EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 3: DESIGN/COST TRADEOFF STUDIES
- Appendix C: EOS Program Requirements Document
**REPORT**

**No EOR-74-001**

**DATE** May 31, 1974

**E O S REQUIREMENTS DOCUMENT**

**CODE 26512**

**PREPARED BY** R. Pratt/B. Sidor

**TECHNICAL APPROVAL**

**CHECKED BY**

**APPROVED BY**

**DEPARTMENT**

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**SECTION**

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**REVISIONS**

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</table>
| 1   | Replace 1, 11, iii, vi  
Add 2.6.1-1, 2.6.1-1, 2, 3, 5, 6, 6; 2.6.2-1, 2.3, 4; 2.6.3-1, 2, 3, 4; 3.18.1-1, 2, 3, 4, 5, 6, 7 | 6/6/74 |
| 2   | Delete: 2.4-1; 2.5-1  
Replace: i, ii, iii, iv, v, vi, vii, viii, ix, x, xi; 1.0-2; 2.1-1; 2.2-1; 2.3-1; 3.4-1; 3.6-1  
Add: xii; 2.1-2, 3, 4; 2.3-2, 3, 4, 5, 6, 7, 8, 9, 10; 3.1-1, 2, 3; 3.2-1; 3.3-1; 3.8-1; 3.9-1, 1-2; 3.9.2-1, 2; 3.9.3-1, 2; 3.10-1, 2, 3, 4, 5, 6, 7; 3.11.1-1, 2; 3.11.2-1; 3.11.3-1; 3.11.4-1, 2, 3, 4, 5, 6, 7, 8, 9; 3.11.5-1, 2; 3.13-1; 3.14-1; 3.15-1; 4.1.1-1; 4.1.7-1; 4.4.4-1 | 6/14/74 |
| 3   | Replace v | 5/18/74 |
| 4   | Delete: 3.10-1, 2, 3, 4, 5, 6 & 7; 4.1.5-2  
Replace: ii; 3.6-1; 3.18.1-4 & 7; 4.1.5-1  
Add: 3.6-6; 3.17-1, 2, 3, 4, 5, 6, 7, 8, 9; 3.16-1 & 2 | 6/21/74 |
| 5   | Replace i, iv, v, vi, xi, xii, 1.0-3; 2.1-2; 2.2-1; 4.1.1-1; 4.1.7-1  
Add: 2.1-5, xv, 4.1.7-2  
Revise: Change page no. vi to vii, vii to viii, viii to ix, ix to x, x to xiii, xi to xiv | 6/28/74 |
| 6   | Delete: vi  
Replace: ii, iv, v, 2.2-1  
Add: 2.6.1-7, 3.18.2-1, 2, 3, 4, 5, 6, 7 & 8 | 7/5/74 |
| 7   | Document re-issued as option designation revised on all pages  
Replace: vi, vii, viii, ix, xi, xiv; 2.1-1, 2, 4 & 7; 3.5-1; 3.16-1; 4.1.2-3; 4.1.3-3  
Add: 2.1-3; 2.1-5; 6, 8, 9; 3.5-3, 4; 3.9.4-1, 2; 3.11.4-10, 11, 12; 3.12-1; 3.13-2; 4.1.8-1, 2; 4.2.3-5, 6, 7, 8 & 9 | 7/12/74 |

Insert after title page.
CONTENTS

Table of Contents
Introduction iv
Requirement Page Nomenclature iv
Spacecraft Options v
Trade Studies vi
Table of WBS vs Requirements vii
List of Acronyms x
Source Documentation xii

1.0 PROGRAM REQUIREMENTS 1.0-1
2.0 MISSION REQUIREMENTS 2.0-1
2.1 MISSION MODEL 2.1-1
  2.1.1 LRM Mission 2.1-1
  2.1.2 Seasat Mission 2.1-2
  2.1.3 Solar Maximum Mission 2.1-3
  2.1.4 SEOS Mission 2.1-4
  2.1.5 TIROS 0 Mission 2.1.4
2.2 TRAFFIC MODEL 2.2-1
2.3 SHUTTLE RELATED PERFORMANCE 2.3-1
2.4 DELETED 2.4
2.5 DELETED 2.5
2.6 BOOSTER RELATED PERFORMANCE 2.6-1
  2.6.1 Delta 2910 2.6.1-1
  2.6.2 Titan IIIIB/SSB/NUS 2.6.2-1
  2.6.3 Titan IIID/NUS 2.6.3-1
CONTENTS

1.0 SYSTEMS REQUIREMENTS

3.0 SAFETY

3.2 RELIABILITY

3.3 MAINTAINABILITY

3.4 SPACECRAFT

3.5 INSTRUMENTS

3.5.1 Thematic Mapper (TM)

3.5.2 High Resolution Pointable Imager (HRPI)

3.5.3 Synthetic Aperture Radar (SAR)

3.5.4 Passive Multichannel Microwave Radiometer (PMMR)

3.6 DATA COLLECTION SYSTEM

3.7 DELETED

3.8 SHUTTLE RESUPPLY PROJECT

3.9 S/C TO INSTRUMENT INTERFACES

3.9.1 Thematic Mapper (TM)

3.9.2 High Resolution Pointable Imager (HRPI)

3.9.3 Synthetic Aperture Radar (SAR)

3.9.4 Passive Multichannel Microwave Radiometer (PMMR)

3.10 DELETED

3.11 S/C TO SHUTTLE INTERFACES

3.12 DATA MANAGEMENT

3.13 FLIGHT OPERATIONS

3.14 FLIGHT OPERATIONS SUPPORT

3.15 S/C GSE
## CONTENTS (CONT)

3.16 S/C TO DELTA 2910 INTERFACES &
3.17 S/C TO TITAN III/ آخر/\\NSES INTERFACES &
3.18 SPACECRAFT STRUCTURAL TEST &
  3.18.1 Component Dynamic Environment &
  3.18.2 Spacecraft Dynamic Environment &
3.19 SPACECRAFT THERMAL TEST &
3.20 SPACECRAFT MECHANICAL TEST &
3.21 SPACECRAFT GROUND & FLIGHT SYSTEMS TEST &
3.22 SPACECRAFT SHUTTLE INTERFACES TEST &

### 4.0 SUBSYSTEM REQUIREMENTS

#### 4.1 SPACECRAFT

- **4.1.1** Orbit Transfer &
- **4.1.2** Communication & Data Handling &
- **4.1.3** Electrical Power &
- **4.1.4** Attitude & Control &
- **4.1.5** Structure &
- **4.1.6** Thermal &
- **4.1.7** RCS/Orbit Adjust &
- **4.1.8** Instrument Data Handling &

#### 4.2 DATA MANAGEMENT SYSTEM

- **4.2.1** Data Acquisition &
- **4.2.2** DELETED &
- **4.2.3** Data Processing &
- **4.2.4** Data User Service &
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<thead>
<tr>
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<th>Title</th>
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Introduction

This document serves as the basis for the subsequent EOS System Specification. It consists of requirements obtained from existing documentation and those derived from functional analysis. After EOS trade studies have been completed the requirements identified will be incorporated.

Requirement Page Nomenclature

Requirements follow the hierarchy of Program, Mission, System and Subsystem.

The "Source" column on the attached pages references the location of the requirements contained in existing documentation or those derived by GAC functional analysis.

\[ X/XX.X.X/X \]
\[ FA \]
\[ X.X.X \]

Source Document  Part. No.  Page No.  Functional Analysis

In addition, where applicable, relevant System Trades which constrain the requirement are identified in parentheses.

\[ (TE X) \]

Study Number (refer to Systems Trades list, page vi)

Trade Study designation

The "Option" column identifies the applicability of requirements to each of the GAC EOS options being considered by placing a dot in the appropriate column. An open dot (o) is for interim requirements and a solid dot (e) indicates a verified requirement. Options are contained in the table on page v.
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SYSTEM TRADE STUDIES

1. Orbital Altitude Selection
2. Launch Vehicle Selections
3. Shuttle Compatibility
4. Instrument Approach
5. Data Operations
6. Attitude Control System/Central Processing Facility
7. Spacecraft Autonomy/Hardware vs. Software
8. Electronic Technology
9. International Data Acquisition
10. User/Science and Orbit Time of Day Studies
11. Utilization of Control Center Personnel
12. Coupled vs. Uncoupled Pneumatics
13. Wide Band Data Format
14. Modularity Level
15. Design Growth Economic Study
16. Single Satellite vs. Multiple Satellites
17. Management Approach
18. Test Philosophy
19. Reliability and Quality Assurance
## TABLE OF WRS VS. REQUIREMENTS

**WRS**: (Rev. 4)

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LIST OF ACRONYMS

ACM  Attitude Control Module
ACR  Attitude Control System
AGS  Aerospace Ground System
ACP  Advanced On-Board Processor
ARC  Absolute Radiometric Calibration
ATS-F Applied Technology Satellite F
BER  Bit Error Rate
B/L  Baseline
BPA  Bus Protection Assembly
BST  Boreighted Star Tracker
BPSK  Biphase Shift Keying
CC  Control Center
CCP  Ground Control Points
C&DH  Communications & Data Handling
CDP  Central Data Processing
CIPS  Conical Image Plane Scanner
CMD  Command
CMDF/TLM  Command/Telemetry
CDPF  Central Data Processing Facility
CSC  Computer Sciences Corporation
DMS  Data Management System
DOD  Department of Defense
DOMSAT  Domestic Satellite
DPS  Data Processing System
EBA  Electronic Beam Recorders
ELS  Earth Limb Measurements Satellite
EMC  Electro Magnetic Compatibility
EOS  Earth Observatory Satellite
ERTS  Earth Resources Technology Satellite
FHT  Fixed Head Tracker
FMEA  Failure Mode Effects Analysis
FOM  Figure of Merit
FSK  Frequency Shift Keying
FSS  Flight Support System
GAC  Grumman Aerospace Corporation
GFE  Government Furnished Equipment
GLS  Ground Logistics System
GPS  Ground Processing System
GSE  Ground Support Equipment
GSFC  Goddard Space Flight Center
HFT  High Resolution Pointable Imager
ICD  Interface Control Document
IMPATT  Impact-Avalanche and Transit Time
IMS  Information Management SYSTEM
LBR  Laser Beam Recorder
LCPS  Linear Image Plane Scanner
LOPS  Linear Object Plane Scanner
LRM  Land Resource Management
LSC  Limited Space Charge Accumulation
LV  Launch Vehicle
MBPS  Multi-Bit Per Second
MEM  Module Exchange Mechanism
MLF  Multi-Layer Insulation
MOMS  Multi-Megabit-Operation
MPS  Multiplexer System
MSS  Multi-Spectral Scanner
MUS  Magnetic Unloading System
NASCOM  NASA Communications
NEFD  Noise Equivalent Flux
NM  Nautical Mile
NRZL  Non Return to Zero Level
NTTF  NASA Test & Training Facility
OAO/LST  Orbiting Astronomical Observatory/Large Space Telescope
OCAS  Orbit Adjust Subsystem
OBC  On-Board Computer
OBDC  On-Board Data Compaction
OBP  On-Board Processor
OPS  Orbit Operations
OTS  Orbit Transfer System
SKYLAB  Orbital Workshop (Skylab)
PMR  Pulse Code Modulation
PDU  Power Distribution
PDSS  Power Control Unit
P/DMS  Precision Digital Sun Sensor
PRN  Precision Gimbaled Star Tracker
PST  Payload
PMR  Passive Multichannel Microwave Radiometer
PRN  Pseudo Random Noise
PRU  Power Regulation Unit
### DEFINITIONS

<table>
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<tr>
<td>S/V</td>
<td>Spacecraft and Launch Vehicle</td>
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<td>S/C</td>
<td>Spacecraft</td>
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<td>PW/C</td>
<td>Payload-Instruments</td>
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**Basic S/C-Standard Modules**

<table>
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<th>Abbreviation</th>
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<td>Phase Shift Keying</td>
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<td>PSM</td>
<td>Power Supply Module</td>
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<td>QPSK</td>
<td>Quadrophase Shift Keying</td>
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<td>REL</td>
<td>Reliability</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>RGA</td>
<td>Rate Gyro Assembly</td>
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<td>RNS</td>
<td>Remote Manipulator System</td>
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<td>ROM</td>
<td>Read Only Memory</td>
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<td>RQA</td>
<td>Reliability &amp; Quality Assurance</td>
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<td>RS</td>
<td>Resupply System</td>
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<td>RTC</td>
<td>Real Time Commands</td>
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<td>RTS</td>
<td>Remote Tracking Site</td>
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<td>SAMS</td>
<td>Shuttle Attached Manipulator System</td>
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<td>SAR</td>
<td>Synthetic Aperture Radar</td>
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<td>S/C</td>
<td>Spacecraft</td>
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<td>WCO</td>
<td>Sub-Carrier Oscillation</td>
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<td>SBRAT</td>
<td>Sea Satellite</td>
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<td>SEOS</td>
<td>Synchronous &quot;EOS&quot;</td>
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**Definitions**

- $\beta$ - Beta angle is the minimum angle formed by the earth sun line and the orbit plane.

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**Abbreviations**

- PSK: Phase Shift Keying
- PSM: Power Supply Module
- QPSK: Quadrophase Shift Keying
- REL: Reliability
- RF: Radio Frequency
- RGA: Rate Gyro Assembly
- RNS: Remote Manipulator System
- ROM: Read Only Memory
- RQA: Reliability & Quality Assurance
- RS: Resupply System
- RTC: Real Time Commands
- RTS: Remote Tracking Site
- SAMS: Shuttle Attached Manipulator System
- SAR: Synthetic Aperture Radar
- S/C: Spacecraft
- WCO: Sub-Carrier Oscillation
- SBRAT: Sea Satellite
- SEOS: Synchronous "EOS"


E. GSFC Report EOS-410-05, "Demonstration Model Spacecraft Description," dated September 1973 (Ref. 1.5.2).


N. GSFC Table, "SEO S Instrument." (Ref. II.D.3)

O. GSFC Table, "Seasat Instrument." (Ref. II.B.4)


Q. GSFC Table, "SMM Instrument." (Ref. II.A.2).


T. MDAC Report DAC-6 1687, "Delta Spacecraft Design Restraints," Revised November 1973 (Ref. 2.4.1)


X. Unpublished GAC Memo, "Tentative Sensor Interface - Hughes TM"


AD GSFC Internal Memo to W.A. White from E. Painter, Data Collection System for EOS-A, dated May 21/74

AE Martin Marietta Document, Titan Candidate Launch Vehicles for EOS Missions at WTR, dated 10/73

AF GAC Memo, EOM 74-085 Impulse Requirements for Pneumatics & Orbit Adjust Modules, dated 6/7/74

AG GAC Memo, EOM 74-127, Spacecraft Dynamic Test Requirements, dated 6/28/74

AH GAC Memo, EOM 74-113 CUP-Thruput Considerations and Data Output Formats, dated 6/24/74

AI GSFC Document, Payloads Description, dated 10/73

AJ GAC Memo EOM 74-090, Meeting With J. Purcell at GAC 6/7/74


xx Rev. 7 dated: 7/12/74
## 1.0 PROGRAM

1.0.1 The Earth Observatory Satellite (EOS) Program shall provide a flexible, low cost spacecraft for use with existing launch vehicles that will enable even lower costs when used with the Space Shuttle.

1.0.2 The baseline system shall consist of:
- Instruments: Thematic Mapper & High Resolution Pointable Imager
- Shuttle Compatible Design
- Resupply Capability
- Data Collection System
- Modular Subsystem Design
- Transition Ring Concept for Booster Compatibility
- Launch vehicles are Delta 2910, Titan III D/NUS, and Shuttle

1.0.3 The system contractor will assume responsibility for the instruments.

1.0.4 Provide flexibility in S/C design to accommodate follow-on mission instruments.

1.0.5 Follow on instruments are the Synthetic Aperture Radar (SAR) and the Passive Multichannel Microwave Radiometer (PMR).

