, and it is capable of performing essentially all subsystem tests by use of a computer.

Although alternative 2) was selected, the recommended approach is the one described in paragraph 2.2.2 above. This approach is, in essence, a modification of alternative 2). The major difference is in the quantity and size of computer systems. Alternative 2) would have provided two smaller computer systems for the Entry Science Package/Capsule Bus contractor, while the proposed approach provides one larger computer system. This selection was made on the basis that at least one of the STC computer systems for the Entry Science Package/Capsule Bus contractor would be available to support flight subsystem production testing during peak testing periods.

2.2.3.2 Problem Areas and Recommendations

Further study is required in the following areas to assure optimum implementation of flight subsystem testing by use of general-purpose computer systems:

1) Location of standard decoding and encoding equipment in computer test stations versus location in individual subsystem OSE test sets as proposed

2) Evaluation of alternative real time-sharing techniques for the various subsystem OSE test sets. This evaluation should take into account both computer system hardware and software designs to optimize common usage of software designs for subsystem OSE and STC.

2.3 Structures and Mechanisms

The Voyager Entry Science Package structures and mechanisms subsystem has no operational functions to be tested and verified; therefore, no structures and mechanisms OSE is required.

2.4 Thermal Control

2.4.1 Requirements and Constraints

General Requirements - The thermal control test support equipment in conjunction with the environmental space chamber facilities provides all the functions necessary to test and check out the thermal control subsystem to ascertain the operational integrity of the subsystem.

Functional Requirements - The thermal control test support equipment is designed to provide the following functions:

1) To test and verify the operation of electrical heaters, thermostats, and temperature sensors
2) To validate thermal performance of thermal insulation materials
3) To validate thermal emissivity and absorptivity of optical finishes.

2.4.2 Preferred Preliminary Design

The preferred preliminary design of the equipment to satisfy requirements 2) and 3) above is laboratory test equipment and facility instrumentation. This equipment is used to validate the thermal properties of the Entry Science Package thermal control system. This equipment is not subsystem OSE. The preferred preliminary design of the equipment to satisfy requirement 1) is one chassis in the structures, mechanisms, and thermal control monitor set, which is shared with the Capsule Bus system. The power distribution portion of this set is shared for the thermal control functions.

2.5 Entry Science

Entry science is composed of the instruments and signal conditioning that make up the entry experiments plus the science data subsystem. The experiments are:

1) Visual imaging experiment (TV)
2) Atmospheric instruments experiment
3) Accelerometer triad experiment
4) Mass spectrometer experiment.

Figure 2.5-1 is a block diagram of the entry science subsystem. The subsystem OSE is used to support flight acceptance testing, approval testing, and development testing. It is capable of evaluating, controlling, and supporting functional checks, performance checks, and calibration.

Each of the experiments listed above is supported by a test set. The sets are designed to be flexible because the experiments are subject to change. Partly for this reason the test sets have a great deal of manual equipment. This subsection describes each of the experiment test sets.

The science data subsystem OSE is described in subsection 3.1, ESP test complex. Its test requirements are very similar to those of the Entry Science Package. As a subsystem of the Entry Science Package, its testing occurs before the Entry Science Package testing, and therefore the same OSE can be used sequentially with both.

2.5.1 Requirements and Constraints

The requirements and constraints of paragraph 1, including NASA/JPL documents for subsystem OSE, apply to the equipment discussed in this subsection.

2.5.1.1 Ground Rules

The following additional constraints and boundary conditions must be considered in the design of the Entry Science Package OSE:

1) The OSE design must emphasize flexibility to accommodate the fluid character of the experiment configurations
2) Standard, multipurpose OSE units are used in order to extend the useful life of portions of the OSE beyond the 1973 flight and to reduce engineering and equipment costs
3) Commercial test equipment is incorporated into the OSE design wherever possible
4) The OSE should provide data for in-depth system evaluation. This implies periods of continuous data collection on parallel test points.

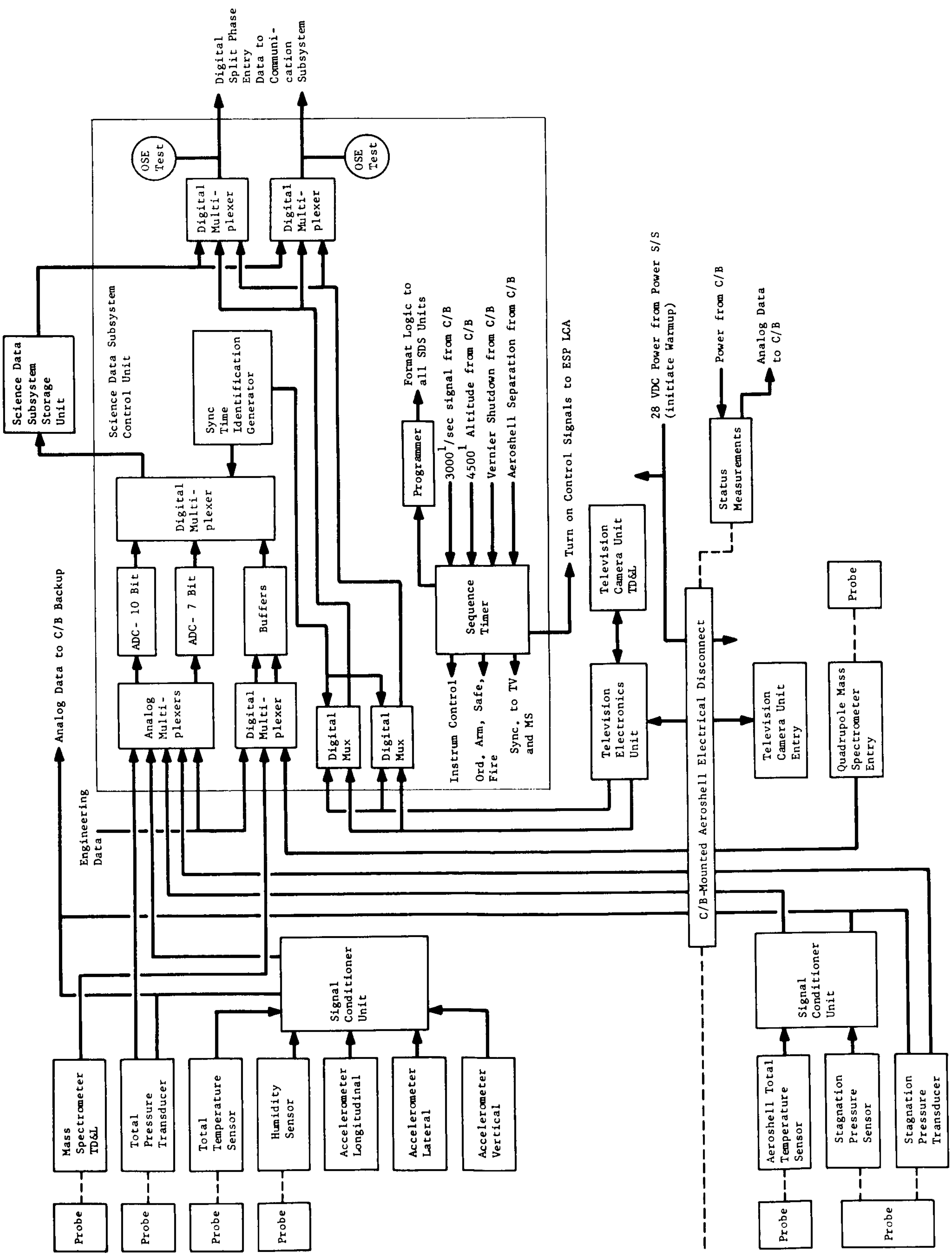


Fig. 2.5-1 Entry Science Subsystem Block Diagram

2.5.1.2 Functional Requirements

The following are general activities or capabilities that all entry science OSE provides:

1) A work surface or mounting structure for holding the unit under test
2) A test harness for accessing test points and cable connector pins in the unit under test
3) All power required by the unit under test (with protection for each circuit), monitoring all power signals, and giving an alarm when specified tolerance levels are exceeded
4) Self-check of portions of the OSE to verify its performance before running tests and isolating malfunctions to within its circuits during the running of a test
5) A log showing accumulated operating time and test running time on the unit under test
6) An automatic record of test results and out-of-limit values in engineering data.

2.5.2 Preferred Preliminary Design

The descriptions of the subsystem OSE that follow cover five areas. Four deal with test sets used for performing tests on the entry science experiment instruments. The primary purpose of these units is to calibrate and acceptance test unique experiments suited for replacement as separate packages. The fifth discusses the science data subsystem.

2.5.2.1 Instrument OSE

2.5.2.1.1 TV Test Set

The Entry Science Package TV experiment consists of two camera units. One is mounted with a view through the quartz window in the aeroshell; it has one vidicon (A). The other operates after aeroshell staging. It has a narrow angle vidicon (B). Table 2.5-1 compares the capabilities of the cameras.

Table 2.5-1 Comparison of Vidicon Capabilities

Capability	Vidicon A	Vidicon B
Vertical Limiting Resolution (TV Lines)	200	200
Horizontal Limiting Resolution (TV Lines)	200	200
Scan Lines	280	280
Field of View (deg)	18	4.7
Data Output	Digital	Digital
Bits/Sample	6	6
Samples/Horizontal Line	240	240
Dynamic Range	60:1	60:1
Linear Gamma	0.9	0.9
Readout Rate (kbps)	50 (1) 25 (2)	50

Requirements - TV test sets are provided at the system contractor's facilities for flight acceptance testing and to support the Entry Science Package approval testing. These sets verify that the TV equipment is free from malfunction during receiving inspection and they support the necessary alignment operations of the TV camera and its electronics. The test requirements for the TV equipment that must be provided by the test set are indicated in the following tabulation.

	Test Level	
Test	Subsystem (Subcontractor)	Subsystem (System Contractor)
Transfer Function	x	x
Response	x	x
Shading	x	x
TV Performance Data	x	x
Test Points	x	Partial
Power	x	
Geometric Distortion	x	x
Optical Alignment	x	x
Field of View	x	x

The performance data points and test points listed in the preceding tabulation allow the following alignments and tests to be verified: sequence timing, deflection voltage alignment, focus current alignment, video amplifier gain, erase lamps, grid, filament and cathod voltage alignment, shutter operation, and beam current alignment.

Preferred Approach - The TV test set interfaces directly with the subsystem OSE computer system. Tests are requested by the test operator and test programing, evaluation, and recording are performed by the computer. Video data are routed to the computer and stored on magnetic tape. Data from the test point commutator are analyzed for tolerance limits concurrently with video data processing. When a complete frame of data is stored on tape, the computer plays back the video frame to the test set display and recording equipment. Figure 2.5-2 is a functional block diagram of the test set plus a view of the rack layout.

Command and Address Decoder - This unit receives command information from the OSE computer, decodes it, and relays the signals to the equipment under test and to other OSE areas. It contains buffers for receiving and storing the commands, an address decoder, and command registers for commanding the OSE and the unit under test.

Power and Resistance Unit - This unit contains the OSE power supplies and a switching matrix. The unit is under the control of the command and address decoder. The switching matrix connects power to the unit under test. Resistance measurements are made by using a microampere power supply. The power supplies are voltage and current limiting and programable.

Test Point Commutator - This unit samples each of the OSE and TV unit test points once each cycle. Subcommutation techniques can be used. The subsystem OSE computer is sent an interrupt signal when data are ready to be sent to it. This unit consists of a commutator, a control section, a sample and hold section, an analog-to-digital (A/D) converter, and buffer registers for holding the output of the analog-to-digital converter until called for by the computer.

Display - The display unit is a CRT and its associated electronics plus a film camera and processor. Figure 2.5-3 is a functional block diagram of this major portion of the TV test set.

Controls and Decommutation - The controls contain the timing and recognition circuitry for the display. This unit monitors and controls status of the other areas of the display. It interfaces with the computer through the following signals: (1) Control signals (from computer) to control start of display process and include any signals required to mate the display characteristics with the

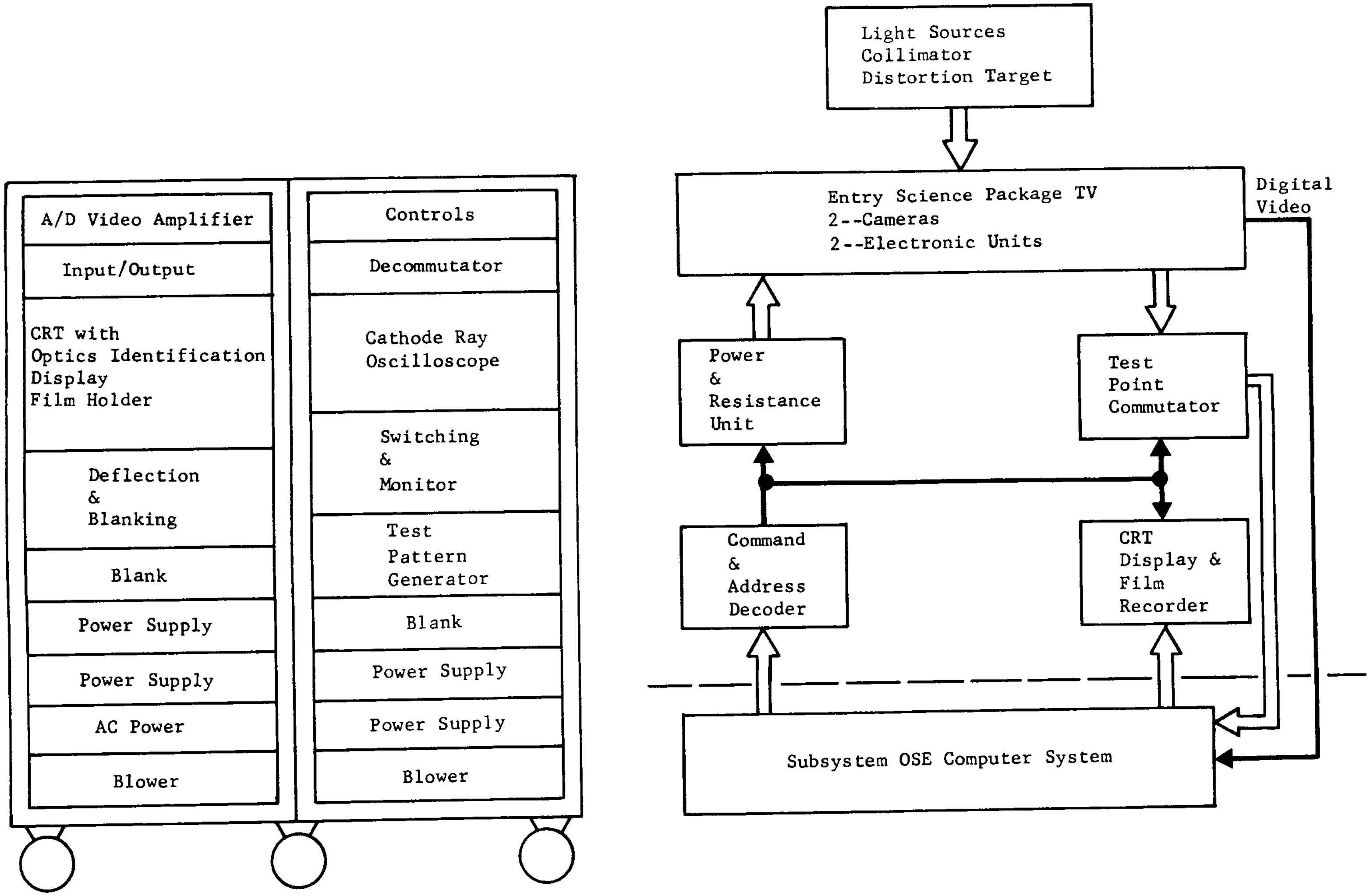


Figure 2.5-2 TV Test Set Block Diagram and Rack Front Layout

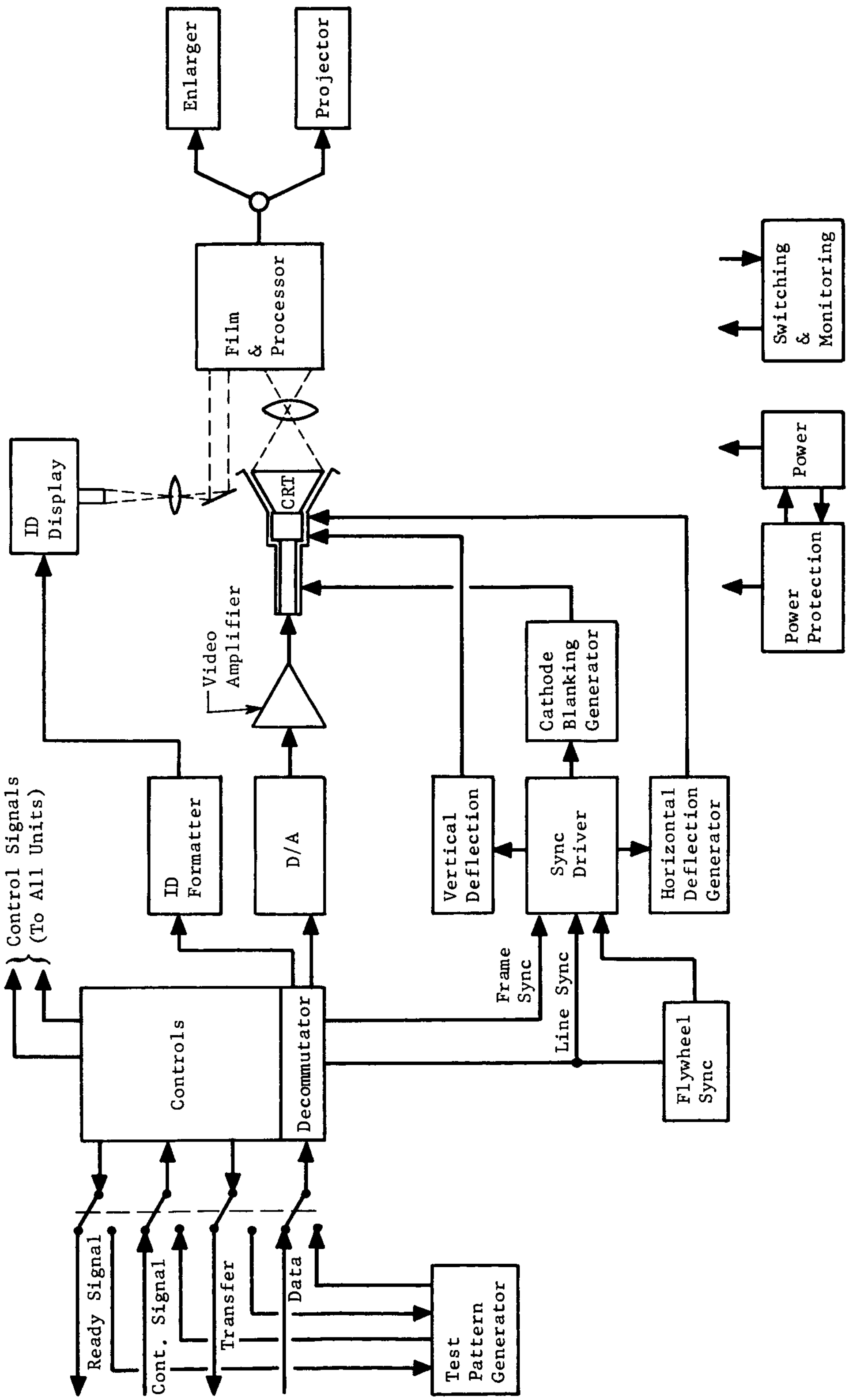


Fig. 2.5-3 TV Display Block Diagram

vidicon characteristics (transfer function, scan lines, dynamic range); (2) Ready signals (to computer) to indicate that the display is ready to receive data; (3) Transfer interrupt (to computer) basic timing for transfer of parallel 6-bit bytes (samples) to the decommutator.

The decommutator accepts six-bit parallel bytes from the computer at 59.5 kbps for ESP TV data. The decommutator inserts a four-byte delay in the data stream to recognize Barker codes for frame sync, line sync, and identification (ID) data. After recognition of a particular Barker code, the pertinent controls and data are routed to using units in the following manner: ID data to the ID formatter; video data to the digital to analog (D/A) conversion unit; and frame and line sync controls to the sync driver unit.

The scan generation chain consists of a sync driver unit, flywheel sync unit, vertical and horizontal deflection generators, and a cathode blanking generator. The sync driver unit accepts frame and line sync control signals from the decommutator and generates gating and blanking signals for the deflection and blanking generators. The flywheel sync unit is also part of the controls. It generates a line sync (in the appropriate time slot) in the absence of recognizable line sync information. The vertical deflection generator generates the vertical deflection sawtooth for the CRT yoke on receipt of gated frame sync commands from the sync driver. Correction signals are also added to the vertical sawtooth to compensate for pincushion distortion and to destroy the raster effect by means of a high frequency "spot wobble" superimposed on the composite wave form.

The horizontal deflection generator generates the horizontal deflection sawtooth for the kinescope yoke on receipt of gated line sync commands from the sync driver. Correction signals are also added to the horizontal sawtooth to compensate for pincushion distortion. The cathode blanking generator circuit supplies bias or cuts off bias from the CRT cathode on command from the sync driver unit. The cathode bias is enabled at all times during the display sequence except for horizontal retrace time, vertical retrace time, and power failures sensed by the power protection circuits.

The ID data chain consists of an ID data formatter, and ID display unit and ID optics. The ID formatter accepts ID data from the decommutator and based on control signals, formats and routes the data for use by the ID display. The ID display consists of miniaturized numeric rear projection readouts focussed on a portion of the film unused by the video data. An alphanumeric display is formed by the readouts and letter masking to make identification data a permanent portion of the video record. The ID optics demagnifies and focuses the ID display on a portion of the film unused by the video data. The video data chain consists of a digital-to-analog converter, video amplifier, CRT, lens, and film/film processor combination. The digital-to-analog converter consists of a precision power supply, precision inverters, and a resistor ladder. A six-bit digital-to-analog conversion is performed on command by the controls unit. A video amplifier filters the converted digital signal and amplifies it to a level required by the CRT grid. The transfer function of the video amplifier is controlled by break points to achieve unity system point gamma, and compensate for compressed spacecraft dynamic range characteristics.

The CRT serves as an exposure source for recording the video data on film and consists of a 5-in. flat-faced CRT with a centering coil, focus coil, deflection yoke and shielding.

Lens - A lens with a magnification of less than one is used to transfer the information from the CRT to the film surface.

Film and Film Processing - The film is 35 mm (this choice is subject to further study) A small-area film was chosen because of availability, adequate response and dynamic range, available enlargement equipment of sufficiently small size, and because of availability of projection equipment.

Film processing is done by automatic processing equipment integrally a part of the camera equipment. The film automatically advances after completion of a video frame. The film processing is closely controlled with respect to chemicals used, temperature of chemicals, and development times to maintain predetermined film transfer characteristics.

Power and Power Protection - Power supplies and protection circuits provide logic power, CRT high voltage, CRT focus voltage, and video power.

Switching and Monitoring - The switching and monitoring panel provides test points for troubleshooting and monitoring functions, switching functions for manual or automatic (computer controlled) operation, and monitor lights indicating display status. A rack-mounted cathode ray oscilloscope is provided to facilitate test point monitoring.

Test Pattern Generator - A test pattern generator is used for operability verification and troubleshooting purposes. A bar pattern and grey scale pattern are generated and selectable by the operator. The test pattern generator simulates the computer inputs and controls TV data.

