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PHASE A CONCEPTUAL DESIGN STUDY OF THE ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS) PAYLOAD

By Program Development

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16. ABSTRACT

This Technical Memorandum records the 12 month Phase A Conceptual Design Study of the Atmospheric, Magnetospheric and Plasmas in Space (AMPS) payload performed within the Program Development Directorate of the Marshall Space Flight Center.

The AMPS payload makes use of the Spacelab pressurized module and pallet, is launched by the Space Shuttle, and will have initial flight durations of 7 days. Scientific instruments including particle accelerators, high power transmitters, optical instruments, and chemical release devices are mounted externally on the Spacelab pallet and are controlled by the experimenters from within the pressurized module. The capability of real-time scientist interaction on-orbit with the experiment is a major characteristic of AMPS.

The AMPS Science Working Group, composed of 49 scientists from the United States and other countries, was recently established by NASA Headquarters (Office of Space Sciences) for the purpose of developing recommended AMPS program scientific objectives, experimental techniques and instrument requirements. The recommendations of this group will supercede the information regarding instrumentation and experiments that served as the basis for this study.

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TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION AND STUDY GUIDELINES	1-1
2.0	SCIENTIFIC OBJECTIVES OF THE AMPS PAYLOAD	2-1
	2.1 Introduction	2-1
	2.2 Scientific Instrument Description	2-4
	2.2.1 Remote Sensing Platform	2-4
	2.2.2 Lidar System	2-6
	2.2.3 Transmitter/Coupler System	2-7
	2.2.4 Boom System	2-9
	2.2.5 Gimbaled Accelerator System	2-10
	2.2.6 Subsatellites	2-12
	2.2.7 Chemical Releases	2-13
	2.3 References	2-15
3.0	DESIGN REFERENCE CONFIGURATION DESCRIPTION	3-1
	3.1 Space Shuttle System Description	3-1
	3.2 Spacelab System Description	3-7
	3.3 AMPS Design Reference Configuration	3-10
4.0	CONFIGURATION DESIGN	4-1
	4.1 Initial Concept	4-1
	4.2 Baseline Concept	4-2
	4.3 Alternate Configurations	4-5
	4.3.1 Reduced Experiments	4-5
	4.3.2 Pallet Forward	4-9
	4.3.3 Forward Platform	4-9
	4.4 Revised Configurations	4-11
	4.4.1 Forward Platform	4-11
	4.4.2 Final Baseline Configuration	4-11
	4.5 AMPS Configuration with ERNO Spacelab	4-14
5.0	AMPS WEIGHT AND CENTER OF GRAVITY STUDY	5-1
	5.1 AMPS Current Design Reference Weight and c.g. Assessment	5-6
	5.2 AMPS Weight and c.g. Assessment of Three Alternate Configurations	5-9
	5.3 AMPS Weight and c.g. Sensitivity Analysis of Various Spacelab and Pallet Lengths	5-14

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TABLE OF CONTENTS (Continued)

Section			Page
6.0	SUBSYSTEMS		6-1
	6.1	Structures	6-1
		6.1.1 50 Meter Booms	6-1
		6.1.2 AMPS Long Wire Antenna	6-6
	6.2	Thermal Control Subsystems	6-26
		6.2.1 Analysis	6-26
		6.2.2 Results	6-26
		6.2.3 Antenna Studies	6-27
		6.2.4 Results and Conclusions	6-27
	6.3	Pointing and Control Subsystems	6-37
		6.3.1 Guidelines and Constraints	6-37
		6.3.2 Design Reference	6-39
		6.3.3 Trade Studies	6-52
		6.3.4 Interfaces	6-55
		6.3.5 Conclusions and Recommendations	6-57
		6.3.6 References	6-58
	6.4	Communications and Data Management	6-72
		6.4.1 Communications	6-72
		6.4.2 Data Management	6-77
		6.4.3 Boom Data Management Trade Analysis	6-81
	6.5	AMPS Electrical Power System Design	6-105
		6.5.1 Guidelines and Assumptions	6-105
		6.5.2 AMPS Baseline Electrical Power System	6-108
		6.5.3 Analysis of AMPS Large Power Users	6-109
		6.5.4 Transmitter Coupler	6-112
		6.5.5 Power Profile	6-113
		6.5.6 Conclusions and Recommendations	6-113
		6.5.7 Electromagnetic Control	6-114
	6.6	AMPS Controls and Displays	6-126
		6.6.1 Guidelines, Assumptions, and Constraints	6-126
		6.6.2 Design Reference	6-126
		6.6.3 Trade Studies	6-128
		6.6.4 Interfaces	6-129
		6.6.5 Conclusions and Recommendations	6-129

TABLE OF CONTENTS (Continued)

Section		Page
7.0	MISSION ANALYSIS	7-1
	7.1 Subsatellite Flight Mechanics	7-1
	7.1.1 Near Shuttle Subsatellite Operations	7-1
	7.1.2 Non-Co-Orbiting Subsatellite Operations	7-2
	7.2 Atmospheric Source Mapping Dynamics	7-29
	7.2.1 Guidelines and Assumptions	7-29
	7.2.2 Description of Problem	7-29
	7.2.3 Task Status	7-30
	7.2.4 Results	7-30
	7.2.5 Observation and Issues	7-31
	7.3 On-Orbit Operations — Experiment/Crew Schedules	7-42
	7.4 Ground Operations	7-62
	7.4.1 Guidelines and Assumptions	7-62
	7.4.2 Block Diagram	7-62
	7.4.3 Activities and Timelines	7-62
	7.4.4 Manpower Requirements	7-63
	7.4.5 Hardware Requirements	7-64
	7.5 Preliminary TDRSS/STDN Tracking Coverage Assessment	7-74
	7.5.1 Introduction	7-74
	7.5.2 Assumptions	7-74
	7.5.3 Coverage Analysis	7-76
8.0	CREW SYSTEMS	8-1
9.0	CONCLUSIONS AND RECOMMENDATIONS	9-1
	9.1 Conclusions	9-1
	9.1.1 Configuration	9-1
	9.1.2 Structures	9-2
	9.1.3 Thermal Control	9-2
	9.1.4 Pointing and Control	9-2
	9.1.5 Communication and Data Management	9-3
	9.1.6 Electrical Power Subsystem	9-3
	9.1.7 Controls and Displays	9-4
	9.1.8 Subsatellite Flight Mechanics	9-4
	9.1.9 Experiment/Crew Timelines	9-5
	9.1.10 Ground Operations	9-5
	9.1.11 Tracking Analysis	9-5
	9.1.12 Crew Systems	9-6

TABLE OF CONTENTS (Concluded)

Section | Page

9.2 Recommendations 9-6

APPENDIX: SHUTTLE SYSTEM PAYLOAD DESCRIPTIONS, LEVEL B DATA A-1

LIST OF ILLUSTRATIONS

Figure	Title	Page
1-1.	AMPS Phase A Study milestone schedule	1-2
2-1.	Transmitter/coupler/antenna concepts	2-8
2-2.	Atmosphere Explorer subsatellite	2-13
3-1.	Space Shuttle flight system	3-1
3-2.	Mission phases	3-2
3-3.	Launch azimuth and inclination limits from VAFB and KSC	3-4
3-4.	Payload mass versus circular orbit altitude — KSC launch, delivery, and rendezvous	3-5
3-5.	Payload mass versus circular orbit altitude — VAFB launch, delivery, and rendezvous	3-5
3-6.	Typical Spacelab configuration	3-8
3-7.	Cross section of Spacelab core segment	3-9
3-8.	AMPS Phase A design reference configuration	3-11
4-1.	AMPS configuration A	4-1
4-2.	AMPS baseline configuration	4-2
4-3.	AMPS deployed platform A	4-3
4-4.	AMPS boom A, stowed configuration	4-4
4-5.	AMPS boom B, stowed configuration	4-4
4-6.	AMPS experiments reduced 50 percent	4-5

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
4-7.	AMPS configuration 2	4-6
4-8.	AMPS configuration B	4-6
4-9.	AMPS configuration C	4-7
4-10.	AMPS configuration D	4-7
4-11.	AMPS reduced experiment-A	4-8
4-12.	AMPS reduced experiment-B	4-8
4-13.	AMPS pallet forward	4-9
4-14.	AMPS tunnel through pallet impact	4-10
4-15.	AMPS platform forward	4-10
4-16.	AMPS revised platform forward	4-11
4-17.	AMPS baseline configuration B	4-12
4-18.	AMPS with ERNO pallet	4-14
5-1.	Orbiter payload coordinate system	5-6
5-2.	AMPS design reference X-c.g. profile	5-7
5-3.	AMPS design reference Y-c.g. profile	5-8
5-4.	AMPS design reference Z-c.g. profile	5-8
5-5.	AMPS configurations under study	5-10
5-6.	AMPS X-c.g. assessment	5-11
5-7.	AMPS Y-c.g. assessment	5-12

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
5-8.	AMPS Z-c.g. assessment	5-13
5-9.	AMPS weight and c.g. sensitivity analysis, X-c.g.	5-15
5-10.	AMPS weight and c.g. sensitivity analysis, X-c.g.	5-15
5-11.	AMPS weight and c.g. sensitivity analysis, X-c.g.	5-16
5-12.	AMPS weight and c.g. sensitivity analysis, X-c.g.	5-16
5-13.	AMPS weight and c.g. sensitivity analysis, X-c.g.	5-17
5-14.	AMPS weight and c.g. sensitivity analysis	5-18
6-1.	Structural characteristics of an AMPS boom	6-15
6-2.	Orbiter with deployed AMPS booms structural model	6-16
6-3.	Torque profiles applied at boom gimbals to effect sweep motion	6-17
6-4.	Pointing error of tip mass 1 (R_x)	6-18
6-5.	Pointing error of tip mass 1 (R_y)	6-18
6-6.	Pointing error of tip mass 2 (R_x)	6-19
6-7.	Pointing error of tip mass 2 (R_y)	6-19
6-8.	Rigid body rotation about X-axis (node 9)	6-20
6-9.	Rigid body rotation about Y-axis (node 9)	6-20
6-10.	Rigid body rotation about X-axis (node 11)	6-21
6-11.	Rigid body rotation about Y-axis (node 11)	6-21

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
6-12.	Elastic deflection of tip mass 1 (T_x)	6-22
6-13.	Elastic deflection of tip mass 1 (T_y)	6-22
6-14.	Elastic deflection of tip mass 2 (T_x)	6-23
6-15.	Elastic deflection of tip mass 2 (T_y)	6-23
6-16.	Displacement of mass 1 in X-direction	6-24
6-17.	Displacement of mass 1 in Y-direction	6-24
6-18.	Displacement of mass 2 in X-direction	6-25
6-19.	Displacement of mass 2 in Y-direction	6-25
6-20.	Thermal model used for analysis of AMPS payload	6-31
6-21.	AMPS configuration with proposed thermal control fluid loop	6-32
6-22.	AMPS fluid loop system schematic	6-32
6-23.	Reentry temperature history of payload bay wall	6-33
6-24.	Payload bay vent entry air temperature	6-33
6-25.	Temperature history of AMPS components during reentry	6-34
6-26.	Orbital temperature history for the AMPS antenna with homogeneous surface, sun-oriented, β = 52 deg	6-35
6-27.	Orbital temperature history for the AMPS antenna with perforated top surface, sun-oriented, β = 52 deg	6-35
6-28.	Orbital temperature history for the AMPS antenna with homogeneous surface, sun-oriented, β = 52 deg	6-36

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
6-29.	AMPS pointing and control information flow chart	6-63
6-30.	RSP gimbal command geometry	6-64
6-31.	Lidar system gimbal control diagram	6-65
6-32.	AMPS 50 m booms scan profile	6-66
6-33.	Conceptual geometry of the RSP and star tracker	6-66
6-34.	AMPS RSP block diagram	6-67
6-35.	Lidar gimbal components	6-68
6-36.	Gimbaled accelerator system	6-68
6-37.	AMPS single-axis gimbal control loop for boom	6-69
6-38.	RSP attitude error budget	6-70
6-39.	RSP fly-by pointing command trajectory	6-71
6-40.	AMPS boom pointing errors during Orbiter thruster firings	6-71
6-41.	AMPS communication subsystem	6-95
6-42.	AMPS subsatellite communications system block diagram . .	6-96
6-43.	Subsatellite design/AMPS- dedicated equipment	6-97
6-44.	Subsatellite antenna configuration	6-98
6-45.	Subsatellite communications distance versus AMPS antenna size	6-99
6-46.	AMPS data management block diagram	6-100

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
6-47.	Communications and data management requirements summary	6-101
6-48.	Boom communication system block diagram	6-102
6-49.	AMPS boom RF antenna concept	6-103
6-50.	AMPS boom data bus concept	6-104
6-51.	Block diagram of AMPS baseline electrical power system	6-122
6-52.	AMPS primary power source, Orbiter Spacelab preferred redundant bus arrangement	6-123
6-53.	Typical lidar block diagram	6-124
6-54.	Typical high voltage source block diagram	6-124
6-55.	Transmitter and power supply block diagram	6-124
6-56.	AMPS electrical power profile	6-125
6-57.	Spacelab rack definition	6-138
6-58.	Spacelab module	6-138
6-59.	AMPS C&D layout	6-139
6-60.	Example of level of data needed in C&D area	6-140

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
7-1.	Relative motion coordinate frames	7-8
7-2.	Motion of subsatellite relative to Orbiter for various in-plane jettison directions, θ	7-9
7-3.	Motion of subsatellite relative to Orbiter for various in-plane jettison directions, θ	7-10
7-4.	Motion of subsatellite relative to Orbiter	7-11
7-5.	Motion of subsatellite relative to Orbiter	7-12
7-6.	Motion of subsatellite relative to Orbiter	7-13
7-7.	Motion of subsatellite relative to Orbiter	7-14
7-8.	Motion of subsatellite relative to Orbiter	7-15
7-9.	Motion of subsatellite relative to Orbiter	7-16
7-10.	Subsatellite orbit altitude	7-17
7-11.	Subsatellite orbit insertion requirement	7-18
7-12.	Subsatellite propulsion capability	7-19
7-13.	Subsatellite propulsion capability	7-20
7-14.	Range requirement for subsatellite acquisition	7-21
7-15.	Speed ratio versus altitude for circular orbit	7-22
7-16.	AE drag coefficient as a function of speed ratio	7-23
7-17.	AE orbital decay	7-24
7-18.	AE station-keeping ΔV requirement	7-25
7-19.	AE station-keeping ΔV requirement	7-26

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
7-20.	AE station-keeping propellant requirement	7-27
7-21.	AE station-keeping propellant requirement	7-28
7-22.	Geometry of source mapping	7-32
7-23.	Shuttle contact data	7-33
7-24.	Three-dimensional geometry of coordinate system	7-34
7-25.	Gimbal platform pointing and control angles	7-35
7-26.	Gimbal clock angle (α) time history	7-36
7-27.	Gimbal clock angle rate ($\dot{\alpha}$) time history	7-37
7-28.	Gimbal cone angle (β) time history	7-38
7-29.	Gimbal cone angle rate ($\dot{\beta}$) time history	7-39
7-30.	Source range (ρ) time history	7-40
7-31.	Source range rate ($\dot{\rho}$) time history	7-41
7-32.	Timeline for 28.5-deg mission	7-44
7-33.	Timeline for polar mission	7-50
7-34.	Crew schedules for 28.5 deg mission and 90 deg mission	7-56
7-35.	Wave characteristics	7-57
7-36.	Wave particle interactions	7-57
7-37.	Wake and sheath experiment	7-58
7-38.	Propulsion and devices	7-58

LIST OF ILLUSTRATIONS (Concluded)

Figure	Title	Page
7-39.	Global emission survey	7-59
7-40.	Energetic particle stability	7-59
7-41.	Magnetospheric topology	7-60
7-42.	Artificial aurora	7-61
7-43.	AMPS ground operations flow	7-72
7-44.	First dedicated AMPS equipment timelines	7-73
7-45.	TDRSS tracking of Shuttle Orbiter and AMPS subsatellite No. 2, first orbit	7-83
7-46.	STDN tracking of Shuttle Orbiter and AMPS subsatellite No. 1, first orbit	7-84
7-47.	TDRSS/STDN tracking of AMPS subsatellite No. 2, first orbit	7-85
7-48.	TDRSS/STDN coverage statistics, Shuttle AMPS mission	7-86
7-49.	Sun illumination history for Shuttle AMPS mission	7-87
8-1.	Sample of command function list	8-4
8-2.	Instrument/experiment matrix	8-5
8-3.	Inboard layout of Spacelab	8-6
8-4.	Support Module C&D	8-7
8-5.	Atmosphere Explorer satellite configuration	8-8

LIST OF TABLES

Table	Title	Page
3-1.	AMPS Pallet Mounted Scientific Instruments	3-13
4-1.	Viewing Angle Requirements and Capabilities, Baseline Configuration	4-13
5-1.	AMPS Design Reference Weight Summary	5-2
5-2.	AMPS Mission-Dependent Equipment List	5-4
6-1.	Coordinates and Inertial Properties for Dynamic Model of AMPS Boom	6-11
6-2.	Structural Properties for Dynamic Model of AMPS Boom . .	6-12
6-3.	A List of Natural Frequencies, Generalized Masses, and Generalized Stiffnesses	6-13
6-4.	Thermal Distortions	6-13
6-5.	Thermal Distortions	6-14
6-6.	Allowable Harmonic Orbiter Motion that Precludes 330 m Antenna Failure	6-14
6-7.	AMPS Heat Distribution for Pallet-Mounted Equipment (Orbit Beta Angle = 0 deg)	6-29
6-8.	AMPS Heat Distribution for Pallet-Mounted Equipment (Orbit Beta Angle = 52 deg)	6-30
6-9.	AMPS Pointing Requirements (SSPD Level B)	6-59
6-10.	AMPS Magnetic Field Vector With Respect to Local Vertical	6-60
6-11.	AMPS RSP Preliminary Hardware Definition	6-61

LIST OF TABLES (Continued)

Table	Title	Page
6-12.	Pointing Error, θ_{ERROR}, Resulting from Inaccuracies in Orbiter and Target Position Vectors	6-62
6-13.	RSP System Error Summary	6-62
6-14.	Communication Requirements Summary, Data Rate Matrix	6-84
6-15.	AMPS Communication Requirements With Respect to Orbiter/Spacelab Capabilities	6-85
6-16.	AMPS Communications Dedicated Equipment	6-87
6-17.	AMPS Subsatellite Equipment Summary	6-87
6-18.	Data Management Digital Data Rate Matrix	6-88
6-19.	Data Storage Requirements	6-89
6-20.	Estimate of AMPS Computer Requirements	6-90
6-21.	AMPS/Spacelab Computer Comparison	6-91
6-22.	RF Link Calculation	6-93
6-23.	RF System Weight Summary	6-94
6-24.	Data Bus System Weight Summary	6-94
6-25.	Spacelab Subsystem Power Requirements	6-115
6-26.	Experiment Instrumentation Power Requirements	6-116
6-27.	Selected AMPS Baseline Electrical Power System Characteristics	6-117
6-28.	AMPS Laser System Characteristics	6-118
6-29.	MPD Arc Accelerator Characteristics	6-118

LIST OF TABLES (Continued)

Table	Title	Page
6-30.	Transmitter Characteristics	6-119
6-31.	Arbitrary Division of the Electromagnetic Spectrum	6-120
6-32.	Space Shuttle Antenna Types Used in this Analysis	6-121
6-33.	Summary Requirements	6-130
6-34.	AMPS Controls and Displays	6-131
6-35.	Additional C&D Required to Support Current Baseline	6-137
7-1.	Atmospheric Explorer System Performance Summary	7-6
7-2.	Scout Third Stage Characteristics	7-7
7-3.	AE Drag and Ballistic Coefficient Range	7-7
7-4.	MSFC Preflight AMPS Activity	7-66
7-5.	MSFC Postflight AMPS Activity	7-67
7-6.	MSFC Preflight AMPS Activity Timelines	7-68
7-7.	MSFC Postflight AMPS Activity Timelines	7-69
7-8.	MSFC Preflight AMPS Activity Required Resource Levels	7-70
7-9.	MSFC Postflight AMPS Activity Required Resource Levels	7-71
7-10.	Shuttle Orbiter Contact and Gap Statistics, Six-Station STDN Configuration	7-79
7-11.	AMPS Subsatellite No. 2 Contact and Gap Statistics, Six-Station STDN Configuration	7-80

LIST OF TABLES (Concluded)

Table	Title	Page
7-12.	AMPS Subsatellite No. 2 Contact and Gap Statistics, Six-Station STDN Configuration	7-81
7-13.	TDRSS/Spacecraft Contact Statistics, Shuttle AMPS Mission	7-82
8-1.	AMPS C&D Panel Space Requirements	8-3

ACRONYMS

A/D	analog to digital
AE	Atmosphere Explorer
AMPS	Atmospheric, Magnetospheric and Plasmas in Space (payload)
ASF	Atmospheric Science Facility
ATM	Apollo Telescope Mount
C&D	control and display
CDMS	command and data management subsystem
c.g.	center of gravity
CMG	control moment gyro
CPSE	common payload support equipment
CRT	cathode ray tube
D/A	digital to analog
EAO	equivalent add operation
ECLS	environmental control/life support
ECS	environmental control subsystem
EMC	electromagnetic control
EMI	electromagnetic interference
EPDS	electrical power and distribution subsystem
EPS	electrical power system
ESRO	European Space Research Organization
EVA	extravehicular activity

ACRONYMS (Continued)

FMEA	failure mode effects analysis
FOV	field of view
GN&C	guidance, navigation, and control
GPME	general purpose mission equipment
GST	gimbaled star tracker
IMP	Interplanetary Monitoring Platform
IR	infrared
KAPS	kiloadds per second
KSC	Kennedy Space Center
Lidar	light detection and ranging system
LOHARP	Lockheed Orbital Heat Rate Program
LOS	line of sight
MFDS	multifunction display system
MPD	magnetoplasmadynamic
MSFC	Marshall Space Flight Center
NIR	near-infrared
OGO	Orbiting Geophysical Observatory
OMS	orbit maneuvering system (subsystem)
PM	permanent magnet
PPEPL	Plasma Physics and Environmental Perturbation Laboratory
PRN	pseudo random noise (generator)

ACRONYMS (Concluded)

PSA	pressurized suit assembly
PSS	payload specialist station
RAE	Radio Astronomy Explorer (satellite)
RAU	remote acquisition unit
RCS	reaction control system (subsystem)
RSP	remote sensing platform
SINDA	Systems Improved Numerical Differencing Analyzer
SRB	solid rocket booster
SSPD	Shuttle System Payload Descriptions
STDN	Spaceflight Tracking and Data Network
TDRSS	Tracking and Data Relay Satellite System
TEE	tubular extendible element
UV	ultraviolet
VAFB	Vandenberg Air Force Base

SECTION 1.0 INTRODUCTION AND STUDY GUIDELINES

1.0 INTRODUCTION AND STUDY GUIDELINES

This Technical Memorandum records the Phase A Study of the Atmospheric, Magnetospheric and Plasmas in Space (AMPS) payload performed within the Program Development Directorate of the Marshall Space Flight Center.

The AMPS Scientific Working Group, composed of 49 scientists from the United States and other countries, was recently established by NASA Headquarters for the purpose of developing recommended AMPS program scientific objectives, experimental approaches, and instrumentation requirements. The recommendations of this group will supersede the information regarding instrumentation and experiments that served as the basis for this study.

The AMPS Phase A Study milestone schedule is shown in Figure 1-1. The study was initiated in November 1973, with the first 5 months' activities oriented toward the first meeting of the AMPS Working Group which was originally scheduled for the latter part of April 1974. It was anticipated that much of the remainder of the 12 month study would be devoted to technical support to the Working Group members and the incorporation of their recommendations into the study. The postponement of that first Working Group meeting to early August 1974 made it necessary to maintain through the remainder of the study the initial assumptions regarding scientific instrumentation and experiments.

It is anticipated that the Working Group will have specified their recommendations to sufficient detail by early CY75 to allow a reiteration of these payload conceptual design and accommodations analyses. An update (revision or addendum) of the Phase A Study Report, reflecting that reiteration, is planned for that time.

Over the past 16 years or so, both passive and active investigations have been pursued in the areas of atmospheric and magnetospheric physics. Passive observations since 1958 include (1) Explorer series spacecraft — including Orbiting Geophysical Observatory (OGO), Interplanetary Monitoring Platform (IMP), Atmosphere Explorer (AE), and Injun Series, (2) sounding rockets, and (3) ground-based networks (e.g., aurora and magnetic storm observations). In recent years, there has been an increasing emphasis on the implementation of experiment programs to actively perturb the environment using ground-based transmitters and payloads aboard sounding rockets (e.g., electron accelerators to create artificial auroras, and barium releases to

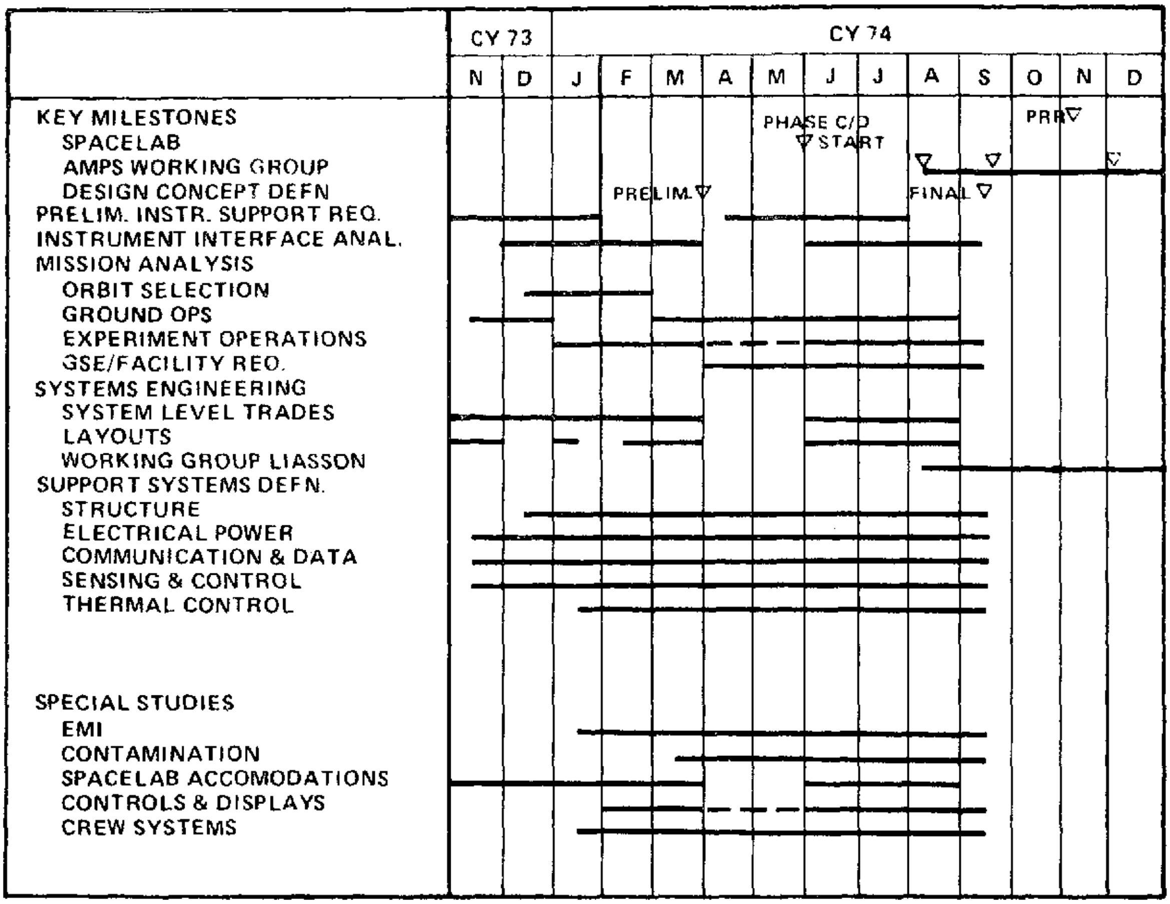

Figure 1-1. AMPS Phase A Study milestone schedule.

study ionospheric winds and electric and magnetic fields). In addition, some "unplanned experiments," such as the Johnson Island high altitude nuclear explosion, provided some interesting results on magnetospheric phenomena. The data obtained from these and other studies have led to a vast improvement in our knowledge of the basic processes that control Earth's atmosphere, magnetosphere, and plasmasphere.

Manned orbital vehicles such as Space Shuttle and Spacelab offer excellent platforms for studies in these regimes in the 1980's. However, it is felt that the idea of experimenters orbiting their individual instruments must give way to the facility concept in which general purpose instruments are housed in a single orbital facility. This concept could open up space science to those scientists whose institutions or countries do not have the resources to mount a full scale rocket probe or satellite program. The European Space Research Organization (ESRO) recently agreed to design and construct standard payload carriers, called Spacelab, consisting of both pressurized modules, capable of holding one to four men, and external platforms (pallets). The plan is to fly Spacelab on the Space Shuttle in Earth orbit, with initial flight times on the order of 7 days and an increase later to 30 days. A payload weight on the order of 5500 kg will be available, the precise amount depending on orbit and other options.

The main objective of the AMPS Spacelab payload is to provide the scientific community with a versatile experiment facility composed of multi-functional scientific and support equipment which will permit extensive scientific advances in the areas of atmospheric and magnetospheric science, and plasma physics. The primary scientific objectives are to carry out controlled active experiments in the areas of space and plasma physics, and observational studies of the coupling between the Earth's atmosphere and the magnetosphere. In the 1980's magnetospheric observational studies will shift from an exploratory and observatory phase to a program involving controlled geophysical experiments designed to perturb the strong, dynamic cause-and-effect relationships in the magnetosphere-ionosphere system to better understand its principles.

Previous studies directly applicable to AMPS and which formed the bulk of the foundation on which this Phase A Study was performed include:

1. Plasma Physics and Environmental Perturbation Laboratory (PPEPL), MSFC/TRW Contract NA58-28047, completed November 9, 1973.

2. Preliminary Design Study for an Atmospheric Science Facility (ASF), JSC/Martin Contract NA59-12255, completed December 1972.

3. Report of Discipline Working Group, Atmospheric and Space Physics, National Academy of Science Conference, Woodshole, July 1973.

The PPEPL and ASF studies were the main inputs to the Shuttle System Payload Descriptions (SSPD) Activity, a General Dynamics/Convair study managed by Marshall Space Flight Center (MSFC), contract number NAS8-29462. The AMPS payload requirements as specified within SSPD as Level B data AP-06-S were utilized in this study and are included here as an appendix.

The Space Shuttle and Spacelab accommodations assumed in this study are specified in (1) JSC 07700, Volume XIV, Revision C, Space Shuttle System Payload Accommodations and (2) Preliminary Draft, Spacelab Accommodations Handbook, June 1974.

Resulting from the early interaction of the AMPS Working Group with the Phase A Study team at MSFC, a number of trade studies have been initiated and will probably be recorded in the revision to this document. These studies include:

1. Feasibility assessment of the use of tethers for probing Earth's atmosphere in the 100 to 120 km altitude level.

2. Evaluation of current and planned spacecraft which might be useable with minor modification as an AMPS subsatellite.

3. Survey of existing ejection mechanism designs and capabilities for releasing, for example, subsatellites or chemical release canisters, in a specified direction with a certain ΔV.

4. Dynamics analyses of dipole antennas and evaluation of steerability.

5. More detailed evaluation of experiment command, control, and data processing and display within the Spacelab pressurized module.

The guidelines against which this Phase A Study was performed include the following:

1. General

a. Launch Date: For schedule and costing purposes, the first launch of the AMPS laboratory will be late CY80.

b. Mission Objectives: To provide scientists an experiment facility from which controlled active experiments in the field of magnetospheric, plasma, and atmospheric physics may be performed.

c. Mission Duration: 7 days, with nominally 6.5 working days per mission. Assume 8 hours from lift-off to experiment operation initiation.

d. Baseline 2 Missions: (1) Low altitude (235 n. mi.), low inclination (28.5 deg); (2) Low altitude (185 n. mi.), high inclination (polar) (90 deg). No orbit maneuvering system (OMS) kit. Shuttle/subsatellite delivery and rendezvous retrieval capability. Altitude: Maximum Shuttle capability.

e. Launch Site: Shall be determined to be the optimum location to carry out the experiment program objectives for each mission.

f. Crew Size: Will be established based on the experiments to be accomplished per mission for a 12 hour shift, two-shift per day operation. Initially, assume a payload crew of four (three physicists and one electrical-mechanical technician).

g. Deployable Hardware: All items which deploy shall be equipped with release/jettison mechanisms to ensure that the cargo bay doors can be closed.

h. Maintenance: The AMPS payload shall be designed so that planned or contingency maintenance can be performed by either one or two crewmen performing extravehicular activity (EVA) for safing operations. Flight-line and depot-type maintenance will be performed on Earth.

i. Subsatellites: Two subsatellites will initially be assumed. However, requirements for the number and type of subsatellites will be reevaluated in a trade study.

j. Subsatellite Retrieval: It shall be a study goal to determine how the AMPS subsatellites can be retrieved at the end of the 7 day mission. Variations on a case-by-case basis will be considered where the probability of mission success is endangered.

k. Payload Weight: The target landed payload weight for the AMPS payload is 32 000 lb (14 500 kg).

l. Center of Gravity (c.g.): The centroid of the AMPS payload must fall within the Orbiter payload c.g. envelope. A goal for this study will be for the c.g. to fall within an image outline of the forward c.g. envelope located in the X-Z plane translated 1.5 feet aft.

m. Consumables: Shall be sized for a scientific crew of four on a 7 day mission.

n. Launch Mode: The launch mode for the AMPS payload is by Shuttle, with the primary mode being all experiment hardware to be carried in the Shuttle cargo bay. The experiment instruments will be pallet-mounted with the control, display, and data management functions within the Spacelab pressurized module.

o. EVA: Baseline AMPS operation primary mode will be from inside the Spacelab pressurized module; however, contingency EVA capability will be provided.

p. Design Concepts: Maximum utilization of proven design concepts from previous programs shall be used to enhance reliability of critical systems and to maintain lower overall costs.

q. Reliability: The design shall be such that mission-critical systems involving loss of life shall not have single failure points.

r. Docking: There are no known docking requirements for AMPS operations.

s. Systems Test: The AMPS shall have been tested in a systems mode prior to launch. Orbital operation verification capability shall be incorporated in the hardware design.

t. Coordinate System: The coordinate system for defining mass locations will be the same as used on the Orbiter.

u. Units of Measure: The system of units to be used in this study will be the international system of units (SI) with customary units in parentheses, except for those measurements related to the Orbiter systems, where English units are used primarily.

v. Protection Devices: These will be incorporated where needed to avoid all credible hazards in order to assure safe termination of the mission.

w. Electrical/Electronics Components: The AMPS electrical/ electronics components shall meet the design intent of MIL-STD-461 and MIL-STD-462 and applicable portions of MIL-E-6051D.

2. Scientific Equipment

a. Subsatellite Design: For the purposes of this study, the AMPS subsatellite design model will be the Atmospheric Explorer unless otherwise specified for a particular mission.

b. Science Payload: The science payload is as described in SSPD level B (AP-06-S). The descriptions and requirements of the scientific instruments in AP-06-S are assumed to be accurate for initial studies and will be refined/ updated as the study progresses.

3. Electrical Power System

a. Circuit Protection: Shall be provided on electrical circuits.

b. Primary Power: Primary electrical power shall be provided by the Space Shuttle Orbiter fuel cell power plant.

c. Secondary Power: The Spacelab shall provide peaking batteries and associated charge controls to meet transient or supplemental load requirements that exceed primary power source capabilities.

d. Emergency Power: Sufficient emergency electrical capacity shall be provided to assure safe shutdown of equipment and egress of personnel in the event of primary power failure. Emergency systems shall be protected from reverse current by the primary power source.

e. Power Conditioning: The Spacelab shall provide the necessary power conditioning and distribution equipment to satisfy the requirements for regulated dc power, single- and three-phase ac power.

f. Distribution: The Spacelab shall furnish the necessary connectors, cable distribution, and control equipment required for the mission equipment that may be located within external pressure modules or on pallets.

g. Grounding: The structure shall not be used as a dc return for power systems. A single point grounding scheme shall be used for distribution independent of the Orbiter electrical power system.

4. Sensing and Control System

a. Full control of all AMPS systems and instruments will be accomplished from within the pressurized Spacelab module unless there are significant and specific advantages in performing functions at other locations.

b. Attitude stabilization of Orbiter in general shall be sufficient for operation of the AMPS experiments. Additional pointing and stabilization requirements will be met with experiment and support system hardware as required.

5. Communication and Data Management

a. The Tracking and Data Relay Satellite System (TDRSS) is to be utilized in this study but is not mandatory for AMPS experimental operations.

b. Communication between ground and orbit will be via the Shuttle communications system.

c. Any computer operation will be performed by the Spacelab computer facilities or payload facility if Spacelab capabilities are inadequate.

d. AMPS shall be capable of receiving data from both subsatellites and both booms simultaneously.

e. Subsatellites will be designed to communicate directly with the AMPS payload or to ground stations. Subsatellite control will be primarily from the Spacelab with ground stations serving as backup and/or optional mode.

6. Structures

a. A safety factor of 1.4 will be applied to limit loads to obtain ultimate loads. A safety factor of 2.0 will be applied to the pressure in pressurized volumes.

b. Acceleration forces and crash landing load factors shall be in accordance with Johnson Space Center document JSC 07700, Vol. XIV, Rev. C.

7. Thermal/Environmental Control

Thermal control will be accomplished by insulation, reflective/absorbtive coatings, and appropriate cold/heat plates. Coolant shall be obtained from the Orbiter. Cryogenic coolant for scientific instruments shall be furnished by the AMPS payload.

8. Controls and Displays

a. Mission critical and safety critical payload parameters will be monitored on caution and warning displays in Orbiter and in Spacelab.

b. Controls and displays for AMPS will be located in the Spacelab pressurized module.

c. The carrier mode will be assumed to be the Spacelab pressurized module plus pallet.

SECTION 2.0 SCIENTIFIC OBJECTIVES OF THE AMPS PAYLOAD

2.0 SCIENTIFIC OBJECTIVES OF THE AMPS PAYLOAD

2.1 INTRODUCTION

Three fields of research are covered by the Atmospheric, Magnetospheric and Plasmas in Space (AMPS) payload — the atmosphere and magnetosphere of Earth, and plasma physics in space. Man will have an opportunity to be intimately involved by being a major element in the experiment operation. The initial interest from the scientific community in an AMPS type program was determined from data collected by a questionnaire which had been distributed to 280 scientists in the United States and 15 foreign countries in 1971. This solicitation yielded a large number of valuable responses.

A large number of scientists are now considering ways to carry out controlled, active experiments in the space plasma environment of Earth. The ideas for these studies first arose naturally when some early active experiments provided unplanned but invaluable information on cause-and-effect relations in the magnetosphere and ionosphere. For instance, the high altitude nuclear explosions of the early 1960's yielded new information on particle injection, wave generation, and wave-particle pitch-angle scattering, and large-β experiments opened new fields involving wave resonances, wave-particle heating, wave-wave interactions, and parametric instabilities. Similarly, the triggering of magnetospheric emissions by ground-based VLF transmitters suggests an obvious generalization to a controlled, satellite-borne, wave-particle interaction study. In recent years, there has also been an increasing emphasis on the implementation of carefully designed active experiment programs using ground-based transmitters, sounding rockets, and unmanned spacecraft. For example, electron accelerators were flown to produce artificial auroras, to study beam-plasma instabilities, and to analyse trapped particle orbits. In addition, radio waves were used to modify the ionospheric characteristics, and artificial tracers were used to study field line topology and particle drifts.

It is expected that in the Shuttle era (1980's) the most important regions of the atmosphere for exploration and understanding will be the stratosphere, mesosphere, and the lower thermosphere, below 120 km. The Spacelab will offer an ideal opportunity to orbit a full complement of instruments for remote sensing using both active and passive systems with large apertures, high spectral resolution, and vastly improved signal-to-noise ratios.

The most significant magnetospheric physics experiment concepts involve natural follow-ons to the present phase of magnetospheric-ionospheric exploration which are based on use of unmanned spacecraft. It seems to be widely recognized that after completion of the International Magnetosphere

Study (1976-1978), the major dynamic phenomena that occur in nature will have been classified, and there will be general knowledge of where and when important events take place. For the decade of the eighties, many scientists now appear to feel that the field will be ripe for a new stage of research in which the primary objective will be to understand the detailed mechanisms and the physical interactions which bring about the observed dynamic phenomena. This understanding can best be gained through active, probing experiments which perturb the magnetosphere and atmosphere in a controlled way and cause the induced changes. This new approach makes maximum use of manned space flight by allowing the scientist himself to conduct the experiments and to react in real time to unexpected results. The AMPS laboratory will make possible an intimate involvement between the space experimenter and his experiment in a way never before attainable.

Controlled experiments in the energetic particles and tracers area have been suggested for providing unambiguous answers about magnetospheric configuration, particle entry, energization and loss processes, distributions of electric field, and magnetospheric convection. A number of experiments in the beam-plasma and wave-particle interaction areas will be designed to study basic magnetospheric plasma instabilities that can limit the stably-trapped flux, will provide the wave-particle scattering that leads to anomalous resistance (and hence parallel electric fields), modulated auroral phenomena, and will introduce coherence effects into magnetospheric radiation processes. Other experiments in these areas, and in the magnetospheric modification area, will be aimed at studying the mechanisms that drive large scale dynamic processes (coherence effects in auroras, triggering of substorms, energy transfer in red arcs, magnetosphere-ionosphere coupling) by introducing major controlled perturbations that can generate the phenomena in a known way (e.g., the artificial aurora) or can vary the natural process (e.g., by modifying ionospheric conductivity, injecting waves to scatter particles, injecting cold plasma to modify instability growth rates).

The Shuttle transportation system and Spacelab sortie missions will provide a unique opportunity to investigate fundamental and applied plasma physics phenomena that are not necessarily or specifically related to geophysical problems. All the Shuttle orbits will be immersed within a natural, magnetically-confined plasma in a high vacuum, with scale lengths that can be enormous in comparison with those available in ground-based plasma laboratories. It is possible to investigate important phenomena free of the sometimes dominant influence of walls. The weightless orbital conditions can be extremely important to the potential experimenter who may wish to study such diverse phenomena as long-term plasma confinement in a field produced by a levitated magnet, the interaction of a spinning conducting fluid with the ambient geomagnetic field and plasma, or the behavior of convection-free plasma arcs; in the ground-based laboratory all of these studies would be strongly affected by gravity.

The National Academy of Science through the 1973 Woods Hole Summer Study has recommended a single laboratory system to be carried into orbit by, and remain with, the Space Shuttle to carry out experiments and observations in the fields of atmospheric and space physics [2-1]. Sortie mission durations for this laboratory would range from 7 to 30 days and would require close manned involvement. The approach defined in this study is for the conceptual design of a facility, the major elements of which are common to the facility and are provided to the users (scientists) as versatile and powerful devices with which to carry out a wide variety of controlled, active experiments and observations.

2.2 SCIENTIFIC INSTRUMENT DESCRIPTION

During this study it was assumed that the following AMPS scientific instruments were located on the external unpressurized pallet:

1. Remote sensing platform with optical sensors.

2. Lidar (light detection and ranging) system.

3. High power transmitters and antenna system.

4. Maneuverable booms.

5. Accelerator systems.

6. Subsatellites.

7. Chemical release devices.

The primary source of instrument requirements was the Shuttle System Payload Data [2-2], AP-06-5, which is included in the appendix. In addition, previous studies (see References 2-3 through 2-6) were used extensively. The following is a brief summary of some qualitative information about the instruments.

2.2.1 Remote Sensing Platform

The remote sensing platform is primarily a cluster of optical instruments (e.g., spectrometers, interferometers, and photometers) boresighted and mounted on a three-axis, gyro-stabilized mount. These instruments will be used primarily in the performance of atmospheric science investigations either as active experiments or in conjunction with, for example, the lidar system, subsatellites, and chemical releases or alone as a passive remote sensing platform. Typical experiments performed may include:

1. Horizon scanning of selected airglow features by high spectral and high spatial resolution photometers and interferometers.

2. Vertical passive probing by infrared (IR) interferometry to determine the vertical distribution of constituents such as CO_2 and CO_3. Cooled optics and detectors may be features of these instruments.

3. Lidar probing of the lower atmosphere by monitoring signal backscatter.

4. Absorption measurements using the lidar system. Measurements will be made in selected spectral regions between the Spacelab and a maneuverable subsatellite located from 1 to 2000 km from the Orbiter. Absorption in the ultraviolet (UV) region would yield the concentrations of O, H_2 and N, while the concentrations of O_3, H_2O, NO, and O_2 could be obtained from IR absorption.

5. Release of chemicals such as barium in the thermosphere above 100 km to observe the light scattered from the cloud. High spectral resolution is required to obtain the wind velocity from the Doppler shift of the spectral line and component of the electric field from the velocity of the ionized portions.

It is currently assumed that the remote sensing platform will house the following instruments (note that only a few of the pertinent details are given here for each instrument; additional information is contained in the appendix):

1. XUV Normal Incidence Spectrometer

Wavelength Range	300 to 1300 Å
Resolution	10 Å
Field of View	10 deg

2. UV-Visible-Near-IR Scanning Spectrometer

Wavelength Range	1150 Å to 1.0 μm
Field of View	13.5 deg (without collection optics) 16 arc sec to 38 arc min (depending on slit width)
Resolution	0.1 to 15 Å
Slit Width	0.044 to 6.5 mm

3. High Resolution Fourier SWIR Spectrometer

Wavelength Range	1 to 5 μm
Resolution	0.05 cm^{-1}
Field of View etc.	3 arc min to 5 deg

4. Cryogenic IR Fourier Spectrometer

Wavelength Range	5 to 150 μm
Resolution	0.1 cm^{-1}
Field of View	3 arc min to 5 deg

5. IR Radiometer

Wavelength Range	3.5 to 4.2 μm

6. Filter Photometer (4)

Wavelength Range	1050 to 3500 Å
	1150 to 6500 Å
	1600 to 6500 Å
	2700 to 8000 Å
Resolution	10 to 20 Å
Field of View	1, 5, 15 min 1 deg

7. UV-VIS Documentation Camera (2)

Wavelength Range	2400 to 7000 Å
	3500 to 7000 Å
Resolution	Variable with filters
Field of View	30 deg

2.2.2 Lidar System

The operation of a laser ranging system in low Earth orbit has frequently been recommended for use in the Shuttle era to enhance the capability for understanding the atmosphere by providing precise observational data. Many areas of investigation remain to be explored, however, before the AMPS lidar is defined. There is the question of single frequency versus frequency doubling versus tuning. Single frequency lasers, both gas (He-Ne, Ar, N) and solid state (ruby, Nd-YAG), are generally speaking space qualified, whereas tunable dye laser technology requires much advancement. Operation in the pulsed mode appears to be the most desirable. The following are estimates of the characteristics of the lidar system:

1. Pulsed dye laser.

2. Laser pumped.

3. Cassegrain optics for receiving and possibly transmitting.

4. Tuning range — 300 n.mi. to 1.5 μm (all dyes).

5. Energy per pulse — up to several joules.

6. Pulse duration — 5 to 30 nsec.

2.2.3 Transmitter/Coupler System

The AMPS pallet-mounted transmitter/coupler system is currently conceived as including three high power transmitter/frequency coupler systems and a long dipole antenna with elements 330 m in length. System concepts are shown in Figure 2-1. The general characteristics of this system are as follows:

Drive System Voltage	Up to 20 kV (10 to 20 kW)
Radiated Power	500 watts

The three general areas of experimental interest are described below:

1. Wave Propagation: The basis for any propagation experiment is that a wave traveling between two points will be affected in some measurable and interpretable manner by the plasma. In cases where the wave behavior is well-understood, the measurement may be interpreted as a plasma diagnostic; while, if the plasma properties are otherwise known, the measurement may indicate the properties of the wave. Experiments typical of this area are:

a. Transmission experiments, either from antenna to antenna on the AMPS, to a subsatellite or to the ground, and vice versa.

b. Reflection experiments, with both transmitter and receiver on the AMPS and specular reflection in the media acting as a second point.

c. Backscatter experiments, with both transmitter and receiver on the AMPS and scattering from various particles in the plasma.

2. Non-linear Interaction: There are two basic types of nonlinear effects, wave-wave interactions and wave-particle interactions. In each case it is necessary to make measurements of several parameters simultaneously concerning the ambient plasma, the wave, and disturbed plasma features.

a. Wave-Wave Interaction: Most of the interest shown in previous studies in this area is in the basic processes involved in wave-wave interaction with application to the ionospheric/magnetospheric plasma either to understand natural processes or to use as a diagnostic tool [2-5].

b. Wave-Particle Interaction: The wave-particle interaction experiments, stated simply, consist of either modifying the ambient plasma by the introduction of particles in order to stimulate a growing wave or to input a

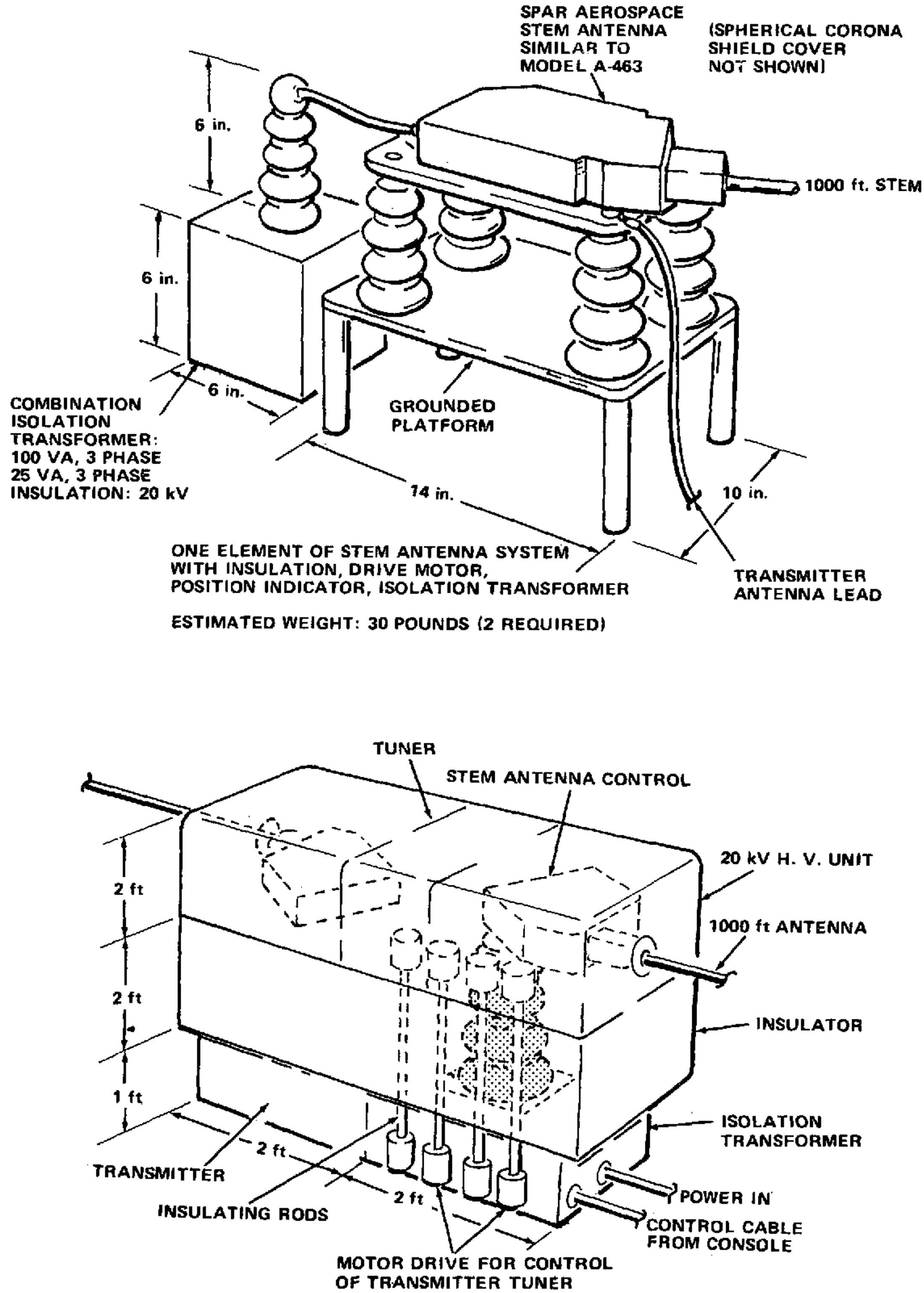

Figure 2-1. Transmitter/coupler/antenna concepts.

wave which interacts to alter the plasma (usually the electron or velocity distribution) in a semipermanent (nonoscillatory) maneuver. The basic ways for altering the plasma to produce waves are by beams and injections (releases). High power transmitters on both the AMPS and the ground have been suggested as sources for waves which could alter the plasma. In some cases the purpose is to study the basic processes of nonlinear wave-particle interactions and, in others, it is to study the ionosphere-magnetosphere with the interactions as a diagnostic tool.

3. Wave Sources: Except for those cases where either natural waves are to be observed or waves are to be excited by sources on the ground or on other vehicles, it will be necessary to stimulate the desired waves by some mechanism on AMPS. Two possibilities are field sources (antennas) and particle sources (beams and releases) [2-5]. The determination of which type of source to use may arise out of practical considerations or may come from an intrinsic interest in a particular system. In this latter instance the system is predetermined. In many cases, however, it has yet to be established as to which, if any, type of source can produce a desired wave with sufficient amplitudes to be used in experiments.

2.2.4 Boom System

It seems that having long extendible and retractable booms in the AMPS payload is highly desirable for use in the performance of experiments involving wake and sheath studies, and wave-wave and wave-particle interactions, and in monitoring the characteristics of the ambient plasma and other measurements that must be made nearby but away from the disturbing influence of the Orbiter.

The passive or diagnostic boom contains a full array of equipment to measure the plasma characteristics (density, temperature, composition, suprathermal particle population) as well as the ambient dc magnetic field vector, one axis of the dc electric field, and the electric and magnetic components of local plasma waves. The following instruments are currently assumed to be located at the end of the passive boom:

1. 5-m subboom with 1-m loop antenna.

2. 5-m subboom with magnetometer.

3. 1-m electric dipole.

4. 33-m electric dipole.

5. Triaxial search coil.

6. Triaxial fluxgate.

7. Alignment TV.

8. Ion mass spectrometer.

9. Spherical ion probe.

10. Cylindrical ion probe.

11. Planar segmented probe.

12. Neutral mass spectrometer.

13. Triaxial hemispherical analyzer.

14. Planar electron trap.

15. Electrostatic analyzer.

17. Magnetic analyzer.

17. Particle detector.

18. Energy detector.

19. Power system.

20. Data system.

The second 50 m boom is the active or perturbing boom and might contain an electrostatic plasma wave generator for boom-to-boom transmission experiments and various targets for wake and sheath studies. These targets might be balloons with various shapes and surface materials, capable of being biased electrically with respect to the ambient plasma.

2.2.5 Gimbaled Accelerator System

In the current conceptual design the accelerator system consists of electron and ion accelerators and a magnetoplasmadynamic (MPD) arc, all mounted on the same gimbal platform. A capacitor bank is provided for electron and ion accelerator operation and a separate bank is provided for the MPD arc. These three particle accelerators constitute one of the primary sources of plasma perturbation on the AMPS facility. They would be used in conjunction with, for example, subsatellites, the remote sensing platform, and chemical releases in the performance of experiments in such areas as artificial aurora generation and electric and magnetic field topology experiments. The following are some of the possibly desirable features of the particle accelerators:

1. Electron Accelerator

Accelerating Voltage	5 to 50 kV
Output Current	0.5 to 1.0 amp
Beam Power	500 kW/burst
Beam Energy	100 000 joules

Some areas of concern are:

a. Current neutralization of the AMPS Laboratory. The emission of charged particles from the AMPS will create a potential difference between the AMPS and the ambient plasma. The beam will thus be unable to escape if a sufficient return current is not collected to neutralize the system. The question of whether the natural collection of a return current collected by the Orbiter/Spacelab surface from the ambient plasma is sufficient has not been fully answered at this time.

b. Contamination of the electron gun filaments resulting in failure or degraded performance must be assessed.

2. Ion Accelerator

Typical Gases	Cesium, Argon, Hydrogen
Accelerating Voltage	5 to 50 kV
Output Current	0.5 to 10 amps
Beam Power	500 kW/burst

Can use same capacitor bank as electron accelerator

3. Magnetoplasmadynamic Arc

Voltage	300 V
Current	20 000 amps
Burst Length	50 msec (1/10 mole)

A separate capacitor bank is required

2.2.6 Subsatellites

The requirements placed on a subsatellite by the AMPS payload appear to vary considerably. Some experimenters suggest a relatively small unsophisticated unit which would remain near the AMPS (e.g., 5 km), while other experiments may require a subsatellite with substantial propulsion and control capability [2-3]. There is also an apparent desire for a geosynchronous orbiting satellite which would be used in correlative type experiments; however, such a satellite would probably not be part of the AMPS payload.

The analyses and trade studies performed to date have been based on only one type of subsatellite – the Atmosphere Explorer (AE) (Fig. 2-2) [2-7]. In addition to the experiment payload [approximately 95 kg (210 lb)] and structural and thermal components, the AE subsatellite includes attitude control, propulsion, power, communications, data handling, and solar pointing subsystems. The attitude control system stabilizes the subsatellite in pitch by means of momentum interchange between the spacecraft and the internally mounted momentum wheel. The system permits selection of spin rates in a range of from 1 revolution per orbit to 10 revolutions per minute. The hydrazine orbit adjust propulsion system is the blowdown type, providing 75 000 lb-sec total impulse equivalent to a velocity capability of 2000 ft/sec (610 m/sec). Three thrusters are provided, each of 17.8 N (4 lb) initial thrust. The subsatellite power system is of the conventional type, consisting of an array of solar cells, three nickel-cadmium batteries, and unregulated -26 V to -39 V supplies. Array output is a function of sun angle with a maximum of approximately 150 watts at 45 deg. The communications equipment is compatible with the Spaceflight Tracking and Data Network (STDN) and comprises a VHF transmitter, redundant S-band transponders, and premodulation equipment. A simultaneous command, ranging, range rate, real-time, and playback telemetry S-band capability is provided. The data handling system

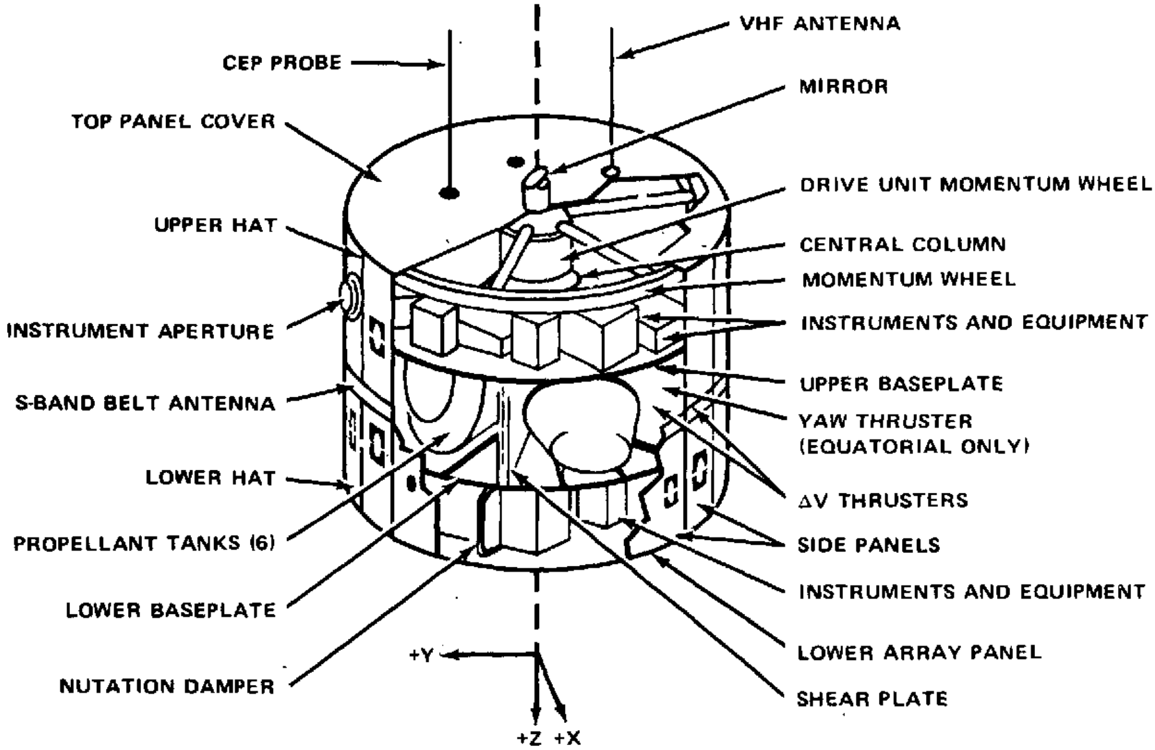

Figure 2-2. Atmosphere Explorer subsatellite.

provides a real-time and remote command capability, and converts analog, discrete and digital science data into a single digital, serial bit stream for storage on board or transmission to AMPS or ground. Telemetry data storage is furnished by two tape recorders, each having a storage capability of 120 min of data. The current design is structured as a 128 eight-bit word main frame, with several words subcommutated. The solar pointing system consists of a two axis gimbaled platform housed within the spacecraft adapter.

The use of tethered platforms or small "throw-away-detectors" to perform measurements away from the Spacelab has not been fully assessed at this time.

2.2.7 Chemical Releases

Experiments that were identified in previous studies [2-3, 2-5] required chemical releases in the magnetosphere and upper atmosphere. These involved a number of chemicals such as barium, lithium, sodium, sulfur hexafluoride, and trimethyl aluminum. Several release techniques could be utilized depending upon the specific experiment; examples are:

1. Barium release by a thermite reaction some distance from the Orbiter. The barium metal is vaporized by the thermite reaction and subsequently partially ionized by solar UV radiation.

2. Barium release by a shaped charge injection. In this case, barium jets are directed along field lines by detonating a hollow charge of high explosive covered with a conical layer of barium metal. Ionization is again provided by the solar UV radiation.

The dispersion of the barium neutral and ionized clouds are observed and measured from the AMPS laboratory and at ground-based observatories. Requirements such as canister injection, the minimum distance canisters must be from the Orbiter before reaction is initiated, safety requirements, and contamination problems have not been fully assessed at this time. It has been assumed, however, that spring ejection mechanisms and/or propulsive units will be required, depending on the distance and rate requirements imposed.

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SECTION 3.0 DESIGN REFERENCE CONFIGURATION DESCRIPTION

3.0 DESIGN REFERENCE CONFIGURATION DESCRIPTION

3.1 SPACE SHUTTLE SYSTEM DESCRIPTION

The Space Shuttle system is composed of the Orbiter, the external tank containing the ascent propellants to be used by the Orbiter main engines, and two solid rocket boosters (SRBs). The Shuttle flight system is shown in Figure 3-1.

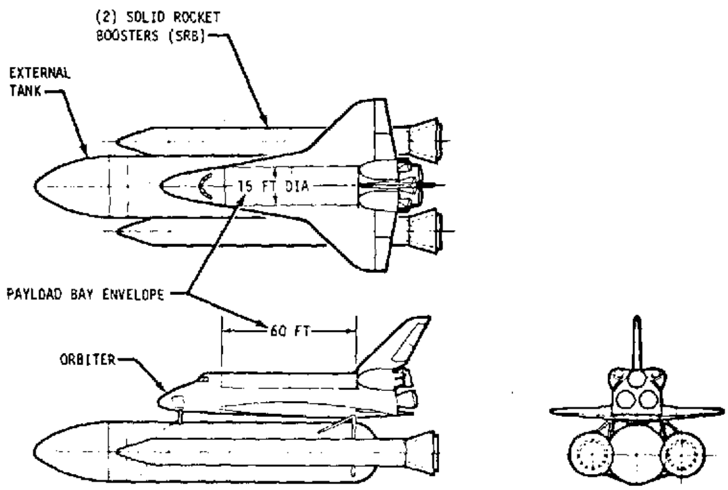


Figure 3-1. Space Shuttle flight system.

The SRBs and the Orbiter main engines fire in parallel, providing thrust for lift-off. The Orbiter main engines continue firing until the vehicle reaches the desired suborbital flight condition. The external tank is jettisoned at that time. The orbital maneuvering subsystem (OMS) is immediately fired to place the Orbiter in the desired final orbit.

The Orbiter shown in Figure 3-1 is a reuseable vehicle designed to operate in orbit for missions up to 7 days duration. However, the Orbiter is being designed so as not to preclude missions of longer duration — up to 30 days.

The mission phases representing a typical operational sequence are illustrated in Figure 3-2.

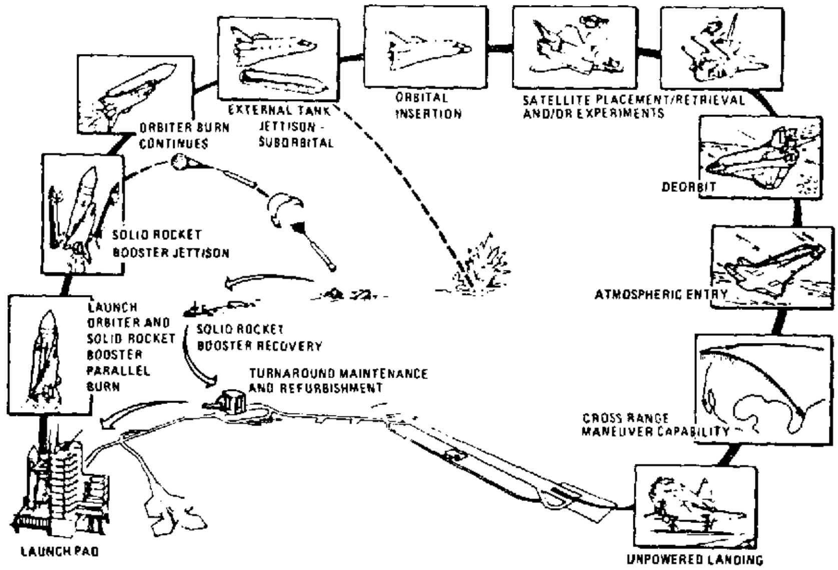


Figure 3-2. Mission phases.

The crew and other personnel will be accommodated in a shirt-sleeve environment in a two-level pressurized cabin. The cabin is being designed for a basic crew of four with expendables provisioning planned for 28 man-days. Provisioning storage capacity is provided for a total provisioning capability of 42 man-days.

The Orbiter crew consists of the commander and pilot. Additional crewmen which are required to conduct Orbiter/Spacelab operations are a mission specialist and payload specialists. The duties of these crew members are defined as follows:

1. Commander: The commander will be in command of the flight and will be responsible for the overall space vehicle operations, personnel, payload flight operations, and vehicle safety.

2. Pilot: The pilot will be second in command and will be equivalent to the commander in proficiency and vehicle knowledge. He will be the backup crewman for EVA operations.

3. Mission Specialist: The mission specialist is operationally oriented and his background/training will be commensurate with Spacelab-type missions. He will work with and assist the payload specialist(s) during Spacelab operations. He is responsible for interfacing and management of Spacelab/Orbiter subsystem operations. He will be knowledgeable about vehicle and Spacelab subsystems and flight operations and will be the prime crewman for EVA operations.

4. Payload Specialist: The payload specialist(s) is the onboard scientist/experimenter and will be responsible for AMPS experiment operations for that flight. He will have a detailed knowledge of the scientific instrumentation and supporting equipment including the Spacelab multifunction display system (MFDS) and the AMPS payload dedicated experiment controls and displays. Up to four payload specialists may be accommodated.

The Orbiter-provided services available for use by the AMPS payload include the following:

1. Structural Attachment: Thirteen payload structural attach points, nine of which are evenly spaced 1.5 m (59 in.) apart, are provided along the payload bay for structural attachment of the payload to the Orbiter.

2. Crew Accommodations: The Orbiter provides 28 man-days of expendables and crew equipment for four people. Stowage is provided for 42 man-days of provisioning.

3. Remote Manipulator System: The Orbiter is provided with a manipulator arm mounted on the left longeron and capable of reaching 50 feet from the pivot point. A second manipulator arm, mounted on the right longeron, is available as a payload-chargeable option.

4. Electrical Power: The Orbiter payload-dedicated 7 kW fuel cell supplies 50 kW-h of nominal 28 Vdc electrical power to Spacelab and AMPS.

5. Environmental Control and Life Support: The Orbiter provides control of the environment within the Spacelab pressurized module, in addition to controlling the environment within the crew cabin. The Orbiter active thermal control system collects excess heat from both the Orbiter and the Spacelab (via the payload heat exchanger) and rejects it to space from the Orbiter radiator.

6. Avionics: Avionics provides to payloads the data necessary to initialize the payload, onboard digital computation, voice communication, reception of uplink commands and data, transmission of digital and wide band data, TV, digital data reception from detached payloads, and tracking capability.

7. EVA: The Orbiter provides the equipment and expendables to support extravehicular activity (EVA) for planned or contingency operations.

The Space Shuttle system provides a general capability for the transportation of a wide variety of payloads to and from low Earth orbit altitudes at various inclinations and it utilizes two launch sites, Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB).

On-orbit translational delta-V is provided by the OMS and the reaction control subsystem (RCS). The OMS provides the propulsive thrust to perform orbit insertion, orbit circularization, orbit transfer, rendezvous, and deorbit maneuvers. The RCS provides the propulsive thrust for three-axis angular control and three-axis translation of the Orbiter.

The Orbiter integral OMS tanks are sized to provide a 1000 fps delta-V with a 65K lb cargo. These tanks provide a useable propellant capacity of 23 876 lb (10 840 kg). Up to three extra OMS kits which are payload chargeable items can be installed in the payload bay for increased operational flexibility. Each kit contains one-half as much useable propellant as the integral OMS tankage, resulting in a total kit propellant capacity 1.5 times that of the integral tankage. Independent of whether one or three OMS kits are flown, approximately the aft 3 m of the payload bay are occupied by the kit(s).

The Shuttle can deliver payloads to and retrieve them from the orbital inclinations shown in Figure 3-3. The suborbital disposal of the external tank does, however, present limitations on some discrete inclinations between 56 and 70 deg from VAFB. Inclinations greater than 104 deg are under study.

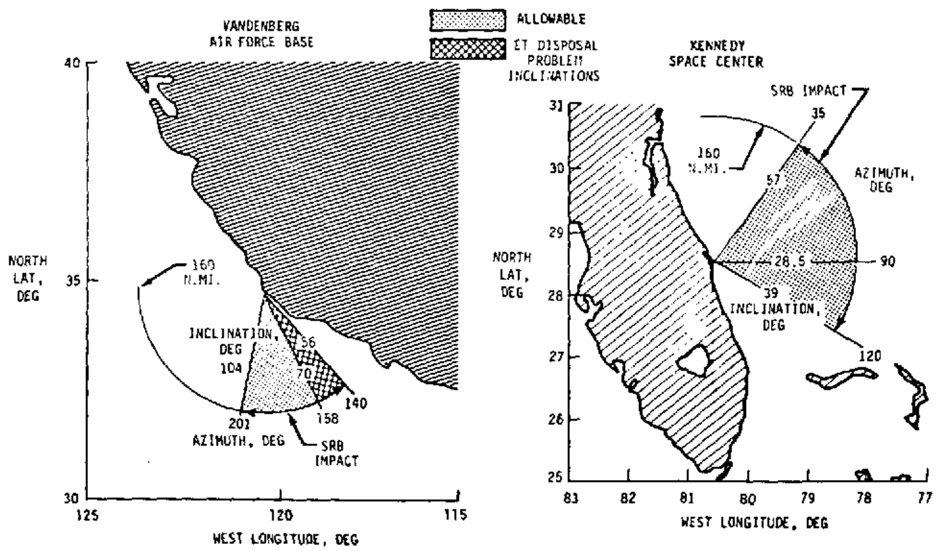


Figure 3-3. Launch azimuth and inclination limits from VAFB and KSC.

Figures 3-4 and 3-5 show the maximum cargo weight that can be placed into a circular orbit as a function of placement orbit altitude and inclination. Figure 3-4 is for missions launched from KSC and Figure 3-5 is for those launched from VAFB. The dashed lines on these figures indicate the orbits

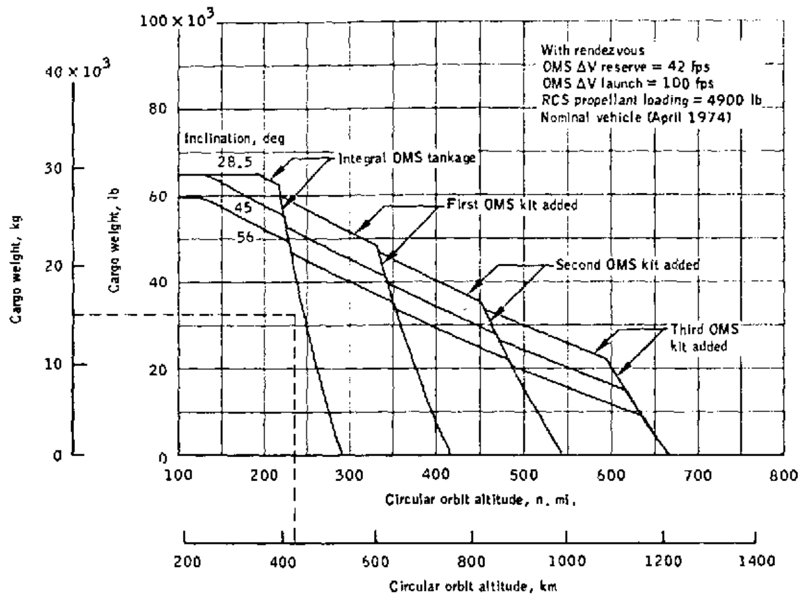


Figure 3-4. Payload mass versus circular orbit altitude — KSC launch, delivery, and rendezvous.

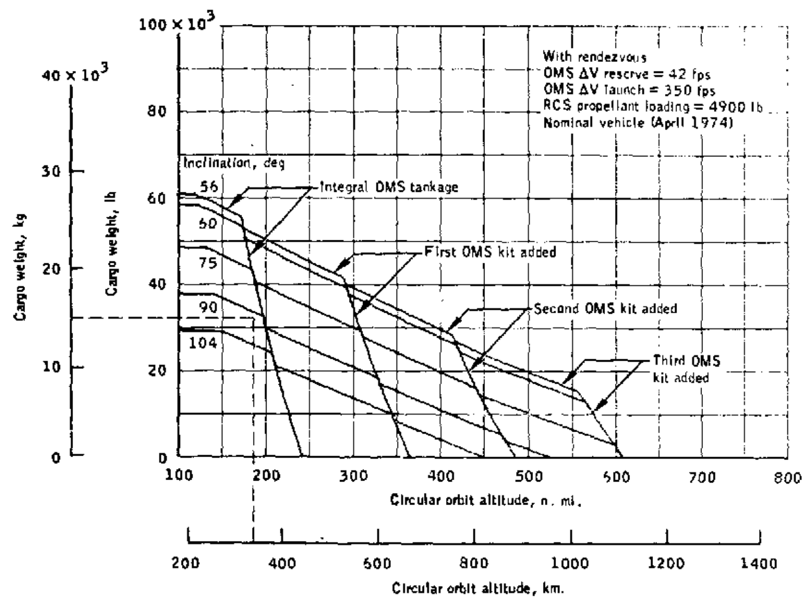


Figure 3-5. Payload mass versus circular orbit altitude — VAFB launch, delivery, and rendezvous.

chosen for the two AMPS missions addressed in this Phase A Study. For a due-east launch (28.5 deg inclination), the Space Shuttle can place a 14 528 kg (32 000 lb) AMPS payload in a 435 km (235 n. mi.) circular orbit. The same payload mass can be placed in a polar (90 deg inclination) orbit of 340 km (185 n. mi.) altitude.

The Orbiter can deorbit and land with a 32 000 lb (14 528 kg) maximum payload mass. Payloads which are to be returned from orbit should not exceed this value. Under abort or emergency conditions, the Orbiter can return and land with payloads between 32 000 lb (14 528 kg) and 65 000 lb (29 482 kg) but must be operationally constrained to the load limits associated with a 32 000 lb (14 528 kg) payload.

3.2 SPACELAB SYSTEM DESCRIPTION

The Spacelab concept is a fully modularized design with sufficient capability and flexibility to accommodate a wide range of AMPS requirements. The Spacelab design and operational concepts greatly enhance the idea of AMPS as a facility where relatively standard equipment contained within the pressurized module will permit the scientist/experimenter to interact with the experiments performed by the multifunctional and multipurpose instruments mounted on the pallet.

With this design, the size of the module, which provides the pressurized (1 atmosphere) habitable volume, can be varied by utilizing a single module or by connecting two cylindrical segments. Each segment is 4.06 m in diameter and 2.689 m in cylindrical length. The pallet segments are 2.895 m in length, are mounted independent from the module, and are suspended in the payload bay using their own attach fittings. The pallet segments may be structurally linked (maximum of three segments in any one pallet train) or may be individually attached to the Orbiter.

Figure 3-6 shows a typical Spacelab configuration composed of a two-segment pressurized module and one 3-m pallet segment. The forward-located "core" segment contains subsystem equipment and crew work space, but it also provides 60 percent of the rack area for experiment installation. The core segment is currently viewed as being sufficient for AMPS controls and displays and is shown in a cross-sectional view in Figure 3-7. The aft experiment segment is dedicated entirely to experiment installation and operations. Crew ingress into and egress from the module is provided by the tunnel at the forward end which connects with the Orbiter crew compartment. This tunnel also provides for EVA by use of a hatch. The module is structurally attached to the Orbiter payload by a series of fittings (two of the four are shown) located on the main ring frames of the module cylindrical segments.

The Spacelab-provided resources that are available for use by the AMPS payload include the following:

1. Structural Support: Spacelab provides structural attach fittings for both pallet-mounted equipment and internal experiment or support hardware. Within the core segment, 60 percent of the total volume is available to AMPS, corresponding to approximately 8 m^2 (85 ft^2) of additional control and display (C&D) panel area.

2. Command and Data Management: Available to the Spacelab payload is scientific and housekeeping data acquisition and distribution, experiment command and control, and onboard data processing, display and recording.

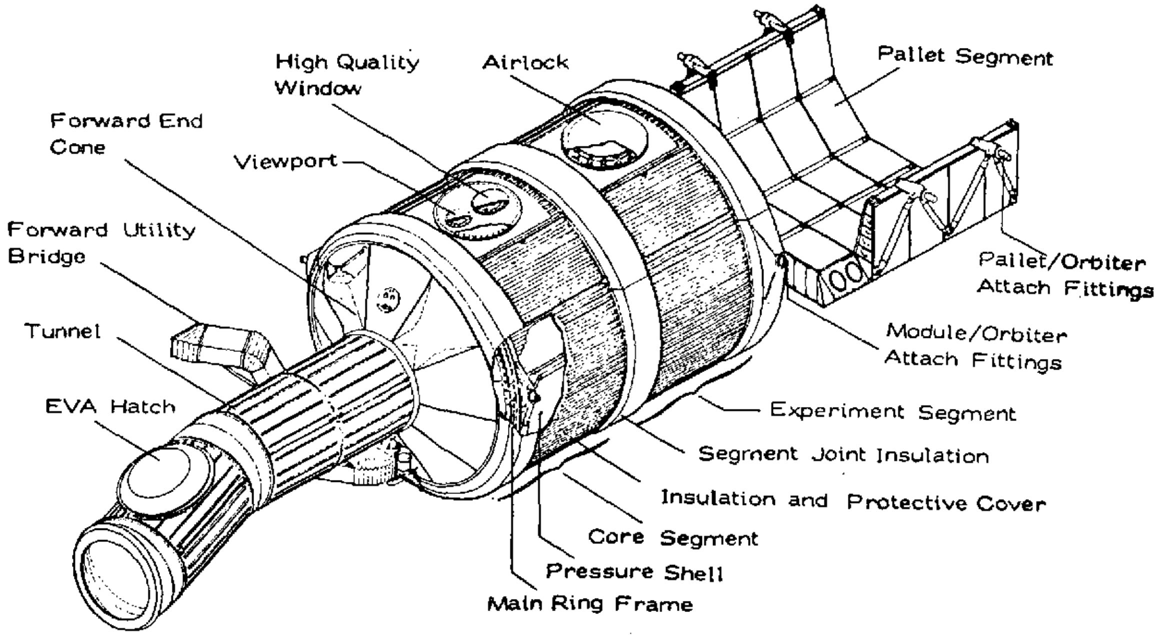


Figure 3-6. Typical Spacelab configuration.

3. Electrical Power Distribution: The Spacelab payload may utilize the unregulated 28 Vdc power from the Orbiter or can make use of Spacelab to regulate that power or convert it to ac at a variety of frequencies.

4. Environmental Control: The Spacelab environmental control subsystem interfaces with the Orbiter active thermal control subsystem in the collection and rejection of heat energy dissipated by both the Spacelab and the Spacelab payload. In the module the primary method of cooling is by convection with an option for cold plate interface, whereas high heat dissipators on the pallet may interface with the cold plates on each pallet segment.

5. Common Payload Support Equipment: Options available to the payload as part of Spacelab include provisions for airlocks, optical windows, viewports, film vaults, and a pressurized igloo for pallet-only missions.

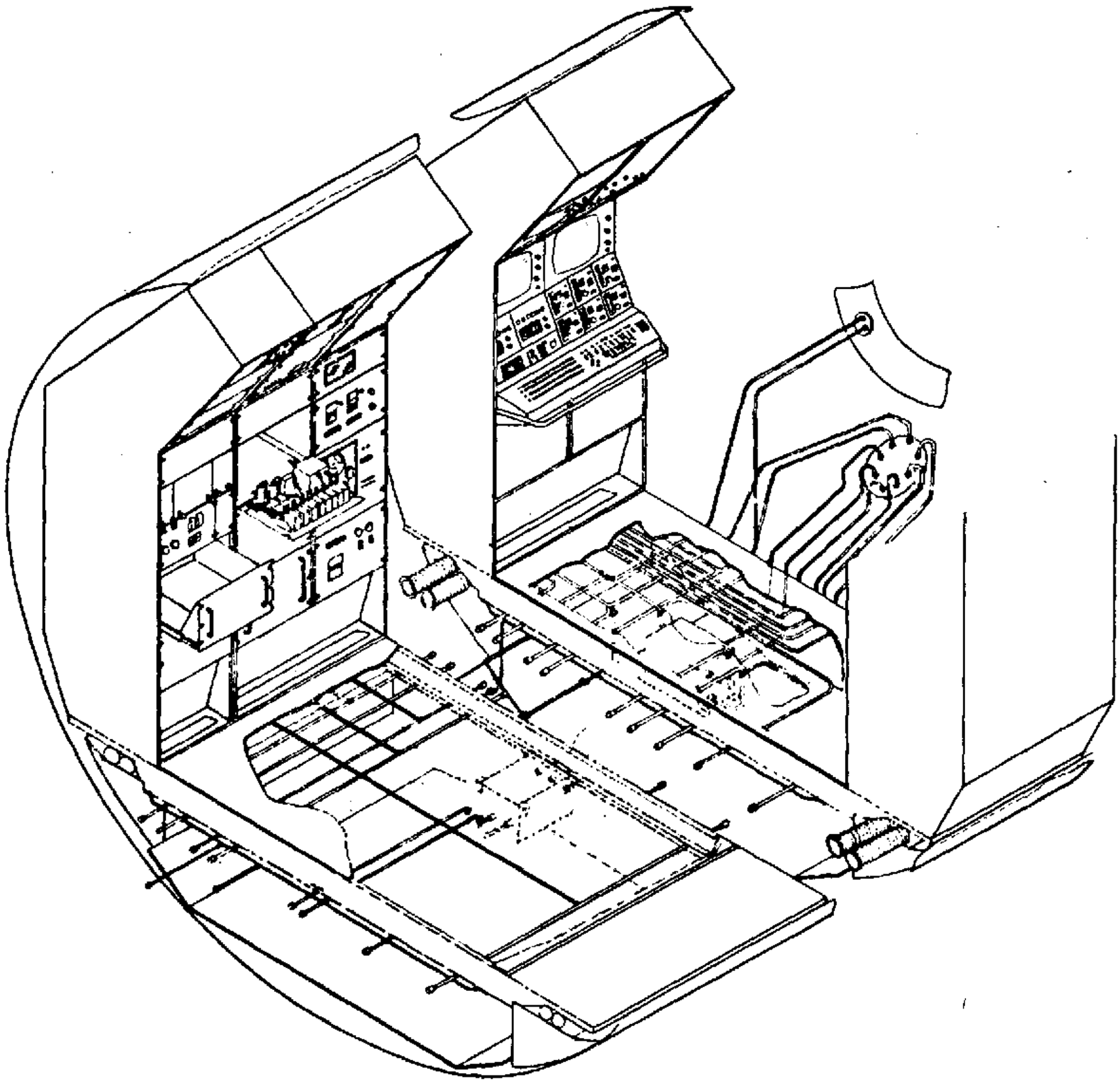


Figure 3-7. Cross section of Spacelab core segment.

3.3 AMPS DESIGN REFERENCE CONFIGURATION

Many AMPS payload configurations were conceived during the Phase A Study. This section is a brief description of the fully complemented, flight-dedicated payload which served as the design reference for the study. The reader is referred to Sections 4 and 5 for additional discussions of the design reference and alternate configurations.

It must be reemphasized at this point that the configuration design and other analyses documented herein are the result of early AMPS-related studies and MSFC in-house engineering. The recommendations of the AMPS Science Working Group regarding instrumentation and experiment operations are not reflected in this report.

The Phase A Study AMPS Design Reference Configuration is shown in Figure 3-8. All of the scientific instrumentation is externally mounted on three 3-m Spacelab pallet segments. To assist in the maintenance of instrument co-alignment, the three pallet segments are structurally linked and attached to the Orbiter with one set of attach fittings.

The 2.689 m cylindrical length Spacelab pressurized module (core segment only) houses the Spacelab MFDS and the AMPS dedicated C& D for experiment control and monitoring. While attempting to maximize both the role of the onboard experimenter and the use of the Spacelab MFDS, it was determined that the panel area available for AMPS-dedicated controls and displays (approximately 8 m^2) is marginally sufficient. The addition of the 2.689 m experiment module for additional C& D space is highly undesirable due to the attendant decrease in area available for pallet-mounted instruments.