1.0.6 Demonstrate the spacecraft is capable of accommodating the instruments for the following missions: SEASAT, solar maximum mission, SEOS, and 5-band MSS.

1.0.7 Provide spacecraft that demonstrate the operational requirements of the Department of Interior.

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1.0.10 Maintain EOS capability in the decade of the '60's using retrieval, re-launch and in-orbit service capabilities of the Space Shuttle System.

1.0.11 The EOS will be launched from WTR except the Shuttle demonstration flight which will be launched from ERS.
## 2.1 MISSION MODEL

### 2.1.1 Land Resources Management (LRM)

#### 2.1.1.1 Mission Objectives

- Develop sensor and other spacecraft systems to acquire spectral measurements and images suitable for generating thematic maps of the earth's surface.
- Operate these systems to generate a data base from which land use information such as crop or timber acreages or volumes, courses and amounts of actual or potential water run-off and the nature and extent of stresses on the environment will be extracted.
- Demonstrate the application of this extracted information to the management of resources such as food and water, the assessment and prediction of hazards such as floods, and the planning and regulation of land use such as strip mining and urbanization.

#### 2.1.1.2 Mission Description

The basic requirement of the LRM instruments is repeating earth coverage under nearly constant observation conditions. This requires a circular sun synchronous orbit with an integral number of orbits and days per repeat ground trace pattern. Preliminary analysis indicates that a solar orbit of 98° inclination with an orbital altitude of 366 nm meets all requirements.

#### 2.1.1.3 Payload Instruments

The following instruments in various combinations are planned for the LRM missions: Thematic Mapper, High Resolution Pointable Imager, Data Collection System, 5 Band Multi Spectral Scanner.
2.1.2 Seasat Mission

2.1.2.1 SEASAT A

Mission Objectives

The SEASAT-A mission is designed for development and demonstration of space techniques for forecasting and monitoring sea state, currents, circulation, pileup, storm surges, tsunamis, air-sea interactions, surface winds, and ice formations.

Mission Description

A nominal orbit altitude of 391 n.m.i. (725 km) is high enough to avoid orbit uncertainties due to drag and low enough to obtain good radar performance with acceptable power consumption. An 82° inclination provides good earth coverage, non-sunsynchronous, to high latitudes.

2.1.2.2 SEASAT B

Mission Objectives

Provide data for short-wavelength gravity field determination for earthquake and geoid mapping. Provide data in support of ocean studies such as large amplitude ocean features, currents, circulation systems, temporal variations, ocean geoid and surface conditions. These conditions include sea state/surface wave height, wind fields, shelf tides, ocean tides, barometric pressure, storm surges and tsunamis

Mission Description

Nominal circular orbital altitude of 324 n.m.i (600 km) at an inclination of 90°.

Payload Instruments

See table 2.1.2-1.
## AUTOMATED PAYLOAD
### MISSION EQUIPMENT

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### ORIGINAL PAGE IS OF POOR QUALITY

**Table 2.1.2-1**

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| Headquarters: H. M. Lord | Date: 7/12/73 | Revision: 7 |
2.1.3 Solar Maximum Mission (SMM)

2.1.3.1 Mission Objectives

The basic scientific goal of the SMM is to study the fundamental mechanisms of a solar flare.

2.1.3.2 Mission Description

Initial launch is scheduled for June 1975 on a Delta vehicle. Subsequent retrieval and re-deployment is planned for Shuttle. Minimum orbital life is 1 year. The nominal orbit is 275-300 n/mi. circular at an inclination of 28-33 degrees.

2.1.3.3 Payload Instruments

See table 2.1.3-1.
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<td>12/1</td>
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**Remarks:**
1. Needs a cold plate.
2. Bit rate requirement is orbital average. Typical requirement is 6000 bps for one minute per flare.
3. Bit rate requirement is orbital average. Typical requirement is 1000 bps for one minute per flare.
4. SMN shall accommodate all of these experiments simultaneously.
5. Indicates relative alignment accuracy between the instrument and the fine pointing sun sensor.
6. Nighttime power requirements approximately 20% of daytime power.
PARAMETER | SOURCE |
--- | --- |
2.1.4 SEOS Mission | L/Eo-09A/5-34 |
2.1.4.1 Mission Requirement | L/Eo-09A/5-34 |
The SEOS mission is intended to investigate remote sensing techniques for measuring transient environmental phenomena from a geosynchronous orbit. |  |
2.1.4.2 Mission Description | L/Eo-09A/5-34 |
Nominal mission altitude will be 19323 n.mi circular at an inclination of 0 degrees. Nominal orbit positioning will be 96° west longitude. Nominal mission duration is to be 2 years with initial launch scheduled for CY 1981. Recovery and/or on-orbit servicing is not planned. |  |
The EOS shall be capable of placing the SEOS experiments in an equatorial orbit of the following characteristics: | L/Eo-09A/5-34 |
ha = 19323 ± 25 n.mi |  |
hp = 19323 ± 25 n.mi |  |
\(\theta\) = 0 ± 0.2 deg. |  |
The EOS shall place the SEOS experiments at a nominal orbit position of 96° west longitude. | L/Eo-09A/5-34 |
The EOS shall maintain the SEOS experiments on-orbit for not less than 2 years. | L/Eo-09A/5-34 |
The EOS shall support an initial launch of SEOS experiments in CY 1981. | L/Eo-09A/5-34 |
2.1.4.3 Payload Instruments | AL/-/- |
2.1.5 TIROS 0 Mission

Mission Objectives

The TIROS 0 vehicle is intended to verify for operational use an advanced environmental operation payload. This spacecraft will have implemented operational versions of remote sensing techniques proven in Nimbus and EOS flight experiments as well as improvements in those sensors carried by the previous N/TICS vehicles. The TIROS 0 satellite will be the first of the operational vehicles to be designed with the shuttle exploitive modular design so that in orbit refurbishment of the payload can be effected and evaluated.

Mission Description

Nominal perigee altitude of 905 nmi (1676 km) and apogee of 915 n mi (1695 n mi) at an inclination of 103°.

Payload Instruments

See table 2.1.5-1.
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<th>Height</th>
<th>Length</th>
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<th>B. Weight kg</th>
<th>B. Power Average W</th>
<th>B. Power Peak W</th>
<th>Field of View (Degrees)</th>
<th>Environment Constraints</th>
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Table 2.1.5-1
Page 2.1-9
Revision 7
Prepared by L. Fauley
## 2.2 Traffic Model

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*Weight Constroed Titan*  

(TS 2)

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2.3 SHUTTLE RELATED PERFORMANCE

2.3.1 Shuttle launch azimuth and orbit inclination limits are as shown in Fig. 2.3-1.

2.3.2 Shuttle performance capabilities are defined in:

- Figs. 2.3-2 through -7
- Fig. 2.3-8
- Fig. 2.3-9

AC/3.2.2/3.3

AC/3.2.3.1/3-4

AC/3.2.3.2/3-4

AC/3.2.3.3/3-5
Fig. 2.3-1 LAUNCH AZIMUTH AND INCLINATION LIMITS FROM VAFB AND KSC

Revision 2 Date: 6/1/74
Fig. 2.3-2: Payload weight versus circular orbital altitude - KSC launch, delivery only.

Revision 2
Date: 6/14/74
No rendezvous

OMS ΔV reserve = 22 fps
OMS ΔV ascent = 350 fps
RCS propellant loading = 4500 lb
250 fps on-orbit OMS ΔV to 104°

Fig. 2.3-3 - Payload weight versus circular orbital altitude - VAFB launch, delivery only.

Revision 2 Date: 6/14/74
Fig. 2.3-1 - Payload weight versus inclination for various circular orbital altitudes - delivery only.

2.3-5
With rendezvous
OMS $\Delta V$ reserve = 42 fps
OMS $\Delta V$ launch = 100 fps
RCS propellant loading = 6300 lb
250 fps OMS $\Delta V$ to 104°

80 RCS propellant loading
60 OMS tankage
40 Integral OMS tankage
20 First OMS kit added
10 Second OMS kit added
0 Third OMS kit added

Fig. 2.3-5 - Payload weight versus circular orbital altitude - KSC launch, delivery and rendezvous.

Revision 2 Date: 6/14/74
With rendezvous

OMS ΔV reserve = 42 fps
OMS ΔV launch = 350 fps
RCS propellant loading = 6300 lb
250 fps OMS ΔV to 104°

Fig. 2.3-6. - Payload weight versus circular orbital attitude - VAFB launch, delivery and rendezvous.

2.3-7
Fig. 2.3-7 - Payload weight versus inclination for various circular orbital altitudes - delivery and rendezvous.

2.3-8
No rendezvous
On orbit OMS ΔV reserve = 22 fps
RSC propellant loading = 4500 lb
Inclination = 28.5°
Orbital perigee = 100 n. mi.

Suborbital tank separation,
Kennedy launch OMS ΔV = 100 fps
250 fps OMS ΔV to 104°

First OMS kit added
Second OMS kit added
Third OMS kit added

Deorbital after circularization
to 100 n. mi.
Direct deorbit from apogee

Fig. 2.3-8 - Payload weight versus elliptical orbital altitude.

Revision 2
Date: 6/14/74
Fig. 2.3-9 - Payload weight versus sun synchronous orbital altitude.

2.3-10

Revision 2
Date: 6/14/74
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Hardpoints - TBD

Guidance - TBD

Stage II - Delta vehicle (96 in/2438 mm diam) with TRW Systems TR-201 propulsion system.

Propellants loaded - TBD
I<sub>sp</sub> nominal - TBD
Thrust - TBD
Loaded weight - TBD

Stage I - Extended Long Tank Thor with Rocketdyne RS-27 engine

Propellants loaded - TBD
I<sub>sp</sub> nominal - TBD
Thrust - TBD
Loaded weight - TBD

Stage 0 - Nine Castor II (TX-354-5) SRM's

Impulse propellant - TBD
TVC loaded - TBD
I<sub>sp</sub> average - TBD
Total impulse - TBD
Loaded weight - TBD

Liftoff
Weight - TBD
Thrust - TBD

Fig. 2.6.1-1 Vehicle Characteristics, Delta 2910
Fig. 2.6.1-2 Two Stage Perigee Velocity, 100 n.mi Perigee Altitude, ETR
USEFUL LOAD IS DEFINED AS WEIGHT OF:
SPACECRAFT, ATTACH FITTING, SPACECRAFT INSTRUMENTATION, THIRD STAGE TRU AND INSTRUMENTATION, HEAT SHIELDS, CONTAMINATION BARRIERS, ETC.

INITIAL FLIGHT AZIMUTH = 196 DEG
ORBIT INCLINATION = 90 DEG

Fig. 2.6.1-3 Two Stage Perigee Velocity, 100 n.mi Perigee Altitude WTR
Circular Orbit Altitude, $H_c$, n.mi

Fig. 2.6.1-4, Sun Synchronous Orbit Capability, ETR
USEFUL LOAD IS DEFINED AS WEIGHT OF:
- SPACECRAFT, ATTACH FITTING
- SPACECRAFT INSTRUMENTATION
- THIRD STAGE TM AND INSTRUMENTATION
- HEAT SHIELDS, CONTAMINATION BARRIERS, ETC.

INITIAL FLIGHT AZIMUTH = 196 DEG
ORBIT INCLINATION = VARIABLE

Circular Orbit Altitude, $H_c$ n.mi

Fig. 2.6.1-5, Sun Synchronous Orbit Capability, WTR

Page 2.6.1-6
Useful load is defined as weight of:
- Spacecraft, attach fitting,
- Spacecraft instrumentation,
- Third stage TM and instrumentation,
- Heat shields, contamination barriers, etc.

Initial flight azimuth = 196 deg
Orbit inclination = 90 deg

Circular orbit altitude

Figure 2.6.1-6 Circular orbit capability, WTR

Page 2.6.1-7
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
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<tr>
<td>2.6.2.1 Titan IIIIB/SSB/NUS</td>
<td></td>
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<tr>
<td>2.6.2.1 General vehicle characteristics are as defined in Fig. 2.6.2-1</td>
<td>U/Fig II-15/II-26</td>
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<tr>
<td>2.6.2.2 Vehicle performance capabilities are as defined in Figures 2.6.2-2 and -3</td>
<td>U/Fig III-17/III-35, U/Fig III-19/III-37</td>
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</table>
Fig. 2.6.2-1 Vehicle Characteristics, Titan IIIB(SSB), ETR and WTR
Fig. 2.6.2-2 Titan III (SSB), Payload Weight vs Characteristic Velocity
Legend:
- ETR, 28.5 deg inclination
- WTR, 90 deg inclination

Note:
1. 100 n mi inject altitude for elliptical orbits.
2. Performance margin in Stage III.
3. 1685-lb payload fairing jettisoned at 400,000 ft at ETR.
4. 1490-lb payload fairing jettisoned at 400,000 ft at WTR.

Fig. 2.6.2-3 Titan IIIB(SSB), Payload Weight vs Altitude, ETR and WTR
<table>
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<th>REQUIREMENT</th>
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<td>2.6.3 Triton IID/III</td>
<td>1/II-9/II-20</td>
<td>123.5</td>
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<tr>
<td>2.6.3.1 General vehicle characteristics are as defined in Fig. 2.6.3-1</td>
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<td></td>
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<tr>
<td>2.6.3.2 Vehicle performance capabilities are as defined in Figures 2.6.3-2 and -3</td>
<td>1/III-11/III-20</td>
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<tr>
<td></td>
<td>1/III-15/III-33</td>
<td></td>
</tr>
</tbody>
</table>

Page 2.6.3-1
Revision 1 Date 2/6/7
Hardpoints - 36 Equally Spaced

Guidance - Radio

**Stage II**
- Propellants Loaded - 67,900 lb
- Isp Nominal - 319 sec (Vacuum)
- Thrust - 102,300 lb (Vacuum)
- Loaded Weight - 73,700 lb

**Stage I**
- Propellants Loaded - 262,200 lb
- Isp Nominal - 302 sec (Vacuum)
- Thrust - 526,300 lb (Vacuum)
- Loaded Weight - 277,600 lb

**Stage 0** - Two 5-Segment SRMs
- Impulse Propellant - 850,100 lb
- TVC (N₂O₄) Loaded - 16,850 lb
- Isp Average - 266 sec (Vacuum)
- Total Impulse - 226.1 x 10⁶ lb-sec (Vacuum)
- Loaded Weight - 1,017,800 lb

Liftoff - Three Stages without Payload or Payload Fairing
- Weight - 1,362,100 lb
- Thrust - 2,295,200 lb

Fig. 2.6.3-1 Vehicle Characteristics, Titan IIID, WTR
Fig. 2.6.3-2 Titan IIID and IIIE, Payload Weight vs Characteristic Velocity, ETR
Note:
1. 100 n mi inject altitude for elliptical orbits.
2. Performance margin in Stage II.
3. 2670-lb payload fairing jettisoned at 400,000 ft.

Fig. 2.6.3-3 Titan III Panel IIIE, Payload vs Altitude, ETR and WTR
3.1 SAFETY

3.1.1 The EOS must be capable of providing a safe mission operation while passively contained within the Orbiter cargo bay and have provisions for relaying immediately to the Orbiter crew, while it is attached to Orbiter, any emergency conditions originating in the EOS.

3.1.2 While in the Orbiter cargo bay on the launch pad or during ascent, retrieval, re-entry and landing, the EOS shall provide a readout of parameters critical to Shuttle system and range safety operations.

3.1.3 As a goal, no single EOS failure shall result in a hazard which jeopardizes the flight or ground crews.

3.1.4 Appropriate safety factors shall be used where necessary to minimize the possibility of failures which might affect manned safety (i.e., structures, pressure vessels, etc.).

3.1.5 Manned factors of safety will be maintained under Shuttle abort load conditions.

3.1.6 Provision for command override of critical EOS functions by the Orbiter crew shall be provided during stowage, deployment and retrieval operations.

3.1.7 EOS elements shall have self contained protective devices or provisions against EOS generated hazards while mounted to the Orbiter. Hazards generated by Orbiter-EOS interactions during load, transport, deploy and retrieval activities shall be identified and mutually resolved.