Collimator - The collimator serves as a collimated light source for slides used to test the TV performance. This function can also be performed by a calibrated light box or distortion target when the collimator cannot be used.

Physical Characteristics - Figure 2.5-2 illustrates a rack layout of the TV test set.

Interface Description - The OSE/instrument interface consists of:

Out of OSE	Optical - Collimator plus target plates
	Power - 28 vdc
	Control - 3 discrete (pulsed)
	Clock - 100 kbps
Into OSE	Engineering data - 10 analog, 4 bilevel
	Video data - 50 kbps, 25 kbps

2.5.2.1.2 Mass Spectrometer Test Set

Two mass spectrometers are supplied as part of the Entry Science Package. One specializes in taking measurements at very low pressures and is mounted on the aeroshell. The other is operational at low pressures. These instruments analyze the composition of gas samples by measuring the mass of the molecules in the sample within the region from 10 atomic mass units to about 50 atomic mass units. They also determine the proportion of each molecule in the sample.

Requirements - Mass spectrometer test sets are provided at the Entry Science Package contractor's facilities for approval and flight acceptance testing. The test sets check that the instruments are free from malfunction during receiving inspection and calibrate the spectrometer before integration with the Entry Science Package. The functional requirements for the Test Set are:

1) Provide gas samples of known composition
2) Verify circuit performance
3) Monitor performance signals and bilevel status signals
4) Perform calibration (the test set is not capable of calibrating the aeroshell QMS)
5) Display test results
6) Check digital output for format, content, and pulse shape.

Preliminary Design - The mass spectrometer is tested by supplying a sample of gas of known composition to the instrument. The test set provides the acquisition system for conducting the gas sample to the instrument and the electronic circuits required to assess the instrument's performance. The set interfaces with the subsystem OSE computer system, which provides a data acquisition and evaluation capability. Figure 2.5-4 is a functional block diagram of the test station plus a view of the front elevation.

Junction Box and Test Panel - This unit provides access to the leads going to the mass spectrometer. It also provides a flexible method of interconnecting the mass spectrometer and the test set used to check it out.

Input/Output Switching - The switching unit can be remotely controlled, but its primary operation is manual under local control. It is assembled from standard modules. Some have a lock-up capability. A self-check on critical circuits ensures that improper signals are not applied to the equipment under test.

Control and Buffer Unit - This unit sends the timing and control signals used to coordinate the operations of the mass spectrometer, the digital voltmeter, the printer, and the test set's digital evaluation circuits. Some of the operations are initiated manually and some are event sequenced. It is capable of interfacing with the subsystem OSE computer system.

Clock - The clock provides the clock pulses required by the digital circuits in the mass spectrometer test set.

Power Supply - The power supply provides power at the required voltage levels and quality for the test set chassis and the unit under test.

Buffer and Digital Logic - This chassis receives the digital output from the mass spectrometer, stores it in buffer memory, and operates on it one byte at a time so that the contents can be evaluated. This unit can interface with the computer.

Digital Voltmeter - The digital voltmeter (DVM) is a standard, commercial unit. It has an output display and a bcd output that interfaces with the test set printer.

Printer - The printer is a standard, commercial unit. It receives digital values from the digital voltmeter and format data, such as test number and unit values, from the control and buffer unit. It supplies a printed record of part of the test results.

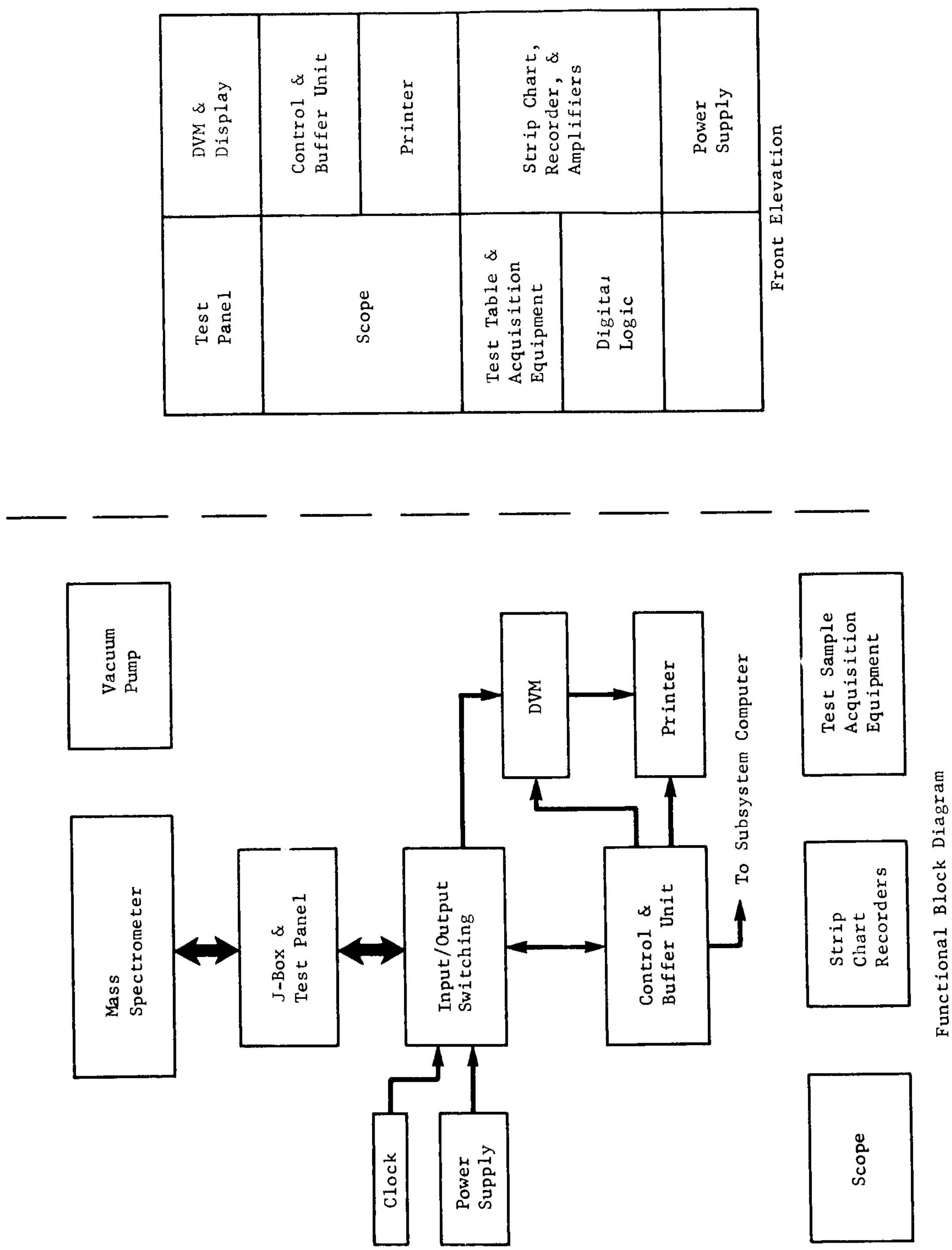


Figure 2.5-4 Mass Spectrometer Test Set

Scope and Strip Chart Recorders - These are commercial units used to supplement the normal capability of the test set. Access to test points is provided at the test panel. They are used as required.

Vacuum Pump - This pump is required to supplement the spectrometer's own pump to achieve the vacuum required in the instrument in a reasonable time.

Physical Characteristics - Figure 2.5-4 is an illustration of the rack layout of this test set.

Interface Description - The OSE/Instrument interface consists of:

Out of OSE:
- Mechanical - Gas acquisition equipment
- Power - 28 vdc
- Control - One discrete (pulsed), one discrete clock

Into OSE:
- Engineering data - six analog
- Output - 392 bits/readout

2.5.2.1.3 Atmospheric Instrument Test Set

This test set is used to check and calibrate the various instruments that make pressure, temperature, and humidity measurements as part of the entry science experiments. The instruments and their functions are described here.

Instrument Description - The instruments tested by this test set include the total pressure transducer, total temperature sensor, humidity sensor, stagnation pressure sensor, stagnation pressure transducer, and aeroshell total temperature sensor.

These instruments take measurements during the Martian entry and terminal descent.

Total Pressure Transducer - During terminal descent, it is anticipated that the ambient pressure will be between 0.4 and 30 mb. The sensor is a stretched diaphragm pressure transducer with capacitive pickoffs. Input power is 28 vdc. The output is an analog voltage 0 to 5 vdc.

Total Temperature Sensor - This sensor measures the total temperature of the gas through which it is passing. This temperature reading results from the internal energy of the gas plus the gas's kinetic energy seen by the sensor. The sensor is composed of several thermocouples connected electrically in parallel. These are mounted in a probe used to control gas flow. Input power is 28 vdc, output signal is 0 to 5 vdc.

Humidity Sensor - The anticipated dew point on Mars is very low (-90°C). The sensor used to make this very small humidity reading is an aluminum oxide hygrometer. The input power required is 1 w of 28 vdc. The output signal is 0 to 5 vdc.

Stagnation Pressure Sensor - Stagnation pressure is measured on the apex of the aeroshell. The sensor used is a vibrating diaphragm pressure transducer that has great range 10^{-5} to 10^{2} mb high accuracy, low weight, and rugged construction. Input power is 28 vdc. The output signal is 0 to 5 vdc.

Stagnation Pressure Transducer - The unit is the same model as the total pressure transducer but its range is extended to 100 mb.

Aeroshell Total Temperature Sensor - This unit is a modified version of the total pressure transducer. It is capable of reading temperatures to 1500°K.

Requirements - Atmospheric instrument test sets are provided at the Entry Science Package contractor's facility. They check that the instruments are free from malfunction during receiving inspection and provide a calibration capability before the instruments are integrated into the Entry Science Package. They are also used to verify instrument malfunctions at system test levels. The following functions are performed by the test set for each of the instruments:

1) Simulate Entry Science Package power
2) Provide very accurately measured sources of vacuum and high and low temperature
3) Verify circuit performance
4) Monitor performance and status measurements
5) Record test results
6) Perform self-check of sensors
7) Display test result measurements
8) Record running time on instruments.

Preferred Approach - Figure 2.5-5 is a functional block diagram and a front elevation of the atmospheric instrument test set. This integrated, multipurpose checkout equipment can handle each of the instruments described above. The test is set up manually. Standard, commercial test equipment is used where possible.

Junction Box and Test Panel - This unit provides access to all the signals going to the atmospheric measurement instruments. It also provides a flexible method of interconnecting the various instruments and the test set.

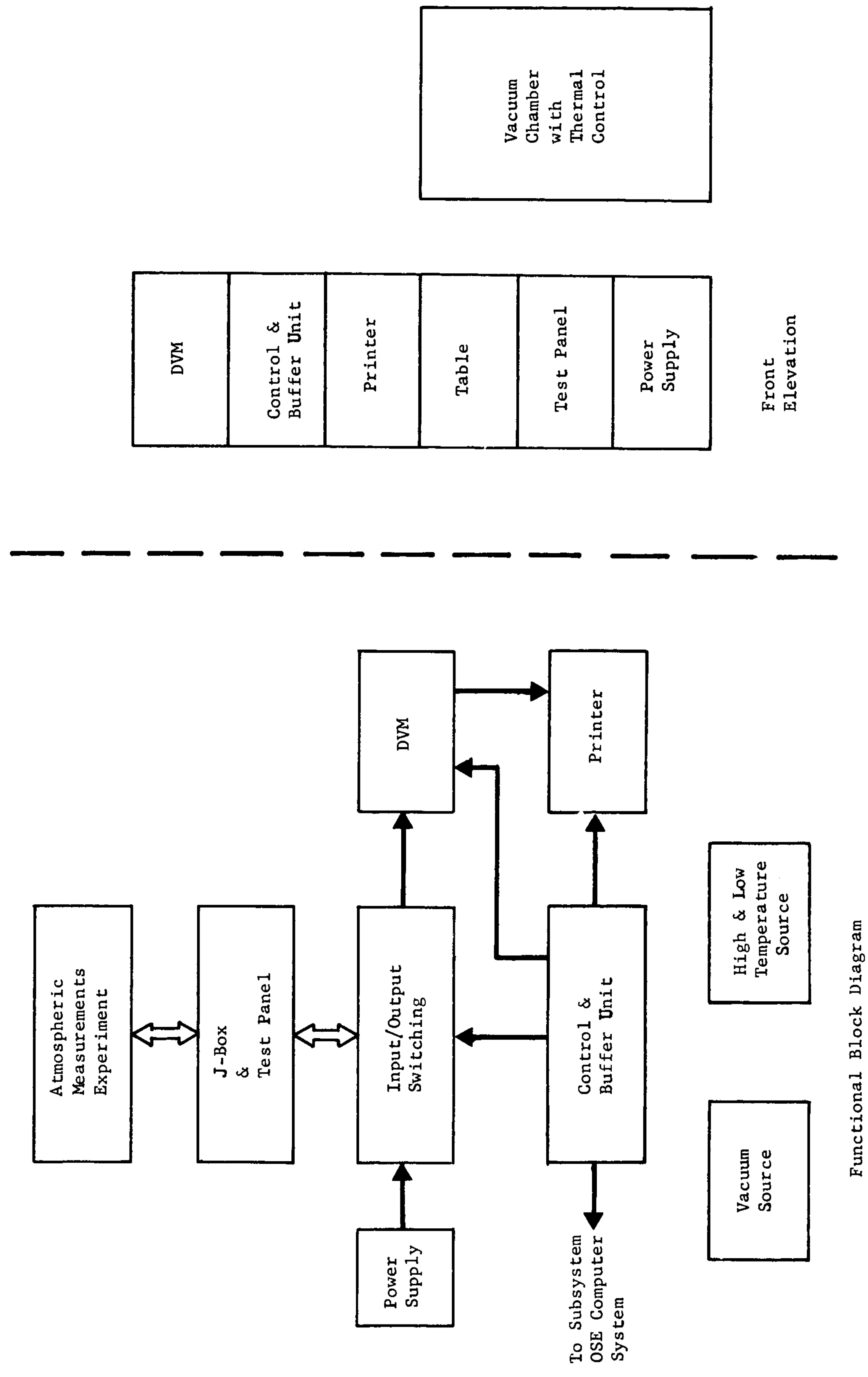


Fig. 2.5-5 Atmospheric Instruments Test Set

Input/Output Switching - The switching unit can be remotely controlled, but its primary operation is manual and locally controlled. It is assembled from standard modules. Some have lock-up capability. Self-check is provided on critical circuits to ensure that improper signals are not applied to the equipment under test.

Power Supply - The power supply provides power at the required voltage levels and quality for the electronic chassis in the atmospheric instruments test set.

Digital Voltmeter - The DVM is a standard, commercial unit. It has a digital display plus a bcd output that is capable of providing a compatible input to the test set printer.

Printer - The printer is a standard, commercial unit. It receives digital numbers from the DVM and format data (such as test number, unit values, and instrument type) from the control unit. It supplies a printed record of test results.

Control and Buffer Unit - This unit sends the control signals to the other test set units and to the instruments under test. Most of these signals are initiated manually. Required logic is derived with few active elements. It is capable of interfacing with the subsystem OSE computer system.

Vacuum and Thermal Control Unit - This is a small transportable vacuum chamber equipped with heating and cooling equipment. A very accurate gage (McLead gage) measures pressure. Low temperatures are achieved by using secondary sources such as liquid nitrogen. A range of temperatures is obtained by varying the pressure on the liquid nitrogen. Thermal plates are used to get high temperatures. This entire unit provides a range of accurately measured environments in which the sensors can be placed.

Physical Characteristics - Figure 2.5-5 illustrates a rack layout of this test set.

Interface Description - The OSE/instrument interface consists of:

- Out of OSE
  - Environmental - very low pressures, low temperatures, high temperatures
  - Power - 28 vdc
  - Control - six discretes
- Into OSE
  - Engineering data - 12 analog
  - Output - six 0 to 5 vdc

2.5.2.1.4 Accelerometer Test Set

The accelerometer test set is used to check the accelerometer triad during receiving inspection. It also has the capability of calibrating this instrument. The test set is located at the Entry Science Package contractor's assembly and test facility. Malfunction detection and isolation is provided with the test set.

Accelerometer Triad Description - The accelerometer triad is used to determine the flight capsule's acceleration history during entry into the Martian atmosphere. Preliminary requirements call for measuring 20 g in the Z-axis direction and 1.5 g normal to the Z axis. The preferred input power is 28 vdc. The output signal is 0 to 5 vdc. Electronics internal to the accelerometer include the torquers, capacitance pickoff, and signal conditioning. The electronics unit associated with the triad contains a power supply, forcer coil amplifiers, and preamplifiers. A self-test capability is required to test the accelerometer when it is mounted in the Capsule Bus. The preferred accelerometer triad is made up of single axis, pendulous, force rebalance instruments. The triad has one accelerometer mounted so that its input axis is coincident with the Z axis of the Capsule Bus. The two other accelerometers of the triad are mounted normal to the Z axis and parallel to the X and Y axes. The accelerometer electronics are mounted with the accelerometers.

Requirements - Accelerometer triad test sets are provided at the Entry Science Package contractor's assembly and test facility. They are used during receiving inspection and for calibrating the triad before integration with the Entry Science Package. The functional requirements of the test set are: (1) simulate Entry Science Package power; (2) provide very accurately known acceleration values; (3) perform accelerometer self-check; (4) verify performance; (5) monitor performance and status measurements; (6) record test results; and (7) display test results.

Preferred Approach - Figure 2.5-6 shows a functional block diagram and a front elevation of the accelerometer triad test set. This unit tests the accelerometer triad by using the rate table to provide very accurately known values of acceleration. Test setup and evaluation are manual operations.

Juntion Box and Test Panel - This unit provides access to all the signals going to the atmospheric measurement instruments. It also provides a flexible method of interconnecting the various instruments and the test set.

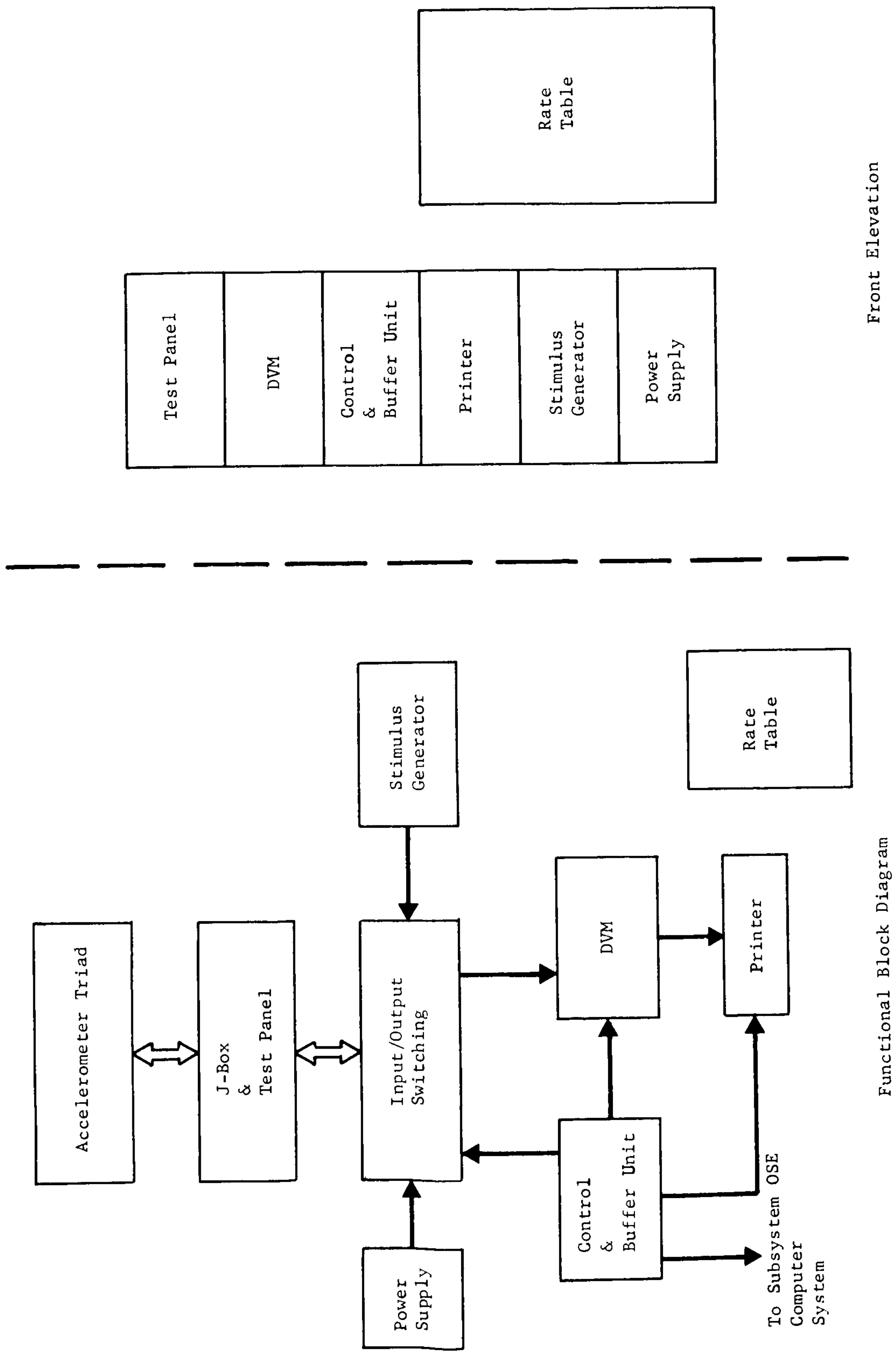


Fig. 2.5-6 Accelerometer Triad Test Set Block Diagram

Input/Output Switching - The switching unit can be remotely controlled, but its primary operation is manual and locally controlled. It is assembled from standard modules. Some have a lock-up capability. Self-check is provided on critical circuits to ensure that improper signals are not applied to the equipment under test.

Power Supply - The power supply provides power at the required voltage levels and quality for the electronic chassis in the test set.

Digital Voltmeter - The DVM is a standard, commercial unit. It has a digital display plus a bcd output that can provide a compatible input to the test set printer.

Printer - The printer is a standard, commercial unit. It receives digital numbers from the DVM and format data (such as test number, unit values, and instrument type) from the control unit. It supplies a printed record of test results.

Control and Buffer Unit - The unit sends the control signals to the other test set units and to the instruments under test. Most of these are initiated manually. Required logic is derived with few active elements. It is capable of interfacing with the subsystem OSE computer system.

Stimulus Generator - The stimulus generator provides very accurately known signals to the accelerometers for electronic test operations.

Rate Table - The accelerometer triad is mounted on the rate table at an accurately determined position. The table is then rotated at a precisely known angular velocity. The accelerometers can be tested at a wide variety of acceleration values depending on table rotation speed and the orientation of the accelerometer with respect to the table.

Physical Characteristics - Figure 2.5-6 illustrates the rack layout of this test set.

Interface Description - The OSE/instrument interface consists of:

Out of OSE	Environmental - Accurately known values of acceleration to 20 g in amplitude
	Power - 28 vdc
	Control - three discrete
	Stimulus - six accurately measured values of current and voltage
Into OSE	Engineering data - Nine analog
	Output - three 0 to 5 vdc
	Status - Nine bilevel

2.5.2.1.5 Science Data System OSE

Science Data System Description - The SDS acquires the output and performance data from the entry science experiments during Martian entry, terminal descent, and landing. It processes and formats these data so that the data can be transmitted over a UHF radio link to the Spacecraft. Specifically it samples, conditions, encodes, and formats the scientific data in a prescribed manner. It also provides the sequencing and control of the science instruments. Because data are acquired at different rates as a function of entry altitude, and also because data cannot always be transmitted in realtime due to entry blackout, a storage capability is provided.