The instruments which are shown in Figure 3-8 are listed in Table 3-1. The instruments interface with the pallet for structural support, active thermal control, and electrical power and to receive commands and transmit scientific or housekeeping data. Each pallet segment is currently envisioned as containing eight cold plates for reception of excessive instrument heat energy. The details of this thermal interface are currently under study. Structurally the instruments can be mounted on both the inner floor panels and the side wall skin panels. To increase operational flexibility and pallet instrument packaging efficiency, additional instrument support platforms are proposed as in Figure 3-8, where it can be seen that three platforms at two different levels have been included. Instruments receive ac and/or dc electrical power from the Spacelab core segment through the distribution box and interface connections on each pallet section. Commands and data are normally transmitted between the

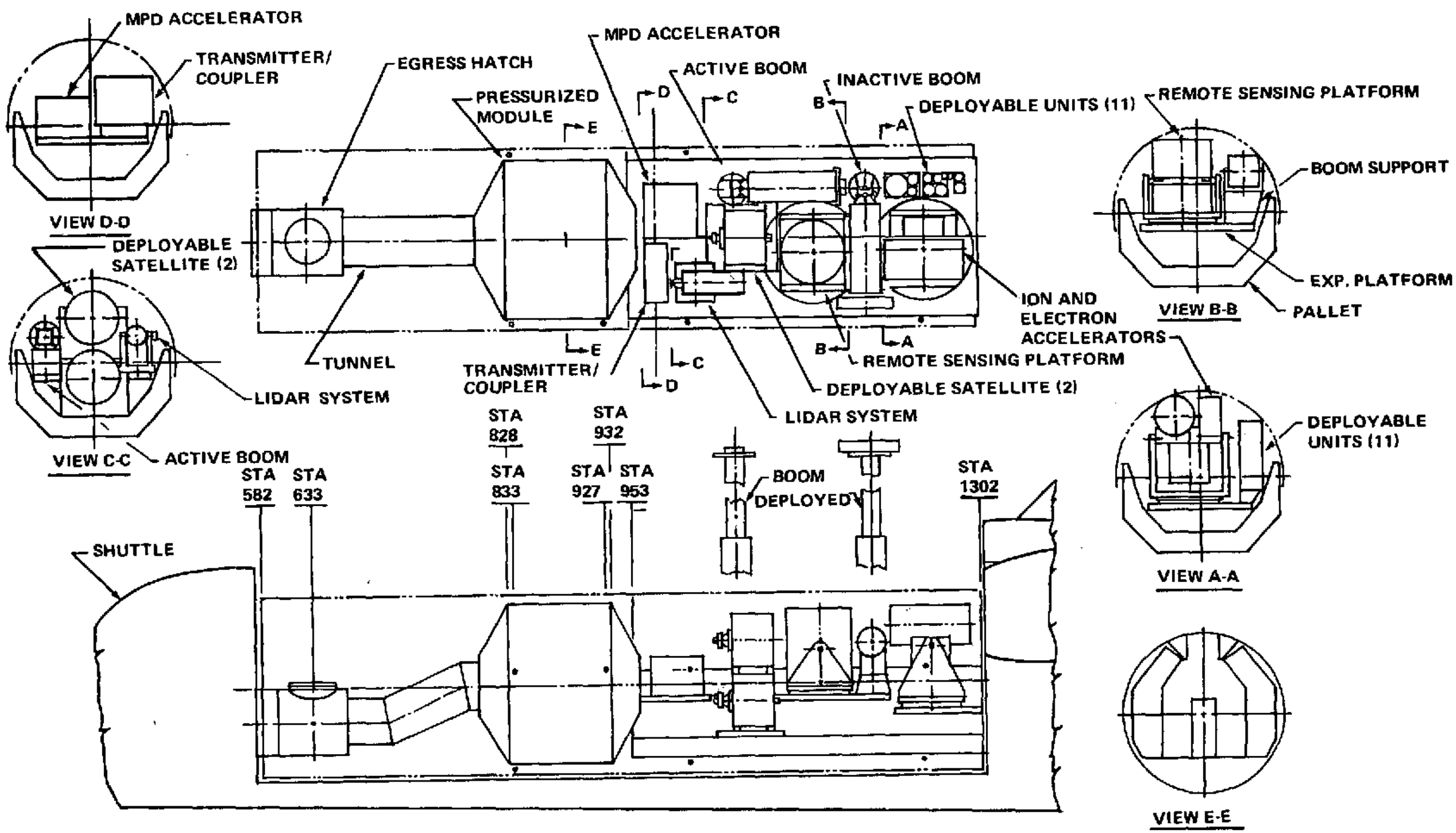


Figure 3-8. AMPS Phase A design reference configuration.

external instruments and the pressurized module via the 1 MBPS data bus with higher rate data hardwired to the Spacelab computer memory or to the Orbiter communications system.

Scientific instrument support equipment on the pallet includes two 50-m booms and their associated extension/retraction mechanisms; electrical energy storage systems (capacitor banks) for pulsed instruments, such as the particle accelerators and the lidar; a three-axis, gyro-stabilized remote sensing platform (RSP) for the optical instruments; and a number of gimbal systems for the RSP, the booms and boom-mounted platform, and the electron and ion accelerators. In addition, it may be necessary to locate special communications equipment on the pallet for commanding and receiving data from subsatellites. The need for and details of such a system are currently under study (see Section 6.4).

TABLE 3-1. AMPS PALLET MOUNTED SCIENTIFIC INSTRUMENTS

Remote Sensing Platform

AP102 XUV Normal Incidence Spectrometer
AP103 UV-Visible-NIR Scanning Spectrometer
AP104 High-Resolution Fourier SWIR Spectrometer
AP105 Cryogenic IR Fourier Spectrometer
AP106 IR Radiometer
AP107 Fabry-Perot Interferometer
AP108 Filter Photometer
AP109 UV-Visible Documentation Camera

Laser Radar System

AP201 Lidar Transmitter/ Receiver

Gimbaled Accelerator System

AP301 Ion Accelerator
AP302 Storage Banks 2 to 5 kJ Hv
AP303 Gimbaled Electron Accelerator
AP304 MPD ARC, with Condenser Bank

Transmitter/Coupler System

AP401 Transmitter/Coupler (10 kW 0.2 to 2.0 MHz)
AP402 Transmitter/Coupler (10 kW 2.0 to 20.0 MHz)
AP403 Transmitter/Coupler (1 kW 0.3 to 200 kHz)
AP404 Dipole Element - 330 m

Boom System

AP501 50 m Boom A
AP502 Gimbaled Platform
AP503 5 m Boom K
AP504 1 m Loop
AP505 Short Electric Dipole
AP506 Triaxial Search Coil
AP507 5 m Boom L
AP508 Rubidium Magnetometer
AP509 Triaxial Fluxgate
AP510 33 m Electric Dipole, Extendible
AP511 Power Supply
AP512 Data System
AP513 Alignment TV
AP514 Ion Mass Spectrometer
AP515 Spherical Ion Probe
AP516 Cylindrical Ion Probe
AP517 Planar Segmented Probe
AP518 Neutral Mass Spectrometer
AP519 Triaxial Hemispherical Analyzer
AP520 Planar Electron Trap
AP521 50 m Boom B
AP522 Wave Generator
AP523 Target

Deployable Units

AP601 Barium Canister, 100 gm
AP602 Barium Canister, 1 kg
AP603 Barium Canister, 10 kg
AP610 Shaped Charge, 1 kg
AP611 Shaped Charge, 5 kg
AP612 Shaped Charge, 20 kg
AP620 Balloon, Spherical Insulated
AP621 Balloon, Spherical Conducting

Deployable Subsatellites

AP700 Deployable Satellite System (2)

SECTION 4.0 CONFIGURATION DESIGN

4.0 CONFIGURATION DESIGN

4.1 INITIAL CONCEPT

The initial AMPS concept (Fig. 4-1) included all the experiments as defined in Shuttle System Payload Description (SSPD) document, AP-06-S. This configuration required a pressurized module with three 1.5 m sections and a pallet consisting of five 1.5 m sections with an extension platform attached to each end. One cylindrical section of the pressurized module contains the Spacelab subsystems, and the experiments consoles are contained in two other sections. The experiments were taken as defined and mounted on the pallet, yielding a configuration that has the center of gravity (c.g.) completely out of the allowable range.

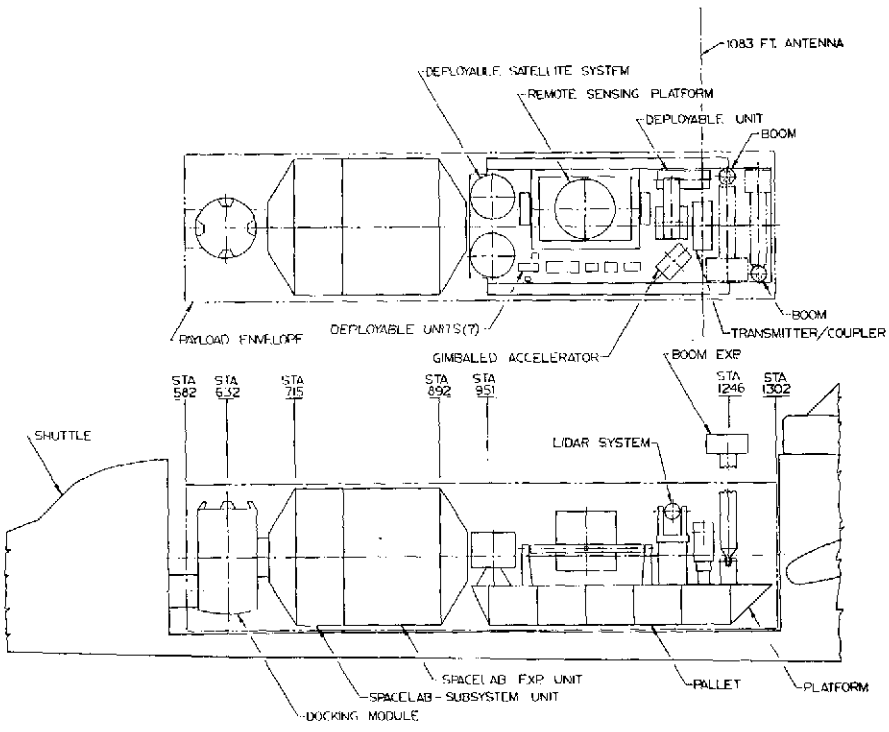


Figure 4-1. AMPS configuration A.

4.2 BASELINE CONCEPT

The first attempt to revise the initial configuration into an acceptable concept involved the reduction of the pressurized module from three sections to two sections. The mount for the remote sensing platform was changed to a more compact design, the deployable satellites were stacked, and the deployable units were mounted on a common frame. All the heavier experiments were located as far aft on the pallet as possible, resulting in the baseline configuration shown in Figure 4-2. This is a very compact configuration but the pressurized module is too small to accommodate the experiment consoles as defined by the SSPD and very little space is available on the pallet for additional equipment or experiment growth.

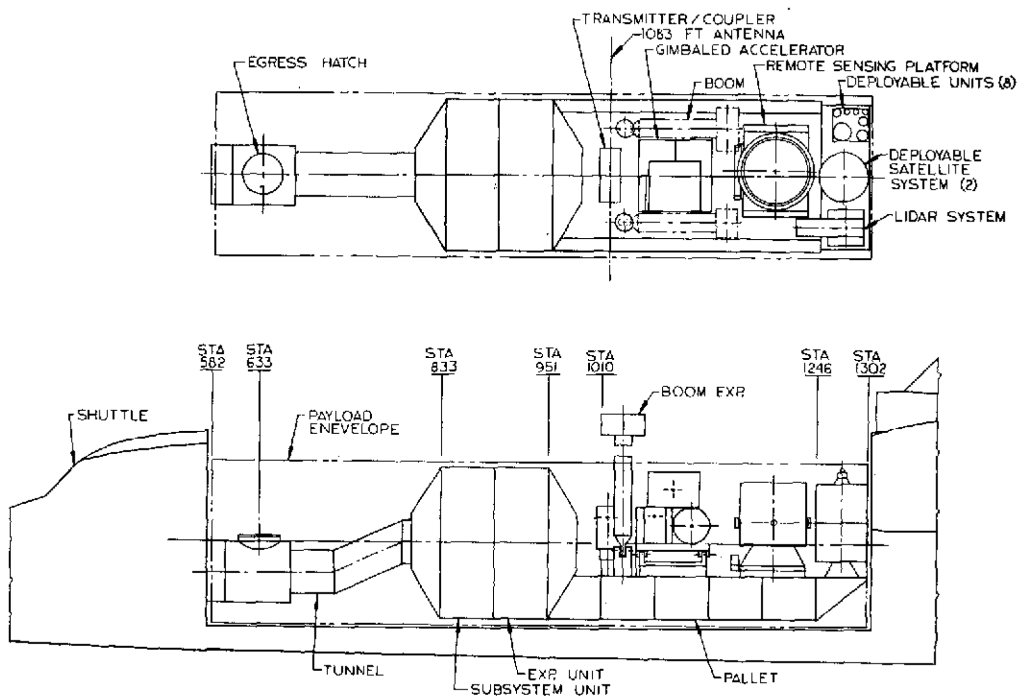


Figure 4-2. AMPS baseline configuration.

The Shuttle manipulator, as defined, cannot deploy and retrieve the satellites located in the aft position of the pallet. In addition, the location of the heavier experiments on the rear of the pallet concentrate a very large load that could be more than a standard type pallet can support. Also, the weight and c.g. of this configuration is out of the acceptable range.

All the experiment view angles required by the SSPD cannot be accommodated by the configuration because they are large and interfere with other experiments or structures. In particular, the smaller view angle requirements of the remote sensing platform and the lidar system cannot be accommodated because of the interference with the Shuttle aft fin, the extended booms, and the other experiments. The gimbaled accelerators, consisting of three accelerators and a storage bank, were mounted on a gimbaled platform. Full rotation of the platform can be accommodated but the instruments can only swing about 30 deg without contacting the pallet floor.

Some of the experiments are located on platforms that are deployed up to 50 m from the Shuttle payload bay by two booms. The experiments mounted on boom A are shown in Figure 4-3. Experiments are mounted on both sides of the platform which can be tilted up to 60 deg. Three of the experiments are deployed from the platform after it is deployed by the boom. A typical platform configuration for mounting experiments on both sides is shown in detail M of Figure 4-3.

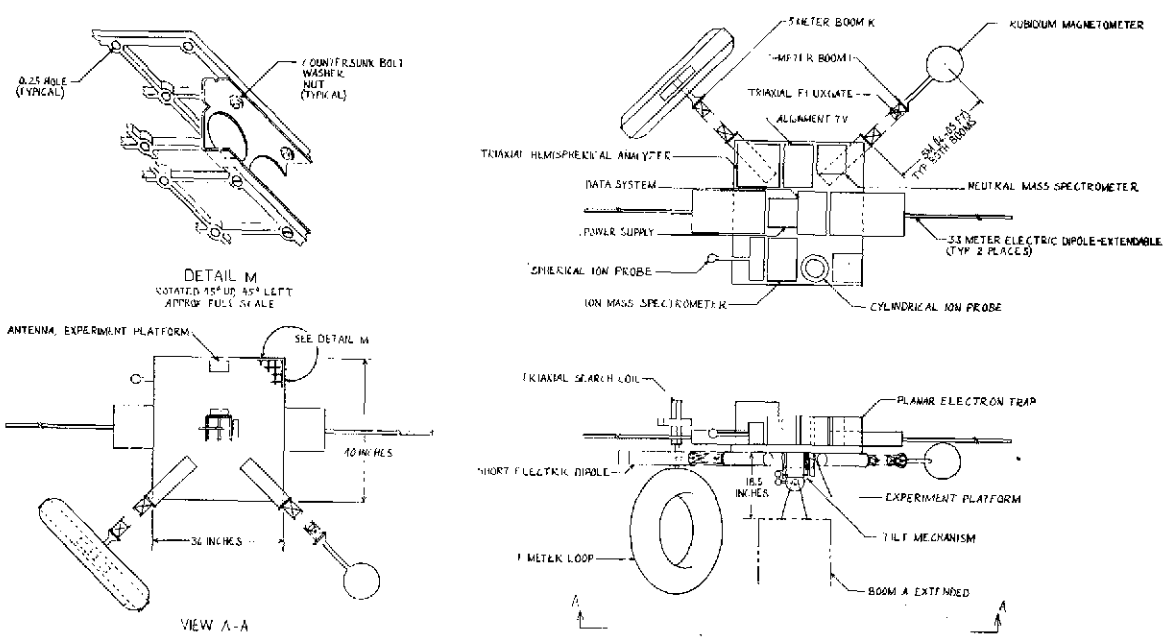


Figure 4-3. AMPS deployed platform A.

The launched configuration of boom A is shown in Figure 4-4. During launch the boom is supported on a cradle that is attached to the pallet. This support has a lock mechanism for releasing and securing the boom. A canister extension on the end of the boom cylinder provides a lock for the experiment platform during launch. Two-axis gimbal mounts are provided at the base of the boom for maneuvering in orbit.

Boom B, Figure 4-5, is similar to boom A except for the experiments and the experiment platform.

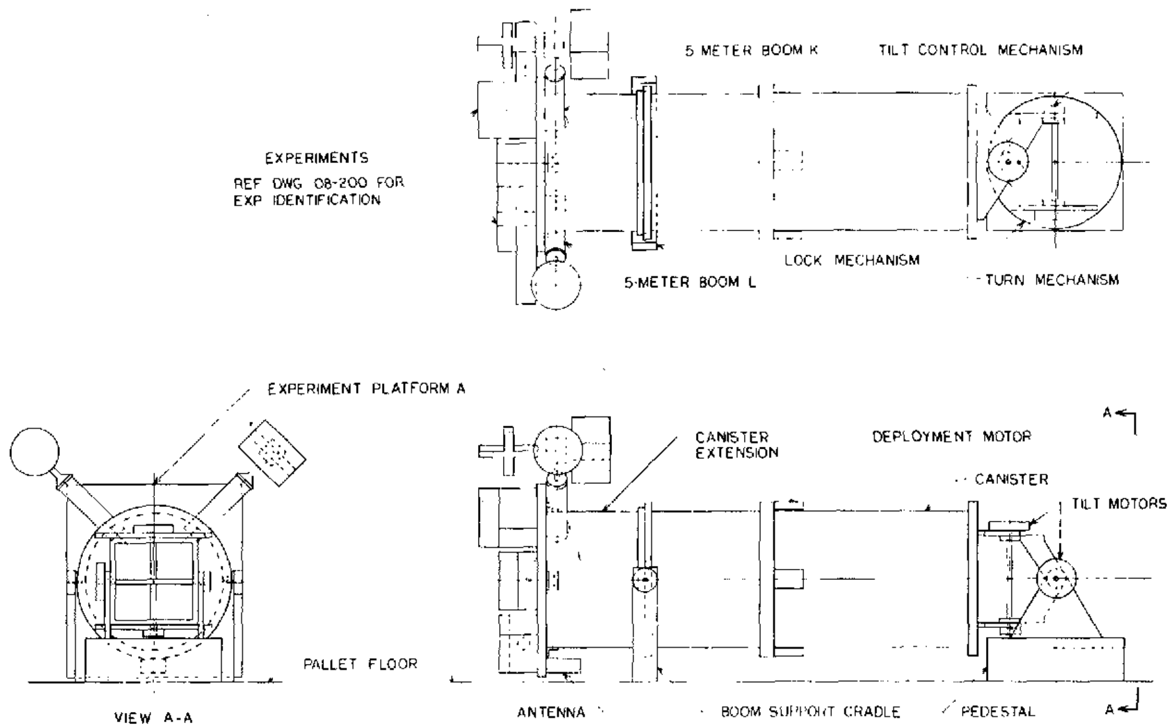


Figure 4-4. AMPS boom A, stowed configuration.

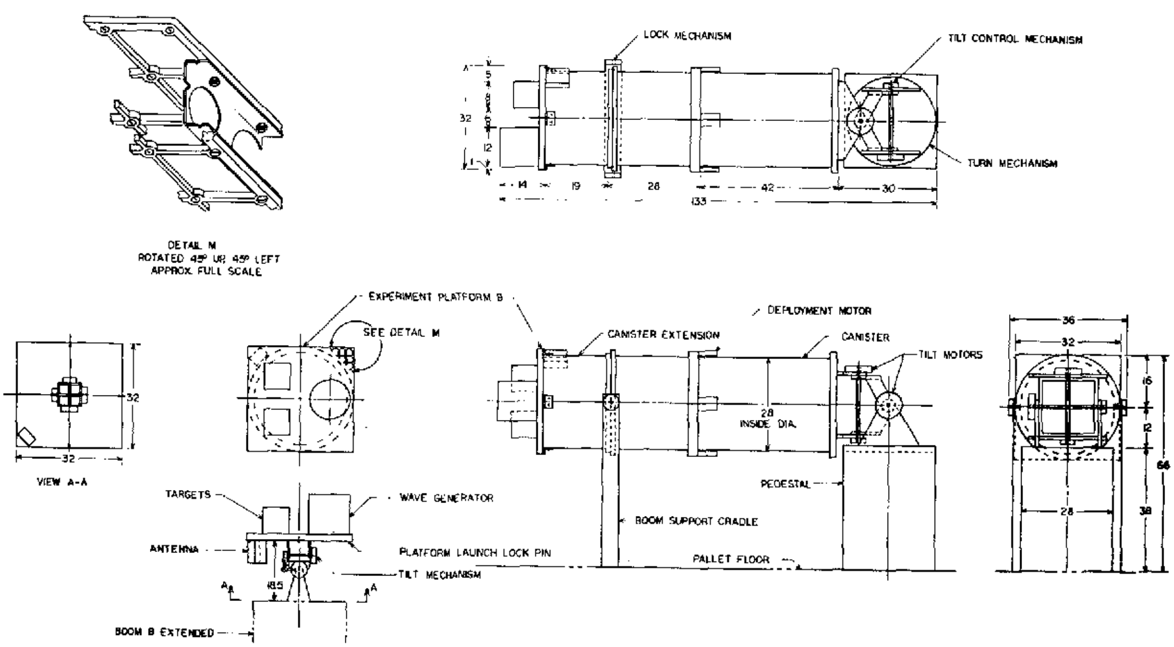


Figure 4-5. AMPS boom B, stowed configuration.

4.3 ALTERNATE CONFIGURATIONS

Since the baseline configuration c.g. location was not acceptable, an effort was made to establish an acceptable configuration.

4.3.1 Reduced Experiments

One method of shifting the c.g. aft is by reducing the size or number of experiments. In Figure 4-6, the volume of each experiment was reduced by 50 percent, thus reducing the required length of the pallet by one section. This allowed the pressurized module to be moved aft 1.5 m and shifted the c.g. within acceptable range.

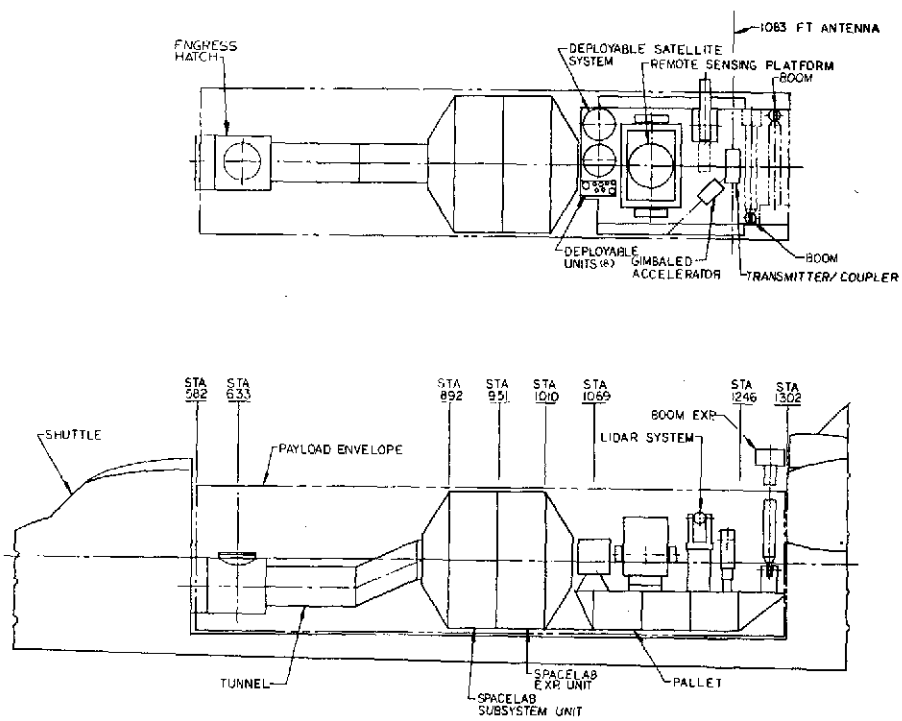


Figure 4-6. AMPS experiments reduced 50 percent.

Another method of shifting the c.g. is to reduce the number of experiments on each mission. Figures 4-7 through 4-10 show some possible configurations with reduced experiments. Figures 4-11 and 4-12 show the experiments divided into two missions with the experiments grouped for compatibility.

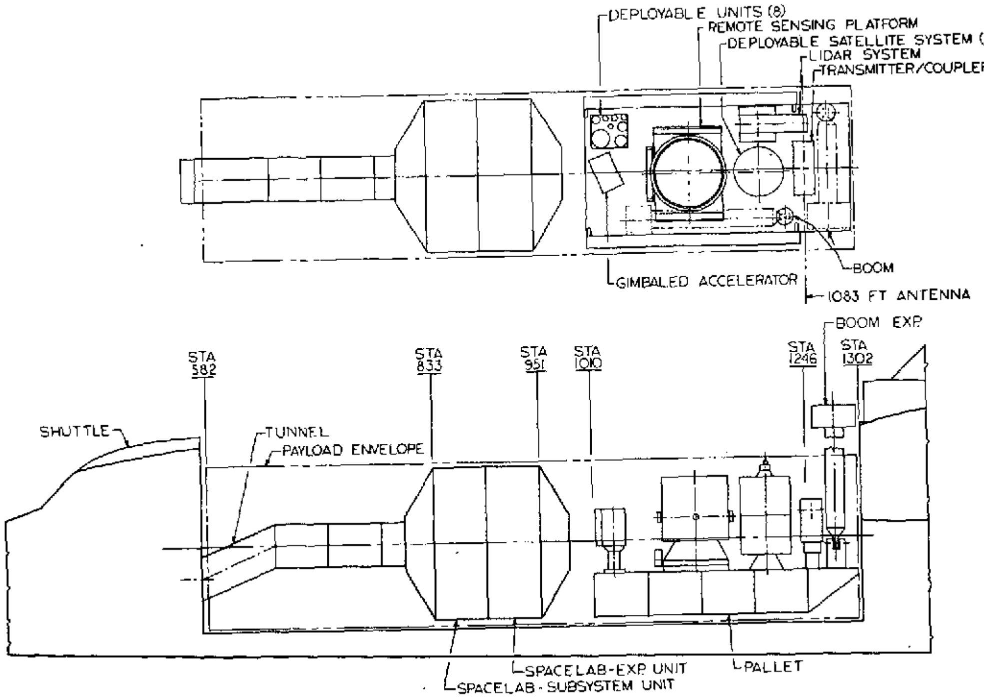


Figure 4-7. AMPS configuration 2.

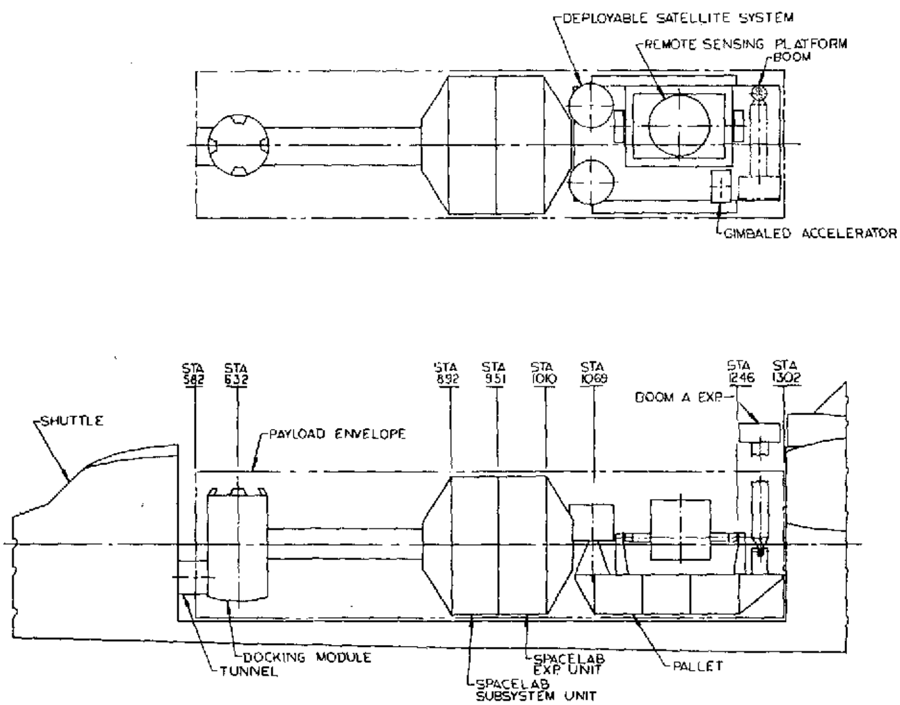


Figure 4-8. AMPS configuration B.

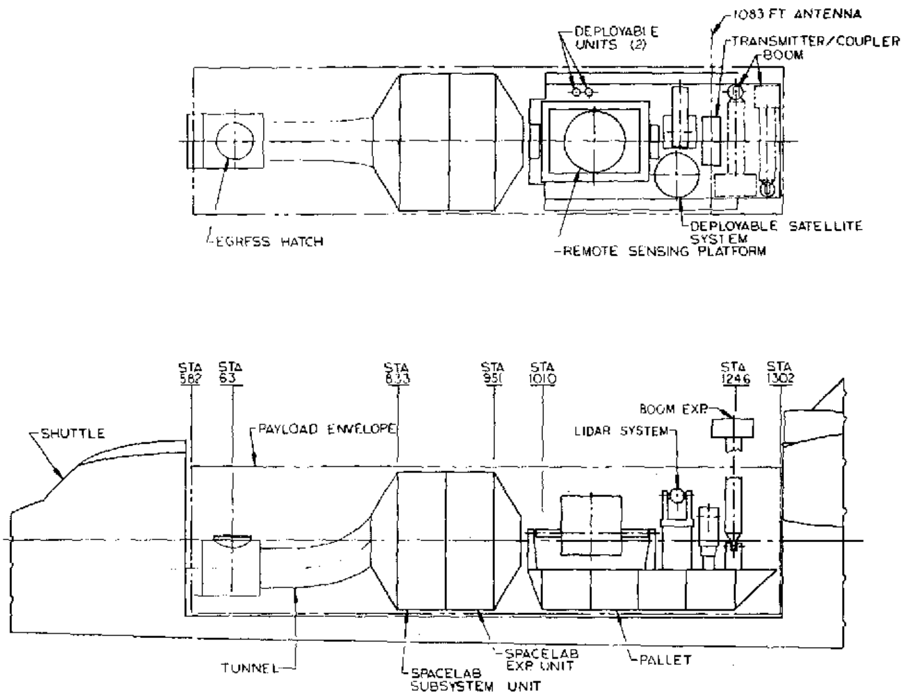


Figure 4-9. AMPS configuration C.

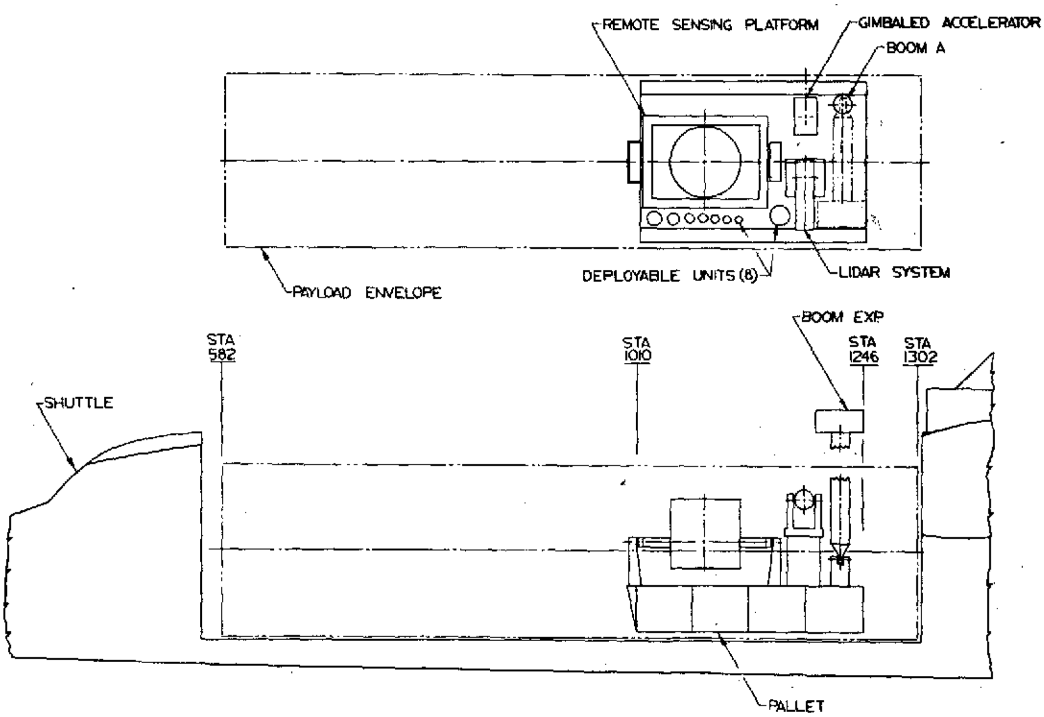


Figure 4-10. AMPS configuration D.

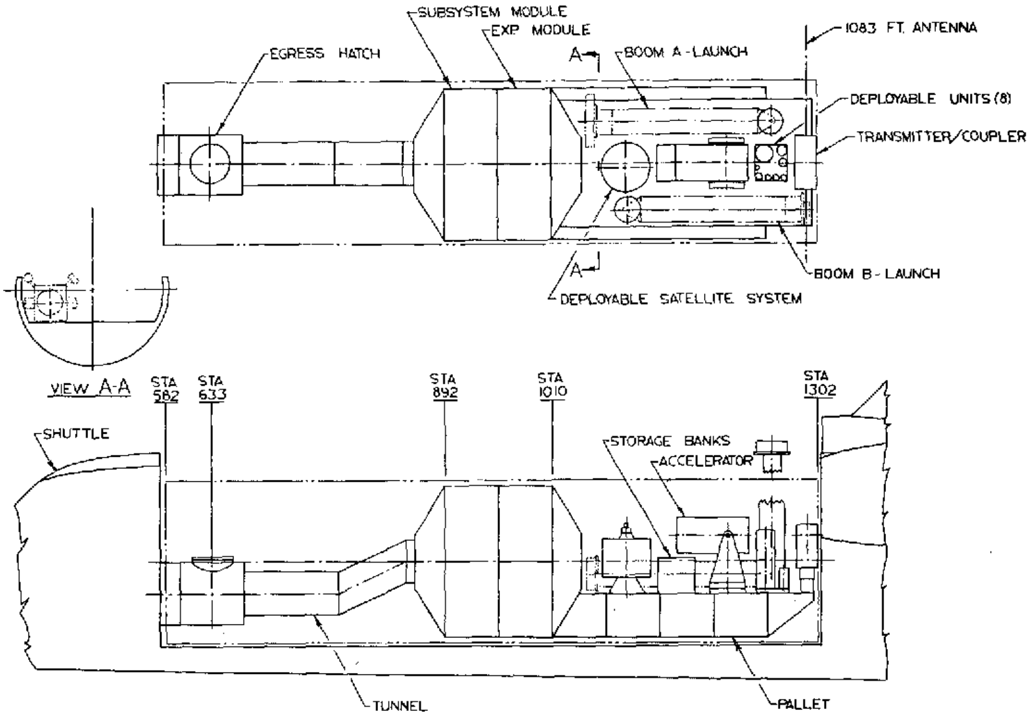


Figure 4-11. AMPS reduced experiment-A.

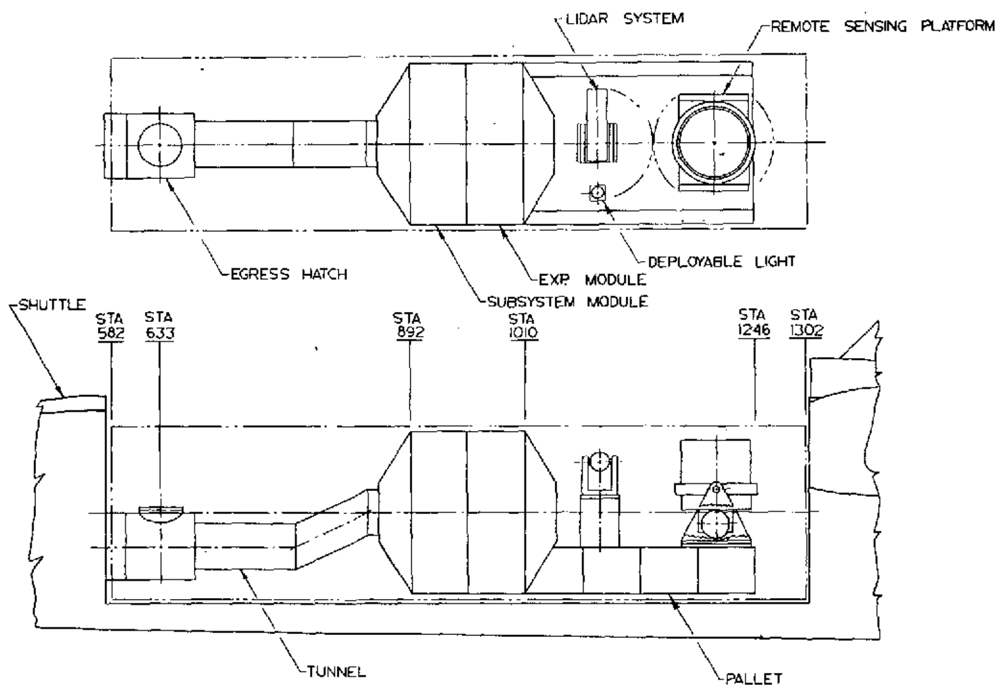


Figure 4-12. AMPS reduced experiment-B.

4.3.2 Pallet Forward

The c.g. is improved by shifting the pallet to the front of the pressurized module as shown in Figure 4-13. The major problem with this configuration is the connection of the tunnel from the Shuttle cabin to the pressurized module. If the tunnel is routed over the top of the pallet floor, the number of experiments that can be mounted on the pallet is reduced considerably. If the tunnel is routed beneath the pallet floor, as shown in Figure 4-14, the floor of the pallet must be raised, which results in some of the larger experiments being outside the 4.3 m payload envelope.

4.3.3 Forward Platform

A combination of an aft pallet and a forward platform is shown in Figure 4-15. The larger experiments are placed on the pallet and the smaller ones are placed on the forward platform. The forward platform, being located away from the Shuttle vertical stabilizer, gives the experiments a less restricted view angle. This configuration did not improve the c.g., however.

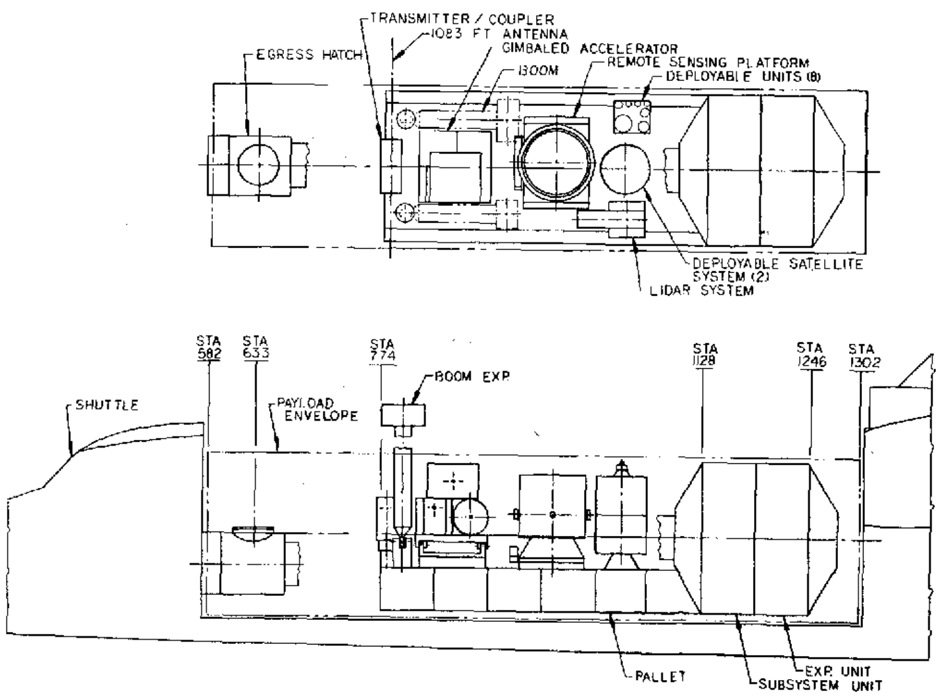


Figure 4-13. AMPS pallet forward.

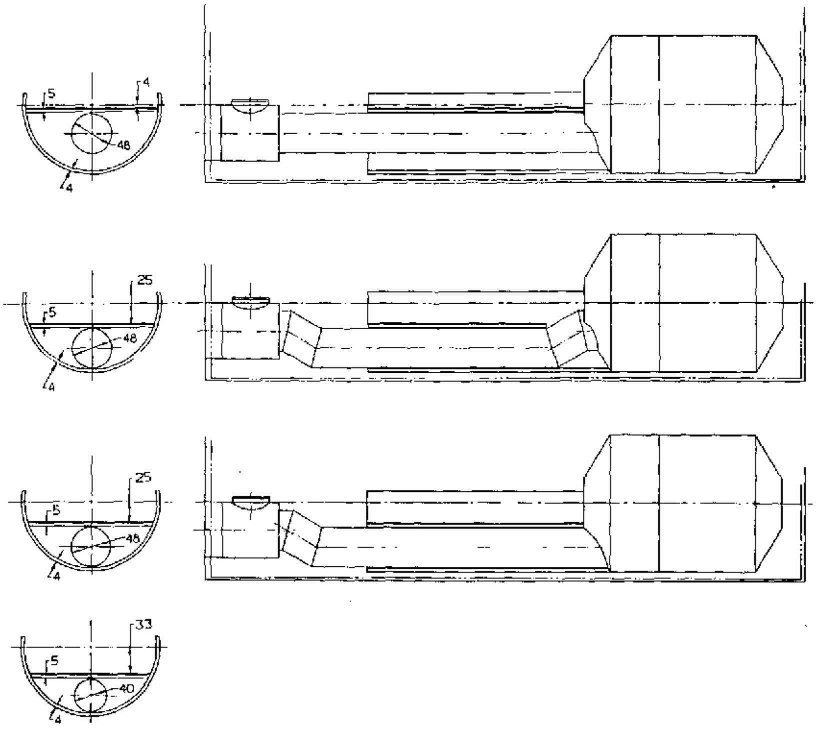


Figure 4-14. AMPS tunnel through pallet impact.

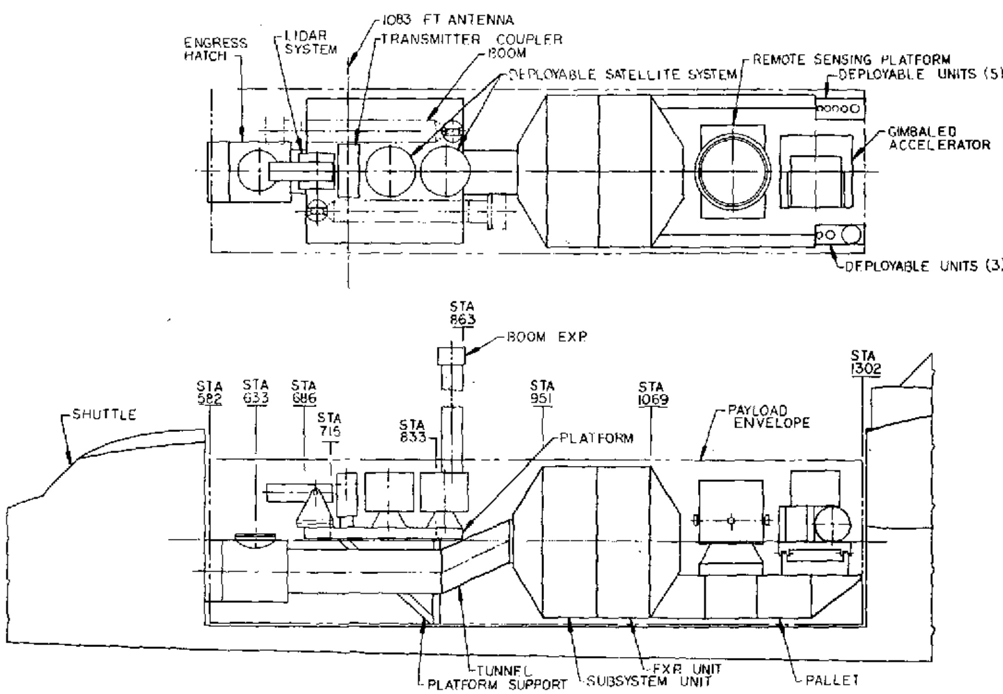


Figure 4-15. AMPS platform forward.

4.4 REVISED CONFIGURATIONS

The forward platform configuration and the baseline configuration were revised to reflect experiment configuration updating, the revised tunnel and pallet configuration, and the rearrangement of experiments for better access and view angle accommodations.

4.4.1 Forward Platform

The tunnel configuration was revised and the platform support and tunnel support were combined as shown in Figure 4-16, thus simplifying the installation of the platform. This configuration has a favorable c.g. location.

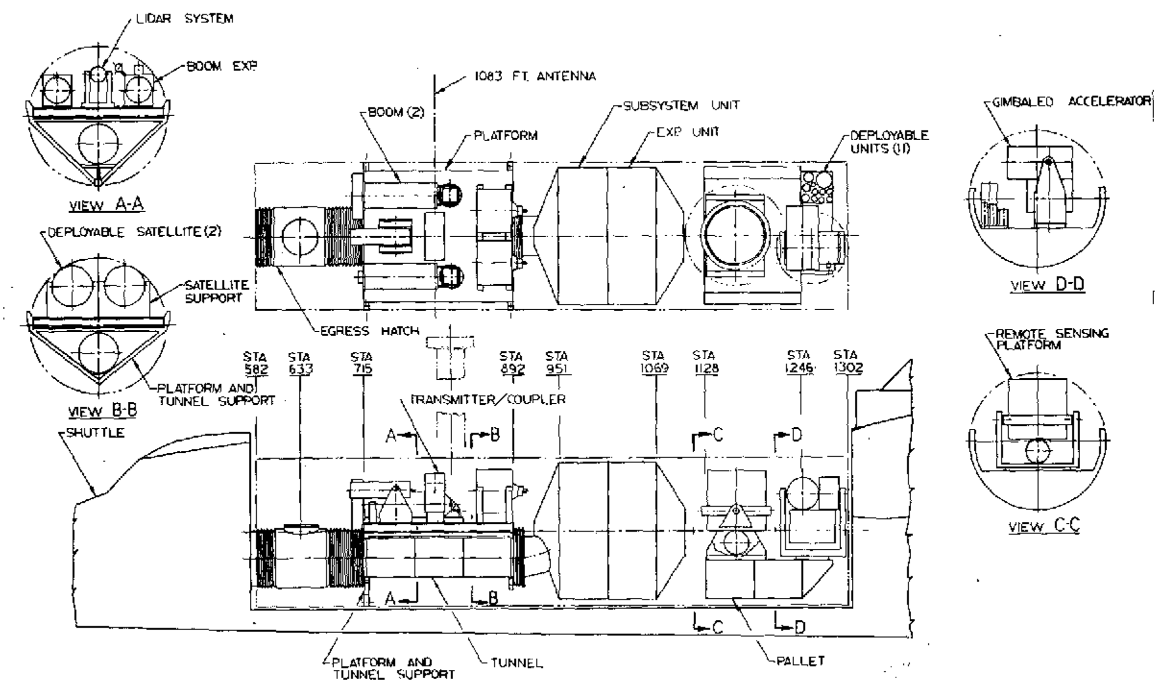


Figure 4-16. AMPS revised platform forward.

4.4.2 Final Baseline Configuration

In Figure 4-17, the tunnel and pallet were revised to reflect the latest configuration changes. The satellites were relocated so they can be reached by the Shuttle manipulator for deployment and retrieval. The configuration of the booms was updated and the accelerator mount was modified for greater maneuverability by removing the storage bank and placing it on the pallet. The cryogenic tank was added to the remote sensing platform. The length of the

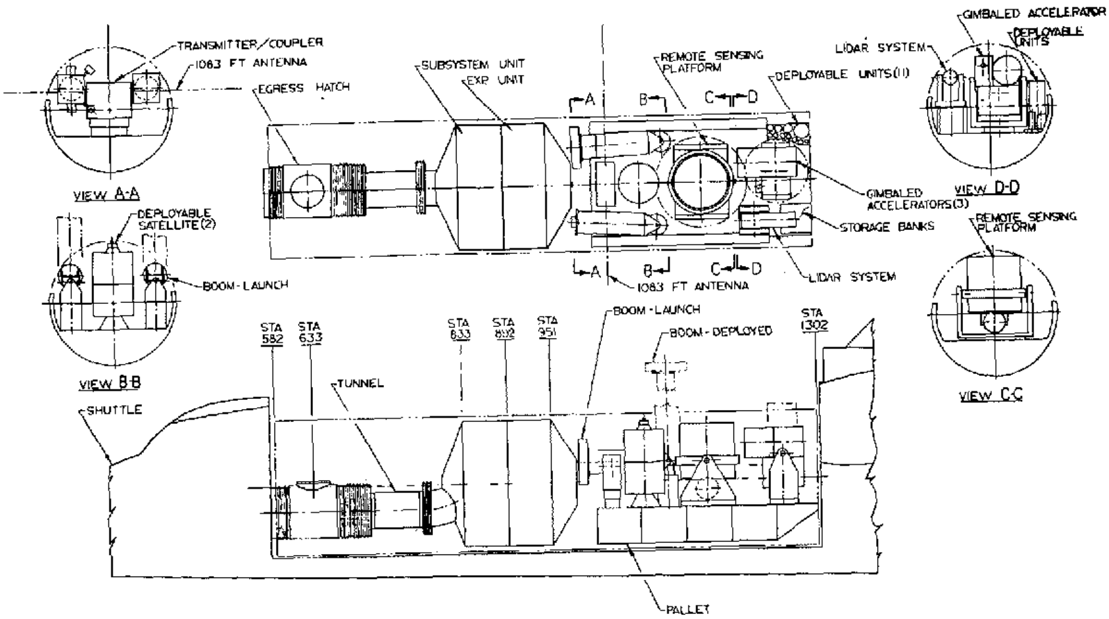


Figure 4-17. AMPS baseline configuration B.

pressurized module cylinder was maintained at two 1.5 m sections although it has already been determined that an additional section is required for the experiment consoles defined by the SSPD.

The view angles required by the SSPD and those provided by the baseline configuration are compared in Table 4-1. These view angles assume that the booms are rotated forward during the operation of the other experiments. There is also some viewing and operation restrictions on the remote sensing platform, the gimbaled accelerator, and the lidar since these experiments can partially block the view of each other and could physically contact each other. There is also some restriction on the boom orientation caused by the remote sensing platform.

TABLE 4-1. VIEWING ANGLE REQUIREMENTS AND CAPABILITIES, BASELINE CONFIGURATION

Experiment		FOV Required ½ Solid Angle	FOV Capability		
			Forward	Aft	Sides
Remote Sensing Platform	AP110	55	75	45	73
	AP111	50	↓	↓	↓
	AP112	55	↓	↓	↓
	AP113	55	↓	↓	↓
	AP114	55	↓	↓	↓
	AP115	60	↓	↓	↓
	AP116	45	↓	↓	↓
	AP117	45	↓	↓	↓
	AP119	180	75	45	73
Lidar		90	80	33	90
Gimbaled Accelerators	AP301	45	80	22	90
	AP303	45	80	22	90
	AP304	10	80	22	90
Transmitter/Coupler		2π sterad	Will vary from π sterad near Shuttle to near 2π sterad at end		

4.5 AMPS CONFIGURATION WITH ERNO SPACELAB

The configuration was adapted to the ERNO pressurized module and pallet with some minor changes in the experiments as shown in Figure 4-18. The MPD accelerator was separated from the ion and electron accelerators and was hard-mounted to the platform. The deployable satellites were stacked in cradles instead of being mounted together.

In adapting the experiments to the ERNO pallet, all experiments are mounted on three platforms which are connected to the pallet cargo attach points.

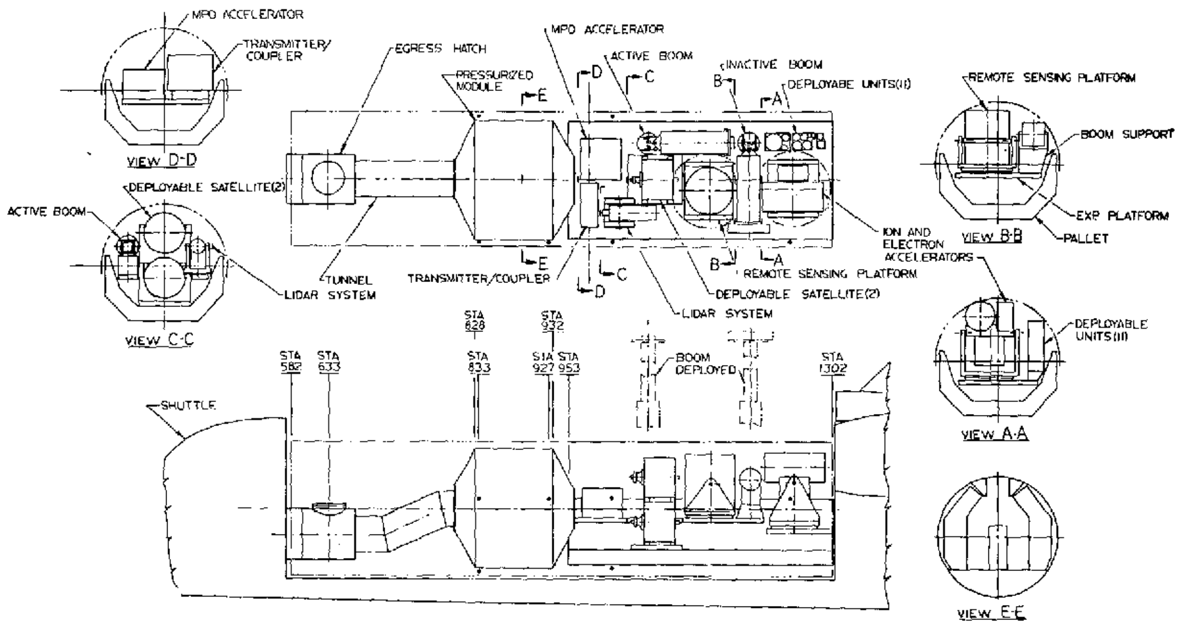


Figure 4-18. AMPS with ERNO pallet.

SECTION 5.0 AMPS WEIGHT AND CENTER OF GRAVITY STUDY

5.0 AMPS WEIGHT AND CENTER OF GRAVITY STUDY

The current Atmospheric, Magnetospheric and Plasmas in Space (AMPS) payload consists of a 2.7-m (cylindrical length) Spacelab and a 9-m pallet which when combined with the complete AMPS experiment complement results in an acceptable weight and c.g. profile. The 9-m pallet is the minimum size on which the complete scientific instrument complement can be packaged. The current design Reference Configuration Layout (dated July 19, 1974) (Fig. 4-18) shows how the scientific instruments may be packaged on the ERNO pallet. The current AMPS design Reference Weight Summary (dated September 23, 1974) (Tables 5-1 and 5-2) indicates the full complement of scientific instruments, the mission-dependent equipment list, Spacelab, and Spacelab-chargeable items for the AMPS payload.

The subsections listed below contain the results of studies that were conducted to assess the weight and c.g. problems and to attempt to identify and define a configuration that would meet the Orbiter c.g. envelope and weight constraints:

5.1 AMPS Current Design Reference Weight and c.g. Assessment

5.2 AMPS Weight and c.g. Assessment of Three Alternate Configurations

5.3 AMPS Weight and c.g. Sensitivity Analysis of Various Spacelab and Pallet Lengths

TABLE 5-1. AMPS DESIGN REFERENCE WEIGHT SUMMARY

	Weight	
	kg	lb
Spacelab[a]	6 267	13 816
Module (2.7 m)	3 175	7 000
Pallet (9 m)	1 873	4 130
Payload Specialist Station (PSS)	56	123
Utility Bridge (Pallet/Module)	56	123
Utility Bridge (Spacelab/Orbiter)	146	322
Mission-Dependent Equipment	961	2 118
Spacelab Chargeables[a]	1 836	4 046
Orbiter Retention Fittings	125	275
Power Kit	717	1 580
Heat Rejection Kit	142	312
Tunnel/Egress Hatch	852	1 879
Spacelab Payload		
Total	7 767	17 123
Located on Pallet at Launch	6 010	13 250
Located on Pallet at Landing	4 960	10 935
Crew	651	1 435
Rescue Equipment	35	78
Reaction Control System (RCS) Propellant	227	500
Instrument/Pallet Attachments	454	1 000
Remote Sensing Platform (RSP)	408	900
Star Tracker	33	72
Lidar[b] Gimbal Platform	187	412
Capacitor Bank (MPD[c] Arc)	544	1 200
Accelerator Gimbal Platform	396	872
Capacitor Bank (Ion and Electron Accelerators)	136	300
Transmitter/Coupler Mount	20	43
Deployable Boom A	250	551
Deployable Boom B	250	551

TABLE 5-1. (Concluded)

	Weight	
	kg	lb
Communication/Data System (Booms)	24	52
Power Supply (Booms)	14	30
Deployable Units Release Mechanisms	73	160
Subsatellite Supports (2)	136	300
Subsatellite Communication/Data System	115	254
Controls and Displays	844	1 861
RSP Instruments	393	866
Lidar	100	220
MPD Arc	10	22
Ion Accelerator	150	331
Electron Accelerator	15	33
Transmitter/Coupler	190	419
Boom A Instruments	57	126
Boom B Instruments	6	12
Deployable Units	695	1 532
Subsatellites (2)	1 356	2 990
Total Launch Weight	15 870	34 985
Expended on Orbit	1 737	3 828
Power Kit Reactants	422	930
RCS Propellant	227	500
N_2/O_2 Losses	38	83
Deployable Units	695	1 532
Subsatellite Propellant	333	734
RSP Instruments Cryogenics	22	49
Total Landed Weight	14 133	31 157

a. Current Spacelab Program Office level II weights which contain growth margins.

b. Light Detection and Ranging System

c. Magnetoplasmadynamic

TABLE 5-2. AMPS MISSION-DEPENDENT EQUIPMENT LIST

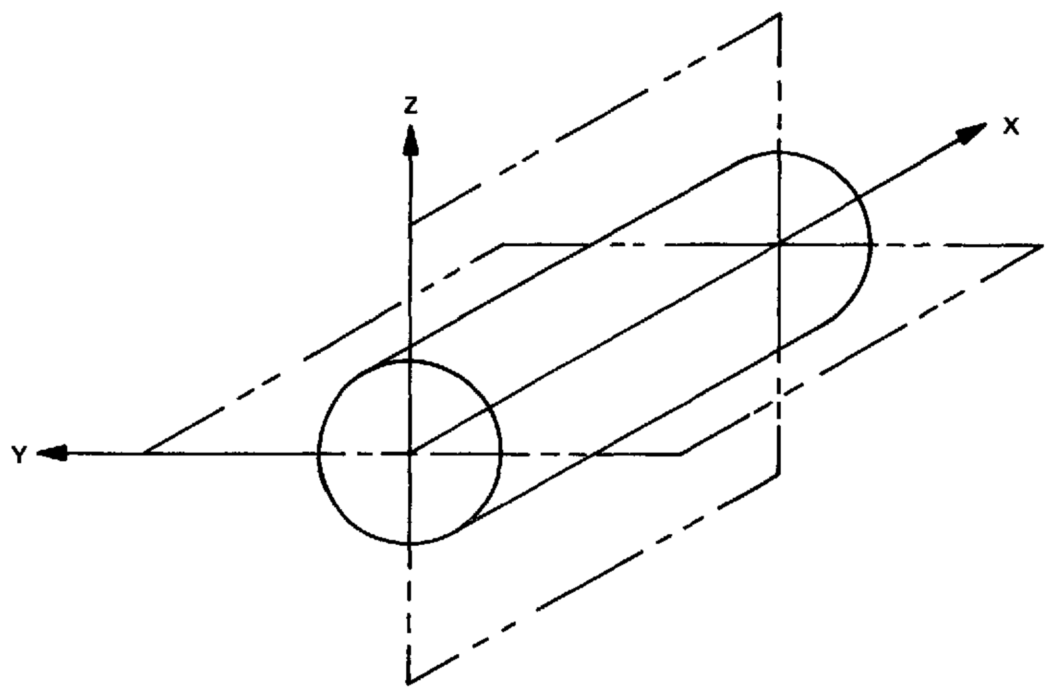
	Number of Each	Weight	
		kg	lb
Structure		272.2	600.1
Rack for Experiments	6	189.4	417.6
Pickup Lugs (28 Hard Points)	83	82.8	182.5
Electrical Power and Distribution Subsystem (EPDS)		250.1	551.6
Inverter; 400 Hz, 2.25 kV-A	4	110.3	243.2
Experiment Switch Panel	3	18.0	39.7
Converter (500 watts)	3	16.2	35.7
Peak Power Battery	1	78.0	172.0
Charge and Protection Unit	2	8.4	18.6
Discharge Regulator	2	19.2	42.4
Command and Data Management Subsystem (CDMS)		188.4	415.3
Experiment Computer	1	18.0	39.7
Experiment Input/Output Unit	1	18.0	39.7
Experiment Remote Acquisition Unit (RAU) (one RAU included with each pallet section)	1	2.4	5.3
Keyboard	1	4.8	10.6
Cathode Ray Tube (CRT) Display	1	24.0	52.9
High Bit Rate Tape Recorder	1	51.6	113.8
Analog/Video Recorder	1	43.2	95.2

TABLE 5-2. (Concluded)

	Number of Each	Weight	
		kg	lb
TV Monitor	1	19.2	42.3
Recorder and Communication Control Unit	1	3.6	7.9
Time Display	1	3.6	7.9
Habitability		25.6	56.4
Rails Console Horizontal	6	2.9	6.4
Stowage Container/Packaging	4	7.7	17.0
Pallet-Pressurized Suit Assembly (PSA) Foot Restraint	5	15.0	33.0
Environmental Control Subsystem (ECS)		179.8	396.4
External Contaminant Monitor	4	7.2	15.9
Freon Lines and Disconnect		15.0	33.1
Freon Charge		50.8	112.0
Pallet Thermal Cover	3	33.5	73.9
Freon Flex Lines		8.4	18.5
Cold Plate	7	32.5	71.6
Payload Dedicated Heat Exchanger	2	31.2	68.8
Water for Payload Heat Exchanger	2	1.2	2.6
Common Payload Support Equipment (CPSE)		44.4	97.9
Viewport	2	34.8	76.6
Experiment Data Storage	1	9.6	21.2
Total		960.5	2117.7

5.1 AMPS CURRENT DESIGN REFERENCE WEIGHT AND c.g. ASSESSMENT

The current design reference configuration has been assessed as an acceptable configuration. The Orbiter payload coordinate system (Fig. 5-1) was used for generating each of the c.g. profiles. The overall launch and landing weight and c.g. profile are within the required Orbiter envelope as shown in Figures 5-2, 5-3, and 5-4.



ORIGIN: PAYLOAD CENTERLINE AT THE FRONT OF THE PAYLOAD BAY

Figure 5-1. Orbiter payload coordinate system.

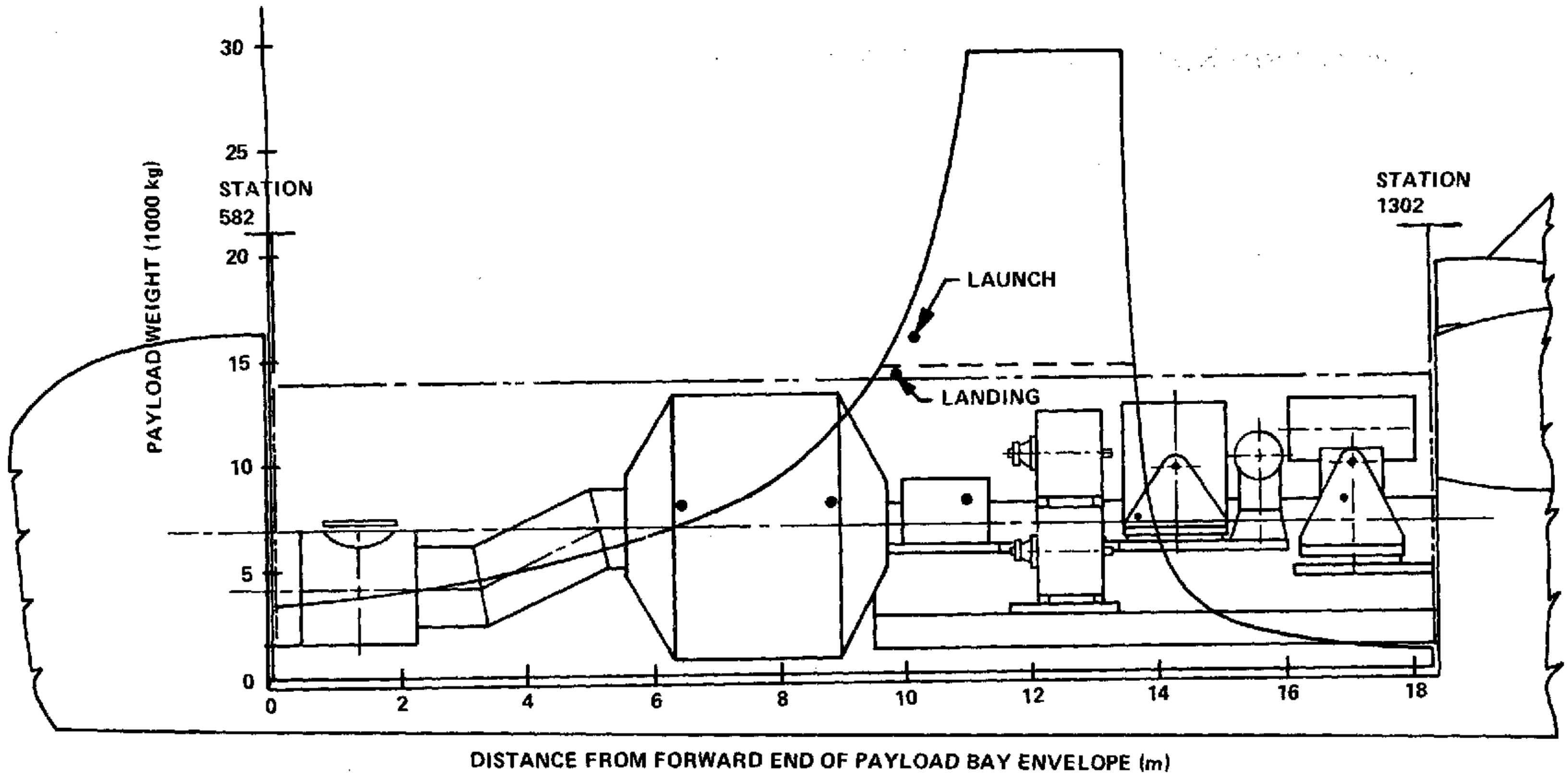


Figure 5-2. AMPS design reference X-c.g. profile.

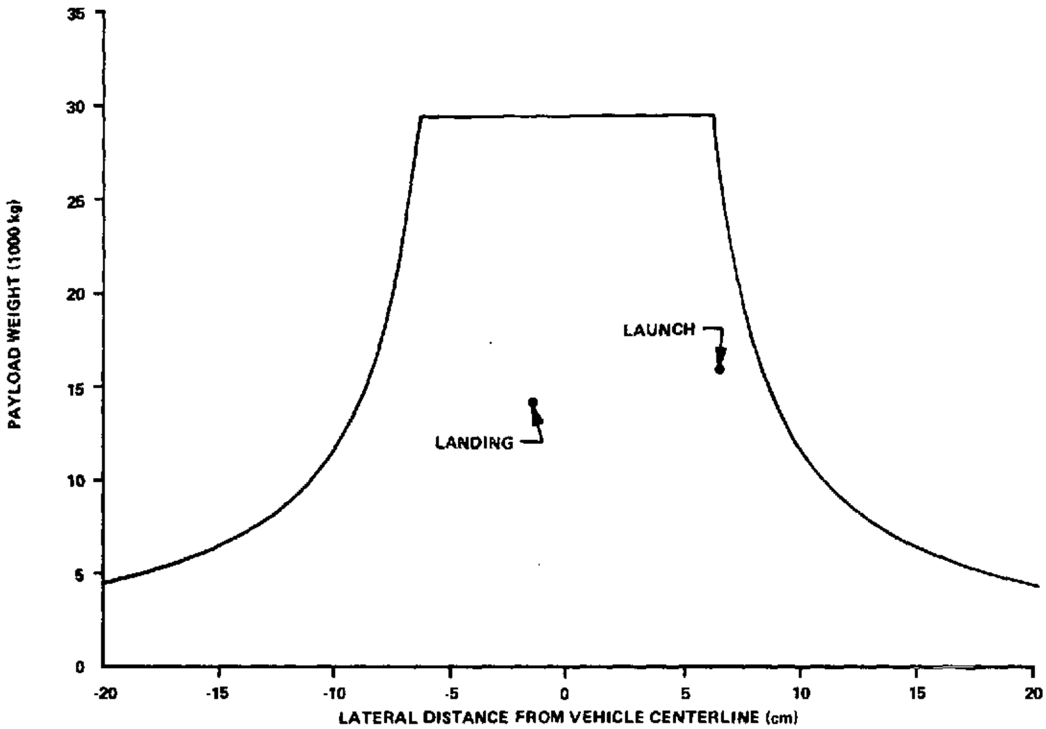


Figure 5-3. AMPS design reference Y-c.g. profile.

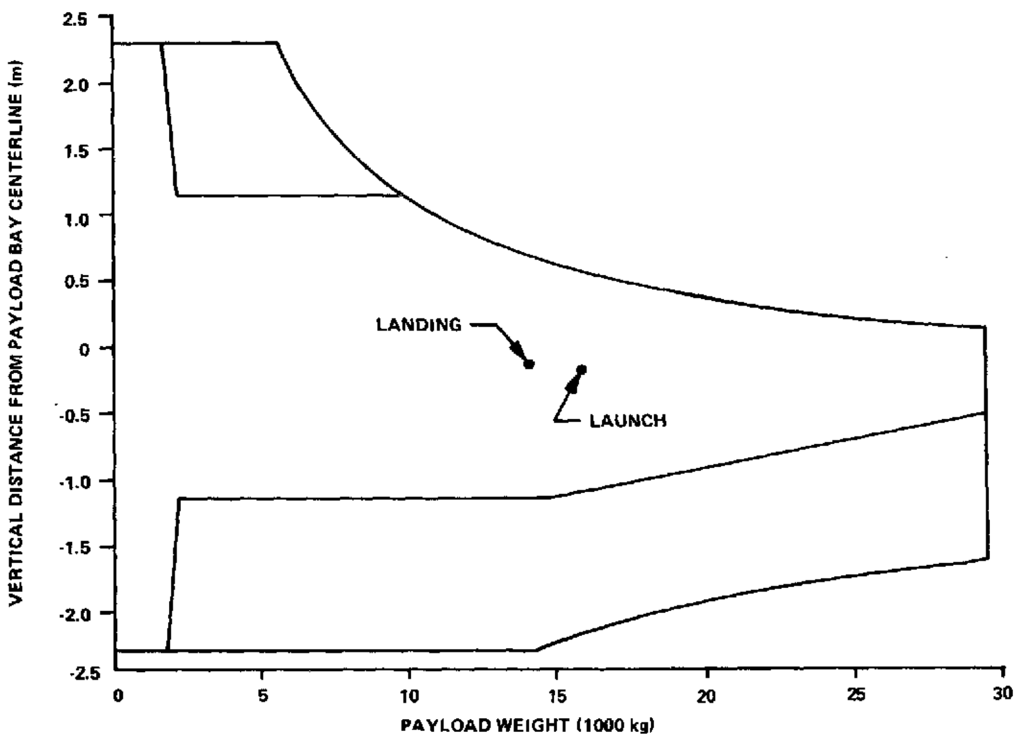


Figure 5-4. AMPS design reference Z-c.g. profile.

5.2 AMPS WEIGHT AND c.g. ASSESSMENT OF THREE ALTERNATE CONFIGURATIONS

An AMPS c.g. impact assessment was made on three alternate configurations: special platform forward, pallet forward, and reduced scientific instruments. These configurations were investigated in an attempt to move the payload c.g. to the rear such that it would meet the Orbiter c.g. envelope constraints.

In the special platform forward concept, low density instruments are mounted on the forward platform so that the pallet length may be reduced, hence allowing the heavy pressurized module to be moved rearward.

Reversing the pallet and Spacelab (second configuration) shows the c.g. impact of moving the pressurized module to the very rear end of the cargo bay.

The last case investigates the impact on the c.g. of arbitrarily reducing instrument size. The instruments were reduced by 50 percent in size and 20 percent in weight. This resulted in a 25-ft pallet length, thus allowing the pressurized module to be moved rearward 5 ft.

The configuration layouts used and the c.g. graphs generated by this study are shown in Figures 5-5 through 5-8. The April 1974 design reference data point is included for comparison purposes.

The following is a summary of results:

1. Landing weight exceeds the 32 000-lb limit for all except the reduced instrument configuration.

2. The X-c.g. is unacceptable for the special platform forward configuration.

3. The X-c.g. is acceptable for the pallet forward and the reduced instrument configurations.

4. The Y-c.g. and Z-c.g. are considered adequate at this time. The Y-c.g. should be monitored to insure that the envelope of approximately ±3 in. is met.

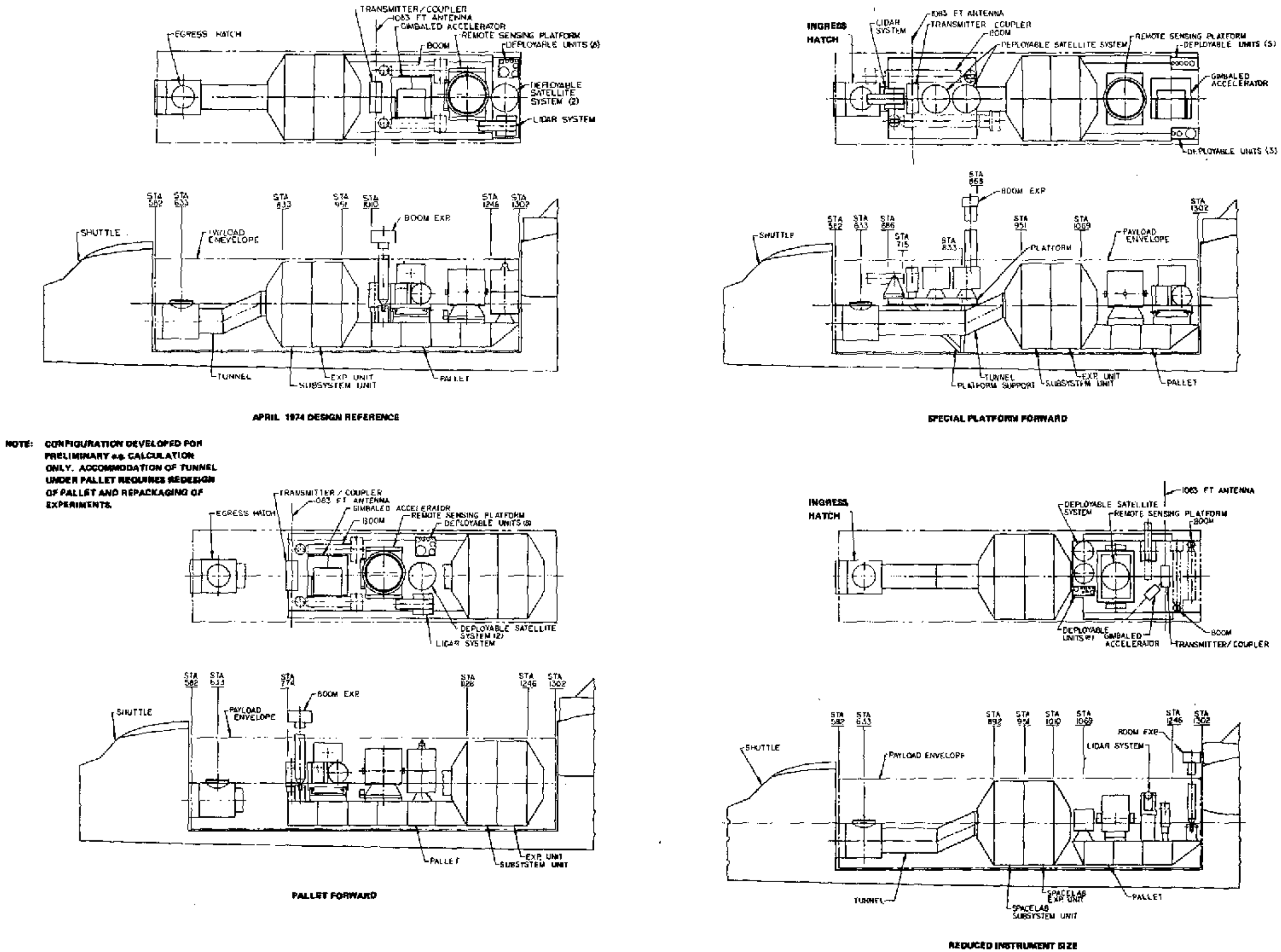


Figure 5-5. AMPS configurations under study.

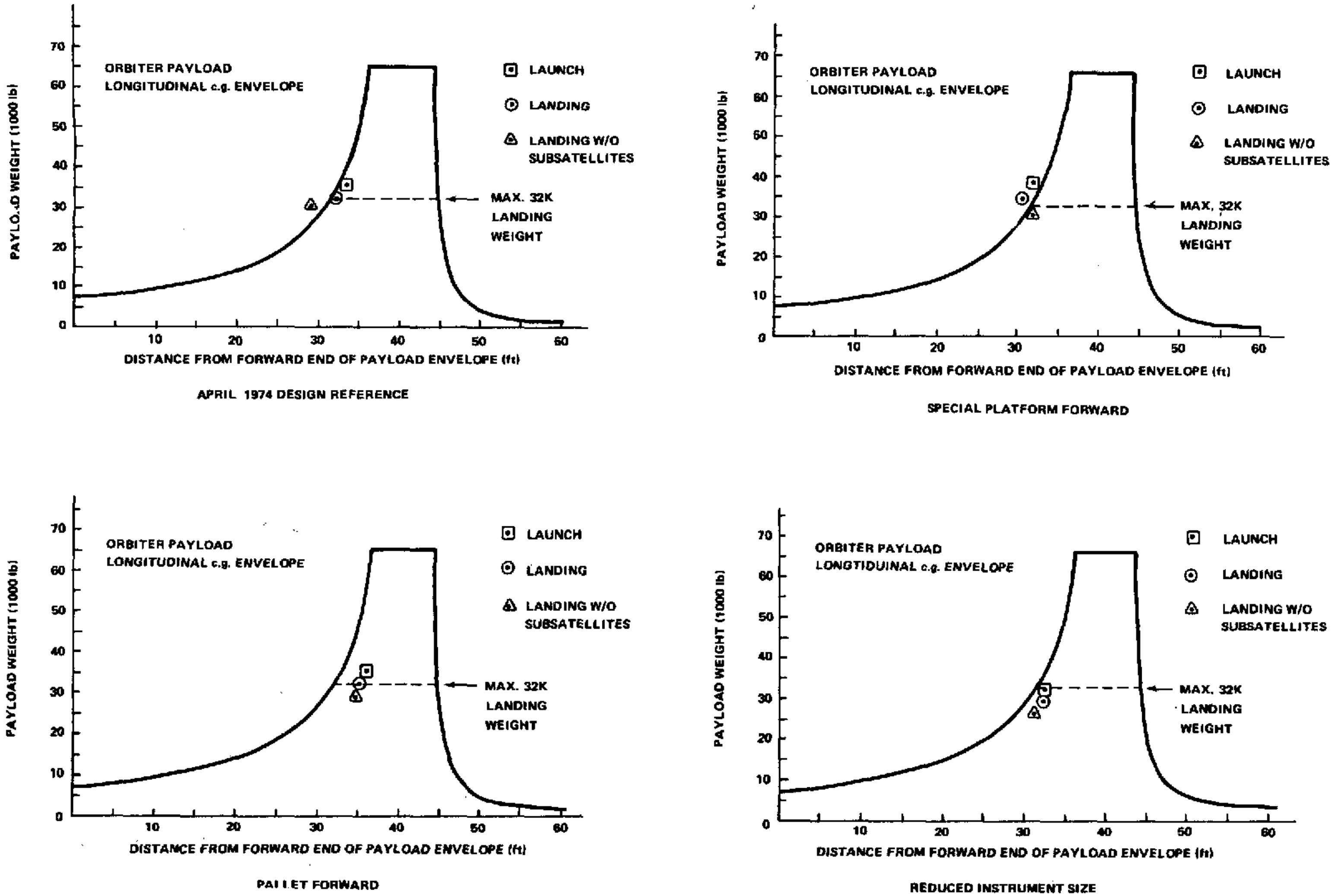


Figure 5-6. AMPS X-c.g. assessment.

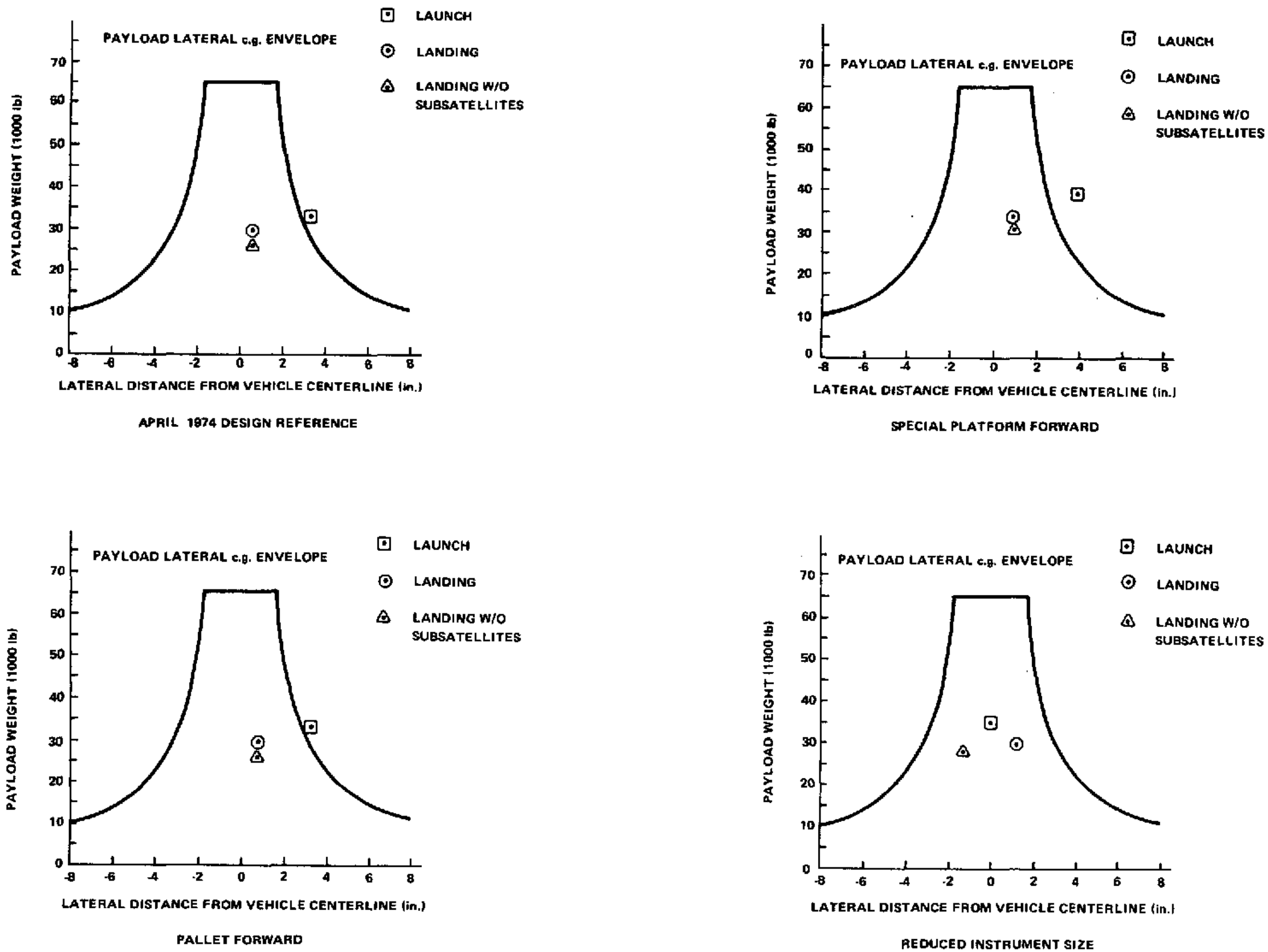


Figure 5-7. AMPS Y-c.g. assessment.