3.1.8 Provisions shall be provided for emergency manual release of EOS to Orbiter connections.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.9 A pressure relief capability shall be provided for the EOS tanks which automatically limits the maximum pressure. Venting shall be through the EOS/Orbiter interface when EOS is in the Orbiter payload bay.</td>
</tr>
<tr>
<td>3.1.10 No single failure shall result in unprogrammed motion of the EOS.</td>
</tr>
<tr>
<td>3.1.11 Provisions shall be provided for remote emergency jettisoning of EOS deployable equipment as necessary to complete retrieval and stowage operations.</td>
</tr>
<tr>
<td>3.1.12 RF communication capability shall be available between the Orbiter and the EOS for command and control functions.</td>
</tr>
<tr>
<td>3.1.13 The critical command and control circuitry shall be designed to be fail-operational/fail-safe as a minimum.</td>
</tr>
<tr>
<td>3.1.14 Safety design features such as interlocks, redundancy, grounding and isolation devices shall be incorporated so that no single detectable failure or combination of undetectable failures shall result in premature detonation of explosive devices.</td>
</tr>
<tr>
<td>3.1.15 Unused explosive devices aboard the EOS must be safed on command and safing verification sent to the Orbiter prior to retrieval.</td>
</tr>
<tr>
<td>3.1.16 Toxic or other chemically hazardous gases, liquids, or particles shall not be vented into the Orbiter payload compartment, and shall be isolated from the Orbiter environmental control system.</td>
</tr>
<tr>
<td>3.1.17 All pressurized tankage in the EOS will be vented to 20 psia after restow in the Orbiter.</td>
</tr>
<tr>
<td>3.1.18 All enclosed EOS volumes into which toxic or flammable vapors or liquid could enter must be purged or inerted with an inert gas and the volumes atmosphere sampled while the EOS is on the ground.</td>
</tr>
</tbody>
</table>
### REQUIREMENT

| 3.1.19 | Provide redundant valves on all lines which can become leak paths overboard. |

### SOURCE

<table>
<thead>
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### 3.2 RELIABILITY

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<tr>
<td>3.2.1 The mean mission duration shall be 2 years.</td>
<td>AA/ - 1</td>
<td>✔️</td>
</tr>
<tr>
<td>3.2.2 Consumables and survival shall be 5 years</td>
<td>AA/ - 1</td>
<td>✔️</td>
</tr>
<tr>
<td>3.2.3 After EOS refurbishment the S/C shall meet the original reliability goal.</td>
<td>GAC</td>
<td>✔️</td>
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</table>
### 3.3 MAINTAINABILITY

<table>
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<th>SOURCE</th>
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</thead>
<tbody>
<tr>
<td>3.3.1 EOS shall have the capability to be refurbished in space by the Shuttle Orbiter</td>
<td>A/1.3.6/1-5</td>
<td>![bullet] ![bullet] ![bullet] ![bullet] ![bullet]</td>
</tr>
<tr>
<td>3.3.2 The Shuttle Orbiter will retrieve the EOS for ground refurbishment</td>
<td>A/1.3.6/1-5</td>
<td>![bullet] ![bullet] ![bullet] ![bullet] ![bullet]</td>
</tr>
</tbody>
</table>
### REQUIREMENT

3.4 SPACECRAFT

3.4.1 The basic EOS reference system shall be three orthogonal axes as defined in Fig. 3.4-1.

3.4.2 The three basic subsystem modules: ACS, EPS, Comm. & Data Handling, shall be the same for all EOS configurations.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
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</thead>
<tbody>
<tr>
<td>3.5 Instruments</td>
<td>TS 2.4</td>
<td>(TS 2.4)</td>
</tr>
<tr>
<td>3.5.1 Thematic Mapper (TM)</td>
<td>A/2.1.1/2-1</td>
<td>( )</td>
</tr>
<tr>
<td><strong>3.5.1.1</strong> The TM images are normally beneath the EOS, but when required shall be available, upon command, from regions offset up to $45^\circ$ from the down-nadir direction</td>
<td>A/2.1.1/2-1</td>
<td>( )</td>
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<tr>
<td><strong>3.5.1.2</strong> TM design parameters are given in Table 3.5-1</td>
<td>A/2.1.1/2-1</td>
<td>( )</td>
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<tr>
<td>3.5.2 High Resolution Pointable Imager (HRPI)</td>
<td>TS 2.4</td>
<td>( )</td>
</tr>
<tr>
<td><strong>3.5.2.1</strong> The HRPI images are normally beneath the EOS, but when required, upon command, shall be available from regions offset up to $30^\circ$ from the down-nadir direction</td>
<td>B/ - /6</td>
<td>( )</td>
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<tr>
<td><strong>3.5.2.2</strong> HRPI design parameters are given in Table 3.5-1</td>
<td>A/2.1.1/2-1</td>
<td>( )</td>
</tr>
<tr>
<td>3.5.3 Synthetic Aperture Radar (SAR)</td>
<td>A/2.3.1/2-9</td>
<td>( )</td>
</tr>
<tr>
<td><strong>3.5.3.1</strong> SAR Parameters</td>
<td>A/2.3.1/2-9</td>
<td>( )</td>
</tr>
<tr>
<td>Frequency</td>
<td>Dual, X- and L- bands</td>
<td>A/2.3.1/2-9</td>
</tr>
<tr>
<td>Swath</td>
<td>$\leq 40$ Km</td>
<td>A/2.3.1/2-9</td>
</tr>
<tr>
<td>Resolution</td>
<td>30 meters</td>
<td>A/2.3.1/2-9</td>
</tr>
<tr>
<td><strong>3.5.3.2</strong> SAR will be &quot;on&quot; for two 10-minute periods per orbit</td>
<td>B/ - /13</td>
<td>( )</td>
</tr>
<tr>
<td><strong>3.5.4</strong> Passive Multichannel Microwave Radiometer (PMMR)</td>
<td>AK/1.1.1/3</td>
<td>( )</td>
</tr>
<tr>
<td>The orbit and scan parameters are contained in table 3.5-2.</td>
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<td>( )</td>
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<td>BAND NO.</td>
<td>SPECTRAL REGION (µm)</td>
<td>ASSUMED RADIANCE, N (W m⁻²sr⁻¹)</td>
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<td>--------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>0.5 - 0.6</td>
<td>2.2</td>
</tr>
<tr>
<td>* 2</td>
<td>0.6 - 0.7</td>
<td>1.9</td>
</tr>
<tr>
<td>* 3</td>
<td>0.7 - 0.8</td>
<td>1.6</td>
</tr>
<tr>
<td>* 4</td>
<td>0.8 - 1.1</td>
<td>3.0</td>
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<tr>
<td>5</td>
<td>1.55 - 1.75</td>
<td>0.8</td>
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<td>6</td>
<td>2.1 - 2.35</td>
<td>0.3</td>
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<td>7</td>
<td>10.4 - 12.6</td>
<td>20.0 @ 300K</td>
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*Spectral Bandwidth may be reduced.
### Table 3.5-2

**System Specifications and Assumptions**

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<th>A. Orbit and Scan Specifications</th>
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<tr>
<td><strong>Orbit Height</strong></td>
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<tr>
<td><strong>Nadir Angle</strong></td>
</tr>
<tr>
<td><strong>Incidence Angle</strong></td>
</tr>
<tr>
<td><strong>Scan Mode</strong></td>
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<tr>
<td><strong>Scan Angle</strong></td>
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<table>
<thead>
<tr>
<th>B. Frequencies and IFOV Specs</th>
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</thead>
<tbody>
<tr>
<td><strong>Frequency, GHz:</strong></td>
</tr>
<tr>
<td><strong>IFOV, km:</strong></td>
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</table>

<table>
<thead>
<tr>
<th>C. Antenna Specs</th>
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<tr>
<td><strong>Main Beam Efficiency</strong></td>
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<tr>
<td><strong>Maximum Sidelobes:</strong></td>
</tr>
<tr>
<td>In Scan</td>
</tr>
<tr>
<td>Cross Scan</td>
</tr>
<tr>
<td><strong>Cross Polarization Isolation</strong></td>
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<table>
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<tr>
<th>D. Bandwidth and Temperature Specs</th>
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<tr>
<td><strong>RF Bandwidth</strong></td>
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<tr>
<td><strong>Temperature Sensitivity</strong></td>
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<td><strong>Target Temperature</strong></td>
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<tr>
<td><strong>Dynamic Range</strong></td>
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<tr>
<td><strong>Absolute Accuracy</strong></td>
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<tr>
<td><strong>TABLE 3.5-2</strong> Continued</td>
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<td>---------------------------</td>
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<tr>
<td><strong>E. Assumptions</strong></td>
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<tr>
<td><strong>Antenna</strong></td>
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<tr>
<td><strong>Scan Mode</strong></td>
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<tr>
<td><strong>Scan Speed</strong></td>
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<tr>
<td><strong>Receivers</strong></td>
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<tr>
<td><strong>Sensing</strong></td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
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<tr>
<td><strong>Temperatures</strong></td>
</tr>
<tr>
<td><strong>Losses</strong></td>
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</tbody>
</table>
### 3.6 DATA COLLECTION SYSTEM (DCS)

#### 3.6.1 The characteristics of the earth-based DCS platforms are contained in Table 3.6.1 and Figs. 3.6-1 and -2.

#### 3.6.2 The DCS shall operate in the VHF RF range

#### 3.6.3 The DCS shall be compatible with an experiment density of at least 200 earth-based platforms within a 200 n.mi. (370.4Km) diameter circle.

#### 3.6.4 The DCS electronic characteristics are:
- **Volume**: 12,000 cc
- **Weight**: 20 kg
- **Power**: 40 watts

#### 3.6.5 The DCS antenna characteristics are:
- **Volume**: 42,000 cc
- **Weight**: 4 kg
- Fig. 3.6-3 contains a sketch of the antenna

#### 3.6.6 DCS commands are:
- **Power**: 4 (2 on/off)
- **Impulse**: 10

#### 3.6.7 DCS telemetry:
- **Analog**: 12
- **Bilevel**: 10
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<tr>
<th><strong>Time Frame:</strong></th>
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<tbody>
<tr>
<td>- Time of Implementation</td>
<td>...</td>
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<tr>
<td>- Duration of Operation</td>
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<th><strong>Data Dissemination</strong></th>
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<td>- DCP Data Delay</td>
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<tr>
<td>- Position Location Data Delay</td>
<td>...</td>
</tr>
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</table>
Fig. 3.6-3  DCS Antenna
FIGURE 3.6-1. TOTAL DATA COLLECTION PLATFORM POPULATION VS TIME
FIGURE 3.6-2 SATellite THROUGHPUT
### 3.8 SHUTTLE RESUPPLY PROJECT

3.8.1 On orbit Shuttle resupply shall utilize the Special Purpose Manipulator provided by the Canadian Government

<table>
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<th>OPTION</th>
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<tr>
<td>3.8 SHUTTLE RESUPPLY PROJECT</td>
<td>A/1.5.4/1-7</td>
<td>1/23/15</td>
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</tbody>
</table>

Page 3.8-1

Revision 2

Date 6/14/74
### 3.9 S/C-TO-INSTRUMENT INTERFACES

#### 3.9.1 Thematic Mapper (TM)

##### 3.9.1.1 Communications and Data Handling

1. **3.9.1.1.1 The EOS shall provide for transmission of instrument sensor data to be selected from the following candidate rates:**
   - a. 50.8 Mbps
   - b. 73.2 Mbps
   - c. 88.9 Mbps
   - d. 100 Mbps
   - e. 102.5 Mbps
   - f. 118.3 Mbps

2. **3.9.1.1.2 The EOS shall provide for transmission of instrument status and health data in real-time and stored/playback modes:**
   - a. Digital TBD
   - b. Analog TBD

3. **3.9.1.1.3 The EOS shall provide timing signal clock pulses accurate to $10^{-5}$ sec to the instrument.**

4. **3.9.1.1.4 The EOS shall provide for relay from the ground to the instrument of 16 digital (On/Off) commands**
   - Logic 1 = +3.5 VDC to +5.5 VDC
   - Logic 0 = 0 ± 0.5 VDC
3.9.1.2 Electrical Power

3.9.1.2.1 The EOS shall provide 28 ± 7 VDC electrical power at levels of:
   a. Full operation 50 watts
   b. Dark side ≤ 50 watts

3.9.1.3 Attitude Control

   TBD

3.9.1.4 Structure/Mechanical

3.9.1.4.1 The EOS shall accommodate an instrument weight of 350 lb.

3.9.1.4.2 The EOS shall provide a clear volume to accommodate an instrument configured as shown in Fig. 3.9.1-1

3.9.1.4.3 The instrument shall be aligned relative to structural and ACS references to ± 0.1 mrad.

3.9.1.5 Thermal

3.9.1.5.1 The EOS shall be compatible with an instrument total heat dissipation rate of 130 watts continuous.

3.9.1.5.2 The EOS shall provide thermal insulation to isolate the instrument from the spacecraft, including insulating barriers in attachment hardware.
Figure 3.9.1-1 Candidate TM Configuration

Hughes TM

Scheme II
(parallel to flight vector)
Scale: 1" = 240 cm
Weight = 350 lbs
Field of View shown
North and West Views
(15° X 0.03°)

Cooler located for
Q930 T.O.O. Launch
(145° from Nadir)
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.9.2 High Resolution Pointing Imager (HRPI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9.2.1 Communications and Data Handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9.2.1.1 The EOS data interface shall be compatible with High Speed Multiplexing</td>
<td>Y/ D/ 1.2</td>
<td>(TS 4)</td>
</tr>
<tr>
<td>3.9.2.2 Electrical Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9.2.2.1 The EOS shall provide 28 ± 7 VDC electrical power at an average level of 100 watts, not including heaters.</td>
<td>Y/ D/ 1-2</td>
<td>(TS 4)</td>
</tr>
<tr>
<td>3.9.2.3 Attitude Control</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>3.9.2.4 Structure/Mechanical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9.2.4.1 The EOS shall accommodate an instrument weight of 600 lb</td>
<td>Y/ D/1-2</td>
<td>(TS 4)</td>
</tr>
<tr>
<td>3.9.2.4.2 The EOS shall provide a clear volume to accommodate an instrument of:</td>
<td>Y/ D/ 1-2</td>
<td>(TS 4)</td>
</tr>
<tr>
<td>Diameter = 36 in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length = 84 in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9.2.4.3 The instrument shall be mounted to the spacecraft via 4 lugs located 42 inches up from the base of the HRPI.</td>
<td>Y/ D/ 1-2</td>
<td>(TS 4)</td>
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</tbody>
</table>
### 3.9.2.5 Thermal

<table>
<thead>
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<th>Requirement</th>
<th>Source</th>
<th>Option</th>
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<tr>
<td>3.9.2.5.1 The instrument shall be insulated from the spacecraft</td>
<td>Y/D/1-2 (TS 4)</td>
<td><strong>Y</strong></td>
</tr>
<tr>
<td>3.9.2.5.2 Heat leaks to the spacecraft through insulating blankets and mounts shall be less than 10 watts (as a goal)</td>
<td>Y/D/1-2 (TS 4)</td>
<td><strong>Y</strong></td>
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</table>
3.9.3 Synthetic Aperture Radar (SAR)  
Currently, two alternate SAR configurations are under consideration.
Where requirements differ between configurations, both are identified.