Requirements - The requirements discussed in subsection 2.5.1 apply to the OSE used to check out and test the SDS. This OSE is used for development testing, type approval, and acceptance on the flight articles. To test the SDS, a great deal of the Entry Science Package must be simulated. In many respects testing this unit is a more complex job than testing the complete package. Because the two tasks are comparable and because they are sequential (the SDS must be tested before the Entry Science Package can be assembled and tested because of its vital role in the Entry Science Package) the Entry Science Package test complex is used to test both the SDS and the Entry Science Package.

Functional Requirements - The functional requirements of the SDS are:

1) Simulate instrument interfaces
2) Simulate TV interface
3) Simulate Capsule Bus inputs
4) Exercise SDS through all mission events
5) Evaluate SDS output for content, format, pulse shape, accuracy
6) Display test results
7) Time tag and record bilevel status changes
8) Monitor performance signals.

Science Data System OSE Description - Refer to subsection 3., System Test Complex, for a description of the OSE used to checkout and test the SDS.

Physical Characteristics - Figure 3.1-2 (in subsection 3) shows a rack layout of the Entry Science Package test set.

Interface Description - The OSE/SDS interface consists of:

Out of OSE:
- Power - 28 vdc
- Control - 21 discretes
- Stimuli - Two frames of TV data (400,000 bits/frame, 50 kbs)
  - One word QMS data (392 bits in 2 sec)
  - 10 bilevel
  - 53 analog (0 to 40 mv dc)

Into OSE:
- Engineering Data - 12 analog
- Output - Three separate digital formats, 50 kbs
- Status - 30 bilevel

2.5.3 Subsystem Analysis

The Entry Science Package experiments are difficult to test and calibrate. In most cases these operations can be done more easily before the intrument is packaged in the Entry Science Package. Experiments are very likely to have requirements change far later in the program than other electronic units. In addition the instruments will probably be supplied by a subcontractor. Thus, they require separate checkout gear to adequately prepare them for mating with the Entry Science Package and to gather extra test data for performance evaluation.

The design for these OSE sets emphasizes flexibility and economy. Both are achieved by using manual equipment where test requirements are not too complex. Multipurpose, standard modules are also used wherever possible and extra capacity is built in to accommodate new and changing requirements. Where there are complex performance requirements in the form of high data rates, a digital computer is used with the test set. Its primary function in these cases is to perform data acquisition, evaluation, processing, and printout. Direct control of the test operations does not appear desirable at this level and if used, should come about as a result of evolutionary steps.

2.6 Communications

2.6.1 Requirements and Constraints

The communications test set is designed to test and evaluate the performance of the Entry Science Package communications subsystem. Using the subsystem OSE computer system for test control and data evaluation, the OSE is capable of exercising the subsystem through all of its standard and backup operating modes to assure its performance within design limits.

The OSE tests the flight subsystem at the replaceable assembly level; signal paths and diagnostic assistance are provided for fault isolation to the flight subsystem spares level.

As a design approach, the communications test set described here can, with minimum modification, test the Capsule Bus, Entry Science Package, and the Surface Laboratory UHF communications subsystem.

2.6.1.1 Functional Requirements

For the performance test and evaluation of the communications subsystem and verification of OSE status, the Test set provides:

1) Split-phase PCM input signals for simulation of the subsystem interface signals and conditions
2) UHF receivers and bit detectors for reception and error detection of the flight- and OSE-generated signals
3) Spectrum analysis equipment to evaluate the flight equipment- and OSE-generated predetection signal outputs
4) Display equipment for waveform analysis
5) Power supplies for subsystem independent operation
6) Signal paths and hardware for OSE configuring to accommodate all test modes
7) Signal routing and conditioning for conversion of subsystem test results to computer language
8) UHF transmitter for verification of OSE performance.

2.6.1.2 Design Requirements

The communications test set is designed to verify that the flight subsystem is operating within design specified limits. Included in the OSE are commercial and special test equipment designed for the degree of accuracy necessary to establish confidence in the subsystem test results. Complemented by the subsystem OSE computer system, the test set satisfies design requirements of the flight subsystem as defined in succeeding paragraphs.

Integrated Subsystem - The subsystem meets the following design requirements:

1) Signal spectrum - The subsystem output is analyzed as to spectral energy within the mark-space bandwidth with the OSE spectrum analyzer. Response to programed conditions of input voltage levels, rates, and power supply noise is evaluated
2) Bit error detection - Subsystem bit errors are detected with an accuracy of 1 part in 10^5 over programed input conditions
3) Telemetry voltages - Telemetry outputs are calibrated, monitored, and measured within an accuracy of $\pm 2\%$
4) Power consumption - Input power supplied to the flight equipment is measured with an accuracy of $\pm 2\%$
5) Output power - The dual transmitter power input to the antenna is measured to accuracy of ± 1 db. Spectrum analysis measures power balance within ± 1 db
6) Frequency output - The two transmitter frequencies are measured with an accuracy of ± 10 Hz
7) Spurious outputs - The OSE measures harmonically and nonharmonically related spurious signals over a dynamic range of 50 db or better.

Transmitters - Transmitter design requirements are:

1) Frequency output and stability - The test set independently tests each transmitter for absolute frequency, stability, and spurious outputs
2) VCO frequencies - The test set measures the static frequency of each VCO to an accuracy of 1 part in 10^7
3) Modulation characteristics - Using a calibrated discriminator, the test set measures the modulation deviation with an accuracy of $\pm 5\%$ or better.

Transmitter/Antenna Mating - The VSWR resulting from antenna/transmitter coupling is measured with an accuracy of $\pm 5\%$ or better.

2.6.1.3 Design Constraints

Major design constraints on the communications OSE, in addition to those listed in subsection 1.0 include:

1) The OSE must be designed for automated test control and data evaluation to the extent practicable
2) The design of the Entry Science Package communications test set, even though readily adaptable to the Surface Laboratory-UHF communications subsystem and the Capsule Bus communications system, shall not compromise test results

3) OSE hardware and software design must, to the extent applicable, be adaptable to STC usage
4) The OSE will retain the capability of manual operation, using analog display and control peripheral equipment, for nonstandard, lower level testing.

2.6.2 Preferred Preliminary Design

2.6.2.1 Subsystem Definition

Flight Equipment Applicability - The Entry Science Package communications subsystem is comprised of two UHF transmitters, a UHF antenna, and an antenna coupler. Each transmitter operates at a different frequency within the UHF range. Transmitter outputs are coupled to the UHF antenna and radiated as left- and right-hand circularly polarized signals.

The communications subsystem accepts a split-phase baseband signal from the telemetry subsystem, the signal controlling a temperature stabilized voltage-controlled crystal oscillator (VCXO); a multiplier and power amplifier follow the VCXO.

The OSE simulates the telemetry subsystem-supplied data; the UHF transmitter output is FSK demodulated and the baseband PCM data and sync pulses detected.

The UHF subsystem comprises two replaceable assemblies: two UHF transmitters and cabling, and a UHF antenna and coupler assembly. The OSE is designed to test each assembly independently or as an integrated subsystem.

Functional Description - A functional block diagram of the communication test set is shown in Fig. 2.6-1. Only major signals paths and functions are shown. In the block diagram dashed lines represent control functions, signal and data paths are shown as solid lines. Functional operation of the OSE is described in the following paragraphs.

Computer Interfacing - The OSE receives, decodes, and sequences the computer-generated test commands to the test set. Through hardline discrete and analog voltage applications, the command sequencer (1) initiates and controls the level of input stimulus generators; (2) controls relay switching within the input and receiver switching units and the data select unit; and (3) programs loading and terminating hardware.

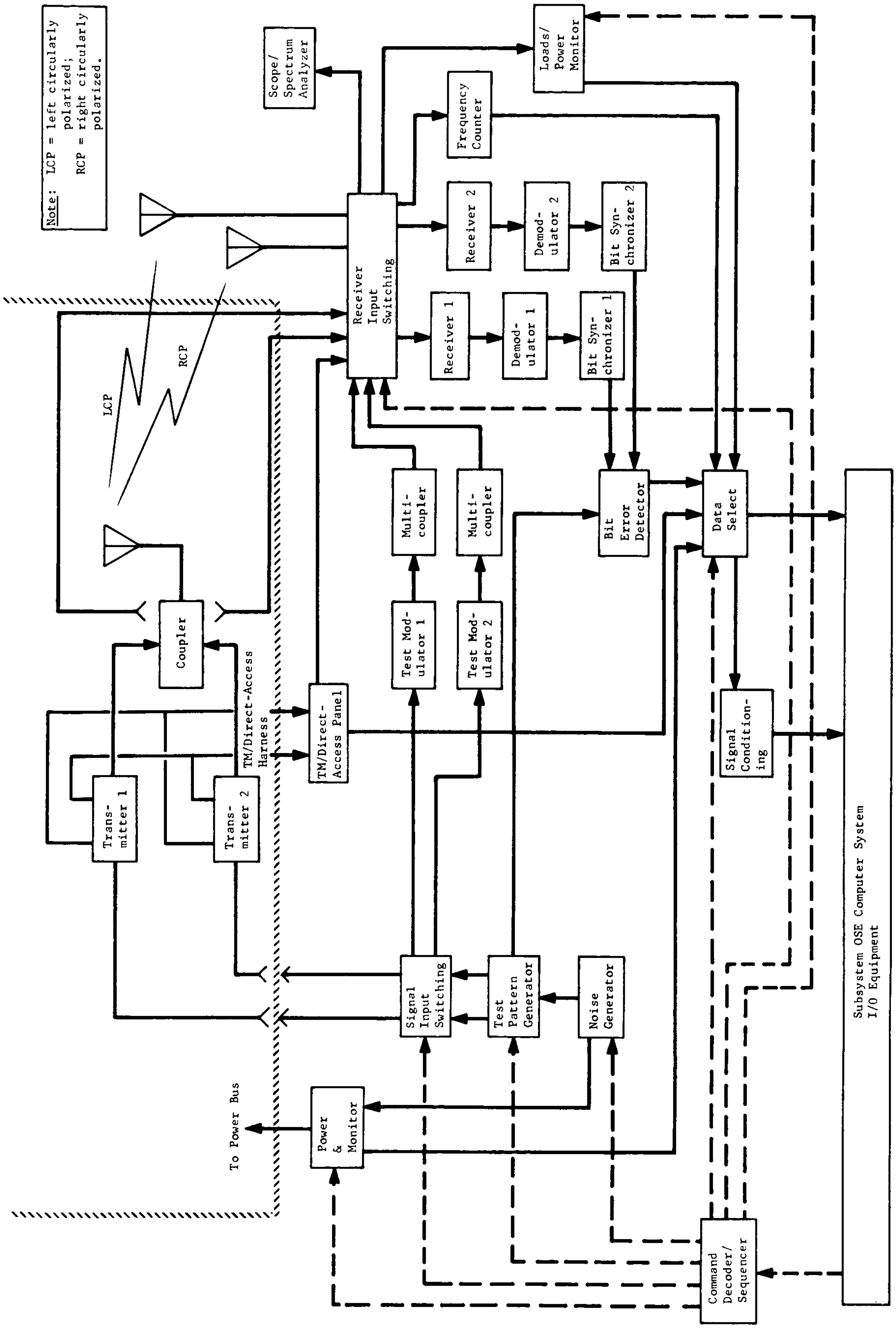


Fig. 2.6-1 Functional Block Diagram, ESP Communications OSE

All data inputs are received within the data select unit. Relay switching, under computer control, provides data inputs to the computer input/output and/or the signal conditioning unit. Analog-to-digital conversions are performed and the data converted to computer language for transmission to the subsystem OSE computer system.

Stimulus Generation and Signal Routing - The OSE, through the signal generators, simulates the Entry Science Package-supplied subsystem input signals. A test pattern generator provides the split-phase baseband signal to the flight or OSE modulators. Input power to the flight equipment is supplied and monitored. A programable noise generator allows testing at discrete input signal-to-noise levels.

The OSE provides the requisite cabling and data paths to perform testing in all test configurations. Hardline and radiated signal paths interface with the flight equipment.

Receiving and Processing - The OSE receives the flight equipment-generated RF signals by hardline or radiation. Two receiver assemblies convert the frequency and demodulate the received signal. The predetection RF signals are analyzed directly by the spectrum analyzer. OSE test loops are provided by two test modulator-exciter assemblies operating at the flight equipment frequencies.

The OSE contains power metering, frequency counter, oscilloscope, and other equipment for discrete measurements and waveform display of flight equipment parameters.

2.6.2.2 Physical Characteristics

The communications test set configuration includes:

1) Rack-mounted special and commercial test equipment
2) Flight equipment test harnesses for telemetry and test point connector access
3) OSE ancillary equipment to adapt the test set to all test configurations.

A rack layout of the Entry Science Package communications test set is shown in Fig. 2.6-2.

2.6.2.3 Description of Interfaces

The communications OSE is primarily concerned with the subsystem OSE computer system, and flight equipment interface areas. Preliminary interface definitions are given below.

Computer/Test Set Interface - To adapt standard and special test equipment to automated testing, the test set contains the required command decoding and sequencing and output data signal conditioning circuitry. This circuitry interfaces with the subsystem OSE computer system test station.

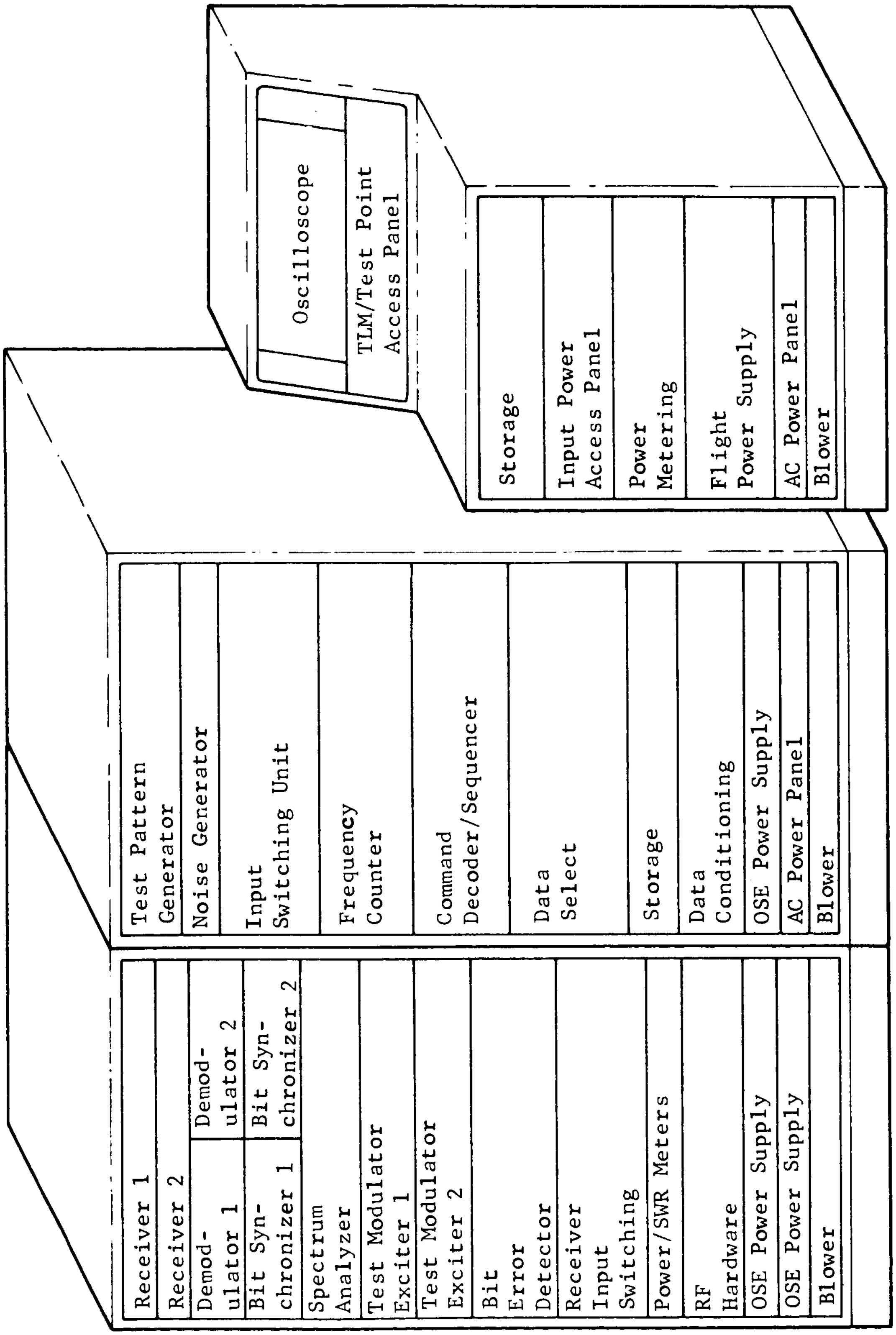


Fig. 2.6-2 Rack Layout, Communications Test Set

OSE/Flight Equipment Interface - The OSE interfaces with the flight equipment both with hardline and radiated RF signal paths. The latter is limited to subsystem output signals and consists of transmitted, left- and right-hand circularly-polarized UHF frequencies. The OSE includes test antennas for receipt of transmission. Other hardline connections to the flight equipment include:

1) Input power - Simulated bus voltages are supplied the communications subsystem. Turn-on and steady-state voltage characteristics are preserved and monitored
2) Signal inputs - Simulated telemetry subsystem signals are supplied the transmitters by hardwire connection
3) Monitor harnesses - Test harnesses, for telemetry and direct access monitor points are a part of the OSE
4) RF - The OSE provides the proper impedance matching cabling, attenuation, and isolation for hardwire RF monitoring.

2.6.3 Subsystem Analyses and Tradeoffs

Preliminary analyses and tradeoffs have been conducted in this area to date. Summaries and descriptions of these and continuing efforts are described in succeeding paragraphs.

Automated vs Manual Operation - In adapting an RF test system for automated operation, basic disadvantages and obstacles must be considered:

1) Complexity and size of hardware required
2) Reduced accuracy of test measurements
3) Inability to practically perform automated predetection measurement and analysis.

The advantages of automated checkout, however, are obvious. They include:

1) Marked reduction of test time
2) Integrity of data from test to test
3) Continuity of data for all levels of test through the use of common hardware and software
4) More efficient and economical data reduction.

Fault Isolation Techniques - The prime OSE tools in deriving a fault isolating technique are input/output signal sources, flight-designated telemetry voltages, and test connector test signals. The first two signal sources are heavily constrained by overall system requirements; the use and specification of test connectors and signal availability is then the remaining area of OSE study.

Test connectors, or direct access points, are available on all flight equipment; however, equipment accessibility and reliability limit their numbers, size, and usage. A comprehensive study has been initiated into the level of fault isolation to be reached absolutely by direct signal monitoring, and the level to be inferred from such available signals.

2.7 Power

The power and pyrotechnic subsystem test set checks out the Entry Science Package load control equipment.

2.7.1 Requirements and Constraints

The general requirements and constraints for subsystem OSE are described in paragraph 2.1.1. Specific requirements and constraints resulting from the design of the flight power equipment and the parameters tested are discussed below.

Test Requirements - Performance parameters tested with the OSE are:

1) Load control response to commands and faults
2) Isolation and grounding integrity
3) Parametric variation margins.

Functional Requirements - To perform these tests, in the context of the general subsystem OSE requirements the test set:

1) Simulates input power as provided by Capsule Bus batteries
2) Simulates electrical loads
3) Provides discrete control signals in simulated mission sequences
4) Provides for varying power voltage, electrical loads, and discrete signal amplitude and duration beyond the normal flight subsystem interface tolerances
5) Provides automatic test sequencing.

2.7.2 Preferred Preliminary Design

The Capsule Bus power and pyrotechnic subsystems test set is used to test the Entry Science Package power subsystem. The design incorporates automatic test control, using the subsystem OSE computer system for sequencing, data acquisition, and evaluation.

Functional Description - Figure 2.7-1 illustrates the functional configuration. Software test procedures stored in the subsystem OSE computer control the test sequence, values of stimulus parameters, and electrical loads. Programable power supplies and a rechargeable battery provide isolated power sources, and simulation of flight battery characteristics. Power resistors and switching matrixes provide variable electrical loads and fault simulation. Power and load switching units and adapter cables connect the OSE to the appropriate input and output terminals for each test sequence. The command generator issues discrete control signals, variable in amplitude and duration, to the power subsystem.

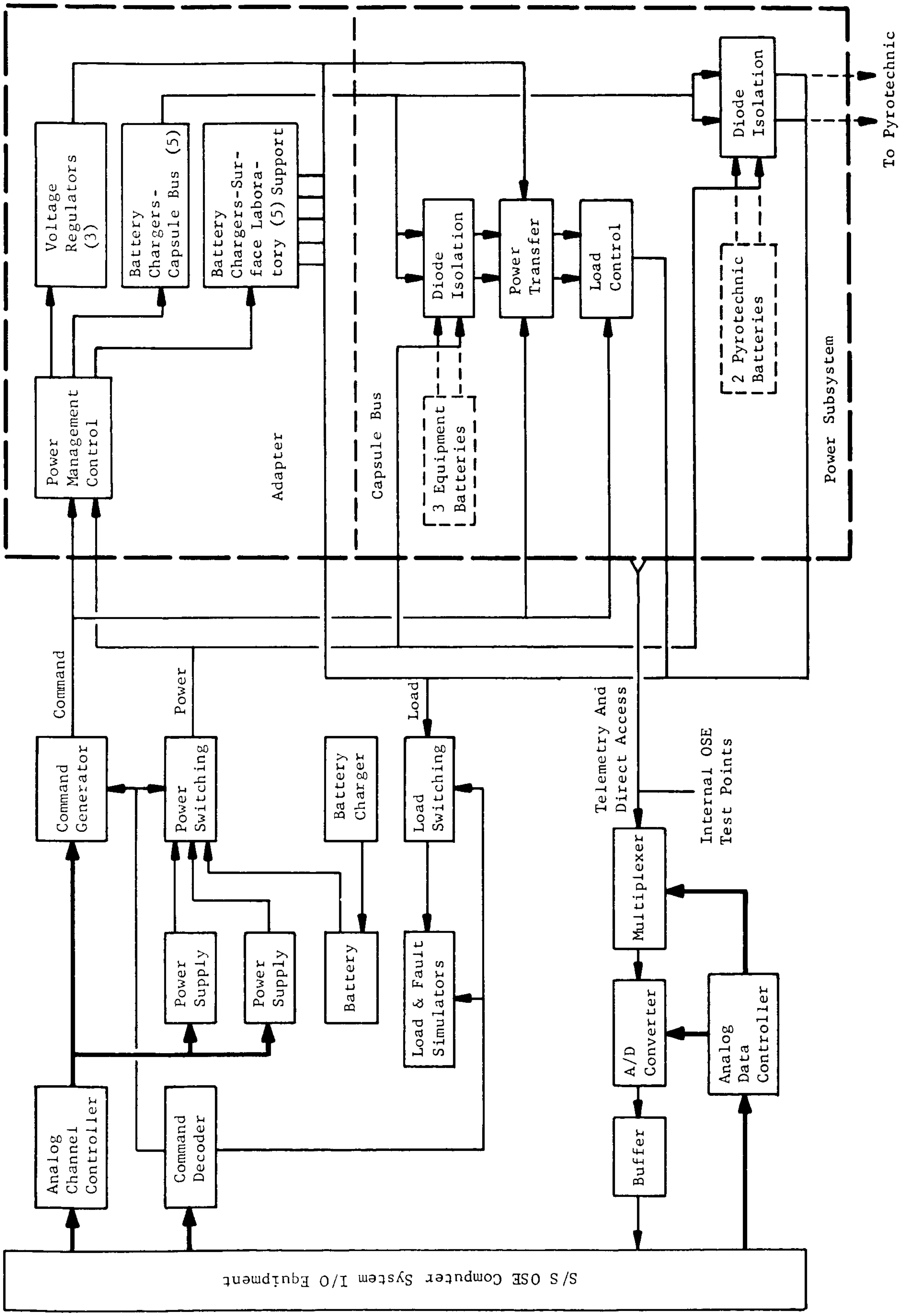


Fig. 2.7-1 Power Subsystem Test with Power and Pyrotechnic Subsystem Test Set

A multiplexer and analog-to-digital converter provide the test data acquisition interface with the subsystem OSE computer system. All direct access points, subsystem power interfaces, and telemetry outputs are accessed through appropriate power subsystem connectors. OSE test points include most of the parameters required to isolate problems between OSE and equipment under test.