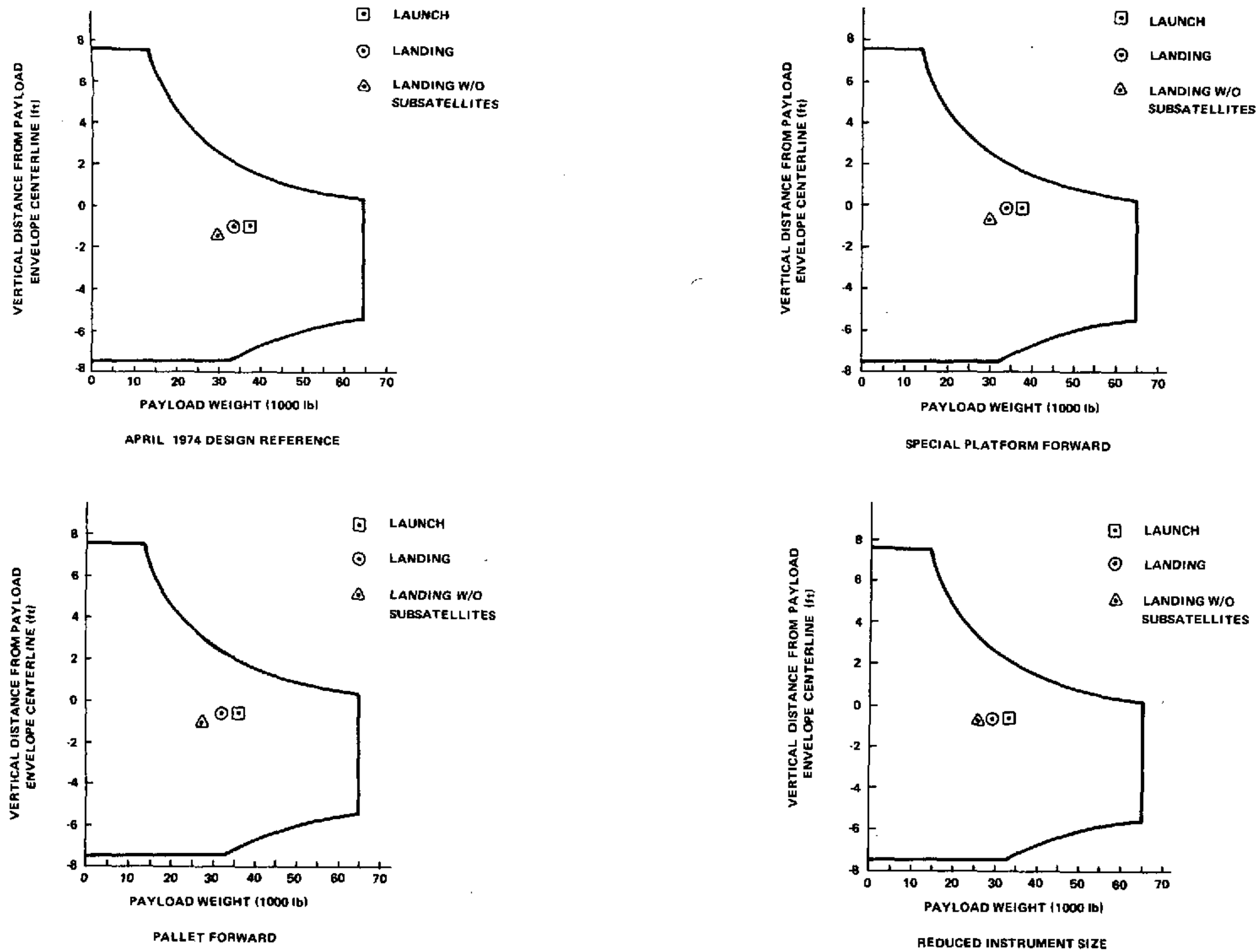


Figure 5-8. AMPS Z-c.g. assessment.

5.3 AMPS WEIGHT AND c.g. SENSITIVITY ANALYSIS OF VARIOUS SPACELAB AND PALLET LENGTHS

A study has been completed to determine the sensitivity on AMPS weight and longitudinal c.g. envelope of different combinations of pallet and Spacelab lengths of 10, 15, 20, 25, and 30 ft. Lengths greater than 30 ft and combinations greater than 40 ft were not considered because of the overweight and longitudinal c.g. problems.

The design reference scientific instrument layout, which is very tightly packaged, requires a 30-ft pallet and results in an average pallet packaging density of 4.4 lb/ft^3 (504 lb/linear ft). This was assumed to represent the maximum average pallet packaging density for determining the payload loading for pallets shorter than 30 ft as shown in Figures 5-9 through 5-14.

The scientific instrument weights located on the pallet were reduced at 10- and 20-percent intervals to determine the longitudinal (X) c.g. trend. This X-c.g. trend is forward and down which requires a minimum instrument weight in a few cases to maintain an acceptable X-c.g. envelope.

The AMPS weight, longitudinal (X) c.g., and payload capability impact may be determined from Figures 5-9 through 5-14 for any combination Spacelab/ pallet lengths considered in this study. The X-c.g. would be acceptable for the April, 1974 design reference and most of the configurations considered if the overall weight could be reduced uniformly from the Spacelab, integration and support equipment, and the scientific instruments.

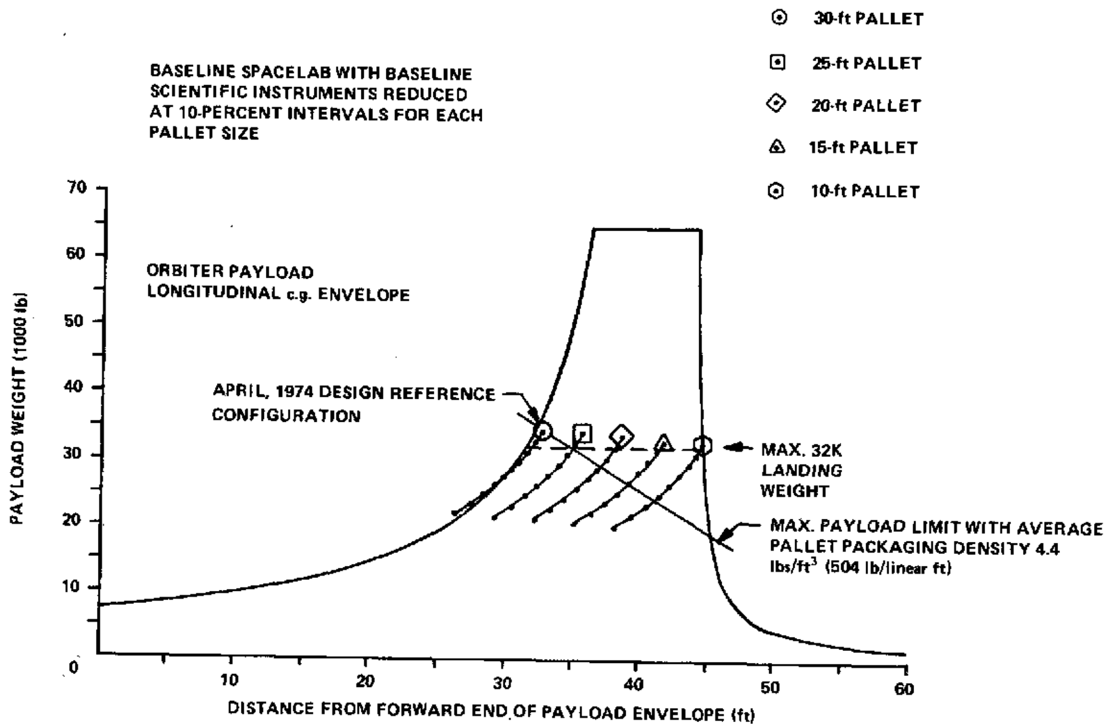


Figure 5-9. AMPS weight and c.g. sensitivity analysis, X-c.g.

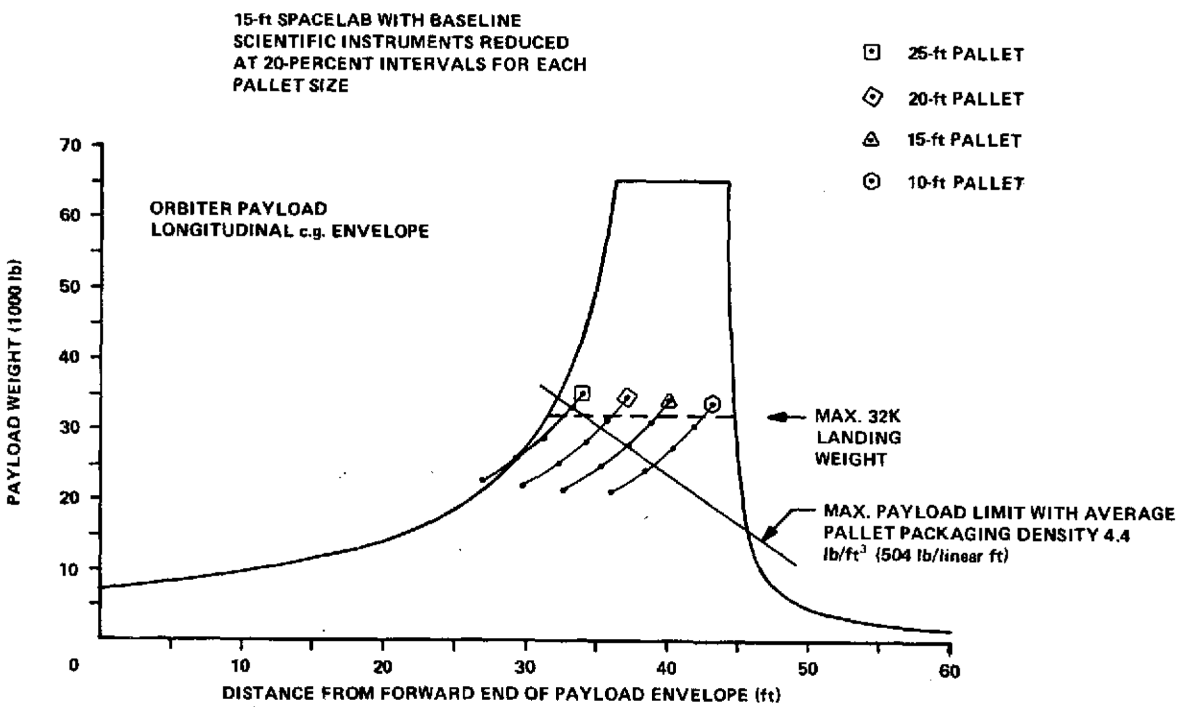


Figure 5-10. AMPS weight and c.g. sensitivity analysis, X-c.g.

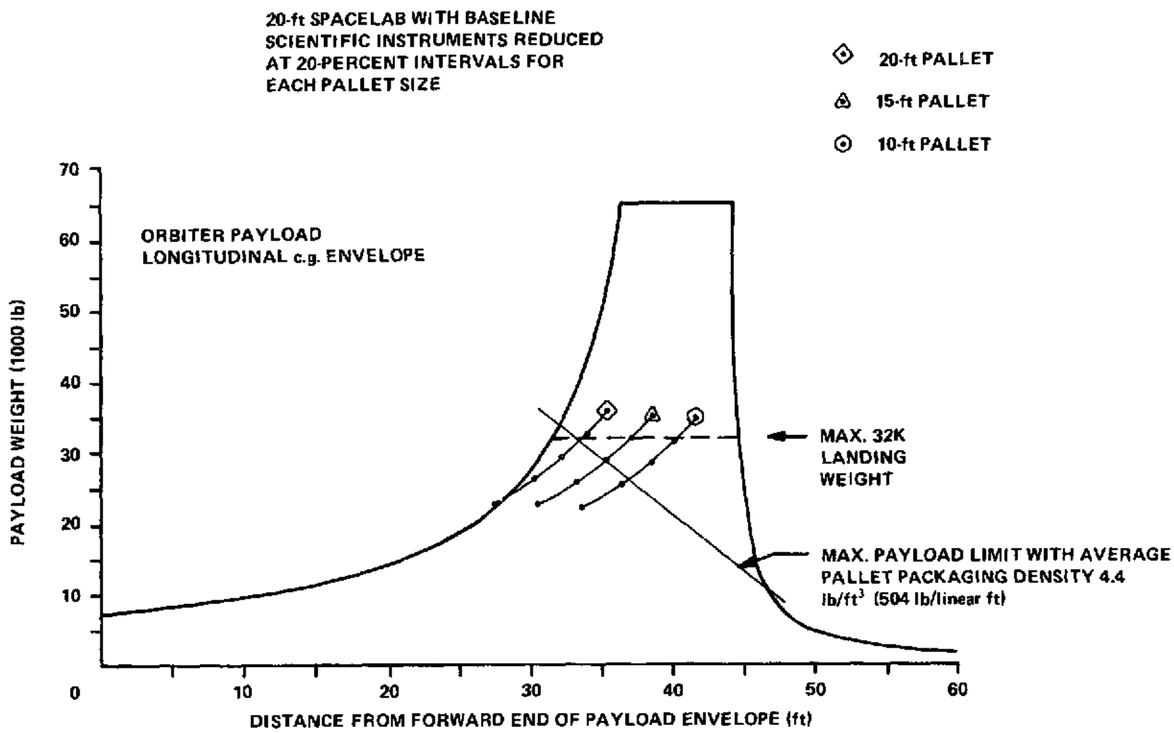


Figure 5-11. AMPS weight and c.g. sensitivity analysis, X-c.g.

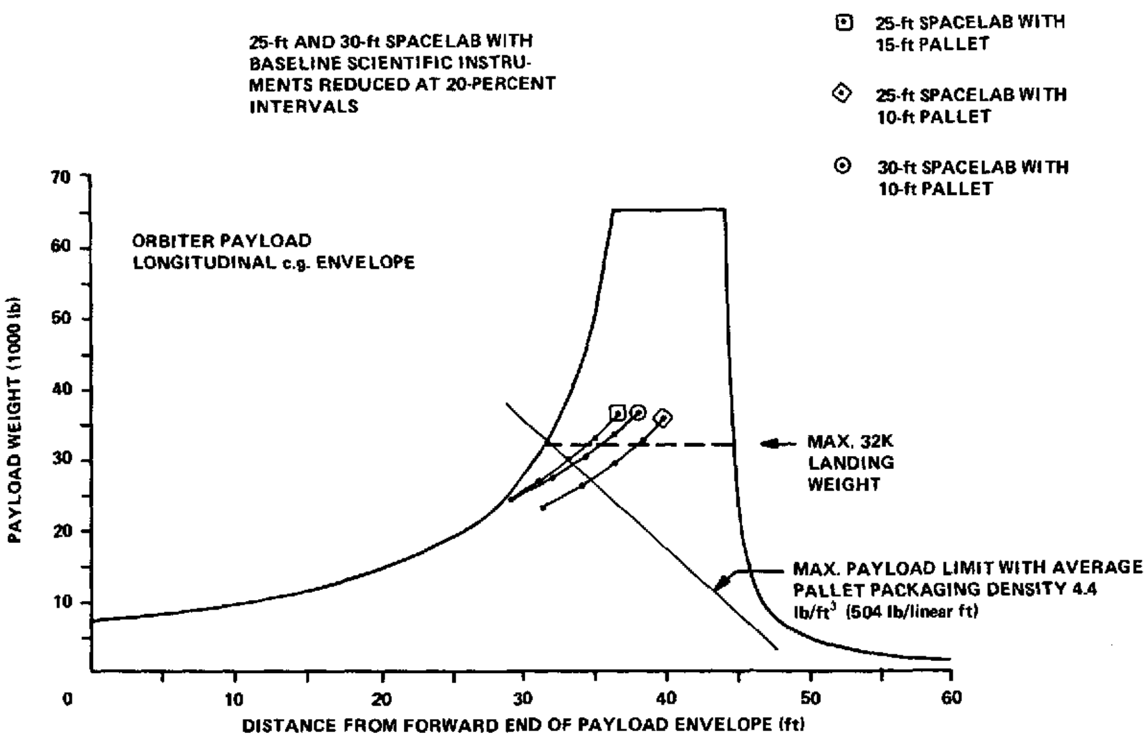


Figure 5-12. AMPS weight and c.g. sensitivity analysis, X-c.g.

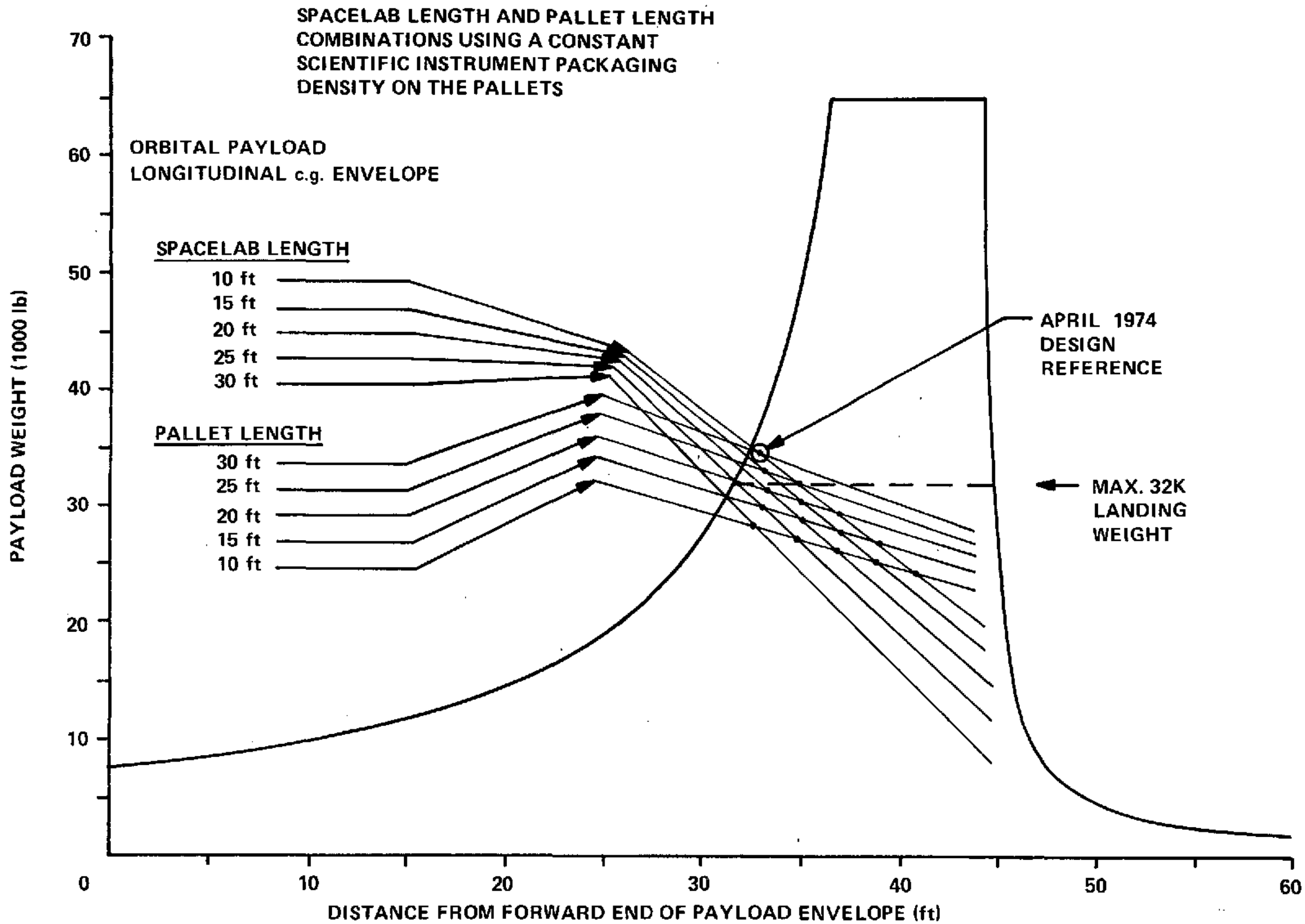


Figure 5-13. AMPS weight and c.g. sensitivity analysis, X-c.g.

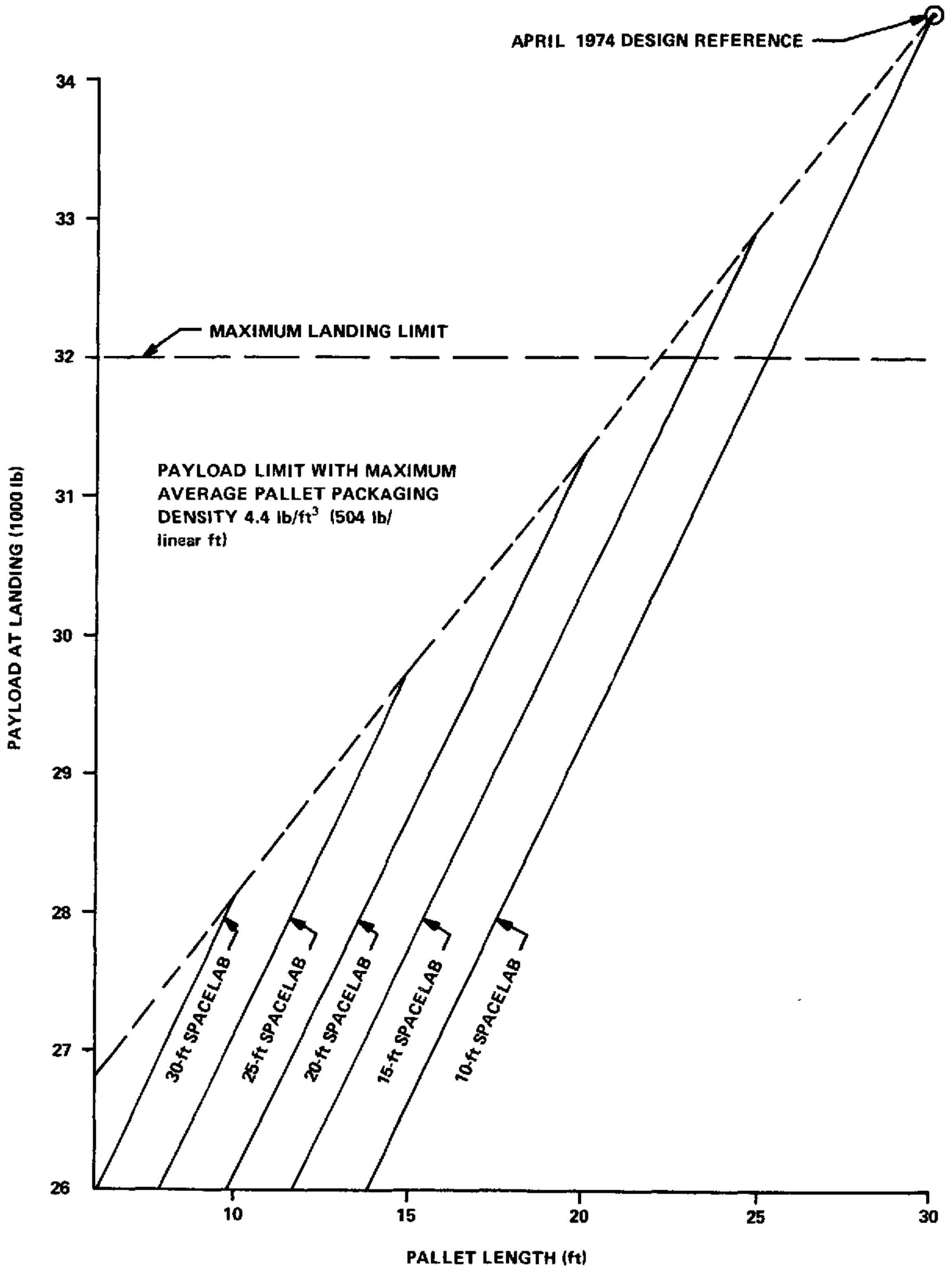


Figure 5-14. AMPS weight and c.g. sensitivity analysis.

SECTION 6.0 SUBSYSTEMS

6.0 SUBSYSTEMS

6.1 STRUCTURES

6.1.1 50 Meter Booms

6.1.1.1 Introduction

This section documents the considerations and analysis performed on the Atmospheric, Magnetospheric and Plasma in Space (AMPS) facility booms which are to be used for the wake and sheath experiments. The experiments require two booms, of which one is the exciter and the other is the measurement boom. To place the exciter and measurement package out of the Orbiter wake, the booms extend the instruments 51 m (167.8 ft) above the pallet floor. The base of both booms are gimbaled so that the boom can be moved in a motion pattern that will determine the detail characteristics of the wake structure.

It is required that the booms' instruments be separated by 85 m and then moved laterally. When the instruments reach the wake boundary, the booms are moved again bringing the instruments closer together, at which time another lateral motion in the opposite direction is started. The entire sweep pattern is discussed in Section 6.3.

While the instruments are making measurements, the relative rate between the exciter and measurement instruments is limited to 0.5 m/sec and, at the wake boundary where the instruments are moved closer together, a rate of 2.0 m/sec is allowed. Relative position of the instruments at the ends of the booms is important since relative pointing errors are limited to 0.5 deg. This zig-zag motion associated with the rates, length of boom and experiment instrument mass poses a severe dynamic problem.

6.1.1.2 Boom Type

There are two basic types of deployable booms that could be used for these types of application: (1) a furlable tube [(STEM) or tubular extendible element (TEE) being two specific types] and (2) a lattice structure that is stowed in a canister by coiling or articulating its members. Both of these types of booms can be made in various lengths and cross sections and can be constructed of many different materials. However, due to the extreme length of the boom and strength requirements that will obviously exist, a single furlable tube design would not be satisfactory and a design utilizing multiple tubes would become too complex and unreliable. Therefore, only lattice structure booms have been considered for the AMPS.

The articulated type of lattice boom was selected first primarily because of the practically unlimited boom size capability. The member sizes could also vary over a wide range and they could be constructed from a large variety of materials. This was an important aspect since the overall characteristic requirements of the boom were not known and the dynamic analysis would probably require boom characteristic iterations. It was believed that the size and materials could be selected to yield the final requirements without much difficulty.

In the articulated lattice design, the longeron and batten, or frame, members are attached at rotating joints. This proved to be undersirable since these joints necessarily require clearance in their components to allow trouble-free motion during stowing. The clearance allows a large free motion or slack in the boom. Calculations show that the tip rotations were excessive and, for this reason, the articulated design was dropped.

The coilable lattice boom is similar to the articulated boom but the movable joints are eliminated. Its longeron-to-batten joints are located so that, when the boom is forcibly twisted to buckle the battens, it then has the mobility necessary to coil into the stowed configuration. Its longerons and batten members are usually made of fiberglass and the diagonal members are typically steel cables.

The coilable boom is deployed and stowed by a motor-driven canister whose upper portion is a rotating three-lead screw nut. Lugs, which are attached to the boom at the longeron and batten joint, are engaged by the rotating nut threads. Thus, the boom is simply screwed into and out of the canister.

The physical characteristics of the AMPS boom are shown in Figure 6-1. These initial characteristics were established from a cursory analysis done on a simple cantilever beam model.

6.1.1.3 Dynamic Analysis

A transient response analysis of the booms was performed while they were being moved by torques applied to the gimbals. This analysis also includes the rigid body motions relative to the Orbiter. The configuration used for modeling is shown in Figure 6-1.

6.1.1.4 Model Description

An idealized discrete mathematical model of both booms attached to the Orbiter was constructed as shown in Figure 6-2. The motion of the structural system which includes the Orbiter was represented by 19 grid points connected by elastic members which have different mass densities. Concentrated masses were also included. A large mass of 9.5×10^4 kg located at node 10 represents the Orbiter. The Orbiter inertia properties are also lumped at this node. Masses were also located at nodes 1 and 19 which represent the measuring instrumentation, and at nodes 9 and 11 which represent the movable portion of the boom gimbal equipment. The 171.36 kg boom structural mass is located at discrete points along the boom length.

The geometrical locations of all node points and the lumped inertia properties at the nodes are summarized in Table 6-1 and the structural stiffness properties of the members are shown in Table 6-2. Elastic members 9, 19, and 10 simulate the Orbiter body and the stiffness of these members were made several orders of magnitude larger than those of the booms to represent the relatively high Orbiter body stiffness.

As shown in Figure 6-2, the measuring boom and exciter boom are hinged to the Orbiter at nodes 9 and 11, respectively, and are allowed to rotate about the X and Y axes.

6.1.1.5 Actuator Torques

Since the booms are hinged to the Orbiter at nodes 9 and 11, two deg of freedom of rigid body motion is permitted at each of these nodes. Actuator torques applied at these nodes are assumed to be equal and opposite. The torques about the X axis were applied at time t = 0 in the analysis and torques about the Y axis were applied 40 sec later. Figure 6-3 shows the details of the torque profiles used in this analysis. These torques are the forces required to drive the booms over their sweep pattern. The pattern is described and discussed in Section 6.3.

6.1.1.6 Inertia Coupling Between Booms and Orbiter

The joints at nodes 9 and 11 are structurally modeled as hinges which do not transmit torque. However, the motions of the booms are in reality controlled by actuators which do provide some constraint and will transmit torque all of the time. Without loss of generality, these constraints can be written in terms of the following kinetic 1 deg of freedom relationships between the boom and Orbiter:

$$I_o \ddot{\theta}_o = T_r \quad , \tag{1}$$

$$I_m \ddot{\theta}_m = T_r - F R_m \quad , \tag{2}$$

$$I_b \ddot{\theta}_b = T - F R_b \quad , \tag{3}$$

where

I_o = mass moment of inertia of the Orbiter about the hinge point,

I_m = mass moment of inertia of actuator,

I_b = mass moment of inertia of the boom about the hinge point,

$\ddot{\theta}_o$ = acceleration of Orbiter about the hinge point,

$\ddot{\theta}_m$ = acceleration of Orbiter about the actuator,

$\ddot{\theta}_b$ = acceleration of boom about the hinge point,

T = torque at the hinge point,

T_r = reaction torque of the Orbiter,

F = interface force in gear train,

R_m = radius of driver gear,

R_b = radius of boom gear.

The gear ratio N is defined as

$$N = R_b / R_m \quad . \tag{4}$$

Since the gears must rotate together, a kinematic relationship can be established:

$$R_m \theta_m = -R_b \theta_b$$

or

$$\theta_m = R_b \theta_b / R_m \quad .$$

Thus,

$$\ddot{\theta}_m = -N \ddot{\theta}_b \quad . \qquad (5)$$

By eliminating the T_r and F from equations (1) through (3) and substituting equations (4) and (5) into equations (1) through (3), the following inertia coupling relationship is derived:

$$I_b + N^2 I_n \ddot{\theta}_b - N I_o \ddot{\theta}_o = T \quad . \qquad (6)$$

A Laplace transform of equation (6) was input in the transient analysis as a transfer function. This will allow the effects of elastic deflections of the boom to be fed back to the Orbiter.

6.1.1.7 Results of the Analysis

Output of the NASTRAN analysis consists of a list of system natural frequencies, displacements, velocities, and accelerations at nodes 1, 9, 10, 11, and 19. The pointing errors and elastic deflections of nodes 1 and 19 are also computed through use of multipoint constraint relationships. Table 6-3 gives the list of natural frequencies, generalized masses, and generalized stiffnesses of the first 40 vibration nodes of the system.

Figures 6-4 and 6-5 show the pointing errors of the measuring boom tip in the X and Y directions, respectively. Figures 6-6 and 6-7 are the pointing errors of the exciter boom tip in the X and Y directions, respectively.

The rigid-body rotations about the X and Y axes of the measuring boom are shown in Figures 6-8 and 6-9. Figures 6-10 and 6-11 show the rigid body rotation, as a function of time, about the X and Y axes of the exciter boom. Elastic deflections in X and Y directions of the measuring boom are shown in Figures 6-12 and 6-13. Figures 6-14 and 6-15 show the elastic deflections in the X and Y directions of the exciter boom. Figures 6-16 through 6-19 show the tip mass displacements in the X and Y directions. These displacements include rigid body motions and the elastic deflection.

The final position of the Orbiter center of mass changed slightly: -0.12 mm (-4.79×10^{-3} in.) and -0.13 mm (-5.11×10^{-3} in.) in the X and Y directions, respectively, and 1.02×10^{-5} radians and -1.5×10^{-3} radians about the X and Z axes, respectively.

6.1.1.8 Conclusions

The boom system, as presently configured in the analysis, appears to provide only marginally acceptable performance since the pointing error exceeds the 0.5 deg limit for many seconds after the gimbals are torqued. It should be understood, however, that this limit is preliminary and can probably be increased, making the performance much more acceptable.

The overall size of the boom and the size of the structural members have been increased to what is believed to be the maximum for present day manufacturing capability. Any additional requirement for stiffness to reduce the deflection will result in extensive changes in the configuration and materials used.

The deflection can be reduced by decreasing the boom length and tip masses. Considerable reduction in deflection will result if the length is reduced; however, a smaller decrease will result if the tip masses are reduced.

The sweep pattern and, thus, the gimbal torque are considered very extreme. Sweep patterns that will minimize the acceleration forces on the booms should be devised. If this is accomplished, the boom configuration should provide adequate performance with deflections less than 0.5 deg.

6.1.2 <u>AMPS Long Wire Antenna</u>

6.1.2.1 Introduction

A 305 m (1000 ft) long wire antenna is proposed for use on the AMPS payload. It will be used primarily for ionospheric sounding and magnetospheric particle precipitation experiments. Other uses will be for electric field distributions and studies related to the long antenna itself. The experiments currently identified do not require steering of the antenna to obtain a specific orientation; however, this may become a requirement later.

Exact operating frequency requirements for the experiments are not defined yet but ranges are 100 kHz to 20 MHz with radiated power levels up to 1 kW. The lower frequency operation will provide the worst case conditions for design.

Two TEE type booms forming a dipole antenna have been proposed for use on AMPS. By varying the element length, a wide range of frequencies can be accommodated. The boom is a thin metal strip that is spool-wound as a ribbon during storage but upon controlled release it forms into a tubular shape. A typical motorized TEE type boom mechanism consists of an element storage reel, a motor with gear or belt drive, element guide supports, and the associated control electronics. The entire mechanism is housed in a relatively small, lightweight support structure.

Several boom configurations are available for use. One of these has tabs along its longitudinal edges that engage when the boom deploys. This results in a "zippered" seam which provides the boom with a degree of torsional rigidity and mechanical properties that approach those of a closed tube. This type of boom was chosen for the AMPS use because the extreme length will cause torsional motions to be introduced even though the system may not be directly excited in that direction. Material thickness of the nominal boom is 0.05 mm (0.002 in.) and the diameter when the boom is extended is 14.7 mm (0.58 in.). These dimensions and the choice of material were varied as applicable during the analysis and these changes will be discussed in the other sections of this report.

Several payloads have employed various lengths and configurations of TEE type booms. The Radio Astronomy Explorer (RAE) satellite, for instance, used a dipole antenna that had an element length of 750 ft. This satellite's antenna had several design problems and annoying deflection and dynamic problems that had to be overcome. Since the AMPS will use a similar but longer antenna, many of the same problems will obviously exist.

6.1.2.2 Thermal Bending

The boom element can be made of several materials but steel and beryllium copper are the most common materials, particularly for very long booms.

A thermal analysis was performed to determine the temperature difference between the surface exposed to the sun and the surface in the shade. The results of this analysis are given in the thermal analysis section of this report.

The antenna deflection caused by the temperature gradient was computed by the equation:

$$\text{Deflection} = \frac{L^2 A \Delta T}{2d} ,$$

where

L = length,

A = thermal coefficient of expansion,

d = diameter of boom,

ΔT = temperature gradient.

The results are shown in Table 6-4. As can be seen in the table, the large temperature gradients cause unacceptable deflections; therefore, methods of reducing the gradient were investigated.

The first method employed was to perforate the boom material with small randomly placed holes. This will allow some of the solar energy to pass through the holes and be absorbed by the opposite side of the tube, thus reducing the thermal gradient. The deflections resulting from these temperature differences are shown in Table 6-5.

The deflections shown in Table 6-5 are also large but several other techniques can be used to reduce the gradients. The outside of the element can be coated with highly polished silver or aluminum, thus reflecting some of the solar energy. In conjunction with a perforated tube, the inside surface of the tube can be coated black so that energy would be absorbed by the far side of the tube. Theoretically, the temperature gradient would approach zero but will probably be about 0.014°C (0.25°F). The deflection with a 0.014°C temperature difference will still be in excess of 15 m (49 ft).

Trade analyses to determine the material thickness, size and number of holes, and hole spacing will have to be performed in order to obtain an optimum configuration.

6.1.2.3 Antenna Strength Analysis

The weight, bending stiffness, and local buckling stress for the element are expressed by:

$$W = 8.78\,D\,R\,T\,L \quad ,$$

$$EI = 4.92\,E\,R^3\,T \quad ,$$

$$f_{cr} = \frac{0.2\,E\,T}{R} \quad ,$$

where

D = density,

R = element radius,

T = thickness,

L = length,

E = modulus of elasticity.

The strength of the antenna does not appear to be a problem with static conditions; however, the stiffness and the critical buckling strength are the more important parameters when dynamic motions are considered. The critical buckling strength (f_{cr}) will be used in the dynamic analysis to determine the allowable base excitation.

6.1.2.4 Antenna Dynamics

The antenna elements are long and very flexible and will have very low natural frequencies. An eigenvalue analysis was performed to obtain the mode shapes and natural frequencies. The resulting bending frequencies are shown in Table 6-6. Associated with these frequencies is the allowable harmonic base rotation motion that, if imposed for a sufficient length of time, will cause a buckling failure at the boom base.

As can be seen in the table, the allowable base excitation is very frequency-dependent and the range of frequencies is wide. From this, it is expected that thermal bending, gravity gradients, and many mechanical vibrations will have effects on the antenna elements and will result in very large deflections, if not failure, if they are allowed to excite the boom for a long enough period of time. If the orbital period coincides with the period of the first few modes, motions large enough to cause failure will result. Loads resulting from solar pressure and aerodynamic loadings can also be significant even at the higher altitudes.

No attempt to identify all of the possible excitations has been made but it is imperative that the more prevalent ones be identified and studied.

6.1.2.5 Conclusions

Dynamic and thermal deflection of the boom will obviously be a problem. The thermal deflections can probably be brought within the acceptable range with design changes; however, the dynamic problems cannot be alleviated as easily. Boom stiffness cannot be increased effectively with material thickness or boom diameter changes. Therefore, the obvious solution to this problem is to choose an adequate timeline that will allow the antenna to be used under optimum loading conditions and to retract the elements when the experimentation is complete. Another solution is to reduce the length of the boom elements.

Booms that are adequate for the AMPS's nominal operating conditions can be supplied with the current technology and manufacturing capability.

TABLE 6-1. COORDINATES AND INERTIAL PROPERTIES FOR DYNAMIC MODEL OF AMPS BOOM

Grid Point	Mass[a] (kg)	x (m)	y (m)	z (m)	I_x[b] (kg-m²)	I_y[b] (kg-m²)	I_z[b] (kg-m²)
1	59.72	-6.85	1.53	-50.00	61.9	61.9	8.83
2	13.44	-6.85	1.53	-43.17	115.0	115.0	–
3	13.44	-6.85	1.53	-36.34	115.0	115.0	–
4	13.44	-6.85	1.53	-29.51	115.0	115.0	–
5	13.44	-6.85	1.53	-22.68	115.0	115.0	–
6	13.44	-6.85	1.53	-15.85	115.0	115.0	–
7	13.44	-6.85	1.53	- 9.02	115.0	115.0	–
8	12.59	-6.85	1.53	- 2.18	72.9	72.9	–
9	5.86	-6.85	1.53	0	15.4	15.4	–
10	95 000	0	0	0	1 100 000	8 100 000	8 400 000
11	5.86	-6.85	-1.53	0	15.4	15.4	–
12	12.59	-6.85	-1.53	- 2.18	72.9	72.9	–
13	13.44	-6.85	-1.53	- 9.02	115.0	115.0	–
14	13.44	-6.85	-1.53	-15.85	115.0	115.0	–
15	13.44	-6.85	-1.53	-22.68	115.0	115.0	–
16	13.44	-6.85	-1.53	-29.51	115.0	115.0	–
17	13.44	-6.85	-1.53	-36.34	115.0	115.0	–
18	13.44	-6.85	-1.53	-43.17	115.0	115.0	–
19	64.22	-6.85	-1.53	-50.00	57.5	57.5	–
20	–	-6.85	0	0	–	–	–

a. Total mass = 95 322.1 kg (210 185 lb).

b. I_x, I_y and I_z are the mass moments of inertia about the X-, Y-, and Z-axis, respectively.

TABLE 6-2. STRUCTURAL PROPERTIES FOR DYNAMIC MODEL OF AMPS BOOM

Member		Area		I_y[a]		I_x[a]		E[b]		G[c]	
From	To	cm^2	($in.^2$)	10^3 cm^4	($in.^4$)	10^3 cm^4	($in.^4$)	10^6 kg/cm^2	(10^6 psi)	10^6 kg/cm	(10^6 psi)
1	2										
2	3										
3	4										
4	5	3.08	(0.477)	1.96	(0.047)	1.95	(0.047)	0.5284	(7.5)	0.02554	(0.363)
5	6										
6	7										
7	8										
8	9	96.68	(14.985)	79.8	(1.917)	159.6	(3.834)	0.74	(10.5)	0.285	(4.05)
20	9	100	(15.5)	5000	(120)	5000	(120)	0.5284	(7.5)	0.02554	(0.363)
10	20	100	(15.5)	5000	(120)	200	(4.8)	0.5284	(7.5)	0.02554	(0.363)
20	11	100	(15.5)	5000	(120)	5000	(120)	0.5284	(7.5)	0.02554	(0.363)
11	12	96.68	(14.985)	79.8	(1.917)	159.6	(3.834)	0.74	(10.5)	0.285	(4.05)
12	13										
13	14										
14	15										
15	16	3.08	(0.477)	1.96	(0.047)	1.95	(0.047)	0.5284	(7.5)	0.02554	(0.363)
16	17										
17	18										
18	19										

a. I_x and I_y are area moments of inertia about member longitudinal- and lateral-axis, respectively.

b. E is the modulus of elasticity.

c. G is the shear modulus.

TABLE 6-3. A LIST OF NATURAL FREQUENCIES, GENERALIZED MASSES, AND GENERALIZED STIFFNESSES

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	10	.0	.0	.0	4.351483+01	.0
2	9	.0	.0	.0	4.352323+01	.0
3	8	.0	.0	.0	1.803749+05	.0
4	7	.0	.0	.0	8.100600+06	.0
5	6	.0	.0	.0	1.100000+06	.0
6	5	.0	.0	.0	9.500000+04	.0
7	4	.0	.0	.0	9.528092+04	.0
8	3	.0	.0	.0	9.528092+04	.0
9	2	.0	.0	.0	8.649943+01	.0
10	1	.0	.0	.0	8.649943+01	.0
11	33	1.000391+00	1.000196+00	1.591861-01	6.115744+01	6.118136+01
12	35	1.000511+00	1.000256+00	1.591956-01	6.116153+01	6.119279+01
13	34	1.364050+00	1.167926+00	1.858811-01	6.305864+01	8.601515+01
14	32	1.364193+00	1.167987+00	1.858908-01	6.306122+01	8.602765+01
15	31	1.180613+01	3.436005+00	5.468572-01	8.887909+00	1.049318+02
16	27	1.180665+01	3.436080+00	5.468691-01	6.359174+01	7.508052+02
17	28	1.180693+01	3.436121+00	5.468756-01	6.329130+01	7.472757+02
18	30	1.329984+01	3.640034+00	5.793294-01	7.569647+01	1.002966+03
19	29	1.325012+01	3.640072+00	5.793355-01	7.569772+01	1.003004+03
20	25	4.815659+01	6.939495+00	1.104455+00	9.957681+01	4.795240+03
21	23	4.816042+01	6.939771+00	1.104499+00	9.957260+01	4.795458+03
22	26	5.048037+01	7.104954+00	1.130789+00	9.738288+01	4.915924+03
23	24	5.048451+01	7.105245+00	1.130835+00	9.737770+01	4.916065+03
24	16	1.217766+02	1.103524+01	1.756314+00	1.091167+02	1.328786+04
25	15	1.217984+02	1.103623+01	1.756471+00	1.090944+02	1.328753+04
26	17	1.243451+02	1.115102+01	1.774739+00	1.108645+02	1.378546+04
27	18	1.243670+02	1.115200+01	1.774896+00	1.108563+02	1.378606+04
28	12	2.353437+02	1.534092+01	2.441583+00	1.664273+02	3.916762+04
29	11	2.353957+02	1.534261+01	2.441852+00	1.664556+02	3.918294+04
30	13	2.379711+02	1.542631+01	2.455174+00	1.643460+02	3.911006+04
31	14	2.380210+02	1.542793+01	2.455431+00	1.643646+02	3.912228+04
32	20	3.774562+02	1.942823+01	3.092099+00	2.384794+02	9.001554+04
33	19	3.775145+02	1.942973+01	3.092338+00	2.385313+02	9.004902+04
34	22	3.808006+02	1.951411+01	3.105766+00	2.337702+02	8.901983+04
35	21	3.808567+02	1.951555+01	3.105996+00	2.338066+02	8.904683+04
36	37	5.009566+02	2.238206+01	3.562216+00	5.624334+02	2.817547+05
37	36	5.009724+02	2.238241+01	3.562272+00	5.626038+02	2.818490+05
38	39	5.059124+02	2.249250+01	3.579792+00	5.174380+02	2.617783+05
39	38	5.059267+02	2.249282+01	3.579843+00	5.175801+02	2.618576+05
40	42	1.084135+03	3.292621+01	5.240369+00	7.475399+01	8.104342+04

TABLE 6-4. THERMAL DISTORTIONS

Deflection (m)	Material	ΔT (°C)
85	Be-Cu	1.4
475	Steel	12.0

TABLE 6-5. THERMAL DISTORTIONS

Deflection (m)	Material	ΔT (°C)
39	Be-Cu	0.65
277	Steel	7.0

TABLE 6-6. ALLOWABLE HARMONIC ORBITER MOTION THAT PRECLUDES 330 m ANTENNA FAILURE

Mode	Natural Frequency (Hz)	Period (hr)	Base Excitation (degrees allowable)
1	0.35×10^{-4}	7.94	239.0
2	0.246×10^{-3}	1.13	34.0
3	0.69×10^{-3}	0.40	12.0
4	0.13×10^{-2}	0.21	6.4
5	0.208×10^{-2}	0.14	4.0
6	0.29×10^{-2}	0.096	2.9
70	1.0	3.0×10^{-4}	0.008

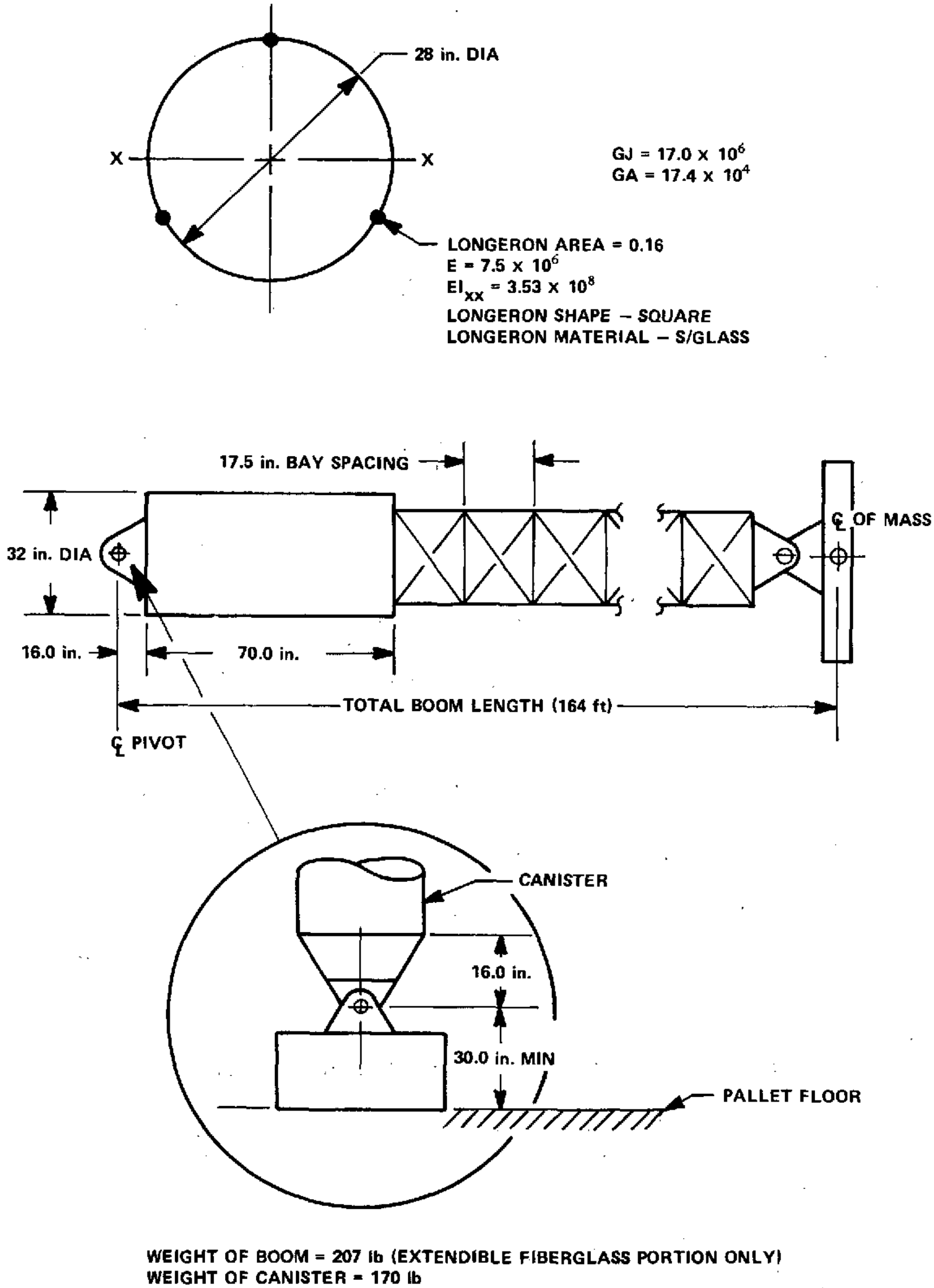
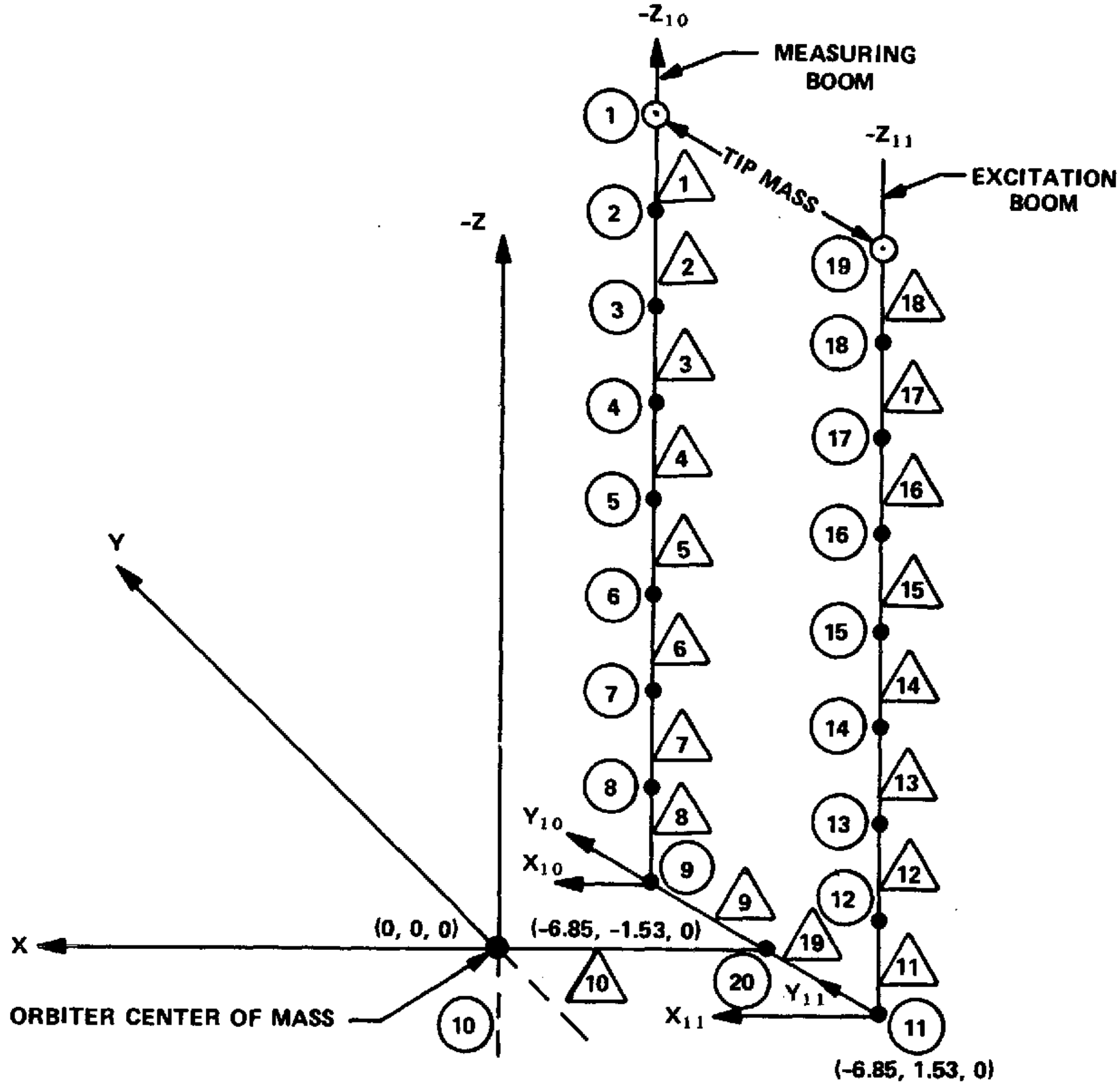


Figure 6-1. Structural characteristics of an AMPS boom.



GRID IDENTIFICATION NUMBERS (TOTAL GRID POINTS = 20)

ELEMENT IDENTIFICATION NUMBER (TOTAL ELEMENTS = 19)

(X, Y, Z) REFERENCE COORDINATE SYSTEM

(X_{10}, Y_{10}, Z_{10}) DISPLACEMENT COORDINATE SYSTEM FOR GRID POINTS 1 THROUGH 9

(X_{11}, Y_{11}, Z_{11}) DISPLACEMENT COORDINATE SYSTEM FOR GRID POINTS 11 THROUGH 19

Figure 6-2. Orbiter with deployed AMPS booms structural model.

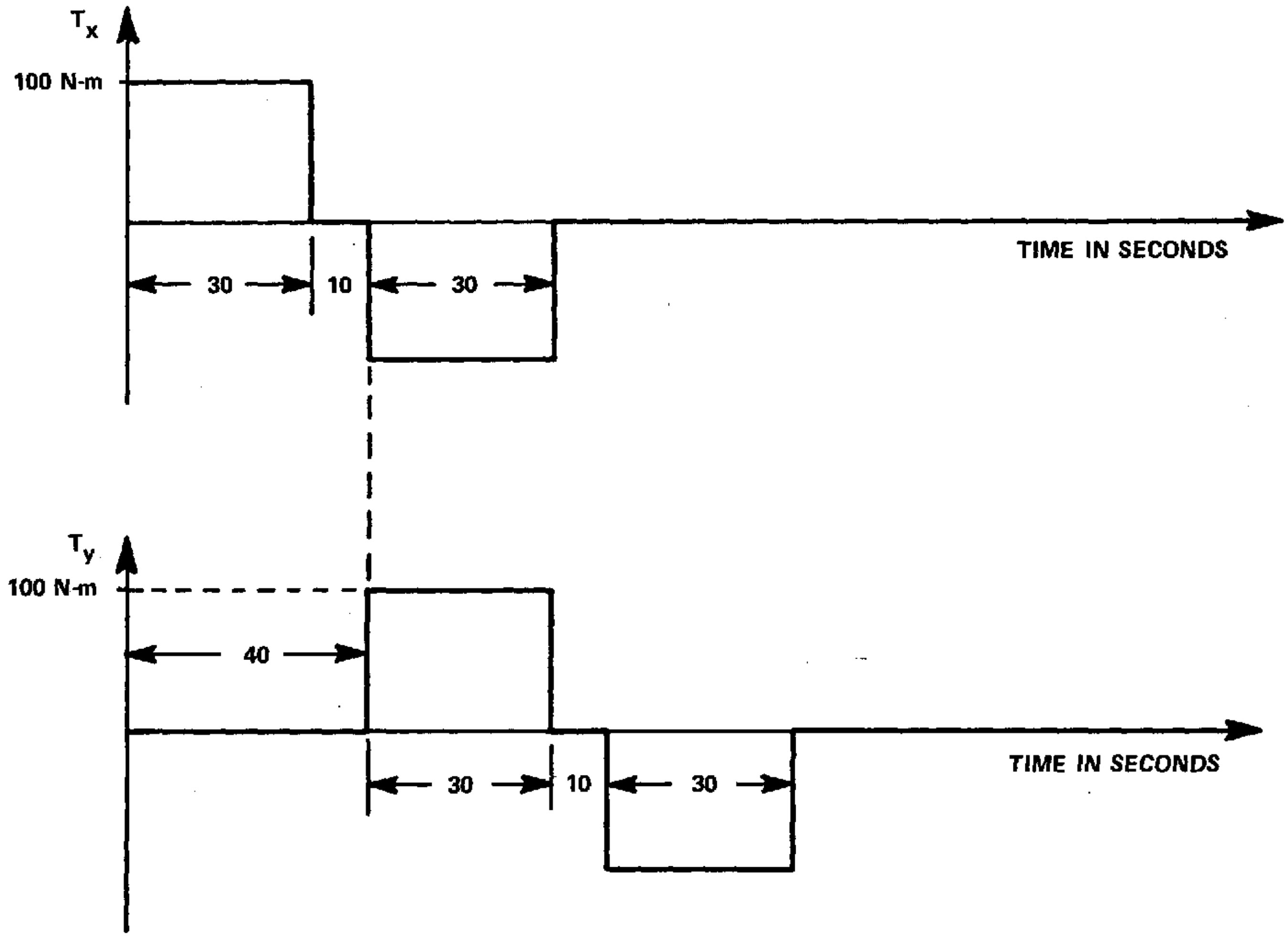


Figure 6-3. Torque profiles applied at boom gimbals to effect sweep motion.

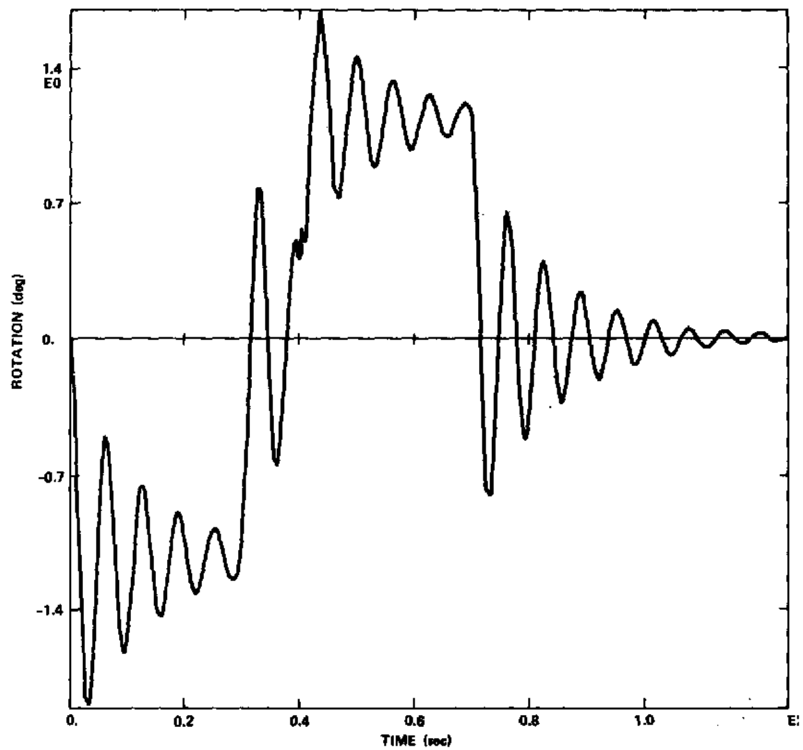


Figure 6-4. Pointing error of tip mass 1 (R_x).

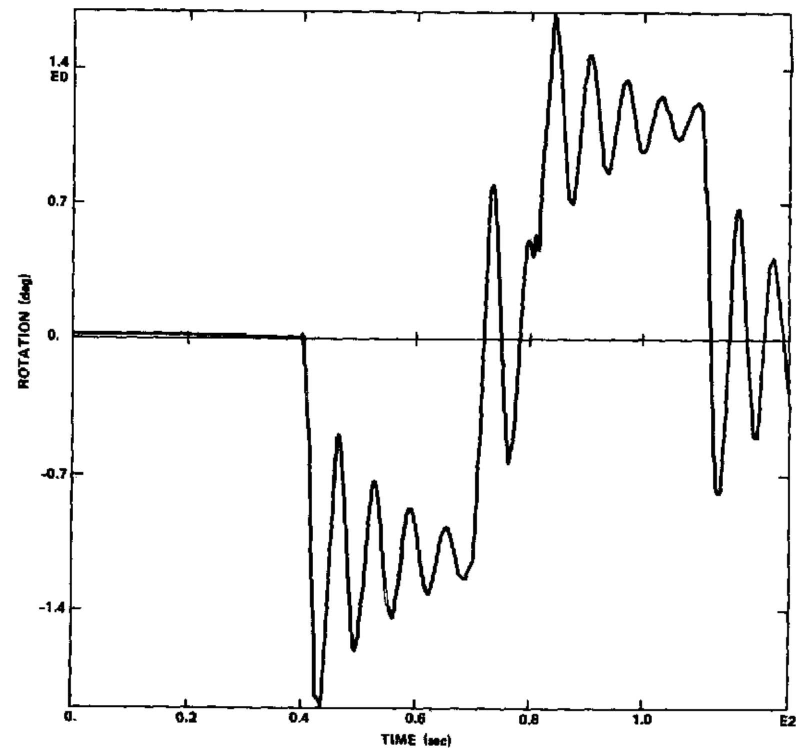


Figure 6-5. Pointing error of tip mass 1 (R_y).

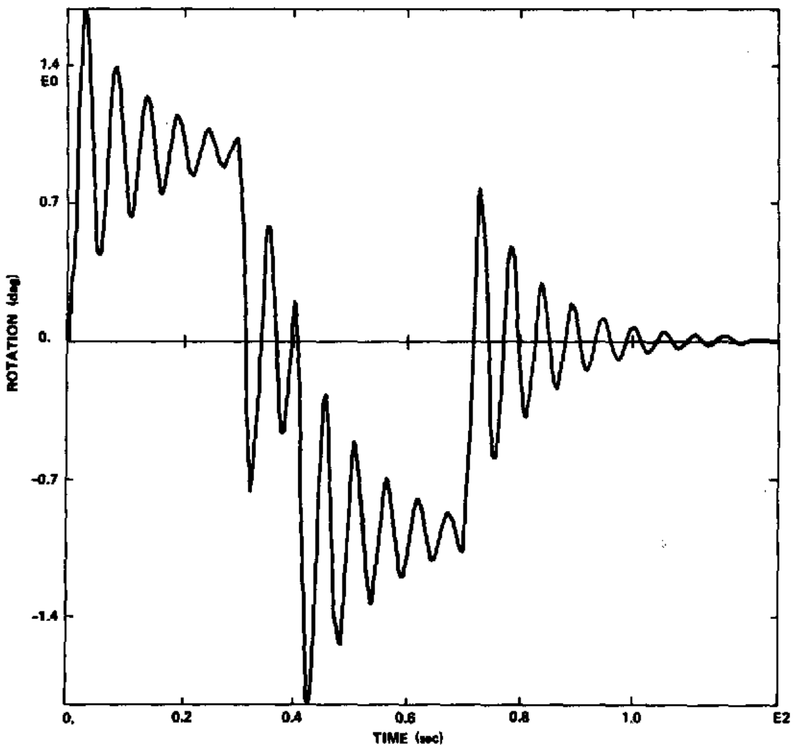


Figure 6-6. Pointing error of tip mass 2 (R_x).

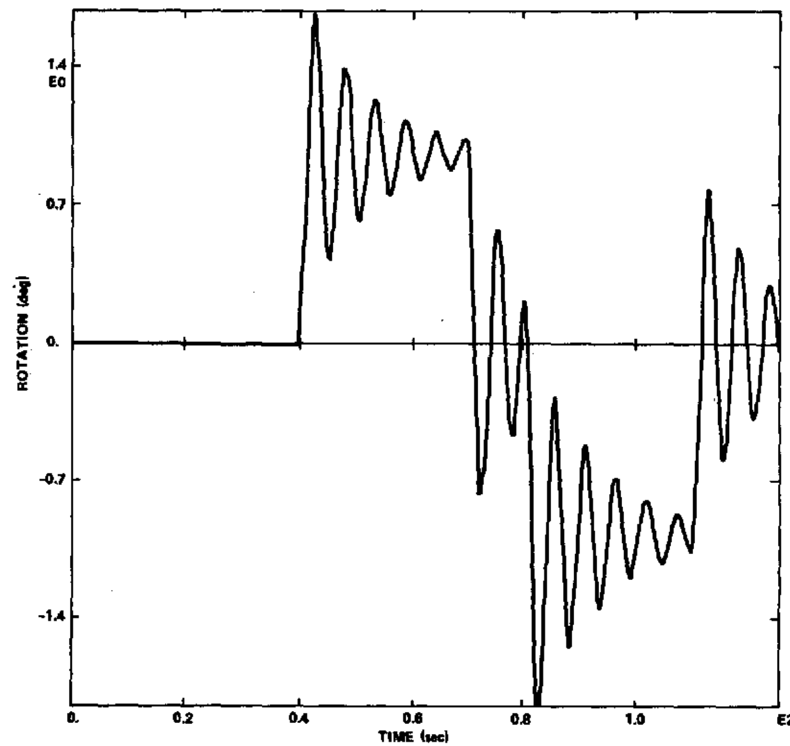


Figure 6-7. Pointing error of tip mass 2 (R_y).

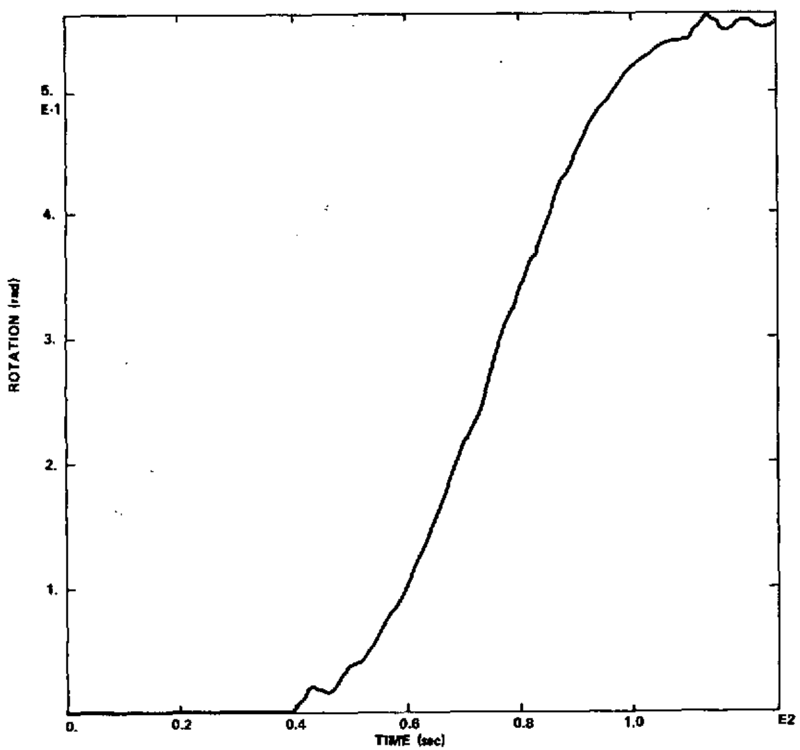


Figure 6-8. Rigid body rotation about X-axis (node 9).

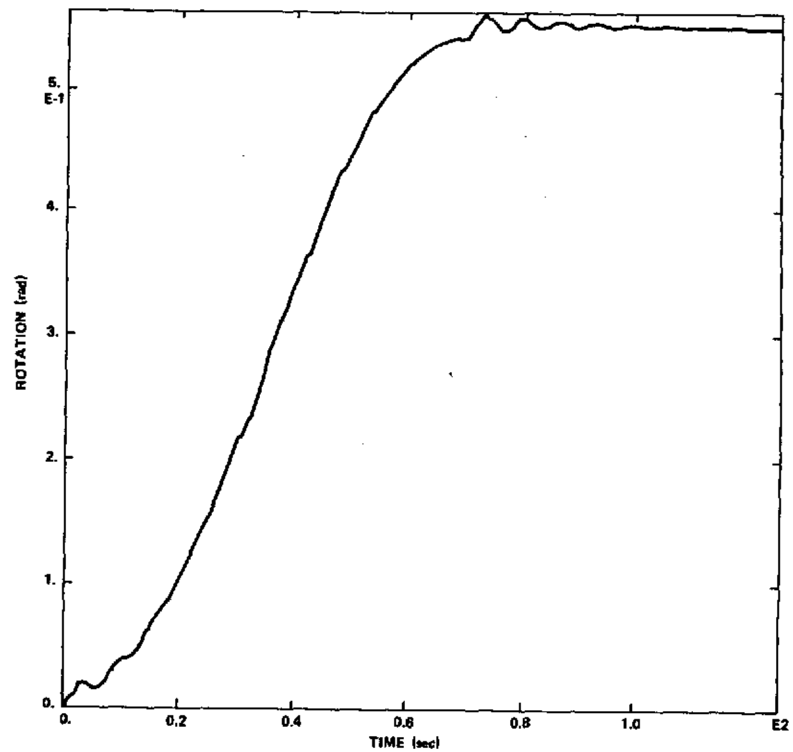


Figure 6-9. Rigid body rotation about Y-axis (node 9).

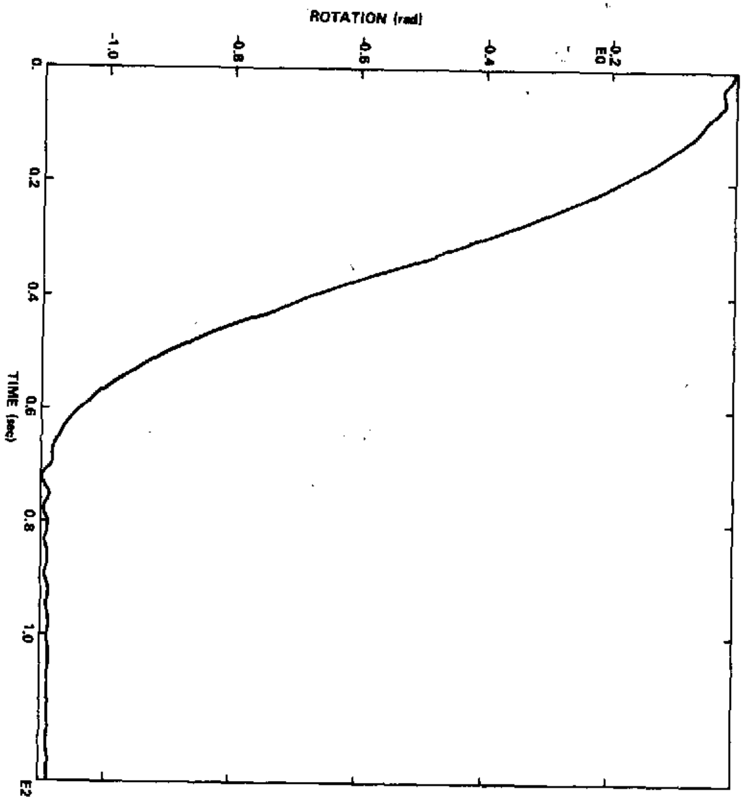


Figure 6-10. Rigid body rotation about X-axis (node 11).

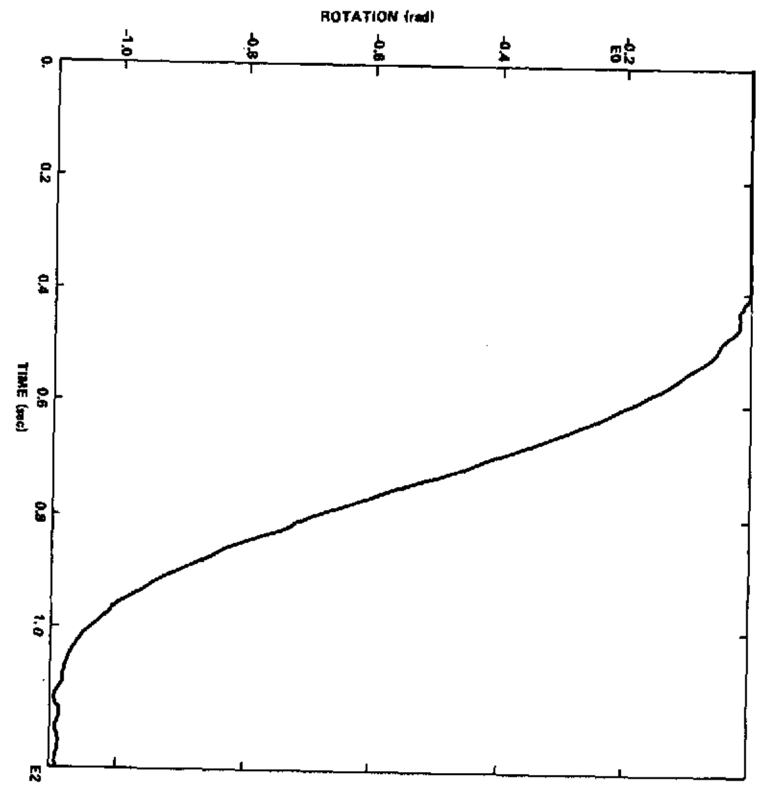


Figure 6-11. Rigid body rotation about Y-axis (node 11).

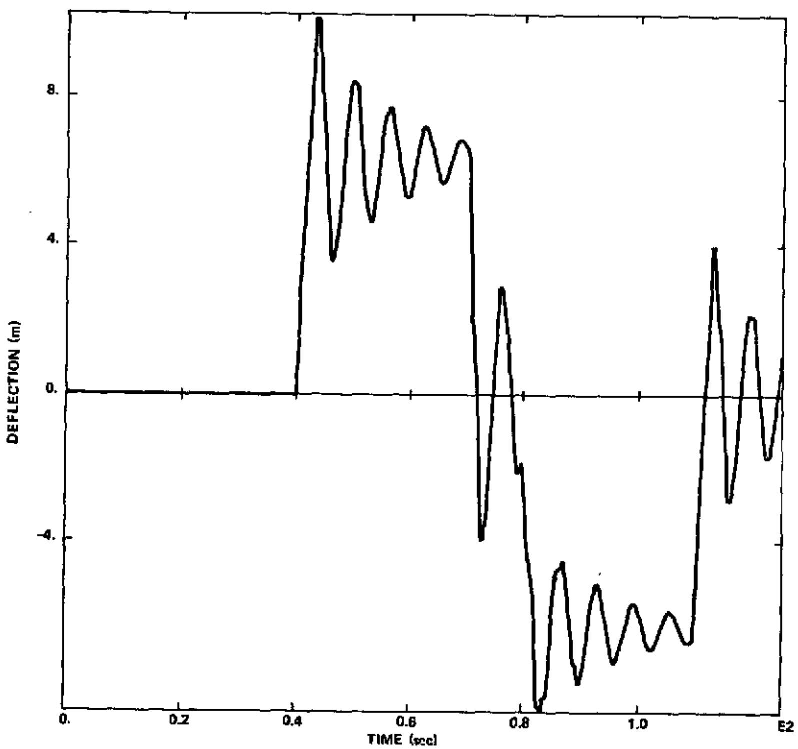


Figure 6-12. Elastic deflection of tip mass 1 (T_x).

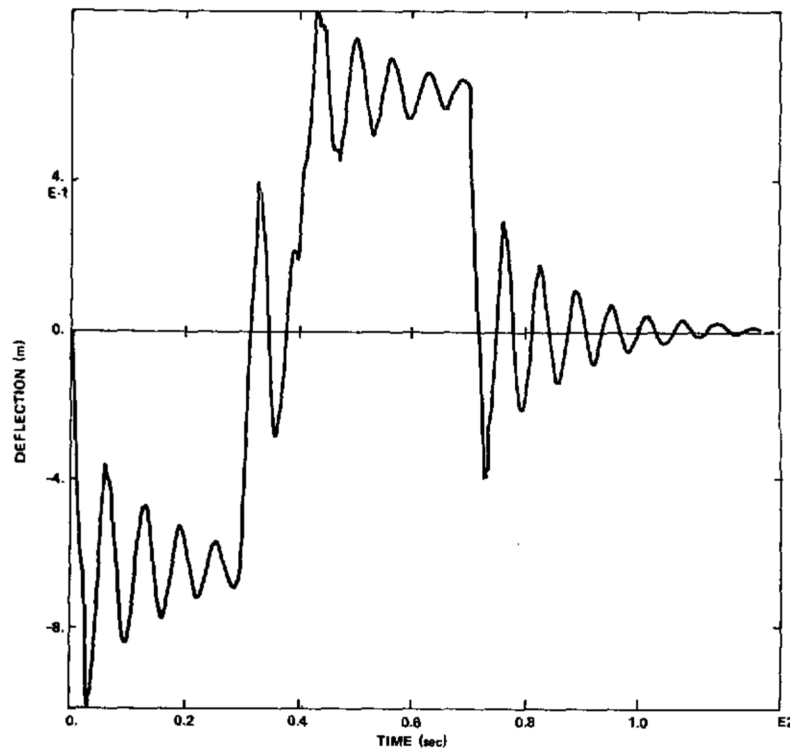


Figure 6-13. Elastic deflection of tip mass 1 (T_y).

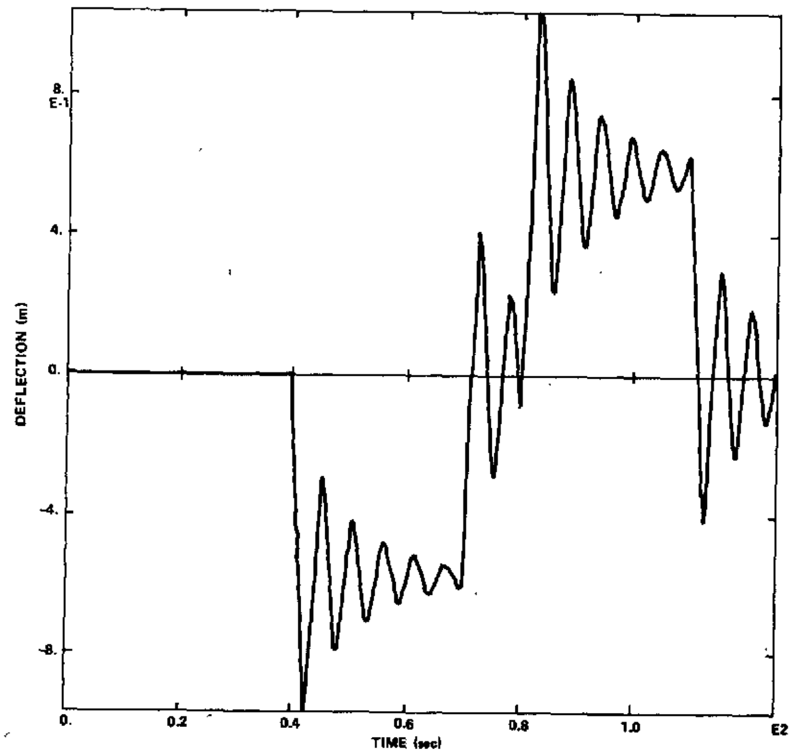


Figure 6-14. Elastic deflection of tip mass 2 (T_x).

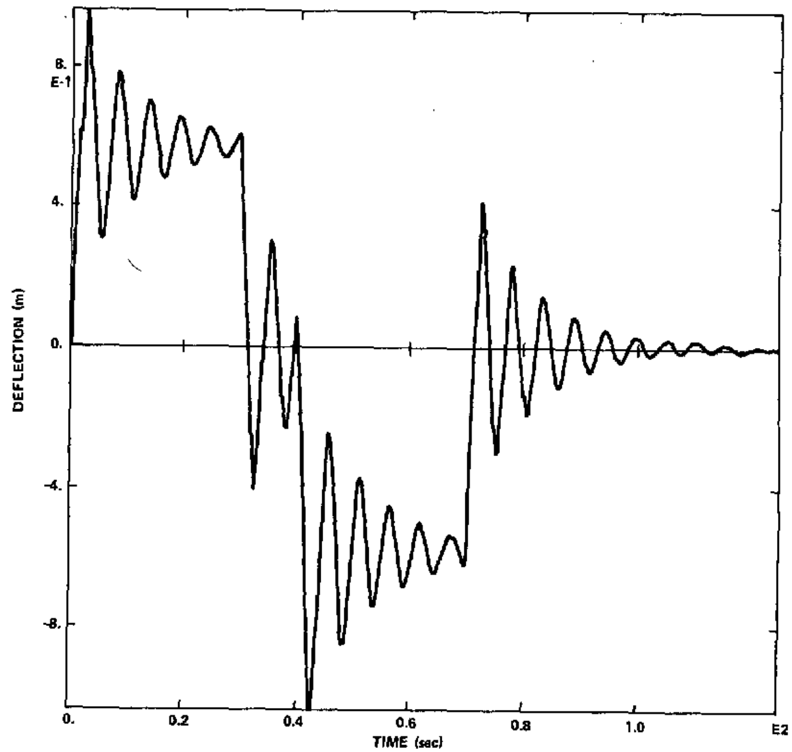


Figure 6-15. Elastic deflection of tip mass 2 (T_y).

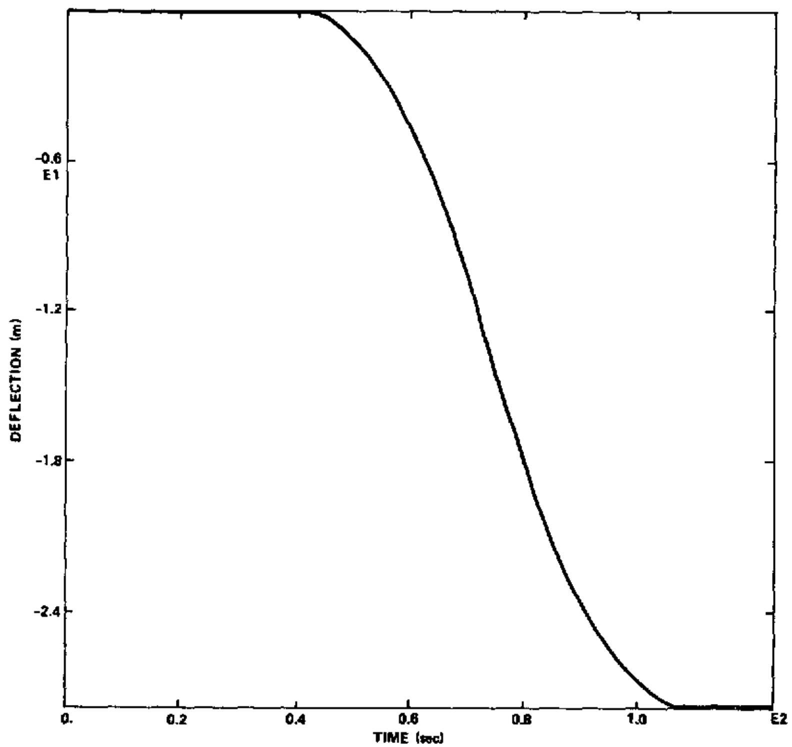


Figure 6-16. Displacement of mass 1 in X-direction.

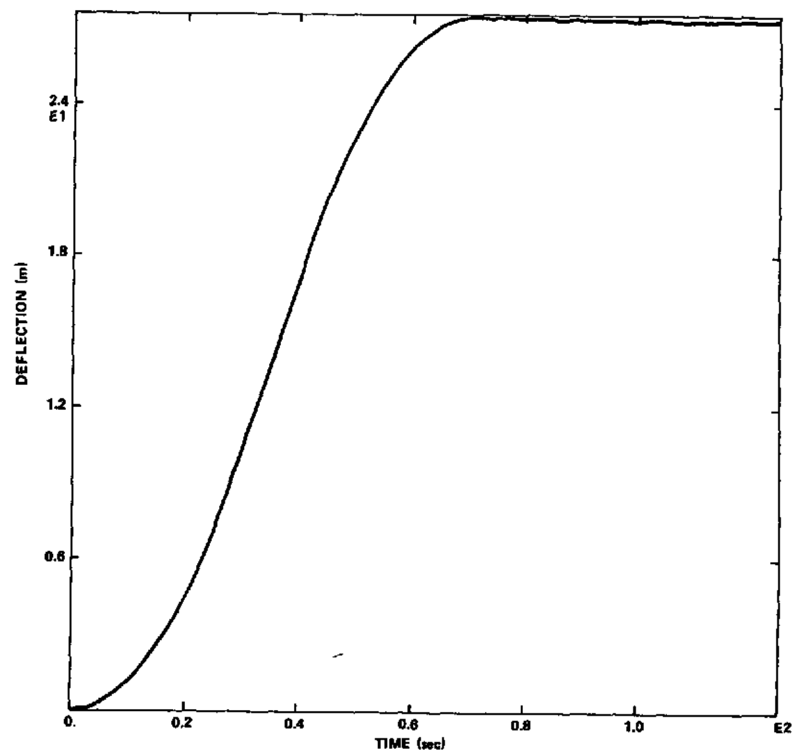


Figure 6-17. Displacement of mass 1 in Y-direction.

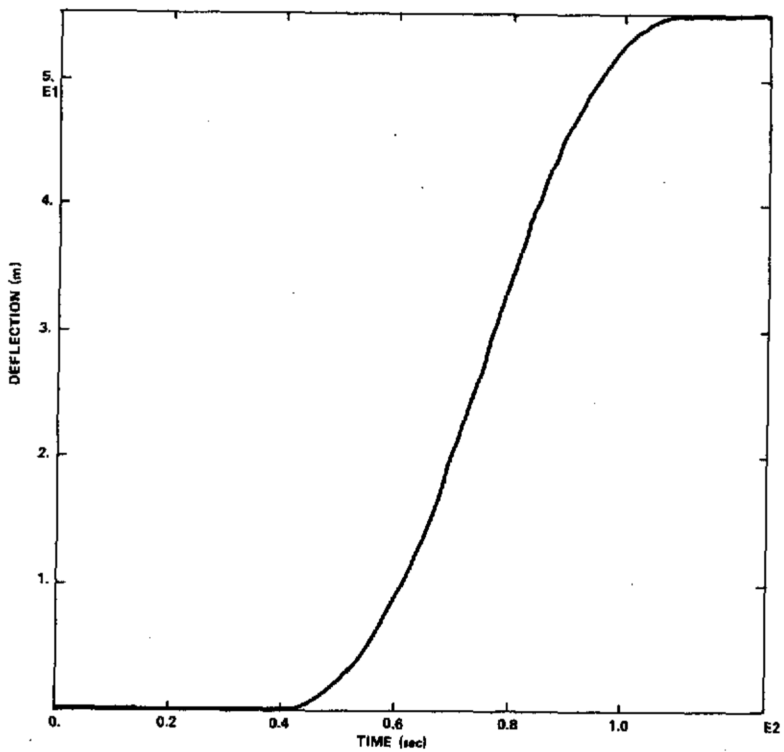


Figure 6-18. Displacement of mass 2 in X-direction.