3.9.3.1 Communications and Data Handling

3.9.3.1.1 The EOS shall provide for transmission of instrument
data in real-time at a rate of 170 Mbps

3.9.3.2 Electrical Power

3.9.3.2.1 The EOS shall provide TBD V electrical power to the
instrument at:
  a. Configuration 1 - 1140 watts
  b. Configuration 2 - 1250 watts

3.9.3.3 Attitude Control

3.9.3.3.1 The EOS shall provide attitude control to the following
limits for a period of 10 min/orbit

<table>
<thead>
<tr>
<th></th>
<th>Pointing</th>
<th>Stability Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch, Yaw</td>
<td>0.02 deg</td>
<td>0.01 deg/sec</td>
</tr>
<tr>
<td>Roll</td>
<td>0.06 deg</td>
<td>f (f)</td>
</tr>
</tbody>
</table>

3.9.3.4 Structure/Mechanical

3.9.3.4.1 The EOS shall accommodate an instrument electronics
package of the following characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Config. 1</th>
<th>Config. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>31 x 22 x 9.5 in</td>
<td>38 x 24.5 x 9.5 in</td>
</tr>
<tr>
<td>Weight</td>
<td>172 lb</td>
<td>213.5 lb</td>
</tr>
</tbody>
</table>
3.9.3.4.2 The EOS shall make provisions for a side mounted radar antenna of the following characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Config. 1</th>
<th>Config. 2</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>13.5 x 2.5 x 1 ft</td>
<td>27 x 2.5 x 1 ft</td>
<td>Z/Table 3.1.2-1/3-7</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>92 lb</td>
<td>174 lb</td>
<td>Z/Table 4.3.1-1/4.3</td>
<td></td>
</tr>
</tbody>
</table>

Page 3.9.3-2  Revision 2  Date 6/14/74
3.9.4 Passive Multichannel Microwave Radiometer (PMR)

The radiometers have the 80 cm scanning reflector and a set of four 7 cm diameter cold horns mounted on the spacecraft structure to view the earth (reflector) and cold space (horns) respectively. The reflector can be positioned to look in front or behind the spacecraft nadir. It scans symmetrically about this track ± 35°. The antennas are mounted so their field of view does not intersect the spacecraft or any solar panels or experiments. The antenna itself must not obstruct the solar paddles or any horizon scanners.

The four cold horns are pointed to avoid looking at the sun if possible. Sun temperature corrections can be made, but these corrections require additional data processing.

The radiometer receivers can be packaged into a volume of 0.06 m³ with the cold horns and antenna feeds mounted external to the spacecraft interior.

Table 3.9.4-1 shows the power and weight estimates for the passive facility excluding only the 13.9-GHz radiometer presently integrated into the active facility.
<table>
<thead>
<tr>
<th>Component</th>
<th>Power (W)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>53-GHz channel</td>
<td>5.0</td>
<td>2.268</td>
</tr>
<tr>
<td>36-GHz channel</td>
<td>8.0</td>
<td>7.2576</td>
</tr>
<tr>
<td>22-GHz channel</td>
<td>5.0</td>
<td>3.6288</td>
</tr>
<tr>
<td>18-GHz channel</td>
<td>5.0</td>
<td>3.6288</td>
</tr>
<tr>
<td>5-GHz channel</td>
<td>5.0</td>
<td>3.6288</td>
</tr>
<tr>
<td>Power supply (loss)</td>
<td>12.0</td>
<td>4.5360</td>
</tr>
<tr>
<td>Feed system</td>
<td>-</td>
<td>0.9072</td>
</tr>
<tr>
<td>Cold horn/radiation</td>
<td>-</td>
<td>0.9072</td>
</tr>
<tr>
<td>TM data system</td>
<td>5.0</td>
<td>-</td>
</tr>
</tbody>
</table>

**Total System Weight and Power**

<table>
<thead>
<tr>
<th>Component</th>
<th>Power (W)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receivers</td>
<td>45W</td>
<td>26.8 kg</td>
</tr>
<tr>
<td>Antenna Reflector</td>
<td>-</td>
<td>3.0 kg</td>
</tr>
<tr>
<td>Antenna Drive and Support Structure</td>
<td>18W</td>
<td>6.8 kg</td>
</tr>
<tr>
<td>Cabling and Thermal</td>
<td>-</td>
<td>2.27 kg</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>63.0W</strong></td>
<td><strong>38.8 kg</strong></td>
</tr>
</tbody>
</table>

**Note:** The 13.9-GHz radiometer's power and weight are included as part of the active sensor power and weight.
3.11  S/C-TO-SHUTTLE INTERFACES

3.11.1 Communications and Data Handling

3.11.1.1 While the EOS is attached to Orbiter, the Orbiter will support EOS telemetry as follows:

   a. Up to 25 Kbps of EOS/Instrument status data (hardline) to be interleaved with Orbiter operational telemetry.
   b. Up to 256 Kbps of EOS/Instrument data to be relayed to the ground via wideband FM transmitter.

3.11.1.2 After EOS release from the Orbiter, the Orbiter will accept up to 16 Kbps EOS/Instrument telemetry having the following characteristics:

   o S-band, phase modulation
   o Frequency band, 2200 - 2300 MHz

3.11.1.3 While the EOS is attached to the Orbiter, the Orbiter will provide to the EOS a 2.4 Kbps hardline command channel, of which 0.4 Kbps is allocated to vehicle and subsystem overhead.
3.11.1.4 After EOS release from the Orbiter, the Orbiter will be capable of generating and transmitting to the EOS 2.4 Kbps of command data, of which 0.4 Kbps is allocated to vehicle and subsystem overhead, with the following characteristics:

- S-band, phase modulation
- Frequency band, 2025-2120 MHz
- Time division multiplex (TDM) serial data of 8 Kbps consisting of encoded command data and synchronization.

3.11.1.5 The EOS shall provide commutation and subcarrier oscillators compatible with the Orbiter wideband transmitter for television and wideband experiment data. For digital data, the EOS shall perform the required encoding at a bit rate compatible with the capabilities of the Orbiter wideband transmitter.

3.11.1.6 Orbiter will provide both RF and hardline (umbilical) interfaces between the Orbiter communications subsystem and launch facilities for prelaunch telemetry, commands, TV, and wideband data.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.11.2 Electrical Power</td>
<td>AC/6.0/6-1</td>
</tr>
<tr>
<td>3.11.2.1 During ascent and descent Orbiter will provide electrical power to EOS/Instruments as follows:</td>
<td></td>
</tr>
<tr>
<td>o 1 Kw average</td>
<td></td>
</tr>
<tr>
<td>o 1.5 Kw peak</td>
<td></td>
</tr>
<tr>
<td>3.11.2.2 During orbital operations Orbiter will provide electrical power to EOS/Instruments as follows:</td>
<td>AC/6.0/6.1</td>
</tr>
<tr>
<td>o 5 Kw average</td>
<td></td>
</tr>
<tr>
<td>o 8 Kw peak</td>
<td></td>
</tr>
<tr>
<td>3.11.2.3 Orbiter will provide total electrical energy to EOS/Instruments of 50 Kwh.</td>
<td>AC/6.0/6.1</td>
</tr>
<tr>
<td>3.11.2.4 Additional energy requirements of EOS/Instruments may be provided with the necessary additional consumables, tankage, and plumbing chargeable to EOS/Instrument weight.</td>
<td>AC/6.0/6.1</td>
</tr>
<tr>
<td>3.11.2.5 The electrical power characteristics at the EOS/Instruments - Orbiter interface is as follows:</td>
<td>AC/6.0/6.1</td>
</tr>
<tr>
<td>o Power: 28VDC nominal, two wire, structure ground (payload must not use structure for DC return)</td>
<td></td>
</tr>
<tr>
<td>o Steady-state limits:</td>
<td></td>
</tr>
<tr>
<td>23-32.0 VDC intermittent duty</td>
<td></td>
</tr>
<tr>
<td>24-32.0 VDC continuous duty</td>
<td></td>
</tr>
<tr>
<td>o Ripple voltage: 1V peak-to-peak</td>
<td></td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>3.11.3.1 EOS shall provide data to the Orbiter for attitude control requirements prior to separation from Orbiter.</td>
<td>AC/3.3.2/3-5</td>
</tr>
<tr>
<td>3.11.3.2 The Orbiter will maintain attitude to ± 0.1 degrees.</td>
<td>AC/3.3.2/3-5</td>
</tr>
</tbody>
</table>
3.11.4 Structural/Mechanical

3.11.4.1 The EOS/Instrument shall fit within a maximum dynamic envelope of 15 ft diam by 60 ft length

3.11.4.2 The EOS shall structurally interface with the Orbiter via the standard attachments defined in Fig. 3.11.4-1

3.11.4.3 Orbiter payload c.g. shall fall within the envelope defined in Figs. 3.11.4-2 through -4

3.11.4.4 The Orbiter will induce random vibration levels within the payload bay as shown in Fig. 3.11.4-5, not including payload impedance effects

3.11.4.5 The acoustic environment within the Orbiter payload bay is defined in Figs. 3.11.4-6 and -7

3.11.4.6 The pressure environment within the Orbiter payload bay during ascent-to-orbit is defined in Fig. 3.11.4-8

3.11.4.7 The deployment and retrieval of EOS is accomplished by the general purpose remote manipulator system (RMS). Table 3.11.4-1 lists some basic characteristics of the RMS. One manipulator arm is provided by the orbiter and may be mounted on either left or right longeron. If a second manipulator is required, the weight is chargeable to the payload. The manipulator has a maximum reach of 52 ft. (Ref. Fig. 3.11.4-9).
Fig 3.11.4 - 1  - PAYLOAD ATTACHMENT LOCATIONS
Fig 3.11.4 - 2  PAYLOAD LONGITUDDLAL CG. ENVELOPE
Fig 3.11.4-3: Payload Vertical CG Envelope
MAXIMUM DESIGN PAYLOAD WEIGHT

ALLOWABLE PAYLOAD C.G. ENVELOPE

MAXIMUM DESIGN LANDING WEIGHT - 32k.

LATERAL DISTANCE FROM VEHICLE CENTERLINE IN CENTIMETERS

Fig 3.11.4-4 PAYLOAD LATERAL C.G. ENVELOPE
Fig 3.11.4-5 - ANALYTICAL PREDICTIONS OF THE UNITS FEED-OUTLAGE PRIMARY STRUCTURAL VIBRATION SPECTRA
Fig 3.11.4-6 - ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC ENVIRONMENT
Fig 3.11.4-7  ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC SPECTRA.
<table>
<thead>
<tr>
<th>Operational Mode</th>
<th>BMS Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload deployment</td>
<td>32K payload in less than 7 minutes</td>
</tr>
<tr>
<td></td>
<td>65K payload in less than 10 minutes</td>
</tr>
<tr>
<td></td>
<td>Residual rates 1.0 - 2.0 fps and 0.15 deg/sec</td>
</tr>
<tr>
<td></td>
<td>Up to 5 payloads/mission</td>
</tr>
<tr>
<td>Payload retrieval</td>
<td>Stabilized payloads up to 65K</td>
</tr>
<tr>
<td></td>
<td>Stopping distance:</td>
</tr>
<tr>
<td></td>
<td>65K payload -- 2.5 feet at a tip speed of 0.2 fps</td>
</tr>
<tr>
<td></td>
<td>Unloaded tip speed -- 2.0 fps</td>
</tr>
<tr>
<td></td>
<td>Miss distance -- 2 inches</td>
</tr>
</tbody>
</table>

Table 3.1.4-1 Remote Manipulator System (RMS) Characteristics
FIGURE 3.11.4-9 REMOTE MANIPULATOR SYSTEM REACH CAPABILITY

LEVEL "A" Z₀ 490

PIVOT-MANIPULATOR
Z₀ 447.6 - Y₀ 108 - X₀ 680

PIVOT-MANIPULATOR SUPPORT
Z₀ 411.25 - Y₀ 94.5 - X₀ 680

Page 3.11.4-11

Rev. 7 Dated: 7/12/74
FIGURE 3.11.4-9 REMOTE MANIPULATOR SYSTEM REACH CAPABILITY (CONT)
### 3.11.5 Thermal

#### 3.11.5.1 The Orbiter will provide nominal payload bay environments, not considering EOS/Instruments heat addition or removal, as noted in Table 3.11.5-1

#### 3.11.5.2 The Orbiter will provide additional, active thermal control through a heat exchanger. The active heat rejection capacity dedicated to the EOS/Instruments is as follows:

- **Average capacity**
  - Nominal: 3400 Btu/hr
  - Peak: 5200 Btu/hr
- **Orbital operations capacity (maximum)**
  - Nominal: 11,250 Btu/hr
  - Peak: 21,500 Btu/hr

#### 3.11.5.3 During on-orbit operations, the EOS/Instruments will normally be exposed to the space environment
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>DESIGN MINIMUM</th>
<th>DESIGN MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prelaunch</td>
<td>+400°F</td>
<td>+1200°F</td>
</tr>
<tr>
<td>Launch</td>
<td>+400°F</td>
<td>+1500°F</td>
</tr>
<tr>
<td>On-orbit (doors closed)</td>
<td>See CEF</td>
<td>See AEE</td>
</tr>
<tr>
<td>Entry and portlanding</td>
<td>-1000°F</td>
<td>+200°F</td>
</tr>
</tbody>
</table>

Heat leak criteria into or out of a 100°F constant payload are as follows:

A. Total bay heat gain, average ≤ 0 Btu/ft²-hr
B. Heat gain, local area ≤ 3 Btu/ft²-hr
C. Total bay heat loss, average ≤ 3 Btu/ft²-hr
D. Heat loss, local area ≤ 4 Btu/ft²-hr

Table 3.11.5-1 Payload Bay Wall Thermal Environment
3.12.1 The DMG shall contain the ground located EOS system operational elements that convey, handle, convert, distribute, and manage high-rate and edited lower rate spacecraft earth sensing instrument generated payload data.

3.12.2 The DMG is composed of the following subsystems:
- Instrument Data Acquisition & Recording
- Data Processing & Product Generation
- S/C & Processing Management & Control
- Data User Services

3.12.3 Two types of Data Acquisition & Data Processing configurations exist:
- Primary or high data rate configuration composed of the Primary Ground Station (PGS) and the Central Data Processing Facility (CDPF).
- Secondary or Local User System (LUS) including the Low Cost Ground Station (LCGS) which receive compacted instrument data at lower rates than the PGS.
### 3.13 FLIGHT OPERATIONS

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.13.1 The EOS shall support retrieval by the Shuttle Orbiter</td>
<td>A/1.3.6/1-5 (TS 1) (TS 3)</td>
</tr>
<tr>
<td>3.13.2 The EOS shall provide for on-orbit servicing by the Shuttle Orbiter</td>
<td>A/1.3.6/1-5</td>
</tr>
<tr>
<td>3.13.3 The EOS shall provide for Level THD autonomy</td>
<td>GAC (TS 3)</td>
</tr>
<tr>
<td>3.13.4 All EOS venting while within THD distance of the Shuttle Orbiter shall be non-propulsive</td>
<td>GAC (TS 3)</td>
</tr>
<tr>
<td>3.13.5 Contaminants from EOS system effluents, including outgassing, shall not impinge harmfully upon:</td>
<td>GAC</td>
</tr>
<tr>
<td>a. The instruments</td>
<td></td>
</tr>
<tr>
<td>b. The Shuttle Orbiter</td>
<td></td>
</tr>
<tr>
<td>3.13.6 The EOS shall not discharge or jettison solid debris in orbit in the vicinity of instrument operations</td>
<td>GAC</td>
</tr>
<tr>
<td>3.13.7 Two hours shall be allotted between deployment from the Shuttle Orbiter and the first major EOS maneuver.</td>
<td>GAC</td>
</tr>
<tr>
<td>3.13.8 The EOS shall be targeted 10 n.mi above and 300 n.mi ahead of the Orbiter on the return from mission orbit for recovery</td>
<td>GAC (TS 1)</td>
</tr>
<tr>
<td>3.13.9 Three hours shall be allotted in all EOS mission timelines for Orbiter catch-up during EOS retrieval</td>
<td>GAC (TS 3)</td>
</tr>
<tr>
<td>3.13.10 The EOS shall maintain a stable attitude during Shuttle Orbiter terminal rendezvous and capture</td>
<td>GAC (TS 3)</td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>3.13.11 Contaminents from the launch vehicle shall not impinge harmfully upon the instruments</td>
<td>FA-2.16.3</td>
</tr>
<tr>
<td>3.13.12 Provide S/C health data during launch (max. q), subsequent L/V burns and during SRM firing.</td>
<td>FA-2.16.5.24, FA-2.1, 4, 6, 10 &amp; 19</td>
</tr>
</tbody>
</table>

Page 3.13-2
Revision 7
Date 7/12/74
## 3.14 FLIGHT OPERATIONS SUPPORT

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.14.1 Flight Operations Support (FOS) shall be capable of controlling two spacecraft in orbit concurrently.</td>
<td>B/-/9</td>
<td>(TS 74/1)</td>
</tr>
<tr>
<td>3.14.2 Maximize use of existing NASA facilities.</td>
<td>GAC</td>
<td></td>
</tr>
<tr>
<td>3.14.3 Minimize use of mission-peculiar hardware/software.</td>
<td>GAC</td>
<td></td>
</tr>
<tr>
<td>3.14.4 Data acquisition, tracking, and orbit determination will be provided by GSFC.</td>
<td>A/2.1.6/2-7</td>
<td></td>
</tr>
<tr>
<td>3.14.5 Data acquisition facilities for complete U.S. coverage will be provided at three STIN sites:</td>
<td>A/2.1.6/2-7</td>
<td></td>
</tr>
<tr>
<td>o Greenbelt, Maryland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Goldstone, California</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Fairbanks, Alaska</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.14.6 Communications with the primary and other data acquisition facilities will be via NASCOM.</td>
<td>A/2.1.6/2-7</td>
<td></td>
</tr>
<tr>
<td>3.14.7 The Mission Control Center (MCC) shall be used for real-time support of the EOS, including operations scheduling.</td>
<td>B/-/9</td>
<td>(TS 74/1)</td>
</tr>
</tbody>
</table>
### 3.15 S/C GSE

#### 3.15.1 Factory

3.15.1.1 The S/C will consist of three assemblies:
- Instrument, S/S Module & Orbit Adjust/Transfer, assembly
- Therefore holding fixtures must be provided for each module during assembly and test.