A cathode ray oscilloscope and multimeter are built into the test set for further trouble analysis by the operator, and for visual monitoring.

Physical Characteristics - The test set is housed in two standard OSE racks (Fig. 2.7-2). Input power is a nominal 115 v, 60 Hz, single-phase at approximately 1200 w maximum. The operator's console is the standard test station console described in paragraph 2.2.2 as a part of the subsystem OSE computer system.

Interfaces - The test set interfaces with the Entry Science Package power subsystem and the subsystem OSE computer system for tests of the Entry Science Package power subsystem. Control commands, input power, and load and fault simulation are provided through interfacing cable sets. Pyrotechnic subsystem test equipment is located in one of the racks (Fig. 2.7-2) and has functional interfaces identified in paragraph 2.9. The test set also interfaces with the Capsule Bus power and pyrotechnic subsystems for their checkout, as described in Volume II.

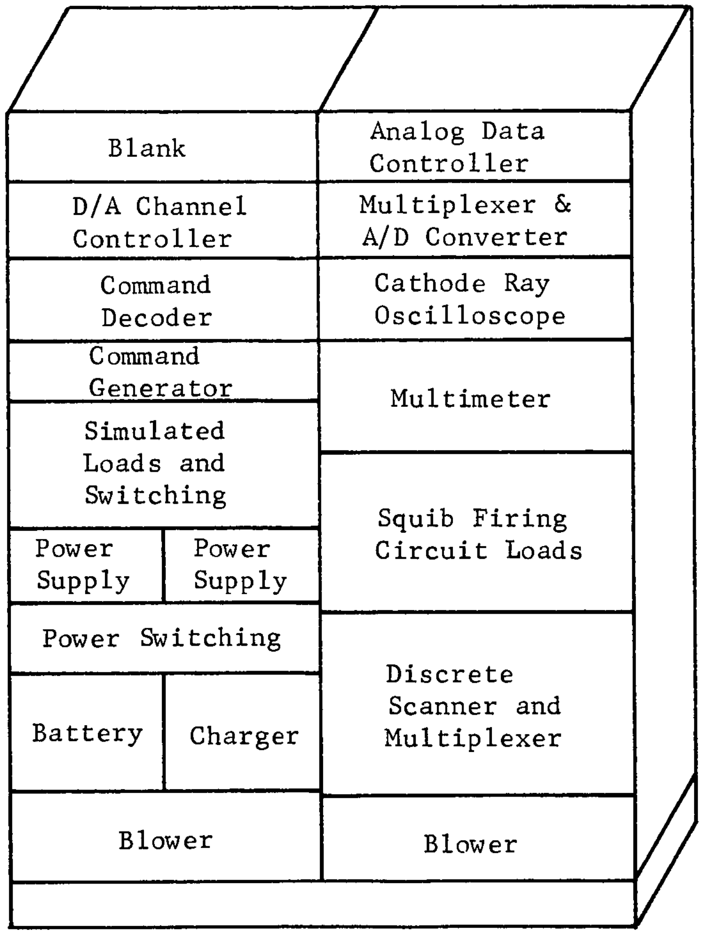


Fig. 2.7-2 Power and Pyrotechnic Subsystem Test Set

2.8 Cabling

The qualification and acceptance of interconnection cable harnesses for the flight systems require equipment in support of these tests. These equipment requirements are satisfied by standard manufacturing tooling and no cabling subsystem OSE is required.

2.8.1 Requirements and Constraints

Qualification cable harness assemblies are subjected to continuity and insulation resistance checks, environmental exposures, and connector engagement and pull tests. Cable assemblies are also installed in the proof test model for qualification at the assembled flight system level.

Acceptance testing of cable assemblies for the mission flight systems consists of physical inspection, continuity and insulation resistance tests, and ethylene oxide and heat sterilization exposures, followed by retest.

2.8.2 Preferred Preliminary Design

The above requirements are satisfied as follows:

1) The qualification of cable assemblies is accomplished in facility-provided environmental test fixtures and chambers, and verified with commercial test equipment (e.g., meggers, ohmmeters)
2) Acceptance testing is accomplished with standard manufacturing tooling, i.e., Hughes analyzers
3) Final qualification and acceptance is accomplished in an assembled flight system and is demonstrated by proper operation of interconnected subsystems as monitored by the System Test Complex.

2.9 Pyrotechnics

The power and pyrotechnic subsystem test set automatically tests the pyrotechnic control equipment as a subsystem, as well as the spares and replacement level packages. Squibs are tested separately.

2.9.1 Requirements and Constraints

The two test configurations are a pyrotechnic control assembly (consisting of two safe-arm relays and four squib-firing circuits), and a subsystem that includes the pyrotechnic control assembly plus two current limiter assemblies and interconnecting cables. Performance parameters tested include "all-fire" and "no-fire" margins, redundancy validity, and parametric variation margins. To test these parameters, in the context of the general requirements, the OSE provides power, discrete command signals, and electrical simulation of squib bridgewire circuits. It independently detects current above the "no-fire" and "all-fire" margins in each simulated bridgewire circuit.

2.9.2 Preferred Preliminary Design

The Entry Science Package pyrotechnic subsystem is tested with the Capsule Bus power and pyrotechnic subsystems test set. The pyrotechnic test equipment is combined with the power subsystem test equipment, for common use of the power supply, battery, control, and data acquisition equipment.

Functional Description - Figure 2.9-1 functionally illustrates the test set and its interfaces. For test of a complete subsystem, simulators are connected to the outputs in place of each squib. Each redundant path is exercised separately, which corresponds to a single failure in each path, while the scanner and multiplexer system monitors the threshold sensing signals from each simulator. For test of the replaceable control assembly package, a load is connected to the output of each squib-firing circuit. The current and voltage at each load is measured as the equipment is exercised.

Physical Characteristics - The pyrotechnic test equipment added to the test set occupies approximately half a rack (Fig. 2.7-2). In addition, small portable squib simulators are designed to be substituted for squibs, using identical connectors.

Interfaces - The test set interfaces with the pyrotechnic subsystem, the power subsystem OSE, and the subsystem OSE computer system. Functional interfaces include the power and command signals supplied by the power subsystem test equipment, the electrical loads and squib simulation, and the control and data acquisition interface with the subsystem OSE computer system.

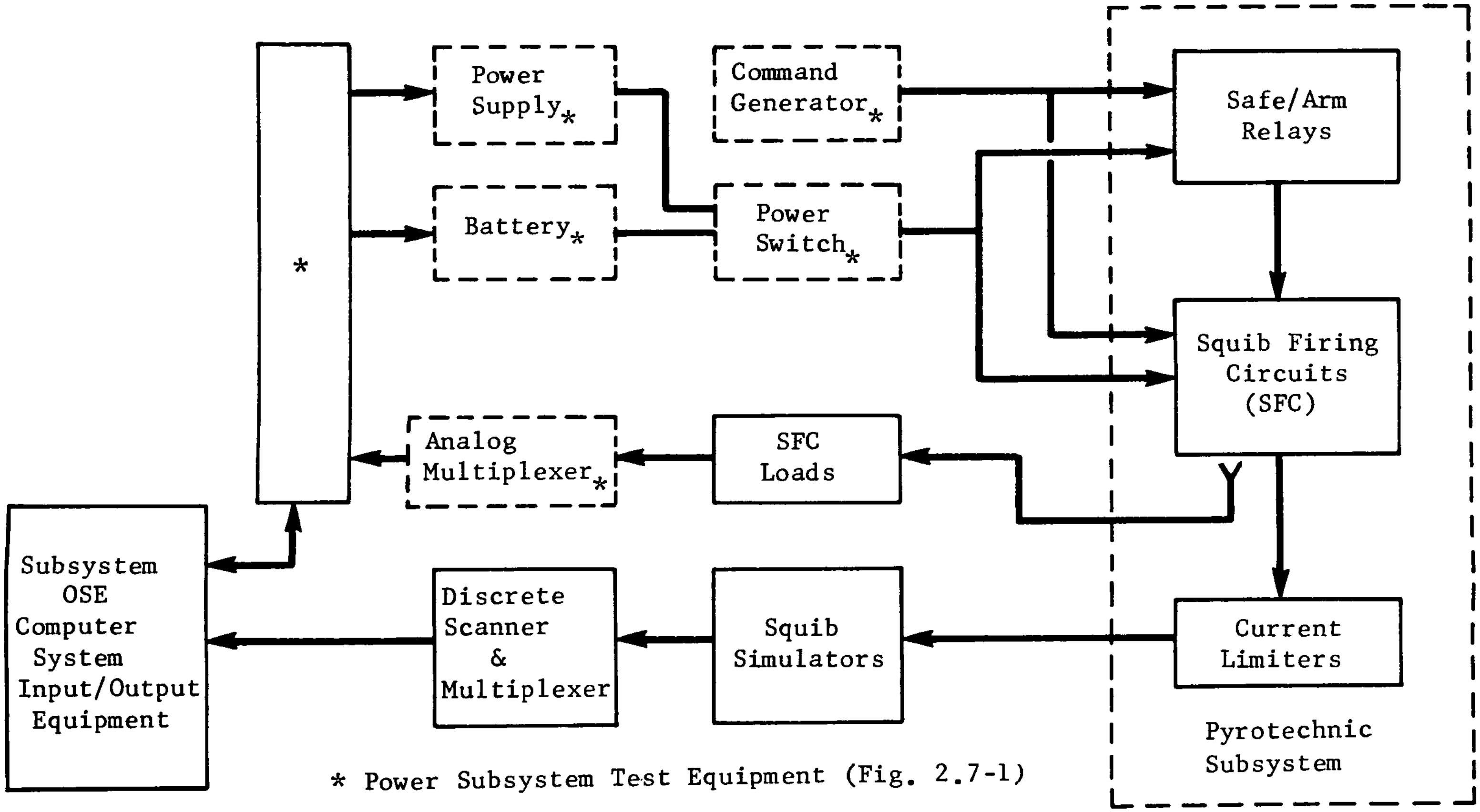


Fig. 2.9-1 Pyrotechnic Subsystem Test with Capsule Bus Power and Pyrotechnic Subsystems Test Set

2.10 Spacecraft-Mounted Entry Science Package Support Equipment

The Spacecraft-Mounted Flight Capsule Support Equipment serves the Entry Science Package, and is provided by the Capsule Bus System. The associated OSE is provided by the Capsule Bus System.

3. SYSTEM TEST COMPLEX

Two system levels of test capability are provided for the Entry Science Package. The first level is the Entry Science Package Test Complex (TC), which functionally tests the complete Entry Science Package before integration with the Capsule Bus. The second level is the Capsule Bus STC, which provides integrated testing of the Entry Science Package and Capsule Bus. The Capsule Bus STC is integrated with the Surface Laboratory STC to support Flight Capsule launch complex operations.

Paragraph 3.1 describes the Entry Science Package test complex. Paragraph 3.2 describes the Capsule Bus STC.

3.1 Entry Science Package System Test Complex

The Entry Science Package TC is a grouping of a subsystem OSE computer system (paragraph 2.2), unique subsystem OSE, and interfacing equipment that can perform complete functional testing of the Entry Science Package. The Entry Science Package TC is also used to test the Entry Science Package science data subsystem before package integration.

3.1.1 Requirements and Constraints

Functional and Design Requirements - The functional and design requirements for the Entry Science Package TC are:

1) OSE requirements as identified in paragraph 1.0
2) Capability for acceptance, environmental, and mission simulation testing of the Entry Science Package or replacement elements
3) Handling equipment for holding the unit under test
4) Test harness
5) Log showing accumulated operating time and test running time on the unit under test
6) Test requirements -
   a) Stimulate Entry Science Package subsystems and experiments
   b) Verify circuit performance and compatibility of integrated components
   c) Perform calibration
   d) Monitor all Entry Science Package output signals
   e) Display test results
   f) Record test results
   g) Provide OSE self-test
   h) Simulate Capsule Bus power
   i) Provide accurately measured sources of vacuum and temperature

- j) Record operating times
- k) Perform automated tests
- l) Provide accelerations at precise values (for accelerometer tests)
- m) Control and monitor input/output power margins and stability
- n) Control and monitor input/output signal margins and stability
- o) Measure radio frequency stability, power, modulation, etc
- p) Perform malfunction isolation
- q) Perform data compression

7) Subsystem elements required to be tested -
- a) Entry Science experiment instruments and transducers, including TV cameras, TV electronics, accelerometer triad, quadrupole mass spectrometer, and atmospheric instruments
- b) Communications including antennas and transmitters
- c) Science data subsystem
- d) Power
- e) Pyrotechnics
- f) Thermal control
- g) Cabling.

3.1.2 Preferred Preliminary Design

3.1.2.1 System Definition

The Entry Science Package TC uses the subsystem OSE computer system (paragraph 2.2) and an Entry Science Package test set to perform the testing and support functions. The test set contains the computer interfacing equipment and the special purpose equipment required for interfacing directly with the Entry Science Package, and for interfacing with the OSE computer system's test station. Figures 3.1-1 and 3.1-2 are a functional block diagram and a physical presentation of the test set.

3.1.2.1.1 System Characteristics

The test complex is categorized into different types of equipment as follows:

1) Signal conditioning equipment that converts Entry Science Package analog and discrete monitoring data into digital form and accepts Envry Science Package digital data, for interfacing with the computer system
2) Signal conditioning equipment that converts digital data as generated by the computer system into analog and discrete stimuli for exercising Entry Science Package hardware items
3) Communications OSE for testing the communications equipment
4) Entry Science Package/Capsule Bus simulator

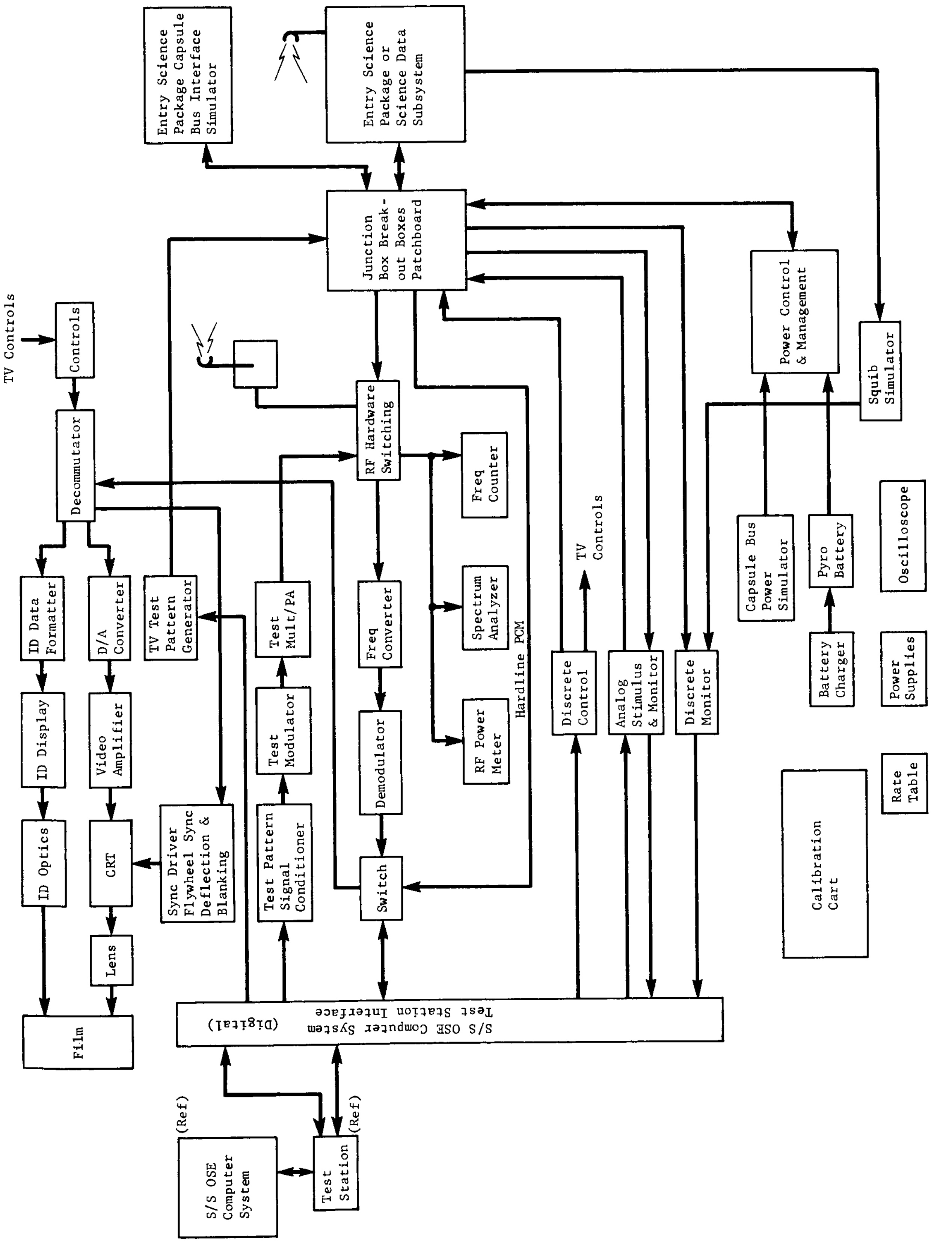


Fig. 3.1-1 Functional Block Diagram, Entry Science Package Test Complex

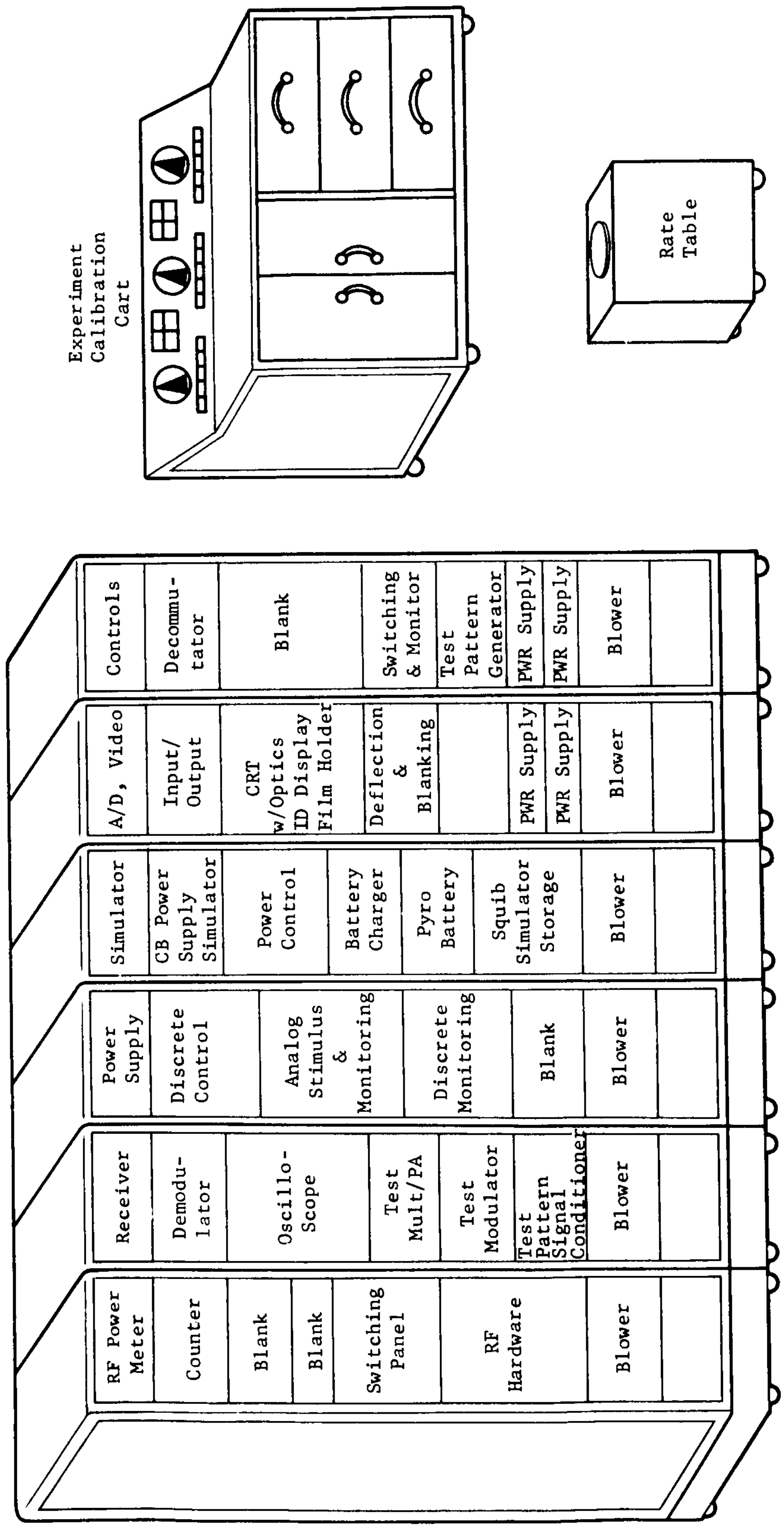


Figure 3.1-2 Entry Science Package Test Set

5) Power and pyrotechnic OSE
6) TV OSE
7) Experiment calibration OSE
8) Subsystem OSE computer system.

The functional descriptions of individual OSE hardware groups required in the test set are presented in the following paragraphs.

3.1.2.1.1.1 OSE Signal Conditioning Equipment

Subsystem Definition - The OSE signal conditioning equipment provides:

1) Receiving, address decoding, and function decoding of digital data received from the computer system
2) Stimulus generators capable of -
   a) Generating voltage and current stimuli for exercising the Entry Science Package subsystems
   b) Being programed as to range, polarity, frequency, and level control information by a single digital word
   c) Incrementing the stimulus level at such a rate and amplitude to create various wave forms
3) Relay switching of all analog and digital signal interfaces with the Entry Science Package
4) Discrete stimulus
5) Hardware interlocks, which with computer software techniques, protect the Entry Science Package from damage due to improper signal sequencing
6) Detection, digitizing, multiplexing, and transmitting functions for conveying Entry Science Package discrete data to the computer system
7) Analog-to-digital conversion, multiplexing, and transmitting functions for conveying Entry Science Package analog data to the computer system
8) Self-test circuitry and provisions for monitoring stimulus before application to the Entry Science Package or subsystem element
9) Conditioning of digital data for conveying it to the Entry Science Package OSE computer system.