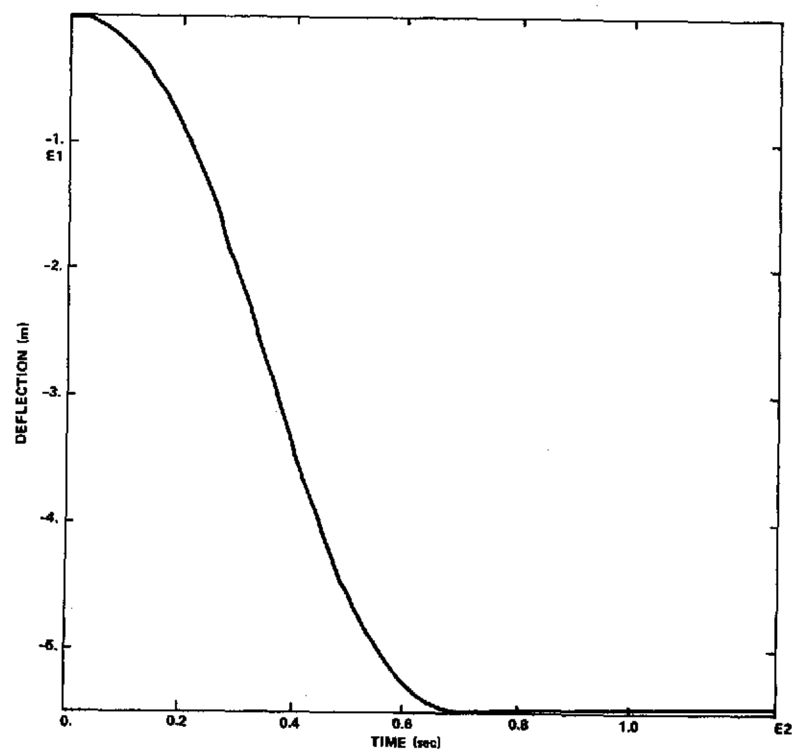


Figure 6-19. Displacement of mass 2 in Y-direction.

6.2 THERMAL CONTROL SUBSYSTEMS

6.2.1 Analysis

The AMPS payload was thermally modeled and analyzed by using the Lockheed Orbital Heat Rate Program (LOHARP) and the Systems Improved Numerical Differencing Analyzer (SINDA). The configuration used was per MSFC drawing number 08-187.

The model utilized to study this payload is shown in Figure 6-20. It was analyzed in a 465 km circular orbit with beta angles of 0 and 52 deg. The vehicle was Earth oriented with the payload always pointing to the Earth. An analysis was also performed with the Shuttle bay doors closed and conditions simulated to represent reentry. A special study was done on the 330 m transmitter coupler antenna to determine the lateral temperature gradient throughout an orbit.

6.2.2 Results

6.2.2.1 Orbital

Tables 6-7 and 6-8 depict the pallet-mounted components and associated data needed to determine the heat removal requirement for the orbit beta angles of 0 and 52 deg, respectively. These results were based on a component temperature of 21° C. The component surface absorptance and emittance values were optimized to reduce the required fluid heat removal and to prevent components from dropping below minimum temperature limits. In both cases it was assumed that all the components were energized at the same time. Based on the study, the fluid loop system is required for the gimbaled accelerator, lidar system, and transmitter coupler. A liquid helium dewar is required to cool a cryogenic Fourier IRR spectrometer and a high resolution Fourier spectrometer located inside the remote sensing platform to 4° K and 77° K, respectively. Figure 6-21 presents a possible plumbing layout for the fluid loop system; Figure 6-22 presents the schematic.

6.2.2.2 Launch

For launch analysis the component temperature was set at 21° C. The maximum temperature rise was only 3° C for any one component for launch.

6.2.2.3 Reentry

For the reentry analysis the component temperature was set at 21° C at beginning of descent. Wall temperature and the incoming vent air temperature profiles from the Space Shuttle Program Thermodynamic Design Data Book (shown in Figures 6-23 and 6-24) were applied to the model. Convection heat transfer between the vent air and components was included in the analysis. Encompassed time was 2 hours, which included descent, touchdown, and ground cooling for approximately 0.5 hour.

Resulting temperature histories for the components are presented in Figure 6-25. The transmitter coupler reached a temperature of 42° C which was the high for the payload. This is well within the nonoperating temperature maximum limit of 60° C.

6.2.3 Antenna Studies

The thermal investigation of the transmitter coupler 330 m antenna was conducted to determine the temperature gradient which could develop across the thin-skinned cylindrical surface as a result of the orbital environment. Consideration was given to two configurations: (1) a homogeneous surface and (2) a 20 percent perforated surface. Materials considered were stainless steel and beryllium copper. The thermal analysis was conducted with the antenna sun-oriented and in a $\beta = 52$ deg orbit, which results in a worst-case condition.

The results of this analysis are presented in Figures 6-26 through 6-28. Average temperature gradients for the 0.051 mm stainless steel wall of 25° C and 14° C were observed for the homogeneous and perforated antenna elements, respectively. The wall thickness of the beryllium copper element was increased to 0.076 mm to obtain the same structural stiffness as that of the 0.051 mm stainless element. This, in combination with material thermal properties, resulted in temperature gradients of only 3° C and 1.8° C for the homogeneous and 20 percent perforated elements, respectively.

6.2.4 Results and Conclusions

The conclusions drawn from this study are as follows:

1. No thermal difficulties were identified during any mission phase of AMPS.

2. All experiments can be controlled passively while in orbit except the gimbaled accelerator, lidar system, and transmitter coupler which will use the freon cooling loop supplied by the Spacelab.

3. There is insignificant difference in required heat removal between orbit angles of 0 and 52 deg.

4. A maximum rise of 3° C occurs in the transmitter coupler during launch. For all other components the change was insignificant.

5. During reentry the lidar system and transmitter coupler (the two hottest components) rise to 34° C and 42° C, respectively. This is well below the nonoperating maximum temperature limit of 60° C.

6. The analysis of the 330 m antenna indicates that, to obtain a minimum delta temperature of 1.8° C across the antenna, a 0.076 mm wall of beryllium copper with 20 percent performation is required.

TABLE 6-7. AMPS HEAT DISTRIBUTION FOR PALLET-MOUNTED EQUIPMENT (Orbit Beta Angle = 0 deg)

Node ID	Component	Oper. Temp. Limits (°C)	Gen. Heat (watts)	Enviro. Heat Abs. (watts)	Total Heat (watts)	Component Surface α/ϵ	Radiated Heat at 21°C (watts)	Net Heat to be Removed by Fluid Loop System (watts)
100	Gimbaled Accelerator	0 - 30	2000	387	2387	0.185/0.92	1195	1192
101	Deployable Unit	↓	0	40	40	0.2/0.25	66	-26
102	Remote Sensing Platform	↓	462	717	1179	0.2/0.4	1204	-25
103	Lidar System	↓	2000	290	2290	0.185/0.92	500	1790
104	Transmitter Coupler	↓	2500	593	3093	0.185/0.92	1041	2052
105	Boom	↓	136	173	309	0.23/0.37	311	-2
106	Deployable Satellite System	0 - 30	0	606	606	0.2/0.3	603	3

TABLE 6-8. AMPS HEAT DISTRIBUTION FOR PALLET-MOUNTED EQUIPMENT (Orbit Beta Angle = 52 deg)

Node ID	Component	Oper. Temp. Limits (°C)	Gen. Heat (watts)	Enviro. Heat Abs. (watts)	Total Heat (watts)	Component Surface α/ϵ	Radiated Heat at 21°C (watts)	Net Heat to be Removed by Fluid Loop System (watts)
100	Gimbaled Accelerator	0 - 30	2000	395	2395	0.185/0.92	1195	1200
101	Deployable Unit		0	49	49	0.2/0.25	66	-17
102	Remote Sensing Platform		462	540	1002	0.2/0.4	1204	-202
103	Lidar System		2000	287	2287	0.185/0.92	500	1787
104	Transmitter Coupler		2500	574	3074	0.185/0.92	1041	2033
105	Boom		136	182	318	0.23/0.37	311	7
106	Deployable Satellite System	0 - 30	0	526	526	0.2/0.3	603	-118

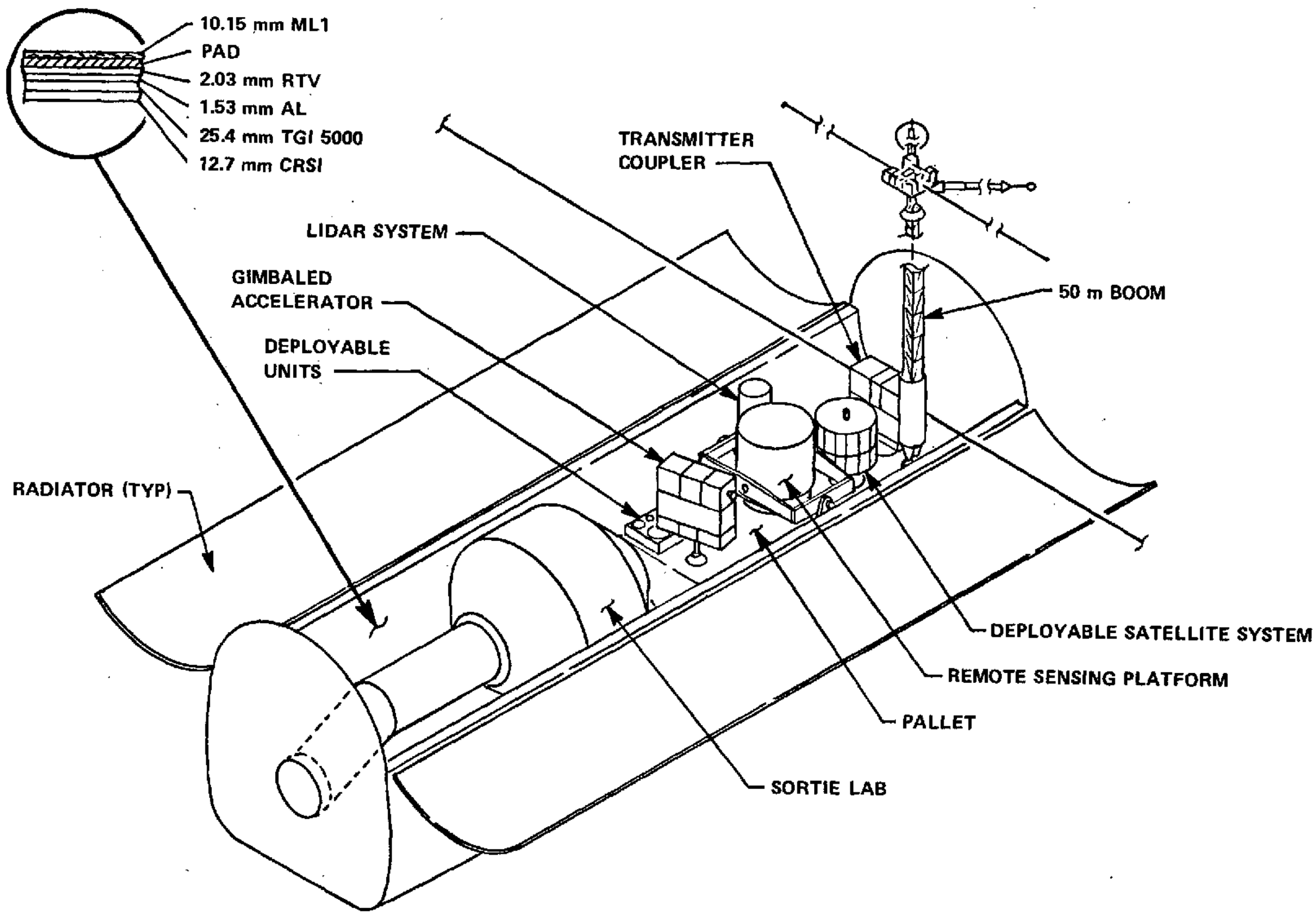


Figure 6-20. Thermal model used for analysis of AMPS payload.

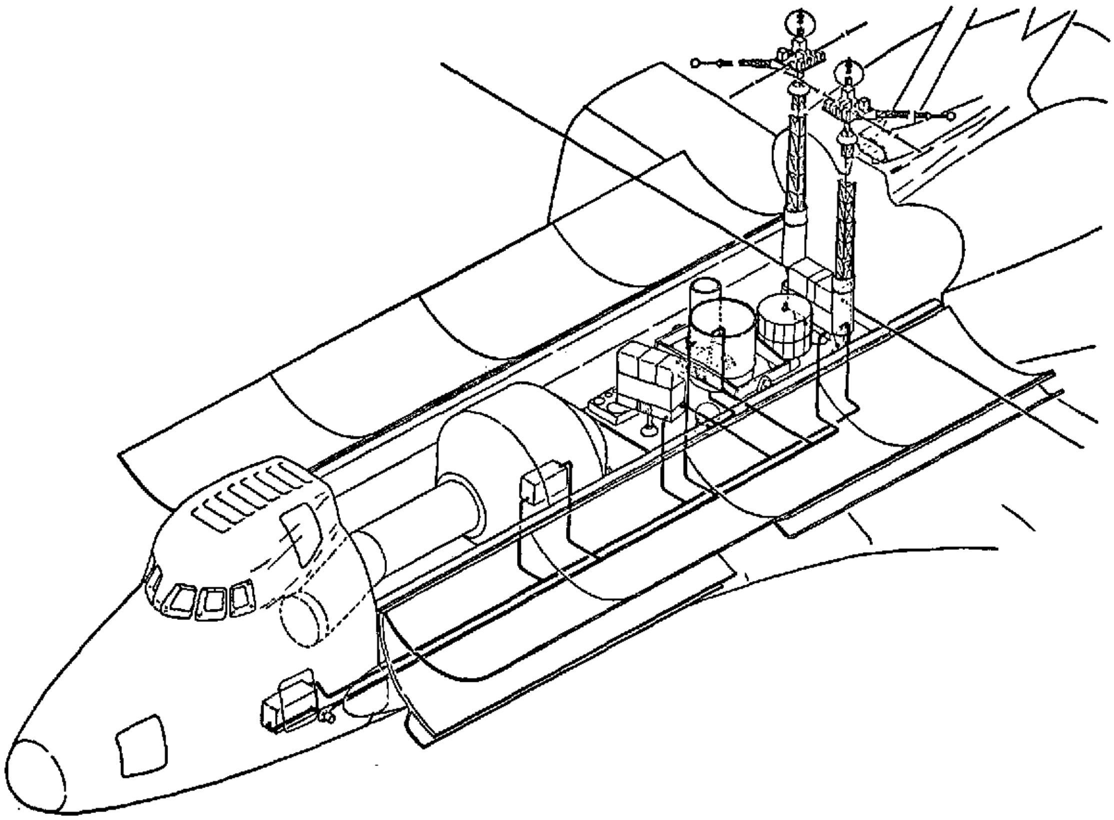


Figure 6-21. AMPS configuration with proposed thermal control fluid loop.

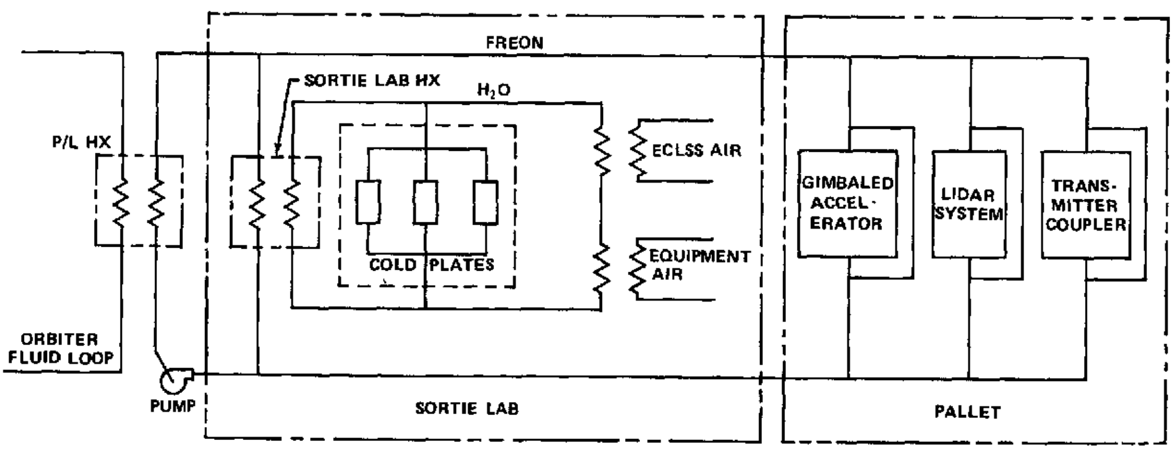


Figure 6-22. AMPS fluid loop system schematic.

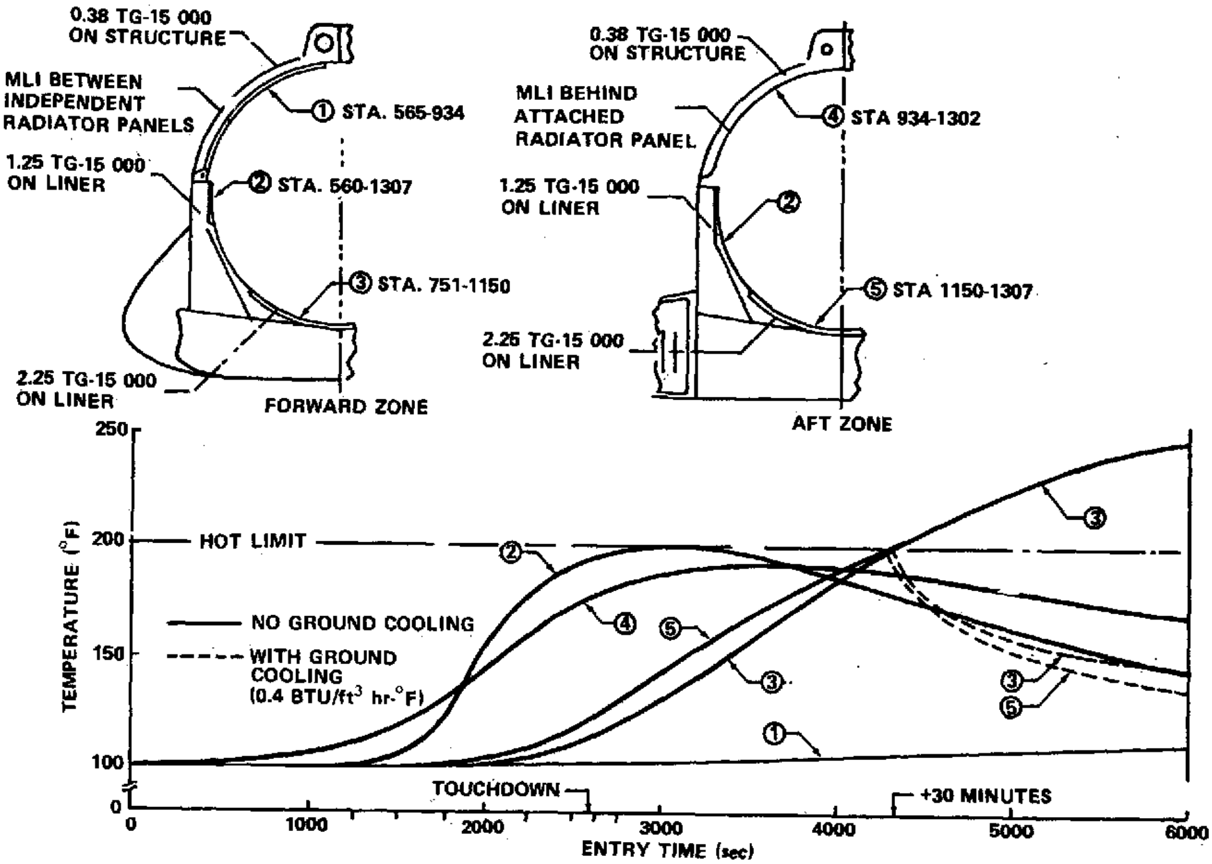


Figure 6-23. Reentry temperature history of payload bay wall.

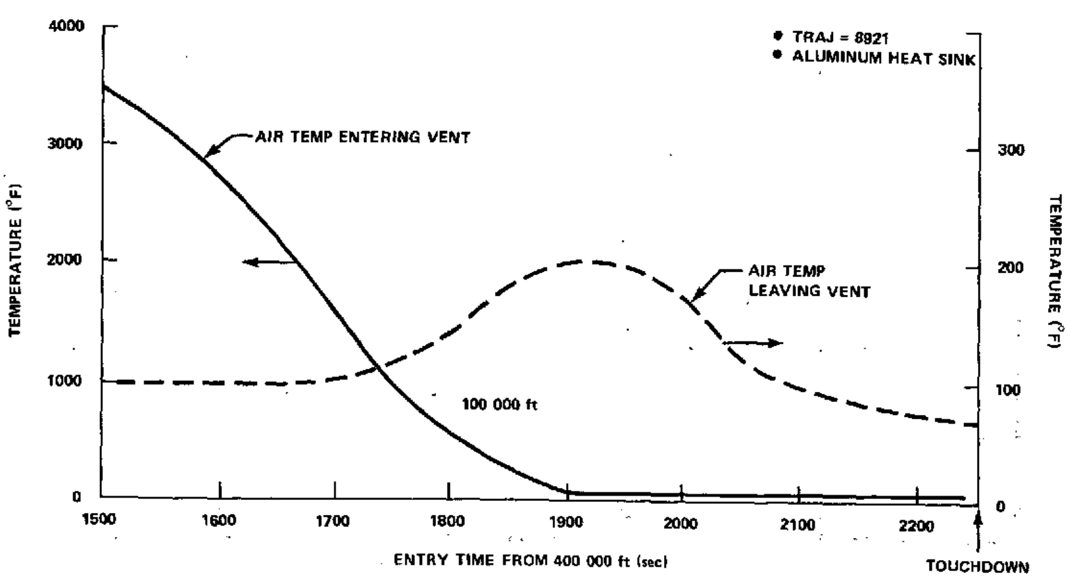


Figure 6-24. Payload bay vent entry air temperature.

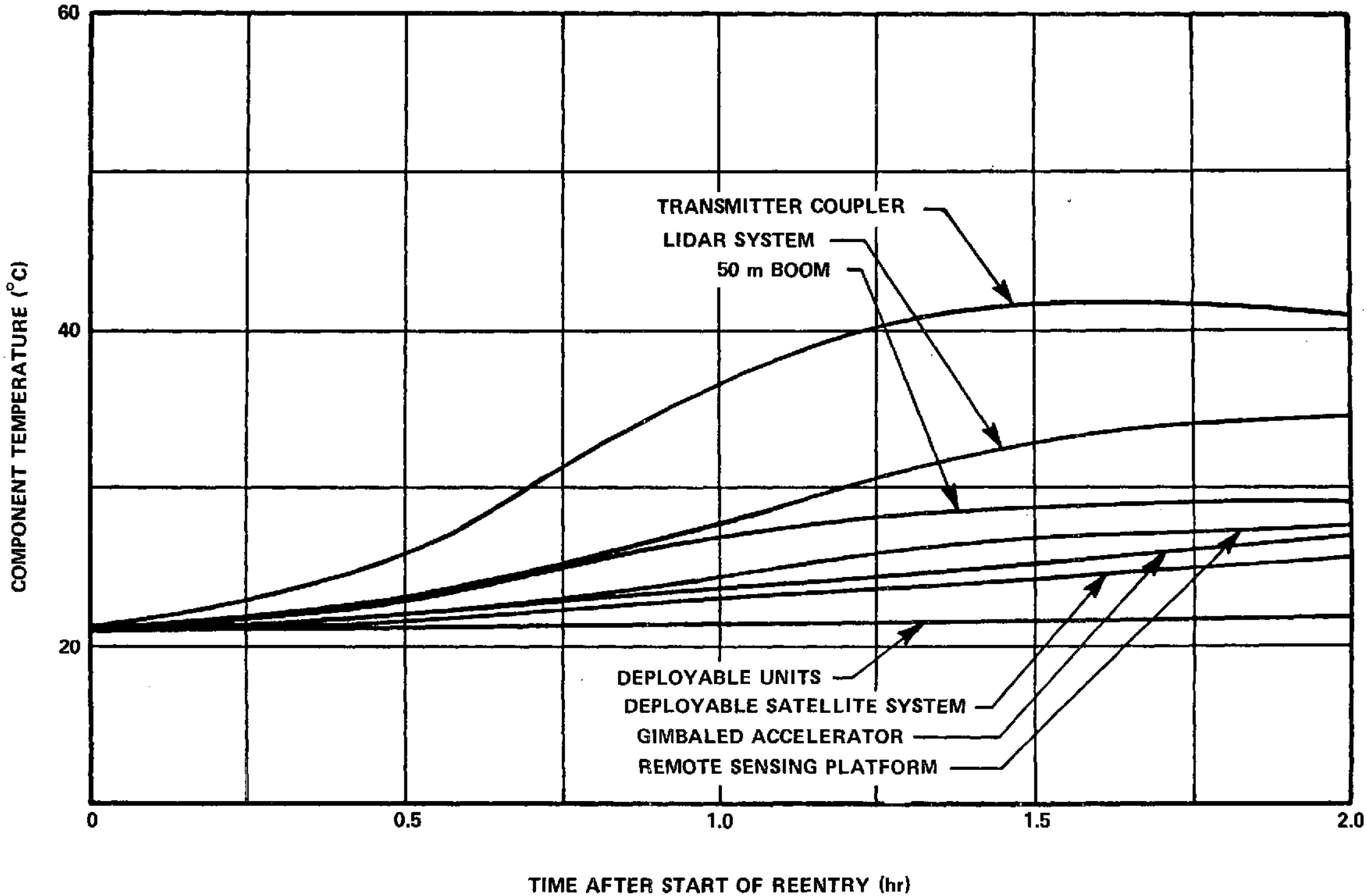


Figure 6-25. Temperature history of AMPS components during reentry.

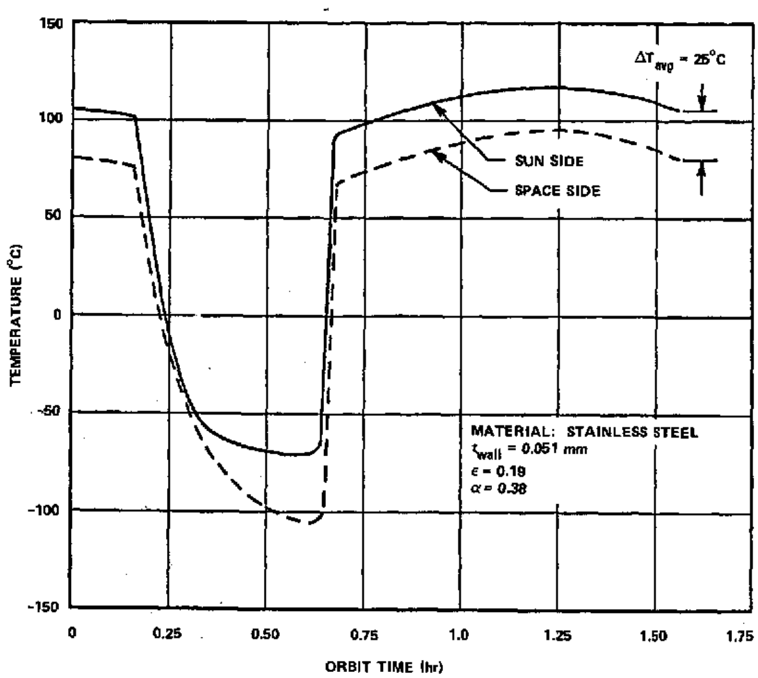


Figure 6-26. Orbital temperature history for the AMPS antenna with homogeneous surface, sun-oriented, β = 52 deg.

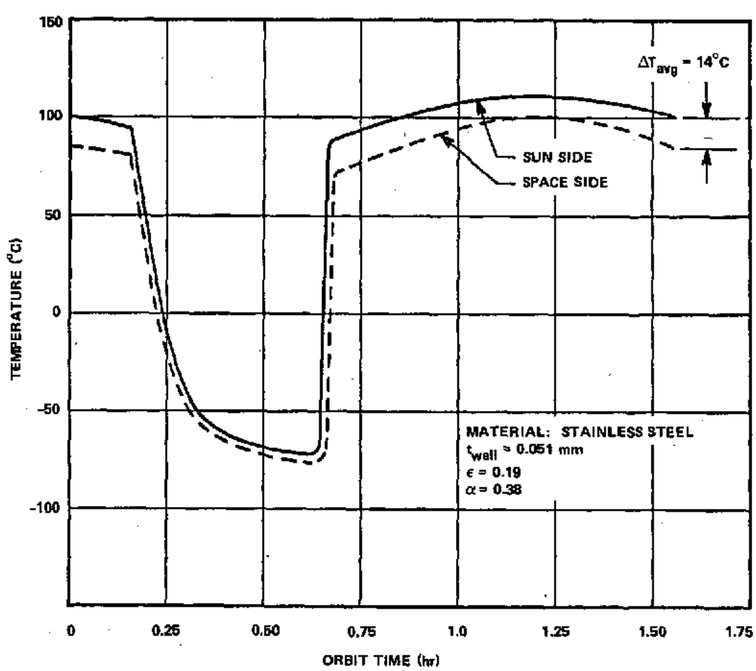


Figure 6-27. Orbital temperature history for the AMPS antenna with perforated top surface, sun-oriented, β = 52 deg.

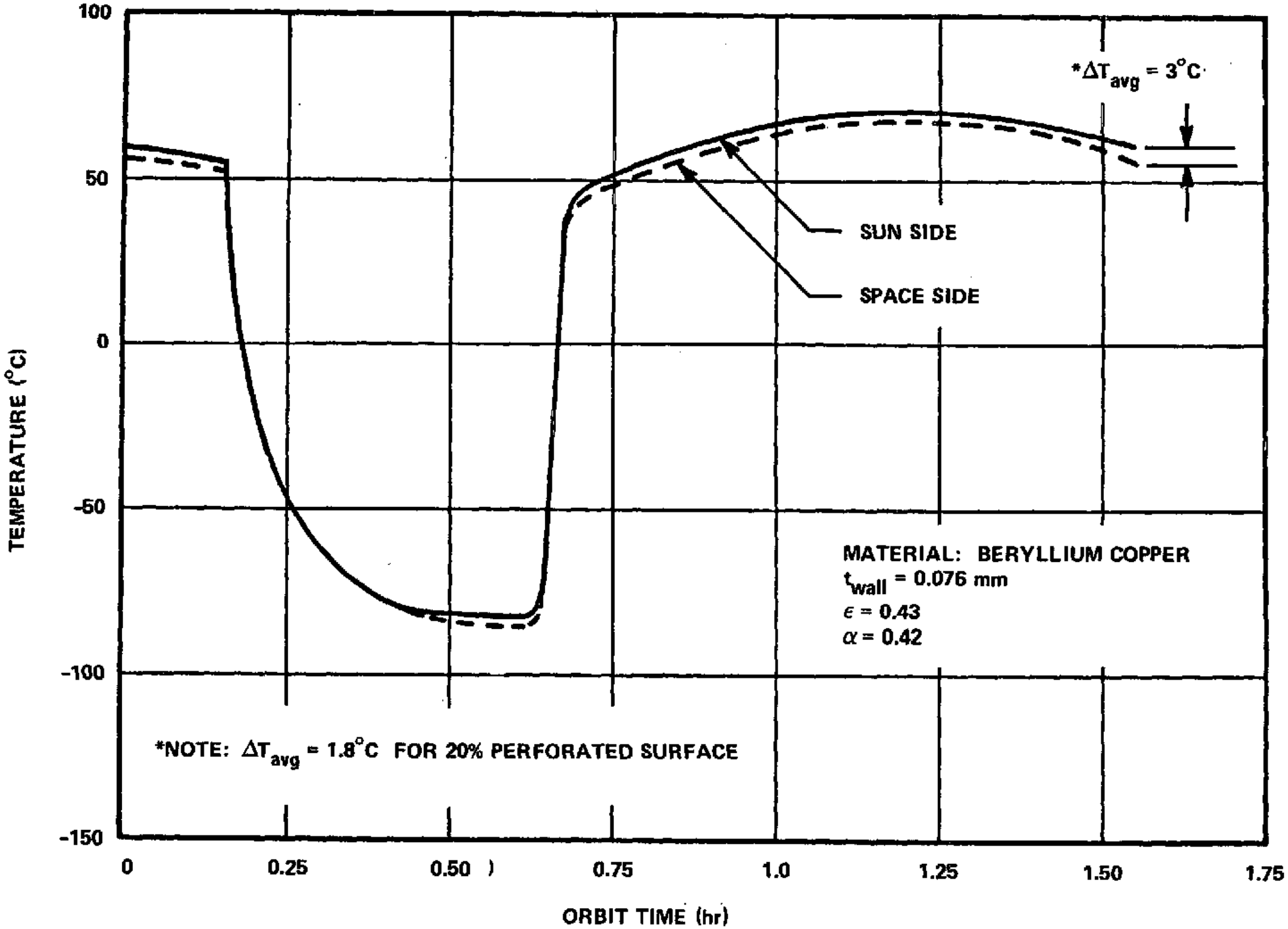


Figure 6-28. Orbital temperature history for the AMPS antenna with homogeneous surface, sun-oriented, β = 52 deg.

6.3 POINTING AND CONTROL SUBSYSTEMS

6.3.1 Guidelines and Constraints

The Shuttle System Payload Descriptions (SSPD) document, level B data, was the principal source for pointing accuracy, pointing stability, and rate stability requirements for the AMPS payload. A summary of these requirements is tabulated in Table 6-9, along with expanded orientation and target definitions.

The data supplied in the SSPD document are inconsistent in many respects. The time durations in particular are critical items since in some cases the defined targets are not available because of occultation for the time durations specified. Full advantage of the expected Orbiter pointing accuracy of 0.16 deg using vernier thrusters and a 0.1 deg deadband has not been utilized. In some instances, the Orbiter requirements specified place a hardship on the designs of the individual gimbaled systems. Comments about the most critical experimental systems are contained in the following paragraphs.

6.3.1.1 Remote Sensing Platform (RSP)

6.3.1.1.1 Stability

The 2 arc sec and 0.2 arc sec/sec numbers are very stringent when applied across the board to experiments using the RSP. When viewing Earth-located targets or atmospheric phenomena in the regions of 50 to 80 n.mi. above the Earth's surface, these requirements suggest a precision gyro-stabilized platform mount for the instruments. If this precision platform is available, the problem becomes one of open-loop tracking of a target that, in general, provides no energy source for use in obtaining error signals suitable for maintaining closed-loop acquisition. A preliminary investigation has indicated that this open-loop tracking must take place over angles of as much as 140 deg at maximum rates of 1.5 deg/sec. A review of the SSPD referenced documents has disclosed only one experiment requiring this precise stability. This experiment involves measurements of the energy of a star as filtered by the atmosphere during the star's transition from visibility to occultation. Early in the AMPS program, the experiments designated for the RSP must be classified, the instruments defined, and the pointing and stability requirements determined for each classification.

6.3.1.1.2 Pointing Accuracy

The 180 arc sec absolute pointing specification can be readily achieved with the precision gimbaled mount and an auxiliary payload sensor such as a gimbaled star tracker. However, the 20 arc sec required for relative pointing accuracy requires further justification in terms of experiment timelines and operational procedures. For example, it has been determined that the 20 arc sec are required for mapping radiation and absorption profiles of atmospheric regions, but it must be determined whether a scan mode, either by the gimbal mount or individual instruments, is satisfactory or whether pointing at discrete points while taking data is desirable.

6.3.1.1.3 Time Duration

It has been ascertained that the 1800 sec specified is not realistic. Studies made of target viewing times for the baseline orbital altitudes and inclinations indicate that a selected target will be available for viewing from approximately 600 to 900 sec before occultation. To obtain 1800 sec integrated viewing time would necessitate reacquiring a selected target at least once at probably a 20 arc sec accuracy. The case necessitating reacquisition does not appear to be a real requirement.

6.3.1.2 Lidar System

6.3.1.2.1 Stability

Stability was not specified as a requirement; however, if experiments materialize requiring the transfer of data between the lidar system and a subsatellite, stabilities in the subarc sec range may be desirable. For normal transmission and receiving of the laser energy, the 3 arc min pointing accuracy may be sufficient.

6.3.1.2.2 Pointing Accuracy

The 3 arc min accuracy requires a moderate precision computer controlled mount for the telescope and a payload attitude reference system consisting of a star tracker and gyros. Conceptual designs have been defined that readily satisfy this requirement.

6.3.1.3 Boom Systems

6.3.1.3.1 Stability

The specification of 360 arc sec appears to be borderline in view of the fact that a 50 m flexible member with a relatively large tip mass is being controlled by gimbals. Orbiter vernier thruster firings with minimum impulse bit durations of 40 msec do not appear to be a problem. Preliminary analysis indicates a resulting error angle of approximately 7 arc sec. Flexing of the boom during gimbal torque motor excitation may give transient errors greater than 1 deg. For further discussion of boom dynamics see Section 6.1. A realistic requirement must be obtained from the scientific investigators because it is reasonably certain that the specified stability is not required for all experiments that use the boom system. In particular, the wake and sheath experiments require the most severe exercising of the booms and the stability requirements for this experiment may be 1 deg or more.

6.3.1.3.2 Pointing Accuracy

The measuring boom poses most of the problems because of the presence of a set of gimbals at the boom tip. Here again, a reassessment of the individual experiments operations will probably ease the requirements for certain types of experiments, such as wake and sheath. However, the specified accuracy is attainable under most circumstances.

6.3.1.3.3 Time Duration

The 1800 sec may be required primarily for wave transmission experiments and should not result in problems because no large excursions are required of the booms. During wake and sheath experiments large scans are required but in general the scan profile must be completed in about 900 sec.

6.3.1.4 Gimbaled Accelerator, Transmitter/Coupler, Deployable Units and Satellite Systems

No particular problems are expected with these systems since all requirements are within the projected capabilities of the Orbiter. It is assumed that subsatellites will have the necessary attitude control capability incorporated. However, a payload attitude reference system may be required because of misalignments between the Orbiter navigation base and the payload mounts.

6.3.2 Design Reference

6.3.2.1 Concept

The AMPS payload pointing and control discipline involves the management of several multigimbaled systems that have varying degrees of accuracy and stability requirements. Figure 6-29 provides a conceptual information flow chart. The digital computer, interface unit, displays, and controls are provided by the Spacelab. The interface unit provides the functions for switching, multiplexing, analog to digital (A/D) and digital to analog (D/A) conversions, etc., that link the various instrument assemblies. Interfaces with the Orbiter to obtain outputs from the Orbiter guidance, navigation, and control (GN&C) system and to transfer commands and data via the ground link are provided by the interface unit. Although the provision of payload sensor signals to the Orbiter GN&C system is not a part of the preliminary concept, eventually it may be required and the signals would be routed through the interface unit.

Configuration control and initial gimbal position commands are provided by the Spacelab controls array. Final positioning of the gimbals and subsequent gimbal tracking commands will be under the control of the Spacelab computer in order to utilize guidance and navigation data from the Orbiter GN&C system. Manual override of automatic gimbal control is available through the Spacelab controls. TV outputs from the remote sensing platform and booms will be displayed in the Spacelab and will provide information for monitoring, initial pointing, and pointing corrections.

The Spacelab computer provides the computational support functions for all systems. These support functions will include error signal processing, coordinate transformations, gimbal command generation in response to error signals, the processing of ground and control console commands, and the final processing of housekeeping data as required.

The gimbaled star tracker (GST) serves as a payload attitude sensor and provides information to update the remote sensing platform gyros. This star tracker and the RSP gyros are to be used as a payload attitude reference unit that serves all the payload gimbaled systems. This scheme introduces error because of the required transfer of the RSP gyro unit error signals through the RSP gimbals. However, initial analysis indicates that this error magnitude is not large enough to preclude the use of this concept in lieu of providing a separate gyro/star tracker attitude reference unit to serve all gimbaled systems that require high accuracy.

6.3.2.2 Operation

Pointing and control operations for the AMPS payload involve six gimbaled experiment mounts plus the double gimbaled star tracker. In general, the simultaneous operation of all gimbaled systems is not required; however, there will be occasions where more than one system must be operational. Typical examples are the simultaneous use of the RSP and lidar, or the RSP operation while boom experiments are being performed. Final experiment determination will govern whether there are other occasions requiring the use of multiple operations.

6.3.2.2.1 Attitude Reference

The management of the numerous gimbaled systems requires a common attitude reference. In the present concept, the three sources of attitude information are the RSP, star tracker, and the Orbiter GN&C system. Future concepts may require a separate payload attitude reference system with optical alignment links between various systems. The Orbiter GN&C computer supplies to the Spacelab computer the Orbiter state (position, velocity, angle, time), target coordinates, the states of co-orbiting vehicles, and other basic references as required. The RSP, including the payload star tracker, provides to the Spacelab computer a continuously updated inertial reference frame for instrument pointing subsystems.

6.3.2.2.2 Remote Sensing Platform

The primary function of the RSP is to control the orientation of the common line-of-sight of a group of scientific instruments. An additional function is to provide an attitude reference for all of the AMPS gimbaled instrument mount assemblies. To accomplish these functions the RSP operational modes have been given a preliminary classification as follows:

1. Target Pointing and Tracking Mode.

2. Attitude Determination Mode.

3. Initial Alignment and Update Mode.

A key factor in how the RSP operates is the method of interfacing with the Orbiter. The following mode descriptions provide a preliminary concept.

1. Target Pointing and Tracking Mode: This mode provides the capability to point to a target, track the target in the presence of Orbiter motion, and to align an instrument pointing subsystem with respect to a specified frame, such as the geomagnetic. Figure 6-30 shows the geometry and transformations used in generating commands for the RSP gimbals. The target is initially specified in the Earth-fixed coordinates of longitude, latitude, and altitude (L). The Orbiter position may be expressed in local vertical coordinates (P) or inertial coordinates (G) obtained from the Orbiter GN&C system computer. This initial concept assumes that the Orbiter position is expressed in P coordinates and the target expressed in L coordinates.

The Orbiter position and the target position are transformed into inertial coordinates and differenced to obtain a command vector in inertial coordinates. The command vector is then transformed into RSP line-of-sight (LOS) coordinates in terms of the middle and outer gimbal angles. The gimbal errors represent the rotation required of the middle and outer gimbals to align the RSP LOS to the desired pointing direction. In general the pointing problem is two-axis and the inner gimbal rotation has been ignored.

For tracking purposes the calculations must be performed repeatedly to maintain the pointing direction while both the target and Orbiter are moving.

2. Attitude Determination: Outputs from the three gyros mounted on the RSP instrument package, operating strap-down, are used to maintain an updated attitude for the RSP LOS. The coordinate transformation $|A_{G, RSP}|$ between the RSP LOS and the inertial reference frame (G) is repetitively calculated using the gyro outputs. This transformation is initialized by outputs from the gimbaled star tracker. The transformation to be calculated, $|A_{G, RSP}|$, may be described by the following equation:

$$|\dot{A}_{G,RSP}| = |A_{G,RSP}| \begin{vmatrix} 0 & -w_3 & w_2 \\ w_3 & 0 & -w_1 \\ -w_2 & w_1 & 0 \end{vmatrix} = |A_{G,RSP}| \, |\tilde{w}|$$

where $w_{1,2,3}$ are the gyro measured angular rates. The discrete equation developed from the above equation is:

$$|A_{G,RSP}|_{K+1} = |A_{G,RSP}|_K \left(I + |\tilde{\Delta}\theta| + \frac{|\tilde{\Delta}\theta|^2}{2} \right) ,$$

where

$$|\tilde{\Delta}\theta| = |\tilde{w}| \Delta T = \begin{vmatrix} 0 & -\Delta\theta_3 & \Delta\theta_2 \\ \Delta\theta_3 & 0 & -\Delta\theta_1 \\ -\Delta\theta_2 & \Delta\theta_1 & 0 \end{vmatrix}$$

and I is the identity matrix. Using this discrete equation, successive updated values of the matrix are computed. The updated A matrix is in turn used to generate RSP gimbal commands.

3. **Initial Alignment and Updating:** The initial value of the matrix $|A_{G,RSP}|$ is determined by successive star sightings with the AMPS star tracker. Fixes on at least two noncolinear stars are required. In order to establish the successive star sightings in a common reference frame, the RSP will be operated in an inertial hold mode during this phase. By immediately transforming the star tracker outputs into the arbitrary reference frame, the two successive readings will be located in a fixed frame for subsequent alignment calculations. An outline of the procedure follows:

a. Slew the middle and outer gimbals to zero.

b. Set $|A_{G,RSP}|$ to $|I|$.

c. Set $\{R_{CMD}\}_G$ to $\begin{Bmatrix} 1 \\ 0 \\ 0 \end{Bmatrix}$.

d. Close the gimbal loops and the RSP will remain inertially fixed.

e Acquire and track the first preselected guide star.

f. Transform first guide star orientation into RSP coordinates. (Current RSP and star tracker gimbal angles are continuously supplied to the computer to form the transformation matrices.)

g. Repeat the last two steps for the second guide star.

h. Confirm star identities by comparison with computer stored star catalog. (If incorrect stars can be identified by computer search, they can be used.)

i. Solve for the $|A_{G,RSP}|$ matrix. (See Reference 6-1 for one method.)

j. Repeat the procedure as required to update attitude error computations and gyro drift compensations (once per orbit is ample — a partial procedure can be used during experimentation).

6.3.2.2.3 Lidar System

The two operational modes conceived for the pointing and control functions of the lidar system are (1) pointing and (2) tracking. The pointing mode will be initiated in the same manner as that described for the RSP. Target location will be specified in a convenient coordinate frame and transformed into inertial coordinates. By a comparison of the Orbiter radius vector in inertial coordinates and the target coordinates, commands will be generated for the azimuth and elevation gimbals. These commands are transformed into the lidar telescope coordinates, using the RSP as a reference, to generate the number of step motor steps required. It is expected that the telescope will be positioned in azimuth first and then elevated to point at the target. The gimbal commands must be computed on a continuing basis in order to account for Orbiter and target motions.

Figure 6-31 is a simplified block diagram of the lidar gimbal control system. The computer generated commands enter through a mode switch to provide gimbal control from the Spacelab console or automatic tracking via an auxiliary sensor. Resolvers provide gimbal position readouts for use by the computer in generating both the initial and updated pointing commands.

The tracking mode provides the capability of maintaining a lock on the target in the presence of Orbiter and target motions. Where no auxiliary sensor is involved, it differs very little from the pointing mode. The updated Orbiter states are used to generate open-loop lidar gimbal commands to continuously reposition the gimbals. The RSP and gimbaled star tracker provide the computational reference base. Automatic tracking has been incorporated to maintain a precise lock on a transponder carried by a subsatellite. This would permit transmitting and receiving laser energy over long distances (5000 km has been proposed) for atmospheric absorption experiments. Automatic tracking requires a lidar telescope-mounted sensor to generate error signals for gimbal positioning in a closed loop manner similar to the procedure used by a two-gimbaled star tracker to maintain star acquisition. This has not been discussed in the SSPD data or in reports leading to the SSPD data. Techniques do exist for sensing LOS deviations, one in particular being the use of interferometric techniques.

6.3.2.2.4 Boom Systems

Boom A, designated as the measuring boom, requires the management of two sets of gimbals. One set is at the Orbiter end, and the other serves as an instrument platform mount at the extreme end of the boom. Boom B, designated as the exciter boom, has one set of gimbals at the Orbiter end to control the positioning of a tip mass having the desired geometrical shape for wake and sheath measurements. The boom B tip mass also contains a wave generator for wave transmission experiments, whose pointing requirements may lead to the requirement for gimbals at the tip mass end of boom B.

For wake and sheath experiments, boom A must be effectively repositioned with respect to boom B in order to map the plasma energy function. During this repositioning scan, the platform at the tip of boom A must be reoriented to maintain the measuring axis parallel to the exciter boom velocity vector. Figure 6-32 shows one candidate scan profile designed to minimize disturbances to the Orbiter. Assuming that the booms are fully extended and initially at point O, boom A progresses to point A at a constant rate and, concurrently, boom B progresses to point A' at an equivalent rate. The other legs of the profile (i.e., A to B and A' to B') are also performed concurrently until the final positions J and J' have been reached. The total scan time must not exceed 15 min and the included angle with apex at the origin of the Orbiter gimbal mount and with the boom tip locations at points J and J' (or A and A') is approximately 120 deg (60 deg per boom). During this scan, the boom A instrument platform gimbals are continuously torqued to negate the effects of the scan gimbals and to maintain the measuring axis parallel to the exciter boom velocity vector. The objections to this scan profile are the sharp corners that the booms must turn and the resultant accelerations of the booms.

For wave transmission experiments, the two booms will be separated at discrete intervals with measurements being made at each discrete position. During these measurements the gimbals will have been commanded to coalign the boom A measuring axis and the wave generator line of action.

Additional orientations of the boom A instruments can be accommodated by appropriately commanding the gimbals. One candidate orientation is the orientation of the 33 m antennas with respect to the geomagnetic field lines. Data sources for command generation are magnetometers located on the measuring platform and computed magnetic field orientations based on a magnetic field model.

A summary of the sources of attitude information follows:

1. Gimbal angle resolver readouts.

2. TV system (camera on boom A).

3. Orbiter GN& C system.

4. RSP.

5. Boom-mounted magnetometers.

The information will be made available to the computer and display consoles as required. Command sources are:

1. Preprogrammed scan profiles with manual override.

2. Manual from control console.

6.3.2.2.5 Gimbaled Accelerator

The basic operational mode is pointing with respect to the geomagnetic field lines. Thus, a knowledge of the geomagnetic field vector is required. The two sources of the field vector definition are ground calculation and a continuous onboard calculation by the Spacelab computer. Both sources will be made available.

The actual pointing maneuver will be in most cases a combination of Orbiter maneuver and accelerator azimuth and elevation gimbal rotations. Table 6-10 provides information for the AMPS reference orbits on the magnetic field vector orientation with respect to local vertical for various orbital positions. The vector varies sinusoidally and has minimum and maximum angular deviations from the local vertical as shown. The table also provides the maximum rates of change. Thus, there are orbital times, when the Orbiter is flying a local vertical attitude, that the accelerator can be fired along the Orbiter +Z axis with only small angle adjustments required of the gimbals. However, if subsatellites or ground stations are involved in the experiments, a combination of Orbiter and gimbal pointings may be required due to the limited gimbal freedoms and the possibility of obstruction by the Orbiter and other payload equipment. Generally, the operation of the accelerator consists of the following steps:

1. Compute the magnetic vector orientation for the predicted time of operation start.

2. Position accelerator to align the line of action with the Orbiter +Z axis.

3. Maneuver Orbiter to align +Z axis with the predicted magnetic field orientation.

4. Maintain updated field vector calculation.

5. Compare in the reference frame the field vector and accelerator orientation.

6. Generate gimbal commands to maintain orientation of the accelerator with respect to the magnetic field.

Each of the above steps includes several intermediate operations such as coordinate transformations, the updating of orbit ephemeris, the updating of the payload reference frame, and control and monitoring from the Spacelab console. The possibility exists to do the complete line of action orientation by maneuvering the Orbiter, provided that other concurrent experiments are not impacted.

6.3.2.3 Implementation

6.3.2.3.1 Remote Sensing Platform

The design reference RSP consists of:

1. A three-axis gimbal set; the inner gimbal provides the instrument assembly mount.

2. A three-axis gyro reference unit, mounted on the inner gimbal as a part of the instrument assembly.

3. Interface electronics signal processor.

Included as a functional part of the RSP system, but not physically a part of the RSP, are:

1. A two-axis gimbaled star tracker.

2. Digital computer (Spacelab-furnished).

3. Command/control and display consoles (Spacelab equipment).

Figure 6-33 is a sketch of the conceptual geometry of the RSP and star tracker. The star tracker will be mounted near the RSP and reference aligned to the RSP mounting base. The selected RSP gimbal freedoms are ±45 deg for the outer and middle gimbals and ±180 deg for the inner gimbal. This gimbal arrangement is not optimum from a size standpoint and other possible configurations will be addressed during trade studies. Each of the gimbal systems has two torque motors (one on each end), a tachometer, and an inductosyn angular readout. Gimbal alignment and inductosyn readouts are adequate to provide 5 arc sec resolution.

The gyro package consists of three orthogonally mounted gyros, power supplies, and rebalance electronics. The Nortronics GI-K7G gyro was selected as a typical one. Characteristics of the gyro package are:

Quantization	0.5 arc sec/pulse
Bias Stability (6 hr)	0.015 arc sec/sec
Bias Stability (200 hr)	0.10 arc sec/sec
Noise	1.5 arc sec
Power per Channel	12.5 watts

Figure 6-34 is a simplified block diagram of the RSP. The electronic signal processors contain preamps, servo power amplifiers, A/D and D/A converters, multiplexing equipment, inductosyn processing electronics, and gyro rebalance pulse counting electronics. The digital computer is assumed to be furnished by the Spacelab and will perform attitude update and target pointing and tracking computations.

The preliminary gimbaled star tracker selected is similar to the Apollo Telescope Mount (ATM) star tracker and has the following characteristics:

Acquisition Field of View	1 deg × 1 deg
Gimbal Freedom (two axes)	Outer ±87 deg Inner ±40 deg
Noise Equivalent Angle	5 arc sec
Operational Accuracy	22 arc sec
Star Magnitude Sensitivity	+2 or brighter
Weight	20 kg
Power	15 watts
Dimensions (cm)	
Electronics	40 × 28 × 10
Optics	45 × 28 × 40

Table 6-11 contains a hardware summary of the pointing and control portions of the RSP.

6.3.2.3.2 Lidar System

An elevation over azimuth two-gimbal arrangement has been selected. The computer controlled mount of the SSPD level B data has been retained, including dimensions, weight, gimbal arrangements, etc. Figure 6-35 shows the mount with the lidar telescope. Also itemized are the characteristics of a typical stepper motor suitable for torquing the gimbals and the definition of a two speed resolver to measure gimbal angles. The gear train between the stepper motor and load has been selected to give a 1 arc min load step for each 1.8 deg increment of the step motor. Upon further definition of the lidar instrument assembly, the gear train and stepper motor will be resized to better optimize the response and power characteristics.

6.3.2.3.3 Gimbaled Accelerator

The gimbal arrangement, sizes, and weights have been retained from the SSPD level B data. The azimuth and elevation two-gimbal system is shown in Figure 6-36. The permanent magnet (PM) step motor selected to torque the gimbals has a dynamic torque of about 0.05 N-m and applies about 22 N-m of torque to the load through the gear train. The gear train also provides a 0.1 deg incremental load step for each basic 45 deg motor step. A single speed resolver with an accuracy of 0.1 deg measures the gimbal angles.

6.3.2.3.4 Boom Systems

The passive boom has three gimbals at its base for orientation control and two or three gimbals to serve as an attitude mount for the instrument assembly located on the tip of the boom. The active boom requires three gimbals at the base for orientation control. A complete design of the gimbal systems has not been accomplished. However, a single gimbal design for the base has been constructed with suitable torque motors to control the booms. Figure 6-37 is a simplified block diagram of a single-axis boom gimbal control loop. Three similar loops are required for each of the two booms.

The torque motor characteristics and gain constants selected for the control loop are listed below. The system bandwidth is approximately 0.63 Hz with a relative damping of 0.5.

DC Torque Motor, Aeroflex TFR 90-1

Peak Torque	21.7 N-m (16 ft-lb)
Power Peak Torque	180 watts
Resistance per Winding	0.26 ohm
Inductance per Winding	0.001 H
No Load Speed	75 rpm (7.85 rad/sec)
Weight	6.1 kg (13.5 lb)
Rotor Inertia	9.5×10^{-3} kg-m^2
Outside Diameter	23 cm
Thickness	6.35 cm
Torque Sensitivity (K_t)	0.83 N-m/A
Back EMF Constant (K_v)	0.83 V/rad/sec

Gimbal Loop Constants

R	0.26 ohm
N	60
J_a	$J_b + N^2 J_m$
J_b	0.3×10^6 kg-m^2
J_m	9.5×10^{-3} kg-m^2
K_t	0.83 N-m/A
K_v	0.83 V/rad/sec
K_r	81.4 V/rad/sec

Provisions for gimbal caging must be added to the overall gimbal control system. This will provide the capability to maintain the boom in a fixed orientation when desired for experimentation, retraction and extension of the booms, and Orbiter maneuvers.

6.3.2.4 Performance Analysis

Essentially all of the performance analysis was concentrated on the RSP and boom systems. The RSP has the most stringent accuracy requirements, and the multiple gimbal systems of the boom systems together with boom flexibility required considerable study.

6.3.2.4.1 Remote Sensing Platform

The RSP was analyzed from the following standpoints:

1. Absolute pointing accuracy — based on attitude determination, computation, gimbal servo, and Orbiter ephemeris errors.

2. Open-loop tracking of fly-by target.

Figure 6-38 gives the estimated attitude error budget based on realistic estimates of the individual component errors and resolutions. The estimated effects of inaccuracies in the Orbiter and target radius vectors on the pointing accuracy are summarized in Table 6-12 for four cases of inaccuracies and two distances of the target from the Orbiter. Table 6-13 provides a summary of the system errors.

The estimated errors in open-loop tracking of a fly-by target were determined with a single-axis digital simulation of the RSP gimbal servo. Figure 6-39 describes the trajectory of the target for an orbit altitude of 235 n. mi. and an Earth-fixed target altitude of 81 n. mi. In this trajectory, rates as high as 1.3 deg/sec are encountered and the total angle to be tracked through is about 140 deg. The tracking time is the estimated time that the target is in view. The nonlinear effects of 10 Hz digital sampling, gimbal friction, and torquer limiting were included in the simulation.

The results indicated that with a lead-lag compensator, a 13 arc sec offset error is present. The addition of integral control reduced the offset error to about 1 arc sec.

6.3.2.4.2 Boom Systems

The boom systems were studied to determine the following [6-2]:

1. Boom pointing errors due to Orbiter thruster firings.

2. Boom pointing errors due to boom gimbal servo torquers.

In addition, an assessment was made to determine the uncontrolled Orbiter attitude errors due to boom motions. Figure 6-40 summarizes the results for the case of Orbiter thruster firings.

For the 3 cases of vernier thruster firings (T_o = 254 N-m), the pointing error ranged from 0.002 to 0.17 deg. The large thruster firings (T_o = 11 200 N-m) gave permissible pointing errors only for the minimum impulse bit of 40 msec. From an Orbiter maneuver standpoint, it appears to be permissible to maneuver the Orbiter while the booms are extended.

For the case where the gimbal torque motor is applying a 100 N-m peak rectangular torque waveform between the base and the boom in order to scan the boom, transient errors on the order of 1.5 deg occur. The applied torque required and the resulting transient error are functions of the speed with which a scan profile must be performed and the shape of the profile with respect to accelerations and decelerations. A more detailed discussion of the boom dynamics is contained in Section 6.1. In general, it appears desirable to torque both booms simultaneously in order to minimize the disturbances transmitted to the Orbiter. For a 10 percent mismatch in the torques applied to the booms, it has been estimated that a 2 deg attitude disturbance is incurred by an uncontrolled Orbiter.

6.3.3 Trade Studies

6.3.3.1 Mounting Pallet

From a pointing and control viewpoint the following options were considered:

1. Fixed pallet.

2. Fixed pallet with control moment gyros (CMGs) to control the Orbiter during pointing.

3. Suspended pallet with CMG pallet pointing and control.

The fixed pallet with individual instrument assembly gimbal sets is preferred for the following reasons:

1. It relieves the Orbiter from frequent maneuvers and complicated target-tracking slew maneuvers.

2. RSP is the only system requiring the capabilities of the CMG controlled suspended pallet.

3. Gimbal freedoms can be selected and controlled more readily.

4. It appears to be cost, power, and weight effective.

6.3.3.2 Computer

The options appear to be the use of a Spacelab, subsystem dedicated, or Orbiter computer. The Spacelab computer was preferred for pointing and control because of its availability, simplification of interfaces between control consoles and instrument assemblies, ground checkout of Spacelab and instrument assemblies as a package, and software change impacts. The lone possible requirement for a dedicated computer occurs in connection with the RSP. Under some conditions, such as open-loop target tracking, the computation rate required may be too high to be compatible with the Spacelab computer. In this instance a small, high speed computer can be dedicated to the RSP with data being dumped to the Spacelab computer as required for the less frequently required computations, such as those required for interfacing with the Orbiter and Spacelab consoles.

6.3.3.3 Attitude Reference Sensors

6.3.3.3.1 Star Trackers Versus Horizon Sensors

A two-gimbaled star tracker is preferred as an attitude reference because:

1. Potential accuracy is better than horizon sensors.

2. Probably four horizon sensors would be required, leading to increased cost and field of view problems.

6.3.3.3.2 Orbiter GN&C Sensors Versus AMPS-Dedicated Sensors

The misalignments between the Orbiter and instrument mounts are at present undefined. Therefore, the pointing requirements of the individual assemblies dictates a payload-referenced sensor system to eliminate inaccuracies. Also, the RSP has a set of gyros for stabilization purposes and, by the addition of a star tracker, an attitude reference system can be implemented.

6.3.3.4 Gimbal Systems

Because numerous gimbaled assemblies are required for AMPS, the individual gimbal sets must be as simple as possible. The RSP and boom system gimbals appear to be the ones requiring the most study. For this phase of the study, the analyses were done mostly on the basis of SSPD-supplied configurations. Future studies must be concerned with detailed gimbal designs to reduce complexity, to provide minimize size and weight, and to simplify operational procedures.

6.3.3.5 Continuous Alignment to the Earth's Magnetic Field

The results of a study made to determine the impact of maintaining one axis of the Orbiter aligned continuously to the Earth's magnetic field vector are given below.

1. It is feasible to maintain an Orbiter axis aligned to the Earth's magnetic field for 7 days.

2. The impact on the overall experiment timeline must be considered.

3. Two-axis attitude control of the Orbiter is required with the third axis arbitrarily constrained.

4. Pointing along a major axis of inertia should be selected to conserve RCS propellant.

5. RCS propellant estimate (nonoptimal control law):

   a. 10 kg per orbit for pointing along minimum inertia axis.

   b. 4 kg per orbit for pointing along major inertia axis.

6. Propellant usage [6-3]:

   a. 100 n. mi. orbit — Z-POP inertial, 6.2 kg/orbit; Z-LV, 0.3 kg/orbit.

   b. 200 n. mi. orbit — Z-POP inertial, 2.5 kg/orbit; Z-LV, 0.3 kg/orbit.

7. It may be advantageous to point antennas (or accelerators) using Orbiter attitude control only.

It was found that pointing a major axis of inertia along the vector requires about 40 percent of the RCS propellant required for pointing the minimum axis of inertia. Therefore, the antennas, accelerator line-of-action, or other devices requiring alignment should be physically oriented to require pointing of a major axis of inertia. The total fuel requirements do not appear to be excessive when compared to the propellant usage for standard reference Orbiter attitudes.

Polar orbits create some problems due to the fast rate of change of the magnetic vector direction in the polar regions. This may require special control logic during polar crossings to conserve fuel.

The impact on the overall experiment timeline must be assessed when considering alignment to the magnetic field for the full mission time. Since primarily only two-axis control is required, some freedom can possibly be obtained for experimentation by applying arbitrary constraints to the third Orbiter control axis.

6.3.4 Interfaces

6.3.4.1 Spacelab

The AMPS pointing and control concept requires the following Spacelab furnished support equipment:

1. Digital Computer — Coordinate transformations, RSP gyro outputs processing, gimbal commands, star catalog and star identification processing, Orbiter GN&C-furnished ephemeris processing, magnetic field computations.

2. Interface Unit — Multiplexing, switching logic, A/D and D/A conversions, input and output signals routing, and telemetry interface.

3. Controls — Manual and automatic gimbal controls, control of checkout and calibration procedures, subsystem configuration control, boom controls (deployment, scan).

4. Displays — Monitoring of pointing orientations by TV camera output and gimbal readout displays, housekeeping status data.

Additional study is required to obtain better definition of the Spacelab interfaces in the areas of the number of electrical connections, switching circuit design, computer software, display coordinate systems, and Orbiter GN&C interface concept. Also, there is a possibility that the Spacelab program will furnish standardized gimbal mounts which should be utilized to the fullest extent.

6.3.4.2 Orbiter

The general pointing and control concept is to relieve the Orbiter of excessive maneuver requirements and to have the Orbiter fly standard reference attitudes wherever possible. Typically these attitudes would be inertial, and local vertical with X-IOP or X-POP. There are cases where minor variations are desirable, but in general some fixed attitude appears best. The individual instrument pointing assemblies are to be implemented to obtain the final pointing orientation and to provide the required stability.

The Spacelab computer receives the following information via the Orbiter GN&C computer for use in computations:

1. Orbiter position, crosstrack, downtrack, altitude.

2. Orbiter velocity.

3. Orbiter attitude, three axes.

4. Target coordinates as required.

5. Time reference.

6. Star ephemeris (alternately, star catalog in Spacelab computer).

In turn, the AMPS payload reference attitude sensors supply attitude information to the Orbiter GN&C computer to provide the capability for maintaining Orbiter attitude with respect to the payload attitude reference system.

6.3.4.3 Subsystems

The number of gimbaled instrument pointing control subsystems in the AMPS payload makes it necessary to have a common payload attitude reference system. The RSP has a gyro reference unit on the instrument mount gimbal and a gimbaled star tracker has been added to the payload base for attitude determination purposes. The RSP gyros and the star tracker will be used to maintain an updated payload attitude reference system in the Spacelab computer for use in computing pointing commands.

The major sources of error that result from using the star tracker and RSP are:

1. Misalignment between star tracker and RSP gyros.

2. Transformation error from gyros through RSP gimbals.

3. Misalignment between subsystems due to initial errors and pallet flexure.

The first two error sources are manageable by design and calibration techniques. However, the misalignment between subsystems can have a significant impact and for correction would require the addition of optical links for alignment control. The accuracies, in general, do not appear to require these optical links and they have not been included in the preliminary design. Further detailed AMPS studies should investigate the misalignment errors between subsystems and the use of a common reference frame.

6.3.5 Conclusions and Recommendations

6.3.5.1 Conclusions

1. SSPD level B — The pointing and control requirements can be met with designs that require no new technology. However, the RSP stability requirements are very difficult to satisfy for all experiments and it is thought that, upon better experiment definition, these requirements will become less stringent.

2. Boom bending dynamics become a problem only when fast scan profiles, such as those required for wake and sheath studies, are required.

3. Gimbal geometry for the booms can have a significant effect on operational simplicity and procedures.

4. Standardized, computer-controlled gimbal mounts can be used for the AMPS instrument pointing and control subsystems.

5. A small, dedicated computer for the RSP and star tracker combination to do high speed computations is advantageous.

6. The RSP and star tracker can provide a common attitude reference frame for all pointing subsystems if mounting of the individual units does not cause large misalignment errors. Optical links may be required if large misalignments occur.

7. Orbiter vernier thruster firings for durations of less than about 6 sec do not cause boom pointing errors to exceed specifications. Minimum impulse bit thruster firings result in insignificant errors.

8. Boom scan profiles can result in Orbiter disturbances of up to 2 deg when the Orbiter is uncontrolled. The Orbiter control system can handle this disturbance, but during boom sweeps the number of thruster firings should increase.

6.3.5.2 Recommendations

1. A realistic set of pointing requirements, complete with experiment timelines, must be generated before any more detailed pointing and control design studies can be made.

2. The boom gimbal systems should be designed in some detail in order to determine the full capabilities and to permit generation of detailed operational procedures.

3. Consideration should be given to a common attitude reference system.

4. The RSP gimbal design should be updated and performance simulations should be carried out.

5. All instrument pointing control system designs should be reviewed and redesigned as required in the context of a revised set of timelines and specifications.

6. All interfaces, and in particular the Orbiter GN&C to Spacelab pointing subsystems, should be studied in detail.

6.3.6 References

6-1. Sperry Space Support Division: Preliminary Design of a Gimbaled Remote Sensing Platform for the Atmospheric, Magnetospheric and Plasma Sciences (AMPS) Payload. Report No. SP-262-0826, Huntsville, Ala., April 1, 1974.

6-2. Teledyne-Brown Engineering: Preliminary Design and Analysis of a Servo Control System for the AMPS Boom. Technical Letter ASD-PD-18798, Huntsville, Ala., May 3, 1974.

6-3. Space Shuttle System Payload Accommodations. JSC 07700 Vol. XIV Rev. C., July 3, 1974.

TABLE 6-9. AMPS POINTING REQUIREMENTS (SSPD LEVEL B)

Item	Orbiter Pointing Req.				Final Instrument Req.				Orientation or Targets
	Accuracy (arc sec)	Time (sec)	Stability (arc sec)	Rate Stability (arc sec/sec)	Accuracy (arc sec)	Time (sec)	Stability (arc sec)	Rate Stability (arc sec/sec)	
RSP	3600	1800	3600	360	180 Absolute 20 Relative	1800	2	0.2	(1) Horizon (2) Earth (3) Clouds (4) Orbiter Aligned
Lidar System	3600	1800	3600	360	180 Absolute	1800	Not Specified	Not Specified	(1) Earth Point (2) Subsatellite Transponders
Gimbaled Accelerator	3600	360	360	360	3600	360	360	360	Geomagnetic Field Lines
Transmitter/ Coupler	10 deg	360	3600	360	10 deg	360	3600	360	Geomagnetic Field Lines
Boom Systems (Measuring and Exciter)	1800	1800	360	360	1800	1800	360	360	(1) Geomagnetic Field (2) Velocity Vector (3) Wave Generator Alignment
Deployable Satellites	1800	360	360	360	1800	360	360	360	Experiment Dependent
Deployable[a] Units	3600	360	360	360	3600	360	360	360	Experiment Dependent

a. Orbiter hold following release of units.

TABLE 6-10. AMPS MAGNETIC FIELD VECTOR WITH RESPECT TO LOCAL VERTICAL[a]

Altitude (n. mi.)	Inclination (deg)	Ω E[b] (deg)	Ω O[c] (deg)	Magnetic Vector with Respect to Local Vertical (deg)					Max Rate (deg/sec)
				Initial	Max	Mid Orbit	Min	End Orbit	
235	28.5	345	0	79	132	80	46	96	0.06
235	28.5	345	180	80	151	94	32	66	0.10
235	55	345	0	79	160	80	20	98	0.12
235	55	345	180	80	166	90	13	73	0.12
185	90	345	180	80	178	80	2	68	0.11
185	90	345	0	76	180	74	3	86	0.15

a. Sun position at winter solstice (all cases).
b. Ω E is the initial position of Greenwich with respect to Aries.
c. Ω O is the ascending line of nodes with respect to Aries.

TABLE 6-11. AMPS RSP PRELIMINARY HARDWARE DEFINITION

Component	No. Required	Unit Size (cm)	Unit Weight (kg)	Unit Power (watts)	Total Weight (kg)	Total Power (watts)
Inductosyn Resolver	3	20 × 2.5	1	5	3	15
Tachometer (dc)	3	18 × 5	2.1	1	6.3	3
Dc Torque Motor	6	15 × 2.5	0.54	70	3.2	420
Gyros Package	1	25 × 20 × 18H	8.2	38	8.2	38
Electronic Signal Processor	1	13 × 21 × 15H	4.5	10	4.5	10
Mechanical Gimbals	1 set		363		363	0
Mounting Base			201		201	0
Totals					589.2	486

TABLE 6-12. POINTING ERROR, θ_{ERROR}, RESULTING FROM INACCURACIES IN ORBITER AND TARGET POSITION VECTORS

Case	Orbiter Error, R_{RE} (m)	Target Error, R_{TE} (m)	$\left(R_{TE}^2 + R_{RE}^2\right)^{\frac{1}{2}}$	θ_{ERROR} (arc sec) 150 n. mi.	500 n. mi.
1	130 + j 130	0	184	137	41
2	230 + j 230	100 + j 100	354	263	79
3	150 + j 130	0	199	147	44
4	250 + j 230	100 + j 100	368	27.3	82

TABLE 6-13. RSP SYSTEM ERROR SUMMARY

Error Source	Error (arc sec)
Pointing Vector Determination	82
Altitude Determination	26
Computation	3
Gimbal Servos (Star Tracker and RSP)	4
Gyro Drift	10
Total Estimated Error (RSS)	87

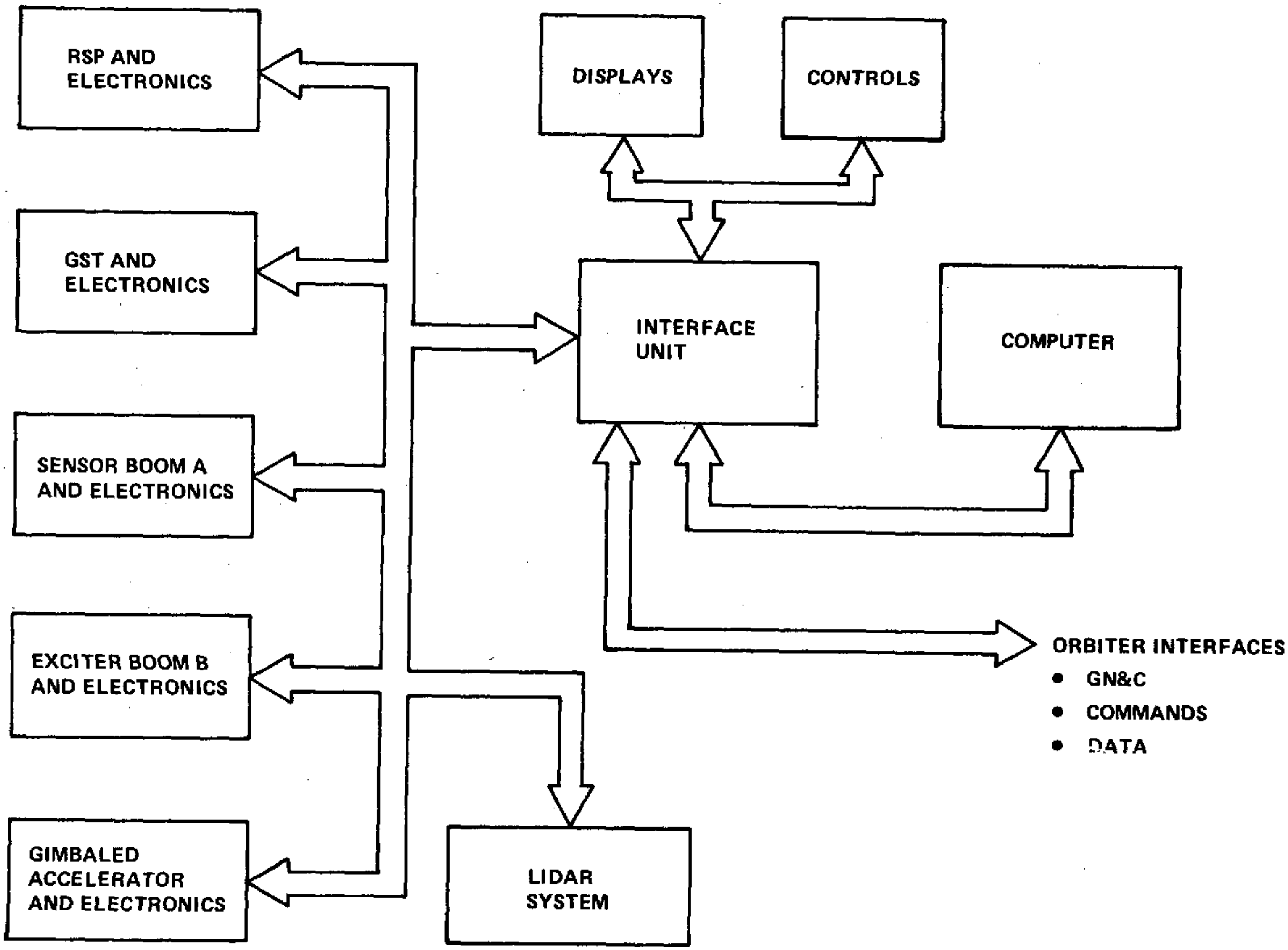
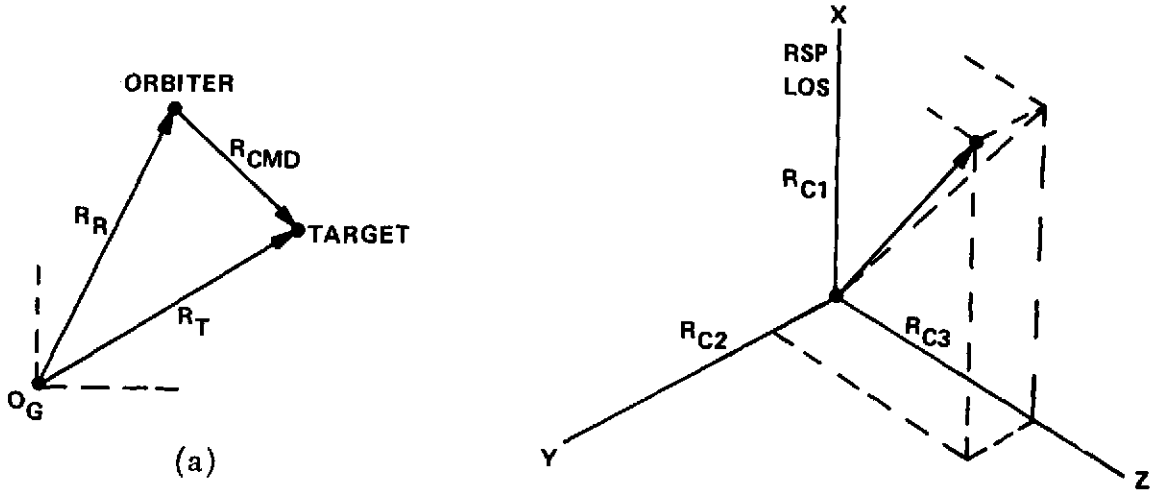


Figure 6-29. AMPS pointing and control information flow chart.



(a) (b)

- $R_R = \begin{Bmatrix} R \\ 0 \\ 0 \end{Bmatrix}_P \qquad R_T = \begin{Bmatrix} R_T \end{Bmatrix}_L$

- $\begin{Bmatrix} R_R \end{Bmatrix}_G = |A_{GE}|\ |A_{EO}|\ |A_{OP}| \begin{Bmatrix} R \\ 0 \\ 0 \end{Bmatrix}_P$

- $\begin{Bmatrix} R_T \end{Bmatrix}_G = |A_{GL}| \begin{Bmatrix} R_T \end{Bmatrix}_L$

- $\begin{Bmatrix} R_{CMD} \end{Bmatrix}_G = \begin{Bmatrix} R_T \end{Bmatrix}_G - \begin{Bmatrix} R_R \end{Bmatrix}_G$

- $\begin{Bmatrix} R_{CMD} \end{Bmatrix}_{RSP} = |A_{RSP,G}| \begin{Bmatrix} R_{CMD} \end{Bmatrix}_G = \begin{Bmatrix} R_{C1} \\ R_{C2} \\ R_{C3} \end{Bmatrix} = \begin{Bmatrix} -\cos(\Delta a_0)\cos(\Delta a_M) \\ +\sin(\Delta a_0)\cos(\Delta a_M) \\ -\sin(\Delta a_M) \end{Bmatrix}$

GIMBAL ERRORS

- $\Delta a_M = \sin^{-1} R_{C3} \approx -R_{C3}$ = MIDDLE

- $\Delta a_0 = \sin^{-1}\left[\dfrac{-R_{C2}}{\cos(\Delta a_M)}\right] \approx R_{C2}$ = OUTER

(c)

Figure 6-30. RSP gimbal command geometry.

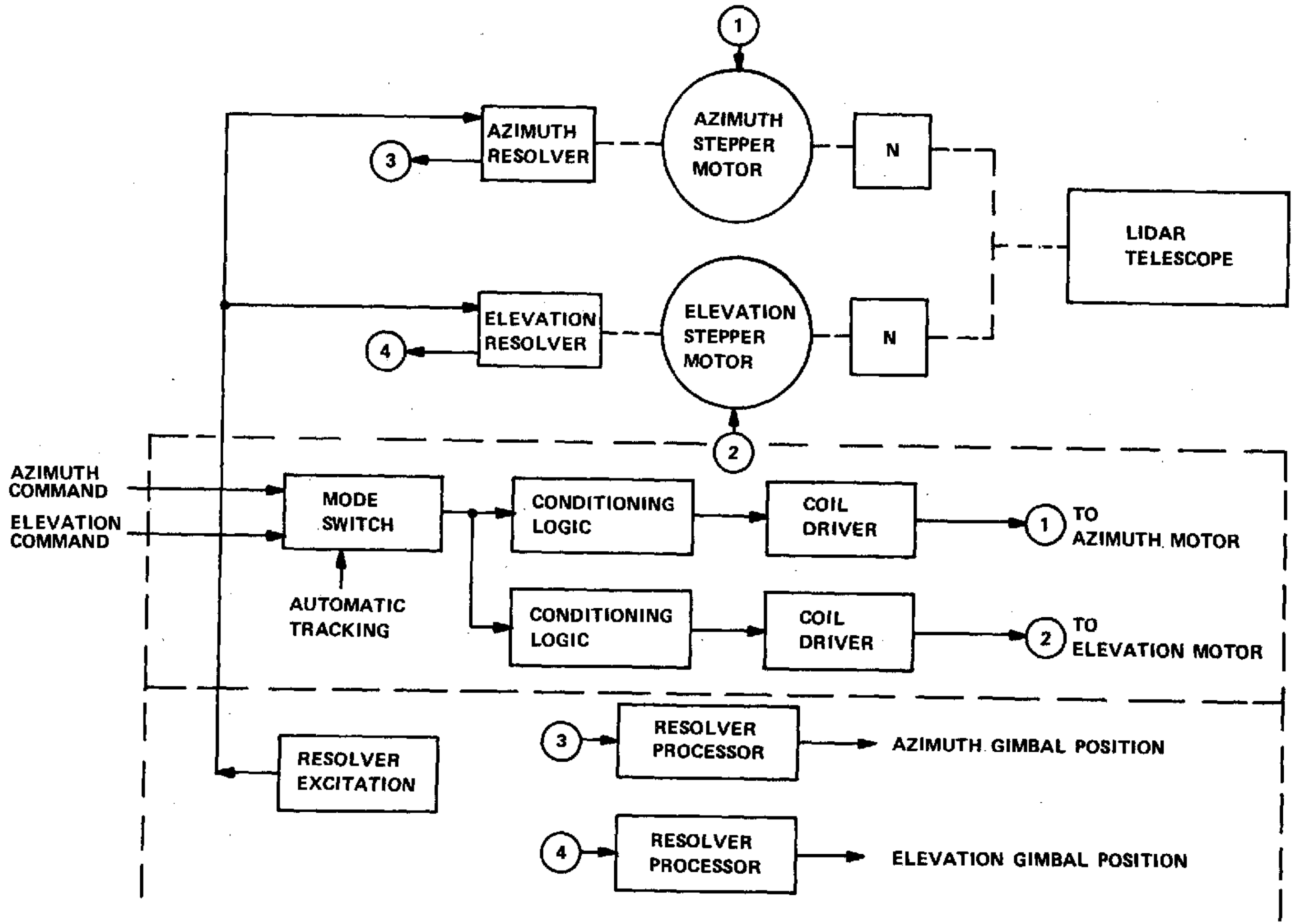


Figure 6-31. Lidar system gimbal control diagram.

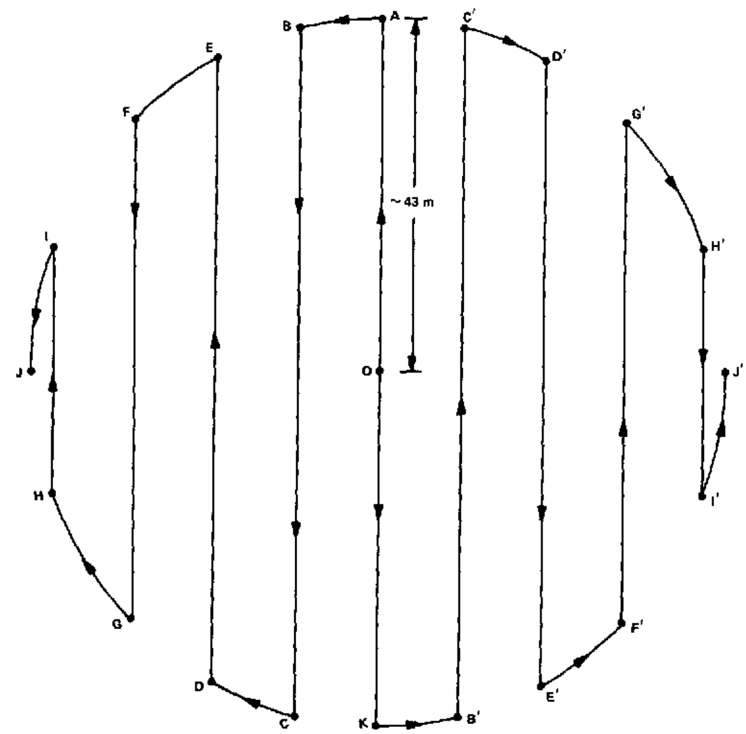


Figure 6-32. AMPS 50 m booms scan profile (preliminary).

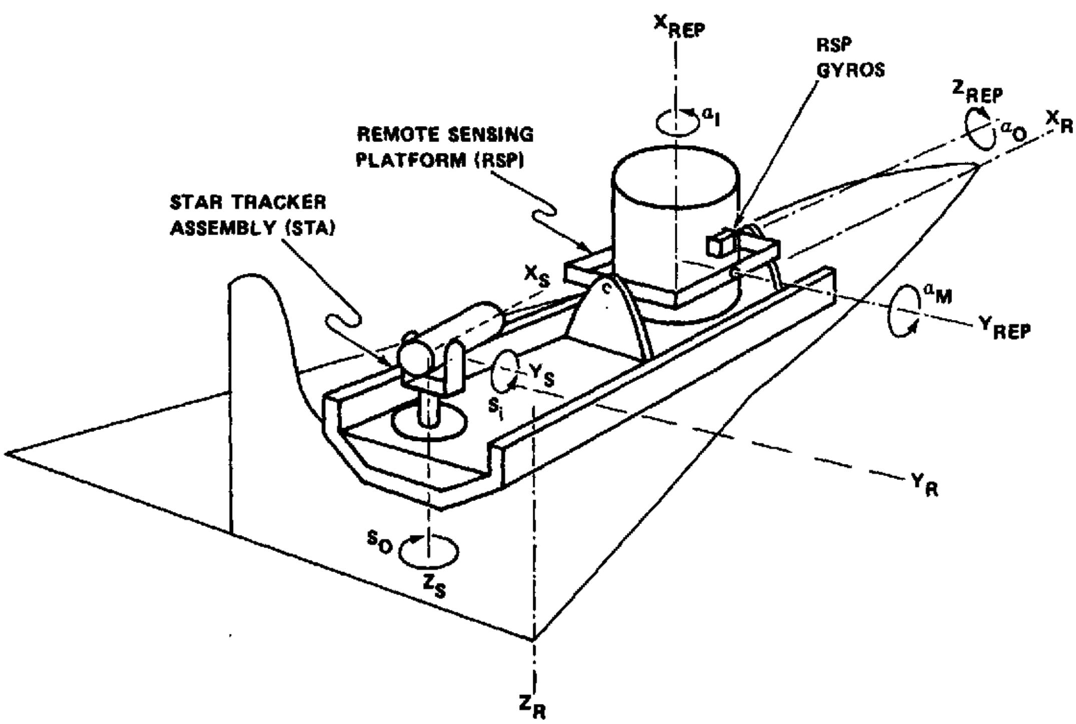


Figure 6-33. Conceptual geometry of the RSP and star tracker.