3.15.1.2 Provisions shall be made to assemble the S/C vertically for systems tests.

3.15.1.3 Provide bench checkout equipment for each of the three basic S/S modules:
- ACS, EPS, Comm. & Data Handling

3.15.1.4 Provide power to S/S modules, which simulates S/C power, variable within S/C limits

3.15.1.5 Provide loads to the S/S modules during test, which simulates S/C interfaces

3.15.1.6 Provide work stands for vehicle assembly and checkout

#### 3.15.2 Launch Site

3.15.2.1 Provide flexibility in the design of bench checkout equipment so that its use can grow to a module maintenance bench during Shuttle operations

3.15.2.2 Provide for conditioning of S/C flight batteries
### REQUIREMENT

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.16 S/C TO DELTA 2910 INTERFACES</td>
<td>T/3.16-1 Revision 7, Date 7/12/74</td>
</tr>
</tbody>
</table>

#### 3.16.1 Structural/Mechanical

3.16.1.1 The EOS shall attach to the Delta 2910 launch vehicle attach fitting via:

- a. A two-piece man clamp arrangement
- b. A four-bolt attachment arrangement

3.16.1.2 The EOS shall accept a relative separation velocity of 2-3 ft/sec (0.61 - 2.4 m/s).

3.16.1.3 The EOS shall fit within the payload envelope defined in Fig. 3.17-1

3.16.1.4 The EOS shall withstand a maximum steady state longitudinal acceleration of 8.3 g's.

#### 3.16.2 Communication & Data Handling

3.16.2.1 Spacecraft separation is initiated directly from the guidance computer after SECO. It can provide up to six programmed signals to accomplish various functions. Two of the signals are within the range of 30 to 160 sec, after initiation with an accuracy of a 0.5 sec. or 0.5% of the specified set time, whichever is greater. The remaining four programmed signals can be set from 1 to 50 sec. after either of the first two signals with an accuracy of ± 10%.
Note:
Projection of S/C appendages below the S/C separation plane are permitted but must be coordinated with the Delta project.

Fig. 3.16-1  Allowable Payload Envelope, Delta 2910
3.17 S/C to Titan III E/SSR/HUS

3.17.1 Communications and Data Handling

3.17.1.1 The launch vehicle can provide up to 16 discrete outputs, sequenced on the basis of time or event dependency, for S/C control. Maximum output current is 10 amps.

3.17.1.2 Telemetry data transmitted through the launch vehicle shall conform to the characteristics of Table 3.17.1.

3.17.2 Electrical Power

3.17.2.1 EOS electrical demands upon the launch vehicle shall be consistent with the power system characteristics defined in Table 3.17.2.

3.17.2.2 All power leads from the EOS to the launch vehicle shall be:
   a. Physically separated from other wiring
   b. Isolated from EOS structure by at least 10 megohms.
<table>
<thead>
<tr>
<th>DATA TYPE</th>
<th>IMPLEMENTATION</th>
<th>NUMBER OF AVAILABLE CHANNELS</th>
<th>SAMPLE RATE (SPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilevel</td>
<td>In Remote Multiplexed Instrumentation System</td>
<td>6</td>
<td>1600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Analog</td>
<td>In Each Remote Multiplexer Unit</td>
<td>2</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>200</td>
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<tr>
<td></td>
<td></td>
<td>4</td>
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<td>8</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 3.17-1 Typical Titan III B/SSB S/C Instrumentation Services
<table>
<thead>
<tr>
<th>CONSIDERATION</th>
<th>MULTIBUS POWER SYSTEM (STEADY STATE)</th>
<th>TRANSIENT POWER SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power available to spacecraft</td>
<td>5 amp-hr at 28 VDC</td>
<td>4 amp-hr at 28 VDC</td>
</tr>
<tr>
<td>Voltage</td>
<td>25 to 32 VDC</td>
<td>20 to 38 VDC</td>
</tr>
<tr>
<td>Noise and ripple</td>
<td>30 Hz to 20 KHz, with peak of 2.0V on gnd pwr and peak of 1.25V on airborne pwr</td>
<td>No constraints</td>
</tr>
<tr>
<td>Special considerations</td>
<td>Not to be used for spacecraft transient power loads</td>
<td>High-transient-current capacity, suitable for firing ordnance, driving motors, etc.</td>
</tr>
</tbody>
</table>

Table 3.17-2, Titan III B/SSB S/C Electrical Power Services (Estimated)
3.17.3 Attitude Control

3.17.3.1 The launch vehicle shall control attitude at separation to the following limits:

<table>
<thead>
<tr>
<th>Pointing (deg)</th>
<th>Rate (deg/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 0.5</td>
<td>± 0.45 Pitch, Yaw</td>
</tr>
<tr>
<td></td>
<td>± 0.75 Roll</td>
</tr>
<tr>
<td>± 2.0</td>
<td>± 0.1 Pitch, Yaw</td>
</tr>
<tr>
<td></td>
<td>± 0.2 Roll</td>
</tr>
<tr>
<td>± 4.0</td>
<td>± 0.1 Pitch, Yaw</td>
</tr>
<tr>
<td></td>
<td>± 0.2 Roll</td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>3.17.4 Structural/Mechanical</td>
<td></td>
</tr>
<tr>
<td>3.17.4.1 The EOS shall structurally interface with the launch vehicle as shown in Fig. 3.17-1</td>
<td>AE/-/7</td>
</tr>
<tr>
<td>3.17.4.2 The impulse to separate EOS from the launch vehicle shall be provided by a spring-driven separation system carried by and charged to the EOS.</td>
<td>AB/VII/VII-8</td>
</tr>
<tr>
<td>3.17.4.3 The EOS shall fit within the payload envelope defined in Fig. 3.17-2 and 3</td>
<td>U/Fig VI-6/VI-9</td>
</tr>
<tr>
<td></td>
<td>AE/-/8</td>
</tr>
</tbody>
</table>
PAYLOAD & ADAPTER INTERFACE

Figure 3.17-1

Page 3.17-6

Revision 4 Dated 6/21/74
FIG. 3.17 - 2 Allowable Payload Envelope, Titan IIIB/SSB/NUS For WTR Type P 123 Seg. A, D, E, and G
PAYLOAD INTERFACE ENVELOPE

Titan III B or III D

Note: All dimensions and Sta. No.'s are in inches.
### 3.18 SPACECRAFT TEST REQUIREMENTS

#### 3.18.1 Component Dynamic Environmental Requirements

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.18.1.1 Transportation and Handling</td>
<td>V/Appendix I/-</td>
<td>12345</td>
</tr>
</tbody>
</table>

The component shall be capable of operating within specification limits after exposure to controlled environments, while in a non-operating mode during transportation and handling. Controlled environments shall be provided by properly designed shipping containers to insure that the experienced transportation and handling levels are less severe than those pertaining to launch and orbital mission phases.

#### 3.18.1.1.2 Fabrication Shock

In accordance with MIL-STD-810B, Method 516.1, Procedure V.

#### 3.18.1.1.3 Transportation Shock

In accordance with MIL-STD-810B, Method 516.1, Paragraph 3.9.5.

#### 3.18.1.1.4 Transit Shock

In accordance with MIL-STD-810B, Method 516.1 Procedure II.

#### 3.18.1.1.5 Sinusoidal Vibration

In accordance with MIL-STD-810B, Method 514.1, Procedure X. The test levels shall be as indicated in Figure 516.1-7, curve "AW" and "AY." The test procedure and duration shall be as indicated in Table 514.1 - VII.
3.18.1.2 Qualification Environments
The component shall be capable of operating within specification limits during and after exposure to the following environments.

3.18.1.2.1 Acceleration
The test levels shall be 20g applied for one minute in each direction along each of the three orthogonal axes.

3.18.1.2.2 Acoustic Field
The test levels and duration shall be as shown in Table 3.18.1-1. Acoustic tests shall be conducted in lieu of the random vibration test only on selected components which are likely to be susceptible to acoustic noise excitation (e.g., antennas, solar panels).

3.18.1.2.3 Random Vibration
The test levels and duration shall be as shown in Table 3.18.1-2. The levels and duration shall be applied along each of the three orthogonal axes.
3.18.1.2.4 Sinusoidal Vibration

The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.1-3. The levels and sweep rate shall be applied along each of the three orthogonal axes.

Note: In lieu of the 200-2000Hz portion of the sinusoidal vibration test, a shock test (3.18.1.2.5) is preferred.

3.18.1.2.5 Shock

A shock spectral analysis, using Q=10, of the applied shock transient shall be in accordance with the shock response spectrum shown in Figure 3.18.1-4. A sufficient number of shocks shall be imposed to meet the amplitude criteria in both directions along each of the three orthogonal axes at least three times (total of 18 shocks).
### TABLE 3.18.1-1
**ACOUSTIC QUALIFICATION TEST LEVELS**

Duration: 3 minutes

* *(dB Re: 20 μN/m²)*

<table>
<thead>
<tr>
<th>OCTAVE BAND</th>
<th>Center Frequency (Hz)</th>
<th>Sound Pressure Level (dB*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.5</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>141</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>137.5</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>8000</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>OVERALL</td>
<td>149.5</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 3.18.1-2
**RANDOM VIBRATION QUALIFICATION TEST LEVELS**

Duration: 3 Minutes/axis

<table>
<thead>
<tr>
<th>Frequency Range (Hz)</th>
<th>Acceleration Spectral Density (g²/Hz)</th>
<th>Acceleration Overall (g-rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-150</td>
<td>+3dB/Oct</td>
<td>16</td>
</tr>
<tr>
<td>150-1000</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>1000-2000</td>
<td>-6dB/Oct</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 3.18.1-3
**SINUSOIDAL VIBRATION QUALIFICATION TEST LEVELS**

Sweep Rate: 2 Octaves/Minute/Axis

<table>
<thead>
<tr>
<th>Frequency Range (Hz)</th>
<th>Acceleration Zero-to-Peak (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9.5</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td>9.5-15</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td>15-21</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td>21-50</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td>50-200</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td>200-2000</td>
<td>12.7 mm d.a.</td>
</tr>
</tbody>
</table>
3.18.1.3 Acceptance Test Environment

3.18.1.3.1 General

Flight components, which are tested later as part of a completely assembled flight spacecraft, shall be subjected to random vibration or, where applicable, to acoustic noise tests.

3.18.1.3.1.2 Flight Spare Components

Flight spare components that have not been exposed to system tests as part of a prototype or backup spacecraft shall be subjected to both sinusoidal and random vibration.

3.18.1.3.2 Acoustic Field

The test levels and duration shall be as shown in Table 3.18.1-4. Acoustic tests shall be conducted in lieu of the random vibration test only on selected components which are likely to be susceptible to acoustic noise excitation (e.g., antennas, solar panels).

3.18.1.3.3 Random Vibration

The test levels and duration shall be as shown in Table 3.18.1-5. The levels and duration shall be applied along each of the three orthogonal axes.

3.18.1.3.4 Sinusoidal Vibration

The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.1-6. The levels and sweep rate shall be applied along each of the three orthogonal axes.
## Table 3.18.1-4  Acoustic Acceptance Test Levels

*Duration: 1 minute

![](image)

## Table 3.18.1-5  Random Vibration Acceptance Test Levels

*Duration: 1 Minute/Axis

<table>
<thead>
<tr>
<th>Frequency Range (Hz)</th>
<th>Acceleration Spectral Density (g^2/Hz)</th>
<th>Acceleration Overall (g-rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-150</td>
<td>+3dB/Oct</td>
<td>10</td>
</tr>
<tr>
<td>150-1000</td>
<td>0.072</td>
<td></td>
</tr>
<tr>
<td>1000-2000</td>
<td>-6dB/Oct</td>
<td></td>
</tr>
</tbody>
</table>

## Table 3.18.1-6  Sinusoidal Vibration Acceptance Test Levels

*Sweep Rate: 4 Octaves/Minute/Axis

<table>
<thead>
<tr>
<th>Frequency Range (Hz)</th>
<th>Acceleration Zero-to-Peak (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9.5</td>
<td>8.4 mm d.a.</td>
</tr>
<tr>
<td>9.5-15</td>
<td>+ 1.5</td>
</tr>
<tr>
<td>15-21</td>
<td>+ 4.0</td>
</tr>
<tr>
<td>21-50</td>
<td>+ 6.6</td>
</tr>
<tr>
<td>50-200</td>
<td>+ 1.5</td>
</tr>
<tr>
<td>200-2000</td>
<td>+ 3.3</td>
</tr>
</tbody>
</table>
### 3.18.2 Spacecraft Dynamic Environmental Requirements

#### 3.18.2.1 Transportation and Handling

The Spacecraft shall be capable of operating within specification limits after exposure to controlled induced environments, while in a non-operating mode during transportation and handling. Controlled environments shall be provided, by properly designed shipping container, proper selection of modes of transportation and handling methods, to ensure that transportation and handling do not impose environmental conditions which exceed the maximum predicted launch and orbital mission requirements. Controlled environments shall be provided to protect the Spacecraft against the following conditions (TBD).

#### 3.18.2.2 Qualification Test Environments

The Spacecraft qualification test article shall be subjected to the environments specified below and in accordance with the requirements of NASA GSFC S-320-G-1 except as noted. The Spacecraft shall be examined and functionally tested before and after each environmental exposure. During the test, the Spacecraft shall be operated in the appropriate mission phase duty cycle.

##### 3.18.2.2.1 Acoustic Field

The Spacecraft shall be exposed to a broadband random sound field with an overall sound pressure level of 149 dB (Re: 20 μ Newton/m²). The octave band sound pressure levels shall be as specified in Table 3.18.2-1. The Spacecraft shall be mounted on a flight-type adapter during the test.
### 3.18.2.2 Sinusoidal Vibration

The Spacecraft shall be attached to a vibration fixture using a flight-type adapter and flight-type clamp. Sinusoidal vibration excitation shall be applied at the base of the adapter along each of the three orthogonal axes. The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.2-2. The reduction of the sinusoidal vibration test levels, in the Spacecraft's resonant frequency band, will be required in order to prevent the application of unrealistic loads. This "notching" of the input levels shall be determined by dynamic analysis of the Spacecraft in combination with the Launch Vehicle.