Physical Characteristics - The signal conditioning equipment consists of standard OSE modular units identical to those used for subsystem OSE and Capsule Bus STC operations. The equipment is mounted in one standard OSE rack.

3.1.2.1.1.2 TC Communication OSE

Subsystem Definition - The TC communication OSE is used in testing and evaluating the performance of the communication subsystem when the Entry Science Package subsystems are connected as an integrated unit. In addition, it is used in the performance of end-to-end testing of the Entry Science Package. The OSE consists of selected portions of the communication subsystem OSE.

The TC communication OSE provides:

1) A receiver and a demodulator for evaluation of the flight and OSE transmitters. The demodulated telemetry or test bit streams are transmitted to the subsystem OSE computer system for bit error detection and to the TV electronics OSE for evaluation of the Entry Science Package TV subsystem
2) A transmitter for verification of OSE performance
3) Spectrum analysis equipment for evaluating flight equipment and OSE-generated predetection signal outputs
4) RF power and frequency measuring equipment
5) Signal paths and hardware for OSE configuration modes
6) Waveform analysis equipment.

Physical Characteristics - The TC communication OSE contains standard commercial and special test equipment as selected from the communication test set design. The equipment is configured to provide hardline access for all end-to-end subsystem measurements and includes manual patching capabilities for lower level testing.

Communication OSE consists of the following standard commercial equipment:

1) Power meter - Transmitter power outputs are measured with an accuracy of ±1 db by the OSE power meter
2) Frequency counter - The frequency counter will measure VCO and RF frequencies with an accuracy of 1 part in 10^6 or better
3) Oscilloscope - Spectrum analyzer plug-in for evaluation of predetection signals
4) Noise generator - A random noise generator for verifying operation under varying signal-to-noise ratios
5) RF hardware - Attenuators, couplers
6) OSE power supplies.

Special test equipment that comprises the communication OSE include:

1) Frequency converter - A predetection low noise frequency converter stage is included. Crystal selection permits commonality with other VHF subsystems
2) Demodulator - The demodulator is a Spacecraft-Mounted Capsule Bus Support Equipment simulated demodulator

3) Receiver switching panel - This panel permits either manual or automatic (where practical) switching of RF coaxial relays, attenuators, and loads
4) Test multiplier/PA - For OSE verification
5) Test modulator
6) Test pattern signal conditioner - Automatically controlled by computer.

The STC communication equipment is contained in two standard OSE equipment racks.

3.1.2.1.1.3 Entry Science Package/Capsule Bus Simulation Equipment

Subsystem Definition - The Entry Science Package/Capsule Bus simulation equipment is used to verify the integrity of the TC before it is connected to the Entry Science Package, to simulate Entry Science Package/Capsule Bus electrical interfaces, and to simulate loading and interfaces of Entry Science Package subsystems during subsystem testing in the TC, and during assembly and integration of the Entry Science Package.

The simulation equipment provides:

1) Simulation of science instrument inputs, logic sequences, and loads to the science data subsystem
2) Capsule Bus discrete inputs
3) Capsule Bus power simulation
4) RF test signals
5) Loading of Entry Science Package interfaces.

Physical Characteristics - Inputs and loading are simulated in one chassis mounted in the same equipment rack as the power and pyrotechnic OSE. The Capsule Bus power simulator is identical to the power unit contained in the Entry Science Package power and pyrotechnic subsystem OSE as are the squib simulators and the high current low impedance battery used to supply squib-firing current across the Entry Science Package/Capsule Bus interface. The RF test signals are supplied by the test transmitter contained in the communications OSE.

3.1.2.1.1.4 TC Power and Pyrotechnic OSE

The TC power and pyrotechnic OSE consists of selected portions of the Entry Science Package/Capsule Bus power and pyrotechnic subsystem OSE.

The STC power and pyrotechnic OSE provides:

1) A programmable power supply for simulating the Capsule Bus power supplied across the interface to the Entry Science Package. Capability exists for varying the voltage range in incremental steps automatically as programed by the computer

2) An Entry Science Package OSE power control capability (ON-OFF) as programed by the computer. Manual control also exists
3) Squib simulators - These are unique test devices used to test the pyrotechnic squib firing circuits. A simulator is substituted for each squib. It provides accurate electrical simulation of the squib and detects two thresholds independently: (1) current above a "no-fire" margin, and (2) current above the "all-fire" margin. Discrete, independent outputs are provided when each threshold is exceeded. In addition, the simulator provides positive circuit protection to prevent burnout of current limiters when firing occurs. Power is provided to the squib firing circuits by the rechargeable battery; arming, firing, and safing commands are provided to the pyrotechnic control equipment by the stimulus generator unit
4) A rechargeable battery and charger - The battery simulates the high current, low impedance characteristics of the Capsule Bus pyrotechnic batteries, which normally supply the squib firing current across the interface to the Entry Science Package. The battery charger is used to recharge the battery between tests.

3.1.2.1.1.5 Entry Science Package TV Data Processing and Display OSE

Subsystem Definition - The Entry Science Package TV data processing and display OSE provides the electronics, display and photographic processing equipment required to complement the subsystem OSE computer system in the testing and evaluation of the Entry Science Package television vidicons and electronics.

The Entry Science Package TV data processing and display OSE provides:

1) Control electronics
2) Decommutation and stripping of identification, sync, and video data
3) Scan synchronizing, deflecting, and blanking generators
4) Identification formatting and displaying
5) Identification optics
6) Video signal conditioning
7) Video CRT display, optical lens, and film processing
8) Power and power protection
9) OSE self-test equipment.

The identified capabilities are selected from subsystem and MDE OSE designs. Refer to paragraph 2.5.2.1 for functional descriptions of the hardware items.

Physical Characteristics - The Entry Science Package TV Data Processing and Display OSE consists of two standard racks of equipment (Fig. 3.1-2).

3.1.2.1.1.6 Experiment Calibration and Test OSE

Subsystem Definition - The experiment calibration and test OSE consists of the calibration and special-purpose OSE required to test the mass spectrometers, the atmospheric instruments, and the accelerometer triad in the integrated Entry Science Package test configuration.

The OSE provides:

1) Pressure and temperature stimulus equipment for exercising the atmospheric instruments
2) Environmental chambers and controls
3) A rate table and control electronics for testing the accelerometer triad
4) Cabling and interfacing provisions.

Physical Characteristics - The experiment and calibration OSE consists of a calibration cart with electronic controls, displays, storage space for calibration equipment, and the rate table, which is identical to the one used for subsystem OSE.

3.1.2.1.2 Description of Interfaces

TC Electrical Interfaces - The electrical interfaces are:

1) Facility ac power
2) Facility time codes
3) Entry Science Package direct access and intersubsystem connectors
4) Entry Science Package PCM hardlines
5) Entry Science Package RF hardlines and open-loop RF interfaces.

TC Physical Interfaces - The physical interfaces are:

1) Denver installation and assembly test areas
2) Facility grounding system
3) Internal AHSE interfaces.

3.1.3 Entry Science Package Test Complex Analysis and Trade Studies

The Entry Science Package test complex is designed to be compatible with the equipment and testing concepts established for the Flight Capsule over the various levels of testing from replacement component level to system level.

High emphasis has been placed on equipment commonality, on maintaining identical interfaces and testing methods, and on using identical computer software between testing levels.

Refer to paragraph 2.2.3 for analysis of the use of a subsystem OSE computer system in the Entry Science Package test complex.

3.2 Capsule Bus System Test Complex

The System Test Complex (STC) is a grouping of OSE to provide a complete Capsule Bus system test capability. The STC is also required to support Flight Capsule and Planetary Vehicle marriage tests and portions of the STC are required to support launch pad operations. The capability for system level testing of the Entry Science Package after it has been integrated into the Capsule Bus exists in the Capsule Bus and Flight Capsule STCs.

3.2.1 Requirements and Constraints

Requirements and constraints of paragraph 1.0 and those specified in the following documents provide the basis of the design of STCs:

1) SE003BB002-2A21, Voyager Capsule Systems Constraints and Requirements Document, Rev 2, dated June 12, 1967
2) ED-22-6-52, **Trade Study, System Test Complex Configuration.**

3.2.2 Preferred Preliminary Design

3.2.2.1 System Definition

The Capsule Bus System Test Complex implements a highly integrated system test philosophy. A computer data system is used to perform command, control, monitoring, and display functions. Figure 3.2-1 is a functional block diagram of the Capsule Bus STC.

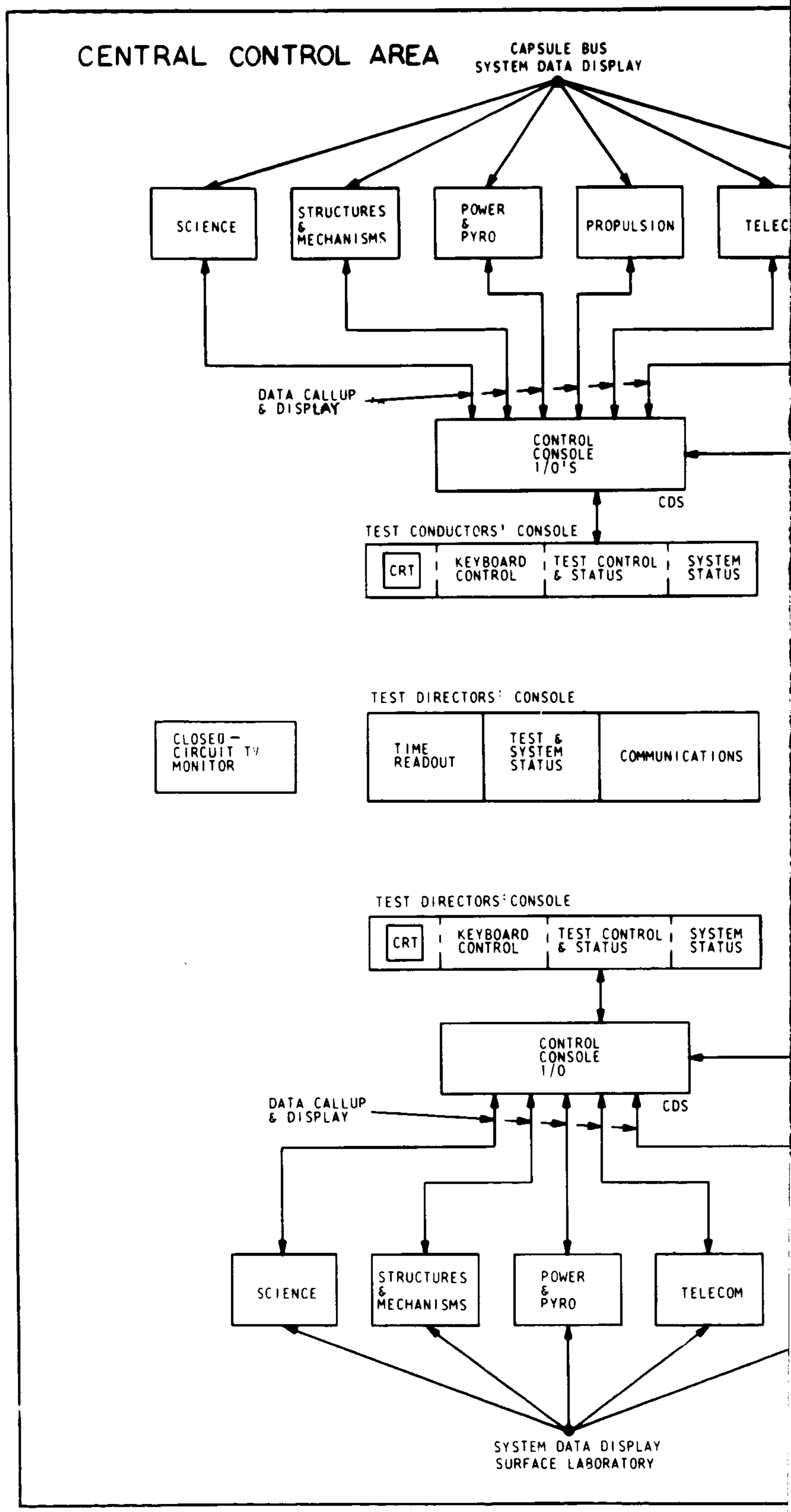
The STC is divided into two separate hardware groupings. A control center grouping that remains at a given contractor facility and at KSC, and a capsule vicinity grouping that moves with the flight system test article from test area to test area. Figures 3.2-2 and 3.2-3 are pictorial representations of Control Center and Capsule-vicinity equipment, respectively.

3.2.2.2 System Characteristics

Functional descriptions of the STC hardware items are provided with special emphasis placed on those items that are unique to the Entry Science Package.

3.2.2.2.1 Computer Data System (CDS)

The selected computer system is capable of testing all systems of two Flight Capsules at the same time. This system is capable of generating the required command and control signals, while continuously monitoring all pertinent Flight Capsule input and output signals.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DATA CALLUP & DISPLAY
CONTROL CONSOLE I/O'S
CDS
TEST CONDUCTORS' CONSOLE
CRT
KEYBOARD CONTROL
TEST CONTROL & STATUS
SYSTEM STATUS
TEST DIRECTORS' CONSOLE
CLOSED-CIRCUIT TV MONITOR
TIME READOUT
TEST & SYSTEM STATUS
COMMUNICATIONS
TEST DIRECTORS' CONSOLE
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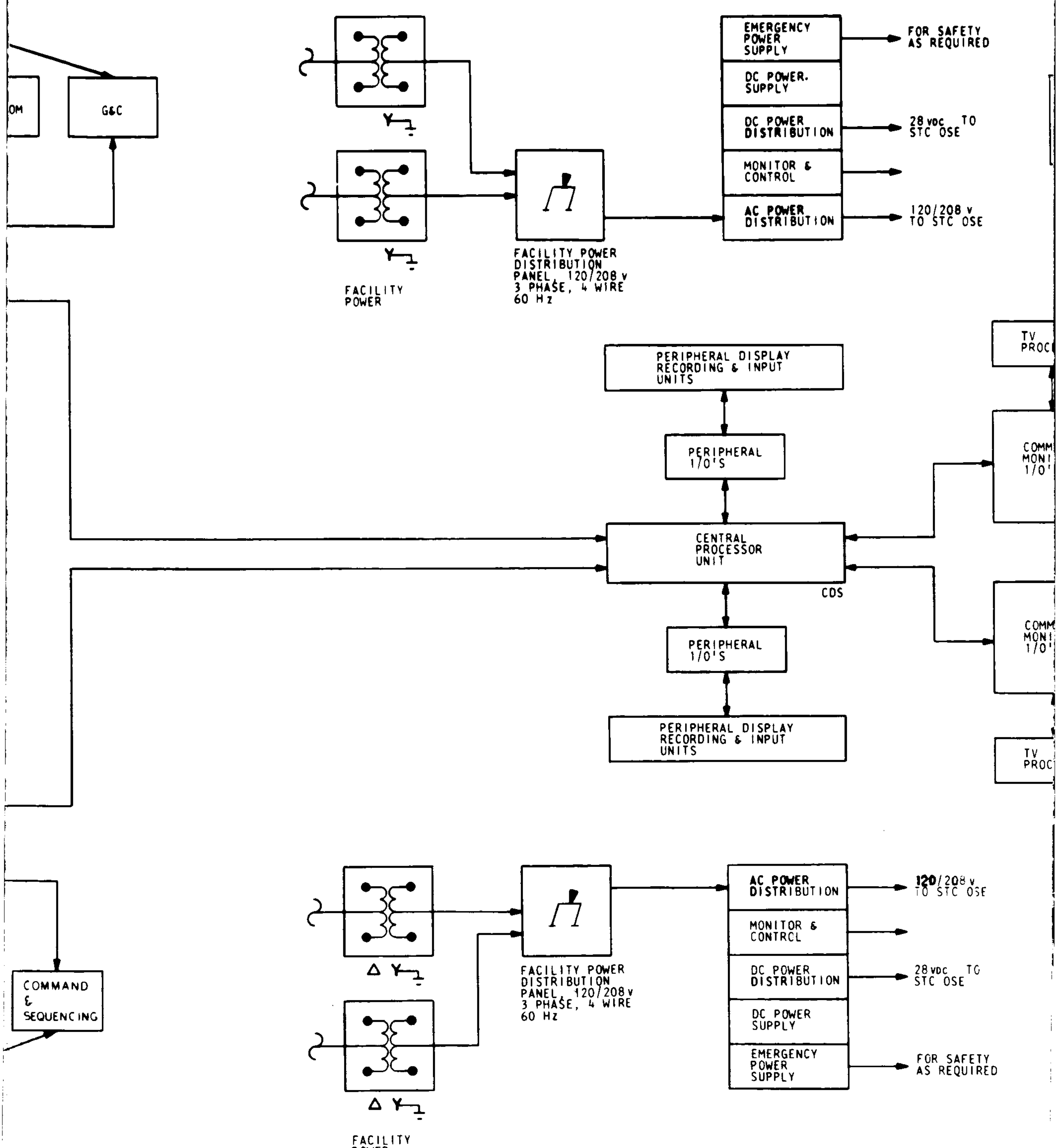

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FACILITY POWER DISTRIBUTION PANEL, 120/208 v 3 PHASE, 4 WIRE 60 Hz
EMERGENCY POWER SUPPLY
DC POWER SUPPLY
DC POWER DISTRIBUTION
MONITOR & CONTROL
AC POWER DISTRIBUTION
FOR SAFETY AS REQUIRED
28 VDC TO STC OSE
120/208 v TO STC OSE
PERIPHERAL DISPLAY RECORDING & INPUT UNITS
PERIPHERAL I/O'S
CENTRAL PROCESSOR UNIT
CDS
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PERIPHERAL DISPLAY RECORDING & INPUT UNITS
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AC POWER DISTRIBUTION
MONITOR & CONTROL
DC POWER DISTRIBUTION
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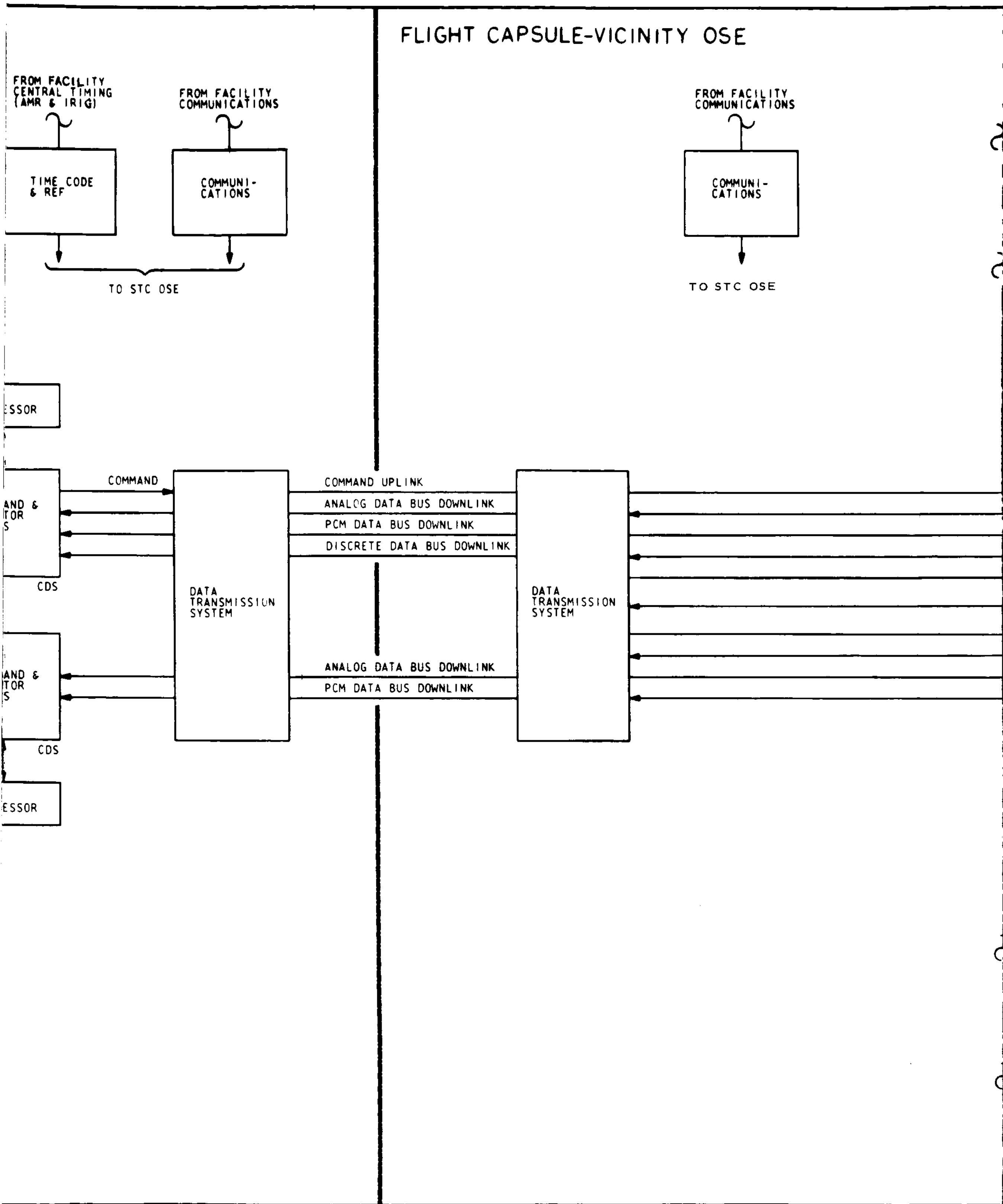
FLIGHT CAPSULE-VICINITY OSE
FROM FACILITY CENTRAL TIMING (AMR & IRIG)
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TIME CODE & REF
COMMUNI-CATIONS
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FROM FACILITY COMMUNICATIONS
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DATA TRANSMISSION SYSTEM
COMMAND UPLINK
ANALOG DATA BUS DOWNLINK
PCM DATA BUS DOWNLINK
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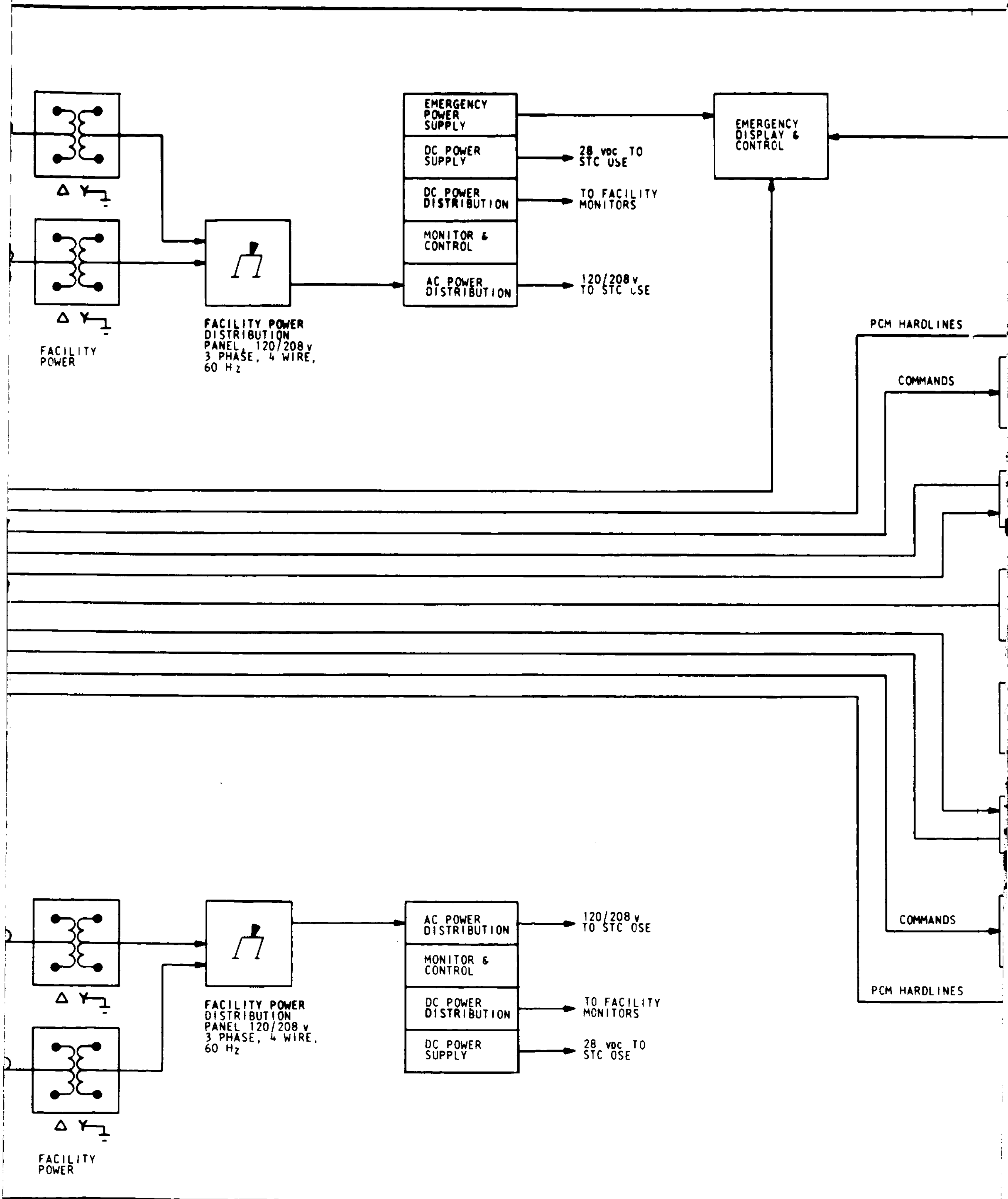
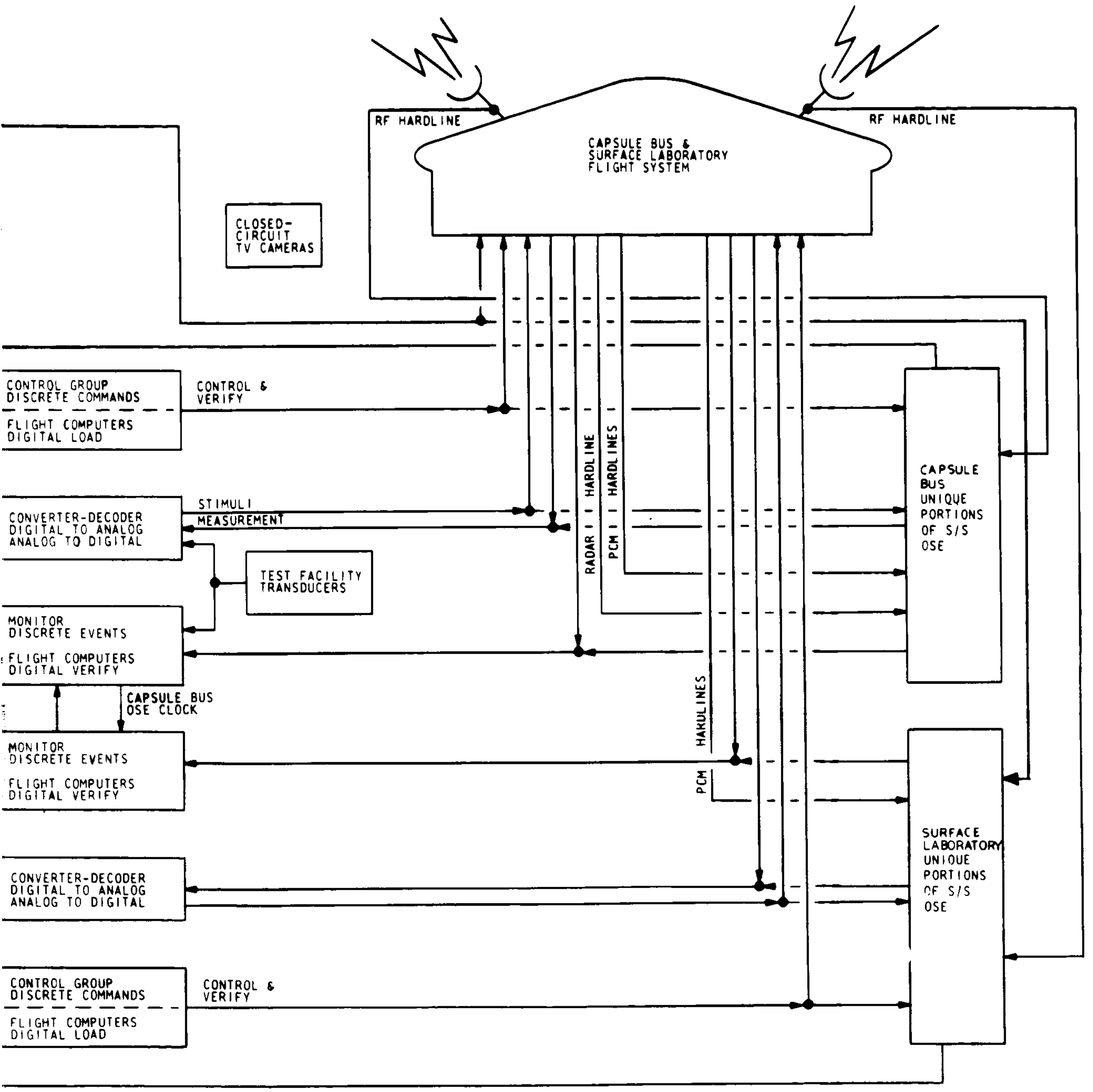
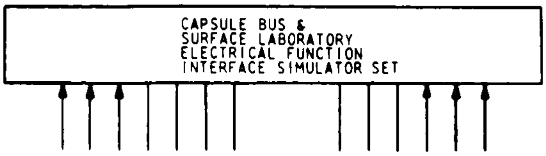
Fig. 3.2-1 C