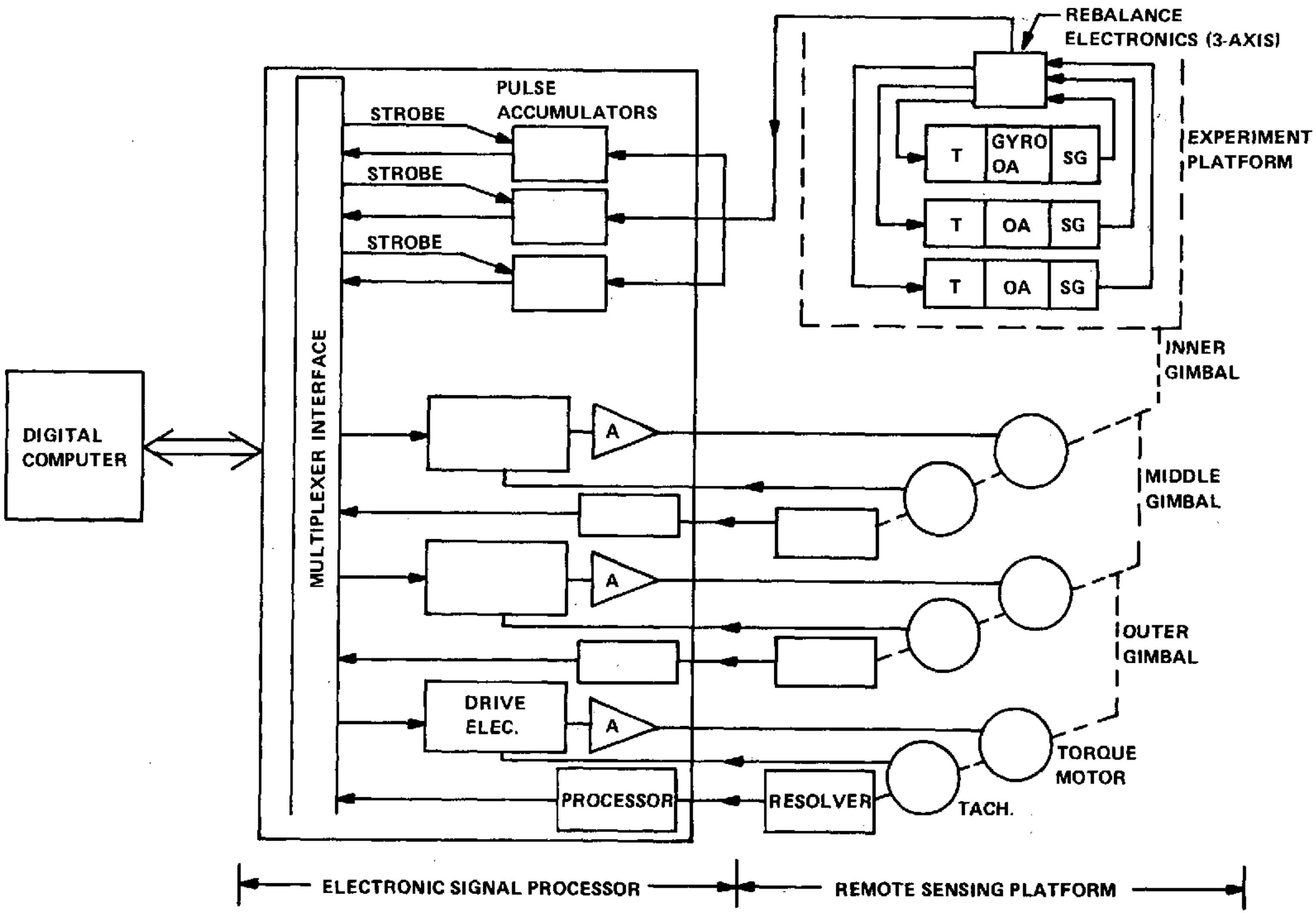
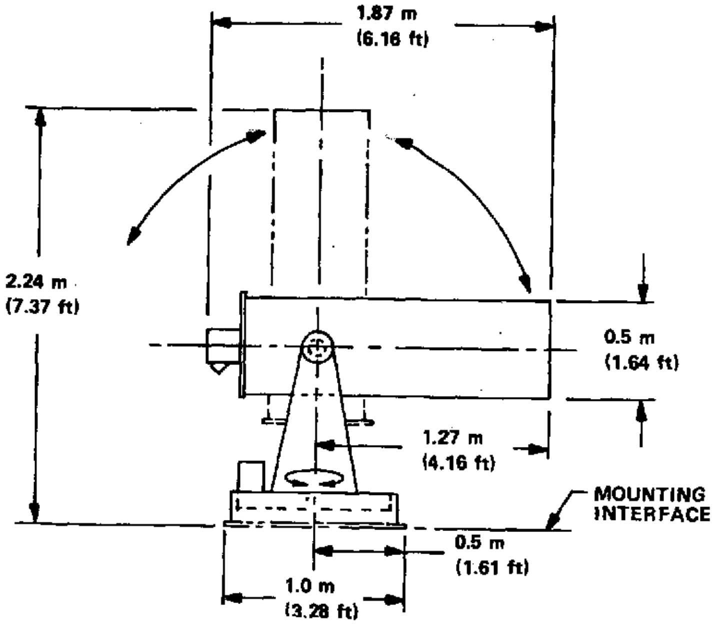


Figure 6-34. AMPS RSP block diagram.



STEPPER MOTOR TYPICAL

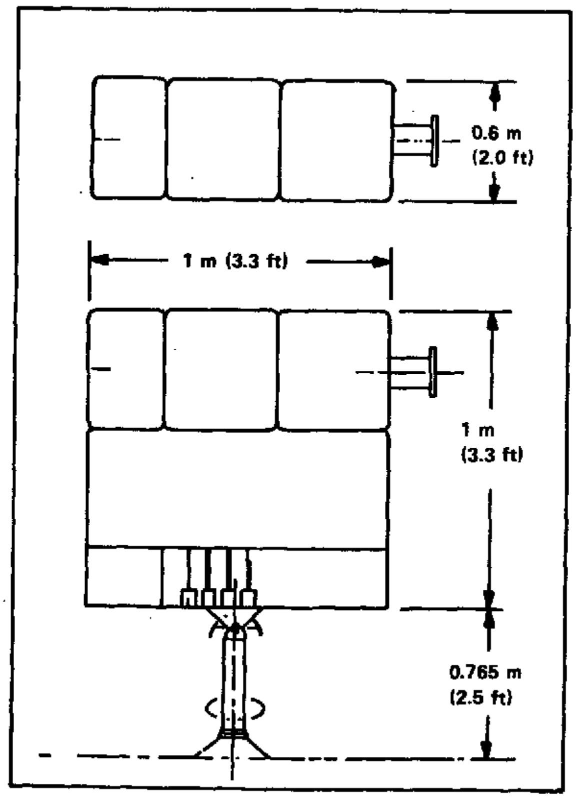
COMPUTER DEVICES CORP.
RAPID-SYN MODEL 34H-901
SIZE 34 - 8.6 cm DIA. x 13.5 cm LONG
WEIGHT - 4.25 kg
STEP SIZE - 1.8 deg*
DYNAMIC TORGUE - 1.8 N-m
DETENT TORQUE - 0.1 N-m
STALL TORQUE - 3.6 N-m

*FOR AMPS USE 108/1 GEAR TRAIN
100 STEPS/SEC

RESOLVER

DUAL SPEED
32 SPEED SINE AND COSINE
1 SPEED SINE AND COSINE
0.028 deg/bit DIGITAL OUTPUT
(0.006 deg CAN BE OBTAINED WITH
SPECIAL PROCESSING)

Figure 6-35. Lidar gimbal components.



PM STEPPER MOTOR

SIZE 20 - 5 cm D x 6.4 cm

WEIGHT - 0.5 kg

STEP SIZE - 45 deg

STALL TORQUE - 0.1 N-m

DETENT TORQUE - 0.003 N-m

GEAR HEAD

450:1 - 0.25 kg

POSITION INDICATOR

SINGLE SPEED RESOLVER

RES/DIG CONVERTER - 14 BIT

0.1 deg ACCURACY

Figure 6-36. Gimbaled accelerator system.

θ_c = MOTOR ROTOR COMMAND
θ_e = POSITION ERROR
K_a = AMPLIFIER GAIN
K_r = TACHOMETER GAIN
J_a = $J_b + N^2 J_m$
J_o = ORBITER INERTIA
J_b = BOOM INERTIA
J_m = MOTOR INERTIA
θ_b = BOOM ANGLE
θ_o = ORBITER ROTATION
T_{vd} = ORBITER DISTURBANCE TORQUE
T_{bd} = BOOM DISTURBANCE TORQUE
N = GEAR RATIO

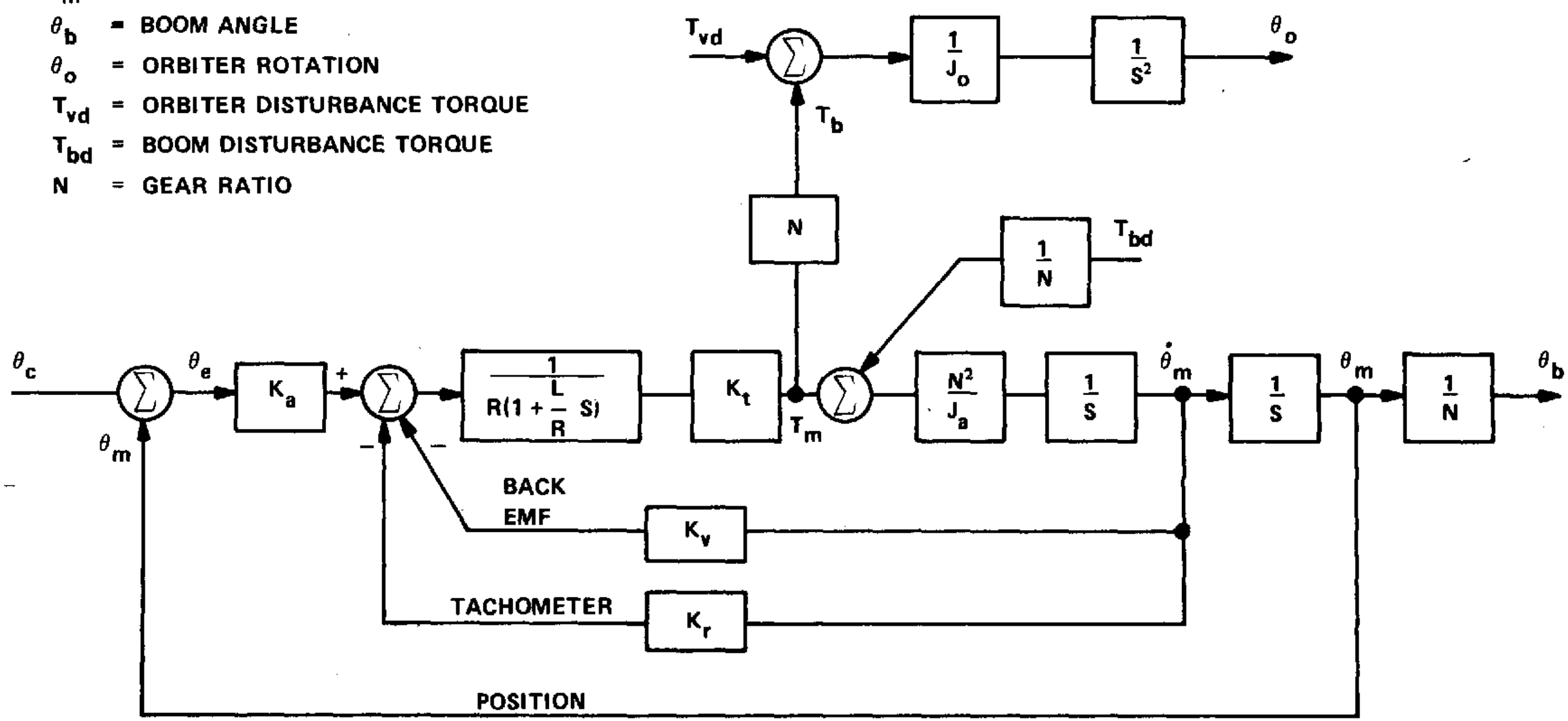
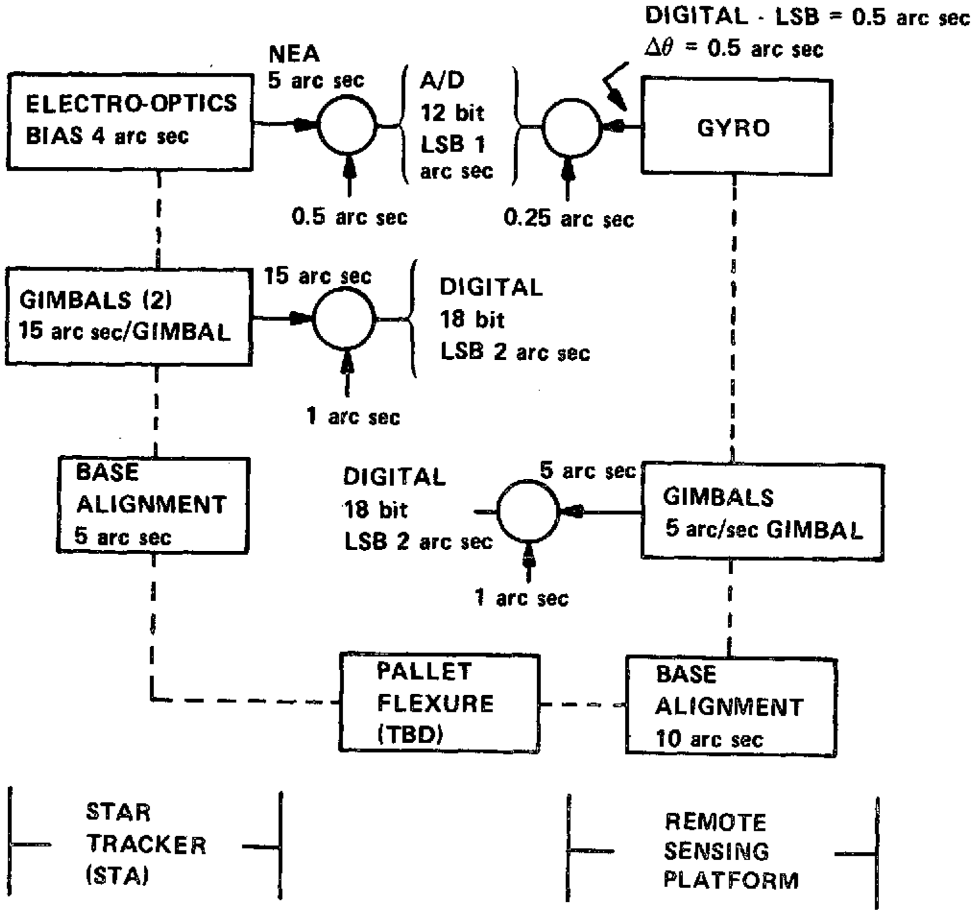


Figure 6-37. AMPS single-axis gimbal control loop for boom.



(a) Attitude determination accuracy.

ABSOLUTE (arc sec)			RELATIVE
5	STA OUTPUT NEA		
0.5	STA A/D QUANTIZATION		
4	STA BIAS ERROR		
21	STA GIMBAL ACCURACY		
1	STA GIMBAL QUANTIZATION		
5	STA BASE ALIGNMENT		
10	RSP BASE MISALIGNMENT		
7	RSP GIMBAL ACCURACY		
0.5	RSP GYRO $\Delta\theta$		0.50
0.25	RSP GYRO OUTPUT QUANT.		0.25
55.25 TOTAL		TOTAL	0.75
(25.8 RSS)		RSS	0.56

(b) Attitude error budget neglecting pallet flexure.

Figure 6-38. RSP attitude error budget.

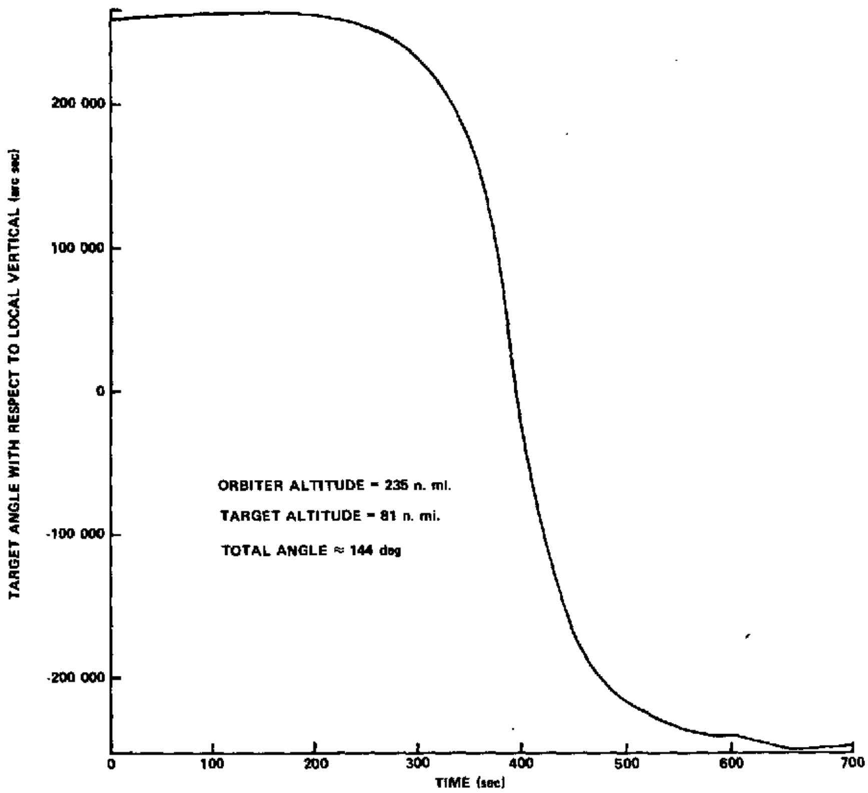


Figure 6-39. RSP fly-by pointing command trajectory.

Δt (sec)	T_o (N-m)	Max Error (deg)
0.04	254	0.002
2.65	254	0.100
≥ 6.0	254	0.17
0.04	11 200	0.09
2.65	↓	4.41
≥ 6.0	↓	7.50

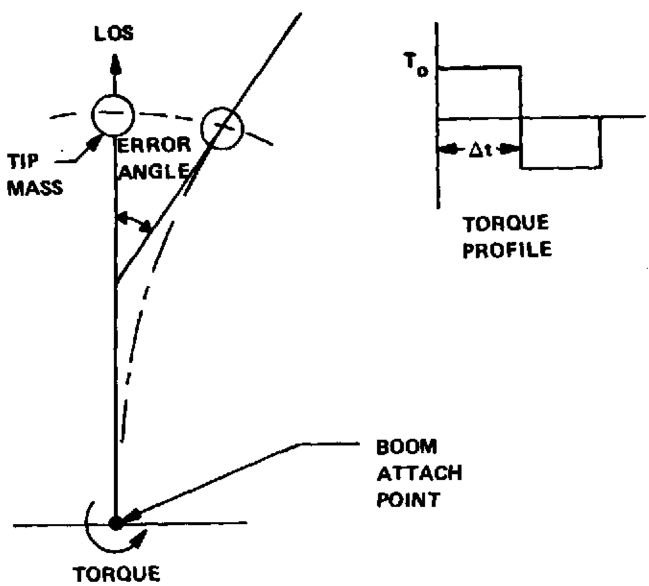


Figure 6-40. AMPS boom pointing errors during Orbiter thruster firings.

6.4 COMMUNICATIONS AND DATA MANAGEMENT

The following general guidelines and assumptions were used in this study:

1. Requirements derived from SSPD data (dated July 1974) and S&E scientific support.

2. Both subsatellites transmit to the Orbiter at the same time.

3. Spacelab definition derived from Spacelab document "Interim Spacelab Reference Document," MSFC Spacelab Program Office memorandum 74-456, and verbal contacts with the Spacelab Office.

4. Seven day mission duration.

6.4.1 Communications

6.4.1.1 Guidelines and Assumptions

1. Tracking and Data Relay Satellite System (TDRSS) baselined for communications.

2. Shuttle and Spacelab capabilities used where possible.

3. Subsatellite physical design based on Atmosphere Explorer spacecraft.

4. Shuttle and subsatellite assumed to be in antenna beamwidth.

5. Subsatellite communications distance to the Orbiter up to 22 540 km.

6. Subsatellite power system capable of providing approximately 100 watts of power for the communications system.

7. Subsatellite will transmit data to the Spaceflight Tracking and Data Network (STDN) when the Shuttle is not on orbit.

6.4.1.2 Requirements

The communications data rate requirements are summarized in Table 6-14. The total data rate varies from 440 kbs to 1.531 MBPS, depending on the experiment. Subsatellite data of 400 kbs and 2 MHz were not included in the total data rate under the assumption that the 400 kbs and 2 MHz data received from the subsatellite would be used by the onboard scientist. Two subsatellites will transmit the above data to the Orbiter at the same time. If the subsatellite data were formatted into the telemetry downlink the highest data rate would then become 2.331 MBPS. The requirements summarized in Table 6-14 are the requirements used to size the onboard data processing, storage, acquisition, distribution, and RF links. Real-time downlink data rates specified in SSPD were interpreted as percent of time at the rate specified. Table 6-14 is based on the Phase A Study timeline.

6.4.1.3 Design Reference

An overall block diagram of the communications system is shown in Figure 6-41. TDRSS is baselined by Spacelab and is utilized on the AMPS mission. The STDN links are depicted to illustrate the existing Orbiter downlinks. Assuming that the Orbiter implements a 50 MBPS digital and a 4 MHz analog transmission capability, the AMPS requirements can be provided via TDRSS. If not, the present AMPS data requirements will be severely restricted by the Orbiter Interface. Present Orbiter baseline provisions include up to 64 MBPS of payload data and a 3 MHz shared downlink direct to STDN ground stations in addition to the Orbiter/TDRSS communication links. However, TDRSS will be the primary link if the Orbiter implements the wideband Orbiter/TDRSS links.

AMPS, Spacelab, and Orbiter blocks are drawn to illustrate the multiple physical interface situation of the AMPS communications subsystem. Both 50 m booms have an RF system including an uplink and a downlink. More details about the subsatellite and booms are contained in another section. Two subsatellites require communications with the Orbiter at the same time during various experiments. The RF links from the subsatellites to STDN are provided when the Orbiter has returned to Earth and the subsatellites remain on orbit.

A command uplink at a basic command rate of 2.4 kbs is provided by the Orbiter communications system. Preliminary investigations indicate that the AMPS requirements are within this capability. The capability to command subsatellites from the Spacelab module using the Orbiter 2.4 kbs link does not presently exist. A software change in the Orbiter computer is necessary to allow this capability. This study will assume that this capability will exist. In addition to these real-time commands, onboard commands will be stored in the computer for execution by the AMPS flight crew. More information is required before these stored commands can be adequately sized.

Table 6-15 summarizes AMPS requirements with respect to the Orbiter/ Spacelab capabilities. Two areas of concern are transmission through TDRSS to ground and detached payload transmission to Orbiter. Proposed Orbiter changes are shown in parentheses. The AMPS requirements for transmission of data to ground is 1.531 MBPS digital, 2 MHz analog, and a voice link. The existing Orbiter capability is up to 64 kbs for payloads and two-voice channels either direct to STDN ground stations or via TDRSS, 1024 kbs and 3 MHz direct to STDN ground stations and 50 MBPS and 4 MHz via TDRSS if this capability is implemented. AMPS requirements can be met by the Orbiter. AMPS requirements for detached payload transmission to the Orbiter consist of two subsatellites transmitting 400 kbs digital and 2 MHz analog data from each subsatellite to the Orbiter simultaneously. The Orbiter provides for only one detached payload transmitting 16 kbs and voice back to the Orbiter. These two subsatellites and high data rates result in payload-dedicated equipment, a list of which is furnished in Table 6-16. A subsatellite communications trade analysis was performed and is available upon request.

6.4.1.3.1 Subsatellite to Orbiter Reference Design

A subsatellite communications block diagram is given in Figure 6-42. The necessary equipment to complete the RF link with the Orbiter is shown in Figure 6-43. Subsatellite requirements specified in SSPD are 400 kbs digital data and 2 MHz analog. Other major considerations in this concept were command system, range, and range rate requirements.

Using the Amtosphere Explorer as a subsatellite reference, a complete data management and communications system redesign is required to accommodate the high data rates. The reference design depicts a data bus system to acquire and distribute the experiment data for the 400 kbs link. The data bus controller formats the composite digital wavetrain for modulation onto the subcarrier. The subcarrier and pseudo random noise generator (PRN) ranging codes both modulate the S-band transponder. Then the S-band carrier is combined with the 2 MHz RF carrier to be commonly amplified and radiated from one of the selected horn antennas. An E field meter outputs a 2 MHz analog signal. This link uses amplitude modulation/single sideband techniques to modulate an S-band transmitter, then it combines with the S-band transponder signal for amplification and transmission. The filter in Figure 6-42 is required to reduce the unwanted RF signals applied to the input of the receiver. Typical hardware characteristics for the Figure 6-42 block diagram is tabulated in Table 6-17. System total weight is 65 lb and it consumes 81.5 watts.

Communications-dedicated equipment is indicated in Figure 6-43 as a block diagram. A dotted line indicates the interface between Spacelab- and AMPS-dedicated hardware. An S-band transponder is recommended for transmitting commands and ranging. Reception of the 400 kbs signal and ranging is also performed by the transponder. A ranging signal is supplied by the PRN generator. Rendezvous and communication by a single Ku-band system is being evaluated for use on the Orbiter. If this system is implemented on the Orbiter, it could possibly be a source for ranging with payloads. This subject has not been adequately evaluated; therefore, more detailed analysis is recommended as a follow-on effort. The power amplifier and high gain parabolic antenna are required for long range transmission at these data rates. RF carrier separation is provided by the multicoupler and is transferred to the appropriate receiver. The composite telemetry signals interface with the Spacelab data management system. The command system was evaluated using 1 kbs as the subsatellite command rate. This is the command rate employed on the Atmosphere Explorer (AE); therefore, it appears reasonable to utilize it as a guideline for the subsatellites until more detail requirements are available.

Typical component weight and power requirements are shown in Table 6-17 for the subsatellite communication-dedicated equipment. This equipment will physically be located on the pallet. Dual components are required since dual systems will be needed to accommodate two subsatellites communicating simultaneously. Dedicated system weight is 252 lb and total power requirements are 116 watts at 28 volts.

Antenna sizing and transmission distance was performed on a parametric basis. The variables are the pallet-mounted parabolic antenna diameter and the transmission distance. Subsatellite antenna configuration and characteristics are illustrated in Figure 6-44. Eight horn type antennas were selected for the 8 dB gain and physical size compatability with AE. Multiple antennas were required to obtain omnidirectional coverage since AE is spin stabilized. If a stable platform is available on the AE, only one antenna would be required, still giving an 8 dB gain. Only one antenna is active at a time with the antenna selection being done by using receiver signal strength. Antenna selection is updated approximately four times per second. Relative position of the subsatellites to the Orbiter cargo bay necessitates a steerable deployable antenna to stay within antenna beamwidth. The characteristics of the deployable boom and the gimbal angle of the antenna is yet to be determined. A parabolic dish antenna is utilized to accomplish high gain at practical physical characteristics. A 1 m diameter antenna with a gain of approximately 25 dB and a beamwidth of 10 deg is included in the reference design. A graph of the range versus diameter of deployable antenna is plotted in Figure 6-45. Extremely large and unrealistic antenna diameters become evident at distances exceeding 2000 km. From a practical hardware viewpoint, a 1 m diameter was chosen as the reference design. Larger antennas present deploying and steering problems. Transmission distances up to 1600 km are obtainable with a 1 m parabolic dish at these data rates.

6.4.1.4 Conclusions

Preliminary investigation indicates that the Orbiter/Spacelab command and voice system is adequate to satisfy existing AMPS command and voice requirements. The SSPD real-time downlink transmission requirement of 10 percent is more than covered by the TDRSS. An RF system of command and data transfer on the 50 m booms is a feasible design concept. Larger weights and higher power requirements are the penalties of using an RF design on the booms versus the data bus approach. The RF system does eliminate routing a cable the length of the boom which could possibly induce electromagnetic interference (EMI) and cause scientific experiment limitations.

AMPS downlink data rate requirements are approximately 2 MBPS digital and 2 MHz analog. If the recently approved change to the Orbiter baseline providing a Ku-band link between the Orbiter and the TDRSS is implemented, the AMPS downlink data rate requirements will be accommodated by the Orbiter/Spacelab. Orbiter baselined capabilities for receiving data from a detached payload are currently defined at 16 kbs from only one payload. The AMPS subsatellite data return link to the Orbiter is 2 MHz analog and 400 kbs digital from each of the two subsatellites at the same time. This requirement resulted in AMPS-dedicated communications equipment as described previously. The high data rates, long transmission distances, and simultaneous transmission from two subsatellites are all significant parts of the subsatellite communications system. More detailed data from the scientific community could conceivably result in smaller data rates, shorter transmission distances, and perhaps only one subsatellite.

6.4.1.5 Recommendations

Two areas of continued effort for better definition is recommended for the communications subsystem:

1. Investigation into subsatellite range and range rate capabilities with the Orbiter being the active element. Additional subsatellite to Orbiter communication analysis should be made if more detailed requirements become available.

2. Analyze the use of laser as a candidate for the boom communication system. Evaluate and compare the laser analysis with the presently defined RF system.

6.4.2 Data Management

6.4.2.1 Guidelines and Assumptions

SSPD has specific data rates and storage requirements for data management; however, only general information was available on computer data processing, command, and experiment control requirements. With this limitation the following guidelines and assumptions were established:

1. Utilize IBM 74W-0059 report entitled "Spacelab Sortie Payload Software Sizing Analysis" where applicable.

2. Experiment control and monitoring, and experiment data processing are onboard functions.

3. An IBM AP101 computer was assumed for the Spacelab data management system in order to perform preliminary comparison and evaluations of AMPS data processing requirements.

4. Each of two subsatellites generate 2 MHz of analog data. This was not included in the computer analysis.

6.4.2.2 Requirements

The data rate requirements for instrument cluster and for each experiment are shown in Table 6-18. Instrument cluster AP-200 is the lidar, or laser radar, system. Cluster AP-700 is the subsatellite system. This system also includes a total of 4 MHz of analog data. The processing requirements of these data have not been defined and therefore have not been included in the computer analysis. Table 6-19 shows the data storage requirements as a function of instrument cluster. Film weight was included as a lump weight of 95 lb. Total digital data storage per mission is 8.3×10^{10} bits. The input data rate varies from 0.3 kbs to 1 MBPS, depending on the instrument cluster. An analog storage requirement of 2 MHz is depicted from the subsatellite.

6.4.2.3 Design Reference

A block diagram of the AMPS data management conceptual design is shown in Figure 6-46. Dotted lines indicate AMPS, Spacelab, and Orbiter functional hardware locations and interfaces. Preliminary investigations and analysis imply that Spacelab data management payload support capabilities are adequate to meet AMPS requirements with a possible exception of computer data processing. Further study and definition are required to adequately define AMPS data processing requirements and to determine Spacelab computer capabilities. Present Spacelab design concepts indicate two separate data bus acquisition and distribution systems — one for subsystem data and another dedicated to experiment information. The data bus will handle bit rates up to 1 MBPS, which is adequate for the AMPS requirements shown in Table 6-18. The lidar experiment requires 16 channels operating at a 1 MBPS data rate each. To accommodate this experiment, a direct hardwired path from the scientific instrument to data storage, to the computer, to the communication system, and to control and displays is provided.

Adequate magnetic tape storage capabilities are provided by the Spacelab data management system with respect to preliminary AMPS storage requirements. Three tape recorders are currently baselined by Spacelab — one digital machine at an input rate of 1 MBPS, a digital recorder with an input data rate of 30 MBPS, and a video recorder. The video recorder is assumed to have the capability of recording the subsatellite 2 MHz analog data to an acceptable signal-to-noise ratio.

An assessment of computer requirements for the AMPS payload was made in a recent study by IBM. The results are listed in Table 6-20. Total data processing is listed at 335 percent of the generated data. Preliminary evaluations indicate a storage requirement of 35 466 words at 32 bits per word. This includes control and monitoring as well as experiment data processing. Computer speed requirements are based upon an average data rate of 1.15 MBPS and an estimated 15 equivalent add operations (EAOs) per data word processed. With these general requirements and specific information on particular experiments, a comparison of AMPS requirements and Spacelab capabilities was performed (Table 6-21). An IBM AP101 computer was used as a typical Spacelab experiment computer for this study.

Table 6-21 illustrates that Spacelab computer memory capacity exceeds currently defined AMPS requirements. The Spacelab baseline utilizing one active experiment computer can provide minimum lidar processing requirements (2.4 kilowords in 1/30 sec). This assumes full dedication to the lidar data except for experiment control and monitoring. One Spacelab experiment computer may be marginal for the AMPS requirements.

6.4.2.4 Conclusions

In general the data management system provided by Spacelab is adequate to meet the AMPS preliminary requirements. One area of concern is the computer data processing capabilities available from Spacelab. An IBM AP101 computer was used as a typical available Spacelab experiment computer for evaluation of the AMPS requirements. One IBM AP101 computer will permit minimum lidar real-time data processing plus real-time processing of between 9 and 68 percent of other experiment data. Lidar is definitely the computer sizing driver on AMPS and would require full dedication for approximately 15 min per orbit except for experiment control and monitoring. The Spacelab experiment computer memory size is 64K and only 35.5K capability is needed by AMPS.

Data acquisition and distribution furnished by Spacelab depicts a data bus technique which is sufficient to meet preliminary AMPS requirements. Data interface units allow a standard interface between the experiments and the Spacelab data management system. Flexibility is available by adding or eliminating interface units as required by the experiments. Access to the Spacelab data management system is provided by hardwires for high data rate experiments; lidar is an example of such an experiment. The general purpose magnetic tape storage capability provided by Spacelab meets the AMPS requirements as currently defined. More information is needed from the scientific community to analyze and evaluate the experiment data received by the Spacelab from the subsatellites. Specifically, the question of how much data processing, storage, display, and real-time transmission is required to accommodate the subsatellite data needs to be answered.

6.4.2.5 Recommended Further Effort

The previously listed guidelines and assumptions were made to produce initial design concepts. Most of the subsystem design and analysis has progressed to an adequate depth of definition until more detailed requirements are furnished by the scientific groups. A specific task that is recommended for further study is an analysis of using a dedicated computer for the lidar experiment versus utilizing the Spacelab-provided central experiment computer.

Listed below are the general areas wherein additional information is needed to effectively produce further definition in the communications and data management subsystem.

1. Communications

   a. Subsatellite requirements that need better definition:

      (1) Distance from Orbiter to subsatellite.

      (2) Position of subsatellite relative to Orbiter cargo bay.

(3) Data rates required from subsatellites.

(4) Power available on subsatellite for communications system.

(5) Quantity of subsatellites.

b. Better definition of down-link data requirements is needed.

2. Data Management

a. Data Processing

(1) Function

(2) Speed

(3) Memory

b. Command and control

(1) Number of commands per experiment

(2) Rate

(3) Resolution

c. Subsatellite data system

(1) Storage and data dump

(2) Data processing

(3) Real-time downlink

(4) Display and control

A specific requirements summary format was generated for liason between MSFC Program Development engineers and the scientific working groups. This summary format is given in Figure 6-47.

6.4.3 Boom Data Management Trade Analysis

Both 50 m booms on the AMPS payload have command and data requirements that necessitate some form of communication or data management system to transfer information from the end of the booms to the pallet. Varying inputs were received from TRW and the scientific groups relating to the feasibility of routing wire up the booms for data transfer. Some sources indicated a possible interference problem with the experiments being performed on the booms as a result of an electrical potential difference between the bottom and top of the boom caused by the conductors cutting the Earth's magnetic field lines. Others advised this potential difference could be compensated for by calibration or by controlling the voltage potential on the booms. No specific guidelines were available on this subject, thus a trade study was implemented to investigate the merits of an RF system versus a data bus technique. The following guidelines and assumptions were formulated:

1. SSPD data rates were utilized.

2. Booms require commands as well as data downlink.

3. Angle between booms less than 120 deg.

4. Both booms transfer data at the same time.

5. Booms are 50 m in length and triangular construction is used which fits in a 20 in. diameter circle.

6. Base analysis on existing hardware where possible.

6.4.3.1 Reference Design

A block diagram of a feasible communication system is shown in Figure 6-48. The block diagram at the top of the page indicates the equipment that would be located at the end of the boom; pallet-mounted equipment is indicated at the bottom of the page. Each boom requires a system as illustrated in Figure 6-48. With the exception of the antennas, the utilization of common equipment is eliminated by the requirement of the booms to transmit simultaneously. The horn type of antenna chosen in the reference design required one pallet-mounted antenna per boom. The Spacelab/AMPS interface is the data bus interface unit and is shown in dotted lines in Figure 6-48.

Antenna design and mounting constraints are significant drivers in the communications system. An antenna functional configuration is depicted in Figure 6-49. A directional antenna (horn) was selected over an omnidirectional one to reduce possible multipath problems. Pallet equipment mounting, Orbiter configuration, and close (50 m) radiating distance contribute to a possible multipath situation. Some of the specific antenna characteristics are included in Figure 6-49. The boom antenna has a nominal 30 deg beam width at the 3 dB points. Under the assumption of using an antenna at both ends of the boom, all four antennas would be the same for equipment commonality. Figure 6-49 is a functional drawing and does not relate to a specific mounting configuration; however, the pallet antennas should be mounted above the normal pallet equipment to eliminate pattern interface. An RF link calculation was performed to establish conceptual hardware characteristics. A summary of the calculation is listed in Table 6-22. An S-band RF system was selected to transmit the 1 MBPS data rate the short 50 m distance. Calculations based on the listed values indicate that a transmitter with an output power as low as 0.1 mW would be acceptable. From a practical availability viewpoint, a 100 mW transmitter would probably be utilized.

A weight and power summary of typical hardware required to implement the RF system for both booms is shown in Table 6-23. The weight and power values are based on currently available equipment. Increased pallet weight is 31 lb, compared to 17 lb on the end of each boom. Figure 6-50 depicts a data bus technique for transferring the information from the booms. Hardware items required to implement this technique are wire to span the boom and a remote addressable multiplexer.

The amount of detail needed from the scientific experiments has not been determined so the number of digital or analog channels in and out of the remote multiplexer cannot be defined. Composite telemetry wavetrain rate is currently predicted at 1 MBPS for boom A and 1.1 kbs for boom B. The Spacelab interface is shown in dotted lines and is the normal interface to the Spacelab data bus. Table 6-24 indicates the data bus concept weight and power estimates. End-of-boom weight is conceived at 3 lb for a typical remote multiplexer with the wire weighing 2 lb. Wire weight was calculated based on 195 ft of number 22 twisted shielded pairs and on 10 lb per thousand feet. An extra length of 31 ft was added to the boom wire for deployment techniques and space wire at both ends of the booms for interfacing requirements. Total data bus concept weight is 5 lb per boom.

6.4.3.2 Conclusions

Either of the two investigated boom data transfer concepts are feasible and practical in terms of current technology. The total system weights are compared at 10 lb for the data bus and 64 lb for the RF system; these weights are for both booms. The RF system is definitely more complex than the data bus technique. A hardware component count is 18 for the RF system and 2 for the data bus concept. End-of-boom weight is important in relation to structural and pointing design considerations. Additional end-of-boom weight for the RF system is 17 lb, compared to 3 lb for the data bus system. Power requirements at the end of the boom are 12 watts for the RF system and 3 watts for the data bus at 28 Vdc.

Final resolution on the boom data transfer concept should not be decided until the scientific groups evaluate the impacts of EMI on the boom experiments. EMI was investigated and is documented in another section of this report.

TABLE 6-14. COMMUNICATION REQUIREMENTS SUMMARY, DATA RATE MATRIX

Instrument Cluster	Experiment XAP												
	410	420	450	460	430	440	470	480	301	302	303	306	308
Remote Platform AP 100	0.216	0.44	0.68	0.68	0.44	0.44	0.68	0.216	0.1	0.1	0.24	0.44	0.24
Lidar AP 200								1.01					1.00
Accelerator AP 300			0.0021	0.0021			0.0021	0.01					
Transmitter/ Coupler AP 400	0.0007	0.0007			0.0001		0.0003	0.0007					
Booms AP 500	0.294	0.294	0.294	0.294	0.293	0.293	0.293	0.294				0.293	
Deployable Units AP 600				a	a		a	a					
Subsatellite AP 700	b	b	b	b	b		b	b					
Total Data Rate MBPS	0.511	0.735	0.976	0.976	0.733	0.733	0.975	1.531	0.44			0.733	1.24

a. No data required from deployables.
b. 400 kbs and 2 MHz transmission from subsatellite during experiment.

TABLE 6-15. AMPS COMMUNICATION REQUIREMENTS WITH RESPECT TO ORBITER/SPACELAB CAPABILITIES

	Orbiter Capability	Spacelab Capability	AMPS Requirements
Transmission Through TDRSS to Ground	Up to 64 kbs (Orbiter-shared) Two voice channels 50 MBPS 4 MHz	Interface permits use of Orbiter's full capability	1.531 MBPS (approximately 10% of the time) 2 MHz analog Voice 25% of data dumped
Transmission Direct to Ground	Up to 64 kbs (Orbiter-shared) 5 MHz, time shared with Orbiter Two voice channels 50 MBPS 3 MHz	Interface permits use of Orbiter's full capability	Same as above
Transmission Direct From Ground or Through TDRSS to Orbiter/Spacelab	2.4 kbs of command Two voice channels 1 MBPS via TDRSS only	Interface permits use of Orbiter's full capability	2.4 kbs command Voice
Detached Payload Transmission to Orbiter	16 kbs Voice	Cannot display 16 kb in Spacelab	Two payloads with 400 kbs digital data and 2 MHz analog data (requirements are simultaneous)

TABLE 6-15. (Concluded)

	Orbiter Capability	Spacelab Capability	AMPS Requirements
Orbiter Transmission to Detached Payload	2.4 kbs of command Voice	Cannot command subsatellite from Spacelab via this link	1 kbs command

TABLE 6-16. AMPS COMMUNICATIONS DEDICATED EQUIPMENT

Item	Quantity	Power (watts)	Weight (lb)
Antenna	2		200
Multicoupler	2		4
Power Amplifier	2	72	8
Receiver (AM-SSB)	2	16	12
Transponder	2	18	20
Pseudo Random Noise (PRN) Generator	2	10	10
Total		116	252

TABLE 6-17. AMPS SUBSATELLITE EQUIPMENT SUMMARY

Item	Quantity	Power (watts)	Weight (lb)
Antenna	8		20
Hybrid (RF)	1		1
Filter	1		1
Transponder	1	9	10
Power Amplifier	1	36	4
Isolator/Combiner	1		1
Transmitter	1	25	3
Subcarrier Oscillator	1	0.5	1
Decoder	1	1	1
Bus Controller	1	4	5
Remote Mux	6	6	18
Total		81.5	65

TABLE 6-18. DATA MANAGEMENT DIGITAL DATA RATE MATRIX (MBPS)

	Experiment XAP												
	410	420	450	460	430	440	470	480	301	302	303	306	308
<u>Instrument Cluster</u>													
AP 100	0.216	0.44	0.68	0.68	0.44	0.44	0.68	0.216	0.1	0.1	0.24	0.44	0.24
AP 200								Lidar 1.01					Lidar
AP 300			0.0021	0.0021			0.0021	0.01					
AP 400	0.0007	0.0007			0.0001		0.0003	0.0007					
AP 500	0.294	0.294	0.294	0.294	0.293	0.293	0.293	0.294				0.293	
AP 600													
AP 700	0.800[a]	0.800[a]	0.800[a]	0.800[a]	0.800[a]		0.800[a]	0.800[a]					
Total Data Rate (MBPS)	1.31	1.535	1.776	1.776	1.533	0.733	1.775	2.64		0.44		0.733	0.24 + Lidar
<u>Data Division</u> (MBPS)													
Data Bus	0.511	0.735	0.976	0.976	0.733	0.733	0.975	0.83		0.44		0.733	0.24
Hi-Data Rate	0.800	0.800	0.800	0.800	0.800	-	0.800	1.84		-		-	Lidar

a. AP 700 also includes 4 MHz of analog data.

TABLE 6-19. DATA STORAGE REQUIREMENTS[a]

Instrument Cluster	Output Data Rate	Duration/Day (sec)	Total Storage/Mission (bits)	Tape[b] Storage Weight (lb)
Remote Sensor Platform	440 kbs	28.8×10^3	1.5×10^9	0.5
Lidar System	16 channels @1 MBPS each	800	7.68×10^{10}	21.5
Gimbal Accelerator	2.1 kbs	28.8×10^3	7.26×10^6	0.002
Transmitter/ Coupler	3 kbs	28.8×10^3	1.04×10^6	0.003
Booms	1.001 MBPS	28.8×10^3	3.46×10^9	1.0
Subsatellite	400 kbs 2 MHz	28.8×10^3	1.38×10^9	0.4
Total			8.3×10^{10}	23.4

a. Total film weight = 95 lb.
b. Used EREP recorder for reference.

TABLE 6-20. ESTIMATE OF AMPS COMPUTER REQUIREMENTS

Function	Percent of Data Processed	Storage Requirement[a]	Speed (KAPS)[b]
Control and Monitor (Including Internal Experiment Sequencing)		4 980	93
Data Processing		30 486	2477
Data Compression	100		
Briefing Material Control	0		
Scientific Data Control	25		
Graphics Processing	10		
Fourier Analysis	100		
Autocorrelation	100		
Total	335	35 466	2570

a. Number of 32-bit words.

b. Kiloadds per second = Number of EAOs × 10^3 per second.

TABLE 6-21. AMPS/SPACELAB COMPUTER COMPARISON

Item	AMPS Requirement	Spacelab Capability	Remarks
Memory-32 Bit Words	35K	Main Storage: 32K Extended: 32K	Spacelab capability is adequate
Computer Processor Speed			
Control and Monitor	93K EAO/sec	93K EAO/sec or greater	Adequate capacity
Lidar Data	Process 2K to 4K 8 bit words in 1/30 sec	1 Computer: 2.4K words in 1/30 sec 2 Computers: 3.1K words in 1/30 sec	One computer can provide minimum lidar processing requirements. Two computers will not provide full lidar capability recommended.
Other Data Processing	Data rate varies from 0.240 to 1.776 MBPS +4 MHz of analog data	1 Computer: 0.505 to 0.606 MBPS 2 Computers: 1.141 to 1.276 MBPS	One computer will process 9 to 100% of other data, depending upon experiment. Two computers will process 18 to 100% of other data. Data compression will require more than two computers.

TABLE 6-21. (Concluded)

Item	AMPS Requirement	Spacelab Capability	Remarks
I/O Processor	High enough rate to process lidar data 8 to 16 MBPS	12.9 MBPS I/O data input rate	I/O will limit data rate on the 16 lines from the lidar output to 0.806 MBPS each.

TABLE 6-22. RF LINK CALCULATION[a]

Parameter	Value
Frequency	S-band (2200 MHz)
Bandwidth	1 MBPS
Cable Loss	1 dBW
Transmitting Antenna Gain	5 dBW
Space Loss	103.5 dBW
Receiving Antenna Gain	8 dBW
Cabling Loss	2 dBW
KB T_e	136.2 dBW
System Margin	3 dBW

a: With these constraints a 100 mW transmitter is recommended.

TABLE 6-23. RF SYSTEM WEIGHT SUMMARY

Item	Quantity	Power (W)	Weight (lb)
Booms A& B			
Antenna	2		3.0
RF Multicoupler	2		2.0
Transponder	2	18.0	20.0
Decoder	2	2.0	2.0
PCM Formatter	2	4.0	6.0
Subtotal		24.0	33.0
Platform			
Antenna	2		5.0
Multicoupler	2		2.0
Transponder	2	18.0	20.0
Endocer/Decoder	2	4.0	4.0
Subtotal		22.0	31.0
Total RF System			64.0

TABLE 6-24. DATA BUS SYSTEM WEIGHT SUMMARY

Item	Quantity	Power (W)	Weight (lb)
Remote Multiplexer	2	6.0	6.0
Wire (Twisted Shielded Pair #22)	120 m		4.0
Total			10.0

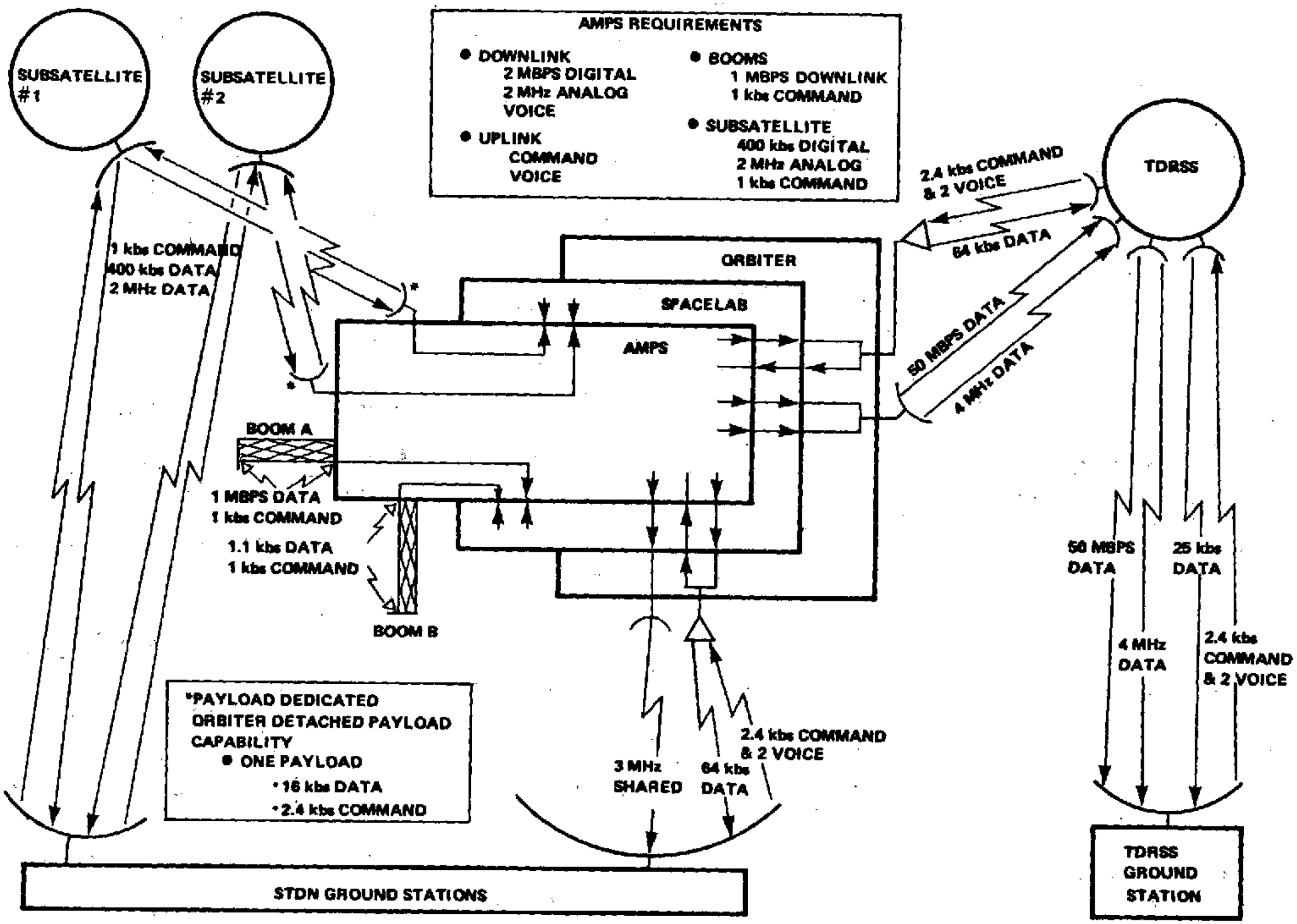


Figure 6-41. AMPS communication subsystem.

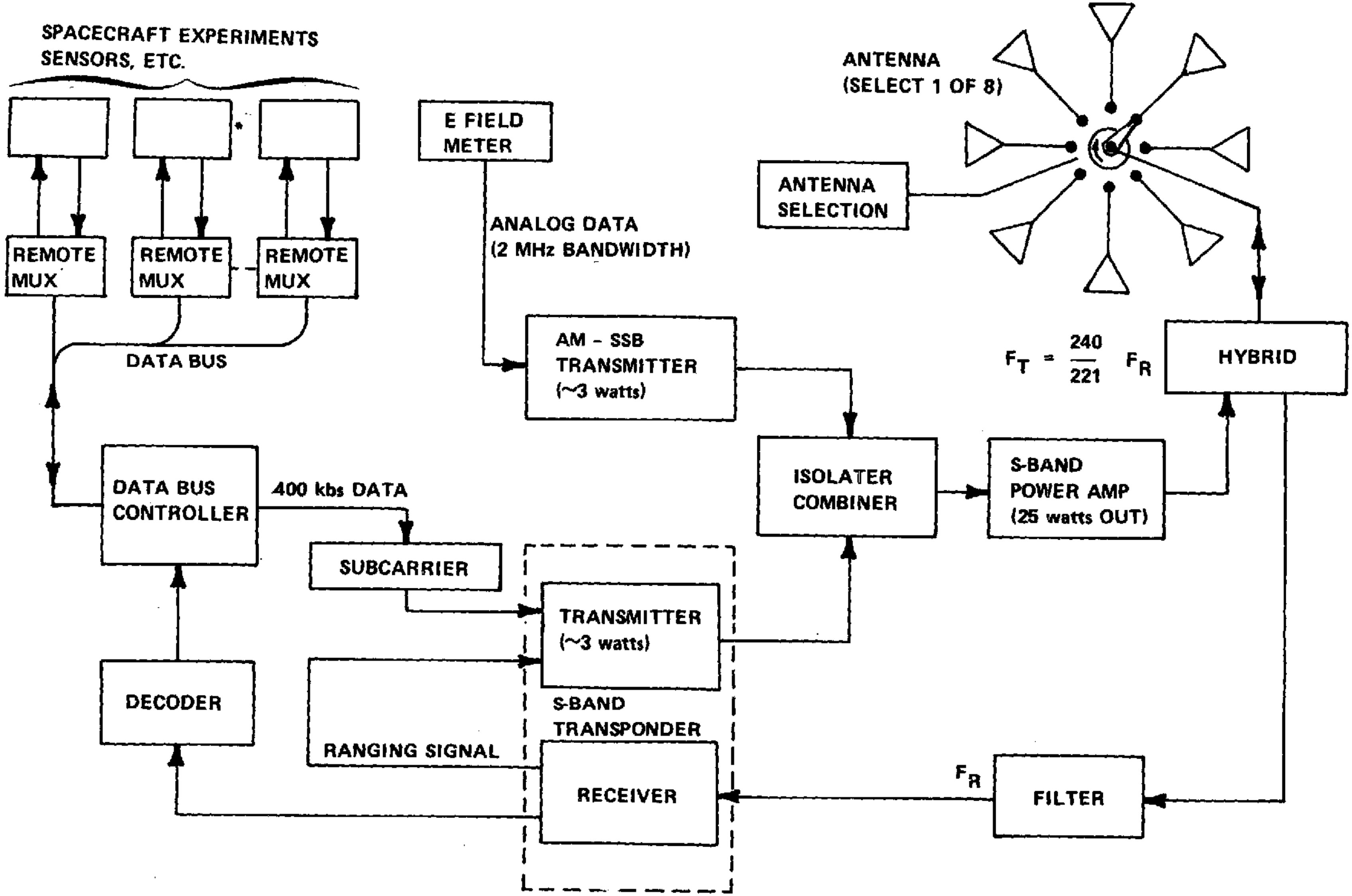


Figure 6-42. AMPS subsatellite communications system block diagram.

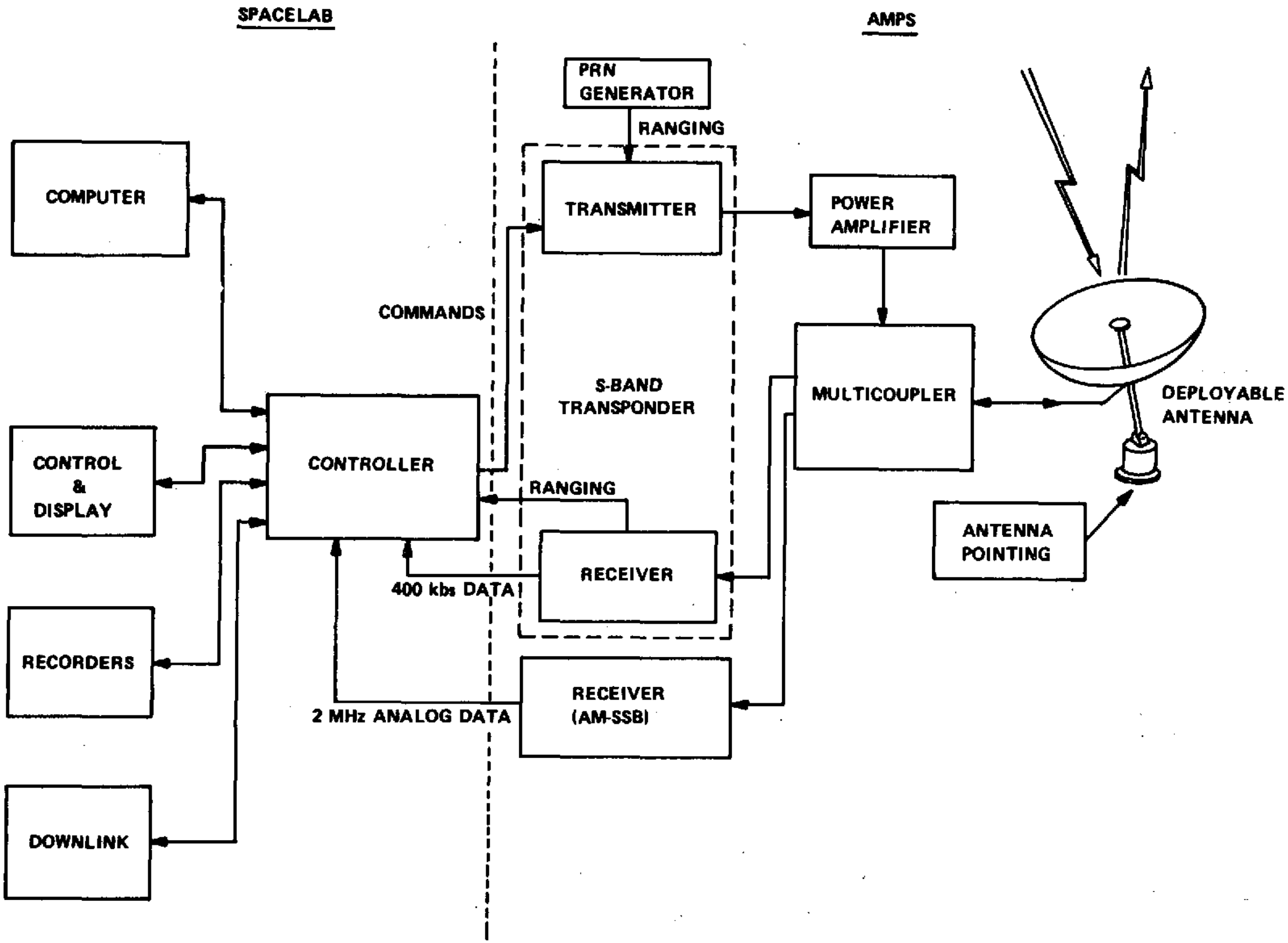


Figure 6-43. Subsatellite design/AMPS-dedicated equipment.

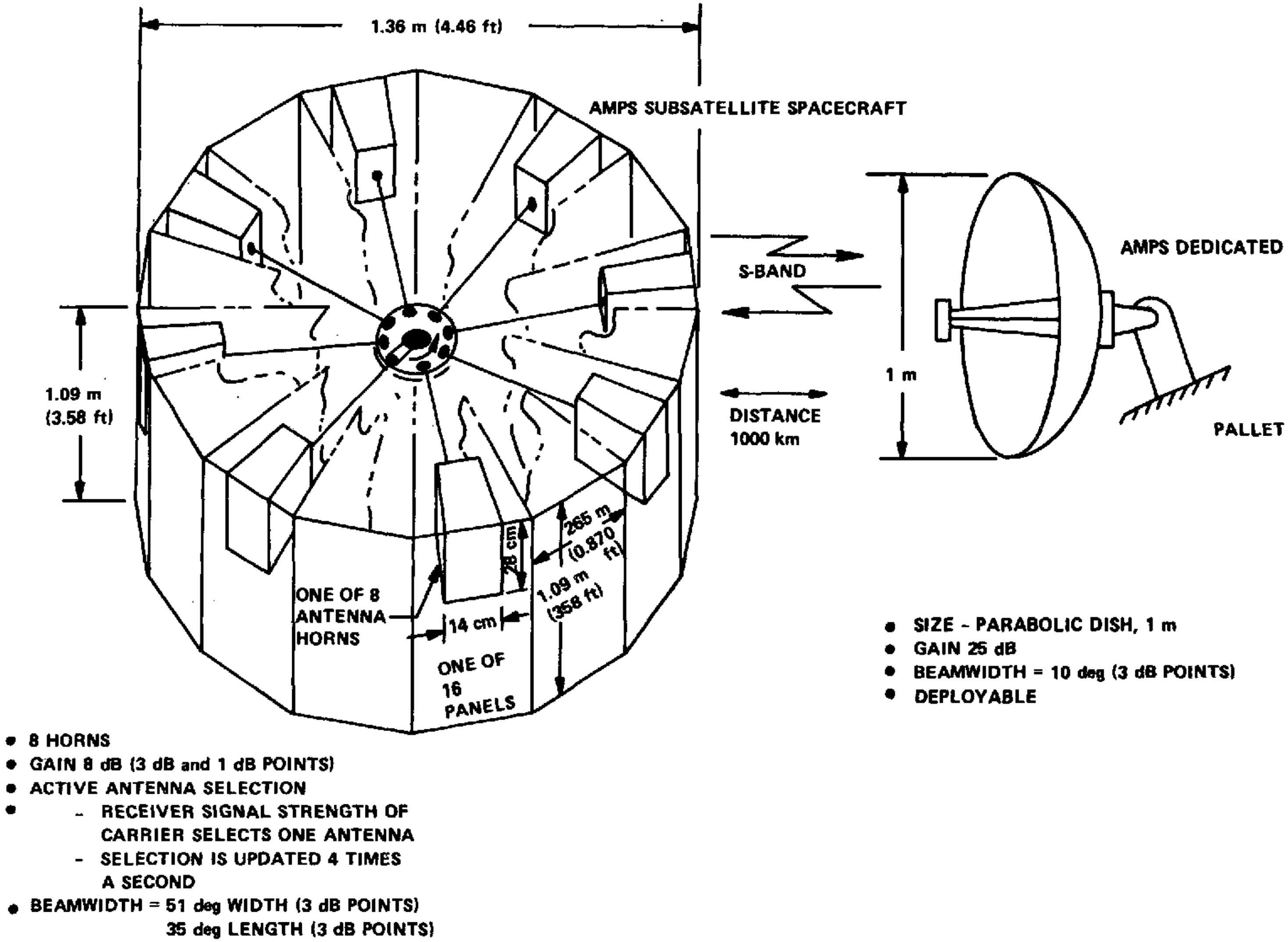


Figure 6-44. Subsatellite antenna configuration.

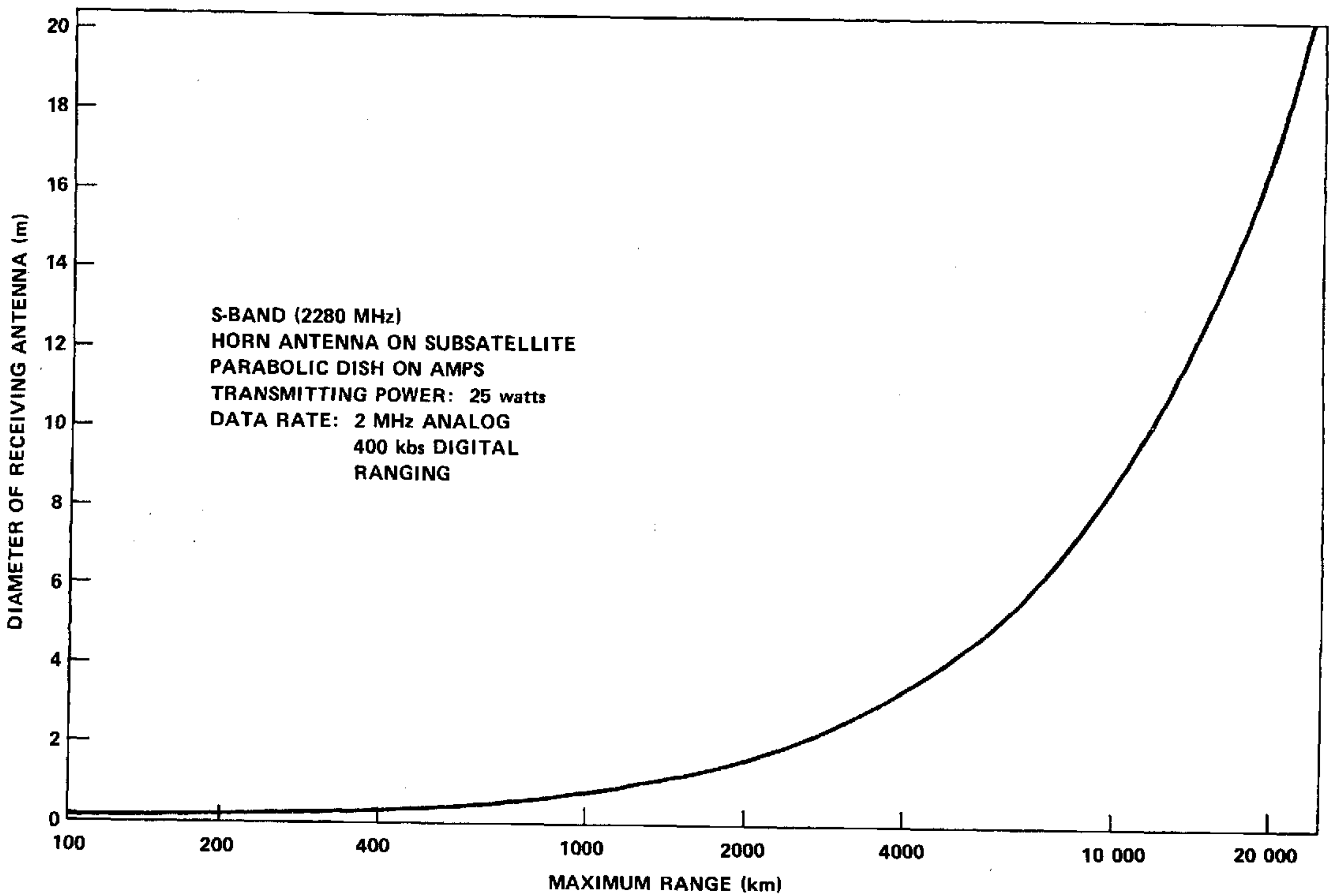


Figure 6-45. Subsatellite communications distance versus AMPS antenna size.

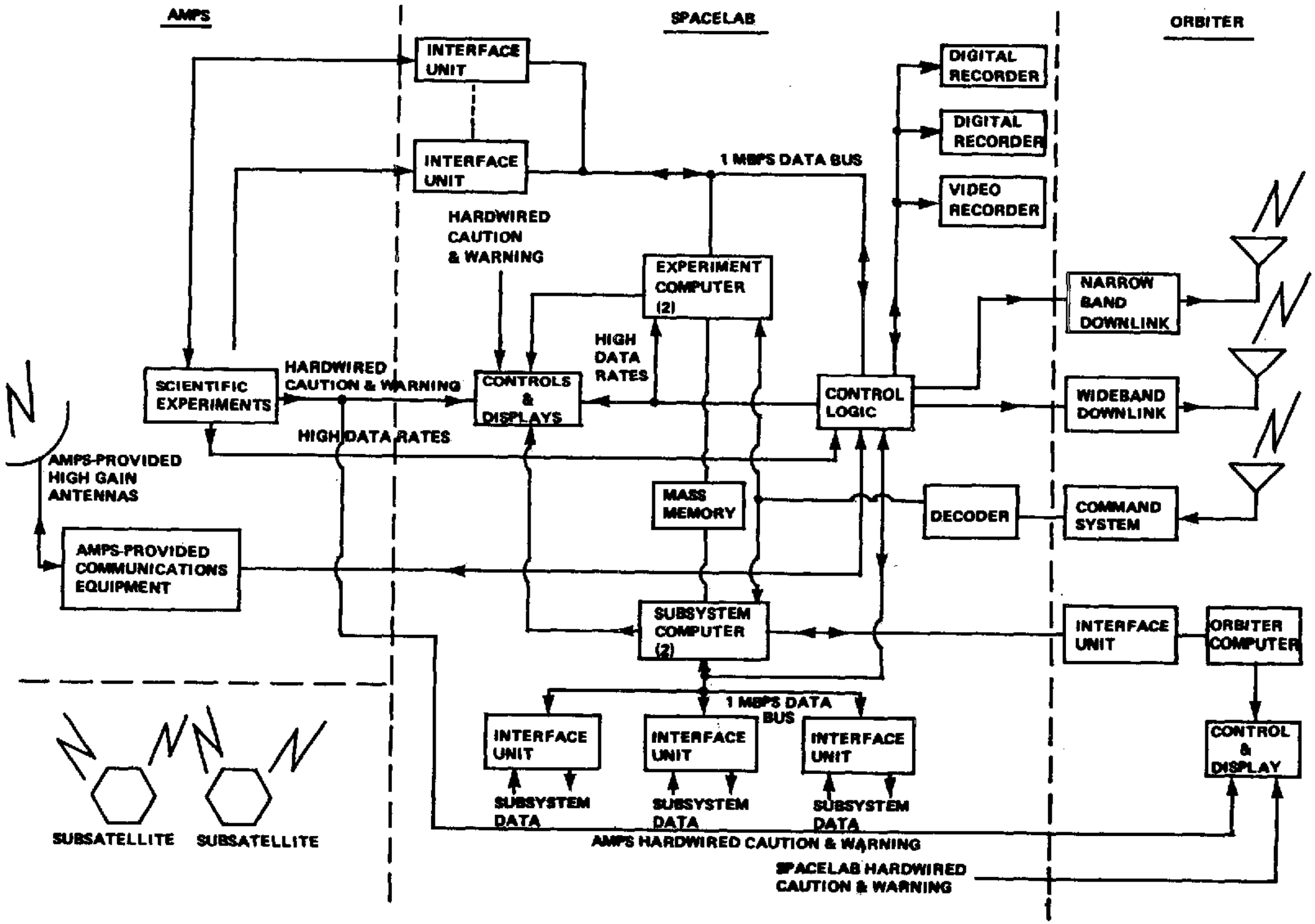
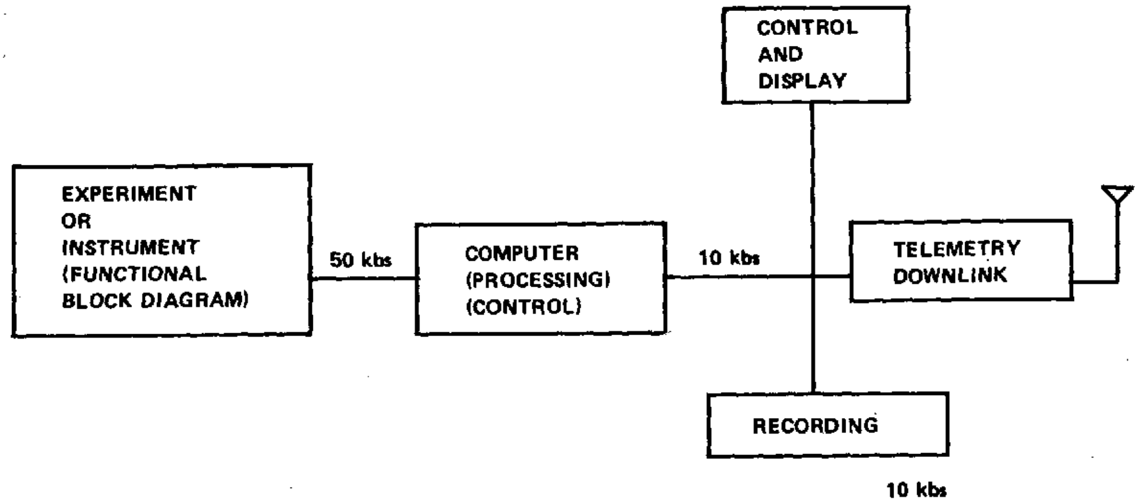


Figure 6-46. AMPS data management block diagram.

BLOCK DIAGRAM OF EXPERIMENT OR INSTRUMENT.

1. INDICATE NUMBER OF OUTPUTS
2. DATA RATES
3. TIE IN SPECIFIC NEEDS SUCH AS COMPUTER, RECORDING, C&D, TELEMETRY DOWNLINK

EXAMPLE



COMMUNICATIONS:

1. COMMANDS
   A. REALTIME
      1. NUMBER OF COMMANDS/ORBIT
      2. RATE
      3. ACCURACY (WORD LENGTH)
   B. STORED (ON BOARD)
      1. NUMBER
      2. ACCURACY (WORD LENGTH)
      3. RATE
2. TELEMETRY
   A. REAL-TIME DOWNLINK
      1. TYPE (ANALOG, DIGITAL)
      2. RATE OR FREQUENCY (bps, Hz)
      3. ACCURACY (%)
      4. TIME PER ORBIT (%)
3. TRACKING
   A. RANGE
      1. DISTANCE
      2. ACCURACY
   B. RANGE RATE
      1. ACCURACY

DATA MANAGEMENT:

1. COMMAND AND CONTROL (COMPUTER)
   A. NUMBER OF COMMANDS OR CONTROL FUNCTIONS
   B. TYPE (ANALOG, DIGITAL)
   C. RATE OR FREQUENCY
   D. ACCURACY (WORD LENGTH)
2. DATA PROCESSING (COMPUTER)
   A. TYPE (FOURIER ANALYSIS, AUTO-CORRELATION, ETC.)
   B. MEMORY SIZE (NUMBER OF WORDS)
   C. ACCURACY (WORD LENGTH)
   D. SPEED
   E. NUMBER OF INPUT CHANNELS REQUIRED
   F. REAL-TIME REQUIRED? HOW LONG?
3. STORAGE REQUIREMENT (MAGNETIC TAPE)
   A. TYPE (DIGITAL, ANALOG)
   B. RATE OR FREQUENCY (bps OR Hz)
   C. ACCURACY (WORD LENGTH, %)
   D. TIME (HOW LONG)
   E. ON-ORBIT DUMP (%)
   F. RETURNED DATA (%)

Figure 6-47. Communications and data management requirements summary.

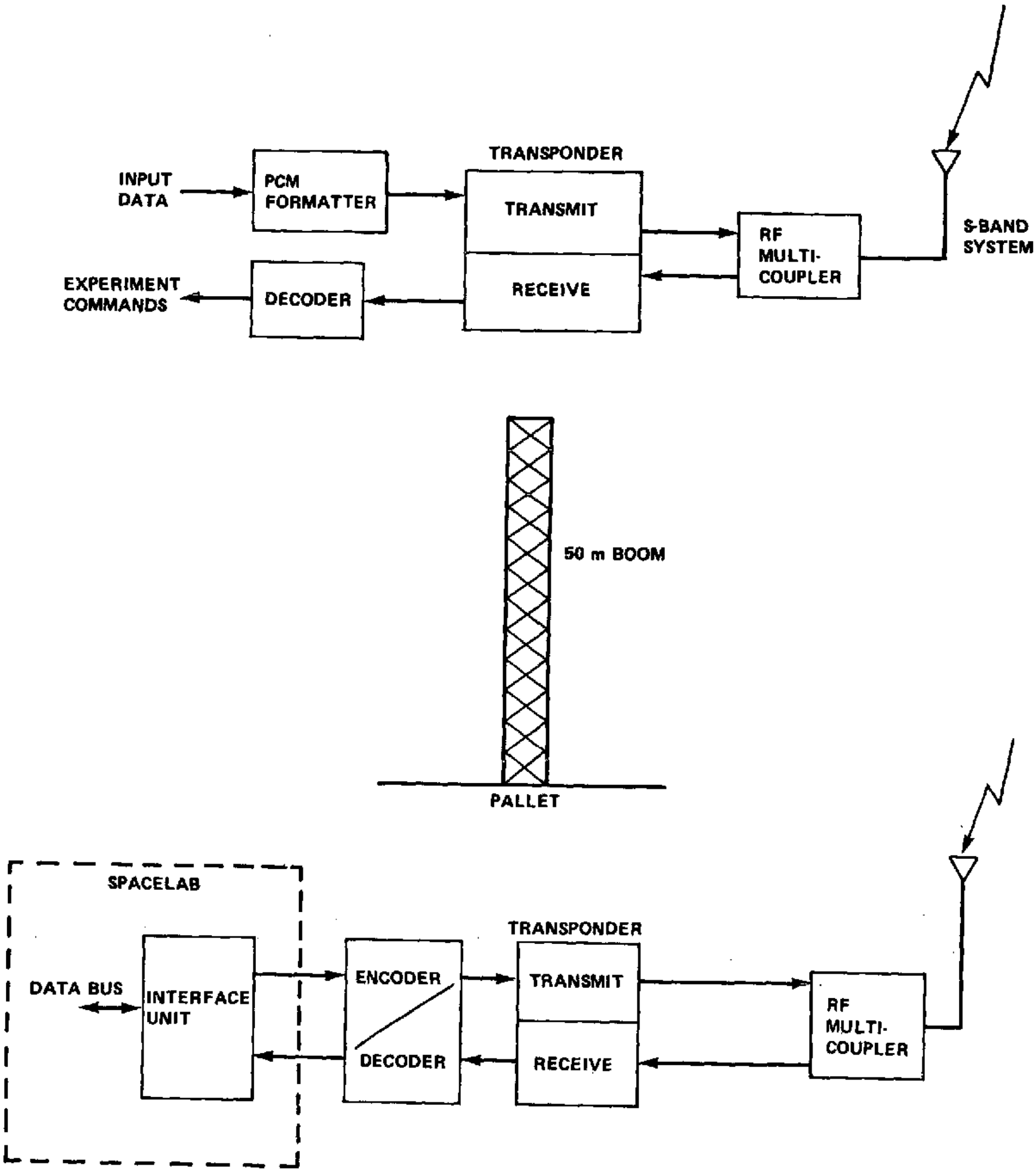
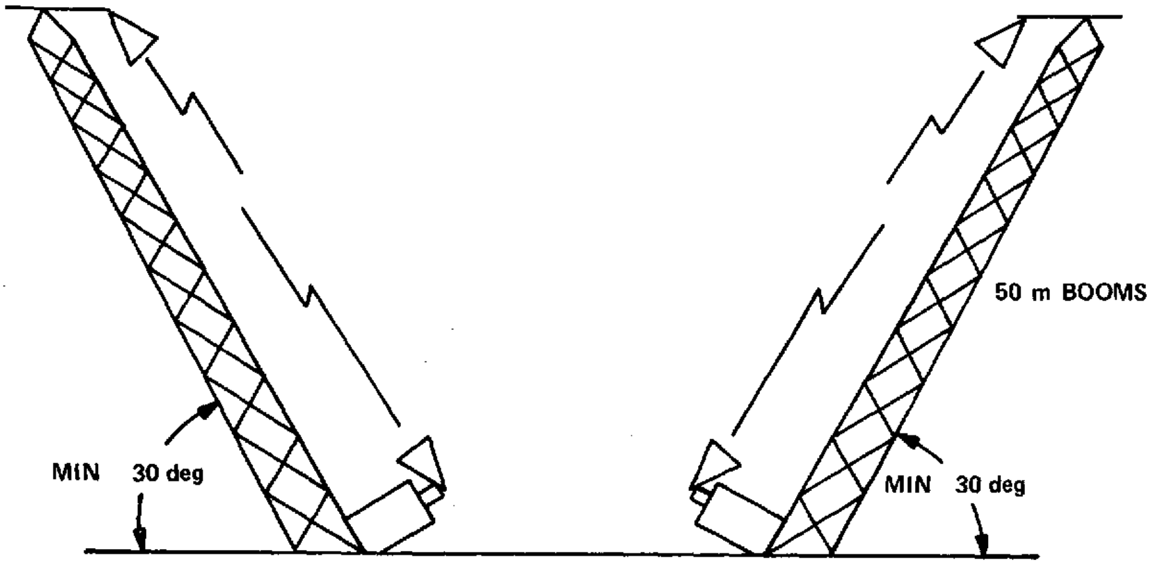


Figure 6-48. Boom communication system block diagram.



BOOM ANTENNA

- HORN TYPE (REDUCES MULTIPATH)
- SIZE - 7 X 5 X 2 in.
- WEIGHT - 1.5 lb
- GAIN - 5 dB AT S-BAND

PLATFORM ANTENNA

- HORN TYPE (REDUCES MULTIPATH)
- SIZE - 10 X 6 X 12 in.
- WEIGHT - 2.5 lb
- GAIN - 8 dB AT S-BAND

Figure 6-49. AMPS boom RF antenna concept.

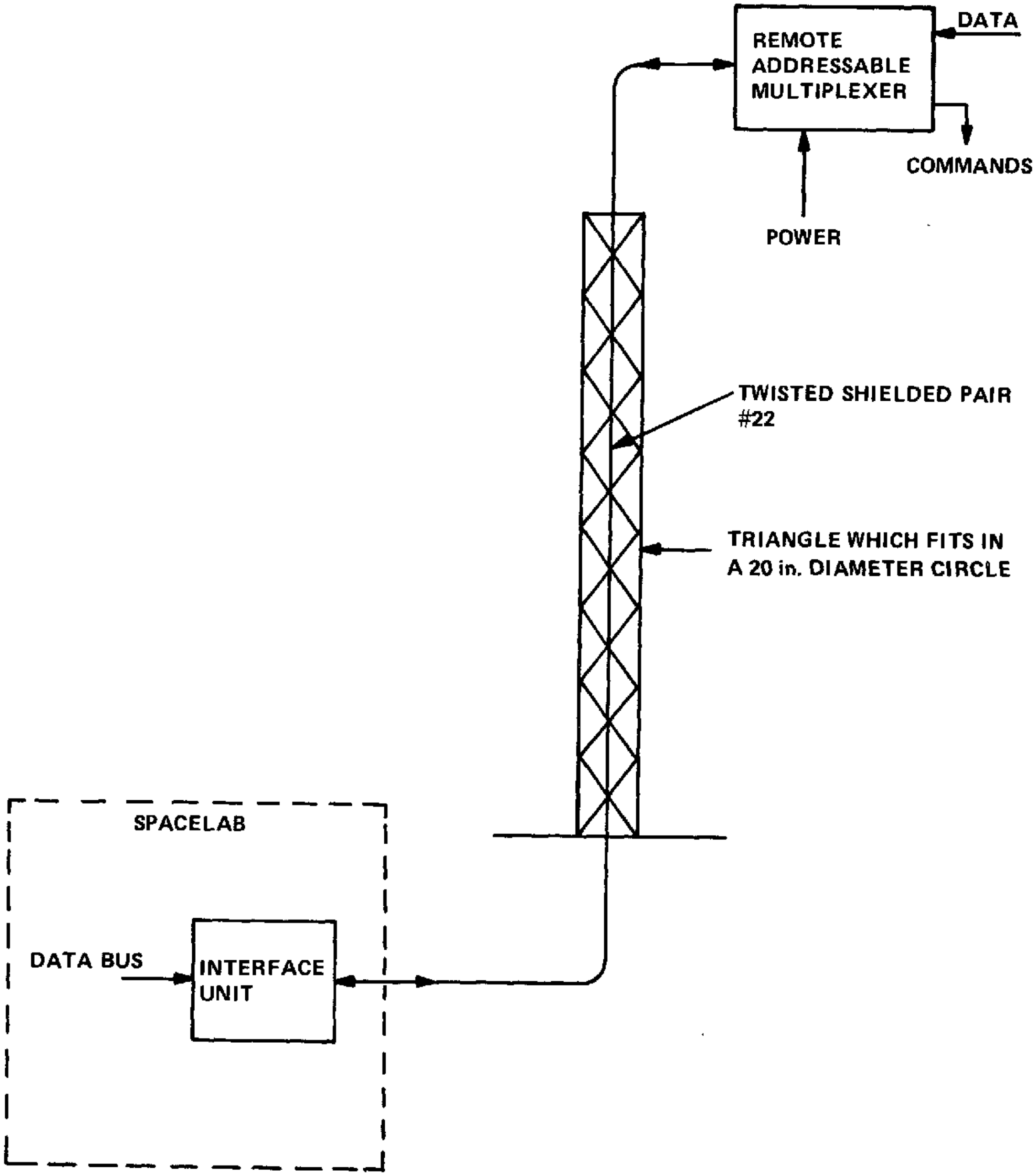


Figure 6-50. AMPS boom data bus concept.

6.5 AMPS ELECTRICAL POWER SYSTEM DESIGN

6.5.1 Guidelines and Assumptions

Power for the AMPS payload is provided by the Orbiter-dedicated fuel cell system. The Orbiter fuel cell has the capacity to deliver 7.0 kW average power and up to 12.0 kW peak power for 15 min. The Spacelab will require approximately 3.6 kW average power leaving 3.4 kW available for experiment instrumentation equipment. The large power users for AMPS, such as laser radar, transmitters, and plasma accelerators, will be accomplished with pulsed power techniques utilizing capacitor banks for storage. Other guidelines and assumptions used in this study are listed below:

1. Design with existing technology as far as possible.
2. Simplicity and economy considerations.
3. Back-up and emergency energy provisions.
4. All subsystems utilize 28 Vdc when practical.
5. Provisions for standard dc and ac voltages.
6. New subsystem use modular design if practical.
7. 7 day normal mission life-time.
8. Pulsed power for all large power users.
9. Secondary power batteries and storage capacitor banks.
10. Shuttle launch vehicle.
11. Orbiter power downtime maximum 30 min.
12. One orbiter fuel cell failed 5.0 kW average power and 8 kW peak power available to Spacelab and AMPS payload.
13. Only nominal voltage of 28 Vdc supplied by Orbiter.
14. Maximum 23 to 30 Vdc Orbiter fuel cell voltage variation.