### 3.18.2.3 Mechanical Shock

The Spacecraft shall be subjected to a mechanically applied shock transient to the Spacecraft/Launch Vehicle interface twice along each of the three orthogonal axes. The test level, using shock spectral analysis with a $Q = 10$, shall be defined in terms of shock response spectrum and in accordance with Figure 3.18.2-1.

### 3.18.2.4 Pyrotechnic Shock

The Spacecraft shall be subjected to two pyrotechnic separation tests. In addition to the Spacecraft, the test shall include the flight-type adapter, flight-type clamp and pyrotechnic devices. The Spacecraft shall also be subjected to additional pyrotechnic shocks dependent on the type and quantity of release devices used for solar arrays, antennas, etc.
3.18.2.2.5 Static Load

The Spacecraft structural model shall be subjected to a static load test. The test levels to be applied shall be determined from a combined Spacecraft/Launch Vehicle dynamic loads analysis, Spacecraft structural loads and stress analyses for the worst case conditions of Tables 3.18.2-3, 4, & 5.

3.18.2.2.6 Modal Survey

The test is a developmental engineering test and not a qualification test. Modal survey of the Spacecraft, with installed mass simulation of components, shall be performed to determine the natural frequencies, mode shapes, and structural damping. This shall be a cantilever test with the Spacecraft structure (including the attach fitting) mounted on a fixed base.

3.18.2.3 Acceptance Test Environments

Each Flight Spacecraft shall be subjected to the environment specified below and in accordance with the requirements of NASA GSFC S-320-G-1 except as noted. The Spacecraft's components shall be operating and monitored for identification of intermittent failure.

3.18.2.3.1 Acoustic Field

The Flight Spacecraft shall be exposed to a broadband random sound field. The Octave band sound pressure levels shall be as specified in Table 3.18.2-6. The spacecraft shall be mounted on a flight-type adapter during the test.
### TABLE 3.18.2-1

**ACOUSTIC NOISE**

**SPACECRAFT QUALIFICATION TEST LEVELS**

*(dB Re: 20 \( \mu \) Newton/M\(^2\))

<table>
<thead>
<tr>
<th>OCTAVE BAND</th>
<th>CENTER FREQUENCY (HZ)</th>
<th>SOUND PRESSURE LEVEL (dB*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal (X-X)</td>
<td>31.5</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>63</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>137.5</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>8000</td>
<td>133</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>149.5</td>
</tr>
</tbody>
</table>

**Duration:** 2 Minutes

### TABLE 3.18.2-2

**SINUSOIDAL VIBRATION**

**SPACECRAFT QUALIFICATION TEST LEVELS**

<table>
<thead>
<tr>
<th>Axis of Excitation</th>
<th>Frequency Range (HZ)</th>
<th>Acceleration Zero-to-peak ( \pm ) (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal (X-X)</td>
<td>5 - 9.5</td>
<td>12.7 mm d.a.</td>
</tr>
<tr>
<td></td>
<td>9.5 - 15</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>15 - 21</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>21 - 50</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>50 - 200</td>
<td>2.3</td>
</tr>
<tr>
<td>Lateral (Y-Y) &amp; (Z-Z)</td>
<td>5 - 7.1</td>
<td>19.0 mm d.a.</td>
</tr>
<tr>
<td></td>
<td>7.1 - 22</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>22 - 200</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Sweep Rate:** 2 Octaves/Minute

---

Page 3.18.2-4

Revision 6 Dated 7/15/7-
FIGURE 3.18.2-1
SHOCK RESPONSE SPECTRUM
AT SPACECRAFT/LAUNCH VEHICLE INTERFACE
LAUNCH VEHICLE INDUCED SHOCKS

FREQUENCY - $f_e$
QUALIFICATION TEST LEVELS
### TABLE 3.18.2-3
ULTIMATE LOAD FACTORS
DELTA LAUNCH VEHICLE

<table>
<thead>
<tr>
<th>Condition</th>
<th>Longitudinal</th>
<th>Lateral Y or Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift - off</td>
<td>+4.35</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>-1.5</td>
<td></td>
</tr>
<tr>
<td>Main Engine Cut off</td>
<td>+18.45</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### TABLE 3.18.2-4
ULTIMATE LOAD FACTORS
TITAN III B/NUS LAUNCH VEHICLES

<table>
<thead>
<tr>
<th>Condition</th>
<th>Longitudinal</th>
<th>Lateral Y or Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift - off</td>
<td>+3.45</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>-1.2</td>
<td></td>
</tr>
<tr>
<td>Stage I shutdown (depletion)</td>
<td>+12.3</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>-3.75</td>
<td></td>
</tr>
<tr>
<td>Stage II shutdown (command)</td>
<td>+16.2</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>-3.0</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Limit load factor times 1.5
2. Load factor carries the sign of the externally applied load.
3. Includes both steady state and dynamic conditions.
### TABLE 3.18.2-5
**ULTIMATE LOAD FACTORS**

**SHUTTLE**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Directions(2)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>Z</td>
</tr>
<tr>
<td>Lift - off (4)</td>
<td>+ 2.55 ± 0.9</td>
<td>± 0.45</td>
<td>+ 1.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 0.30</td>
</tr>
<tr>
<td>High Q Boost</td>
<td>+ 2.85</td>
<td>± 0.30</td>
<td>- 0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 0.75</td>
</tr>
<tr>
<td>Booster End Burn</td>
<td>+ 4.5 ± 0.45</td>
<td>± 0.30</td>
<td>+ 0.60</td>
</tr>
<tr>
<td>Orbiter End Burn</td>
<td>+ 4.5 ± 0.45</td>
<td>± 0.30</td>
<td>+ 0.75</td>
</tr>
<tr>
<td>Space Operations</td>
<td>+ 0.30</td>
<td>± 0.15</td>
<td>+ 0.15</td>
</tr>
<tr>
<td></td>
<td>- 0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entry</td>
<td>± 0.38</td>
<td>± 0.75</td>
<td>- 4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 1.5</td>
</tr>
<tr>
<td>Subsonic Maneuvering</td>
<td>± 0.38</td>
<td>± 0.75</td>
<td>- 3.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 1.5</td>
</tr>
<tr>
<td>Landing and Braking</td>
<td>± 2.25</td>
<td>± 2.25</td>
<td>- 3.75</td>
</tr>
<tr>
<td>Crash(3)</td>
<td>- 9.5</td>
<td>± 1.5</td>
<td>- 4.5</td>
</tr>
<tr>
<td></td>
<td>+ 1.5</td>
<td></td>
<td>+ 2.0</td>
</tr>
</tbody>
</table>

**Notes:**
1. Limit load factor times 1.5 except for crash.
2. Load factor carries the sign of the externally applied factor. 
   Positive X, Y, Z, directions equal forward, right and down.
3. Crash load factors are ultimate and only used to design local 
   payload support fittings and attachments. The specified load 
   factors shall apply separately.
4. These factors include dynamic transient load factors.

---

Revision 6  
Dated: 7/5/74
## TABLE 3.18.2-6

**ACOUSTIC NOISE**

**SPACECRAFT ACCEPTANCE TEST LEVELS**

<table>
<thead>
<tr>
<th>Center Frequency (Hz)</th>
<th>Sound Pressure Level dB (dB Re: 20 µ Newton/m²)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level I</td>
<td>Level II</td>
<td>Level III</td>
<td></td>
</tr>
<tr>
<td>31.5</td>
<td>124</td>
<td>127</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>125</td>
<td>132.5</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>130</td>
<td>137</td>
<td>138</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>135</td>
<td>139</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>139</td>
<td>139</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>133</td>
<td>137</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>130</td>
<td>133.5</td>
<td>133.5</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>126</td>
<td>130</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>8000</td>
<td>123</td>
<td>124</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td><strong>OVERALL:</strong></td>
<td>142</td>
<td>145</td>
<td>145.5</td>
<td></td>
</tr>
</tbody>
</table>

**DURATION:** 1 Minute

<table>
<thead>
<tr>
<th>Level</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>*</td>
</tr>
<tr>
<td>II</td>
<td>*</td>
</tr>
<tr>
<td>III</td>
<td>*</td>
</tr>
</tbody>
</table>
4.1.1 Orbit Adjust

4.1.1.1 Provide thrusters, propellant storage and controls to effect orbit adjustment

4.1.1.2 Provide +x impulse (lb-sec) requirements as follows:

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct injection error</td>
<td>3374</td>
<td>4070</td>
<td>6403</td>
</tr>
<tr>
<td>Correct SRM error</td>
<td></td>
<td></td>
<td>522</td>
</tr>
<tr>
<td>Orbit keys</td>
<td>108</td>
<td>140</td>
<td>168</td>
</tr>
<tr>
<td>Contingency 10%</td>
<td>348</td>
<td>421</td>
<td>704</td>
</tr>
<tr>
<td>Total</td>
<td>3830</td>
<td>4631</td>
<td>7802</td>
</tr>
</tbody>
</table>

4.1.1.3 Provide SRM for orbit insertion

4.1.1.4 The orbit adjust subsystem shall consist of four 75 lb thrusters which shall be used to maintain control during SRM operations

4.1.1.5 For non SRM operations provide four 5 lb thrusters

<table>
<thead>
<tr>
<th></th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G/3.2.2.2.2/3-35</td>
<td>•••••</td>
</tr>
<tr>
<td></td>
<td>AF/Table 4,6,7/-</td>
<td>•••••</td>
</tr>
<tr>
<td></td>
<td>G/3.2.2.2/3-35</td>
<td>•</td>
</tr>
<tr>
<td></td>
<td>G/Fig. 3-12/3-25</td>
<td>•</td>
</tr>
<tr>
<td></td>
<td>GAC</td>
<td>••</td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
<td>OPTION</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------</td>
</tr>
<tr>
<td>4.1.2 Communications and Data Handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.2.1 The variable downlink TLM rates are 32, 16, 8, 4, 2, 1 kbps</td>
<td>B/-/20</td>
<td></td>
</tr>
<tr>
<td>4.1.2.2 The 8 GHz (X-band) frequency should be utilized</td>
<td>E/2.2.2.1.3/-</td>
<td></td>
</tr>
<tr>
<td>4.1.2.3 Use 95% link reliability for sizing the X-band link</td>
<td>B/-/21</td>
<td></td>
</tr>
<tr>
<td>4.1.2.4 The complete optional payload for EOS-B will acquire data at a continuous rate of up to 2.5 Mbps, with individual instrument data ranging from 100 bps to 2.0 Mbps</td>
<td>A/2.3.2/2-9</td>
<td></td>
</tr>
<tr>
<td>4.1.2.5 Provide for STDN compatible, S-band experiment data transmission at the following rates:</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>a. Real-time 6.4 Kbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Stored/playback 128 Mbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.2.6 Provide a command system with both discrete (single) pulse and serial magnitude word capability</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>4.1.2.7 Provide for variable formatting of experiment and spacecraft data upon command</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>4.1.2.8 Provide on-board storage for at least two orbits of experiment and subsystem data</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>4.1.2.9 Provide for simultaneous transmission of real-time and playback telemetry</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>4.1.2.10 Provide an on-board processor for command memory and for use by experiments and EOS subsystems</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>4.1.2.11 The EOS on-board processor, with associated hardware, shall provide for:</td>
<td>M/3.3.3.4/16</td>
<td></td>
</tr>
<tr>
<td>a. Stored commands</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 4.1.2 Communications and Data Handling (Cont’d)

**b. Automatic interaction between experiment data and spacecraft subsystem modes**

4.1.2.12 Provide for maximum instrument data rates of 60 Mbps

4.1.2.13 Provide for two discrete levels of instrument data transmission:
   - a. 0.5 Kbps Real Time
   - b. 10 Mbps Stored/playback

4.1.2.14 Provide a means for tracking, ground and on-board control of all spacecraft and payload sensor functions, and for retrieval of observatory data.

4.1.2.15 An S-band transponder shall be used for ranging, receiving, commanding, and transmitting narrow band sensor and housekeeping data.

4.1.2.16 All communications shall be fully compatible with the GSFC Aerospace Data System Standards X-560-63-2

4.1.2.17 Frequency assignments shall be made on a mission-by-mission basis:
   - a. Transmit 2200 MHz to 2300 MHz
   - b. Receive 2050 MHz to 2150 MHz

4.1.2.18 The probability of executing a false command shall be less than $10^{-10}$ for any input signal conditions.

4.1.2.19 The probability of rejecting a good command shall be less than $10^{-3}$ over a signal range of -105 to -40 dbm.
4.1.2.20 The S-band transmitter shall be capable of simultaneously transmitting:
   - 32 kbps real-time, low rate housekeeping/sensor data
   - Up to 640 kbps stored/playback medium rate data

4.1.2.21 The C&DH system shall be capable of simultaneously distributing within the S/C, 62.5 cmds/sec from the on-board computer while executing 50 cmds/sec from the ground.

4.1.2.22 The C&DH system shall be capable of simultaneously acquiring up to 32 kbps of S/C data for the computer only and acquiring up to 32 kbps of additional S/C data for transmission to both the ground and the on-board computer.

4.1.2.23 RF characteristics shall be as defined in Table 4.1.2-1

4.1.2.24 A general purpose digital computer shall be included in the C&DH subsystem

4.1.2.25 Assure that all receivers cannot be turned off simultaneously when activated for flight
**BASELINE RF CHARACTERISTICS**

**TABLE 4.1.2-1**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit Frequency</td>
<td>TBD MHz ±0.001% (S-Band)</td>
</tr>
<tr>
<td>Receive Frequency</td>
<td>TBD MHz (S-Band)</td>
</tr>
<tr>
<td>Turnaround Ratio</td>
<td>221/240</td>
</tr>
<tr>
<td>Transponder Side Tone Frequency</td>
<td>500 KHz maximum</td>
</tr>
<tr>
<td>Command Bit Rate</td>
<td>2000 bps</td>
</tr>
<tr>
<td>Command Modulation</td>
<td>PCM/PSK - ( \Sigma / FM/PM ) (Uses 70 KHz subcarrier)</td>
</tr>
<tr>
<td>Narrow Band Data Rate</td>
<td>Selectable: 32 kbps, 16 kbps, 8 kbps, 4 kbps, 2 kbps &amp; 1 kbps</td>
</tr>
<tr>
<td>Narrow Band Modulation</td>
<td>Split phase PCM/PM on subcarrier</td>
</tr>
<tr>
<td>Medium Band Data Rate</td>
<td>500 kbps maximum</td>
</tr>
<tr>
<td>Medium Band Data Modulation</td>
<td>Split phase PCM/PM on carrier</td>
</tr>
<tr>
<td>Transmitter Power</td>
<td>2 watts, .2 watts</td>
</tr>
<tr>
<td>T/M Data Coding</td>
<td>Manchester (split phase)</td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>4.1.3 Electrical Power Subsystem</td>
<td>F/III.2.1/-</td>
</tr>
<tr>
<td>4.1.3.1 The EPS shall be capable of controlling, storing, distributing &amp; monitoring power derived from a solar array. The physical &amp; electrical characteristics of the array will be based on individual mission and power subsystem requirements. The subsystem shall contain storage batteries and all associated charge/discharge control and monitoring circuitry.</td>
<td>E/2.1/2-1</td>
</tr>
<tr>
<td>4.1.3.2 Electrical interfaces of subsystem modules shall be standardized</td>
<td>E/3.1/3-1</td>
</tr>
<tr>
<td>4.1.3.3 All S/C power will be supplied by a solar array</td>
<td>E/3.1/3-1</td>
</tr>
<tr>
<td>4.1.3.4 The power output of the array will be adequate to supply normal daylight loads plus recharge the batteries</td>
<td>E/3.2.1.1/3-8</td>
</tr>
<tr>
<td>4.1.3.5 Bus voltage shall be $28 \pm 7$ DC</td>
<td>E/3.2.1.4/3-8</td>
</tr>
<tr>
<td>4.1.3.6 Bus transients:</td>
<td></td>
</tr>
<tr>
<td>Load switching $\pm 1$ V for 100 ms or less</td>
<td></td>
</tr>
<tr>
<td>Fault correction $\pm 20$ to $\pm 39$ V for 100 ms or less</td>
<td></td>
</tr>
<tr>
<td>4.1.3.7 Bus Noise &amp; Ripple: Due to EPS less than 500 mv peak to peak, 5 Hz to 100 KHZ</td>
<td>E/3.2.1.5/3-8</td>
</tr>
<tr>
<td>Due to EOS loads TBD</td>
<td></td>
</tr>
<tr>
<td>4.1.3.8 Operating temperature range for equipment will not exceed: electronic assys. 0 to 130°F</td>
<td>E/3.2.9/3-11</td>
</tr>
<tr>
<td>batteries 32 to 60°F</td>
<td></td>
</tr>
<tr>
<td>4.1.3.9 Fuses will be operated at 20% of rated current</td>
<td>E/3.3.5/3-30</td>
</tr>
</tbody>
</table>