Capsule Bus STC Functional Block Diagram


RF HARDLINE
CAPSULE BUS & SURFACE LABORATORY FLIGHT SYSTEM
RF HARDLINE
CLOSED-CIRCUIT TV CAMERAS
CONTROL GROUP DISCRETE COMMANDS
FLIGHT COMPUTERS DIGITAL LOAD
CONTROL & VERIFY
CAPSULE BUS UNIQUE PORTIONS OF S/S OSE
CONVERTER-DECODER DIGITAL TO ANALOG ANALOG TO DIGITAL
STIMULI
MEASUREMENT
RADAR HARDLINE
PCM HARDLINES
TEST FACILITY TRANSDUCERS
MONITOR DISCRETE EVENTS
FLIGHT COMPUTERS DIGITAL VERIFY
CAPSULE BUS OSE CLOCK
HARDLINES
PCM
MONITOR DISCRETE EVENTS
FLIGHT COMPUTERS DIGITAL VERIFY
SURFACE LABORATORY UNIQUE PORTIONS OF S/S OSE
CONVERTER-DECODER DIGITAL TO ANALOG ANALOG TO DIGITAL
CONTROL GROUP DISCRETE COMMANDS
FLIGHT COMPUTERS DIGITAL LOAD
CONTROL & VERIFY

3-1X-5


CAPSULE BUS &
SURFACE LABORATORY
ELECTRICAL FUNCTION
INTERFACE SIMULATOR SET

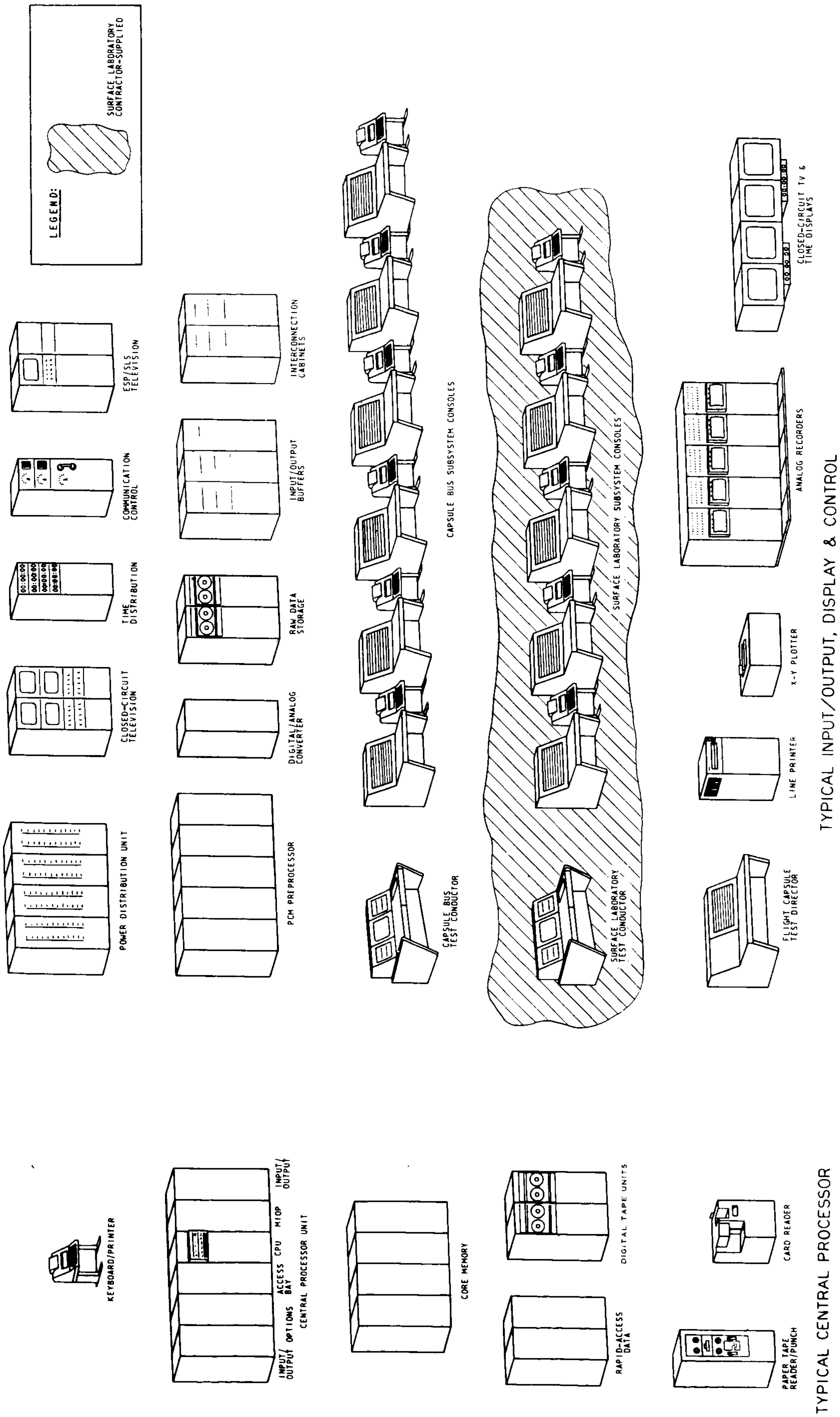


Fig. 3.2-2 Control Center Equipment, Flight Capsule STC

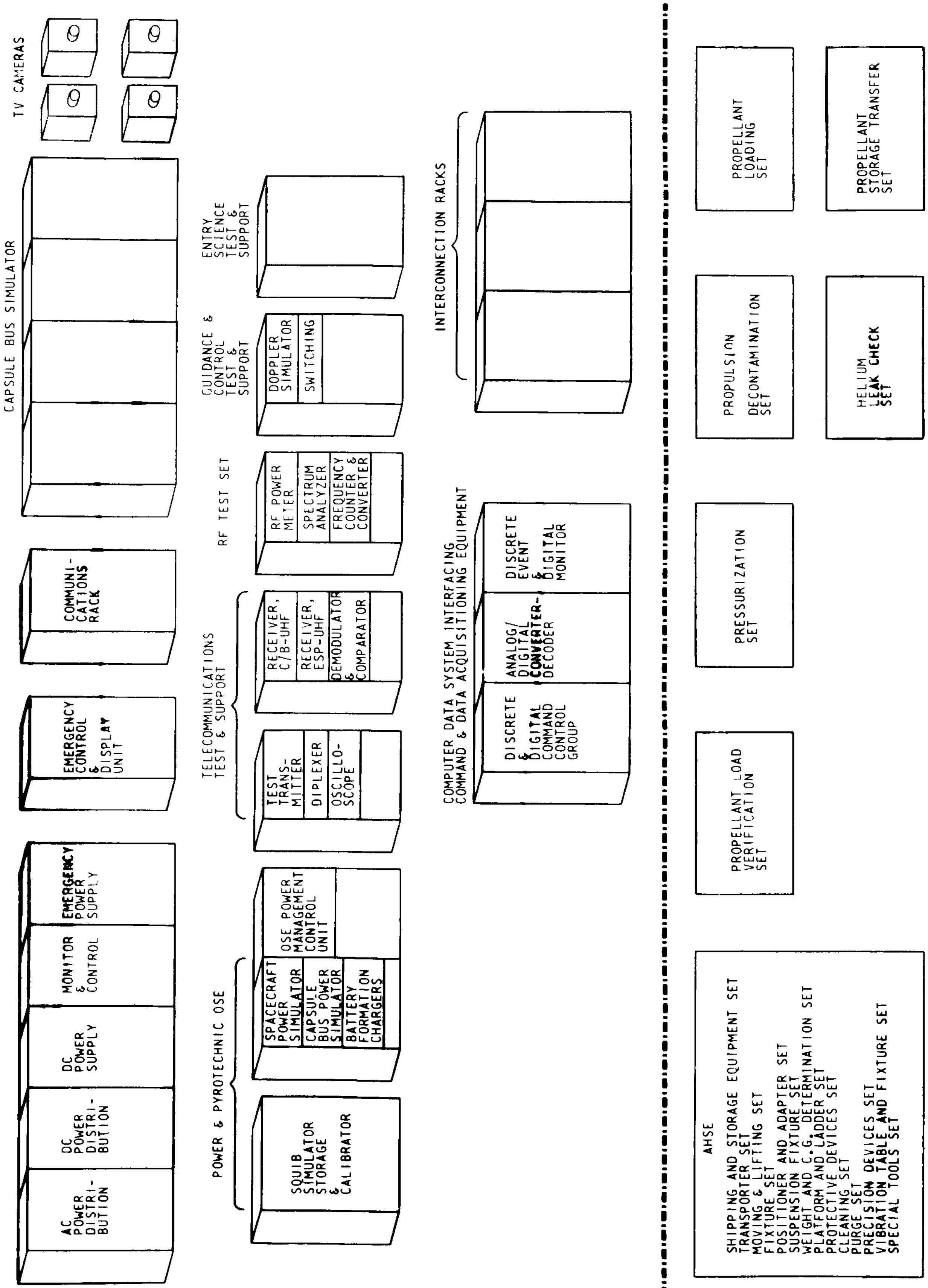


Fig. 3.2-3 Capsule-Vicinity OSE

Subsystem Definition - The test conductor's console provides signals to the CDS to designate the type of tests to be performed and can start, stop, repeat, and recycle the test to a previous point. The stored program is then executed by generating the required commands.

All signals in and out of the Flight Capsule are stored in a raw data storage system capable of recording many data streams. Time codes are stored on one channel to assure proper time tagging.

The incoming data undergoes compression operations that compare the new data to previous samples. Only data that differs significantly will be retained and processed. The criticality of each signal has been predetermined, so that the central processor proceeds to take the appropriate action. For alarm monitoring, appropriate safing or test interruption action takes place immediately and has the highest priority for central processor servicing. The test conductor and the subsystem operator is notified and an alarm is sounded if the alarm condition is hazardous. Out-of-limits data cause subroutines to further isolate the malfunctions or indicate the action to be taken.

All No-Go data, including alarm conditions, are printed on a line printer for a master log of the test data. This printout includes the time of occurrence, the channel designator, the actual reading (in engineering units), the assigned upper and lower limits, and the condition of other associated data.

Compressed or uncompressed data may be selected by the processor for real-time recording. The processor assigns the digital/analog converter (DAC) channel to the recorder channel and to the analog indicator on the display consoles.

All signals are verified and recorded as the signals are sent to the Flight Capsule, in addition other continuous monitors provide testing of the performance of uplink command hardware through decoding phases. Fault-isolation self-testing routines are called up as part of a procedure or during initialization periods.

The CDS equipment required to perform these tasks is subdivided into log and recording equipment, central processing equipment, and input/output equipment.

Log and Recording Equipment - The log and recording equipment provides four types of printed data for the test director, test conductor, or subsystem operators. The display data can be preprogramed to be printed under specific conditions or some data can be called up with console instructions.

The four types of printed data are teletypewriter copies, line printer copies, X-Y plotter copies, and direct writer recorder copies.

Central Processing Equipment - This group of equipment consists of a high-speed general purpose digital computer and its associated peripheral devices that accepts commands and data, processes the input, stores the data, and indicates the results. An SDS sigma-type computer was selected as the reference configuration for its capability to work in a real-time environment and its unique instruction set that facilitates testing using high-speed inputs.

Three types of memory devices service the processors and provide records for later usage. The magnetic core memory contains the programs and procedures to execute the immediate test phase and to store the data of immediate interest. The rapid access data (RAD) file is a mass storage device and is used to store procedures or data tables not immediately required. The digital tape recorders are used in the performance of a test to store compressed data of test results and any additional data displayed on the line printer log.

Input/Output Equipment - The input/output equipment is composed of circuits to buffer and condition all input and output signals for the CDS.

The input/output buffer group contains the signal conditioning, buffering, and signal conversion equipment to insure that signal levels are compatible with the Capsule-vicinity equipment, facilities, Spacecraft OSE, or control center OSE. The digital input/output receives the test conductor discrete commands and converts them to digital signals for processing, and provides driving capabilities for relay or lamp operations. The analog input/output controller permits random or sequential operation of analog devices at pre-specified rates. The communication channel controller controls the signal flow to and from teletypewriters or keyboard/display, which are used by the test conductor and subsystem operators. A general-purpose PCM preprocessor is supplied that not only requires sync without loss of presync data, but identifies errors, restores degraded signals, counts errors, and suppresses insignificant data.

All of the above interfaces are stored on magnetic tape except the status and analog displays (timing signals are included for reference). These signals can be replayed, simulating the conditions just as they occurred, which is especially useful in capturing phenomena that do not occur repeatedly.

Provisions are also included in the STC to receive launch pad signals and to drive remote keyboard displays for LCE requirements. For further details of this signal interchange see paragraph 4.0.

3.2.2.2.2 Control Center Control and Display OSE

The Control Center control and display OSE is the STC equipment provided so that operating and test personnel can communicate with and maintain control of system test and support operations and to obtain data for evaluation of the Capsule Bus System, OSE, and facility performance.

Test Conductor's Console - The test conductor's console provides the man-machine interface with the computer system and the OSE hardware for initiating and controlling testing of the Capsule Bus or any of its subsystems.

System Display Groups - The system display groups are the Control Center monitoring equipment that provides real-time display capability for the Capsule Bus System-oriented test analysis teams to evaluate subsystem performances during normal test and troubleshooting operations. One of these test stations is reserved for the Entry Science Package. The Entry Science Package display group:

1) Provides real-time displays for evaluation of significant test conditions and performance of the Entry Science Package during testing and for isolating sources of malfunctions
2) Provides for calling up data related to the Entry Science Package
3) Provides for displaying test time
4) Contains voice communication equipment.

ESP TV Data Processing and Display OSE - The ESP TV data processing and display OSE provides the electronics, the visual display, and the photographic processing equipment required to complement the CDS in the evaluation of the TV vidicons and electronics. The equipment is shared for Entry Science Package and Surface Laboratory TV tests in Flight Capsule STCs. The Entry Science Package TV data processing and display OSE provides:

1) Control electronics
2) Decommutation and stripping of identification, sync, and video data
3) Scan synchronizing, deflecting, and blanking generators
4) Identification formatting and displaying
5) Identification optics
6) Video signal conditioning
7) Video CRT display, optical lens, and film processing
8) Power and power protection
9) OSE self-test equipment.

3.2.2.2.3 Capsule-Vicinity OSE

Discrete and Digital Command Control Group - The discrete and digital command control group is equipment that interfaces directly with the Capsule and ESP direct access and umbilical connectors and with items of STC OSE for effecting discrete and digital control of Capsule subsystems and of OSE testing operations as commanded by the computer system.

Digital/Analog Converter-Decoder - The digital/analog converter-decoder equipment interfaces directly with the Capsule and ESP direct access and umbilical connectors for providing stimulus to the subsystems and for acquiring analog data for transmission to the CDS.

Discrete Event and Digital Monitor - The discrete event and digital monitor interfaces directly with the Capsule and ESP direct access and umbilical connectors and with items of STC-OSE for effecting discrete and digital signal detection for CDS acquisition.

Power and Pyrotechnic OSE - The STC power and pyrotechnic OSE with the STC command and data acquisition equipment provides the equipment required to support and test the power and pyrotechnic subsystems.

Guidance and Control OSE - The guidance and control OSE is special-purpose equipment that in conjunction with the STC general-purpose OSE provides the capability to support and test the guidance and control subsystem.

Command and Sequencing, Thermal Control, and Structures and Mechanisms - No special purpose OSE is required. All functions are performed by using the STC command and data acquisition equipment.

Telecommunications OSE - The telecommunication OSE is special-purpose OSE which, with the STC RF test set and the command and data acquisition equipment, provides the capability for testing the Capsule Bus and Entry Science Package radio subsystems and the Capsule Bus telemetry subsystem.

Propulsion OSE - The propulsion OSE supports the servicing and testing of the propulsion subsystems.

Entry Science OSE - The Entry Science OSE is the special-purpose OSE required in the STC to support system level testing. Calibration equipment calibrates and verifies the calibration of experiment instruments and transducers.

Testing consists of end-to-end tests with stimulus being applied either physically or electrically to the instrument collecting and input areas.

Optical targets are supplied for TV stimulus, gas samples for the mass spectrometer; velocities are imparted to the accelerometer triad through the Capsule Bus alignment and checkout tilting table; pressure and temperature stimulus is applied to the atmospheric instrument probes. The general-purpose computer is used to monitor data acquisition equipment and the flight system/OSE telemetry links.

The Entry Science OSE consists of a calibration cart and/or standard OSE racks that are used to store and control hardware for the calibration and stimulus equipment.

RF Test Set - The STC RF test set contains the general-purpose RF equipment for measurement of RF parameters.

Emergency Control and Display Unit - The emergency control and display unit consists of equipment to provide capability, independent of other STC OSE, for continuous monitoring, and control and alarm of all functions related to Flight Capsule or personnel safety.

3.2.2.2.4 Ancillary Equipment

The STC ancillary equipment is the STC hardware located in the Control Center and at the Capsule-vicinity to complete the test capability of the STC. It consists of the ac power distribution, dc power supply and power distribution, voice communication, timing, data transmission system, and closed-circuit TV equipment.

3.2.2.2.5 Computer Programs

Software permits efficient use of the CDS for real-time and off-line operations. The CDS software is made up of three major components: test language programs, supervisor control programs, and off-line operating programs.