15. Payloads requiring precise ac and dc voltages will be provided by either Spacelab or AMPS payload.

16. Man-in-loop design considerations.

17. Adhere to safety considerations.

6.5.1.1 Orbiter Capability

The primary power source for Spacelab and the AMPS payload is the Orbiter fuel cell system. The capabilities of this system are listed below:

Power:

1.0 kW average, 1.5 kW peak for all mission phases.

7.0 kW average, 12.0 kW peak dedicated Orbiter fuel cell for payloads.

5 kW average, 8 kW peak degraded mode of operation (one Orbiter fuel cell malfunctioned).

Energy:

50 kW-h supplied by Orbiter without payload penalty.

828 kW-h with Orbiter add-on energy kit payload weight chargeable.

Distribution:

23 to 32 Vdc from Orbiter.

40 volts maximum (0 to 2 kW) load.

4 volts peak to peak maximum ripple.

6.5.1.2 Spacelab Power Requirements

The various Spacelab subsystems will require approximately one-half the output capability of the Orbiter-dedicated fuel cell system. These power requirements are tabulated in Table 6-25.

6.5.1.3 Experiment Instrumentation Power Requirements

There are many experiments to be accomplished by the AMPS payload, which has been broken down into five major areas of scientific investigation. The power requirements of the experiment instrumentation equipment are tabulated in Table 6-26. The experiment instrumentation power requirements indicated with an asterisk are average power values. The peak powers for these cases may be in the kilo- or megawatt range. The energy required for these cases will be stored in capacitor banks and released as required.

6.5.1.4 Design Requirements

The AMPS electrical power system shall provide full operational capability after the first failure, without transients or degradation of power quality. After the second failure, the electrical power system (EPS) must provide sufficient power to maintain a safe condition. All equipment required in a safe return must be powered. These redundancy requirements apply to all elements of the electrical power system. A failure of the dedicated Orbiter fuel cell will result in a degraded mode of operation if the power demand exceeds 5 kW average and 8 kW peak.

6.5.1.5 Electrical Requirements

1. Primary electrical power source.
2. Secondary power capability.
3. Power conversion, inversion, and conditioning.
4. Power distribution control and protection.
5. Electrical integration of systems and subsystems.
6. Interfaces for test, launch, and maintenance support.

6.5.1.6 Electrical System Equipment

Component	Quantity	Supplied By
Primary dc Bus	1	Spacelab
Secondary dc Bus	1	Spacelab
Emergency dc Bus	1	Spacelab
Isolation dc to dc Converter	2	AMPS

Component	Quantity	Supplied By
High Voltage Converter	2	AMPS
High Voltage Capacitors	3	AMPS
Peaking Batteries		Spacelab
Battery Chargers		Spacelab

The equipment interfacing arrangement is shown in Figure 6-51. Characteristics of the baseline EPS are given in Table 6-27.

6.5.2 AMPS Baseline Electrical Power System

The AMPS electrical power system receives power from the Spacelab EPS and distributes it to various payload functions. The primary source of energy is the Orbiter fuel cell system. The AMPS type of baseline electrical power system is very dependent on the configuration selection for Spacelab. The contractural status of Spacelab creates a situation where preferential treatment could be claimed if a contractor baseline Spacelab EPS selection were made at this time.

A block diagram of the preferred cross strapping between Orbiter fuel cells and busses is shown in Figure 6-52. A malfunction of any one fuel cell or bus does not terminate the experiment. The redundant interface cables provide a backup position of the primary power source.

The selected AMPS electrical power system is shown in Figure 6-51. This subsystem is composed of a primary, secondary, and emergency bus system. It is desired that all power users select subsystems that can operate on unregulated dc voltage when practical. Converters dc/dc were baselined to provide the different levels of dc voltages desired. This converter will have the capability of charging a capacitor bank up to 50 000 Vdc. To meet the needs of critical measuring circuits and other circuits where common grounds present a problem, a dc/dc isolation converter was baselined. For those circuits requiring ac voltages a 3 phase, 400 Hz, 115/220 dc/ac inverter was baselined. No 60 Hz power supply was baselined because of weight cost and availability problems associated with flight programs. The secondary bus and its associated subsystems provide the same functions as the primary system. The emergency bus provides only those functions of a critical nature for crew safety.

6.5.3 Analysis of AMPS Large Power Users

The lidar system AP 200, gimbaled accelerator AP 300, and transmitter/coupler have peak powers that exceed the 3.4 kW baselined for AMPS payload. These energy demands will be supplied by the Orbiter fuel cell and peaking batteries. The energy will be stored in capacitor banks and released as needed.

6.5.3.1 AP 200 Lidar System

There are many types of laser systems available today. The Q-switched ruby laser may have an efficiency in the 1 to 7 percent range. The ruby laser requires kilowatts of power just to operate the special coolant loop equipment. The dye lasers are less complex and do not require special coolant loops. Figure 6-53 is a block diagram of a typical laser system. Characteristics of the AMPS laser system are given in Table 6-28.

6.5.3.1.1 Laser Power Analysis

The characteristics given in Table 6-28 were used for this analysis. A laser that releases 1 J per pulse in 100 nsec has a peak power of 10 MW:

$$\text{Peak Power} = \frac{1\ \text{J}}{100 \times 10^{-9}\ \text{sec}} = 10\ \text{MW} \quad .$$

This calculation is correct assuming the laser pulse to be a square wave of energy.

The laser was baselined for 15 min of operation for three consecutive orbits. The electrical power output for one orbit is 7.5 watts:

$$\text{Output Power} = \frac{1 \times 30 \times 15 \times 60}{3.6 \times 10^{3}} = 7.5\ \text{watts}\ (1\ \text{J} = 1\ \text{W-sec}) \quad ,$$

where 1 pulse equals 1 J, 30 pulses per second, and 15 min of operation.

Lasers of this type usually have very low efficiencies, on the order of 1 to 7 percent. The input power for a laser with a 2 percent efficiency is 375 watts:

$$\text{Input Power} = \frac{\text{Output Power}}{\text{Efficiency}} = \frac{7.5}{0.2} = 375 \text{ watts} \quad .$$

The remaining 1625 watts of power allocated to the laser will be used to maintain the constant temperature of the coolant loop. If the laser is operated at a lower pulse rate per second, then more energy could be dissipated per pulse in the output of the laser.

There are various methods whereby the power from either the Orbiter fuel cell or Spacelab batteries may be stored in a high voltage capacitor bank for the laser. The power may be obtained by transformer, rectifier, and filtering scheme from the 3 phase, 400 Hz, 115 Vac supply. A high frequency dc/dc converter for 20 000 volts would probably be smaller in size and lighter in weight than a 400 Hz system. Any one of several voltage doubling schemes can also achieve a light weight, high voltage power system; this approach is somewhat limited in current capacity. Either of the first two methods has a lower output impedance. The laser discharge circuiting has a very low impedance. For these reasons it will not be necessary to synchronize or disconnect the charging network between charge and discharge cylces of the laser.

6.5.3.2 AP-300 Gimbaled Accelerator

6.5.3.2.1 Electron Accelerator

The electron gun accelerator power supply should not be a very difficult system to obtain. Any one of the high voltage power systems briefly described in paragraph 6.5.3.1.2 should be adequate for the electron gun. Many capacitor suppliers can furnish a capacitor bank that meets these requirements. For example, TOBE Deutschmann has a 3 kJ, 20 000 volt, 3 nH unit that measures 14 by 7 by 31 in. and weighs approximately 60 lb. A typical block diagram of a power supply for this application is shown in Figure 6-54. This unit will deliver 300 kW with a 10 msec square wave pulse. The capacitor bank and charging network for the lidar system and the electron accelerator probably can be used interchangeably. Proper equipment location and a switching network will be required.

6.5.3.2.2 MPD Arc

The capacitor bank for the MPD arc involves less of a problem of voltage insulation. The major problem of this capacitor will be the total amount of energy to be stored. The charging network will be similar to the block diagram shown in Figure 6-54.

The state of the art for capacitor banks is approximately 100 J/lb. A megajoule capacitor would weigh approximately 10 000 lb. Since the AMPS payload is weight limited, only a 100 kJ capacitor will be baselined. This capacitor with encapsulation and switching network will probably weigh about 1200 lb. Table 6-29 is a tabulation of the MPD arc accelerator characteristics.

The characteristics given in Table 6-29 were used for analysis. An MPD arc that releases 100 kJ in 10 msec has a peak power of 10 MW:

$$\text{Peak Power} = \frac{100 \times 10^{3}\ \text{J}}{10 \times 10^{-3}\ \text{sec}} = 10\ \text{MW} \quad .$$

If the energy is released in 1 msec, this would be a peak power of 100 MW. Approximately 500 volts is about the upper voltage limit that can be reached in an MPD arc with a controlled breakdown sequence. From this and other given information, the capacitor bank can be sized in farads. Given:

$$W = 1/2\ CV^2 \quad ,$$

where W is joules in watt-sec, C is capacitance in farads, and V is voltage in volts,

$$100\ 000 = 1/2\ C\ (500)^2$$

$$C = \frac{2 \times 10^5}{2.5 \times 10^5} = 0.8\ \text{F} \quad .$$

Typical output impedance for a dc/dc (30 to 500 volt) converter of good design would be 2 to 4 ohms. The time required to charge 0.8 farads through 4 ohms is determined by $t = RC$:

$$t = 4 \times 0.8 = 3.2\ \text{sec} \quad .$$

Approximately 6 ohms output impedance of the dc/dc converter is a maximum if 5 sec is maintained between discharge pulses for the capacitor bank. For 95 percent charge or recharge, it requires three time constants. If this level of recharge is required for each pulse, approximately 10 sec will be required between discharge pulses.

6.5.3.3 Ion Accelerator

The same capacitor bank used for the electron gun can be used for the proton accelerator. To meet the desired level of 10 A and 20 000 volts per pulse discharge, a 20 kJ capacitor bank will be required. Then the electron and proton capacitor bank would weigh approximately 300 lb. It will require a 20 000 volt, 100 μF capacitor for this application. The arrangement of the charging network and storage capacitor bank is as shown in Figure 6-54.

6.5.4 Transmitter Coupler

The charging network and capacitor bank proposed for the proton accelerator should be adequate for the transmitter power requirements. Table 6-30 is a listing of the transmitter characteristics.

The figures given in Table 6-30 were used for this analysis. A transmitter that has a 10 kW output pulse for 10 msec has an average power requirement of 1 kW. If the transmitter and associated circuitry have a 40 percent efficiency in the megahertz range, a 2500 watt power source will be required:

$$\text{Input Power} = \frac{\text{Output Power}}{\text{System Efficiency}} = \frac{10 \times 10^3 \times 10 \times 10^{-3} \times 10}{0.40}$$

$$= 2500 \text{ watts} \quad .$$

The low frequency transmitter power requirements can also be met with the same capacitor bank. At 300 Hz the efficiency of the transmitter will probably be about 4 percent:

$$\text{Input Power} = \frac{\text{Output Power}}{\text{System Efficiency}} = \frac{1 \times 10^3 \times 10 \times 10^{-3} \times 10}{0.04}$$

$$= 2500 \text{ watts} \quad .$$

A typical block diagram of a transmitter and power supply are shown in Figure 6-55. The antenna for a 300 Hz pulse may present the greatest problem. For example, the half wave length for this antenna is

$$\ell = \frac{492 \times 0.96}{300 \times 10^{-6}} = 1.57 \times 10^6 \text{ ft or } 300 \text{ mi} \quad .$$

A special antenna arrangement may be required for this low frequency application.

6.5.5 Power Profile

The power requirements for the AMPS payload have been calculated using SSPD data and mission timelines dated March 20, 1974. Certain deviations have been introduced in cases where the power requirements exceeded the 7.0 kW average for the Orbiter fuel cell. The 2.5 kW average does permit a growth contingency of approximately 1.5 kW. A plot of the average power requirements is shown in Figure 6-56.

6.5.6 Conclusions and Recommendations

The following conclusions and recommendations were made:

1. The AMPS experiment can be accomplished with 7.0 kW average power.

2. Seven days at 7 kW average power is 1176 kW-h of energy. The Orbiter baseline is 50 kW-h plus 828 kW-h, for 878 kW-h total.

3. A 1.0×10^5 joule capacitor bank is maximum for AMPS experiments.

4. The low frequency experiment will be very difficult to accomplish.

5. Detailed analysis of lidar, accelerator, and transmitter power sources is needed for an optimum configuration.

6. Power requirements for detailed instrument complement are needed.

7. Definition of what instruments are used with each experiment is needed.

6.5.7 Electromagnetic Control (EMC)

Rigid controls will be imposed on the design and implementation of the AMPS payload to assure trouble-free operation. The design will have to comply with approved Space Shuttle specifications JSC-SL-E-0001, JSC-SL-E-0002, JSC-07636, MIL-B-5087B, etc. The main requirement of specification JSC-SL-E-0001 is the establishment of an EMC program at the component level. The program will be reviewed by the EMC control board and testing will be conducted on AMPS payload to verify plan. Specification JSC-SL-E-0002 limits component audio, RF, and transient emissions. This specification also requires test of payload components to verify results. The other specifications pertain to bonding requirements.

6.5.7.1 Theoretical EMI Analysis

6.5.7.1.1 Boom

Radiated EMI from a 1 megabit data transmission line between Spacelab and experiment boom for a number 22 twisted shielded pair produces a negligible EMI noise level. The calculation was based on 1.5 MHz transmission rate, 50 m link, 5 volt signal and 200 mA power level. This calculation resulted in a maximum power density of 3.2×10^{-9} W/m^2. The static charge on the cable or metallic boom could be much greater, as much as 20 volts under some circumstances. The high gain S-band parabolic antenna also produces a much greater noise level. The frequency bands for the electromagnetic spectrum were arbitrarily chosen, but they correspond roughly to the operational frequencies of the 14 Space Shuttle antennas. Tabulations of these results are shown in Tables 6-31 and 6-32. A detailed analysis of this effort can be found in MSFC report number SP-262-0829, dated June 4, 1974, entitled Static and Dynamic Field Analysis Associated with Antennas and Deployed Booms and Cables.

TABLE 6-25. SPACELAB SUBSYSTEM POWER REQUIREMENTS

Function	With Energy Kit (W)	With Add-On Plus Radiator (W)
ECLS[a]	1000	1950
Controls and Displays	760	760
Data Management	1060	1060
Communications	55	55
Lighting and Miscellaneous	300	300
Electrical Power and Distribution	100	200
Losses	325	435
Total	3600	4770

a. Environmental control/life support.

TABLE 6-26. EXPERIMENT INSTRUMENTATION POWER REQUIREMENTS

System/Component	Power (W)
Remote Sensing Platform AP-100	
Instrumentation and Platform Power	462
Room Manipulation and Alignment	150
Control System	131
Display Systems	800
Computing and Recording	300
Total	1843
Lidar System AP-200	
Lidar System (Average Power)	2000
Computer and Controls System	525
Display and Recording Systems	400
Total	2925
Gimbaled Accelerator AP-300	
Ion Accelerator (Average Power)	2000*
Selection Accelerator	200
MPD Arc (Average Power)	2000
Accelerator Control Systems	25
Accelerator Display Systems	400
Total	4625
Experiment Instrumentation Average Power	2625
Transmitter/Coupler AP-400	
Transmitter/Coupler 0.2 to 2 kHz Average Power (T-1)	2500*
Transmitter/Coupler 2 to 20 MHz Average Power (T-2)	2500*
Transmitter/Coupler 0.3 to 200 kHz Average Power	2500
Control Systems	100
Display and Recording	450
Total	7800
Experiment Instrumentation Average Power	3050
Boom System AP-500	
Instrumentation and Boom Controls	286
Display Systems	830
Computing and Recording	400
Total	1516

TABLE 6-27. SELECTED AMPS BASELINE ELECTRICAL POWER SYSTEM CHARACTERISTICS

Parameter	Spacelab	AMPS Payload
Primary Power	Orbiter Fuel Cell	Fuel Cell
Secondary Power	Orbiter Fuel Cell	Fuel Cell
Emergency Power	Silver Zinc Batteries	Silver Zinc Batteries
Peaking Power	Silver Zinc Batteries	Silver Zinc Batteries
Voltage	23 to 32 Vdc Intermittent 24 to 32 Vdc Continuous 28 Vdc Nominal 4 V Peak to Peak Ripple	1. Unregulated 28 Vdc 2. Dc/dc Converter 500 Vdc, 50 000 Vdc 3. Dc/ac Inverter 3 Phase, 400 Hz, 115 Vac 4. Dc/dc Isolation 28 Vdc, 5 Vdc
Power	3.6 kW	3.4 kW
Energy	540 kW-h	238 kW-h
Energy Storage	Batteries	Batteries and Capacitor Banks
Distribution	28 Vdc, Three Buses 3 Phase, 400 Hz, ac, Three Buses	28 Vdc, Two Buses 3 Phase, 400 Hz, ac, Two Buses

TABLE 6-28. AMPS LASER SYSTEM CHARACTERISTICS

Parameter	Value
Pulse Width	100 nsec
Pulse Rate	30 pulses/sec
Output Energy	1 J/pulse
Computer and Control	525 watts
Display and Recording	400 watts
Lidar System Average Power	2000 watts
Experiment Instrumentation Average Power	2925 watts

TABLE 6-29. MPD ARC ACCELERATOR CHARACTERISTICS

Parameter	Value
Pulse Width	10 nsec
Pulse Rate	10 pulses/sec
Current Pulse	10 000 A/pulse
Output Energy	100 000 J/pulse
Average Power	2 000 watts
Controls and Display Systems	500 watts
Experiment Instrumentation Average Power	2 700 watts

TABLE 6-30. TRANSMITTER CHARACTERISTICS

Parameter	Value
Pulse Width	10 msec
Pulse Rate	10 pulses/sec
Peak Power	1 - 10 kW
Voltage	20 kV
Frequency	300 Hz to 20 MHz
Controls and Displays	300 watts
Experiment Instrumentation Average Power	3050 watts

TABLE 6-31. ARBITRARY DIVISION OF THE ELECTROMAGNETIC SPECTRUM

Band Number	Spectrum Division Bandwidth	E_1 V/m Max	P_1 W/m Max	Antenna Type[a]
I	0.3 kHz - 0.2 MHz	1.93	9.7×10^{-3}	14
II	0.2 MHz - 2.0 MHZ	2.90	0.0223	14
III	2.0 MHz - 20.0 MHz	2.89	0.0221	14
IV	290.0 MHz - 300.0 MHz	0.993	2.63×10^{-4}	7
V	2045.0 MHz - 2055.0 MHz	0.1232	4.026×10^{-5}	9 and 11
VI	2080.0 MHz - 2090.0 MHz	9.046	0.217	12
VII	2090.0 MHz - 2100.0 MHz	9.406	0.2347	13
VIII	2220.0 MHz - 2210.0 MHz	315×10^{-6}	264×10^{-14}	2
IX	2210.0 MHz - 2220.0 MHz	0.6927	1.273×10^{-3}	3
X	2220.0 MHz - 2230.0 MHz	0.03	8.07×10^{-5}	8 and 10
XI	2243.0 MHz - 2253.0 MHz	0.7749	2.053×10^{3}	1
XII	2257.0 MHz - 2263.0 MHz	0.77	1.579×10^{-3}	6
XIII	2285.0 MHz - 2290.0 MHz	0.75	1.49×10^{-3}	4

a. See Table 6-32 for antenna types.

TABLE 6-32. SPACE SHUTTLE ANTENNA TYPES USED IN THIS ANALYSIS

Antenna	Frequencies (MHz)	Power (watts)	Gain	Direction of Lobe
1. S-Band Hemispheric	2250.0	10.0	0	Hemispheric
2. S-Band Hemispheric	2205.0	10.0	0	Hemispheric
3. S-Band Quad	2217.5	2 - 40	0	Omni
4. S-Band Quad	2287.5	2 - 40	0	Omni
5. S-Band Quad	2245.0	2 - 40	0	Omni
6. S-Band Quad	2260.0	2 - 40	0	Omni
7. UHF Voice	296.8	1	0	Omni
8. Boom A Antenna	2225.5	0.1	5	Axis of Horn
9. Boom A Antenna	2049.3	0.1	8	Axis of Horn
10. Boom B Antenna	2229.5	0.1	5	Axis of Horn
11. Boom B Antenna	2053.0	0.1	8	Axis of Horn
12. S-Band Parabolic	2085.7	25.0	24	Axis of Parabola
13. S-Band Parabolic	2094.9	25.0	24	Axis of Parabola
14. Pallet L.F. Antenna	3 kHz - 20 MHz	500	0	Perpendicular to Axis of Antenna

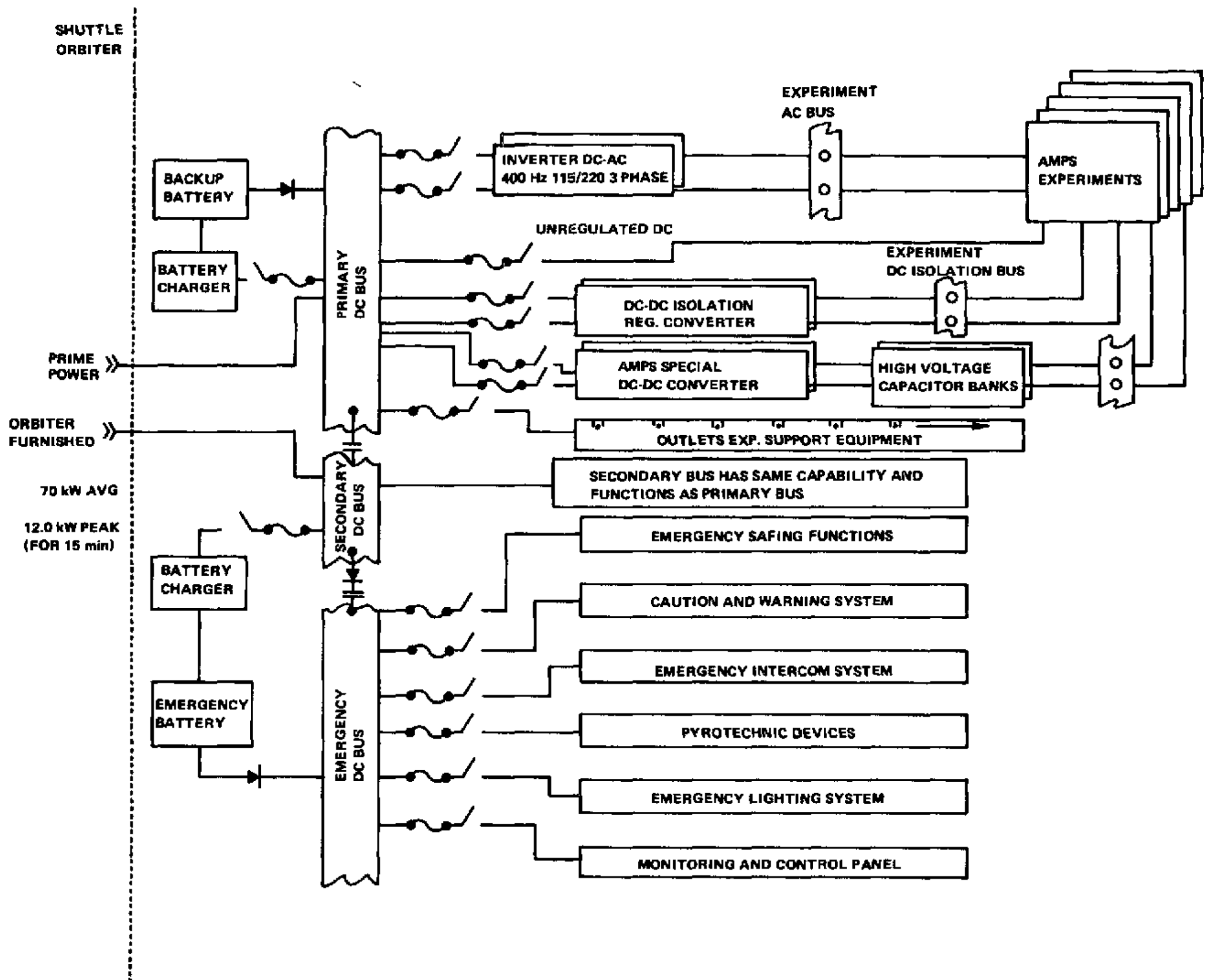


Figure 6-51. Block diagram of AMPS baseline electrical power system.

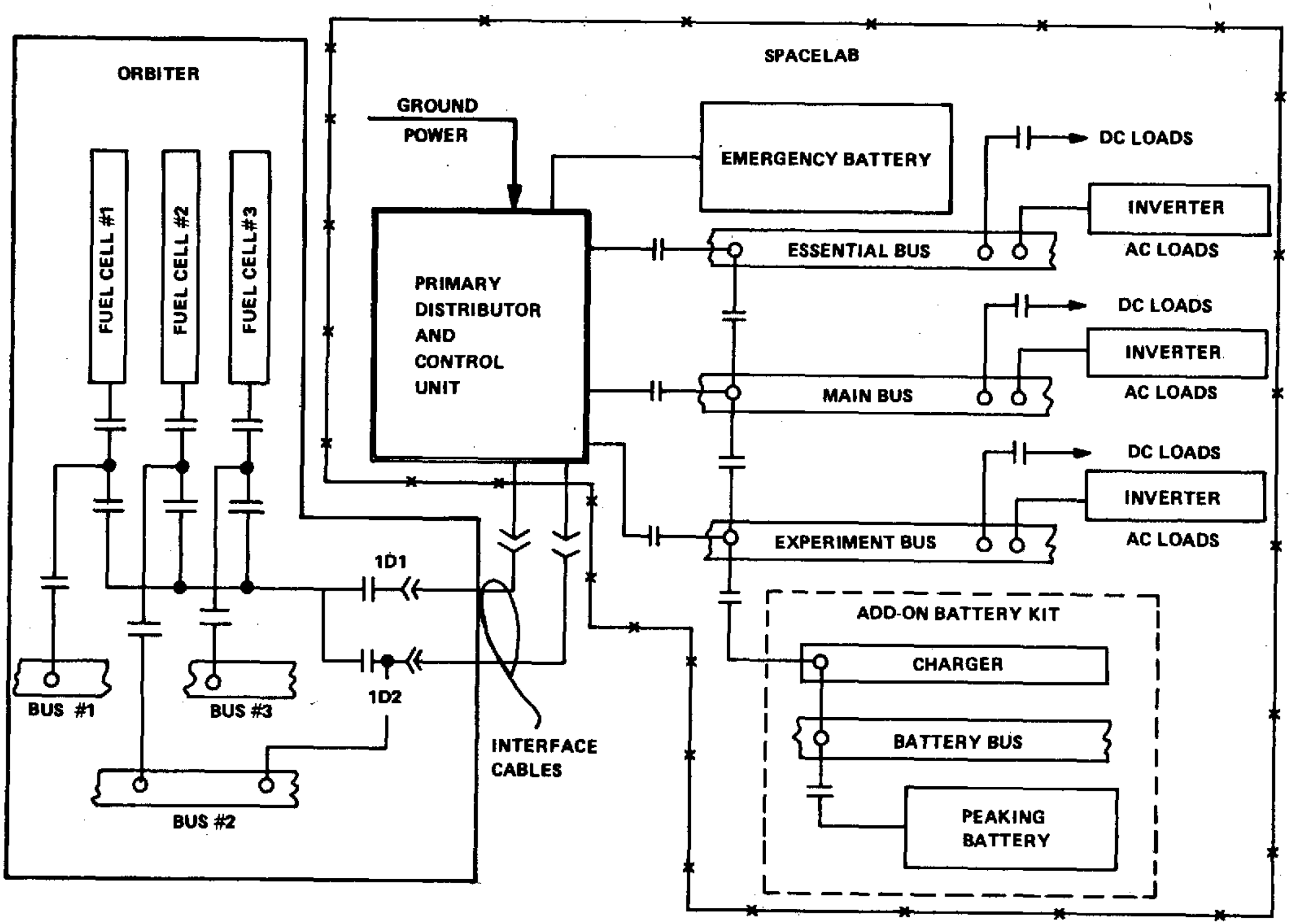


Figure 6-52. AMPS primary power source, Orbiter Spacelab preferred redundant bus arrangement.

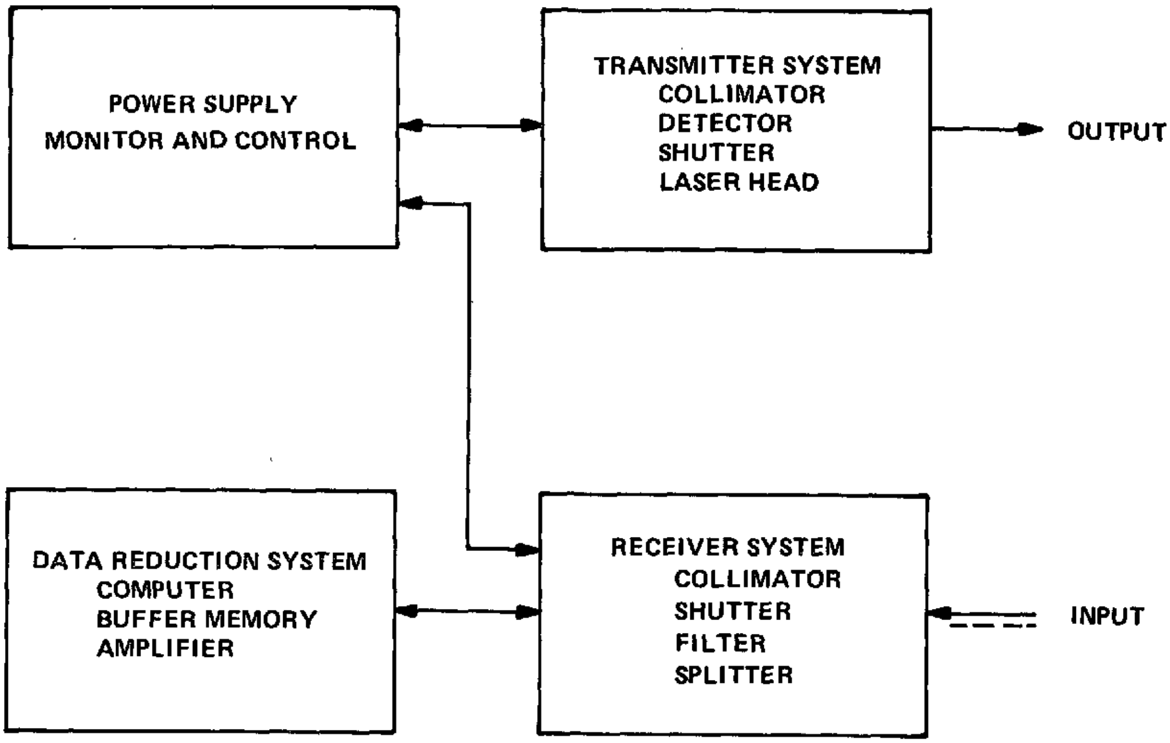


Figure 6-53. Typical lidar block diagram.

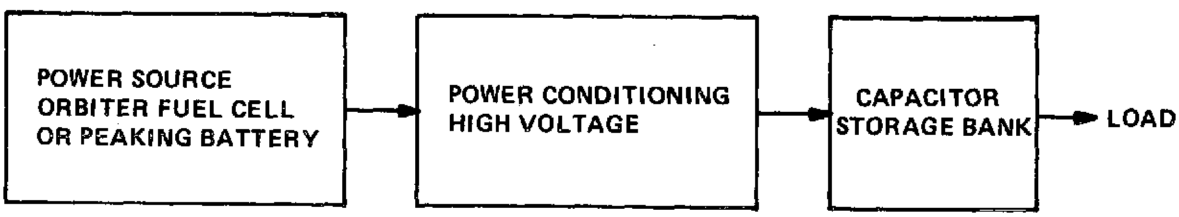


Figure 6-54. Typical high voltage source block diagram.

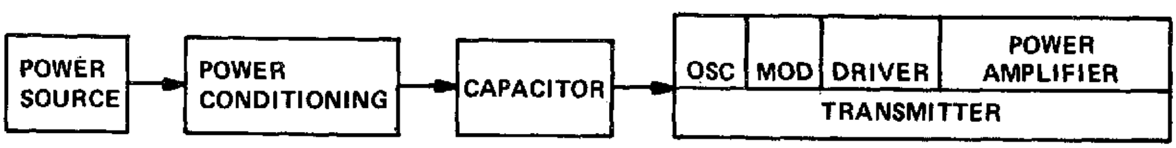


Figure 6-55. Transmitter and power supply block diagram.

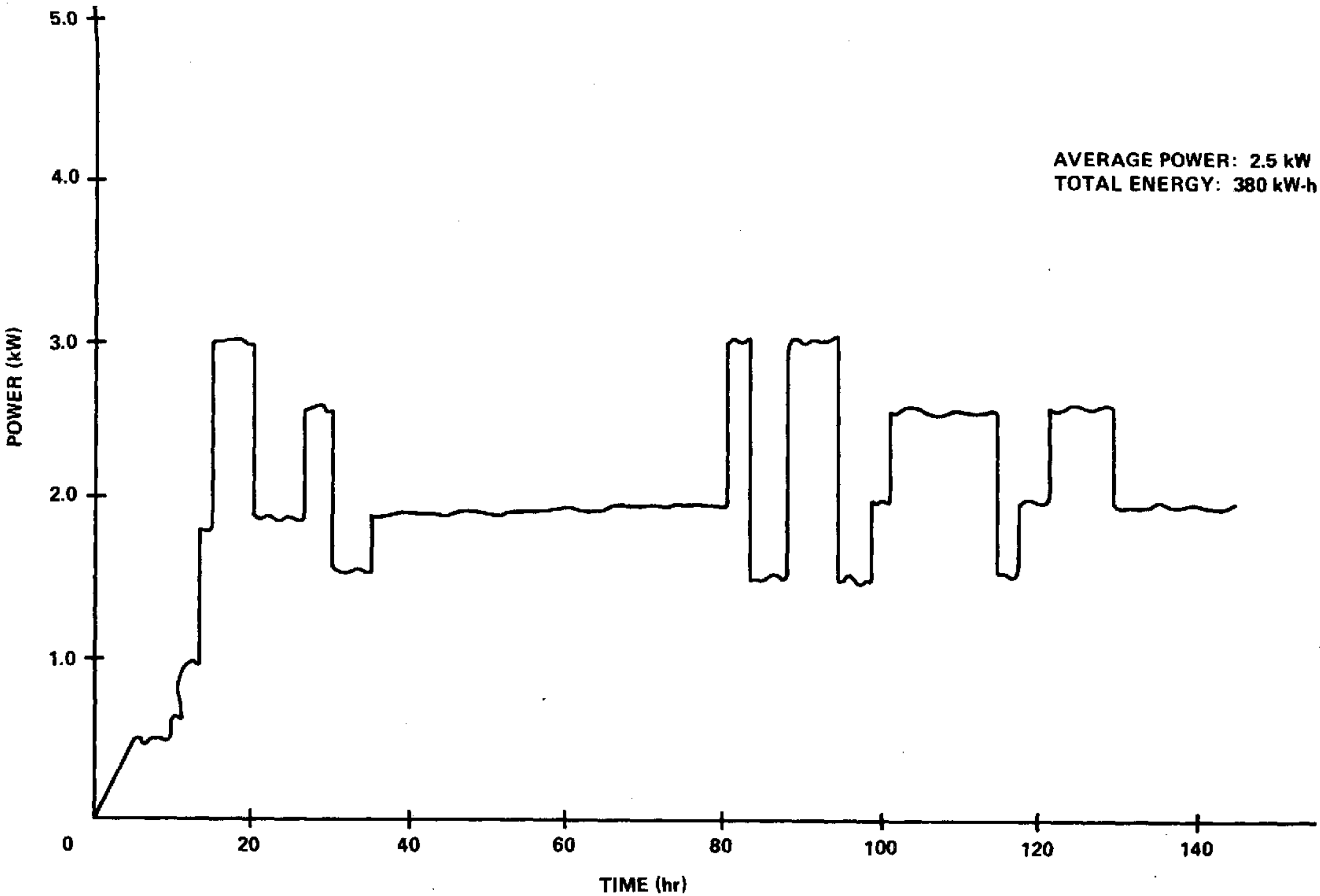


Figure 6-56. AMPS electrical power profile.

6.6 AMPS CONTROLS AND DISPLAYS

6.6.1 Guidelines, Assumptions, and Constraints

There are two main objectives in developing the C&D requirements for AMPS:

1. Using SSPD data as a baseline, analyze C&D requirements to determine drivers for payload accommodations in the Spacelab pressurized module and the Orbiter.

2. Develop a conceptual system design of the C&D equipment complement required for an AMPS mission.

Most of the study effort to date has gone into the first objective. Although an interim C&D layout has been established, it is not of sufficient detail to call it a C&D equipment complement. The SSPD estimates a panel size for control and display associated with each instrument; it does not detail the actual controls or displays. These data and the Phase A Study information were used to determine the C&D weight, space, and power required.

It had been anticipated that a scientific working group would be formed in time to supply information for this report. The group has been formed and is working on the definition of a scientific equipment complement from which realistic C&D requirements will be developed; however, the inputs were not available in time for this report. Therefore, the C&D complement was developed using SSPD and other Phase A subsystems study inputs.

6.6.2 Design Reference

Initial analysis of SSPD data by all subsystems indicated severe weight, center of gravity (c.g.), power, and space problems for the AMPS payload. The C&D analysis began about the first of March 1974. Therefore, the immediate problem was to assess the C&D requirements as presented by SSPD and determine any reductions that could be made through reducing the effect of these problems. After reviewing the requirements it was determined that many functions defined by SSPD data could be performed by the Spacelab support module equipment, especially in the area of computing, recording, gimbal controls, TV, power controls, and multifunction displays.

All functions listed in SSPD were categorized and the weight, space, and power required by those functions that could be performed by Spacelab were considered to be duplicate requirements. The total weight, space, and power required by AMPS SSPD were reduced by this amount. Also, SSPD listed storage requirements (space) as part of the prime rack space required by AMPS but, since these requirements were not large, they were not considered as drivers for total space requirements. The Shuttle Orbiter will have some storage space available for payloads and the Spacelab pressurized module will have storage area available that is not a prime operational area. These other storage areas were considered adequate for AMPS requirements and the total space required for prime operational equipment was reduced by this amount. Some equipment in SSPD data was listed by manufacturer's part number. This equipment was analyzed to see if any could be packaged in the pressurized module so it would not take prime operational space. However, all of this equipment required crew interaction and, therefore, prime space.

It was determined that many panel sizes in the SSPD were over estimated. In July 1974, the SSPD data were updated to reflect the new panel sizes. This effectively reduced the weight and area required for the AMPS C&D. Table 6-33 is a comparison of SSPD data requirements before Phase A Study impacts and the current Phase A AMPS C&D requirements. It must be understood that the Phase A requirements listed in the table do not include the mission-dependent equipment furnished by Spacelab. Mission-dependent equipment is that equipment purchased by Spacelab and made available to payloads on a no-cost basis. However, the weight and power of all mission-dependent equipment are chargeable to payloads. Some typical mission-dependent equipment items are experiment computer, alphanumeric display, keyboard, 30 MBPS recorder, and a video recorder.

The next problem was to develop a C&D layout and determine if it would fit into the Spacelab design reference module. Rack definition and module size for Spacelab would be of prime importance. ESRO picked ERNO as the Spacelab contractor. ERNO selected a two section rack, 19 in. (0.48 m) wide and approximately 9 ft (2.74 m) high. This rack was the most advantageous to the payloads of all the configurations considered because it offered the most C&D space. Figure 6-57 is a description of the ERNO rack configuration. ERNO selected a 2.7 m module for Spacelab; 1 m is devoted to Spacelab subsystems and 1.7 m are available for experiments. The total area available to experiments will be approximately 8 m^2 (86 ft^2) or six 19 in. (0.48 m) racks. Figure 6-58 is a description of the Spacelab module. The Phase A Study also assumed that any mission-dependent equipment required by AMPS would fit into the 1 m area devoted to Spacelab subsystems and the payload specialist station (PSS). The AMPS C&D equipment is listed in Table 6-34. This equipment was separated into 14 groups according to mission operations and was tentatively packaged into the Spacelab module. Figure 6-59 is the AMPS C&D layout with a list of the 14 groups of C&D equipment.

6.6.3 Trade Studies

Currently three C&D studies are being performed. A short synopsis of each is given below:

1. Chuck Quantock: Rockwell study on commercial or off-the-shelf equipment for use in space. This study was started in January 1974 and the final report was September 1974. Equipment listed in SSPD and other sources (studies) was studied; the problems involved with commercial equipment for space use were determined; the mods needed to make this equipment acceptable for space flight were determined; and the practicality of modifying this equipment was studied. Results of this study indicated that it is more cost-effective to modify commercial equipment for space flight than to custom build new equipment.

2. Hugh Feather (ASTR): In-house study and testing of off-the-shelf equipment for CVT. The qualification requirements were determined, a test program was developed, and results were documented. To date four items have been selected and subjected to limited tests. All four passed the outgassing for a 14.7 psi environment and all four failed the vibration test. Mods are to be installed and the equipment retested.

3. Wilber Thomson: Study to identify and define the general purpose mission equipment (GPME) for all classes of payloads. The Martin Company is the contractor and the start date was July 1974; length of contract is 10 months. Monthly progress reports are being made and an end report will give inventory and descriptions of GPME, scheduled needs, and cost.

Reports from the first two studies have indicated that commercial equipment is feasible for space use with certain modifications. The most significant areas for modification appear to be in vibration or shock mounting and crew safety. The first study produced some useful results in a trade analysis of modification cost versus custom-built cost. One subject that has not been addressed in any of the studies is modification for dc operation. The preliminary study on AMPS indicates a substantial saving in weight and power by using dc equipment. Another area for consideration that is indicated in the current studies involves the environmental and safety requirements placed on this commercial equipment for space use. There are some modifications required on some equipment because of polyvinyl chloride insulation on wires. Since the Spacelab pressurized module environment is a two-gas system at 14.7 psia, it does not seem likely that there will be an outgassing or flammability problem. It appears that some requirements and specifications applicable to previous space programs and projects could and should be relaxed for the Spacelab program.

6.6.4 Interfaces

Very little effort has been placed on actual interface definition in the C&D area. Visibility in this area will come later when subsystems hardware, scientific instruments, and Spacelab are better defined; however, some basic observations can be made. The primary interface for the AMPS C&D equipment will be with the Spacelab support module. Most commands and some data will be handled by the Spacelab data bus system. There will be a need for some hardwired interfaces between the AMPS C&D and the scientific equipment on the pallet. The operating power for the C&D equipment (although originating in the Orbiter) will be conditioned and distributed by the Spacelab support system. The Spacelab computer and data management system is the heart of the C&D interface. Physical interfaces include standard 19 in. racks with a depth of at least 24 in. No direct interfaces are currently required between the AMPS C&D equipment and the Orbiter. However, there may be some critical hardware commands located on the PSS. These would primarily be jettison commands and gimbal caging commands. The Orbiter will have some caution and warning signals but these will probably come from the support module subsystems or the scientific instruments themselves.

6.6.5 Conclusions and Recommendations

The most obvious conclusion from the information provided here is that the AMPS C&D required by the Phase A Study will fit into Spacelab module. When the second objective, development of a conceptual system design of the C&D equipment complement, is accomplished, the C&D requirements can be stated more realistically and with more confidence. It was useful at this point to analyze the SSPD data to determine which areas are drivers for C&D requirements. The drivers according to this analysis are displays, remote sensing platform controls, wave analysis controls, and ambient plasma instrument controls. The analysis was expanded to cover power and weight required by these four systems. It was evident that the display system is the biggest driver in each area. Its weight is approximately one-fifth the total C&D weight; its power is about 70 percent of the total power required; and its space is about one-third the total space required. The preliminary investigations at MSFC and the Rockwell study indicate that the state of the art development in oscilloscopes, wave analyzers, recorders, and other such equipment is ahead of the type equipment listed in SSPD. When a more detailed investigation is made of the actual equipment required some savings will surely be realized. Another area which possibly can be reduced and was assumed to be correct by the Phase A Study is the redundant C&D required by SSPD. The following list is required according to SSPD:

Strip Chart Recorders	2
8-Channel Recorders	2
X-Y Plotters	2
Oscilloscopes	2
Synthesizers	2
Wave Amplifiers	2

Redundancy is mainly mission-operation dependent. The amount of work that is to be accomplished simultaneously will dictate the equipment redundancy to a large degree. One other area which has not been addressed is C&D required but not covered in SSPD. Other subsystems personnel have indicated some gimbal controls and subsatellite TV requirements which are not adequately covered by SSPD. Table 6-35 is a preliminary estimate of the additional C&D required to cover these areas.

One other conclusion can be made at this time. It will serve no useful purpose to continue restudying different configurations of the SSPD data. These data were preliminary and were produced with minimal input from the scientific community. A new and more thorough definition of the scientific instruments needs to be accomplished by the recognized scientific working group. Establishment of a lower level of instrument detail and a more realistic approach to mission requirements will enable the AMPS study group to proceed beyond the SSPD level. In the C&D area, the estimate of panel space for each instrument needs to be expanded with control names and display requirements. An example of the level of data needed in the C&D area is represented by Figure 6-60. With this information actual, rather than estimated, C&D space and power can be determined and logical decisions can be made as to redundancy required.

TABLE 6-33. SUMMARY REQUIREMENTS

Requirements	Weight		Area		Power (watts)
	lb	kg	ft^2	m^2	
Old SSPD	4715	2143	184	17	2550
Current Phase A	1861	844	86	8	1725

TABLE 6-34. AMPS CONTROLS AND DISPLAYS

SSPD AP No.	Description	Quantity	Total Weight kg	Total Weight lb
Displays			350	772
802	Experiment TV Displays	2	40	88
803	Spectrum Analyzer	1	14	31
804	Multichannel Analyzer	1	40	88
805	Wave Analyzer	1	12	26
806	Wave Analyzer	1	17	37
807	Coaxial Patch Panel	5	10	22
808	Frequency Counter	1	8	18
810	Camera (35mm Film)	1	5	11
811	X-Y Recorder	2	16	35
812	Strip Chart Recorder	2	24	53
813	8-Channel Recorder	2	70	154
815	Oscilloscope	2	24	53
821	Special Data Acquisition Panel	1	15	33
822	Data Storage Film	2	8	18
823	Data Storage (35mm)	1	7	15
824	Data Storage (Tape)	3	14	31
825	TV Camera	1	4	9
828	Camera Storage, Polaroid	1	5	11
829	Camera Storage, Motion Picture	1	5	11
830	Polaroid Film Exposed	1	5	11
831	35mm Film Exposed	1	7	15

TABLE 6-34. (Continued)

SSPD AP No.	Description	Quantity	Total Weight	
			kg	lb
<u>Controls</u>	Transmitters		494	1089
901	10 kW, 0.2 to 2 MHz	1	2	4
902	10 kW, 2 to 20 MHz	1	2	4
903	1 kW, 0.3 to 200 kHz	1	2	4
904	Electrostatic Wave	1	2	4
	Antennas			
905	Long 330 m Dipole	1	2	4
906	Short VLF Dipole	1	2	4
907	Loop, 1 m	1	2	4
908	RF Antenna	1	2	4
	Antenna Couplers			
909	0.2 to 2 MHz	1	3	7
910	2 to 20 MHz	1	3	7
911	0.3 to 200 kHz	1	3	7
	Wave Analysis			
912	Bandpass Filter	2	8	18
913	Pulse C.W. Modes	1	2	4
914	Patch Panels	4	8	18
915	Amplifiers, Wave (dc)	1	15	33
916	Frequency Synthesizer	2	24	53

TABLE 6-34. (Continued)

SSPD AP No.	Description	Quantity	Total Weight	
			kg	lb
Controls				
	Main Boom			
920	Alignment TV	1	30	66
923	Boom A Power Supply and Data System	1 }		
924	Boom B Target (Inflation, Deflation, Ejection)	1 }	5	11
990	Boom A Artificial Light Source	1 }		
	Accelerator (Ion Beam)			
926	Discharge Filament Heater	1 }		
927	Discharge Potential	1 }	16	35
928	Pulse Sequence and Burst Length	1 }		
929	Gas Selection and Pressure	1 }		
925	Acceleration-Deceleration	1 }		
930	Neutralized Emission and Bias	1 }	16	35
931	Charge Exchange Channel Actuator	1 }		
932	Beam Current Monitor	1 }		
	Accelerator (Electron Beam)			
933	Beam Voltage; Heater Current	1 }		
934	Burst Length; Burst Magnitude	1 }		
935	Expansion Lens	1 }	20	44
936	Beam Current Monitor	1 }		
937	ϕ, θ, I	1 }		

TABLE 6-34. (Continued)

SSPD AP No.	Description	Quantity	Total Weight kg	Total Weight lb
Controls				
	Accelerator (MPD Arc)			
938	Voltage Level	1		
939	Burst Current and Duration	1		
940	Pulse Sequencer	1	20	44
941	Beam Current Monitor	1		
942	Gas Selection and Pressure	1		
	Ambient Plasma			
943	Spherical Ion Probe	1	5	11
944	Cylindrical Ion Probe	1	5	11
945	Planar Electron Probe	1	5	11
946	RF Probe	1	5	11
947	Ion Mass Spectrometer	1	3	7
948	Neutral Mass Spectrometer	1	3	7
949	Triaxial Fluxgate	1	3	7
950	Segmented Planar Probe	1	5	11
951	Rubidium Magnetometer	1	3	7
952	Triaxial Search Coil	1	3	7
953	Amplifiers (Pulse) Particle Detection	1	10	22
954	HV Supplies, Particle Detection	1	10	22
955	Triaxial Hemispherical Analytical Controls	3	15	33

TABLE 6-34. (Continued)

SSPD AP No.	Description	Quantity	Total Weight	
			kg	lb
Controls				
	Subsatellites			
956	TV System	1	10	22
957	Telemetry and Ranging	1	10	22
958	Location and Orientation	1	10	22
959	Instrument Controls and Housekeeping	1	10	22
960	Ejection Mechanism	1	5	11
	Optical			
961	Photometer HV Supply	1	10	22
962	Photometer Amplifiers	2	20	44
963	TV System Control-Image Intensifier	2	24	53
	Releases			
964	Canister Ejection	1	5	11
965	Camera	1	2	4
966	Canister Monitor	1	3	7
967	Shaped Charge Ejection	1	3	7
968	Shaped Charge Monitor	1	3	7
969	Balloon Ejection	1	3	7
970	Gas Control System	1	3	7

TABLE 6-34. (Concluded)

SSPD AP No.	Description	Quantity	Total Weight	
			kg	lb
<u>Controls</u>				
	Remote Sensing Platform			
972	XUV Normal Incidence Spectrometer	1	6	13
973	UV-Visible NIR Scanning Spectrometer	1	12	26
974	High-Resolution Fourier SWIR Spectrometer	1	6	13
975	Cryogenic IR Fourier Spectrometer	1	6	13
976	IR Radiometer	1	6	13
977	Fabry-Perot Interferometer	1	6	13
978	UV-Visible Documentation Camera	1	2	4
981	keV-MeV Particle Detector	1	6	13
982	Total Energy Detector	1	6	13
983	Lidar and Gimbal Platform Monitor	1	25	55
984	Filter Photometer	4	28	62
Total C&D			844	1861

TABLE 6-35. ADDITIONAL C&D REQUIRED TO SUPPORT CURRENT BASELINE

C&D	Quantity	Location	Width (m)	Height (m)	Length (m)	Weight (kg)	Power (W)
Second Subsatellite							
TV System	1	Spacelab	0.48	0.28	0.38	22.7	20
Telemetry and Ranging	1	Spacelab	0.48	0.28	0.38	13.6	10
Instrument Control	1	Spacelab	0.48	0.28	0.38	13.6	10
Antenna Controls	1	Spacelab	0.48	0.12	0.30	4.5	2
Gimbal Controls							
Star Tracker	1	Spacelab	0.48	0.15	0.3	4.5	2
Accelerator System	1	Spacelab	0.48	0.15	0.3	4.5	2

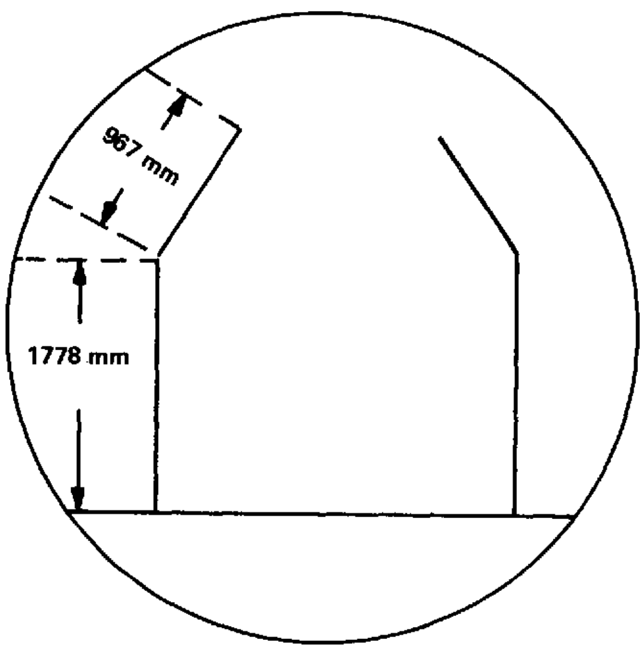


Figure 6-57. Spacelab rack definition.

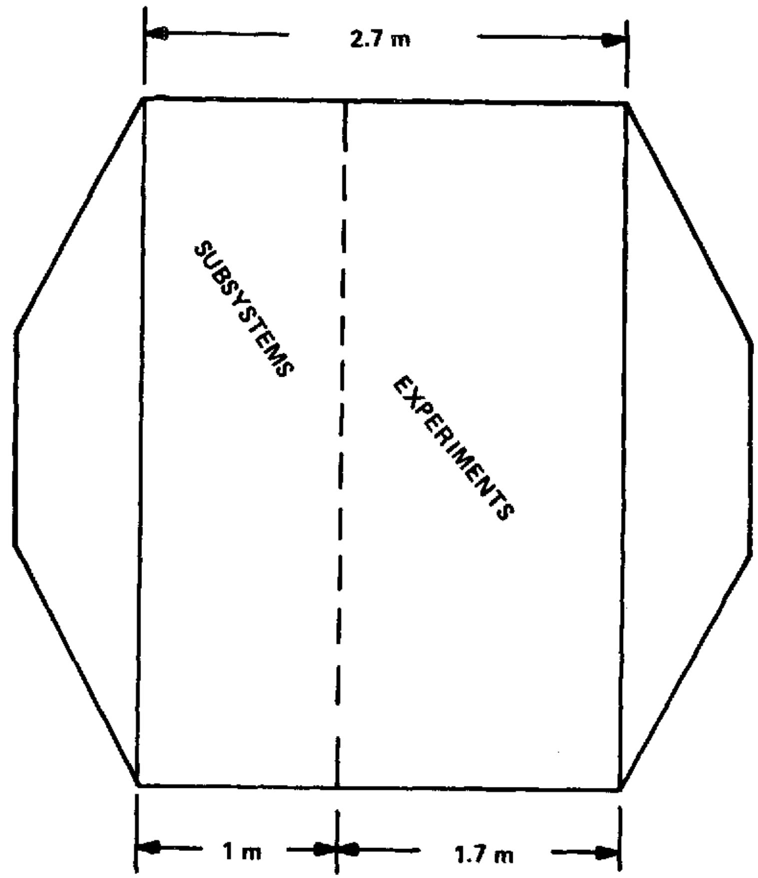


Figure 6-58. Spacelab module.

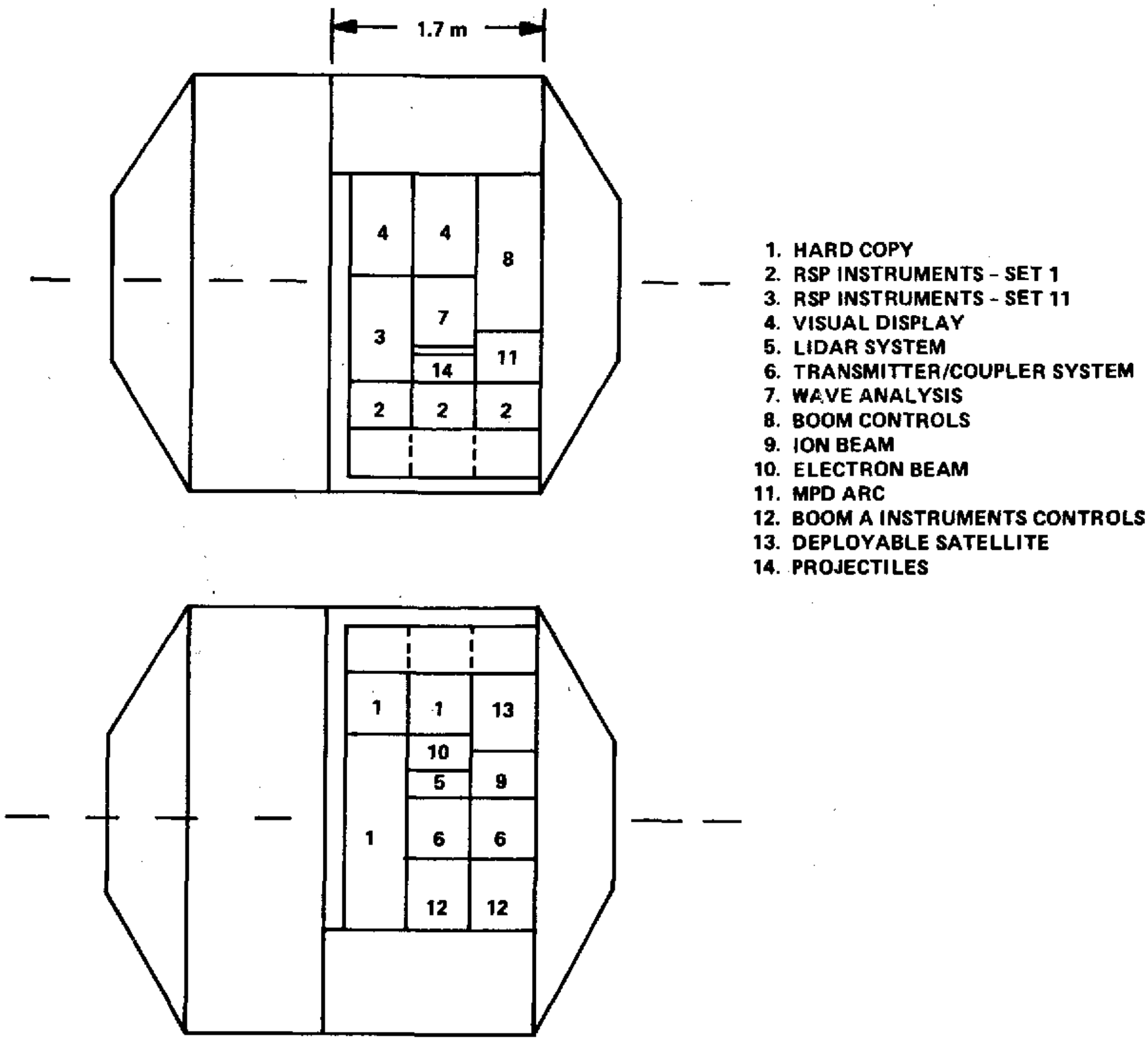


Figure 6-59. AMPS C&D layout.

EQUIPMENT: XUV NORMAL INCIDENCE SPECTROMETER

LOCATION: REMOTE SENSING PLATFORM

FUNCTION REQUIRED	TYPE CONTROL	RESPONSE
POWER ON/OFF	TOGGLE SWITCH	FLAG
VIDICON GAIN	ROTARY SWITCH	
WAVELENGTH LONG/SHORT	TOGGLE SWITCH	FLAG
SCAN SPEED SELECT	ROTARY SWITCH	
CALIBRATION ENABLE/INHIBIT	TOGGLE SWITCH	
APERTURE DOOR OPEN/CLOSE	TOGGLE SWITCH	FLAG
CAMERA INTEGRATION	TOGGLE SWITCH	

RECORD/DISPLAY

SIGNAL DISCRIPTION	TYPE DISPLAY
VIDICON	TV
CALIBRATION	5-DIGIT DIGITAL DISPLAY

Figure 6-60. Example of level of data needed in C&D area.

SECTION 7.0 MISSION ANALYSIS

7.0 MISSION ANALYSIS

7.1 SUBSATELLITE FLIGHT MECHANICS

7.1.1 Near Shuttle Subsatellite Operations

Two main types of subsatellites are being considered to support the Atmospheric, Magnetospheric and Plasmas in Space (AMPS) experiment operations: (1) a subsatellite designed to operate in the near vicinity [less than 25 n. mi. (46.3 km)] of the Orbiter in support of the plasma physics experiments and (2) a subsatellite designed to operate in non-co-orbits with respect to the Orbiter in support of atmospheric physics experiments. The following discussion applies to subsatellites that operate in the near vicinity of the Orbiter.

7.1.1.1 Guidelines and Assumptions

- Orbiter in circular 235 n. mi. (435 km) orbit; the desired result is the relative incentive-to-orbit altitude obtainable by the Shuttle.
- Oblate Earth model.
- No atmospheric drag.
- Coordinate system centered at c.g. of Orbiter.
- Single impulse applied to subsatellite to obtain relative motion profile.

7.1.1.2 Description of Problem

In the plasma physics experiment mapping operations, it is desired that the subsatellite sweep out a particular trajectory profile relative to the Orbiter. The purpose of this task is to derive a program model that will describe the relative motion between the Orbiter and the subsatellite.

7.1.1.3 Task Status

Program models have been derived, implemented, and exercised on the SDS 930 and Hewlett-Packard 9820A computers. Preliminary results have been obtained to indicate how the relative trajectory profile of the subsatellite can be controlled by initial injection conditions.

7.1.1.4 Results

Results have been obtained to indicate how the relative movement of the subsatellite can be controlled by the selection of the initial impulse direction and magnitude. Figure 7-1 depicts the coordinate system and the initial angular orientation of the impulse direction used in deriving the ensuing subsatellite motion. Given in Figures 7-2 and 7-3 is the X-Y planar motion (orbit plane) for various injection angles from 0 to 330 deg in increments of 30 deg and with a relative ΔV of 1 ft/sec (0.3 m/sec). The time history of the profile given in Figures 7-2 and 7-3 is for approximately one orbit period ($\approx$ 90 min). For subsequent motion with time greater than one orbit, the trajectory profiles are essentially repetitive, but displaced to the left or right of the center of the coordinate system. As shown in Figures 7-2 and 7-3 for angular separations of $\approx$85 and $\approx$265 deg, the subsatellite can be made to map out continuous areas about the Orbiter. Figures 7-4 and 7-5 show the relative displacement for a separation ΔV of 25 ft/sec (7.62 m/sec) and initial in-plane angles of 0 and 180 deg, respectively. Figures 7-6 through 7-8 give the relative profile for separation angles near 90 deg for a separation ΔV of 25 ft/sec (7.62 m/sec).

When the subsatellite has an imparted ΔV component out of the orbit plane, a cyclic trajectory excursion from the orbit plane is set up that is repetitive once every orbit. The out-of-orbit plane displacement, Z, versus the X- and Y-axis displacement is given in Figure 7-9. The in-plane motion for this case would be similar to that shown in Figure 7-7.

7.1.1.5 Observation and Issues

Parametric data are given in Figures 7-2 through 7-9 showing the sensitivity of the relative motion between the Orbiter and subsatellite as the initial impulse orientation and magnitude change. It is necessary to determine what the actual trajectory profile is that the plasma physics experiment wants to fly in formulating a realistic mission profile and real time operational experiment mode.

Another factor that must be considered is the type of separation mechanism; i.e., whether the initial separation will be effected by (1) a manipulator arm, (2) a spring system, or (3) a reaction control system.

7.1.2 Non-Co-Orbiting Subsatellite Operations

The atmospheric physics type of experiment requires maneuverable and controllable subsatellites that are capable of operating in orbits with periods several times that of the Shuttle. Suggested candidate spacecraft configurations to satisfy the above requirements are: (1) Atmospheric Explorer (AE) spacecraft and (2) a spacecraft design that uses the third stage of the Scout launch vehicle as the major propulsion system. It is desired that this type of subsatellite be retrieved and returned by the Shuttle. The following paragraphs are related to non-co-orbiting subsatellite operations.

7.1.2.1 Guidelines and Assumptions

- Shuttle in circular 185 n. mi. (343 km) polar orbit.
- Oblate Earth model.
- Atmospheric drag considered for calculating subsatellite station keeping.
- Subsatellite major burn considerations:
  - Four burns for circular orbit injection and return.
  - Two burns for circular orbit injection and no return.
  - Two burns for elliptic orbit injection and return.
  - One burn for elliptic orbit injection and no return.
- Subsatellite propulsion system considered:
  - Atmospheric Explorer propulsion system.
  - Third stage of Scout launch vehicle.

7.1.2.2 Description of Problem

This task involves the analysis of non-co-orbital subsatellite performance and operations for the following purposes:

1. Determine non-co-orbits accessible to the subsatellite propulsion system.

2. Provide communication range requirement during subsatellite acquisition.

3. Orbital lifetime calculations and orbital station-keeping requirements of the subsatellite.

7.1.2.3 Task Status

Preliminary parametric performance and station-keeping data have been developed based on the Atmosphere Explorer spacecraft and the third stage of the Scout propulsion system. When the range of parameters has been narrowed to the desired operating region, a more in-depth analysis will be developed to derive the real AMPS payload design requirements.

7.1.2.4 Results

The subsatellite will have an onboard propulsion system that will permit excursion into the largely unexplored region of the lower thermosphere and of the atmospheric constituents at higher altitudes. The subsatellite should have circular or elliptic orbits with periods of up to three times that of the Shuttle so that a video system can image the entire auroral zone of one hemisphere at one time.

7.1.2.4.1 Subsatellite Performance Capability

Tables 7-1 and 7-2 list the characteristics of the Atmospheric Explorer spacecraft and the third stage of the Scout launch vehicle.

The range of circular orbit and elliptical orbit apogee altitude as a function of the subsatellite normalized orbit period is shown in Figure 7-10. From Figure 7-10, the maximum circular orbit altitude would be 4100 n. mi. (7593 km) for an orbit period three times that of the Shuttle; the maximum apogee altitude would be 8050 n. mi. (14 909 km) for an orbit period three times that of the Shuttle. The energy (ΔV) required to obtain the various subsatellite orbit periods is given in Figure 7-11. The AE spacecraft propulsion system can provide a ΔV of 2000 ft/sec (610 m/sec); as illustrated in Figure 7-11, the AE spacecraft could obtain orbits with periods up to 1.1 times that of the Shuttle and return to be retrieved by the Shuttle. If the spacecraft were expended, orbits could be obtained with periods up to 1.25 times that of the Shuttle. To reach the higher energy orbits it will be necessary for the AE spacecraft to provide more impulse than is possible with the current design.

Figures 7-12 and 7-13 give the payload capability of the AE and the third stage of the Scout propulsion system versus the normalized orbit period for circular orbits and elliptical orbits respectively.

7.1.2.4.2 Shuttle Tracking Range Requirement

The tracking range required of the Shuttle during subsatellite acquisition is given in Figure 7-14 for subsatellites in various operational orbits. Notes B and C of Figure 7-14 give the range requirement for elliptical operational orbits obtainable by the AE spacecraft. Notes D and E are associated with orbits that have periods three times that of the Shuttle.

7.1.2.4.3 Subsatellite Station-Keeping Requirement

Orbital decay history and orbit station-keeping requirements have been developed for subsatellite excursions into the lower atmosphere down to 67.5 n. mi. (125 km). Figures 7-15 and 7-16 and Table 7-3 list the aerodynamic parameters characteristic of the AE spacecraft utilized in calculating the decay history and orbit station keeping.

The orbital decay history is given in Figure 7-17 and assumes there is no reboost applied to the AE spacecraft to maintain its initial orbit. For an excursion down to 125-km altitude without any station keeping, the AE spacecraft orbital altitude will decay down into the dense atmosphere after approximately 10 days for the worst case ballistic coefficient (B) of 100 km/m^2. The impulse (ΔV) required for station keeping as a function of mission duration is given in Figures 7-18 and 7-19. For the 125-km altitude excursion, two reboost intervals were considered: (1) after every 10 revolutions and (2) after every 5 revolutions. Figure 7-18 gives the impulse requirement for the 125-km altitude excursion. For a 7-day mission duration, the station-keeping ΔV is 80 ft/sec (24.4 m/sec) associated with the 125-km altitude and a ballistic coefficient of 150 kg/m^2. The propellant required for the 7 days is 22 lb (10 kg) as indicated in Figures 7-20 and 7-21.

7.1.2.5 Observation and Issues

The nominal payload weight associated with the proposed subsatellite AE spacecraft cannot be injected into the desired high energy orbit by the AE propulsion system or with a third stage of the Scout vehicle. The stringent requirement imposed by the high energy orbit will have to be relieved by injecting the subsatellite into a lower energy orbit or selecting a propulsion system with more propulsion capability than either the AE propulsion system or the third stage of the Scout vehicle.

TABLE 7-1. ATMOSPHERIC EXPLORER SYSTEM PERFORMANCE SUMMARY

Spacecraft Weight (Less Payload)	1240 lb (562 kg)
Payload Weight (Typical)	210 lb (95 kg)
Projected Area	2400 $in.^2$ (1.55 m^2)
Experiment Footprint Available	< 1300 $in.^2$ (0.84 m^2)
Experiment Volume Available	< 12000 $in.^3$ (0.2 m^3)
Energy Available to Experiments (Orbit Average)	4000 watt-minutes
Regulated Voltage	-24.5 V ±2%
Temperature Range (Upper Baseplate)	10° C to 15° C
Temperature Range (Lower Baseplate)	10° C to 28° C
Attitude Determination Accuracy	0.5 deg
Attitude Control Accuracy	1.0 deg
Spin Rates Available	1 rpo; 1 to 10 rpm
Minimum Operating Altitude	120 km → 150 km (Depends on Stabilization Mode and Apogee Altitude)
Orbit Adjust Capability	~ 2000 ft/sec (610 m/sec)
Maximum ΔV per Burn	25 ft/sec (7.62 m/sec)
Memory Capacity	2 × 32 kilobits
Memory Delay Time (Maximum)	72 hours maximum
Command Op-Codes Available to Experiments	250
Recorder Capability	2 × (1.2 × 10^8 bits) 2 × 2 hours Record Time
Maximum Playback Data Rate	~ 130 kilobits/sec

TABLE 7-2. SCOUT THIRD STAGE CHARACTERISTICS

Length	5.0 ft (1.52 m)
Diameter	1.7 ft (0.52 m)
Burnout Weight	54 lb (24.5 kg)
Propellant Weight	606 lb (275 kg)
Thrust Level	5300 lb (2404 kg)
Specific Impulse	284 sec

TABLE 7-3. AE DRAG AND BALLISTIC COEFFICIENT RANGE

Diameter = 1.35 m (End Area = 1.43 m^2)
Length = 1.15 m (Longitudinal Area = 1.55 m^2)
Mass = 663 kg (Fully Loaded with Propellant)
Mass = 495 kg (Without Propellant)

Mass (kg)	Area (m^2)	S	C_D	$B = M/C_DA$ (kg/m^2)
663	1.43	20	2.20	210
663	1.43	4	2.90	160
663	1.55	20	2.65	161
663	1.55	4	3.05	140
495	1.43	20	2.20	157
495	1.43	4	2.90	119
495	1.55	20	2.65	120
495	1.55	4	3.05	105

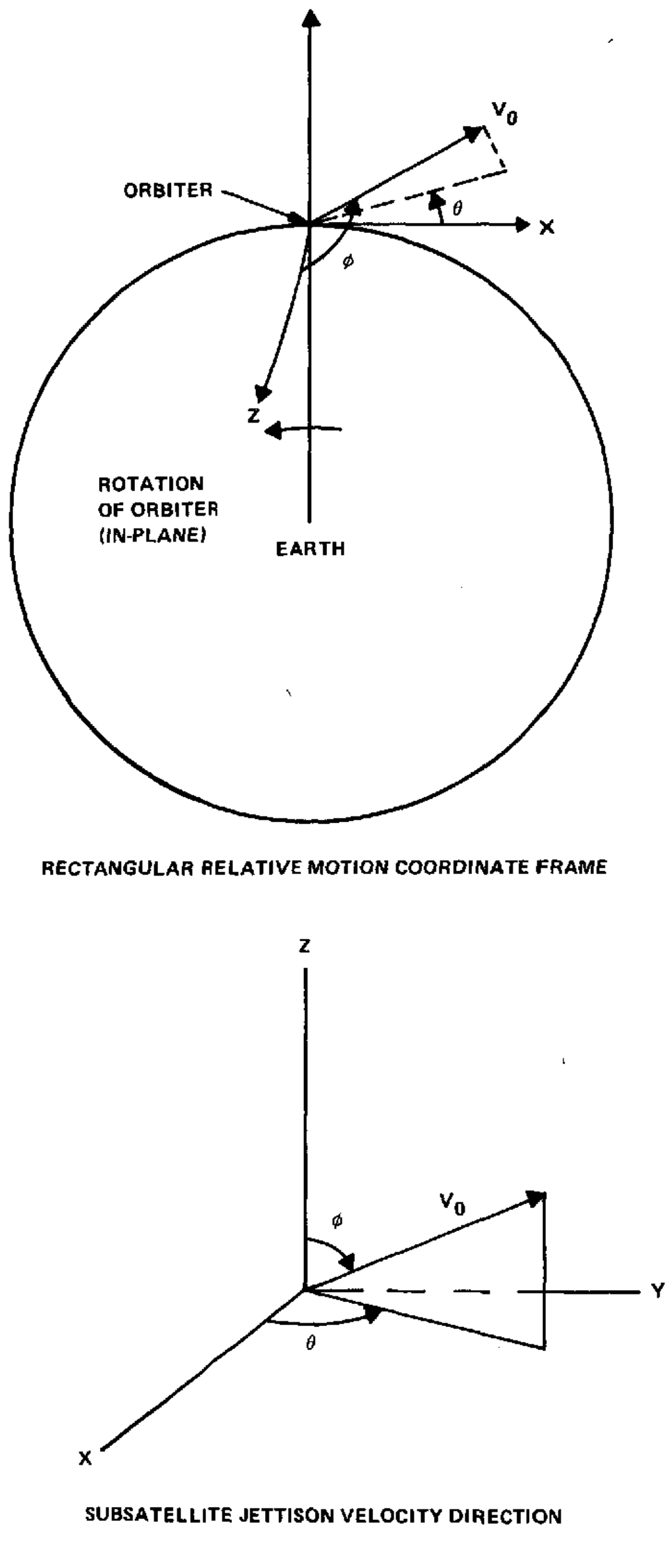


Figure 7-1. Relative motion coordinate frames.

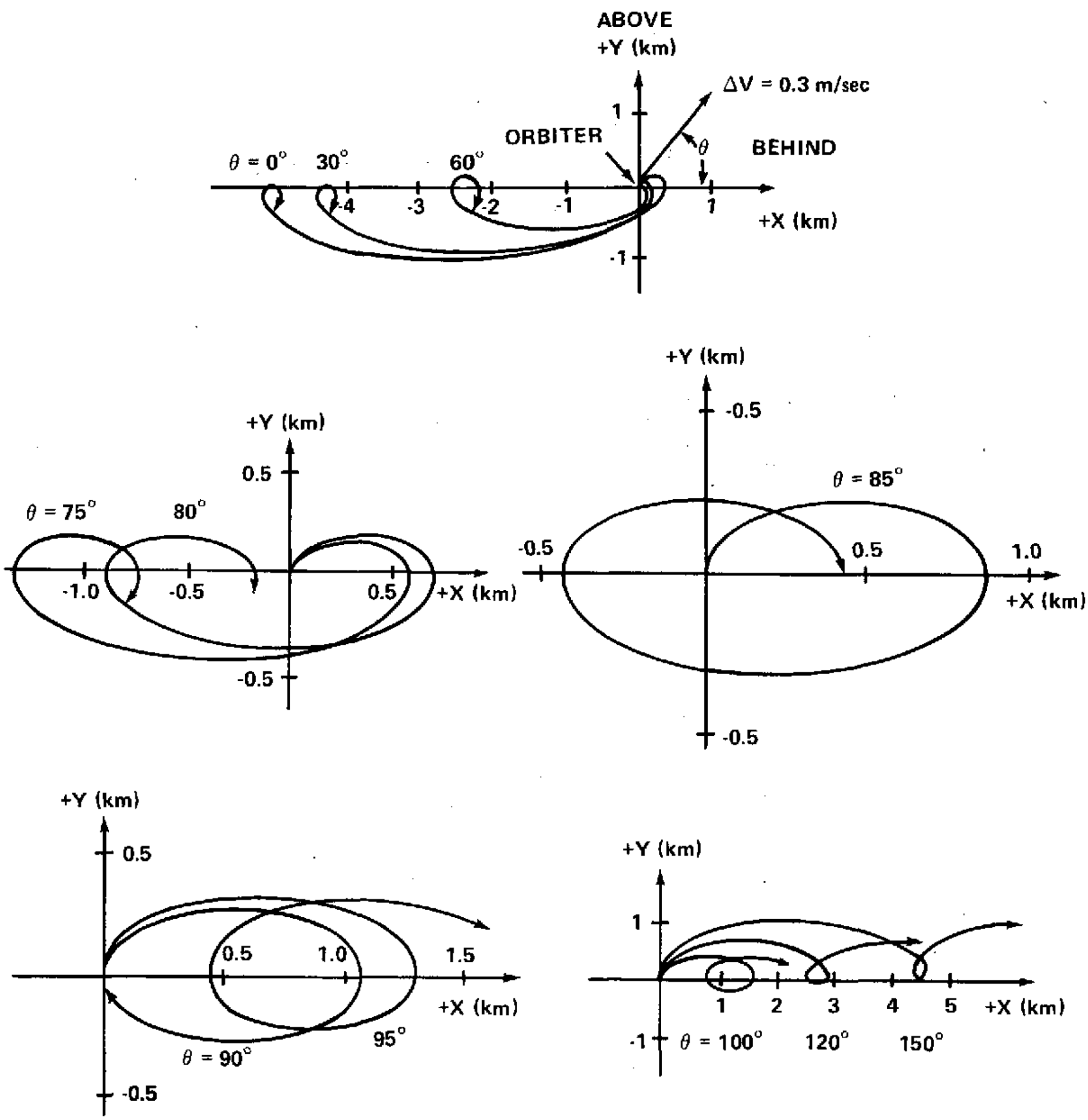


Figure 7-2. Motion of subsatellite relative to Orbiter for various in-plane jettison directions, θ.

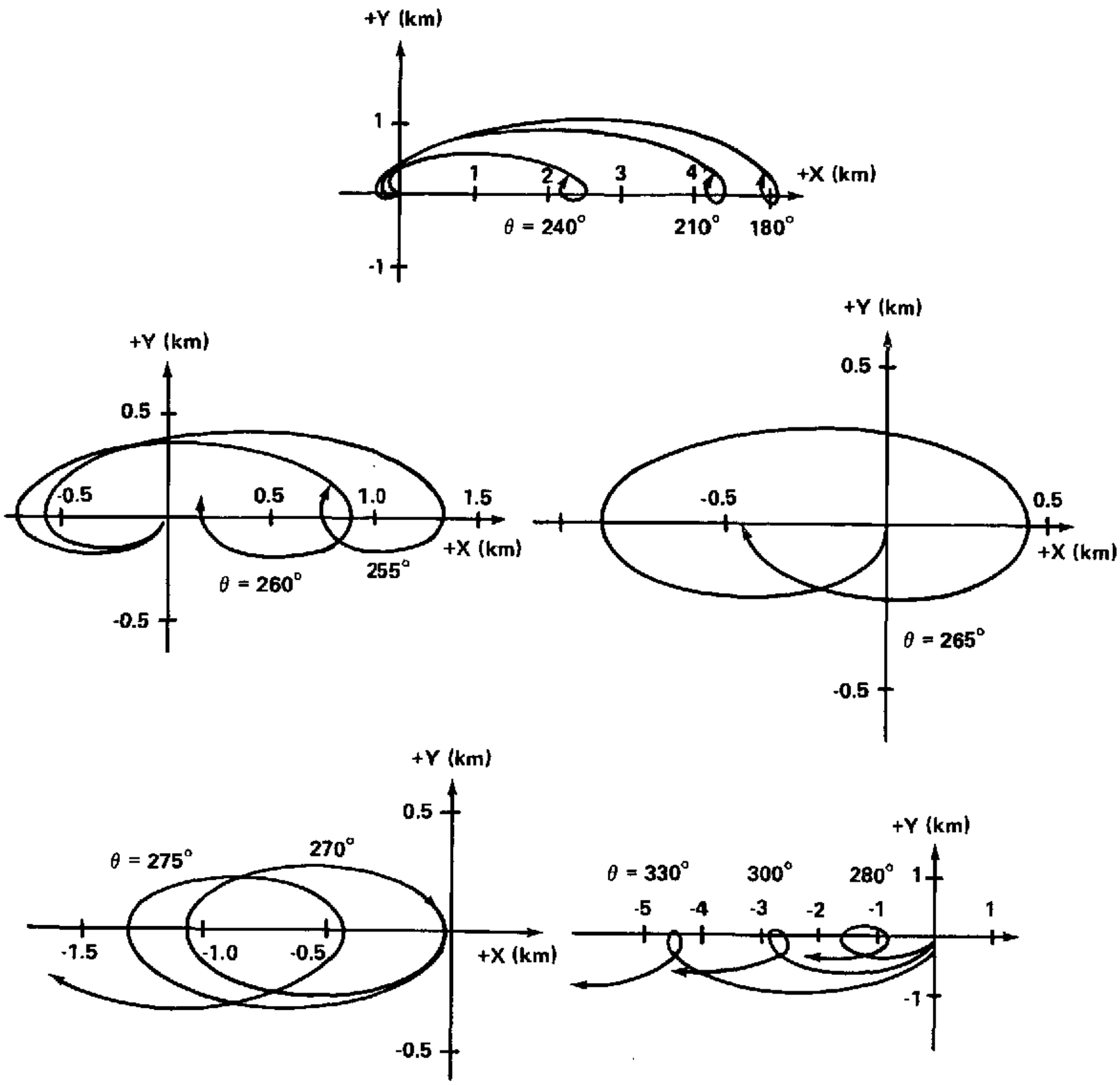


Figure 7-3. Motion of subsatellite relative to Orbiter for various in-plane jettison directions, θ.

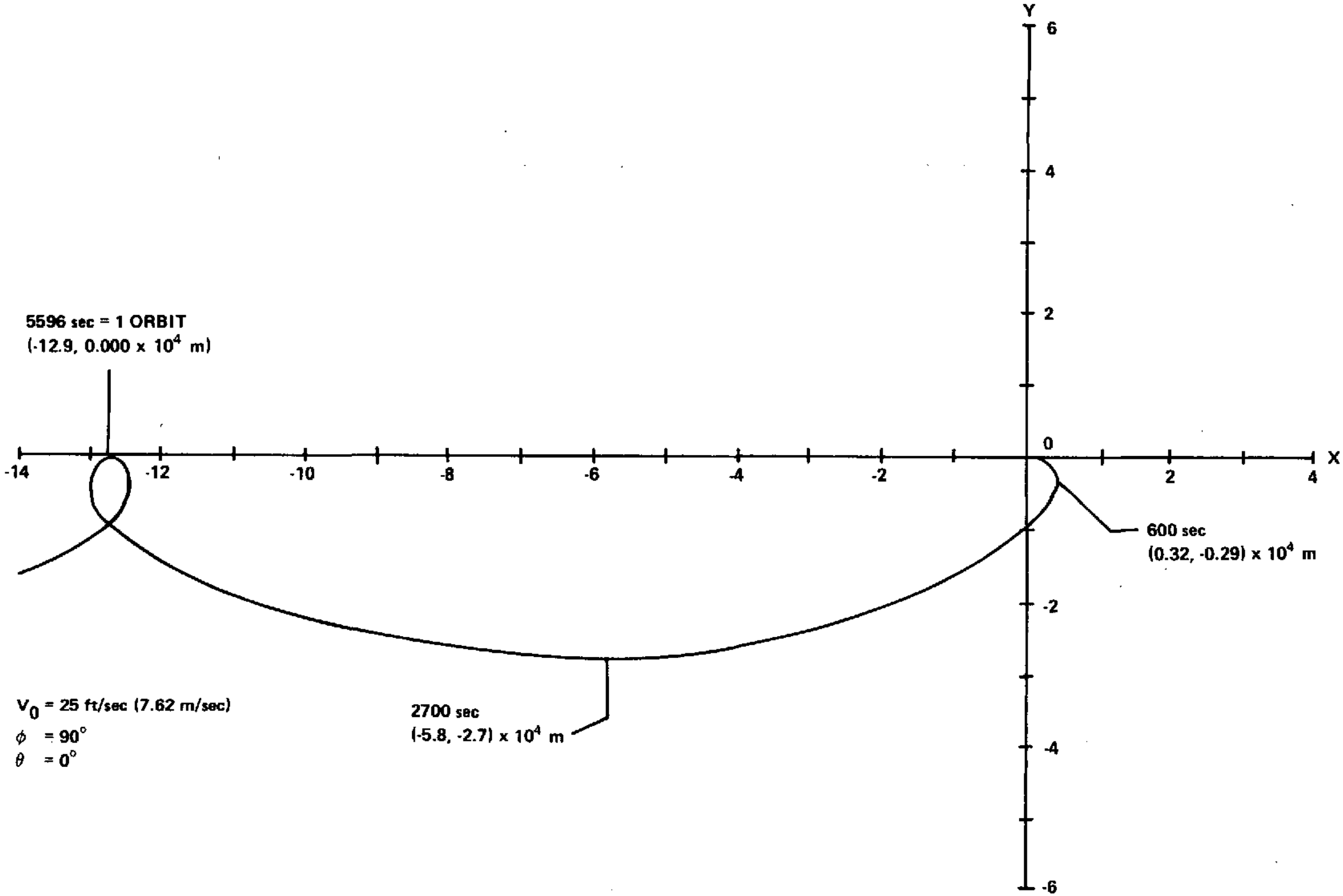


Figure 7-4. Motion of subsatellite relative to Orbiter.