Page 4.1.3-1

Revision Date
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.3.10 EPS shall be designed to automatically maintain a safe state of charge in the batteries for normal orbital operations. Capability shall be provided via command circuitry for overriding all automatic functions except those considered necessary for normal operation or survival of the spacecraft during emergency conditions.</td>
<td>F/III,2.2.3/-</td>
</tr>
<tr>
<td>4.1.3.11 The power distribution bus shall supply power to the subsystems and instruments. Common impedences in the distribution circuitry shall be as low as practical to minimize the coupling of conducted interference between loads.</td>
<td>F/III,2.2.4/-</td>
</tr>
<tr>
<td>4.1.3.12 The distribution circuitry for subsystem loads shall contain devices to protect power busses from short circuits. The bus protection circuitry shall be provided for all loads except those which are non-redundant and/or critical to mission success.</td>
<td>F/III,2.2.4.1/-</td>
</tr>
<tr>
<td>4.1.3.13 Individual groups of power contacts shall be provided for each major subsystem and instruments</td>
<td>F/III,2.2.4.2/-</td>
</tr>
<tr>
<td>4.1.3.14 Current sensors shall be provided for monitoring load currents supplied to each subsystem &amp; instrument.</td>
<td>F/III,2.2.4.3/-</td>
</tr>
<tr>
<td>4.1.3.15 Power subsystem shall contain circuitry for arming &amp; disabling the power input/output circuitry during ground tests &amp; during orbital resupply</td>
<td>F/IV,2.2.5/-</td>
</tr>
<tr>
<td>4.1.3.16 The subsystem shall have the capability for being powered by ground or shuttle orbiter based power supplied during test and those periods when the solar array power is not available.</td>
<td>F/III,2.2.6/-</td>
</tr>
</tbody>
</table>
### Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Source</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.3.17 Power Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orbital average - min. 500 W, max TBD</td>
<td>F/III.2.2.1.2/-</td>
<td></td>
</tr>
<tr>
<td>Peak power - 5.6 KW for 10 min. day or night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.3.18 Impedance (at power module/structure interface connector)</td>
<td>F/III.2.2.1.3/-</td>
<td></td>
</tr>
<tr>
<td>Not to exceed 0.15 ohms - 1 Hz to 5 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 ohms - 5 Khz to 100 Khz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 ohms - 100 Khz to 1 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.3.19 Batteries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type TBD</td>
<td>F/III.2.2.2/-</td>
<td></td>
</tr>
<tr>
<td>Capacity - Total TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum 40 amp hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maximum 120 amp hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth of discharge</td>
<td>F/III.2.2.2.3/-</td>
<td></td>
</tr>
<tr>
<td>Not to exceed 50% for normal orbital operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.3.20 The solar array shall be configured (retractable/jettisonable) to permit EOS retrieval for refurbishment.</td>
<td>FA 2.36</td>
<td></td>
</tr>
</tbody>
</table>
4.1.4 Attitude and Control

4.1.4.1 Provide for spacecraft control during initial acquisition, reacquisition, normal operations, orbit adjustment maneuvers, and coarse attitude hold mode.

4.1.4.2 Where an integral Tug is required, the ACS shall provide attitude and rate signals required for its control.

4.1.4.3 The ACS shall be driven directly in response to error signals generated by sensors or via the on-board computer.

4.1.4.4 The ACS shall be capable of operating within specification cyclic disturbance torque limits of:

<table>
<thead>
<tr>
<th>Orbit Alt (n.mi)</th>
<th>Torque (ft-lb)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average (Secular)</td>
<td>Cyclic (Peak)</td>
</tr>
<tr>
<td>300 - 900</td>
<td>$10^{-5}$ to 0.1</td>
<td>$2 \times 10^{-4}$ to 0.2</td>
</tr>
<tr>
<td>Geosynch</td>
<td>$10^{-6}$ to 0.01</td>
<td>$2 \times 10^{-5}$ to 0.02</td>
</tr>
</tbody>
</table>

4.1.4.5 The ACS shall accommodate the following range of spacecraft mass properties:

- Weight: 2500 - 25,000 lb
- Moment of inertia: 500 - 100,000 slug - ft²

4.1.4.6 ACS response cut-off frequency shall be 0.1 Hz

4.1.4.7 In Acquisition Mode:

a. Reduce S/C rates to less than ± 0.03 deg/sec
b. Define S/C inertial attitude to within ± 2 deg
### Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.4.5 In Inertial Attitude Hold Mode, maintain an arbitrarily selected inertially referenced attitude to:</td>
<td>F/I,2.2.3/-</td>
</tr>
<tr>
<td>a. Before in-orbit calibration, ± 0.03 deg/hr</td>
<td></td>
</tr>
<tr>
<td>b. After in-orbit calibration, ± 0.003 deg/hr</td>
<td></td>
</tr>
<tr>
<td>4.1.4.9 In Coarse Attitude Hold Mode:</td>
<td>F/I,2.2.4/-</td>
</tr>
<tr>
<td>a. Provide a high level of reliability</td>
<td></td>
</tr>
<tr>
<td>b. Maintain the sun line normal to the solar array within ± 7.0 deg (total)</td>
<td></td>
</tr>
<tr>
<td>c. Limit S/C rates to &lt; 0.05 deg/sec/axis</td>
<td></td>
</tr>
<tr>
<td>d. Maintain this mode of operation for up to 30 days</td>
<td></td>
</tr>
<tr>
<td>4.1.4.10 In Slew Mode:</td>
<td>F/I,2.2.5-1/-</td>
</tr>
<tr>
<td>a. Reorient the S/C (on a single axis basis) up to 90 deg with an accumulated error of &lt; ± 0.03 deg</td>
<td></td>
</tr>
<tr>
<td>b. Provide a slew rate ≥ 2 deg/min</td>
<td></td>
</tr>
<tr>
<td>4.1.4.11 For normal operations, the ACS shall meet the following performance levels per axis:</td>
<td>F/I,2.2.5-2/-</td>
</tr>
<tr>
<td>a. Pointing accuracy &lt; ± 0.01 deg</td>
<td>(TS 6)</td>
</tr>
<tr>
<td>b. Pointing stability</td>
<td></td>
</tr>
<tr>
<td>(1) Average rate deviation &lt; ± 10^-6 deg/sec</td>
<td></td>
</tr>
<tr>
<td>(2) Attitude jitter</td>
<td></td>
</tr>
<tr>
<td>(a) Up to 30 sec period, &lt; ± 0.0003 deg</td>
<td></td>
</tr>
<tr>
<td>(b) Up to 20 min period, &lt; ± 0.0006 deg</td>
<td></td>
</tr>
<tr>
<td>c. Maintain these conditions for periods up to 1 hour</td>
<td></td>
</tr>
</tbody>
</table>
4.1.4.12 The ACS shall provide the capability for utilizing error signals generated by a stellar payload instrument for S/C control. It shall meet the following performance levels (per axis) exclusive of instrument error signal limitations:

a. Pointing accuracy \( < \pm 3 \times 10^{-6} \text{ deg} \)

b. Attitude jitter \( < \pm 10^{-7} \text{ deg} \)

4.1.4.13 Maintain spacecraft attitude to \( \leq \pm 0.25 \text{ deg} \) in all axes

4.1.4.14 For initial SMM, provide pointing accuracies of:

a. Pitch \( 1 \text{ to } 5 \text{ sec (rms)} \)

b. Yaw \( 1 \text{ to } 5 \text{ sec (rms)} \)

c. Roll \( 6 \text{ min (rms)} \)

4.1.4.15 For Shuttle launched SMM, provide pointing accuracies of:

a. Pitch \( 2 \text{ sec} \)

b. Yaw \( 2 \text{ sec} \)

c. Roll \( \text{TBD} \)

4.1.4.16 For initial SMM, provide pointing stability of:

a. In each of two axes, \( 1 \text{ sec} \) for not less than \( 5 \text{ min} \)

b. In the third axis (normal to line-of-sight to sun), \( 0.1 \text{ deg} \)

4.1.4.17 For Shuttle launched SMM, provide pointing stability of:

a. In each of two axes, \( 0.22 \text{ sec} \) for not less than \( 5 \text{ min} \)

b. In the third axis, \( \text{TBD} \)
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.4.18</td>
<td>M/4.5.1/63</td>
<td></td>
</tr>
<tr>
<td>4.1.4.19</td>
<td>M/3.3.3.5/18</td>
<td></td>
</tr>
<tr>
<td>4.1.4.20</td>
<td>M/3.3.3.5/18</td>
<td></td>
</tr>
<tr>
<td>4.1.4.21</td>
<td>N/ - / -</td>
<td></td>
</tr>
<tr>
<td>4.1.4.22</td>
<td>N/ - / -</td>
<td></td>
</tr>
<tr>
<td>4.1.4.23</td>
<td>N/ - / -</td>
<td></td>
</tr>
<tr>
<td>4.1.4.24</td>
<td>FA-2.16.5.23</td>
<td></td>
</tr>
</tbody>
</table>

4.1.4  Attitude and Control (Cont'd)

4.1.4.18 Provide pointing to any selected point on the solar disc (+15 min pointing range in each of two axes)

4.1.4.19 Provide the capability to slew 5 min within 1 sec time

4.1.4.20 Provide the capability to acquire the required attitude position from any orientation

4.1.4.21 Provide the capability of pointing sensor to ±1 Km accuracy at subpoint (28 µ rad).

4.1.4.22 Provide the capability of holding pointing to ±25 meters (0.7 µ rad)

4.1.4.23 Provide two classes of slew rate:
   a. Incremental traverses at selectable rates of 100 to 800 km/min
   b. Sustained traverse across CONUS (5000 km) in 5 min (≈ 0.028 rad/min).

4.1.4.24 Provide means of activating attitude control price to S/C separation from L/V

Date 7/12/74
4.1.5 Structure

4.1.5.1 Mechanical configurations of subsystem modules shall be standardized.

4.1.5.2 The only structural contact that the EOS has with the launch vehicle is at the transition ring.

4.1.5.3 The systems contractor shall provide a NASTRAN computer model (desk) of the module structure to S/C subsystem contractors.

4.1.5.4 Only one S/C subsystem module configuration shall be provided which shall satisfy the specific requirements of the 3 basic S/C subsystems (C & DH, Att. Control & Power).

4.1.5.5 The S/C subsystem module shall have a total volume of not less than 23 cu. ft. (approx. 48" x 48" x 18").

4.1.5.6 The max. wt. of S/S module shall be 100 lb.

4.1.5.7 The max. load carrying capability of S/S modules is 600 lb.

4.1.5.8 The S/S module structure shall be designed for max steady-state acceleration of 25 g's longitudinal & 15 g's for lateral.

4.1.5.9 Fittings for the purpose of mounting the S/S modules to the S/C shall be compatible with the module resupply concept. The maximum repeatable mechanical misalignment of a module to S/C structure shall be +15 arc seconds in each axis.

4.1.5.10 Accommodate 600 ft³ (17 m³) of SEASAT experiments

4.1.5.11 Accommodate 500 lb of SEASAT experiments

4.1.5.12 Provide appropriate structure to accommodate interfacing with the Delta launch vehicle.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.5.13 Support a minimum SMM scientific payload weight of 1431 lb (649 Kg)</td>
<td>Q/-/-</td>
<td></td>
</tr>
<tr>
<td>4.1.5.14 Provide a minimum clear viewing area of 7 ft²</td>
<td>M/3.3.3.1/15</td>
<td></td>
</tr>
<tr>
<td>4.1.5.15 Accommodate a minimum total SMM instrument volume of 13.5 ft³ (0.38 m³)</td>
<td>Q/-/-</td>
<td></td>
</tr>
<tr>
<td>4.1.5.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1.5.17 Accommodate a SEOS instrument volume of 459 ft³ (13 m³)</td>
<td>N/-/-</td>
<td></td>
</tr>
<tr>
<td>4.1.5.18 Support a minimum SEOS scientific payload weight of 2646 lb (1200 Kg).</td>
<td>N/-/-</td>
<td></td>
</tr>
<tr>
<td>REQUIREMENT</td>
<td>SOURCE</td>
<td>OPTION</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>------------</td>
<td>--------</td>
</tr>
<tr>
<td>4.1.6.1 Each S/C module will be independently thermally controlled</td>
<td>D/III/25</td>
<td></td>
</tr>
<tr>
<td>4.1.6.2 Internal components heat sink will operate at 70° ± 20°F</td>
<td>E/2.1.2/2-4</td>
<td></td>
</tr>
<tr>
<td>4.1.6.3 Maximize thermal isolation of subsystem modules from instrument</td>
<td>E/2.1.2/2-4</td>
<td></td>
</tr>
<tr>
<td>modules by insulation with an effective emissivity of ≤ 0.05</td>
<td>F/IV.1.3.6.3/-</td>
<td></td>
</tr>
<tr>
<td>4.1.6.4 Maintain SMM experiment temperatures at 15°C ± 10°C</td>
<td>M/3.3.2/15</td>
<td></td>
</tr>
</tbody>
</table>
4.1.7 Pneumatics

4.1.7.1 Provide thrusters, propellant storage and controls to effect attitude control

4.1.7.2 Provide impulse requirements as follows:

<table>
<thead>
<tr>
<th>Option</th>
<th>Maneuver</th>
<th>R</th>
<th>P</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial stabilization</td>
<td>6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Control-orbit correction</td>
<td>0.5</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Stabilization after array deployment</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Gravity Gradient compensation</td>
<td>35</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Contingency 10%</td>
<td>4</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>46</td>
<td>119</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option</th>
<th>Maneuver</th>
<th>R</th>
<th>P</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial stabilization</td>
<td>7</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Control-orbit correction</td>
<td>0.5</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Stabilization after array deployment</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Gravity gradient compensation</td>
<td>105</td>
<td>236</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Contingency 10%</td>
<td>11</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>125</td>
<td>300</td>
<td>41</td>
</tr>
</tbody>
</table>
4.1.7.2 Provide impulse requirements as follows (continued)

Option 3

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>Impulse - lb-sec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>P</td>
</tr>
<tr>
<td>Initial stabilization</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Control during SRM burn</td>
<td>5</td>
<td>210</td>
</tr>
<tr>
<td>Stabilization after SRM jettison</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Control-orbit correction</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Stabilization after array deployment</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Gravity gradient compensation</td>
<td>105</td>
<td>238</td>
</tr>
<tr>
<td>Contingency 10%</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>123</strong></td>
<td><strong>547</strong></td>
</tr>
</tbody>
</table>
4.1.8 Instrument Data Handling.

Provide a Data Handling Subsystem which accepts data from instruments whose outputs are formatted into two identical rate digital streams for transmission to the ground. These instruments are called the Thematic Mapper (TM) and High Resolution Pointable Imager (HRPI). Two additional lower rate digital data streams one for each of the instruments, are also required. The data rate is about one quarter that of the high rate (wideband) data and is referred to as compacted data.