Subsystem Definitions - In general, the test language programs are those used by the test engineer to construct all tests. The supervisory/control program maintains program control over all operations performed by the CDS. The off-line operating system is used to prepare test procedures and further processing of the data after test completion.

Test Language System - Individual computer programs provide for data monitoring and checkout operations. Each of these computer programs uses criteria derived from mission and test requirements in the form of data values, parameters, or tables to program the computer for data monitoring and checkout operations. All CDS test and checkout procedures are implemented by means of an appropriate sequence of these test operations. The operations provided by these computer programs are executed interpretively. A typical example of the approximately 15 elements is indicated in the following paragraph.

The "stimulate" element is used to program the digital-to-analog converters that apply stimulus to the vehicle analog input lines. The range is computed to give the best resolution possible. Engineering units are included as a part of the level modifier as either volts or milliamperes. The "and" designator can be used to cause simultaneous application of stimulus.

The test operations using test language programs are controlled by special executive programs. These executive programs allow the test conductor to execute any stored sequence or to construct a new test sequence. (On-line test generation would not alter or destroy any stored program or criteria.) This controller program also provides for linking the test operations, auditing of the test procedure, and displaying the data and status. System status is maintained during this operation for status displays, and criteria updating, as well as control of the data recorders.

Supervisory Program - Control and service functions that do not require previously prepared data, parameters, or tables for their complete specification are provided by these computer routines. Some of these programs are initiated by control signals from the consoles.

Off-Line Operating Systems - This set of computer programs performs processing functions necessary to prepare input data, parameters, and procedures required for the on-line computer programs. This set also performs further analysis of the data after completion.

3.2.2.3 Description of Interfaces

STC Electrical Interfaces - The STC electrical interfaces are:

1) Facility ac power
2) IRIG and NASA 36 bit time codes
3) Facility countdown timing
4) Capsule Bus direct access and umbilical connectors
5) Capsule Bus hardline and open-loop RF interfaces
6) Entry Science Package direct access connectors
7) Entry Science Package hardline and open-loop RF interfaces
8) PCM hardline
9) Spacecraft OSE (Capsule Bus via Spacecraft umbilical)
10) Facility transducers
11) Flight cabling for simulation of nonreversible functions.

STC Physical Interfaces - The STC physical interfaces are:

1) Denver installation and assembly test areas
2) Thermal vacuum facility
3) Vibration and acoustics facilities
4) Capsule flight qualification test areas
5) KSC installation, encapsulation, and sterilization test areas
6) Planetary Vehicle test areas
7) Facility grounding systems
8) Internal AHSE interfaces.

4.0 LAUNCH COMPLEX EQUIPMENT (LCE)

4.1 Requirements and Constraints

The Entry Science Package (ESP) launch complex requirements are integrated into the Capsule Bus LCE. The Capsule Bus LCE provides, in conjunction with the KSC STC Control Center OSE, complete testing of ESP systems, in accordance with NASA/JPL requirements and with the following limits:

1) The planned Flight Capsule system launch pad operations are limited to monitoring the Flight Capsule system by hardwired safety monitors and in-flight status monitoring through Spacecraft data links
2) A capability is provided to perform a Flight Capsule integrity assurance test if some physical hazard has been encountered (shock, lightning). This test consists of a normal "in-flight" type checkout or specially programed test sequence performed by the onboard sequencing equipment. Command initiation, test program loading, and telemetry data monitoring are accomplished through normal mission preseparation data channels.
3) Except for hardwired safety control and monitoring, all flight system monitoring and testing is performed on Spacecraft power.

4.2 Preferred Preliminary Design

4.2.1 System Definition

The preferred LCE configuration is shown in Fig. 4.2-1. The figure depicts signal flow and location of the LCE. It indicates function of the Capsule Bus LCE in relation to the Entry Science Package requirements.

The capability to perform tests and evaluation of flight capsule systems performance lies with STC. The command capability to the onboard sequencing equipment and the flight systems telemetry data are available at STC Computer Data System (CDS) through Spacecraft OSE. The hardwired safety control and monitored data, as well as LCE and facility data, are received by the CDS from mobile launcher LCE. The CDS operates on available data and displays the data to system specialists. The CDS also transmits summation status of the ESP subsystems to the Launch Control Center (LCC) for display on the Capsule Bus test coordinator console.

The ESP systems are integrated into Voyager launch operation system by the Launch Control Center LCE. This equipment displays summation status of the ESP subsystems and includes provision for call-up of any data available at the CDS. It also provides hardwired safing and monitoring of the flight systems through Mobile Launcher LCE.

The hardwired safing and monitoring are independent of the flight systems or facility power. The safing of the flight systems by the Mobile Launcher LCE is initiated either manually or automatically when hazardous conditions, e.g., inadvertant arming of arm-safe devices are detected. Parallel monitoring is used to determine status of critical functions. A local evaluation, within the Mobile Launcher LCE, determines the Go/No-Go condition of a critical function and transmits the result for display in the LCC. The second method processes the safety functions and other pertinent data for transmission to the STC, where their exact limits are determined by the CDS.

4.2.2 Description of Interfaces

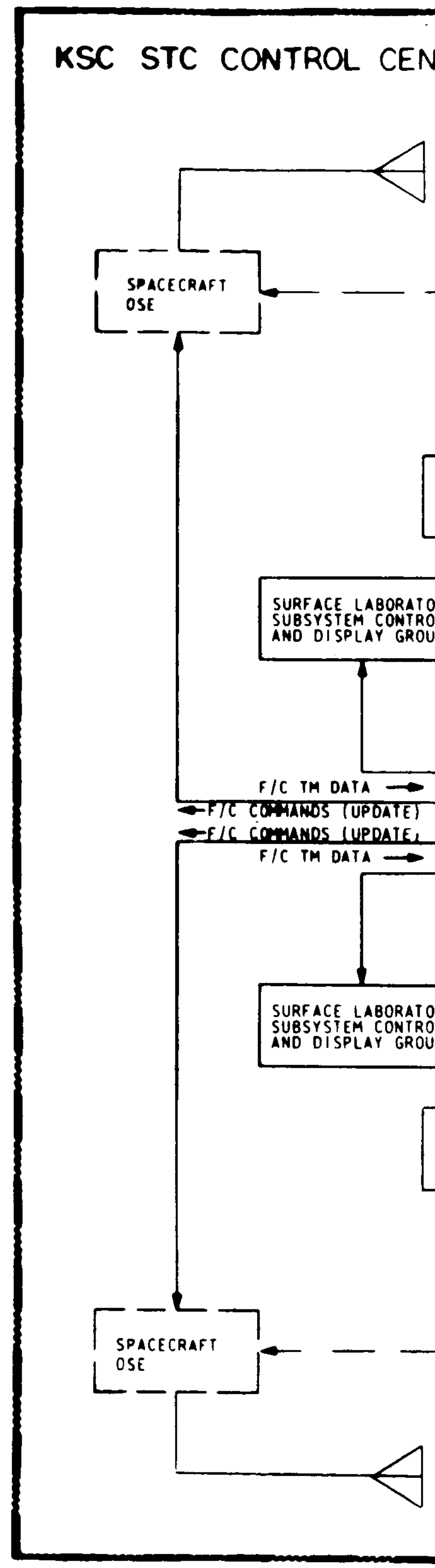
The Capsule Bus LCE/ESP system interface consists of functional and physical accommodation of the ESP launch complex requirements by the Capsule Bus LCE. These accommodations include power for excitation of the safety monitors, monitoring and safing of flight systems through hardwired interfaces, processing and display of ESP data, and necessary cabling between the Planetary Vehicle umbilical interfaces and Capsule Bus LCE.

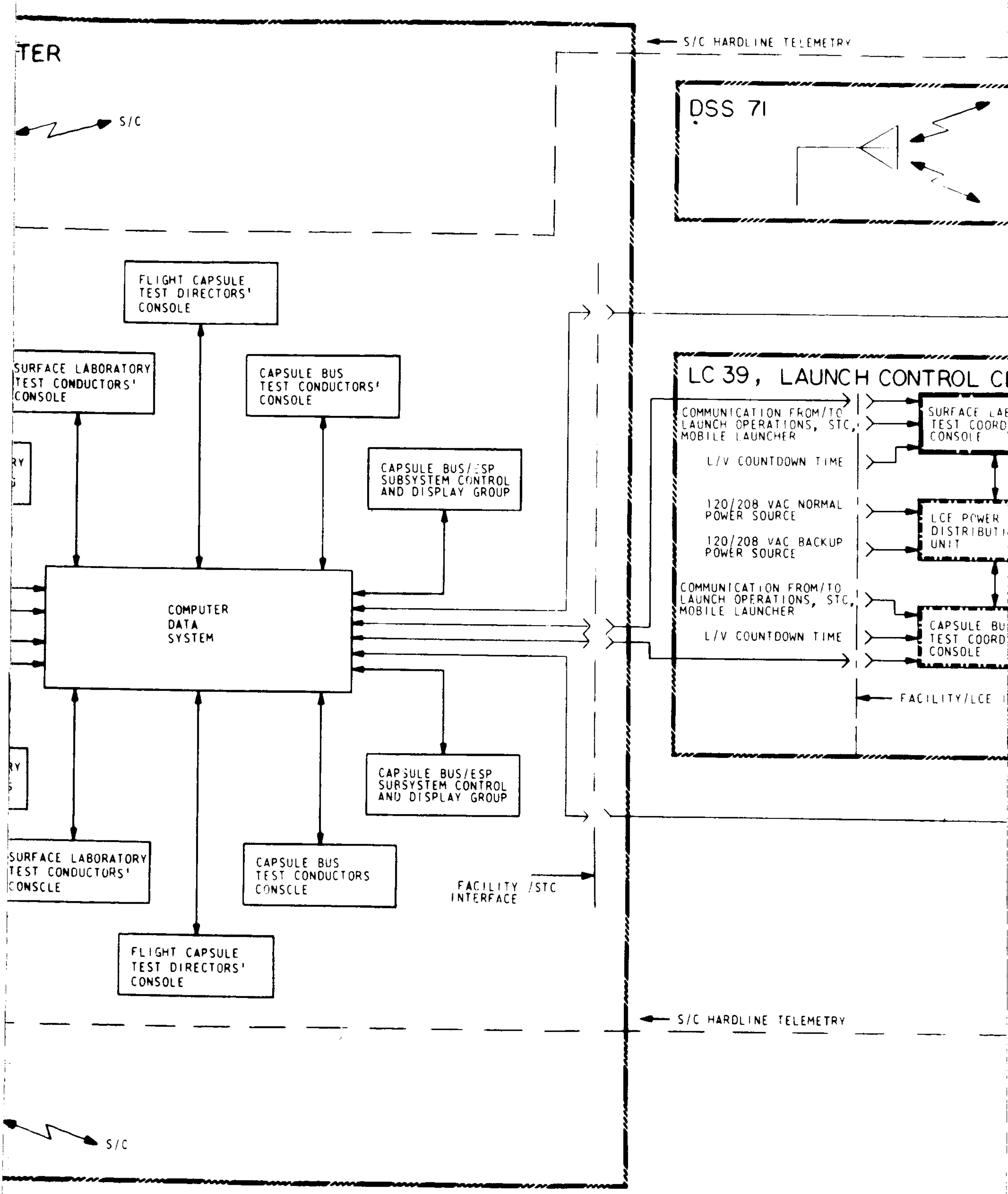
4.3 System Analysis and Trade Studies

The preferred preliminary LCE design presents a very cost-effective implementation of the Entry Science Package launch complex requirements. It provides an optimum service with a minimum effect on the Launch Complex 39 facilities, where space for location of the LCE is at premium.

The detail analysis and tradeoffs leading to the selection of the preferred LCE configuration are presented in the Launch Complex Equipment Configuration Study, ED-22-6-55.

4-3


KSC STC CONTROL CEN
SPACECRAFT OSE
SURFACE LABORATO
SUBSYSTEM CONTRO
AND DISPLAY GROU
F/C TM DATA
F/C COMMANDS (UPDATE)
F/C COMMANDS (UPDATE)
F/C TM DATA
SURFACE LABORATO
SUBSYSTEM CONTRO
AND DISPLAY GROU
SPACECRAFT OSE


TER
S/C
S/C HARDLINE TELEMETRY
DSS 71
FLIGHT CAPSULE
TEST DIRECTORS'
CONSOLE
SURFACE LABORATORY
TEST CONDUCTORS'
CONSOLE
CAPSULE BUS
TEST CONDUCTORS'
CONSOLE
CAPSULE BUS/ESP
SUBSYSTEM CONTROL
AND DISPLAY GROUP
COMPUTER
DATA
SYSTEM
LC 39, LAUNCH CONTROL C
COMMUNICATION FROM/TO
LAUNCH OPERATIONS, STC,
MOBILE LAUNCHER
L/V COUNTDOWN TIME
120/208 VAC NORMAL
POWER SOURCE
120/208 VAC BACKUP
POWER SOURCE
COMMUNICATION FROM/TO
LAUNCH OPERATIONS, STC,
MOBILE LAUNCHER
L/V COUNTDOWN TIME
SURFACE LAB
TEST COORD
CONSOLE
LCF POWER
DISTRIBUTI
UNIT
CAPSULE BU
TEST COORD
CONSOLE
FACILITY/LCE
CAPSULE BUS/ESP
SUBSYSTEM CONTROL
AND DISPLAY GROUP
SURFACE LABORATORY
TEST CONDUCTORS'
CONSOLE
CAPSULE BUS
TEST CONDUCTORS
CONSOLE
FACILITY /STC
INTERFACE
FLIGHT CAPSULE
TEST DIRECTORS'
CONSOLE
S/C HARDLINE TELEMETRY
S/C

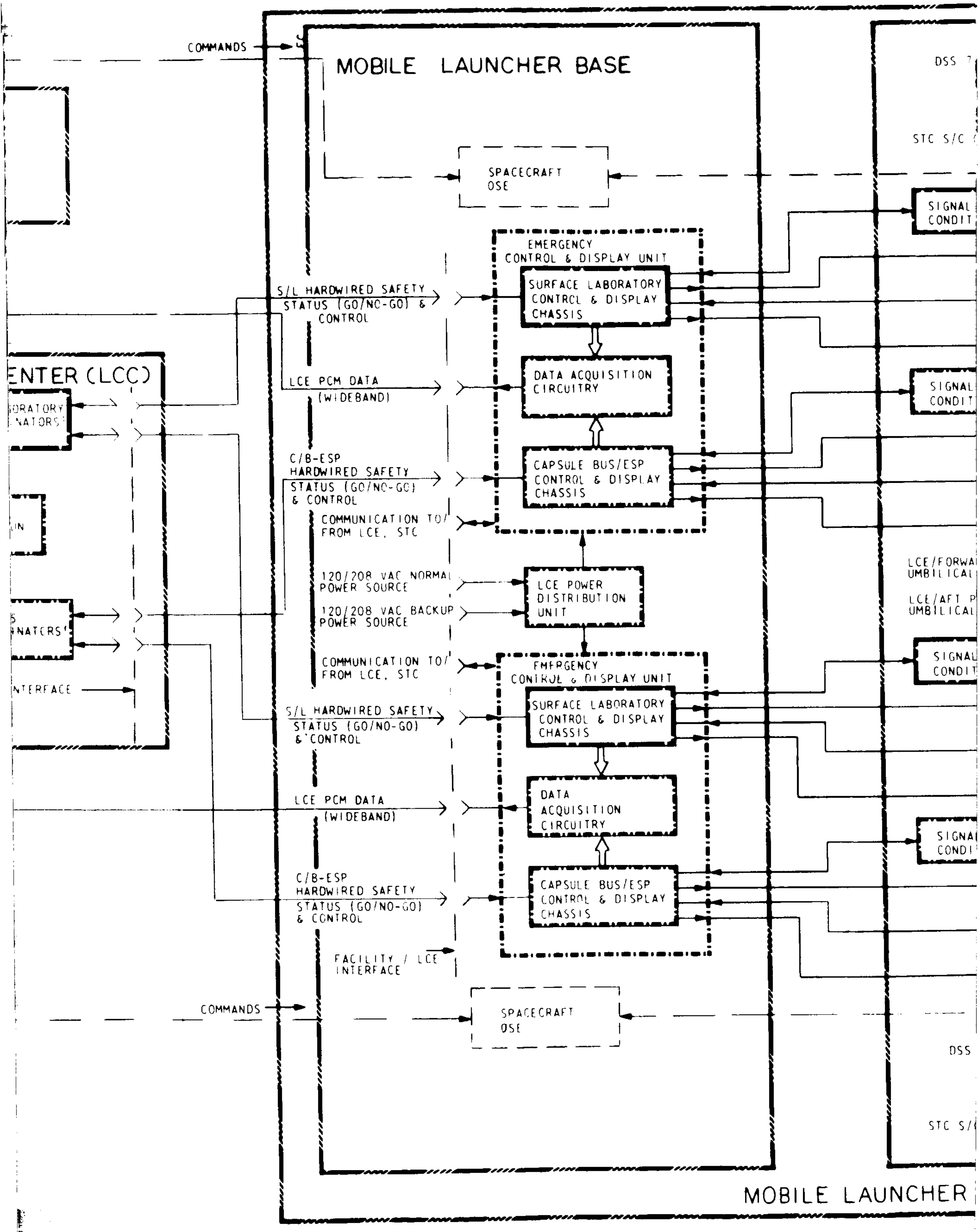
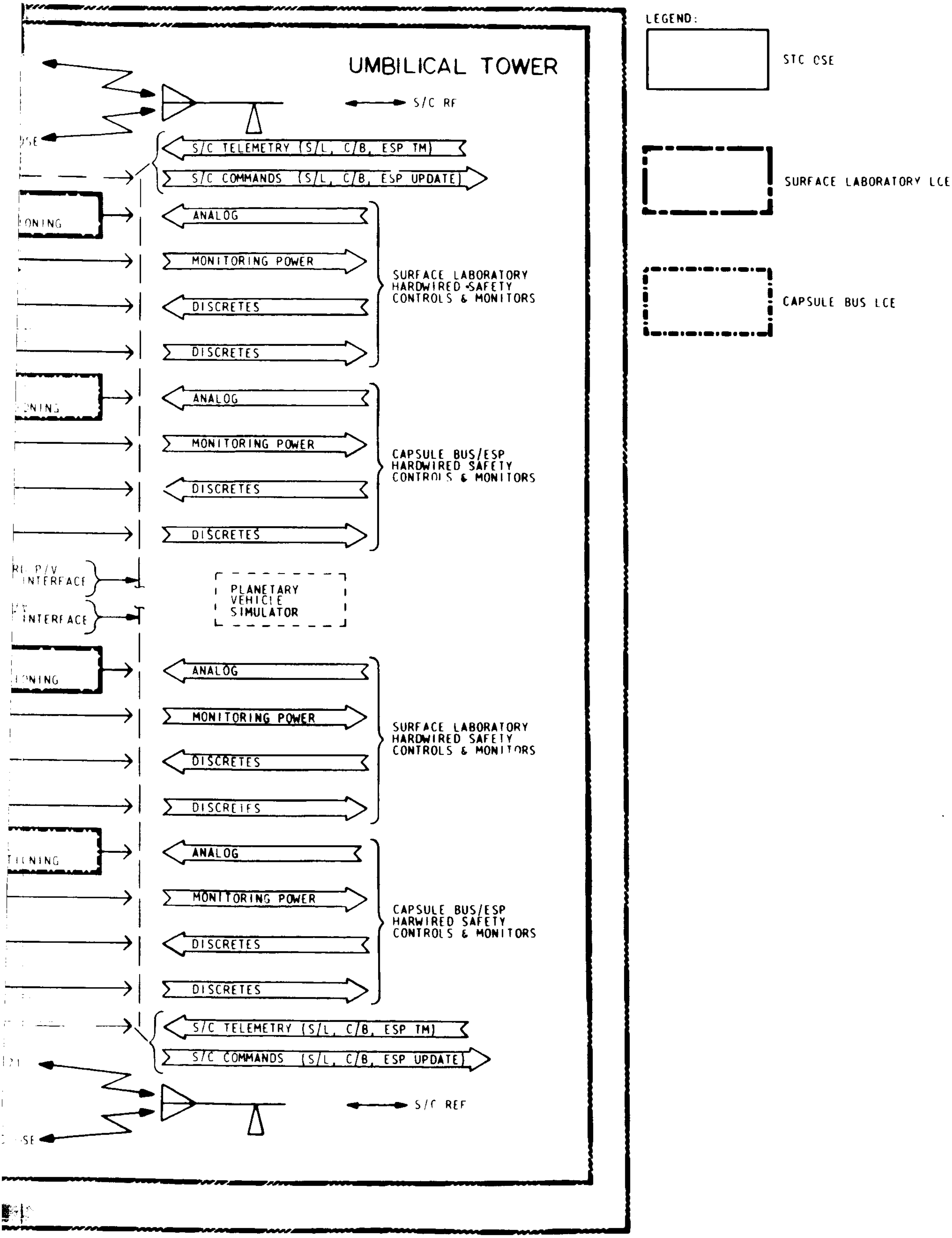


Fig. 4.2-1 LCE Configuration


UMBILICAL TOWER
S/C RF
S/C TELEMETRY (S/L, C/B, ESP TM)
S/C COMMANDS (S/L, C/B, ESP UPDATE)
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
SURFACE LABORATORY HARDWIRED SAFETY CONTROLS & MONITORS
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
CAPSULE BUS/ESP HARDWIRED SAFETY CONTROLS & MONITORS
INTERFACE
INTERFACE
PLANETARY VEHICLE SIMULATOR
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
SURFACE LABORATORY HARDWIRED SAFETY CONTROLS & MONITORS
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
CAPSULE BUS/ESP HARWIRED SAFETY CONTROLS & MONITORS
S/C TELEMETRY (S/L, C/B, ESP TM)
S/C COMMANDS (S/L, C/B, ESP UPDATE)
S/C REF
LEGEND:
STC OSE
SURFACE LABORATORY LCE
CAPSULE BUS LCE

5. ASSEMBLY, HANDLING, AND SHIPPING EQUIPMENT (AHSE)

AHSE includes the equipment necessary to lift, hold, position, align, assemble, test, transport, or store the Entry Science Package in a safe and efficient manner.

5.1 Requirements and Constraints

Specific requirements on the various classifications or types of AHSE are described in the following subparagraphs. The basis of AHSE requirements are as identified in SE003BB002-2A21, Voyager Capsule System Constraints and Requirements Document.

5.2 Preferred Preliminary Designs

Shipping and Storage Equipment Set (Fig. 5.2-1, Part 1) - The shipping container accommodates the assembled Entry Science Package and provides shock and vibration absorbtion features to safely cushion the package. It also provides an environmental atmosphere when the container is outside a normally controlled area.

Positioner and Transfer Set (Fig. 5.2-1, Part 2) - The Entry Science Package is handled by the component positioner. It is used for all assembly, disassembly, or servicing operations. This article of AHSE is common usage equipment (C/B AHSE).

Cleaning Set (Fig. 5.2-1, Part 3) - The universal cleaning set is used to assure specified cleanliness before and after assembly operations (C/B AHSE).

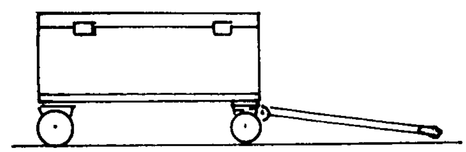
Vibration Table and Fixtures (Fig. 5.2-1, Part 4) - The general usage vibration table is used to verify the integrity of the components and assembled Entry Science Package. Adapters are provided to permit the attachment of the Entry Science Package.