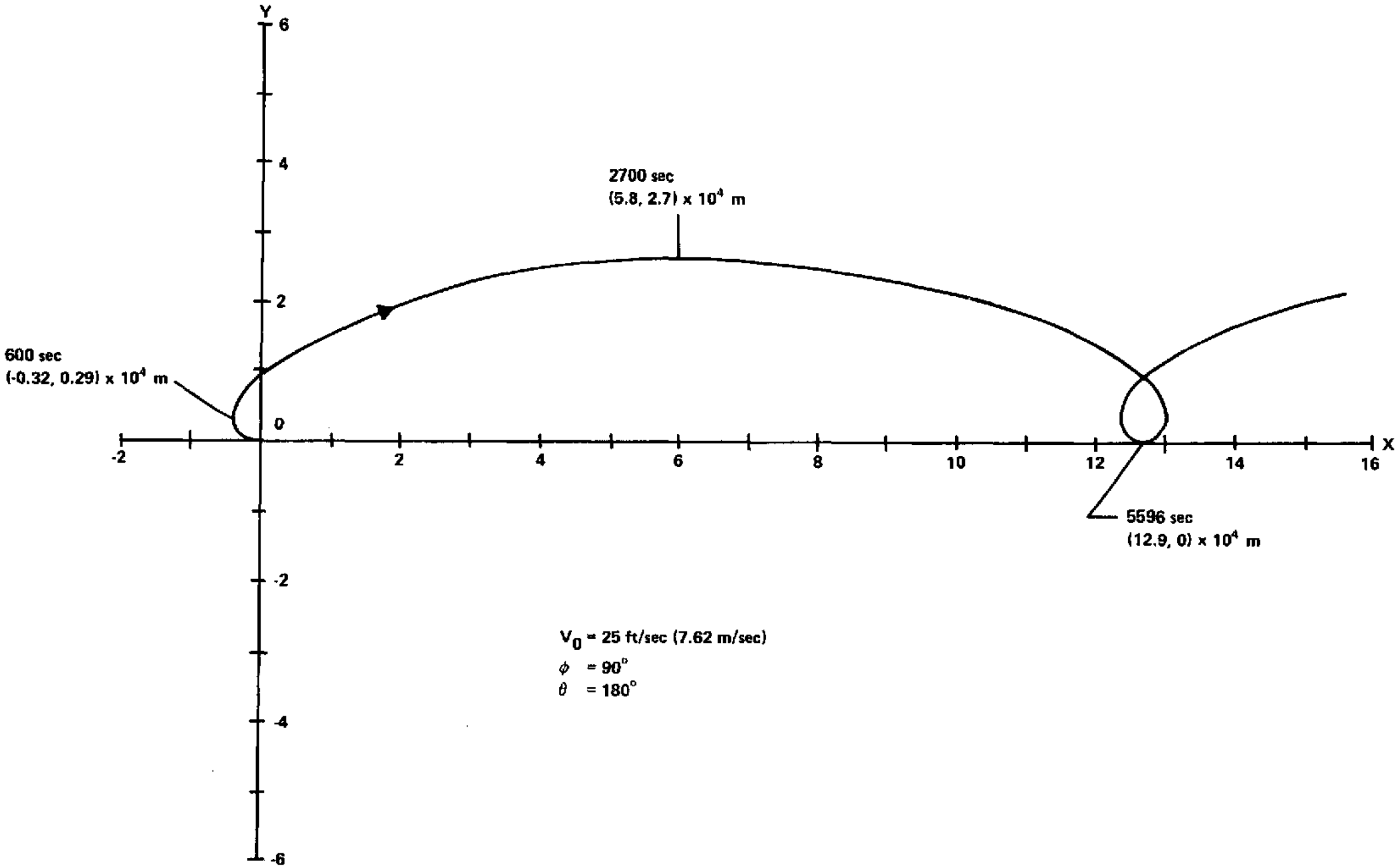


Figure 7-5. Motion of subsatellite relative to Orbiter.

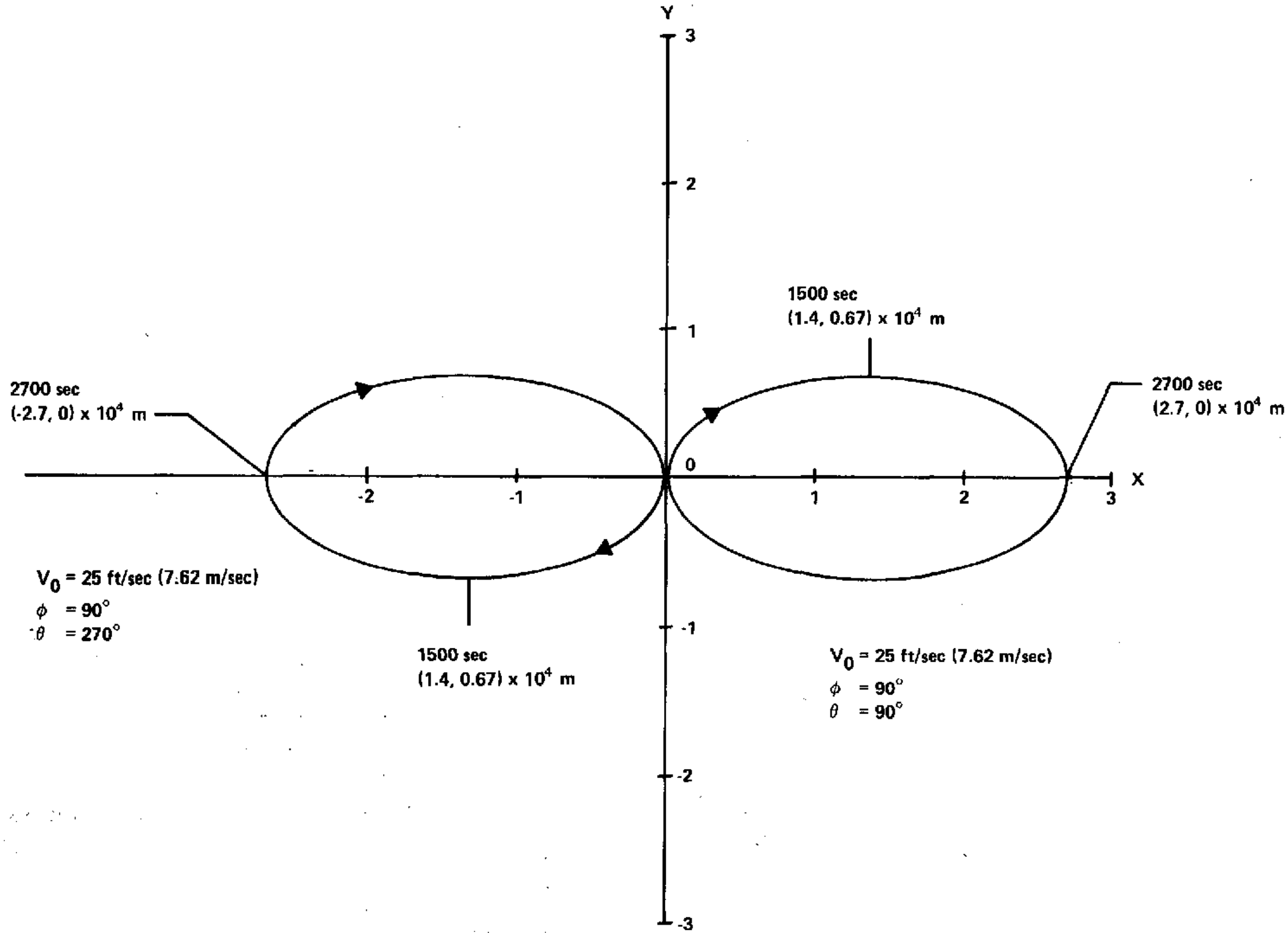


Figure 7-6. Motion of subsatellite relative to Orbiter.

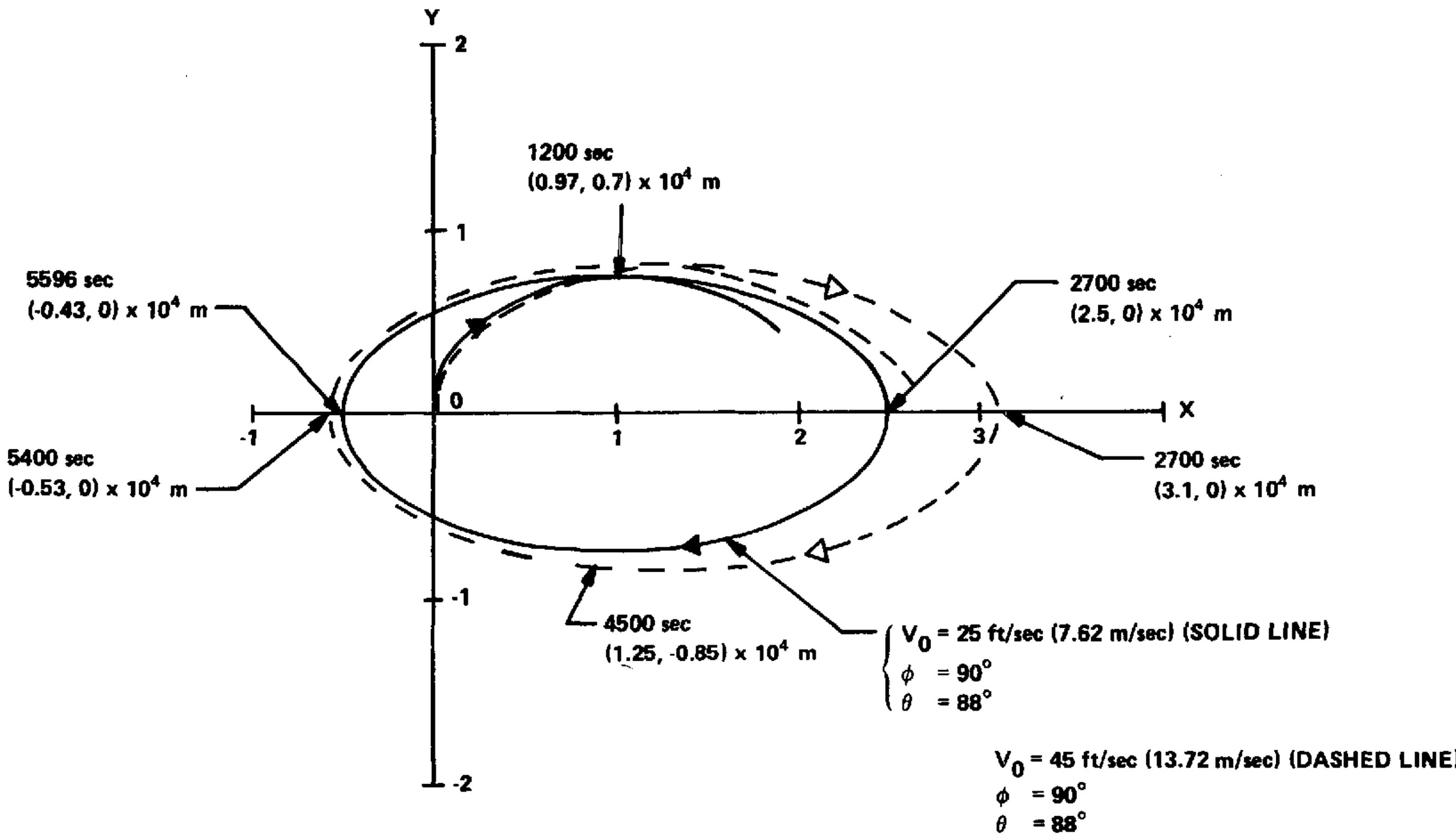


Figure 7-7. Motion of subsatellite relative to Orbiter.

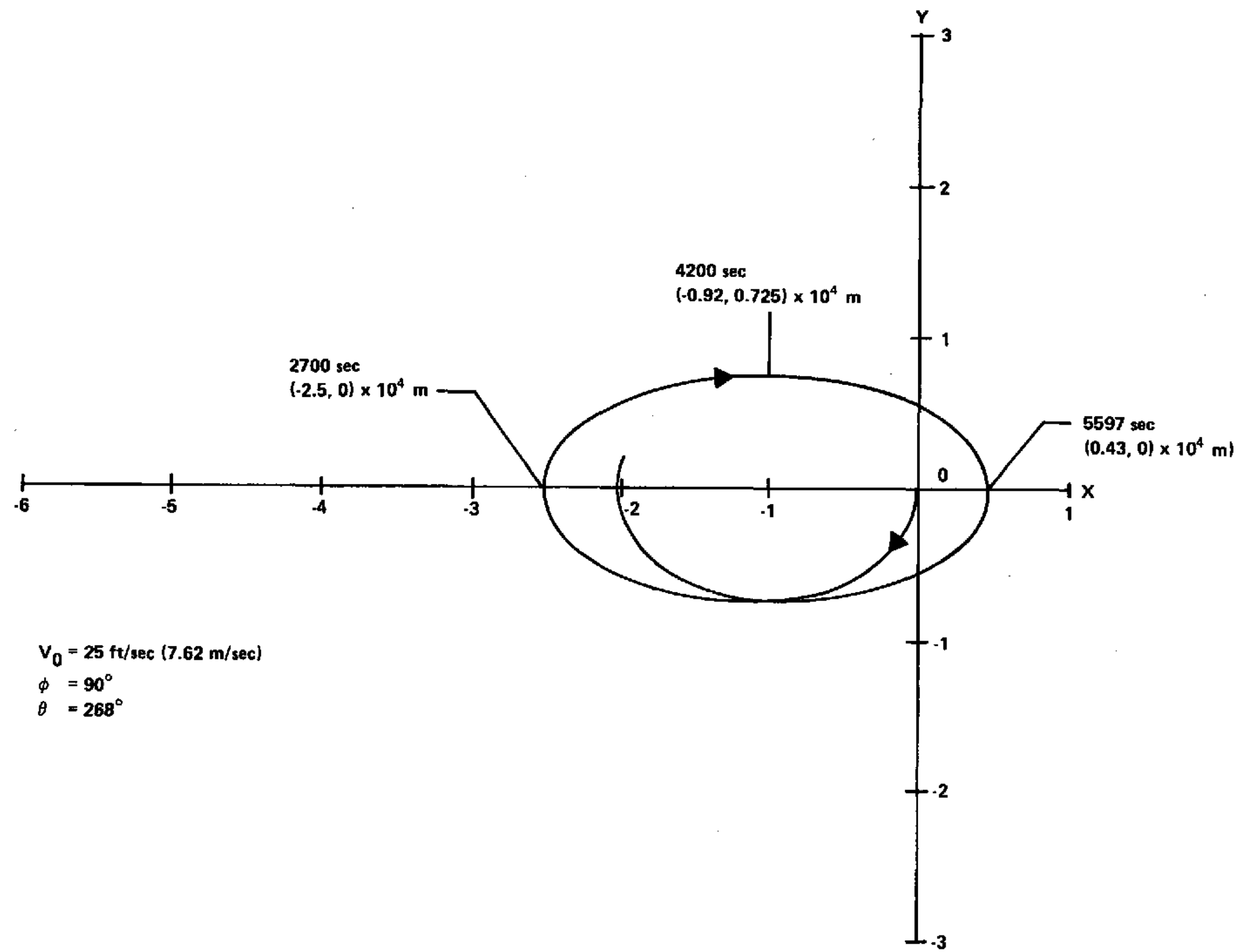


Figure 7-8. Motion of subsatellite relative to Orbiter.

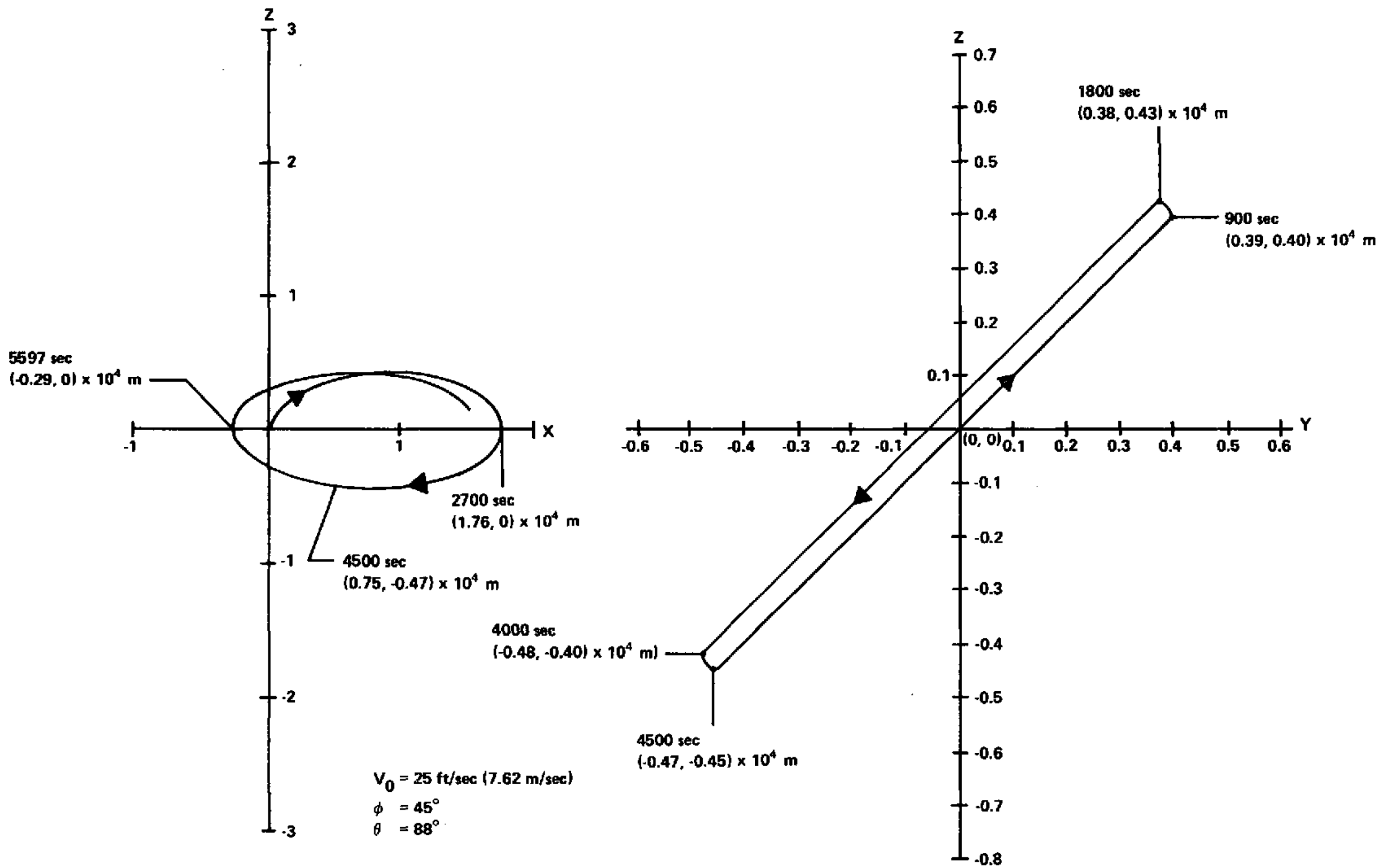


Figure 7-9. Motion of subsatellite relative to Orbiter.

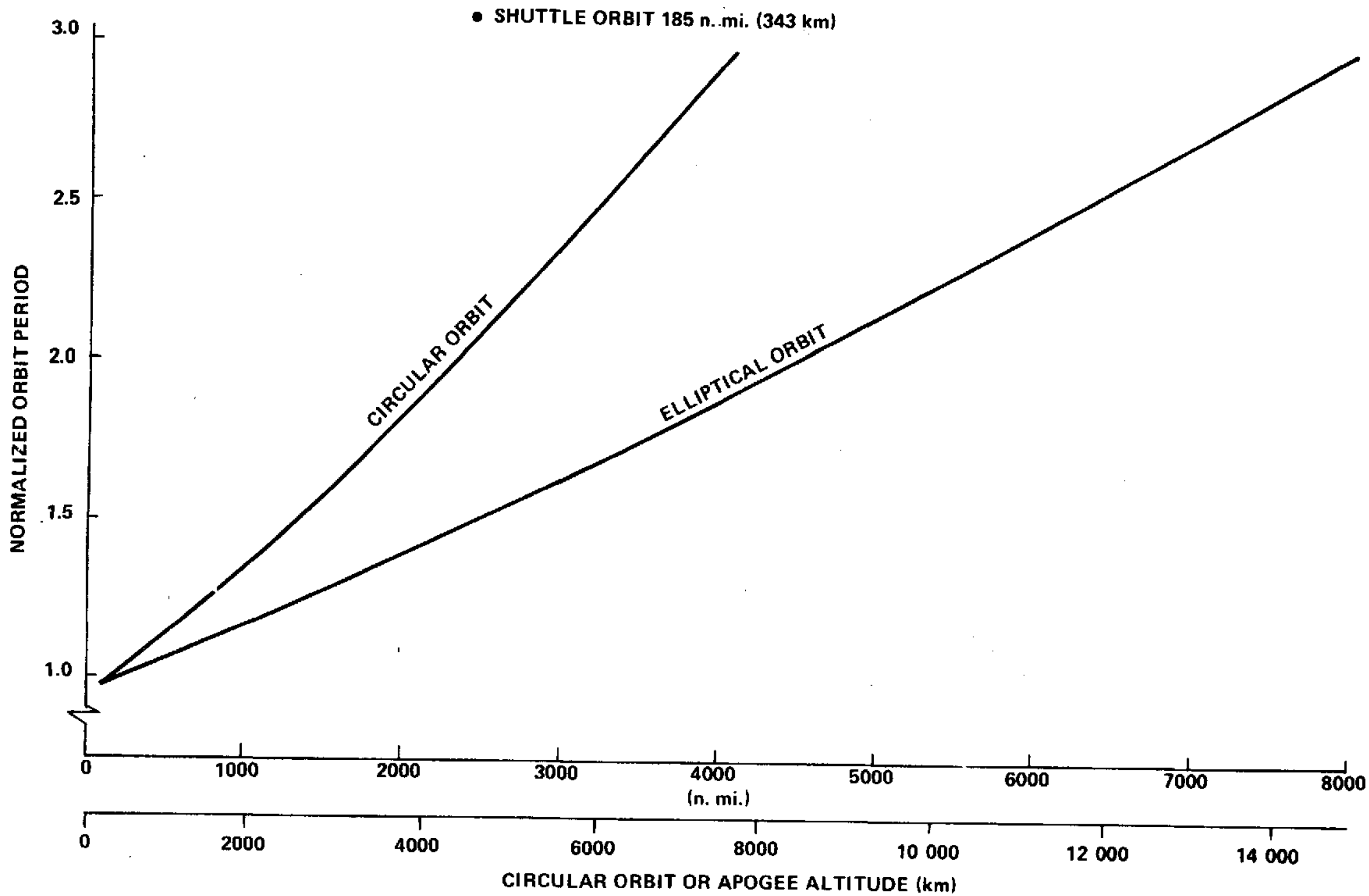


Figure 7-10. Subsatellite orbit altitude.

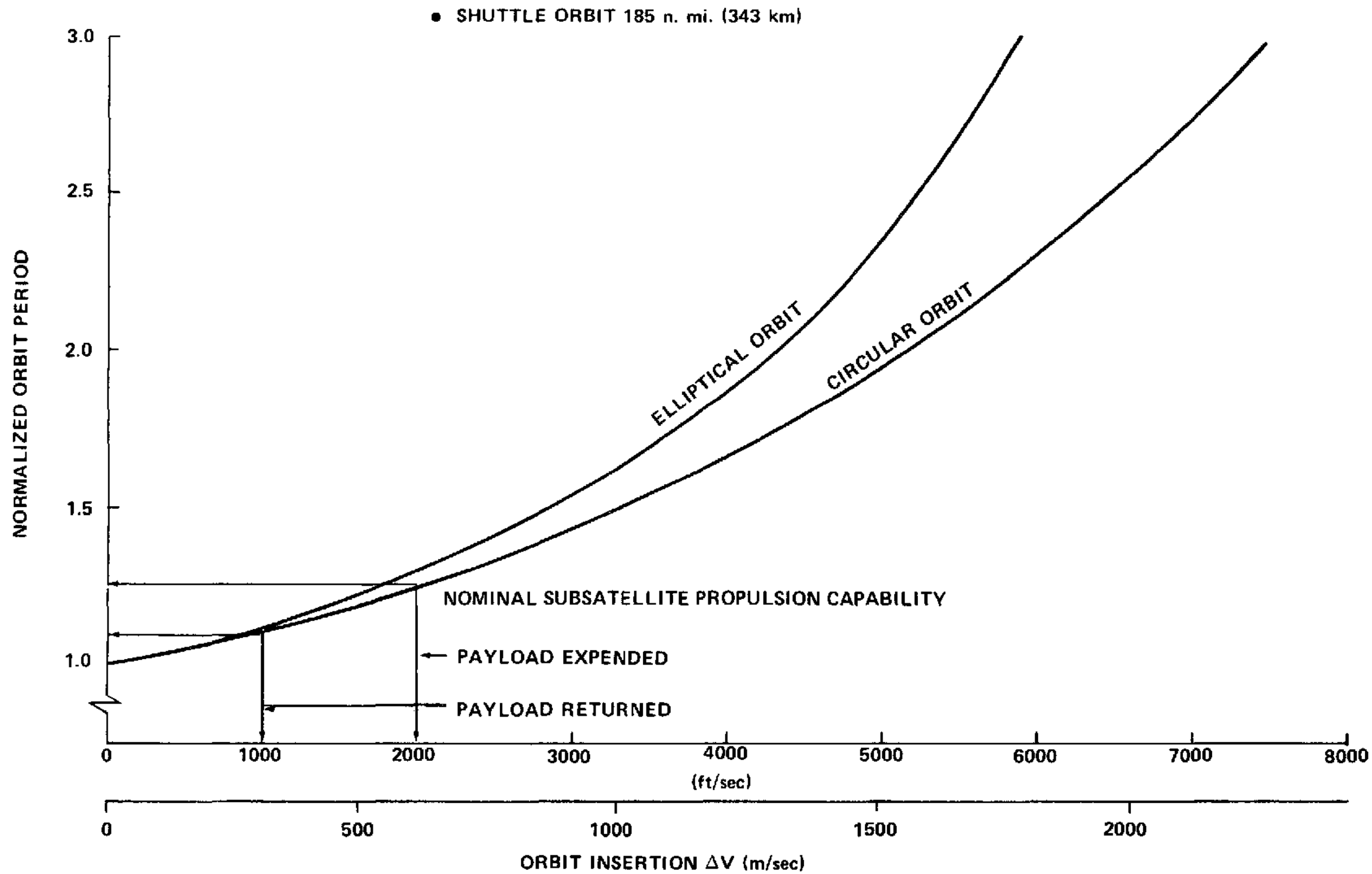


Figure 7-11. Subsatellite orbit insertion requirement.

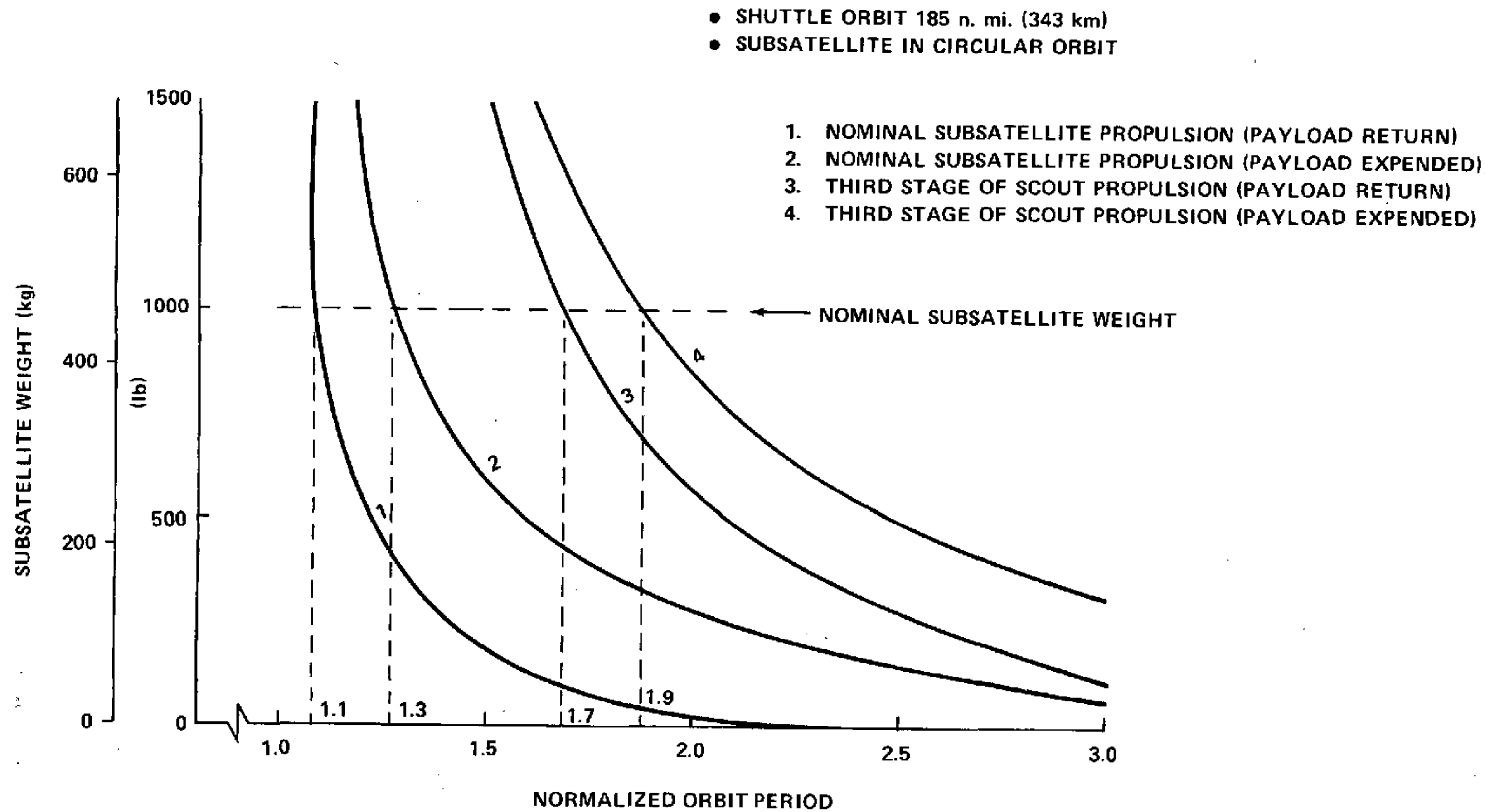


Figure 7-12. Subsatellite propulsion capability.

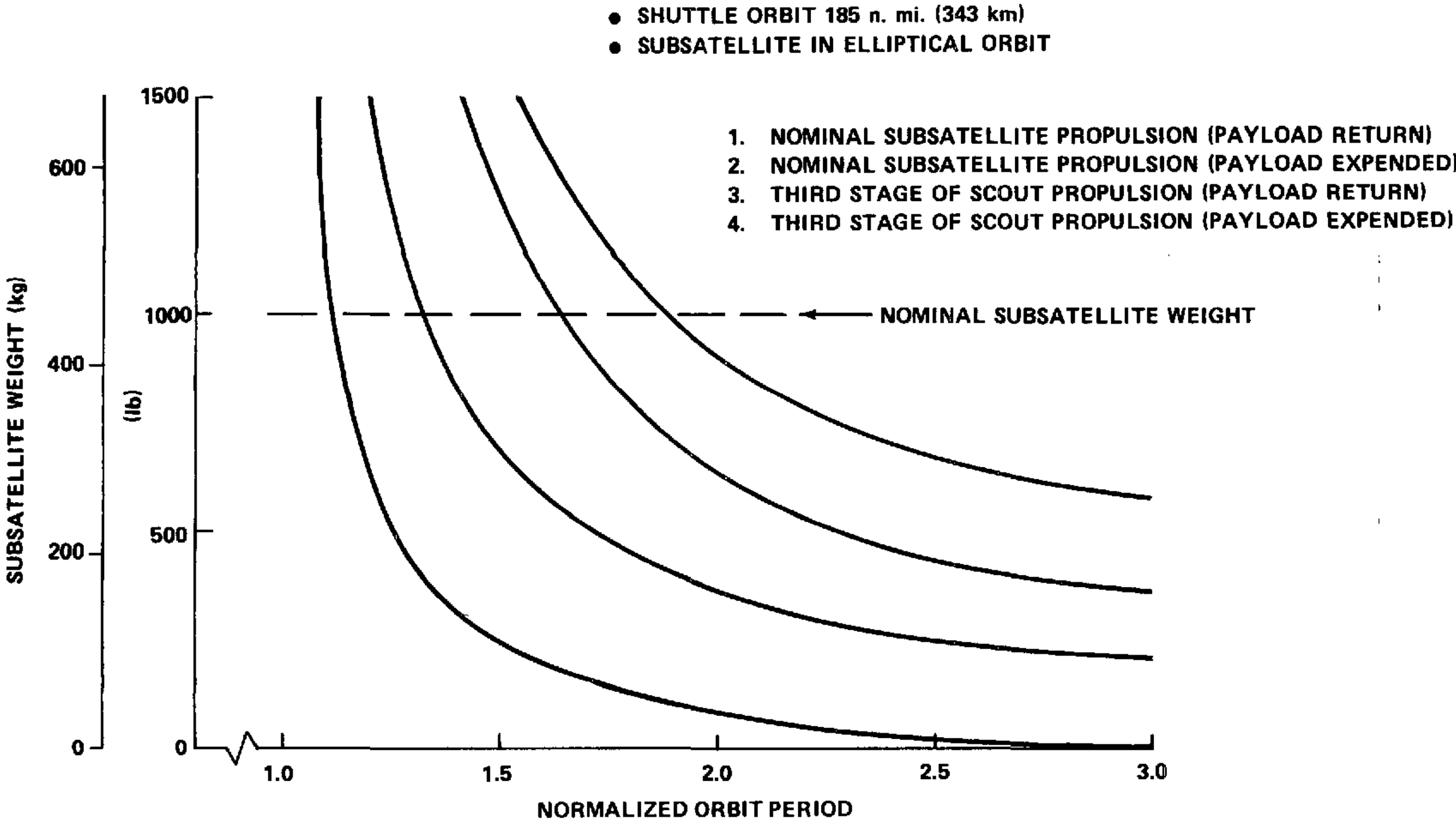


Figure 7-13. Subsatellite propulsion capability.

A. SUBSATELLITE POSITIONED AT 100-km ALTITUDE
- RANGE REQUIRED = 2736 km

B. SUBSATELLITE POSITIONED AT APOGEE BY PROPULSION SYSTEM AND PAYLOAD RETURNED (h_a = 780 n. mi.) (1445 km)
- RANGE REQUIRED = 7155 km

C. SUBSATELLITE POSITIONED AT APOGEE BY PROPULSION SYSTEM AND PAYLOAD EXPENDED (h_a = 1550 n. mi.) (2871 km)
- RANGE REQUIRED = 9070 km

D. SUBSATELLITE IN CIRCULAR ORBIT OF THREE TIMES PERIOD OF ORBITER (h = 4100 n. mi.) (7593 km)
- RANGE REQUIRED =14790 km

E. SUBSATELLITE IN ELLIPTICAL ORBIT OF THREE TIMES PERIOD OF ORBITER (h_a = 8000 n. mi.) (14816 km)
- RANGE REQUIRED = 22540 km

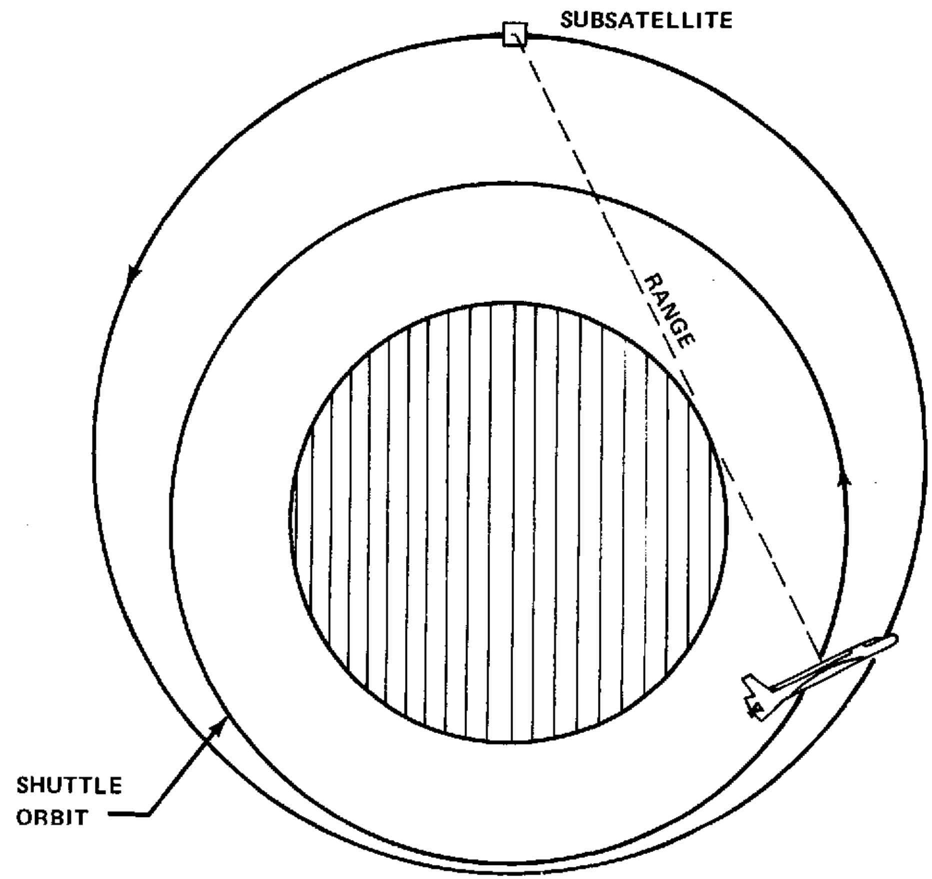


Figure 7-14. Range requirement for subsatellite acquisition.

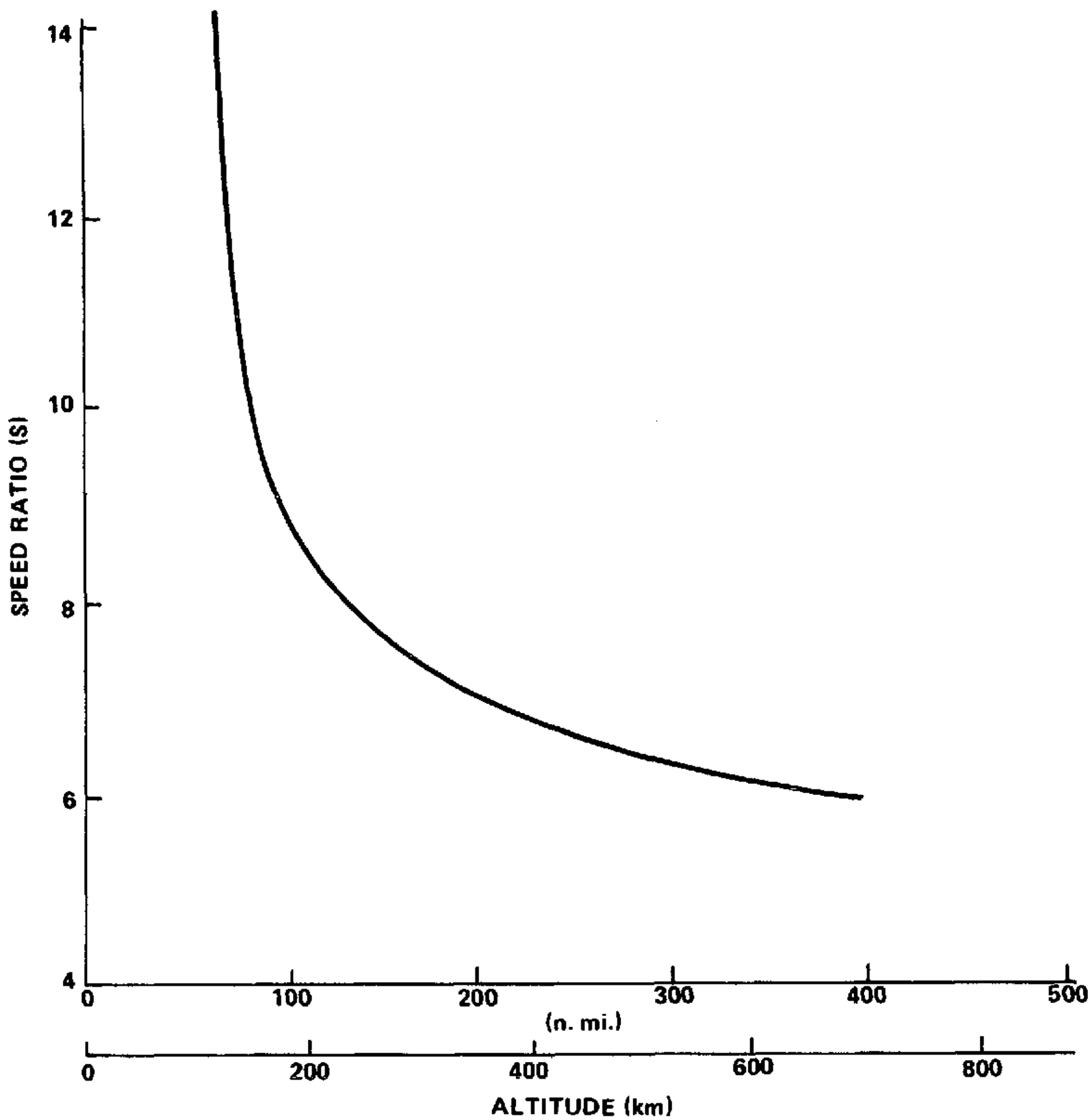


Figure 7-15. Speed ratio versus altitude for circular orbit.

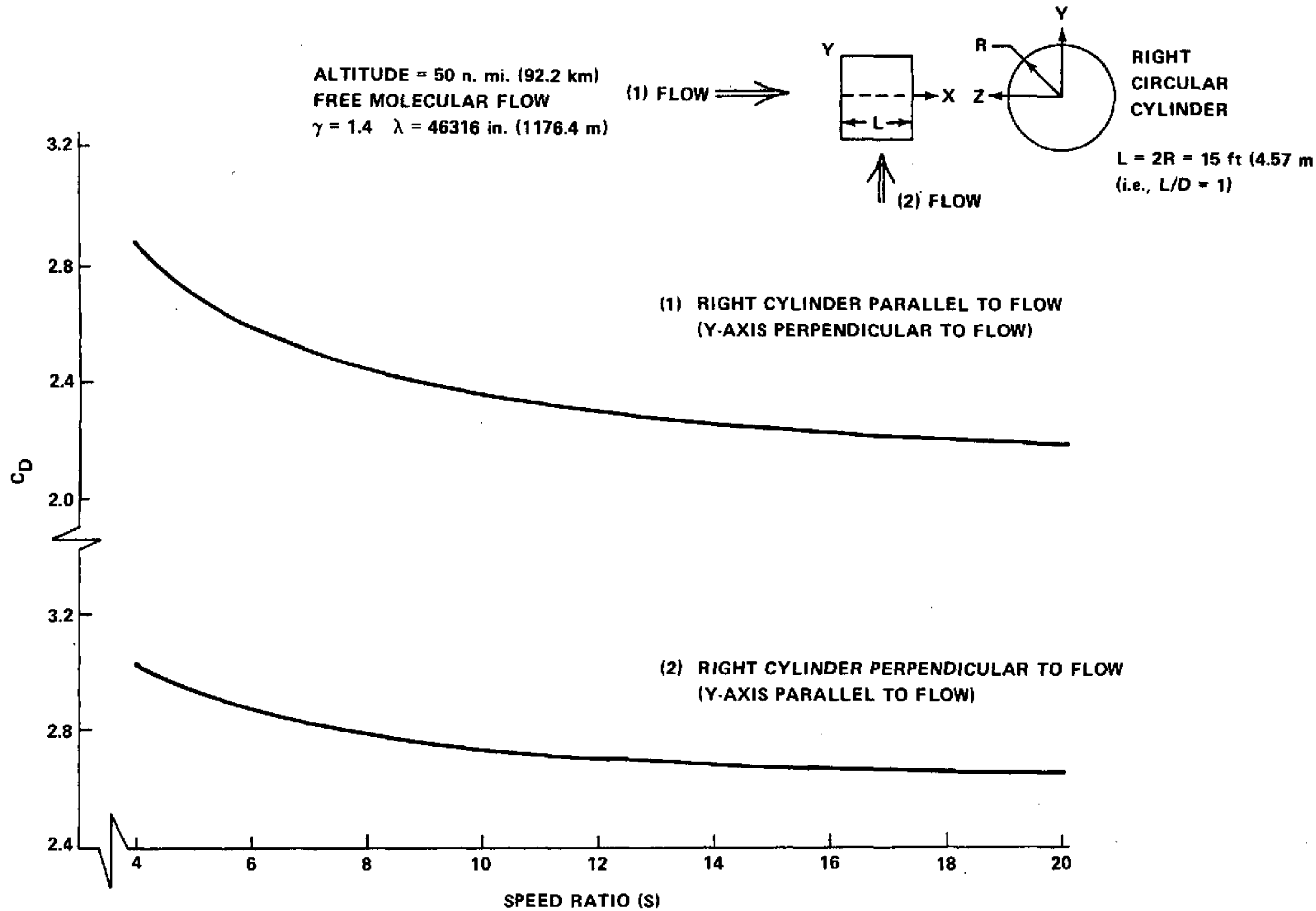


Figure 7-16. AE drag coefficient as a function of speed ratio.

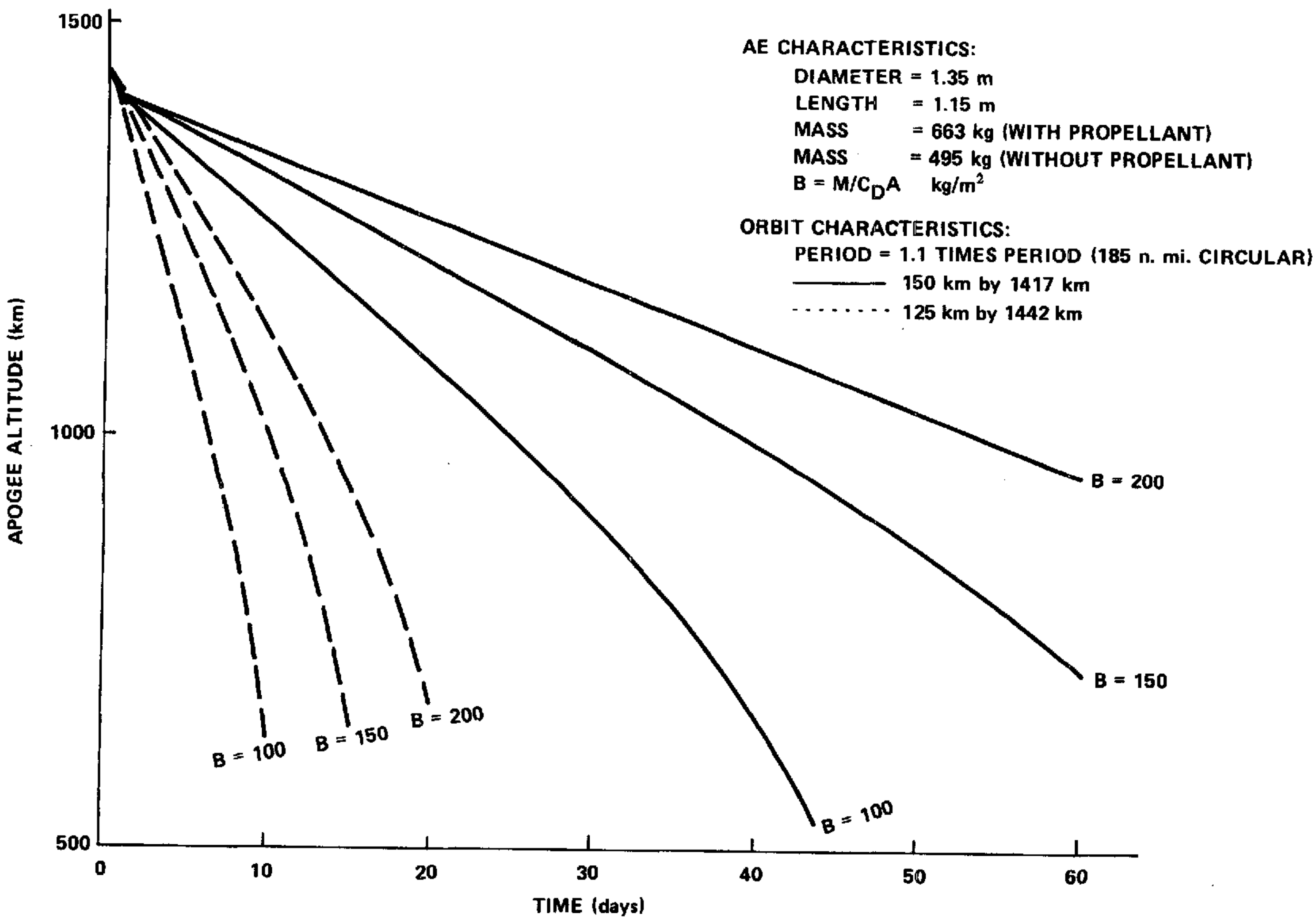


Figure 7-17. AE orbital decay.

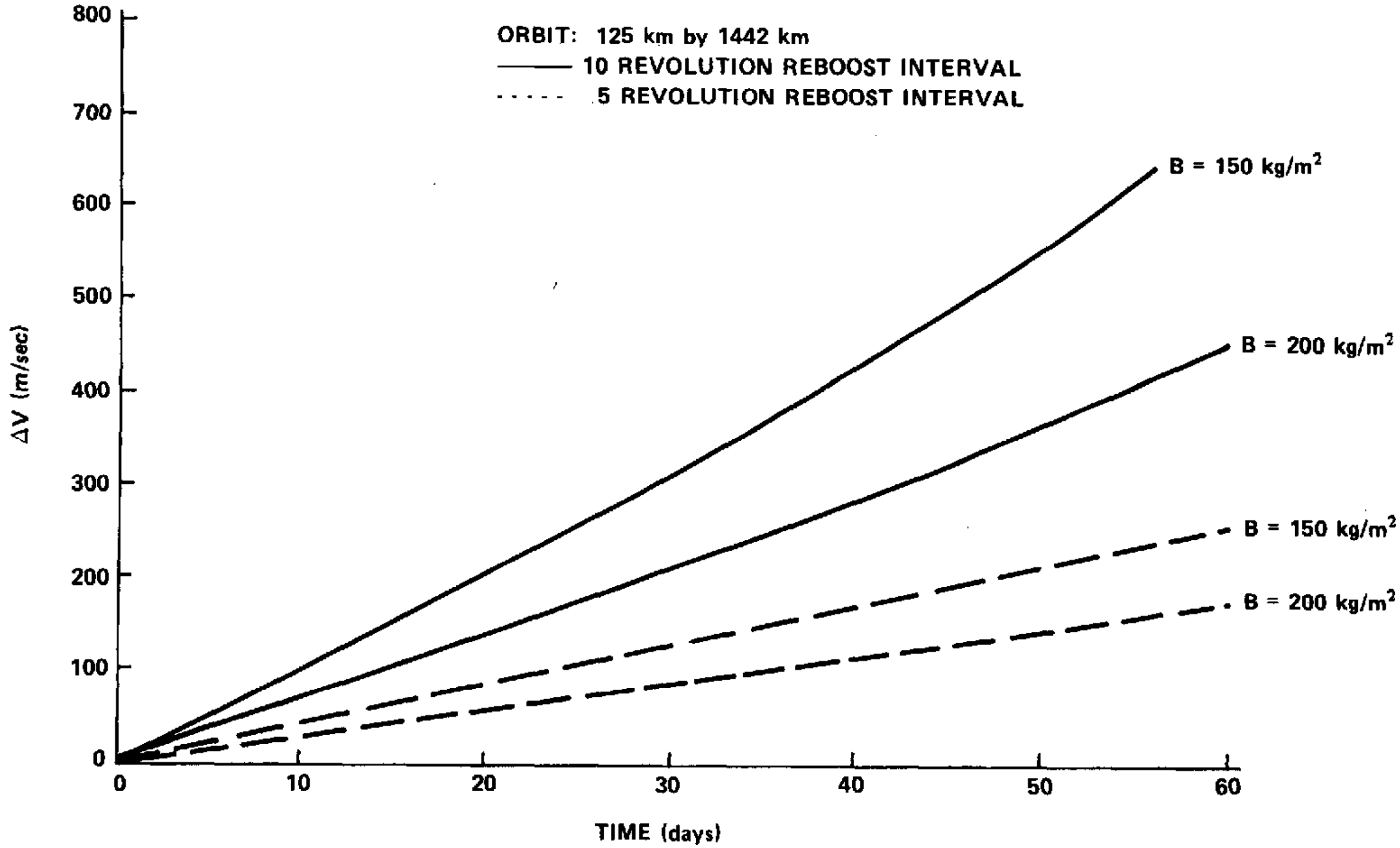


Figure 7-18. AE station-keeping ΔV requirement.

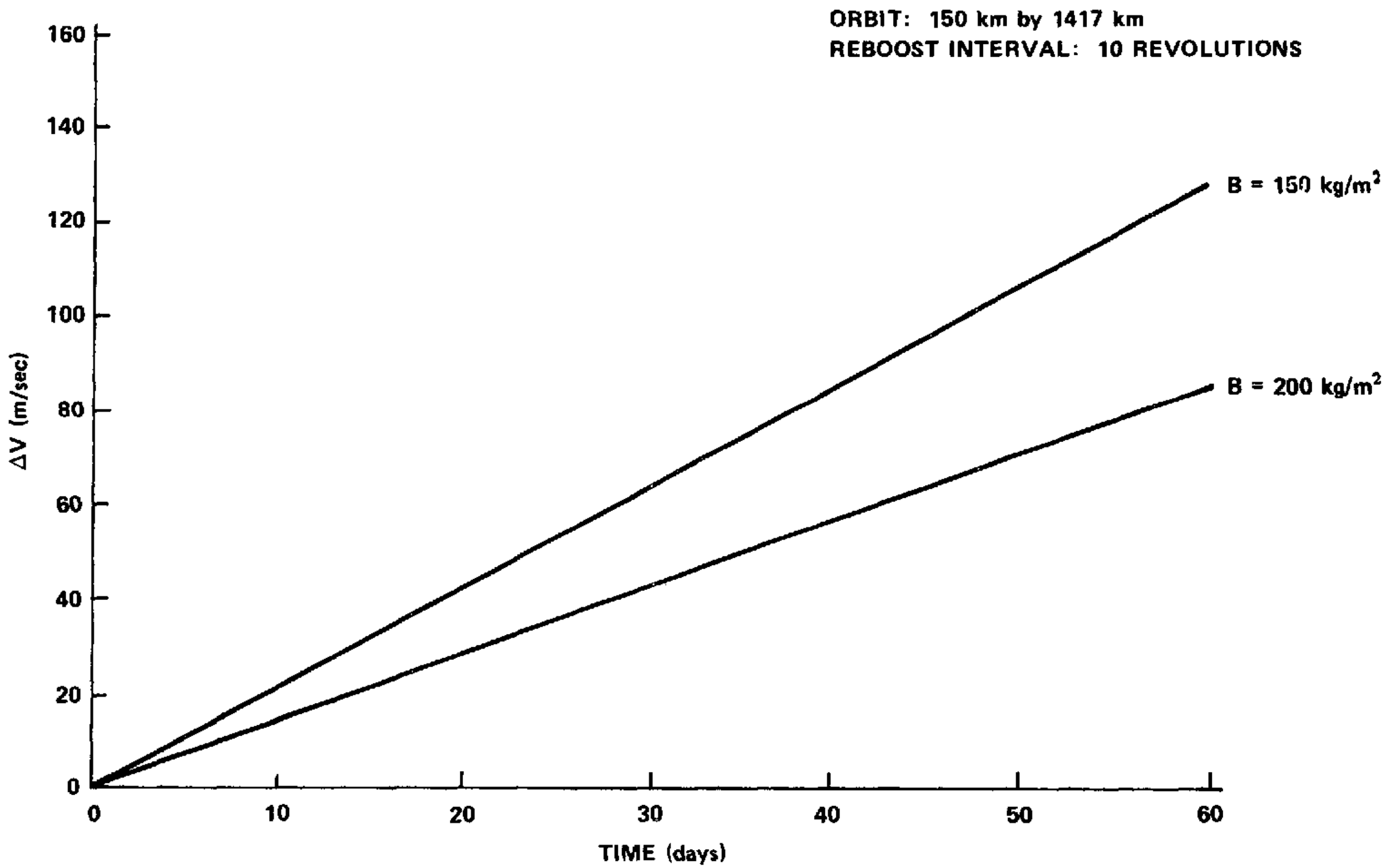


Figure 7-19. AE station-keeping ΔV requirement.

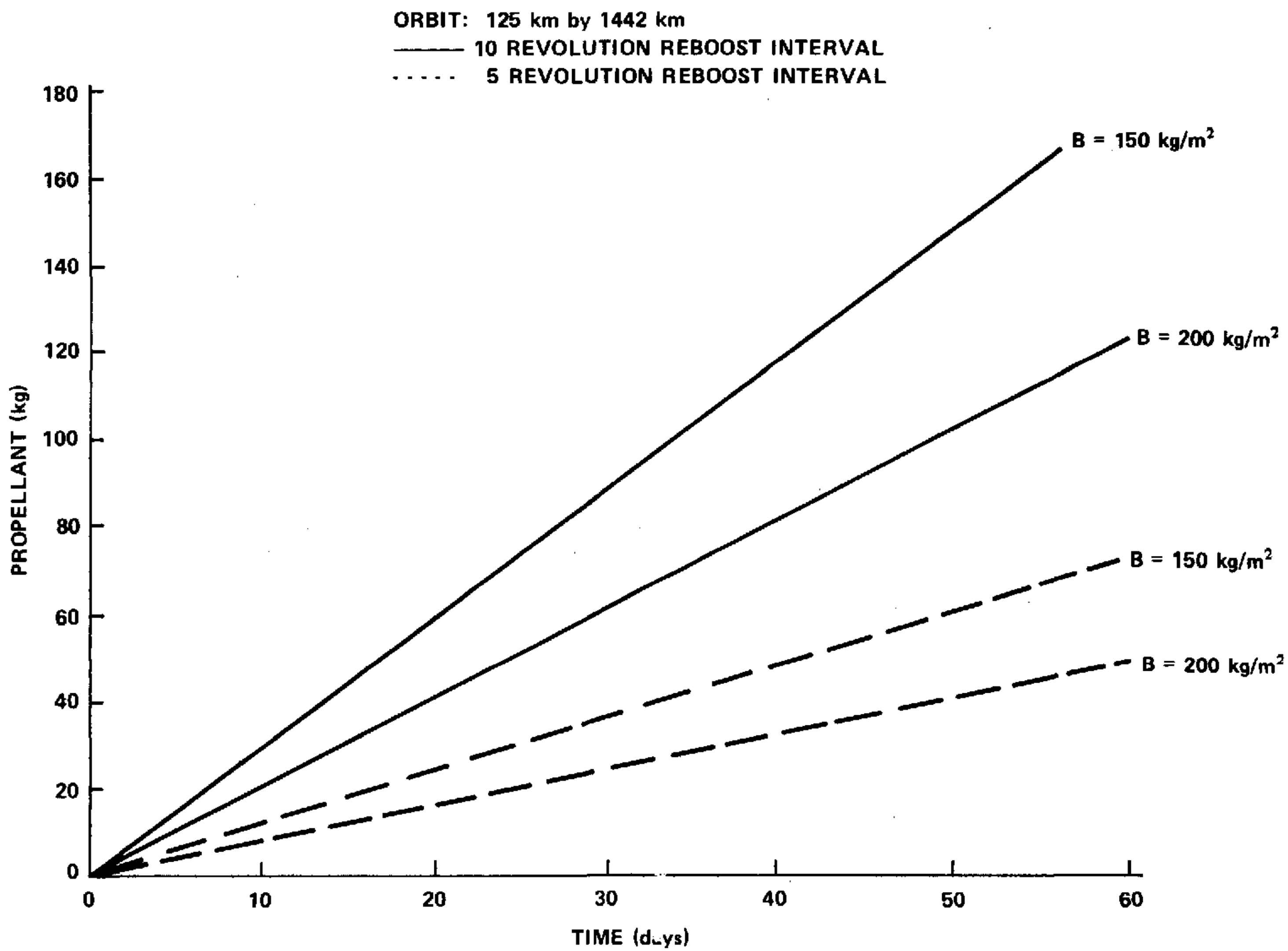


Figure 7-20. AE station-keeping propellant requirement.

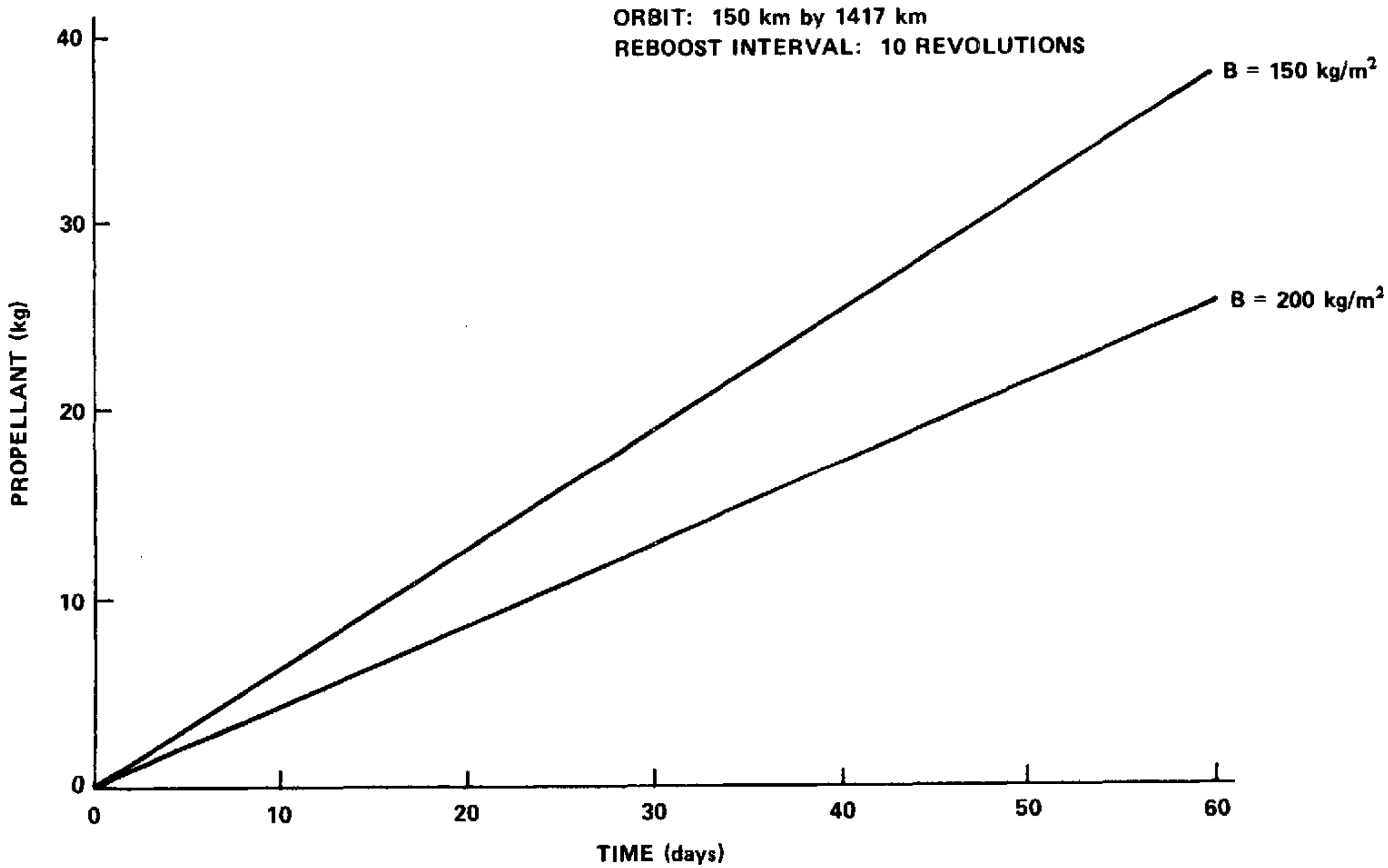


Figure 7-21. AE station-keeping propellant requirement.

7.2 ATMOSPHERIC SOURCE MAPPING DYNAMICS

One of the primary experiments to be performed with the AMPS payload is the mapping of atmospheric phenomena and characteristics. The mode of operation proposed to carry out the atmospheric physics experiment is for the experiment instruments to be mounted on a gimbal platform within the Shuttle cargo bay. The following discussion is related to determining the opportunity for viewing a target atmospheric source and determining the associated gimbal angle time history and angular rates.

7.2.1 Guidelines and Assumptions

- Altitude and latitude of target atmospheric source treated parameter.
- Shuttle altitude assumed to be 235 n. mi. for a 28.5-deg inclination orbit and 185 n. mi. for a polar orbit.
- Minimum elevation angle above the horizon considered to be 5 deg for target atmospheric source acquisition.
- Atmospheric source assumed to have the same rotation rate as the Earth.
- Platform gimbal angles identified as (1) clock angle, α, measured relative to the Z-axis in the Shuttle's coordinate X-Z plane, and (2) cone angle, β, measured from the X-Z plane.
- Results given for Shuttle orientation of the Z-axis along nadir and the X-axis along the velocity vector. However, the computer model is developed to handle any type of Shuttle orientation.

7.2.2 Description of Problem

During the atmospheric source mapping experiment, it is necessary to derive a set of driving parameters for instrument design for the principal observational technique required over the full range of operational modes. The driving parameters considered in this task are the platform gimbal angle magnitude, the gimbal angle rates, the range magnitude, and the range rate required during target source acquisition.

7.2.3 Task Status

A computer model has been derived that will handle any desired orientation of the Shuttle and the associated gimbal angle magnitude, and angular rate. Results have been obtained for an example Shuttle orientation with the Z-axis along the local nadir. A full range of cases will be run and analyzed to evaluate the gimbal platform design requirement problem. Runs will also be made to determine the reacquisition opportunity for various orbit inclinations over the range of source latitudes from 0 to ±90 deg.

7.2.4 Results

The experiments to be performed by the instruments on the gimbal platform will involve the remote sensing of the atmosphere below the operational altitude of the Shuttle. The purpose of these experiments is to determine the spatial distribution of the constituents of the stratosphere and mesosphere with sufficient global coverage to allow an understanding of the dynamics and chemistry of these regions. The following subsection will address the time duration and availability of an atmospheric source during an experiment timeline.

7.2.4.1 In-Plane Contact Time

The geometry of the in-plane source mapping is shown in Figure 7-22, where the experiment source is located at a point R_1 above the surface of the Earth and the Shuttle is in an operational orbit with radius R_2 from the center of the Earth. The total contact cone angle is defined as ϕ , which is dependent on the minimum viewing elevation angle α_E, R_1, and R_2. The contact cone angle and contact time as a function of orbit altitude where the target source is located at an altitude of 67.5 n.mi. (125 km) are shown in Figure 7-23. Data are shown for minimum elevation angles of 0 deg and 5 deg. The maximum contact time during one orbit pass for the Shuttle in a 235 n.mi. altitude orbit is 12 min.

7.2.4.2 Three-Dimensional Source Mapping Dynamics

The three-dimensional geometry considered in deriving the gimbal angles, angular rates, range, and range rate is shown in Figure 7-24. The platform gimbal angles and how they relate to the Shuttle coordinate system are presented in Figure 7-25.

A 28.5-deg inclination and 235 n.mi. Shuttle operational orbit were considered to determine the representative type of data associated with the gimbal platform design requirement. The above Shuttle orbit is compatible with the Shuttle performance capability without the Orbit Maneuvering System (OMS) kit.

In Figure 7-26 the clock angle time history during three different orbit pass opportunities for an atmospheric source located at 0.0 deg latitude is presented. The maximum range on the clock angle for this case is ±73 deg. The clock angle angular rate time history is given in Figure 7-27, with the maximum rate being -1.25 deg/sec. The gimbal cone angle time history is shown in Figure 7-28 which indicates a maximum range of ±73 deg. Cone angle angular rate is given in Figure 7-29 which is less than the clock angle angular rate. The resulting cone angle angular rate is less since the maximum plus to minus range for the cone angle does not occur during the same orbit pass.

Figures 7-30 and 7-31 give the range and range rate time history during an acquisition period.

7.2.5 Observation and Issues

To determine the full range of operations required for the gimbal platform, other Shuttle orientations will be considered.

For complete global coverage, are orbit inclinations between 55 and 90 deg required? Inclinations within this interval have solid rocket booster (SRB) impact targeting problems.

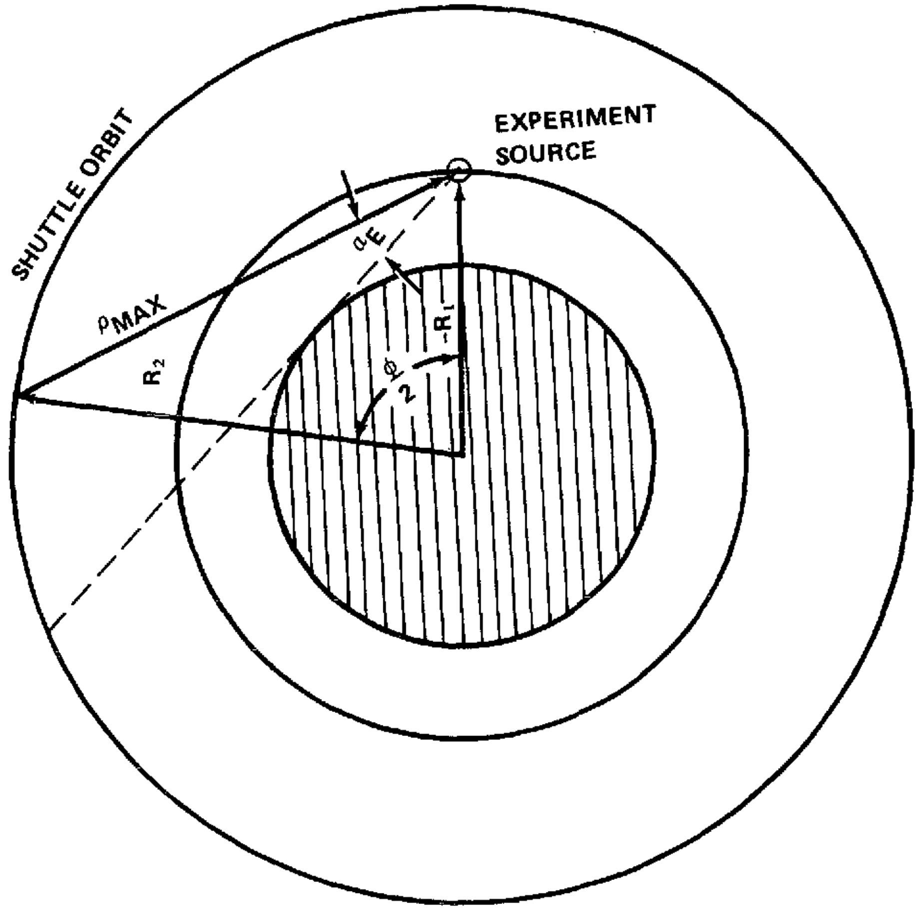


Figure 7-22. Geometry of source mapping.

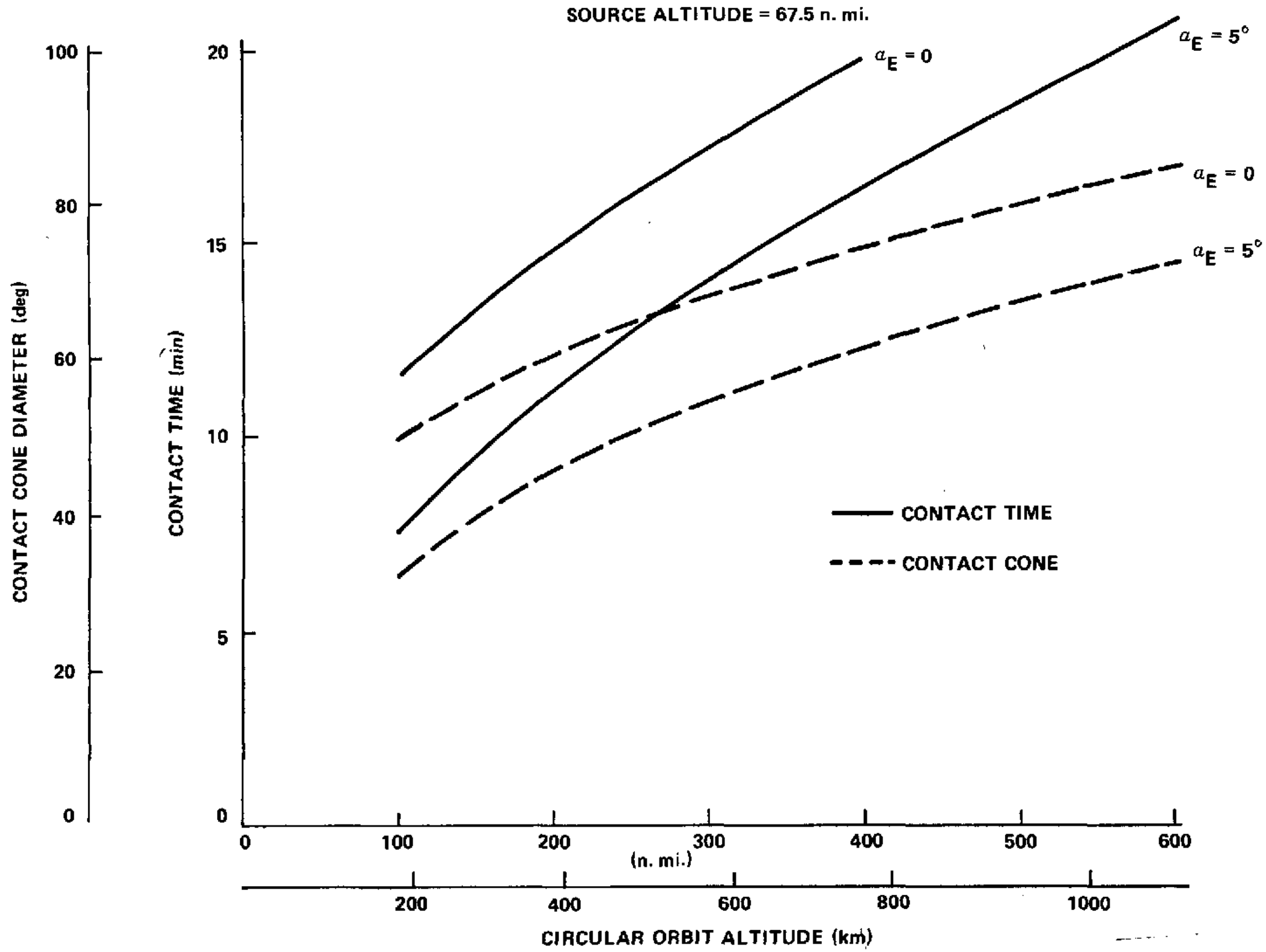


Figure 7-23. Shuttle contact data.

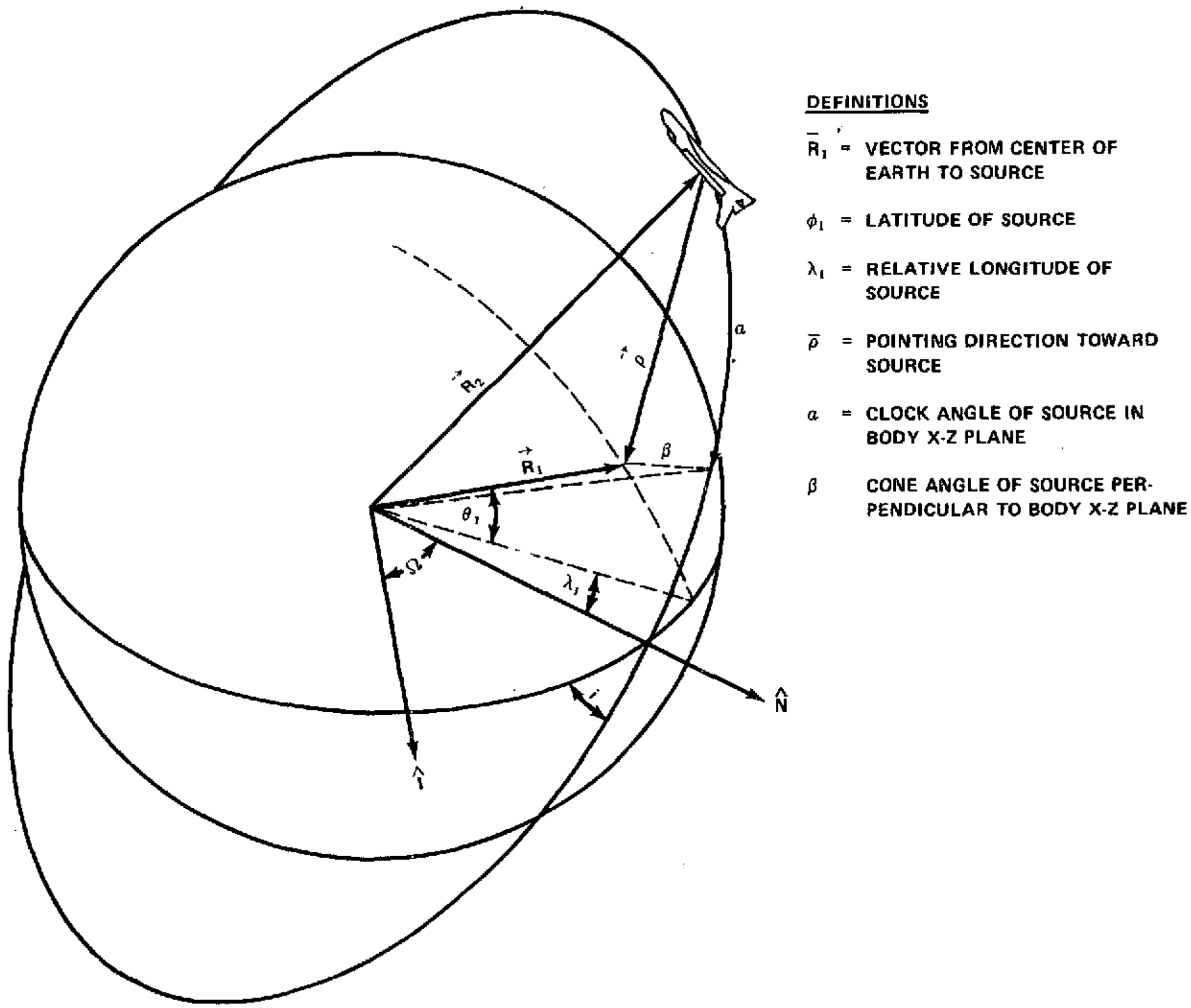


Figure 7-24. Three-dimensional geometry of coordinate system.

$\hat{\rho}$ = UNIT VECTOR IN DIRECTION OF TARGET SOURCE

α = CLOCK ANGLE REQUIRED TO ACQUIRE SOURCE (MEASURED IN BODY X-Z PLANE)

β = CONE ANGLE REQUIRED TO ACQUIRE SOURCE (MEASURED PERPENDICULAR TO BODY X-Z PLANE)

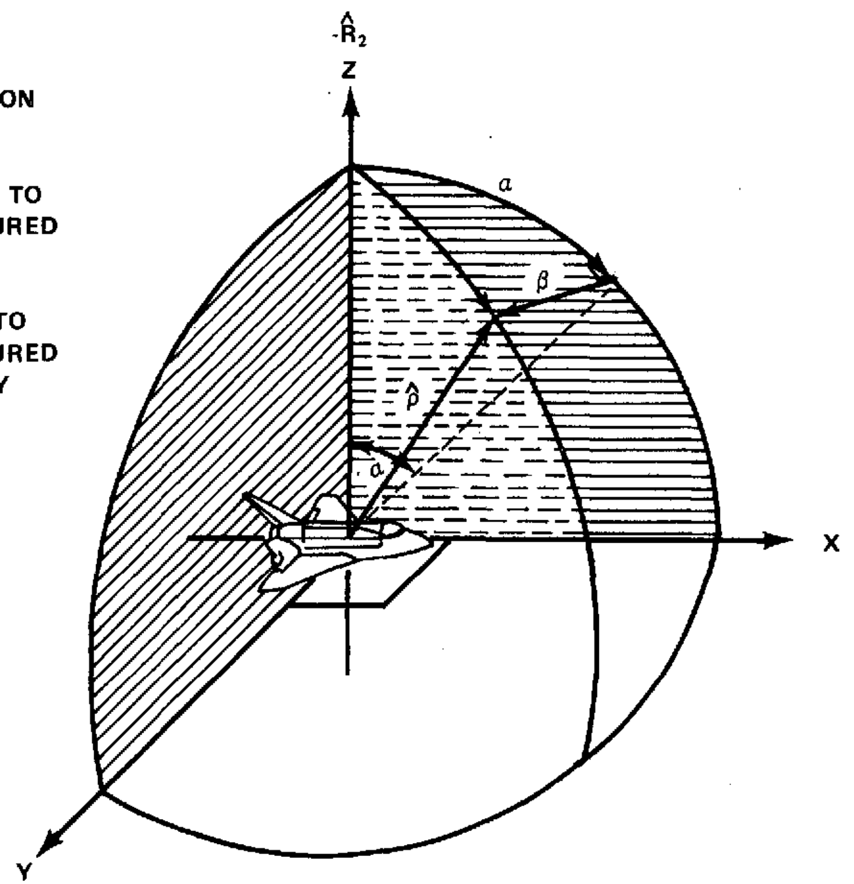


Figure 7-25. Gimbal platform pointing and control angles.

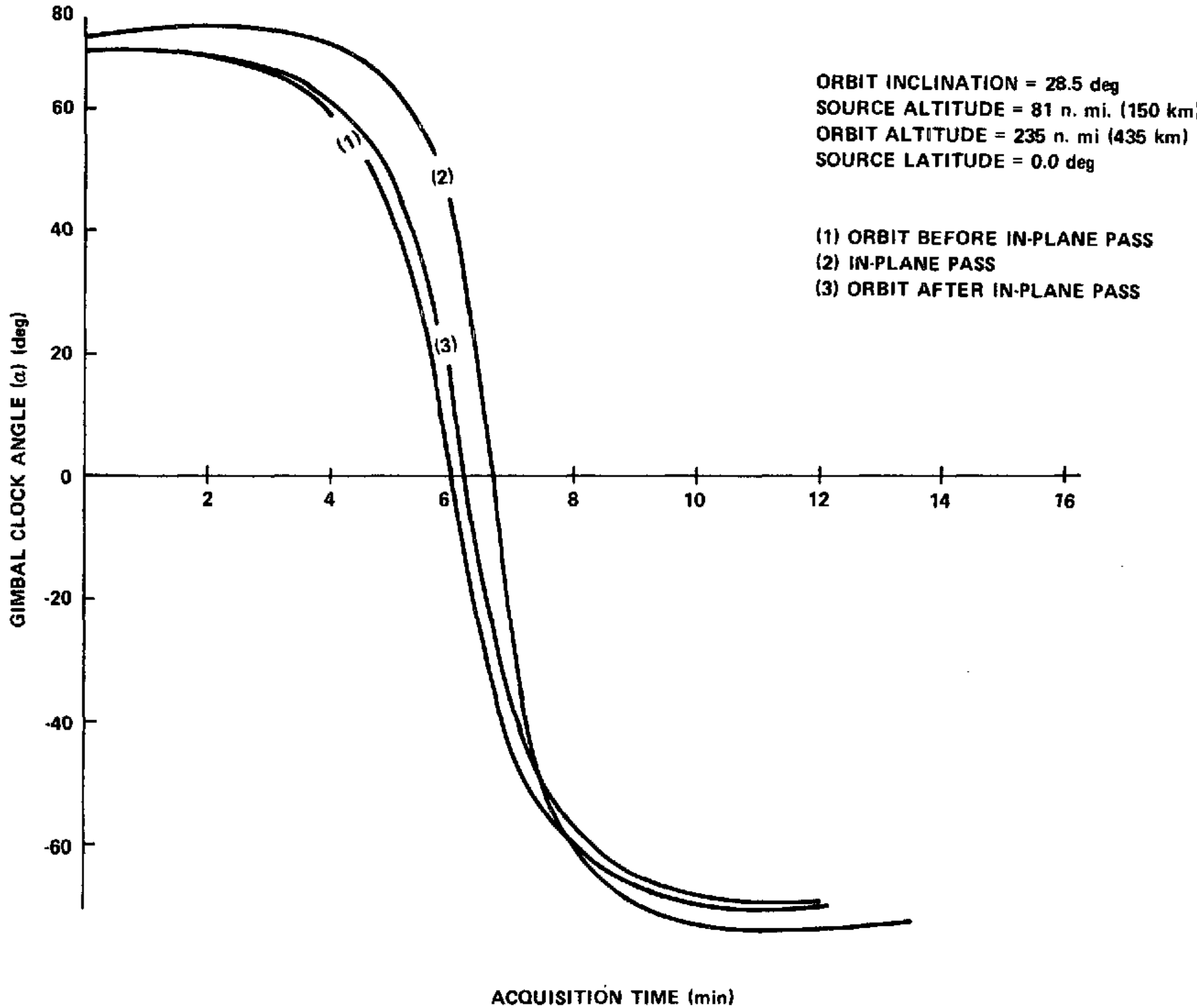


Figure 7-26. Gimbal clock angle (α) time history.