The Data Handling Subsystem has two primary functions, wideband data combining and selective or compacted data combining. In wideband the input data lines (seven for the TM and four for the HRPI) are multiplexed together, framed and combined with a small amount of overhead. These two data streams at 85.7 Mbps (one for HRPI and one for TM) are inputs to a spacecraft QPSK modulator.

Data compaction reduces the wideband data rate to a value that can be handled by a relatively low cost ground station. The data rate selected is exactly one quarter of the wideband rate, or approximately 21.4 Mbps. Data here includes actual data from the instrument plus required overhead and framing.

Three interfaces are defined, as shown in fig.4.1.8-1 between the instrument data handling units and instruments, on-board processor and modulators. Data and framing information are supplied via the interface with the instruments. Overhead information required to process the data on the ground and to select the compaction algorithm is received from the spacecraft on-board processor. The third interface is the wideband and compacted data stream to the modulators.
Fig. 4.1.8-1 Data Handling Subsystem Interface
**4.2.1 Data Acquisition and Communications**

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.2.1.1</strong> Orbit definition shall be sufficiently accurate to permit orbit predictions 2 weeks in advance.</td>
<td>M/5.1.1/71</td>
</tr>
<tr>
<td><strong>4.2.1.2</strong> Orbit predictions shall be sufficient to predict:</td>
<td>M/5.1.1/71</td>
</tr>
<tr>
<td>a. S/C position within 10 km for S-band acquisition with 30 ft diameter antennas (1° beamwidth)</td>
<td></td>
</tr>
<tr>
<td>b. Times of S/C entrance and exit into and from eclipse (spherical, no atmosphere earth and point-source sun) with an accuracy of ± 8 sec in time.</td>
<td></td>
</tr>
<tr>
<td>c. S/C position within 500 meters 24 hours in advance.</td>
<td></td>
</tr>
<tr>
<td><strong>4.2.1.3</strong> Relay real-time command data from the Operations Control Center (OCC) to the spacecraft at 800-1200 bps.</td>
<td>M/5.1.2/71</td>
</tr>
<tr>
<td><strong>4.2.1.4</strong> Command data transmission shall have a bit error rate (BER) ≤ 10^-6</td>
<td>M/5.1.2/71</td>
</tr>
<tr>
<td><strong>4.2.1.5</strong> Provide for at least one command opportunity of not less than 5 minutes on each orbit</td>
<td>M/5.1.2/71</td>
</tr>
<tr>
<td><strong>4.2.1.6</strong> Provide for receipt of a S/C command memory dump and relay to the OCC within three minutes of the start of the dump</td>
<td>M/5.1.2/71</td>
</tr>
<tr>
<td><strong>4.2.1.7</strong> Provide the capability for receipt of real-time S/C telemetry data at 6.4 Kbps for a minimum of one contact/orbit with a minimum contact time of six minutes and relay to the OCC in real-time.</td>
<td>M/5.1.3/71</td>
</tr>
<tr>
<td><strong>4.2.1.8</strong> Provide for receipt of S/C telemetry data at 128 Kbps for:</td>
<td>M/5.1.3/72</td>
</tr>
<tr>
<td>a. One contact per orbit with a duration of 6 minutes</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>b. One contact per two orbits with a duration of 11 minutes</td>
<td></td>
</tr>
</tbody>
</table>
4.2.1.9 Provide for the relay of S/C telemetry data to the OCC as follows:
   a. Five minutes of 128 Kbps data within 30 minutes of receipt
   Or
   b. Ten minutes of 128 Kbps data within 60 minutes of receipt

4.2.1.10 Telemetry acquisition and command opportunity periods must be completely overlapping

4.2.1.11 The telemetry RF link shall provide a BER $\leq 10^{-5}$

4.2.1.12 Tracking, telemetry, and command support shall be provided for a minimum period of launch to launch plus one year. Support is desired from launch to launch plus two years.
### 4.2.3 Data Processing

#### 4.2.3.1 All products, standard and custom, will be radiometrically corrected

#### 4.2.3.2 The standard products requirements are:

<table>
<thead>
<tr>
<th>Geometrically Corrected</th>
<th>Geometrically Uncorrected</th>
<th>Reduced Data Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/W Film</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Color Film</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>High Density Digital</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tape (HDDT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Compatible</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Tape (CCT)</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

#### 4.2.3.3 Custom output products from the system shall include film products geometrically corrected with custom gamma capability and sub-area enlargement capability to specific map scales

#### 4.2.3.4 Custom film products are those of specific false color mix

#### 4.2.3.5 Custom digital products (CCT output) include sub-area, or swath width reduction, band sequential or band interleaved, specific bands, and reduced resolution

#### 4.2.3.6 Quality requirements for the output products are shown in Table 4.2.3-1

#### 4.2.3.7 Processing of the daily volume of data shall be accomplished within a 16 hour day

#### 4.2.3.8 Basic processing of image data (i.e., geometric correcting, radiometric calibration, etc.) shall be performed digitally

#### 4.2.3.9 Data products and ranges are in Table 4.2.3-2
<table>
<thead>
<tr>
<th></th>
<th>GEOMETRICALLY UNCORRECTED*</th>
<th></th>
<th>GEOMETRICALLY CORRECTED+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TM</td>
<td>HRPI</td>
<td>TM</td>
</tr>
<tr>
<td>Swath Width</td>
<td>185km</td>
<td>48km</td>
<td>185km</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible</td>
<td>30m</td>
<td>10m</td>
<td>30m</td>
</tr>
<tr>
<td>Thermal</td>
<td>120m</td>
<td>--</td>
<td>120m</td>
</tr>
<tr>
<td>Linearity (μrad)</td>
<td>0.2 IFOV</td>
<td>0.2 IFOV</td>
<td>0.2 IFOV</td>
</tr>
<tr>
<td>Band to Band Registration</td>
<td>0.1 IFOV</td>
<td>0.3 IFOV</td>
<td>0.1 IFOV</td>
</tr>
<tr>
<td>Position Accuracy (w/o GCP)**</td>
<td>+450m</td>
<td>+450m</td>
<td>+170m</td>
</tr>
<tr>
<td>Position Accuracy (with GCP)**</td>
<td>--</td>
<td>--</td>
<td>+15m</td>
</tr>
<tr>
<td>Relative Radiometric Accuracy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tape</td>
<td>$\pm$ 1.6%</td>
<td>$\pm$ 1.6%</td>
<td>$\pm$ 1.6%</td>
</tr>
<tr>
<td>Film</td>
<td>$\pm$ 5%</td>
<td>$\pm$ 5%</td>
<td>$\pm$ 5%</td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tape</td>
<td>$\pm$ 1K</td>
<td>--</td>
<td>$\pm$ 1K</td>
</tr>
<tr>
<td>Film</td>
<td>$\pm$ 3K</td>
<td>--</td>
<td>$\pm$ 3K</td>
</tr>
</tbody>
</table>

*Includes radiometric correction, earth-rotation correction, line-length adjustment, correction for earth curvature, and predicted ephemeres.

+Additionally includes use of best-fit ephemeris from measured data.

**GCP = ground control points.

SYSTEM OUTPUT QUALITY REQUIREMENT

TABLE 4.2.3-1
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>DATA VOLUME</th>
<th>NUMBER OF DATA USERS</th>
<th>NUMBER OF FORMATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDOT (uncorrected)</td>
<td>$10^{10}$-$10^{12}$bits/day</td>
<td>2 - 10</td>
<td>--</td>
</tr>
<tr>
<td>HDOT (corrected)</td>
<td>$10^{10}$-$10^{12}$bits/day</td>
<td>2 - 10</td>
<td>--</td>
</tr>
<tr>
<td>CCT (corrected)</td>
<td>$10^9$-$10^{10}$bits/day</td>
<td>10 - 100</td>
<td>1 - 5</td>
</tr>
<tr>
<td>BLACK &amp; WHITE POS/NEG (1)</td>
<td>20 - 200 scenes/day</td>
<td>5 - 50</td>
<td>1 - 3</td>
</tr>
<tr>
<td>BLACK &amp; WHITE PRINTS</td>
<td></td>
<td>5 - 10</td>
<td>1 - 3</td>
</tr>
<tr>
<td>COLOR POS/NEG (2)</td>
<td>10 - 100 scenes/day</td>
<td>2 - 20</td>
<td>1 - 3</td>
</tr>
<tr>
<td>COLOR PRINTS</td>
<td></td>
<td>2 - 10</td>
<td>1 - 3</td>
</tr>
</tbody>
</table>

(1) FIRST GENERATION PRODUCT - 241MM (9.5 inch)

(2) SECOND GENERATION PRODUCT - 241MM (9.5 inch)

(3) ENLARGEMENT TO STANDARD MAP SCALES

DATA PRODUCTS AND RANGES

TABLE 4.2.3-2

Page 4.2.3-3
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.3 Data Processing (Cont'd)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2.3.10 Provide processing of experiment data</td>
<td>M/7.1.c/85</td>
<td></td>
</tr>
<tr>
<td>a. 6.4 Kbps telemetry data rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. $6.0 \times 10^8$ bits/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. 100% orbital coverage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2.3.11 Accept investigator's data base on formatted magnetic tapes</td>
<td>M/7.1.d/85</td>
<td></td>
</tr>
<tr>
<td>4.2.3.12 Provide quick-look data processing to 10 principal investigators</td>
<td>M/7.1.e/85</td>
<td></td>
</tr>
<tr>
<td>on a daily basis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2.3.13 Input Data Load

The input to the CDPF consists of digital data as recorded by high speed instrumentation tape recorders. The range of input data to be considered by each of the hardware configurations is:

<table>
<thead>
<tr>
<th>System Instr.</th>
<th>Minimum</th>
<th>Baseline</th>
<th>Expanded</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM</td>
<td>20 scenes*/day</td>
<td>90 scenes/day</td>
<td>1.5x10^11 bits/day</td>
</tr>
<tr>
<td></td>
<td>3.3x10^10 bits/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TM and HRPI**</td>
<td>20 scenes/day</td>
<td>90 scenes/day</td>
<td>400 scenes/day</td>
</tr>
<tr>
<td></td>
<td>3.3x10^10 bits/day</td>
<td>1.5x10^11 bits/day</td>
<td>6.7x10^11 bits/day</td>
</tr>
</tbody>
</table>

*TM scene: 6168 x 6168 7-bit pixels x 64 bands = 1.664 x 10^9 bits/scene.
*HRPI scene: 3200 x 12333 7-bit pixels x 4 bands = 1.105 x 10^9 bits/scene.
**To a first-order approximation the processing requirements for the TM and HRPI are similar.

4.2.3.14 Quantity of Data Processed and Archived

The percentage of the total data input from the above table which are to be processed and archived at each stage is:

<table>
<thead>
<tr>
<th>Processing Stage</th>
<th>% Data Processed</th>
<th>% Archived</th>
<th>Internal Purge (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Input Data</td>
<td>0</td>
<td>100</td>
<td>∞</td>
</tr>
<tr>
<td>I</td>
<td>100</td>
<td>100</td>
<td>3, 6, 12</td>
</tr>
<tr>
<td>II</td>
<td>50,100</td>
<td>50,100</td>
<td>3, 6, 12</td>
</tr>
<tr>
<td>III</td>
<td>20,50,100</td>
<td>50,100</td>
<td>3, 6, 12</td>
</tr>
</tbody>
</table>
The Stage II and Stage III processing are not necessarily mutually exclusive. The Stage II and Stage III processing loads should be considered additive as long as their sum does not exceed 100 percent; above this point Stage III processing replaces Stage II processing. Thus when Stage III processing is 50 percent only the Stage II processing option of 50 percent should be considered.
The following figure shows the requirement for output (user) products at 3 points:

Throughput Model.

The HDDT (High Density Digital Tape) refers to any very high density tape (> 10,000 bpi) not directly readable (without special interface hardware) by a computer. The CCT (Computer Compatible Tape) refers to other magnetic tapes with density < 10,000 bpi that are directly readable by computers. The photo products consist of B&W film (positive and negative), B&W prints, color film (positive and negative) and color prints. The B&W and color film are to be 241mm (9.5 inch). The B&W film is to be a first generation product; i.e., produced directly from the digital data through, for example, a laser beam recorder. The color film is to be a second generation product; i.e., produced from B&W film.
**Table - User Data Products.**

<table>
<thead>
<tr>
<th>Product</th>
<th>Number (Each Different)</th>
<th>Av. Copies of Each*</th>
<th>No. Users Receiving</th>
<th>Number Formats**</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDDT*</td>
<td>2, 20, 200</td>
<td>1</td>
<td>2-20</td>
<td>1</td>
</tr>
<tr>
<td>CCT (6250 bpi)</td>
<td>2, 10</td>
<td>5</td>
<td>10-50</td>
<td>5</td>
</tr>
<tr>
<td>CCT (1600 bpi)</td>
<td>1, 10</td>
<td>10</td>
<td>20-100</td>
<td>5</td>
</tr>
<tr>
<td>B&amp;W Film</td>
<td>20, 200</td>
<td>1</td>
<td>5-50</td>
<td>3</td>
</tr>
<tr>
<td>Color Film</td>
<td>10, 100</td>
<td>1</td>
<td>2-20</td>
<td>3</td>
</tr>
<tr>
<td>Prints (B&amp;W and Color)</td>
<td>Existing ERTS Photolab</td>
<td>2-20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Distributed among Stages I, II and III. Assume a mix of packing densities to equal total specified. The number of HDDTs specified is based on packing roughly \(10^{10}\) bits per HDDT.

** Does not include archive requirements.

*** Formats for tape are discussed separately. Formats for photo included full scenes at 1:10^6 scale and multiple scenes at increased scale.

---

Not shown in Figure are custom products. Custom photo products include special gamma correction, special sub-area enlargement to specific map scales and special false color mix. Custom digital products relate only to CCT and include partial scenes (sub-area or swath width reduction), special format and reduced resolution. Initially, as a first order approximation, assume these custom products to require the same processing required by other products identified in the Figure.
Each CDPF hardware configuration should be sized to handle the required data load in a standard 16-hour day. This implies a 24-hour turnaround for most standing orders. Also assume up to 10 percent demand for retrospective orders for data previously archived, included as part of the load defined in (Table) para. 4.2.3.14.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.4</td>
<td>Data User Services</td>
<td>(TS 9)</td>
</tr>
<tr>
<td>4.2.4.1</td>
<td>Low Cost Ground System (LCGS)</td>
<td></td>
</tr>
<tr>
<td>4.2.4.1.1</td>
<td>The LCGS will accept direct readout of selected TM or HRPT data</td>
<td>A/2.1.5/2-6</td>
</tr>
<tr>
<td>4.2.4.1.2</td>
<td>Basic capabilities of LCGS are to display image data and produce photo products</td>
<td>A/2.1.5/2-6</td>
</tr>
<tr>
<td>4.2.4.1.3</td>
<td>Additional capabilities, electable at user option, are data formatting and editing, computer aided analysis</td>
<td>A/2.1.5/2-6</td>
</tr>
<tr>
<td>4.2.4.1.4</td>
<td>As a means of limiting quantities of data transmitted to LCGS, EOS on-board editing may be considered in the form of limited area coverage, restricted number of channels, or lower spatial resolution.</td>
<td>A/2.1.5/2-6</td>
</tr>
</tbody>
</table>

Page 4.2.4-1
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SOURCE</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4.4 Transportation &amp; Handling</td>
<td>12345</td>
<td></td>
</tr>
<tr>
<td>4.4.4.1 A shipping container shall be provided to transport the S/C horizontally to the launch site</td>
<td>GAC</td>
<td></td>
</tr>
<tr>
<td>4.4.4.2 Shipping containers shall be provided for each of the three S/C assemblies: Instrument, S/S Modules, &amp; Orbit Adjust/Transfer Assembly, since spares will be shipped independently to the launch site</td>
<td>V / / 1</td>
<td></td>
</tr>
<tr>
<td>4.4.4.3 Provide for a constant positive nitrogen purge within the instrument housing for contamination control during transportation.</td>
<td>W / / 3</td>
<td></td>
</tr>
</tbody>
</table>