Platform Set (Fig. 5.2-1, Part 5) - Platforms are provided to permit access during assembly, disassembly, or servicing operations (C/B AHSE).

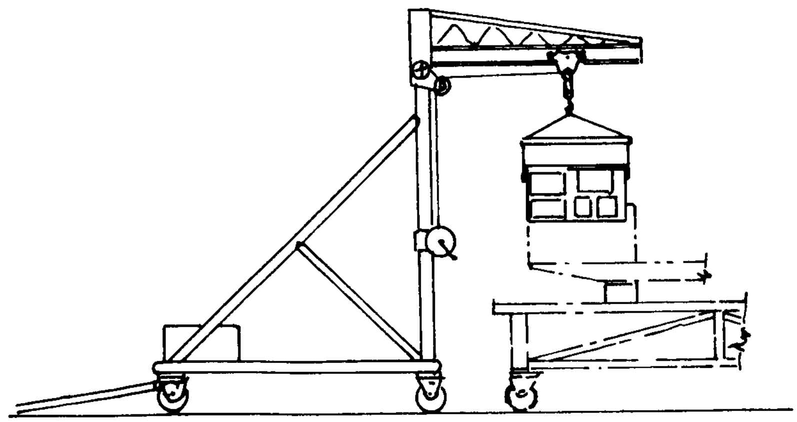
Special Tool Sets (Fig. 5.2-1, Part 6) - Special tools are provided to install, service, or remove the assembly or subassemblies as required.

5.3 Description of Interfaces

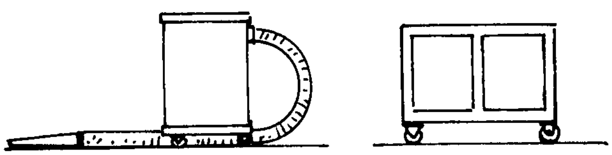
All AHSE that directly supports, lifts, handles, or contacts the Entry Science Package will have coordinated attachments. Shipping interfaces, including air, rail, or highway vehicles will not create any unusual problems. Tiedown provisions will be provided on the shipping container to handle all modes of transportation.



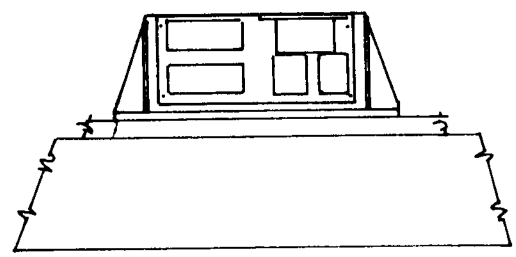
Part 1 Protective Container



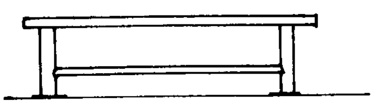
Part 2 Positioner & Transfer



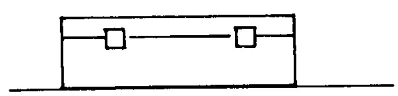
Part 3 Cleaning Set



Part 4 Vibration Adapter



Part 5 Work Platforms



Part 6 Special Tool Set

Fig. 5.2-1 Entry Science Package Assembly, Handling and Shipping Equipment

5.4 Subsystem Analysis and Tradeoff

All selected AHSE items associated with the Entry Science Package have been coordinated with the specific usage areas. Common usage, compatibility between operations, and mobility has been incorporated in all applicable items of AHSE.

No tradeoffs were required due to the combined usage features of most of the equipment. Where AHSE is common to that used in other areas it is supplied by the Capsule Bus inventory.

6. MISSION-DEPENDENT EQUIPMENT (MDE)

Mission-Independent Equipment (MIE) at the Deep Space Instrumentation Facility (DSIF) stations and Space Flight Operations Facility (SFOF) is capable of performing most mission telemetry and command functions. Some Voyager mission functions, however, due to their uniqueness, require additional special equipment. This special equipment is defined as Mission-Dependent Equipment (MDE). Figure 6-1 illustrates the overall implementation of the Entry Science Package telemetry and command functions. All Entry Science Package functions, except for TV picture reconstruction, is accomplished by MIE, Spacecraft MDE, and mission-dependent software. Entry Science Package TV MDE is provided at SFOF for reconstruction of Entry Science Package and Surface Laboratory TV pictures and is described here.

The TV MDE receives digitized video data, processes it, displays the resulting video picture, and records the picture on film. The TV MDE is also used for detailed post-mission video data analysis.

Figure 6-1 illustrates the video data chain from reception at the DSS to display and recording at the SFOF. The DSS TCP decommutates the Spacecraft-relayed Entry Science Package and the Surface Laboratory TV data, and formats it for transmission over the GCS from the DSS to the SFOF. The SFOF computer decommutates the TV data and stores it on magnetic tape. At operator request, a complete frame of data is played back to the MDE for processing, display, and recording on film.

Table 6-1 lists the important Entry Science Package and Surface Laboratory TV camera parameters.

Table 6-1 Entry Science Package and Surface Laboratory TV Camera Parameters

	Entry Science Package		Surface Laboratory	
Parameter	Camera A	Camera B	Camera A	Camera B
Vertical Limiting Resolution (TV Line)	200	200	140	140
Horizontal Limiting Resolution (TV Line)	200	200	166	166
Scan Lines	280	280	200	200
Field of View (deg)	18	4.7	97/25 6.5 Backup	16/4
Data Output	Digital	Digital	Digital	Digital
Bits/Sample	6	6	6	6
Dynamic Range	60:1	60:1	60:1 (Comp)*	60:1 (Comp)
Linear Point Gamma	0.95	0.95	0.9	0.9

*Compressed

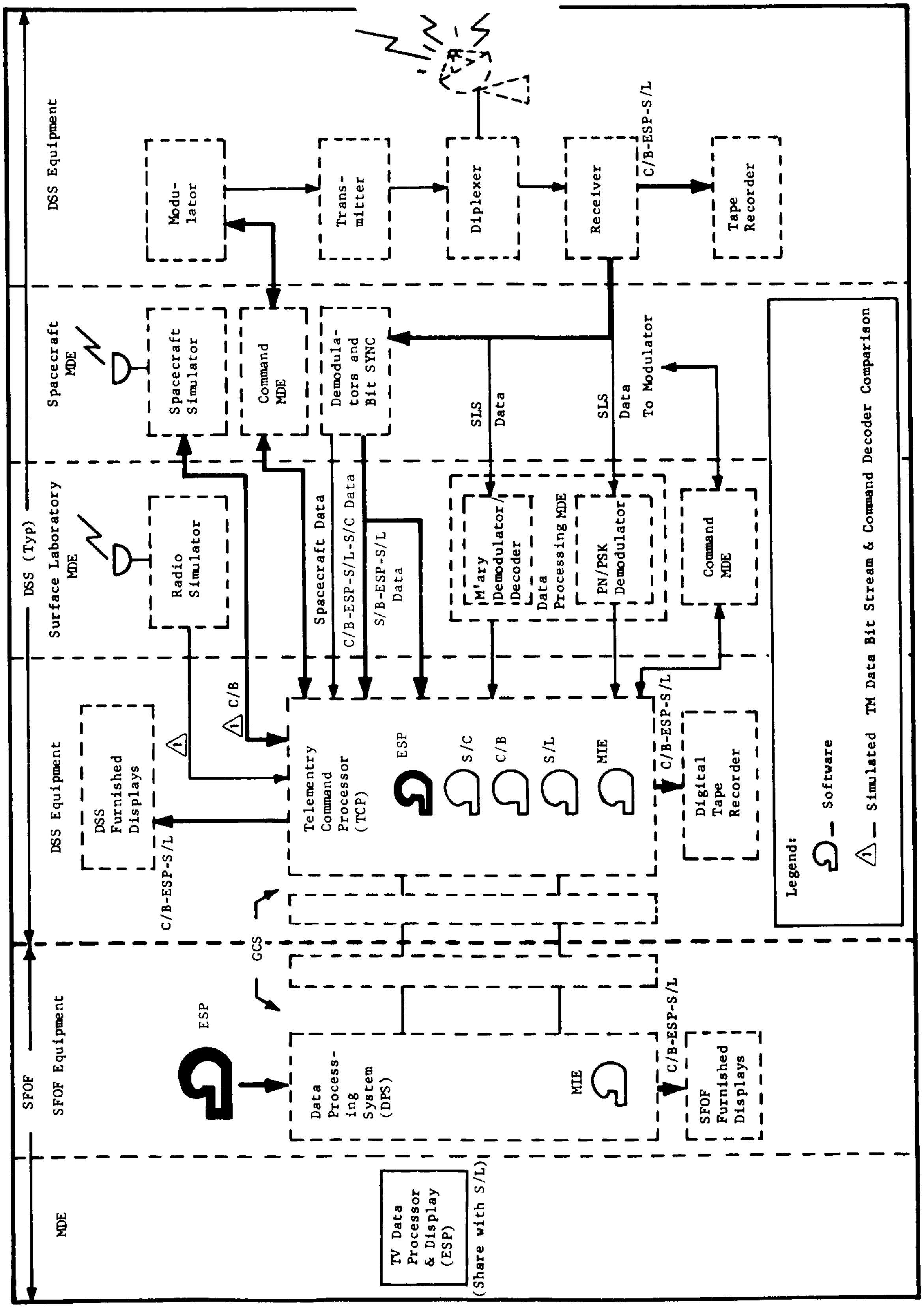


Fig. 6-1 Entry Science Package MDE Implementation

6.1 Requirements and Constraints

6.1.1 Constraints

Those items of MDE that also perform functions included in the STC and subsystem OSE are identical to the hardware in those configurations. MDE uses standard equipment design whenever possible.

The design of the MDE ensures that no mission data are irretrievably lost as a result of MDE malfunction. This implies use of such techniques as raw data recording with provision for off-line playback and analysis.

To provide a high availability for mission usage, the MDE must be designed for a high MTBF and low MTTR. Self-check features are built into the equipment and redundancy techniques are employed for low-confidence items.

6.1.2 Functional Requirements

The TV MDE must be capable of:

1) Receiving digitized video data and control signals
2) Providing accurate records of the video picture
3) Providing an accurate display of the video picture
4) Providing a group display of the video picture
5) Providing a quick-loop display of the video data
6) Quickly isolating malfunctions in its equipment
7) Providing or requesting image enhancement to every picture in computer memory.

A short description of particular display equipment requirements follows.

Transfer Characteristics - The display is capable of reproducing the scene as it would be viewed by an observer in place of the television camera. This requires a unity system transfer function or unity gamma as shown in Fig. 6.1-1. The display must compensate for differences in camera transfer functions to produce unity system gamma. Varying the display transfer function results in image enhancement if the scene brightness is restricted to a portion of the dynamic range.

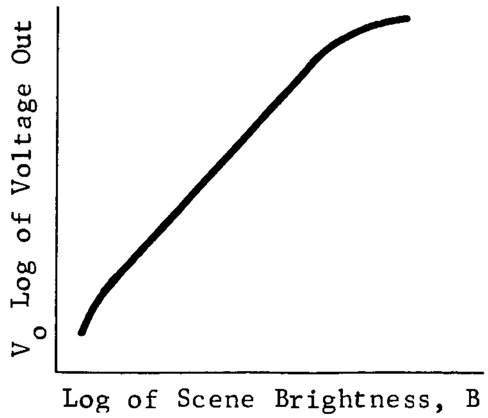


Fig. 6.1-1 Transfer Characteristics of Ideal System

Response - The display should not significantly degrade the system response in the horizontal or vertical directions (Table 6-1).

Dynamic Range - The dynamic range of the display should be as great as the system dynamic range (Table 6-1).

Geometric Distortion - Geometric distortion is defined as the relative (geometric) element placement inaccuracy in the final photograph when referenced to the original scene. Geometric characteristics are obtained in subsystem test and used as data inputs for geometric correction subroutines.

Shading - For a uniform constant scene brightness, the output voltage of the vidicon will vary depending on the geometric coordinates of the sampled point. This effect is generally defined as shading. Shading characteristics are obtained in subsystem test and used as data inputs for shading correction subroutines.

Image Enhancement - Image enhancement is the intentional distortion of display or data characteristics to maximize the information transfer across the photograph-eye interface. The MDE display is capable of displaying image enhanced data.

Other Display Requirements - Other display requirements include:

1) Display of picture identification data
2) Monitoring and status indications
3) Test pattern generator for calibration, checkout, and fault isolation.

6.2 Preferred Preliminary Design

6.2.1 Display System Definition

The display unit is a cathode-ray tube (CRT) and its associated electronics plus a film camera and processor. Figure 6.2-1 is a functional block diagram of the display. Display unit operation is summarized in the following paragraphs.

The control unit contains the timing and recognition circuitry for the display. This unit monitors and controls status of the other areas of the display.

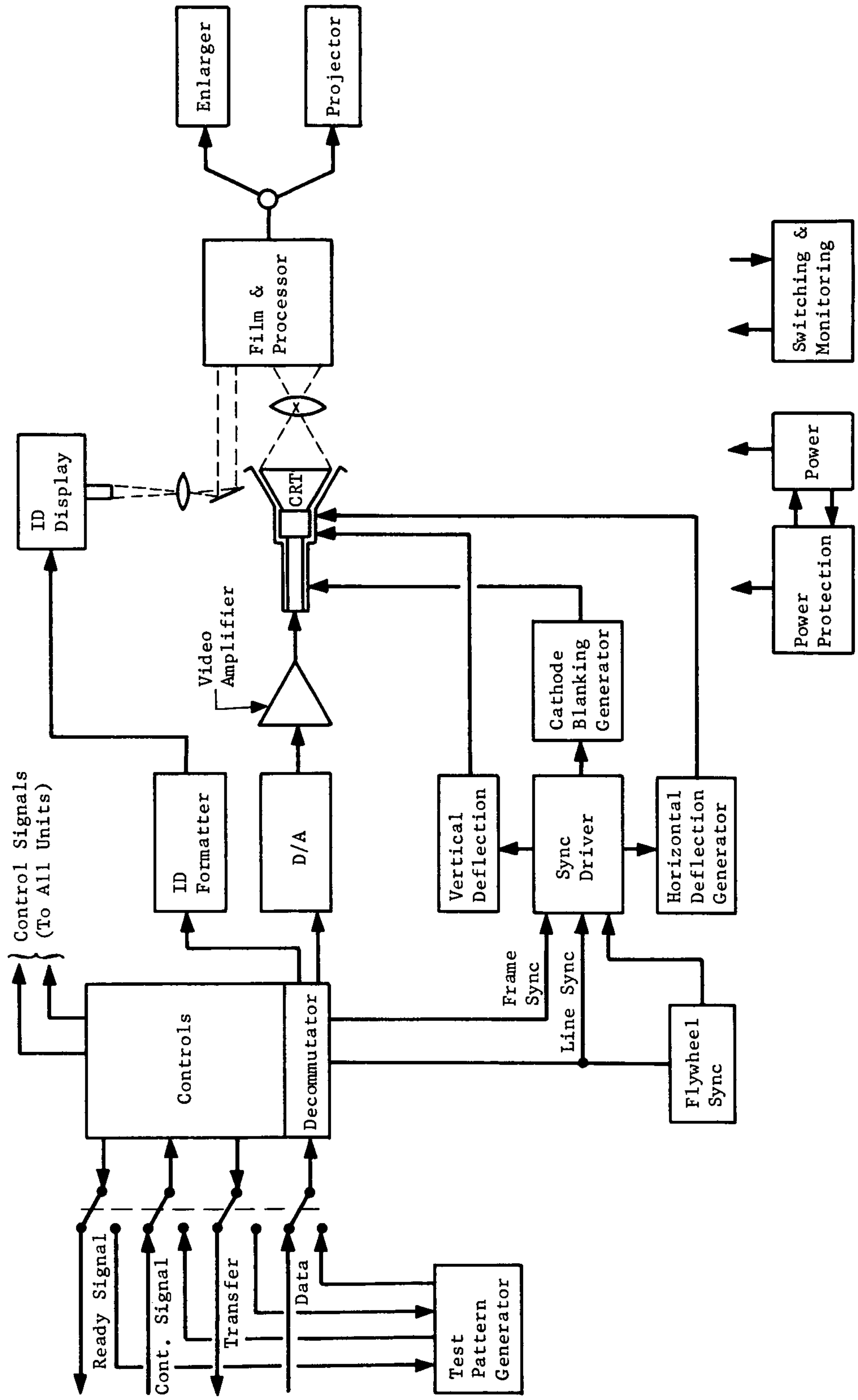


Fig. 6.2-1 TV Display Block Diagram

The decommutator accepts six-bit parallel bytes from the computer at 59.5 kbps for Entry Science Package TV data and inserts a four-byte delay in the data stream to recognize Barker codes for frame sync, line sync, and identification (ID) data. After recognition of a particular Barker code, the pertinent controls and data are routed to using units in the following manner:

1) ID data to the ID formatter
2) Video data to the digital-to-analog (D/A) conversion unit
3) Frame and line sync controls to the sync driver unit.

The scan generation chain consists of a sync driver unit, flywheel sync unit, vertical and horizontal deflection generators, and a cathode blanking generator. The sync driver unit accepts frame and line sync control signals from the decommutator and generates gating and blanking signals for the deflection and blanking generators.

Correction signals are added to the vertical sawtooth to compensate for pincushion distortion and to destroy the raster effect by means of a high frequency "spot wobble" superimposed on the composite wave form. The amplitude and frequency of the "spot wobble" are different for Entry Science Package TV and Surface Laboratory TV data to compensate for differences in TV scan lines. Correction signals are also added to the horizontal sawtooth to compensate for pincushion distortion. The time constant is different for Entry Science Package TV and Surface Laboratory TV data to compensate for differences in TV scan lines. The cathode blanking generator circuit supplies bias or cuts bias from the CRT cathode on command from the sync driver unit. The cathode bias is enabled at all times during the display sequence except during horizontal retrace, vertical retrace, and power failures sensed by power protection circuits.

The ID data chain consists of an ID data formatter, and ID display unit and ID optics. The ID formatter accepts ID data from the decommutator, and based on control signals, formats and routes the data for use by the ID display. The ID display provides an alphanumeric display, formed by rear projection readouts and letter masking, to make identification data a permanent portion of the video record. The ID optics demagnifies and focuses the ID display on a portion of the film unused by the video data. The video data chain consists of a digital-to-analog converter, video amplifier, CRT, lens, and film/film processor combination. A six-bit digital-to-analog conversion is performed on command of the controls unit; a video amplifier filters the converted digital signal and amplifies it to a level required by the CRT grid. The transfer function of the video amplifier is controlled by break points to achieve unity system point gamma and to compensate for compressed Spacecraft dynamic range characteristic.

The CRT serves as an exposure source for recording the video data on film. A 5-in. flat-faced CRT with a centering coil, focus coil, deflection yoke, and shielding is used. A lens with a magnification of less than one is used to transfer the information from the CRT to the film surface.

A small area film (35 mm) was chosen because of availability, adequate response and dynamic range, enlargement equipment is available and of reasonable size, and because projection equipment is easy to obtain. Film processing is done with automatic processing equipment which is an integral part of the camera equipment. Automatic Film advance after completion of a video frame is provided. The film processing is closely controlled regarding chemicals utilized, temperature of chemicals, and development times to maintain predetermined film transfer characteristics.

Power supplies and protection circuits are required for logic power, CRT high voltage, CRT focus voltage, and video power.

The switching and monitoring panel provides test points for troubleshooting and monitoring functions and switching for manual or automatic (computer controlled) operation. A cathode-ray oscilloscope monitors test points. A test pattern generator provides bar, resolution, and grey scale patterns selected by the operator, and simulates the computer inputs and controls for Entry Science Package TV or Surface Laboratory TV data.

An enlarger is supplied for photographic enlargement of negatives. Standard darkroom development techniques will be employed. A projector is also supplied for projection of positives on a screen.

6.2.2 Physical Characteristics

The MDE is mounted in two standard racks plus a group display projection console. Film processing facilities are also provided.

6.2.3 Interface Description

MDE/Computer - MDE/computer interfaces include:

1) Control signals (from computer) to start display process plus the signals required to mate display characteristics with vidicon characteristics (transfer function, scan lines, dynamic range)
2) Ready signals (to computer) to indicate that the display is ready to receive data

3) Request signals (to computer) for calling up particular TV frames from computer memory and specifying type of image enhancement required on these data (if under computer control).

MDE/Observer - MDE/observer interfaces include:

1) Film negatives and enlarged negatives
2) Film positives and enlarged positives
3) Polaroid pictures
4) Projected view of negative and positive.

6.3 System Analysis and Tradeoffs

6.3.1 Preferred Approach

Three concepts for video display and recording were considered in detail and are discussed below. Pertinent parameters are compared in Table 6.3-1.

Table 6.3-1 Comparison of Alternative Display Concepts

Parameter	CRT Recorder	Scan Converter Tube	Computer Scan Conversion
Dynamic Range	35:1 100:1 (Pulsed beam)	12:1	35:1 100:1 (Pulsed beam)
Unity Transfer Function	Yes	Yes	Yes (Computerized)
Limiting Resolution	2000 TV lines	1200 TV lines	2000 TV lines
Photograph	Yes	No	No
Monitor	No	Yes	Yes
Time Available From Receipt of Frame	< 15 minutes	< 1 minute	< 2 minutes
Use of Subsystem OSE	Yes	Partial	No
Use of STC	Yes	Partial	Yes
Computer Size	Small (time shared)	Small (time shared)	Medium (full time)
Software Rating	1	2	3
Display Equipment Size and Complexity Rating	2	3	1
Use in Post Processing Applications	Yes	No	Yes

The video data are stored on magnetic tape until a complete frame is received. On playback the video data and control signals are routed from the SFOF computer to the MDE for decommutation. A CRT/35-mm film recorder, with automatic film processing, is the basic display device.

This approach was chosen for several reasons:

1) Adaptability to use in the STC and subsystem OSE
2) Full dynamic range using CRT pulsed-beam technique
3) Full resolution capability
4) Minimum software and computer capacity requirements
5) Flexibility to compensate for differences in TV parameters
6) Sufficient reproduction quality for post-processing applications.

Scan Converter Tubes - Use of a scan converter tube requires, in addition to time buffering, periodic rewriting of the video information. Resultant disadvantages of this and other characteristics are shown in the Table 6.3-1.

Significant disadvantages are:

1) Dynamic range is inadequate
2) Only low quality pictures possible
3) More electrically and mechanically complex
4) Post-processing applications limited.

A minor advantage is realized by the time gained by presenting the display on a monitor.

Computerized Rate Conversion - The method was considered where rate conversion would be performed by the SFOF computer and digitized video continuously read into the monitor. Although this operation is feasible for this type of picture, the computer would be providing data to the MDE continuously and time sharing might not be possible. Because time sharing might not be possible, this concept was rejected for on-line operation; however, it is similar to operating modes anticipated for off-line processing.

6.3.2 Redundancy Considerations

Redundant displays for the SFOF are recommended for the following reasons:

1) Increased reliability - Both displays are run in parallel
2) Flexibility - One display can take a positive while the other can take a negative photograph giving both enlargement and projection capabilities during the same data run.

Even though the preferred approach has no inherent monitoring capability, a monitoring capability is possible. The resulting photograph may be scanned at commercial rates and the video transmitted to monitors at the SFOF on a closed-circuit basis.

The video may also be transmitted to nationwide TV. In these cases, rapid development techniques on one of the redundant display MDE, or a parallel display, would present a slightly degraded but usable photograph shortly after reception of a complete video frame.