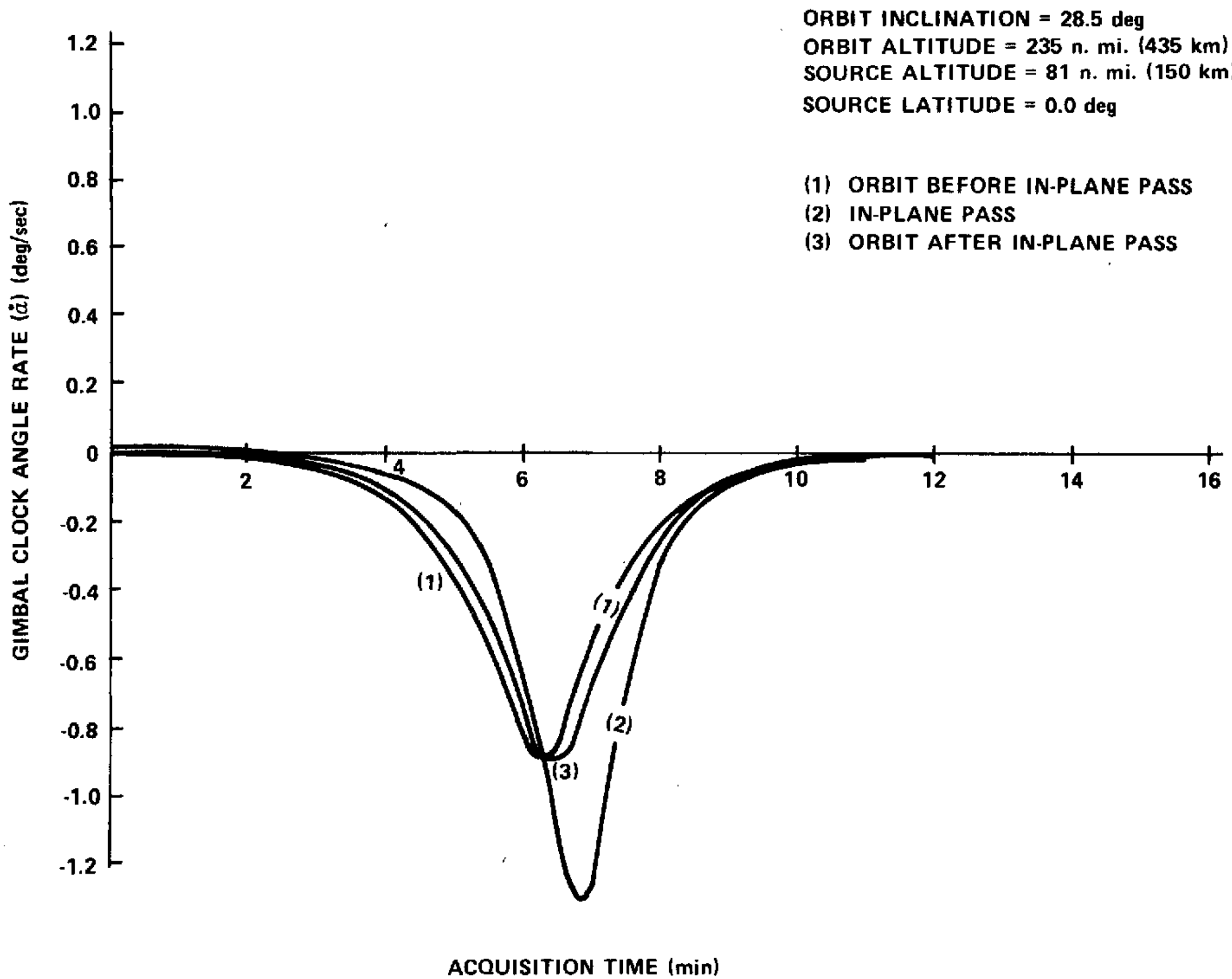


Figure 7-27. Gimbal clock angle rate ($\dot{\alpha}$) time history.

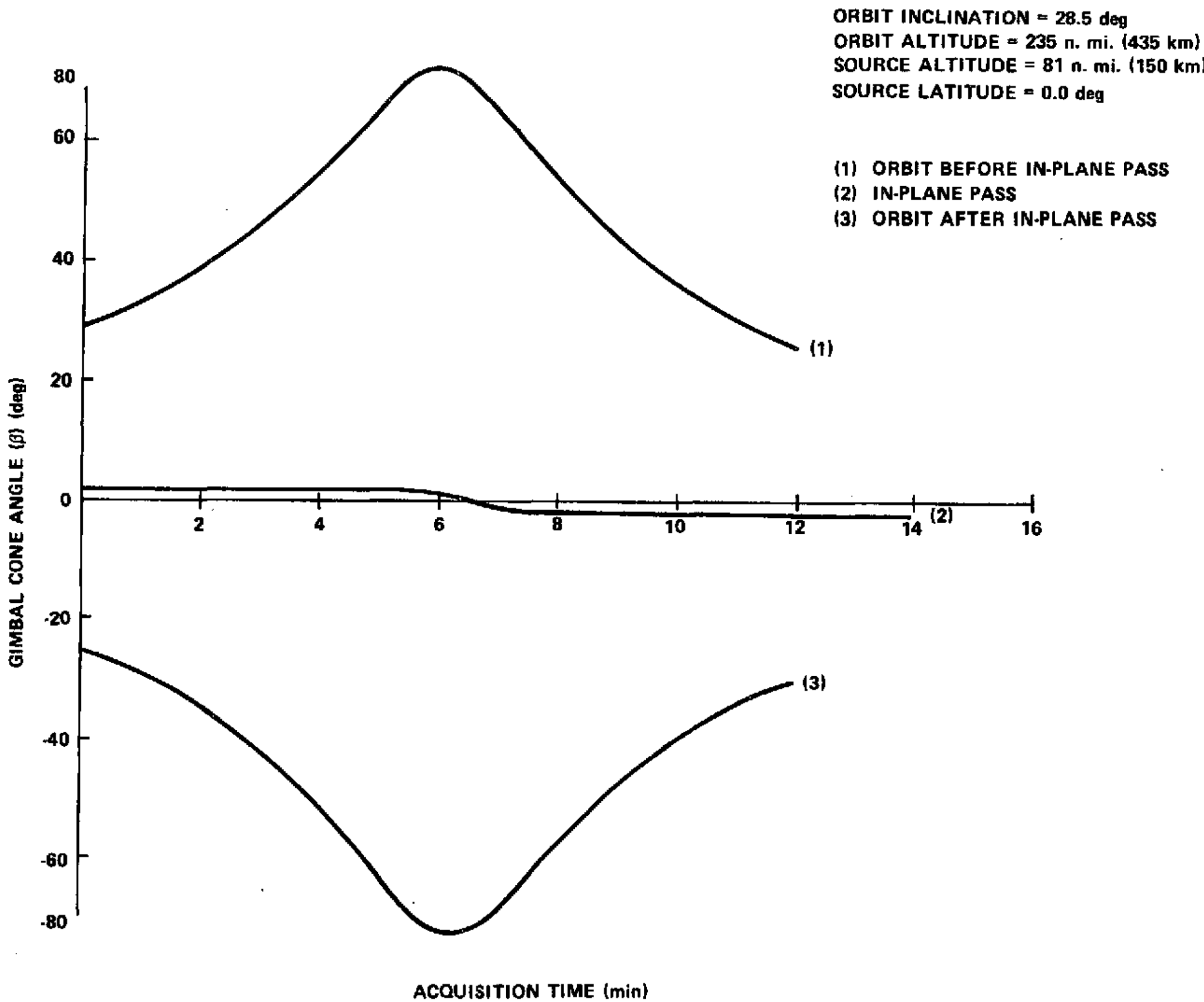


Figure 7-28. Gimbal cone angle (β) time history.

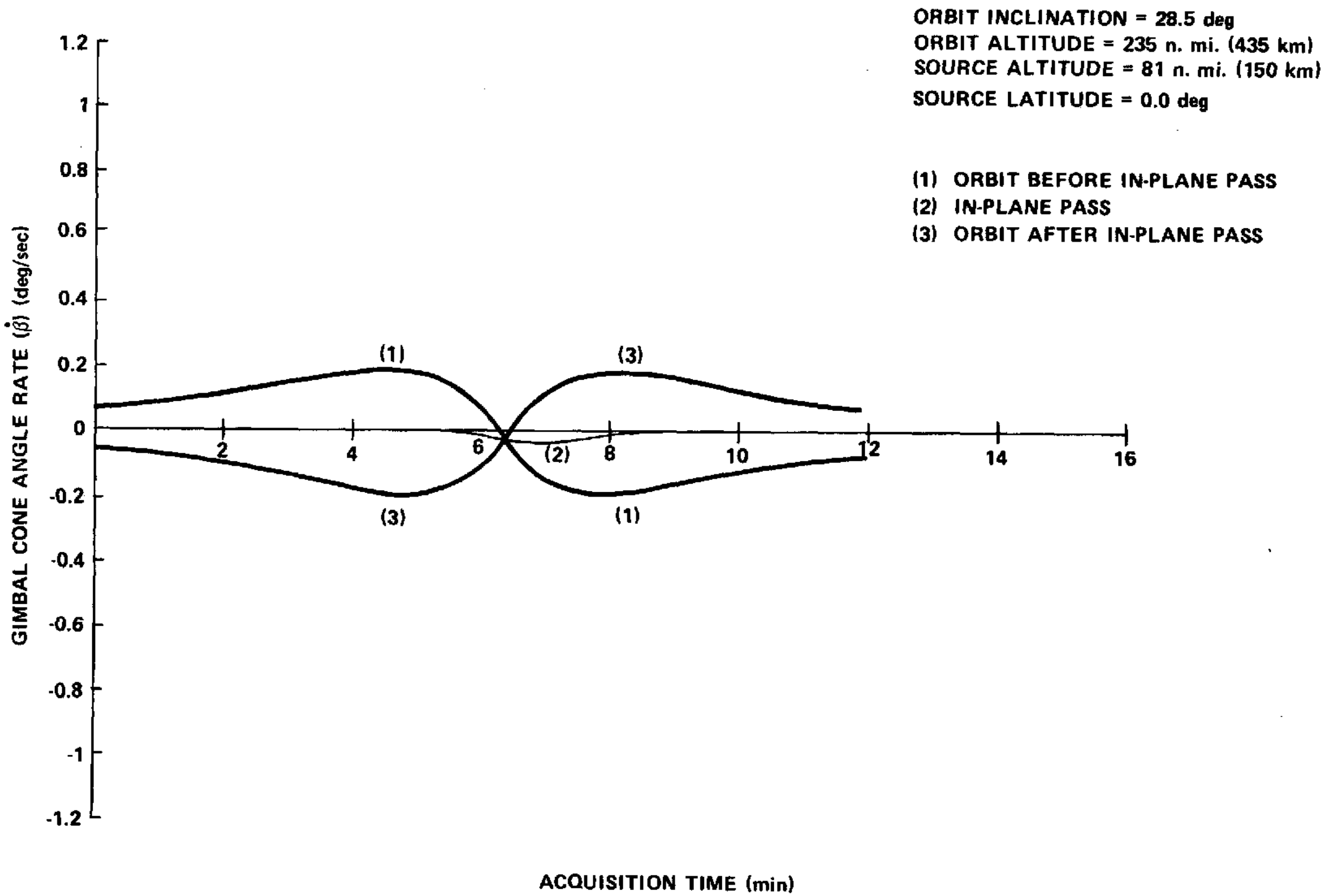


Figure 7-29. Gimbal cone angle rate ($\dot{\beta}$) time history.

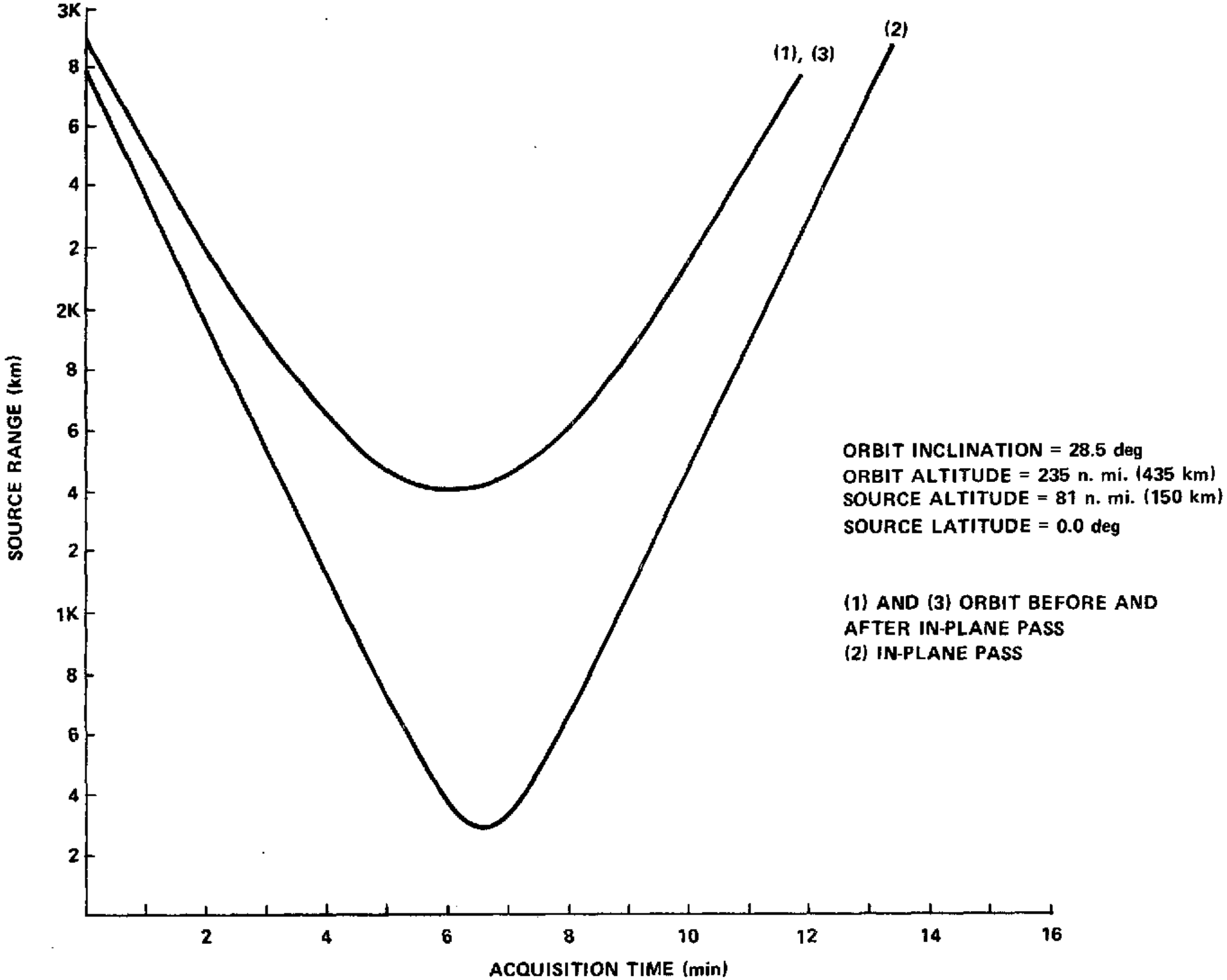


Figure 7-30. Source range (ρ) time history.

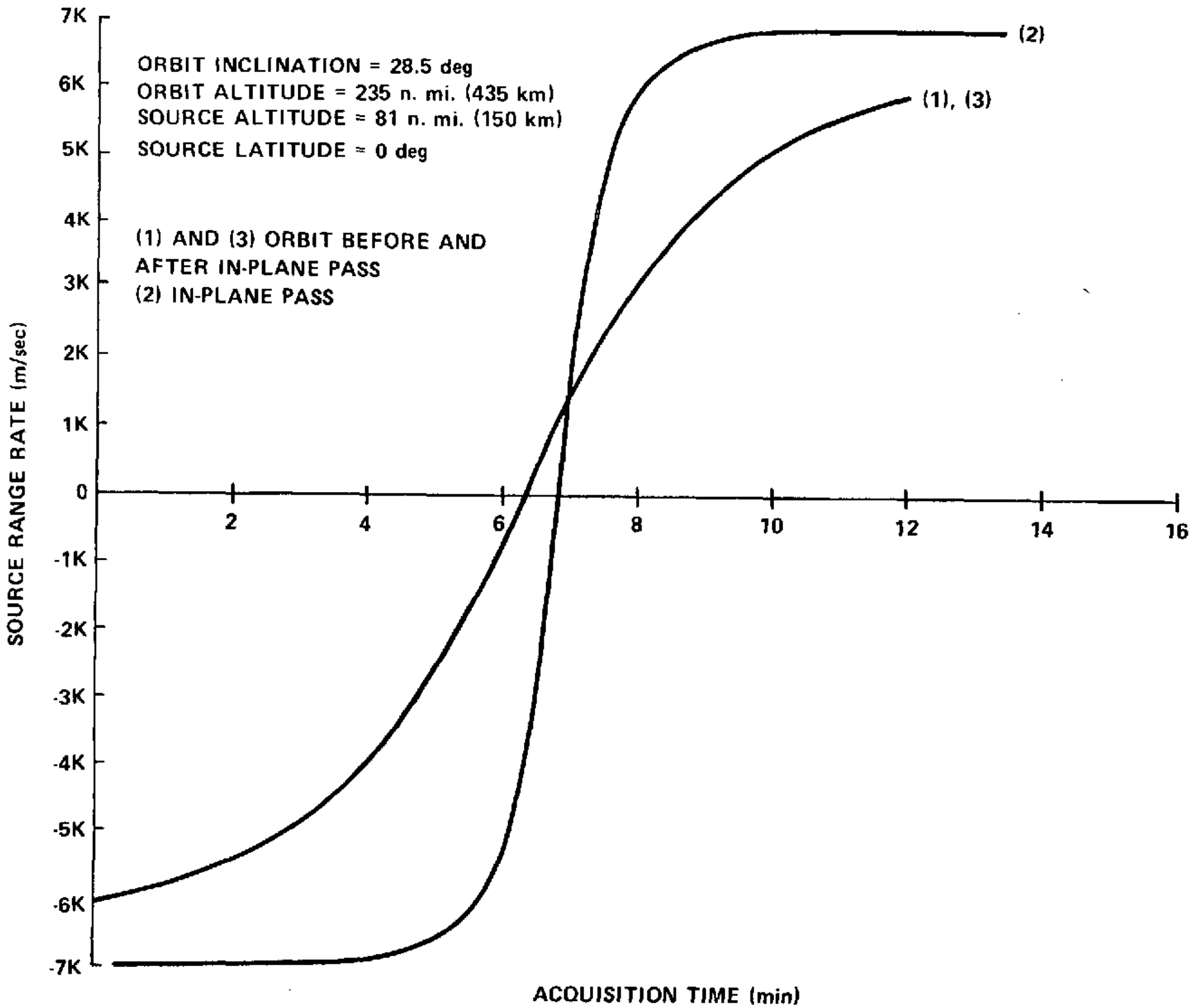


Figure 7-31. Source range rate ($\dot{\rho}$) time history.

7.3 ON-ORBIT OPERATIONS — EXPERIMENT/CREW SCHEDULES

The purpose of the on-orbit mission operations analysis was to identify typical operational activities that are representative of those that would be performed on a dedicated AMPS mission flown at a 28.5 deg inclination and a dedicated mission flown at a 90-deg inclination. The exploring of these activities, presented in the form of mission timelines aided in identifying particular problem areas in mission operations and subsystem design. It is noted that these timelines were generated utilizing the Fast Automated Scheduled Technique (FAST)* option number 5 and are oriented more toward design driver requirements than toward a crewman's actual use on orbit. FAST option number 1 and FAST option number 2 would be more suitable for on-orbit crew use. The experiments were chosen to utilize all the AMPS detectors and instruments. It should be noted that these experiments are only characteristic AMPS-type experiments and should not be interpreted as actual experiment proposals.

The results of the timeline development along with some experiment operations diagrams are shown in the following figures. Figure 7-32 gives the gross operations and estimated times associated with these operations for a 28.5-deg mission. Eight experiment areas were scheduled for this mission. Figure 7-33 is a similar timeline for the polar mission. Eleven experiments were scheduled for this mission. Each of the missions is scheduled for 7 days duration with approximately 10 hours at the beginning required for boost-to-orbit and general setup of the lab.

A crew of four, consisting of two physicists and two physicist/technicians, was considered necessary for this mission. The crew would work in shifts of about 12 hours each, with both a physicist and physicist/technician working each shift. The associated crew schedule is presented in Figure 7-34. Shift changes were planned to coincide as nearly as possible with experiment changes.

Only two guidelines and assumptions pertinent to this phase of the AMPS study were made. They were: (1) only one experiment will be performed at a time, and (2) concurrent ground and on-orbit observations of the artificial aurora experiment will be performed over selected ground sites on the polar mission. The guideline of performing only one experiment at a time is based upon the idea that because of the general complexity of the experiments it appears feasible at this stage of the study to only schedule one at a time. However some experiments could be performed during the long coast periods between performing the artificial aurora experiments. Also, some additional experiments could possibly be performed during the global emissions survey.

*FAST is a system developed by the Preliminary Design Office at MSFC.

The wave characteristics experiment will measure wave amplitude, phase, and spreading as a function of frequency and distance from the generator. Figure 7-35 illustrates the boom alignment for this experiment.

Figure 7-36 shows the dipole antenna, diagnostic boom, and subsatellite orientation for the wave particle interactions experiment. Wave particle perturbations will be determined for parallel and perpendicular orientations of the antennas and for varying power and frequency.

The wake and sheath experiments are designed to measure and map the area in the wake of a sphere traveling through space. Figure 7-37 illustrates this experiment. In this case the velocity is toward the rear of the vehicle. The dashed lines indicate the path of the diagnostic package on boom A.

Figure 7-38 illustrates the plasma ejection principle for the propulsion and devices experiment. Temperature, turbulence, and other characteristics of the plasma will be measured at various distances from the ejection point.

The global emission survey experiment will collect emissions data on the dark side of the orbit. The horizon lock mode will enable data collection for a single altitude, 90 km. The scan mode will cover altitudes from 70 to 110 km. Figure 7-39 shows these Orbiter/orbit orientations.

The energetic particle stability experiment is designed to measure dispersion characteristics of electrons and ions with respect to field lines. The boom A antenna and the subsatellite with its antenna are rotated through the accelerated particles. Figure 7-40 illustrates this configuration.

The magnetospheric topology experiment measures the bounce time of electrons along magnetic field lines versus magnetic latitude, as shown in Figure 7-41. The subsatellite must be used to intercept the returning electron pulse

The artificial aurora experiments will generate artificial aurorae over five different ground stations around the world and observe the aurorae concurrently from the ground and the Orbiter. Figure 7-42 shows how a typical aurora ray is generated. Figure 7-42(a) shows the electron beam directed down a field line while Figure 7-42(b) illustrates how an artificial aurora may be generated in an opposite hemisphere.

Based upon this analysis both of the missions appear operationally feasible.

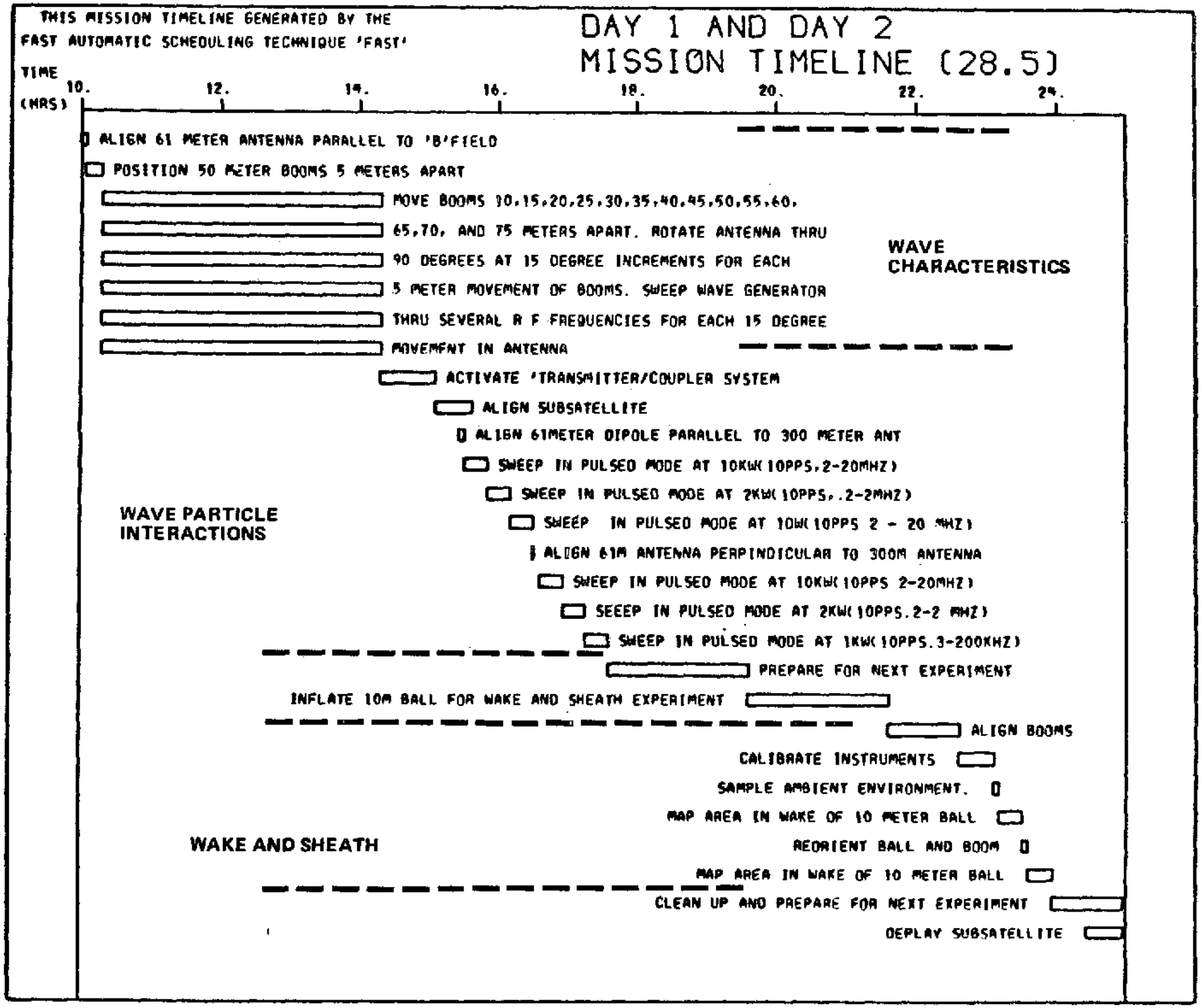


Figure 7-32. Timeline for 28.5-deg mission.

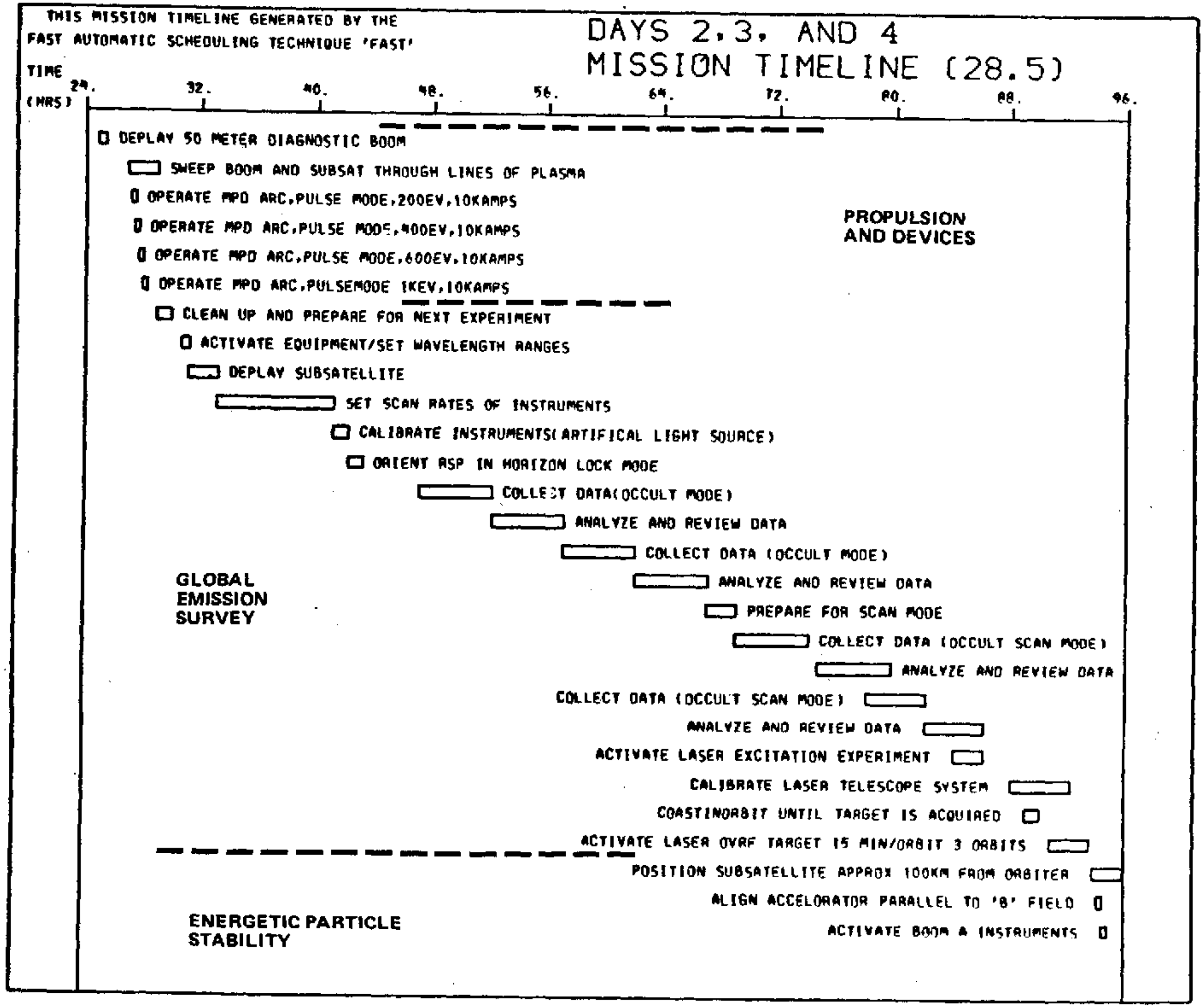
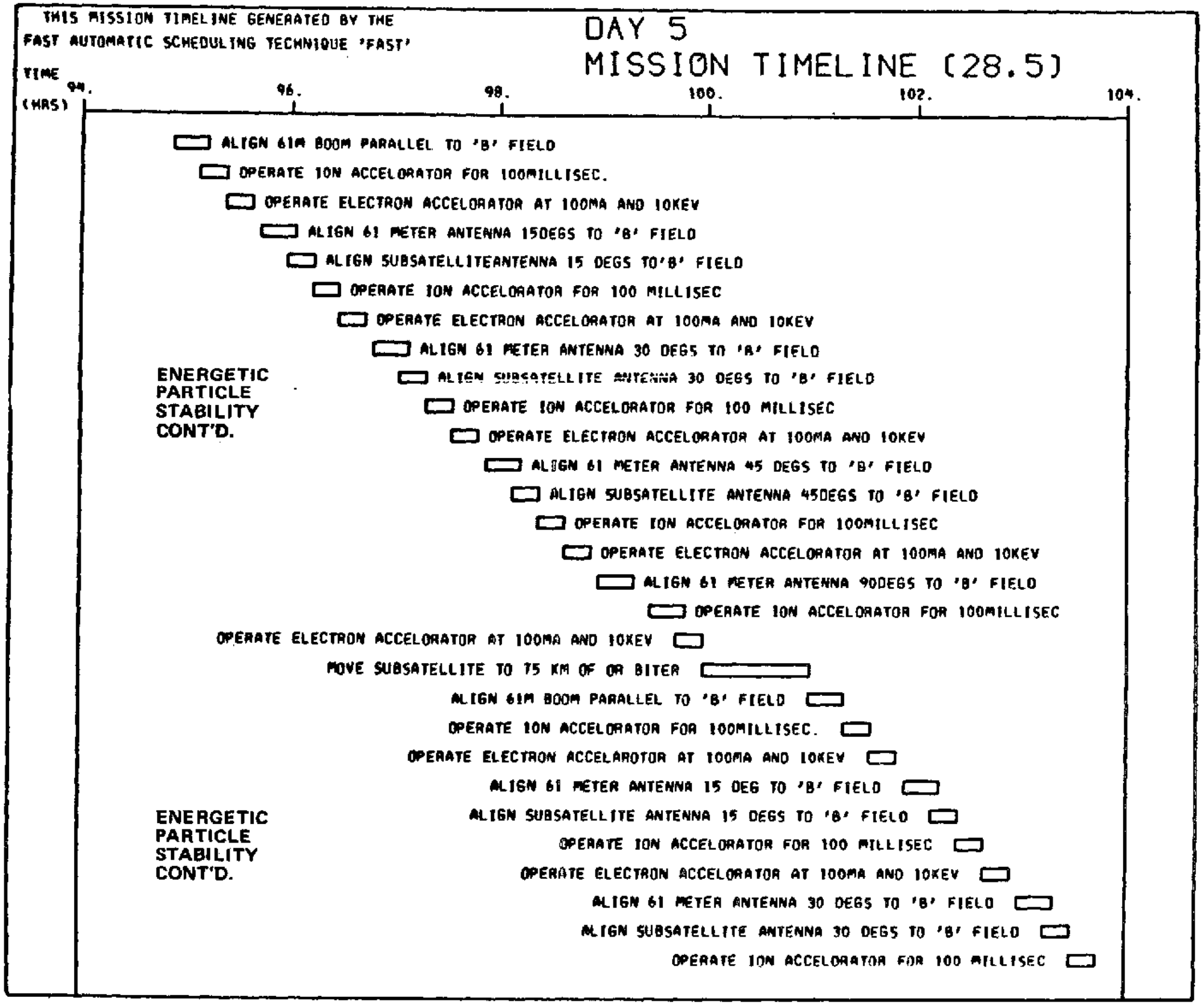


Figure 7-32. (Continued).



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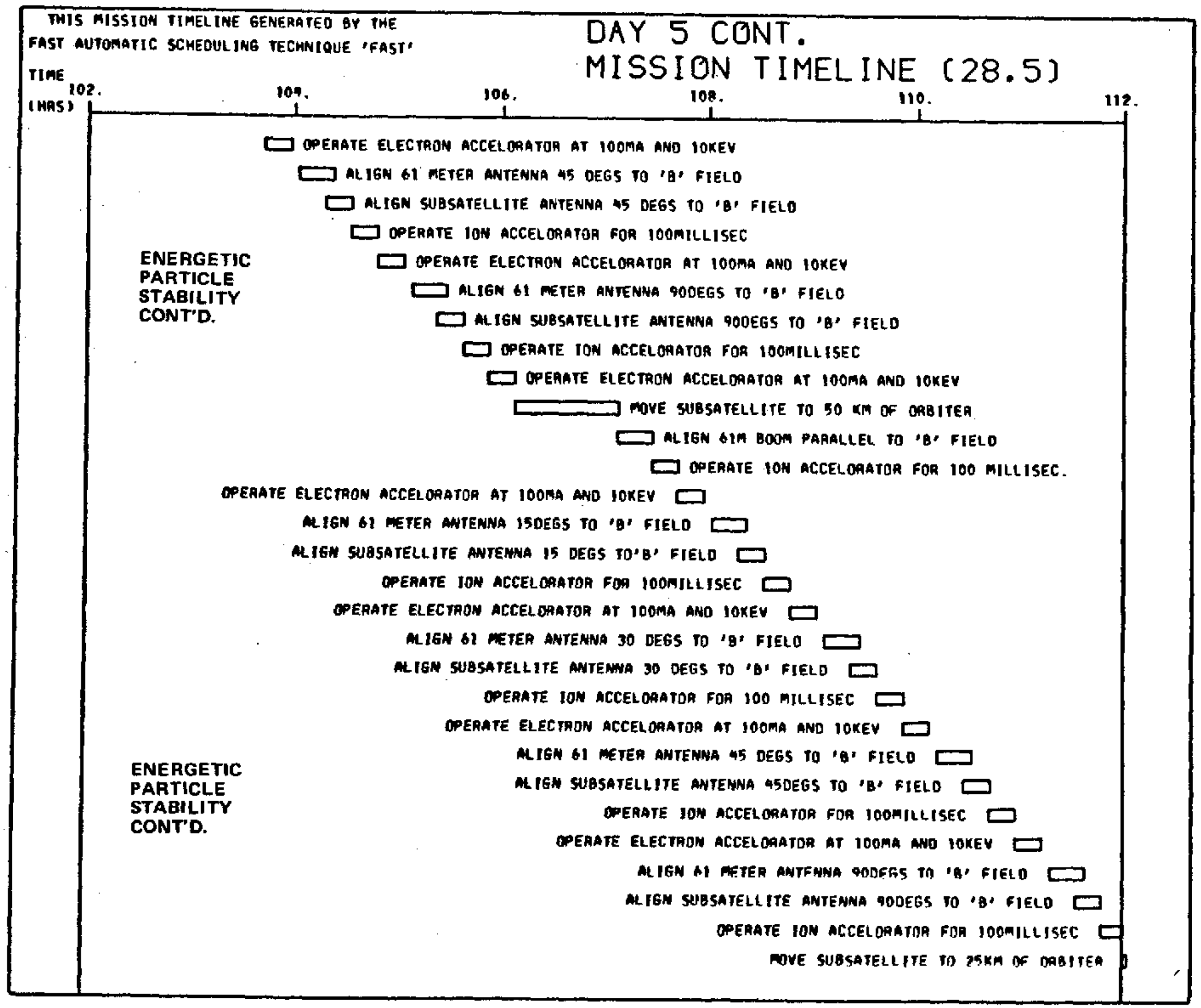

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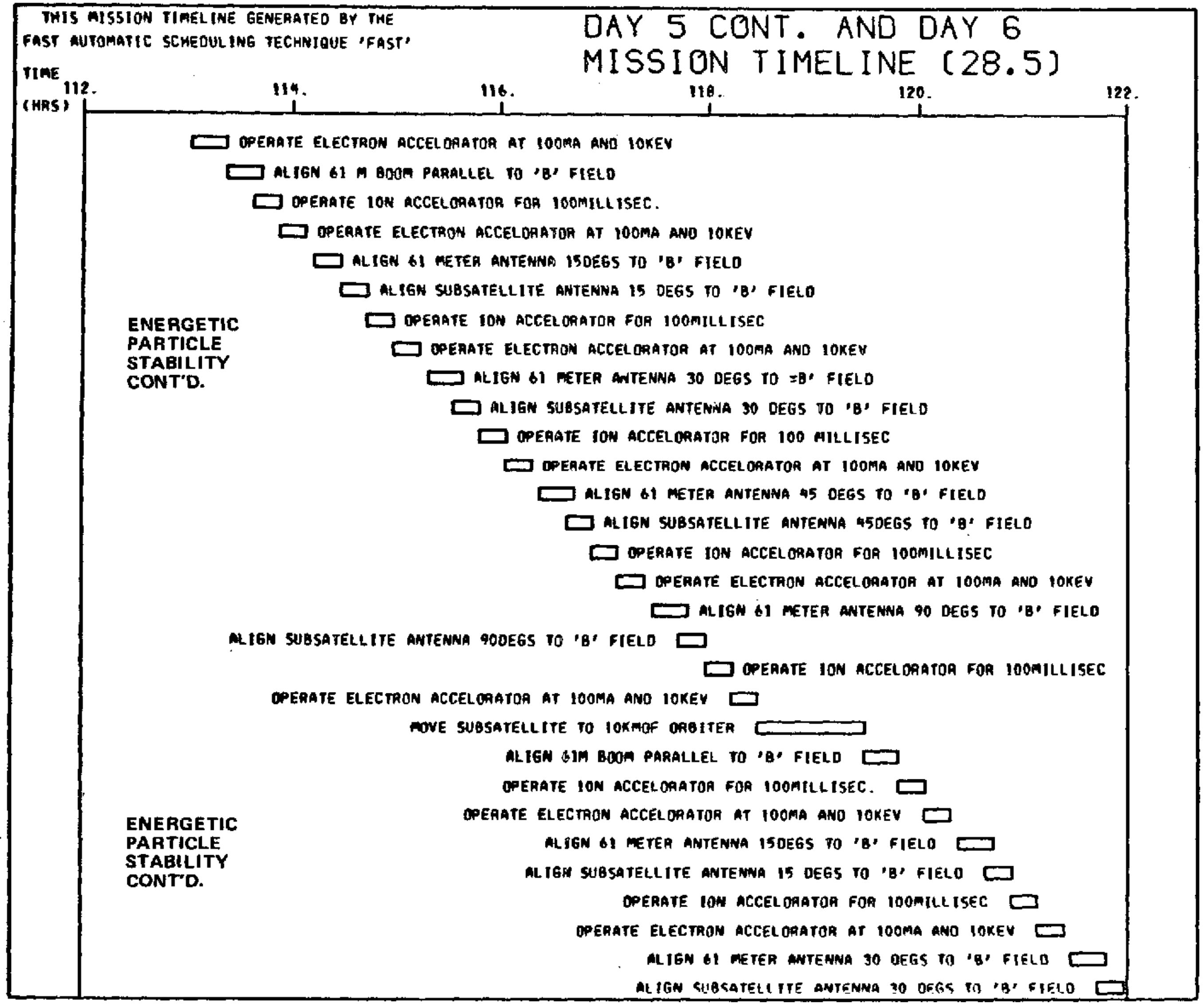

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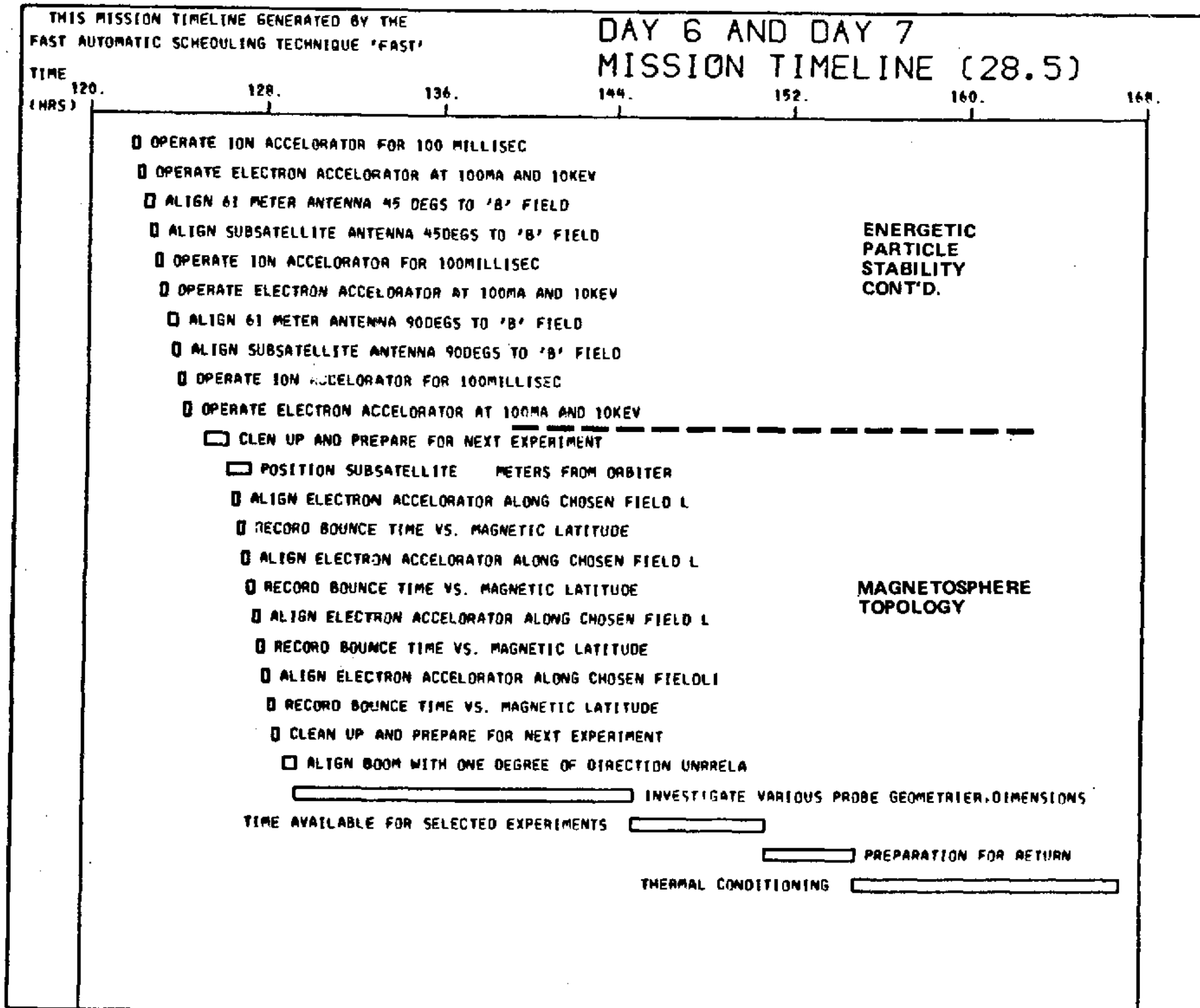

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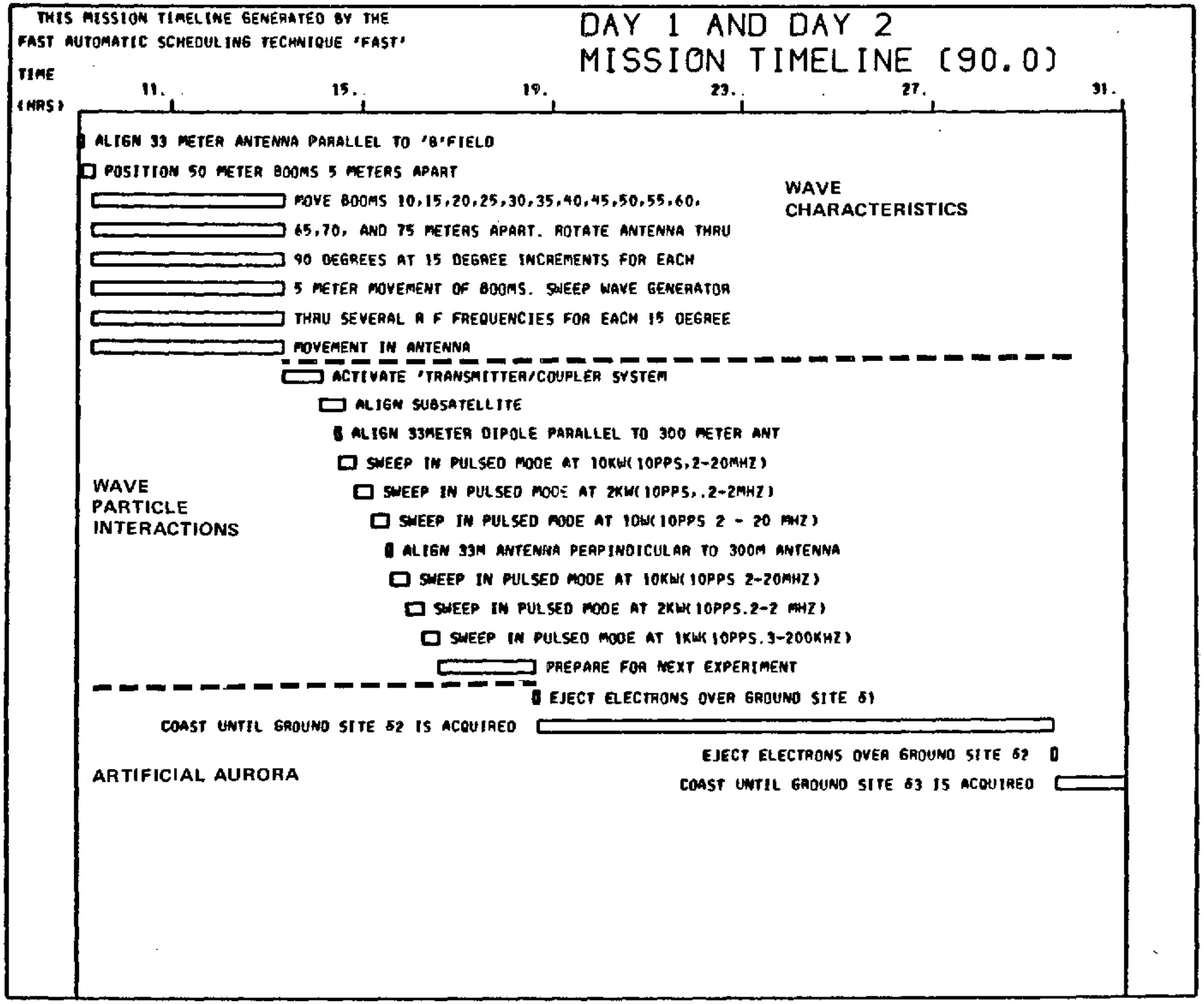


Figure 7-33. Timeline for polar mission.

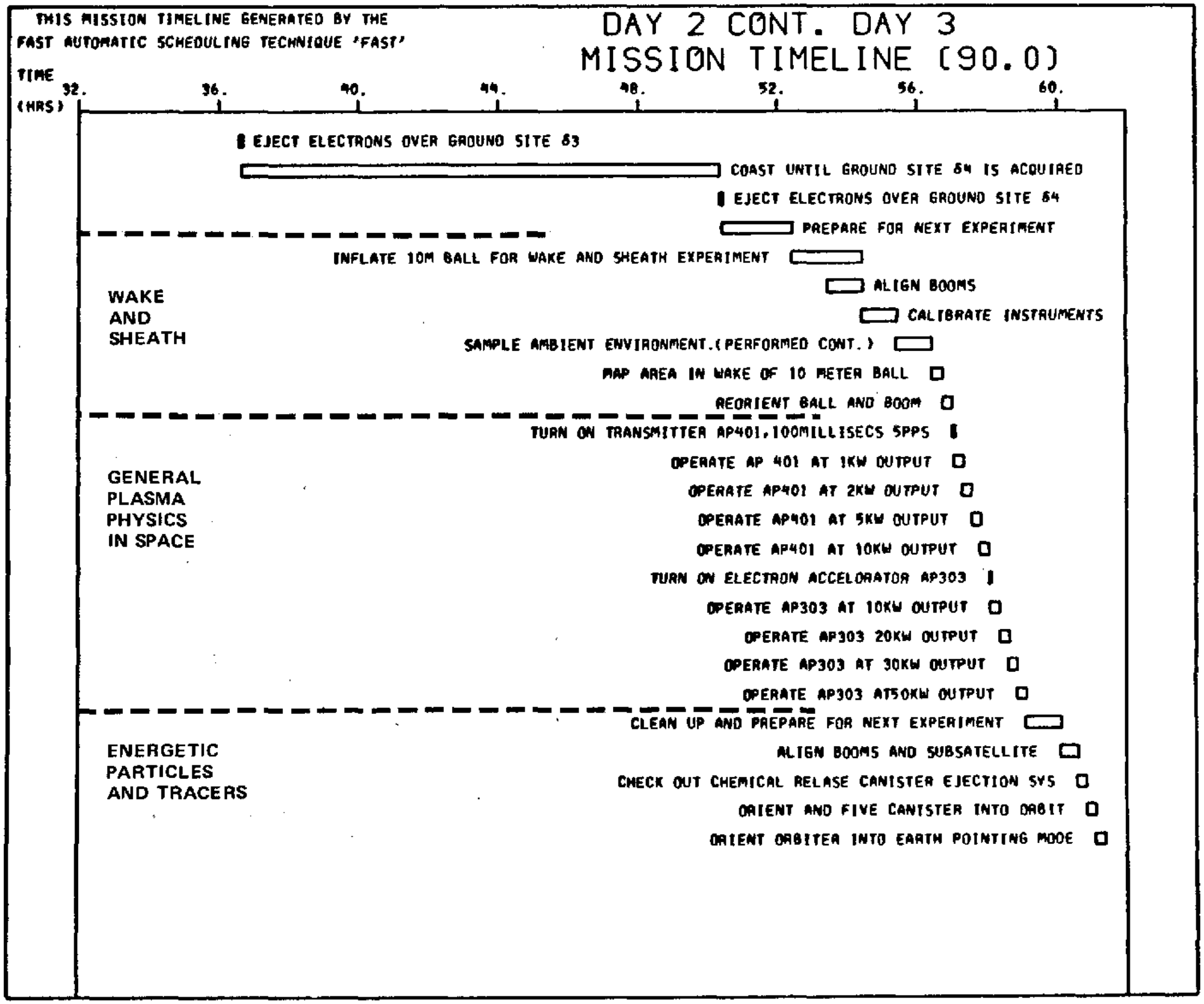
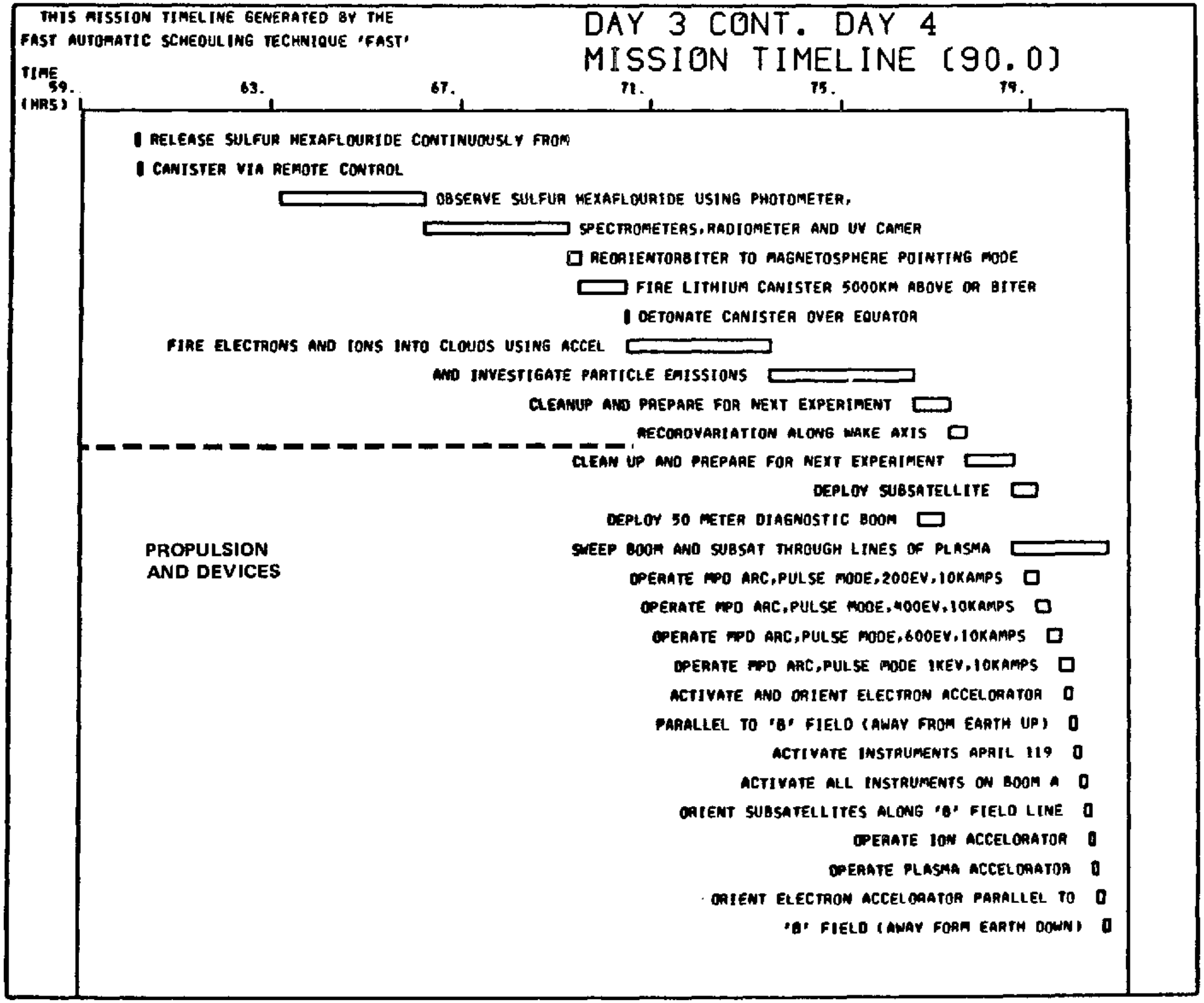


Figure 7-33. (Continued).



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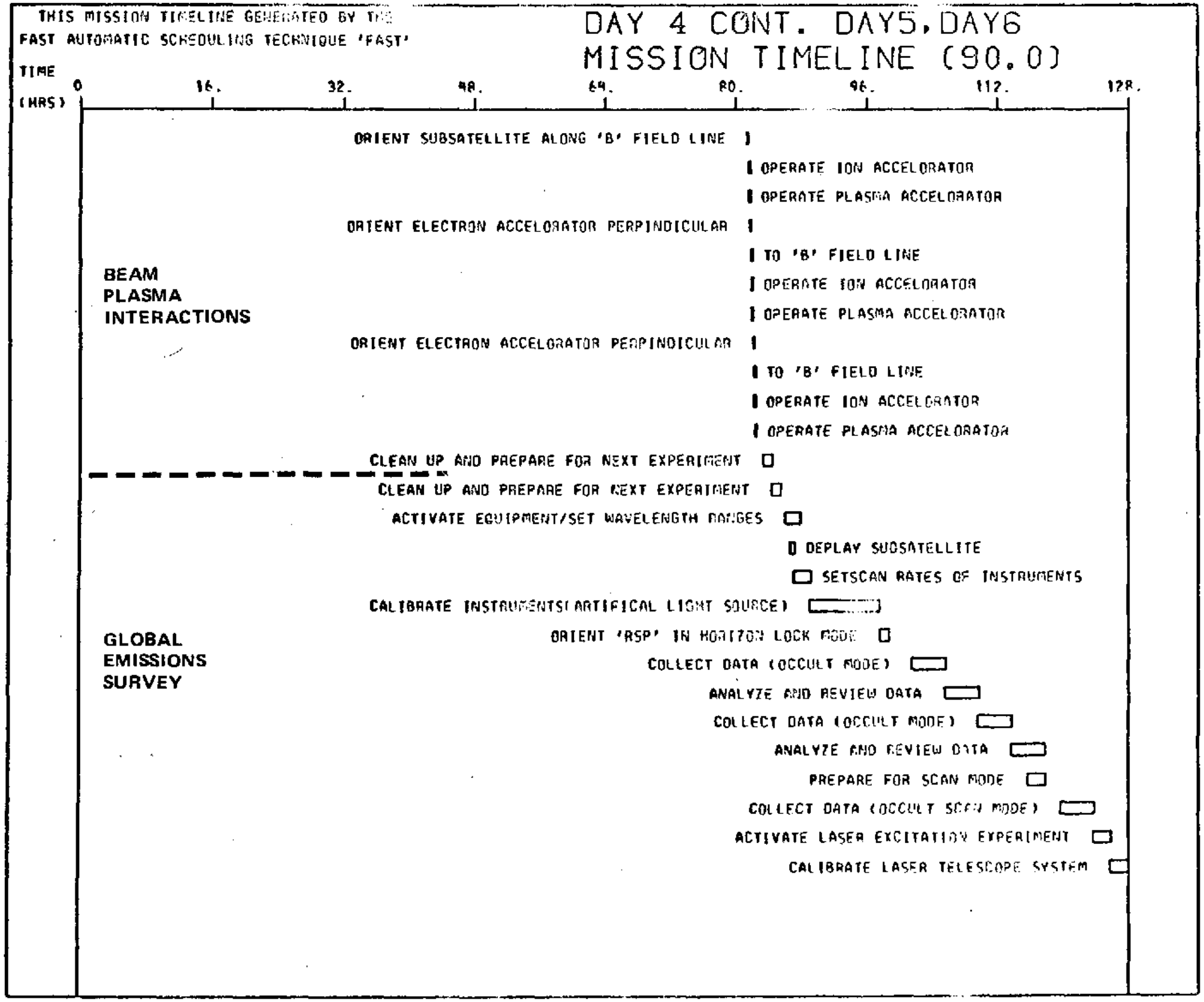

Figure 7-33. (Continued).

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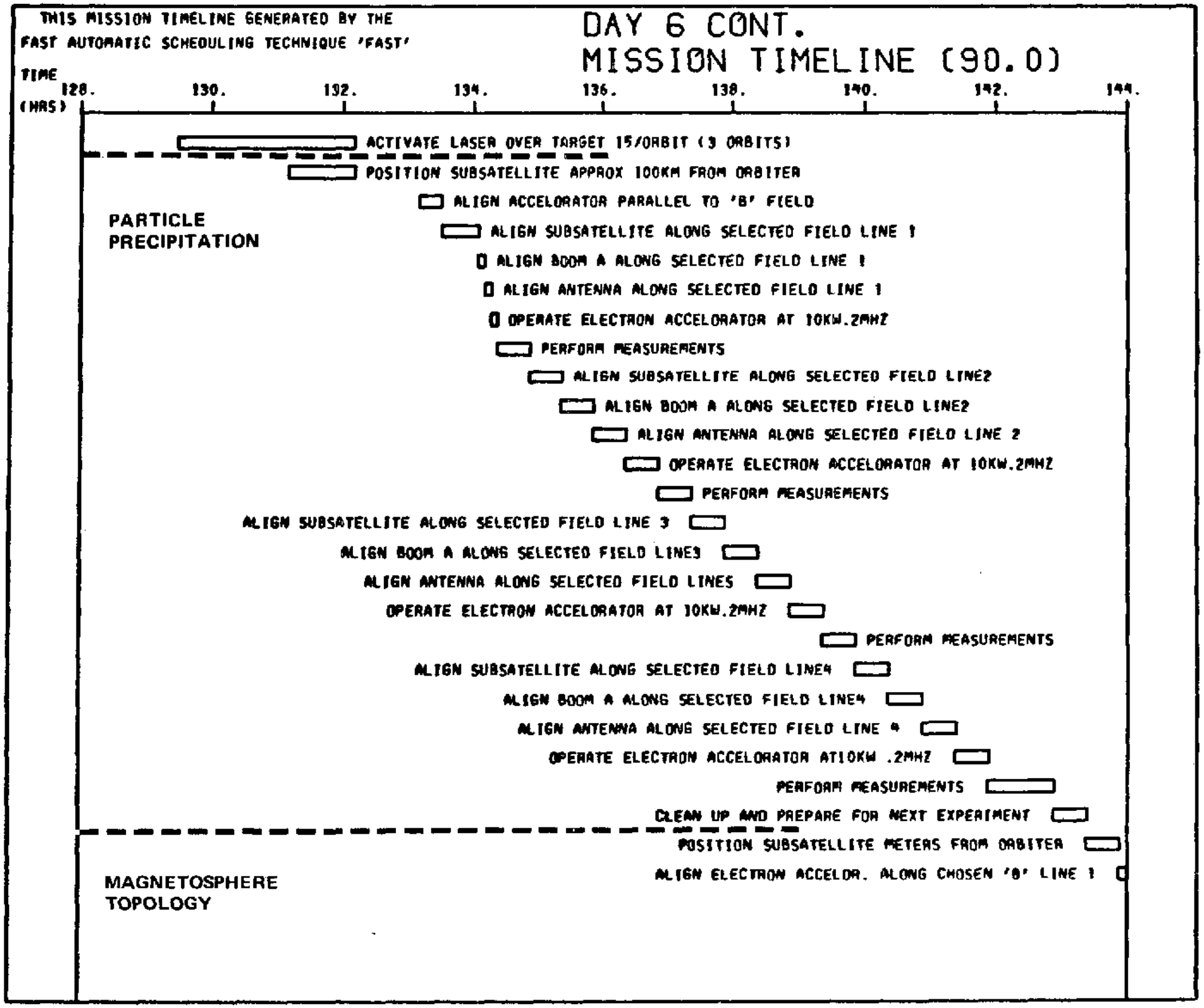


Figure 7-33. (Continued).

C-4

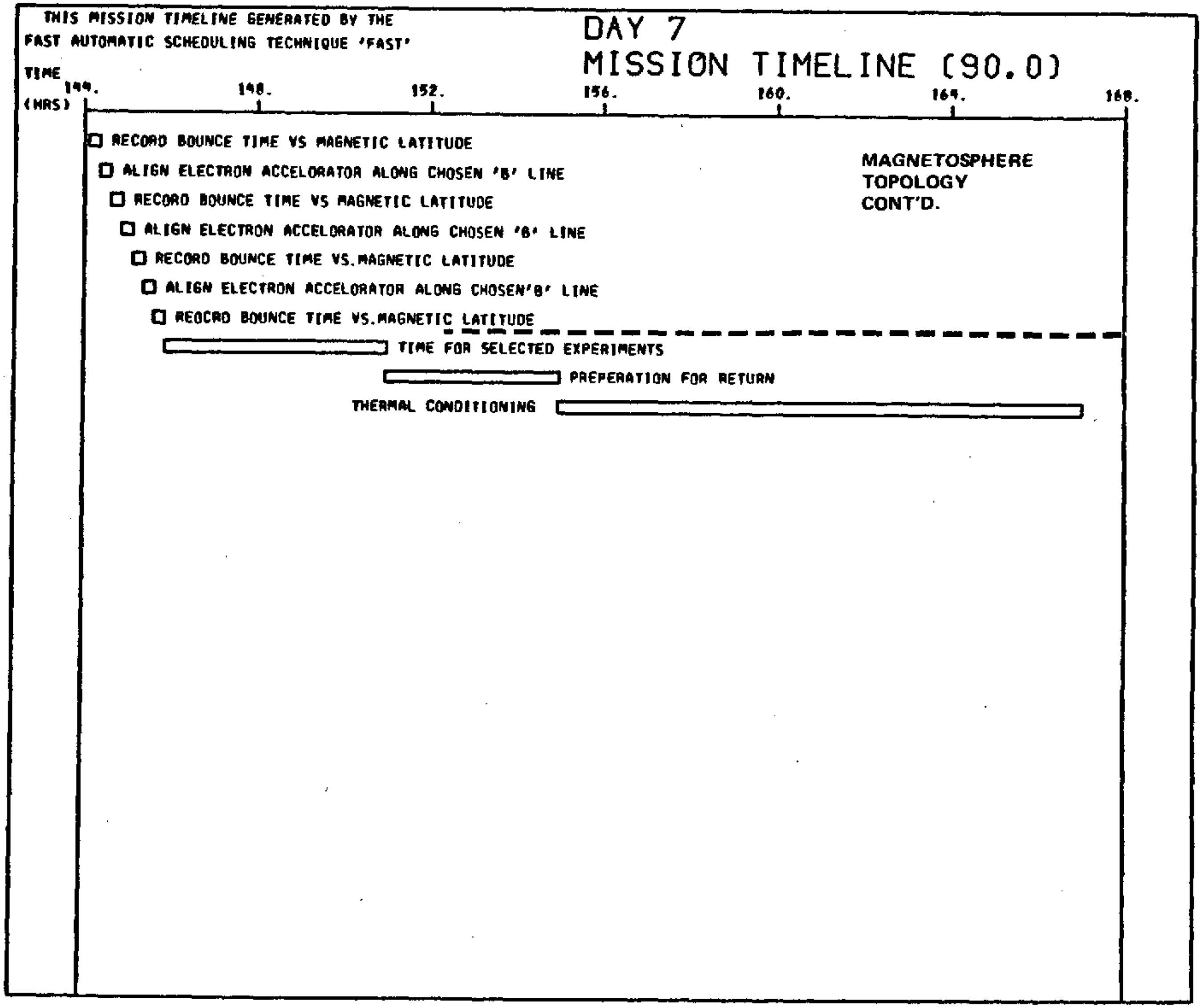


Figure 7-33. (Concluded).

28.5 deg INCLINATION				90 deg INCLINATION			
FROM	(hrs)	TO		FROM	(hrs)	TO	
10.00	–	21.60	P1, T1[a]	10.0	–	19.6869	P1, T1[a]
21.60	–	33.18	P2, T2	19.6869	–	34.6869	P2, T2
33.18	–	45.18	P1, T1	34.6869	–	46.6869	P1, T1
45.18	–	57.18	P2, T2	46.6869	–	58.0808	P2, T2
57.18	–	69.18	P1, T1	58.0808	–	70.4538	P1, T1
69.18	–	82.18	P2, T2	70.4538	–	82.4449	P2, T2
82.18	–	93.88	P1, T1	82.4449	–	94.4539	P1, T1
93.88	–	105.13	P2, T2	94.4539	–	106.4538	P2, T2
105.13	–	117.13	P1, T1	106.4538	–	119.7782	P1, T1
117.13	–	129.63	P2, T2	119.7782	–	131.1782	P2, T2
129.63	–	141.63	P1, T1	131.1782	–	142.8712	P1, T1
141.63	–	153.63	P2, T2	142.8712	–	154.00	P2, T2
153.63	–	163.00	P1, T1	154.00	–	163.00	P1, T1
163	–	168	P1P2, T1T2	163	–	168	P1P2, T1T2

a. P1 – Physicist Number 1
P2 – Physicist Number 2
T1 – Physicist/Technician Number 1
T2 – Physicist/Technician Number 2

Figure 7-34. Crew schedules for 28.5 deg mission and 90 deg mission.

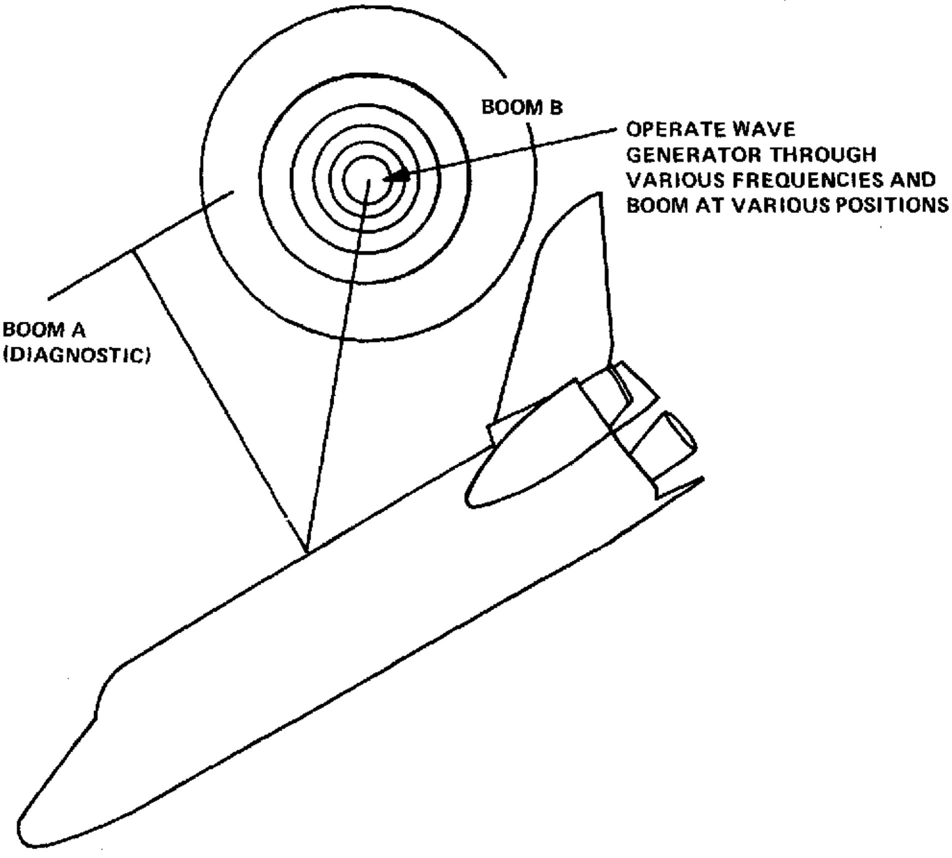


Figure 7-35. Wave characteristics.

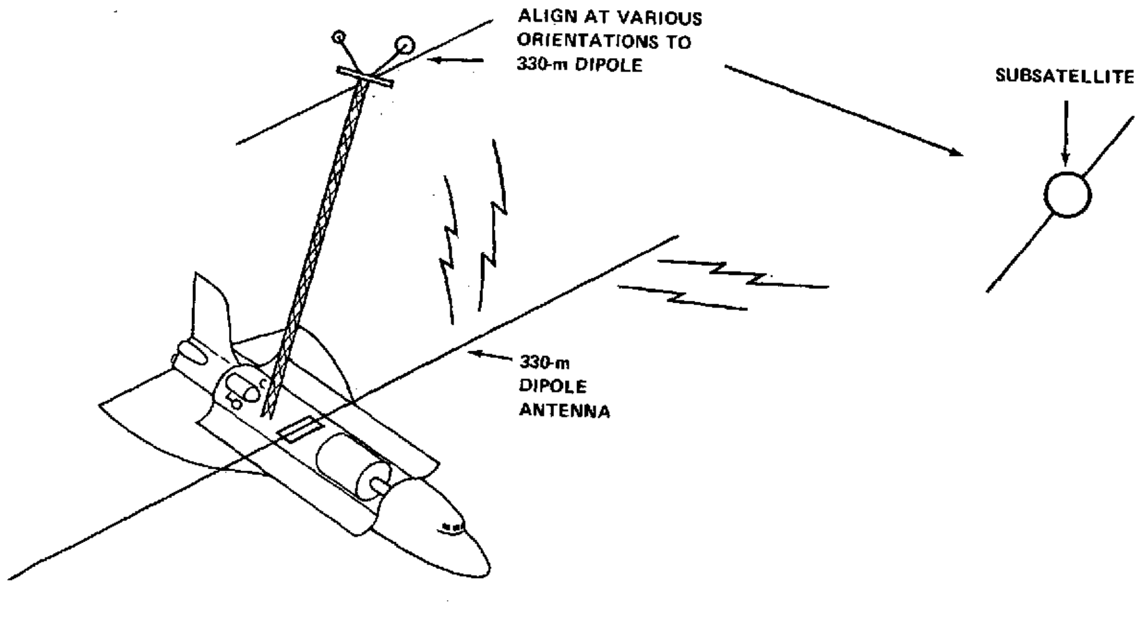


Figure 7-36. Wave particle interactions.

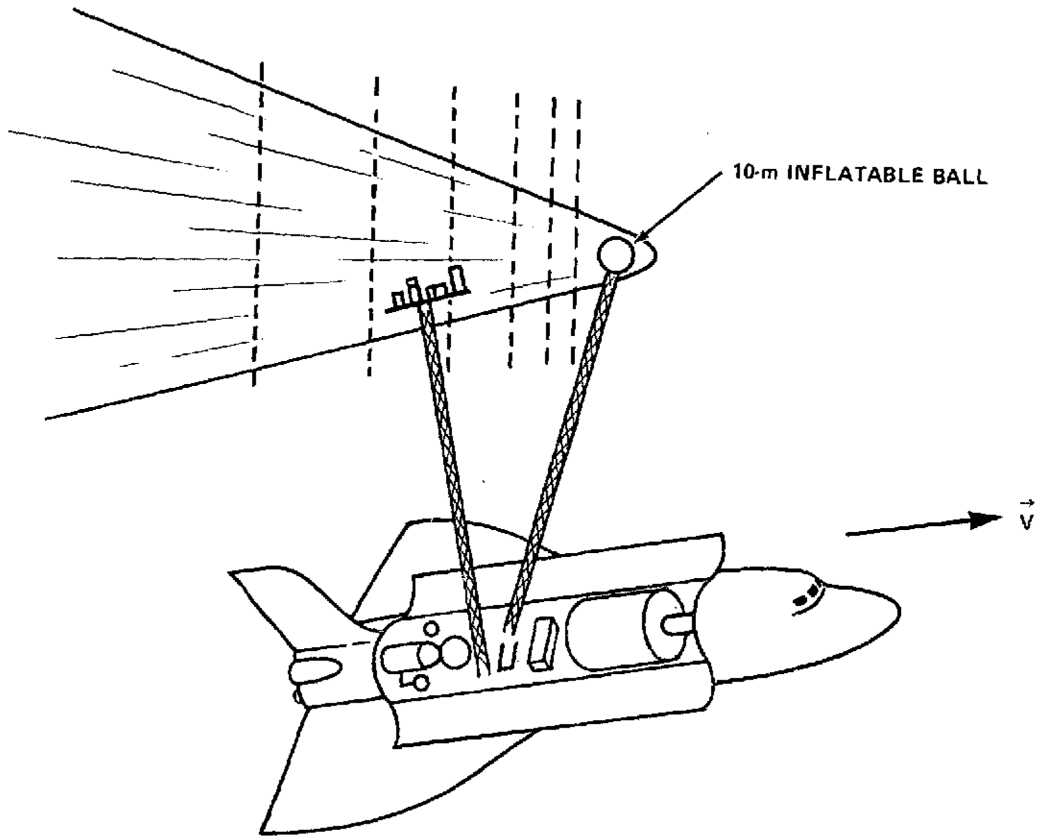


Figure 7-37. Wake and sheath experiment.

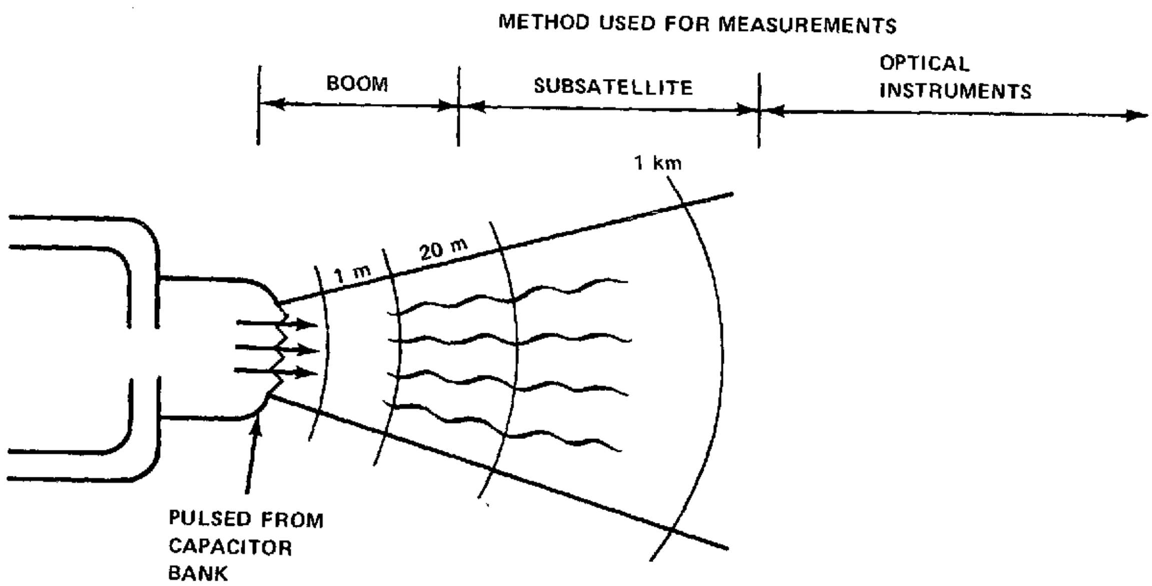


Figure 7-38. Propulsion and devices.

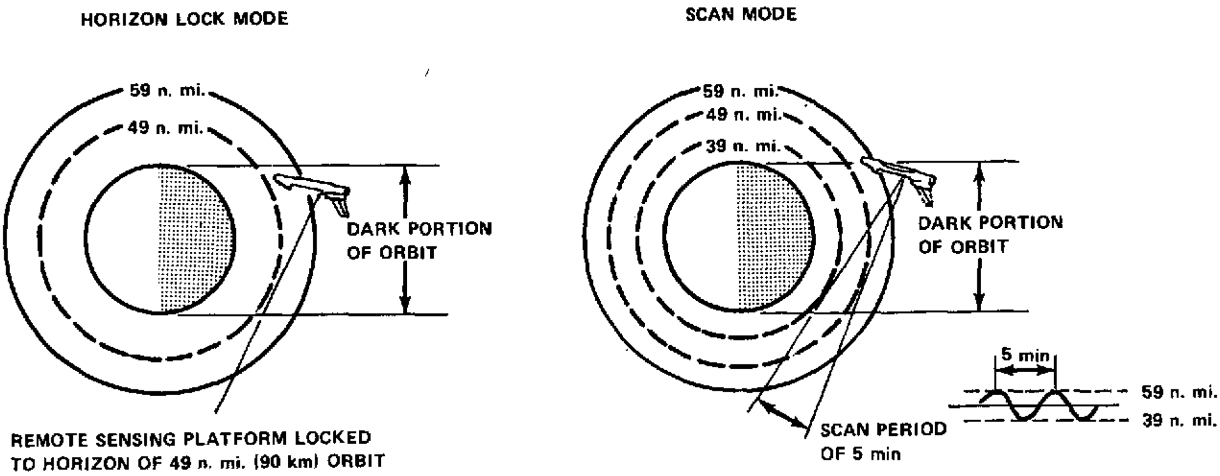


Figure 7-39. Global emission survey.

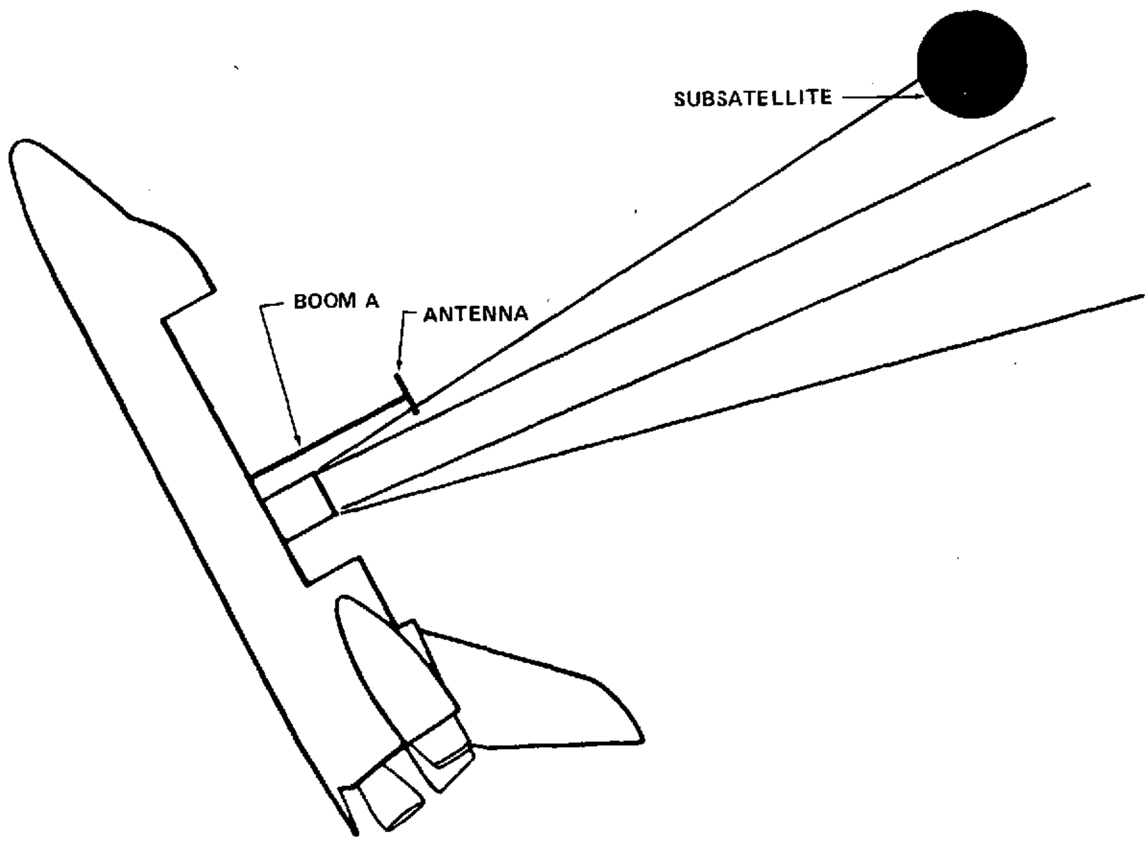


Figure 7-40. Energetic particle stability.

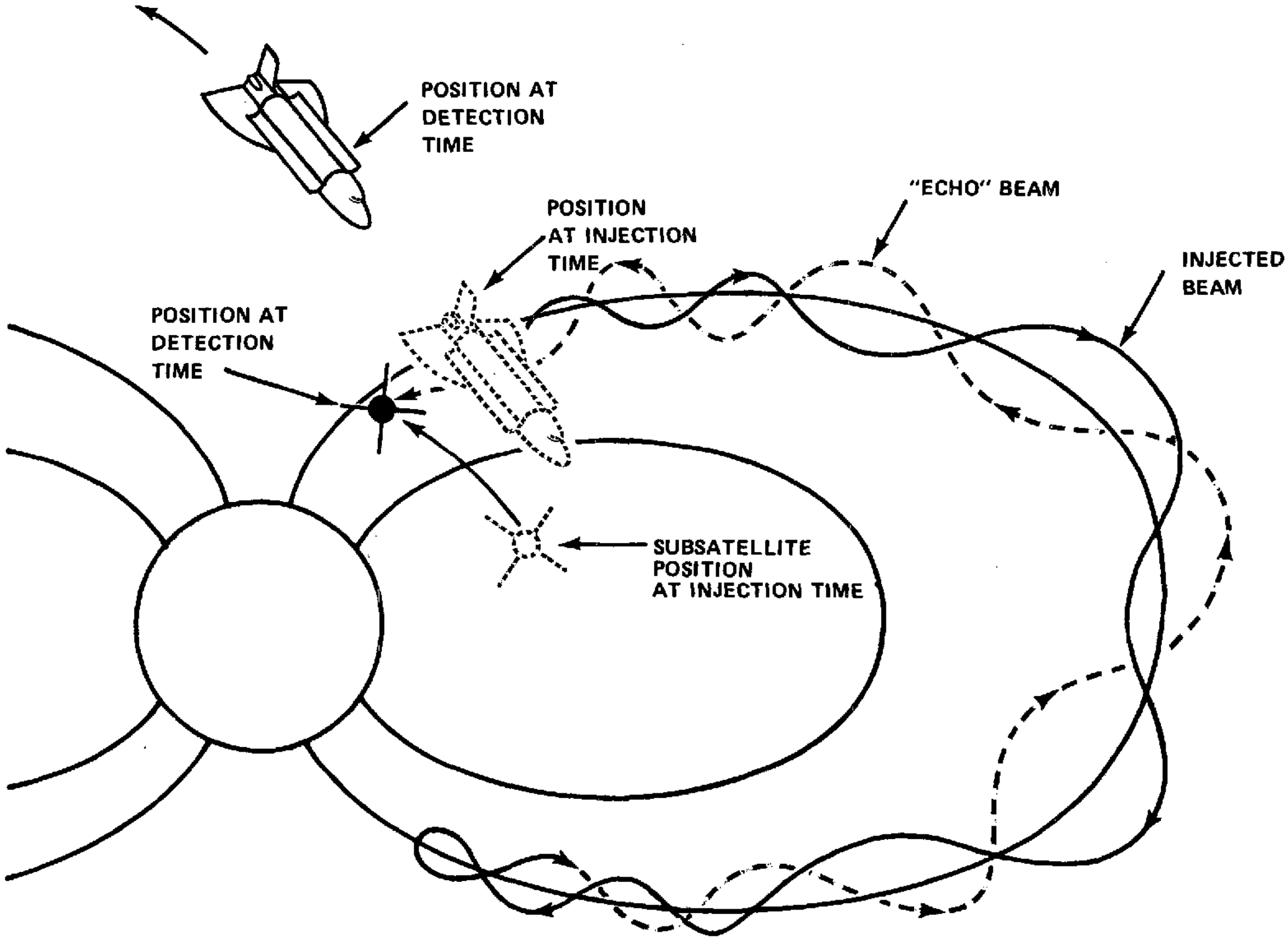


Figure 7-41. Magnetospheric topology.

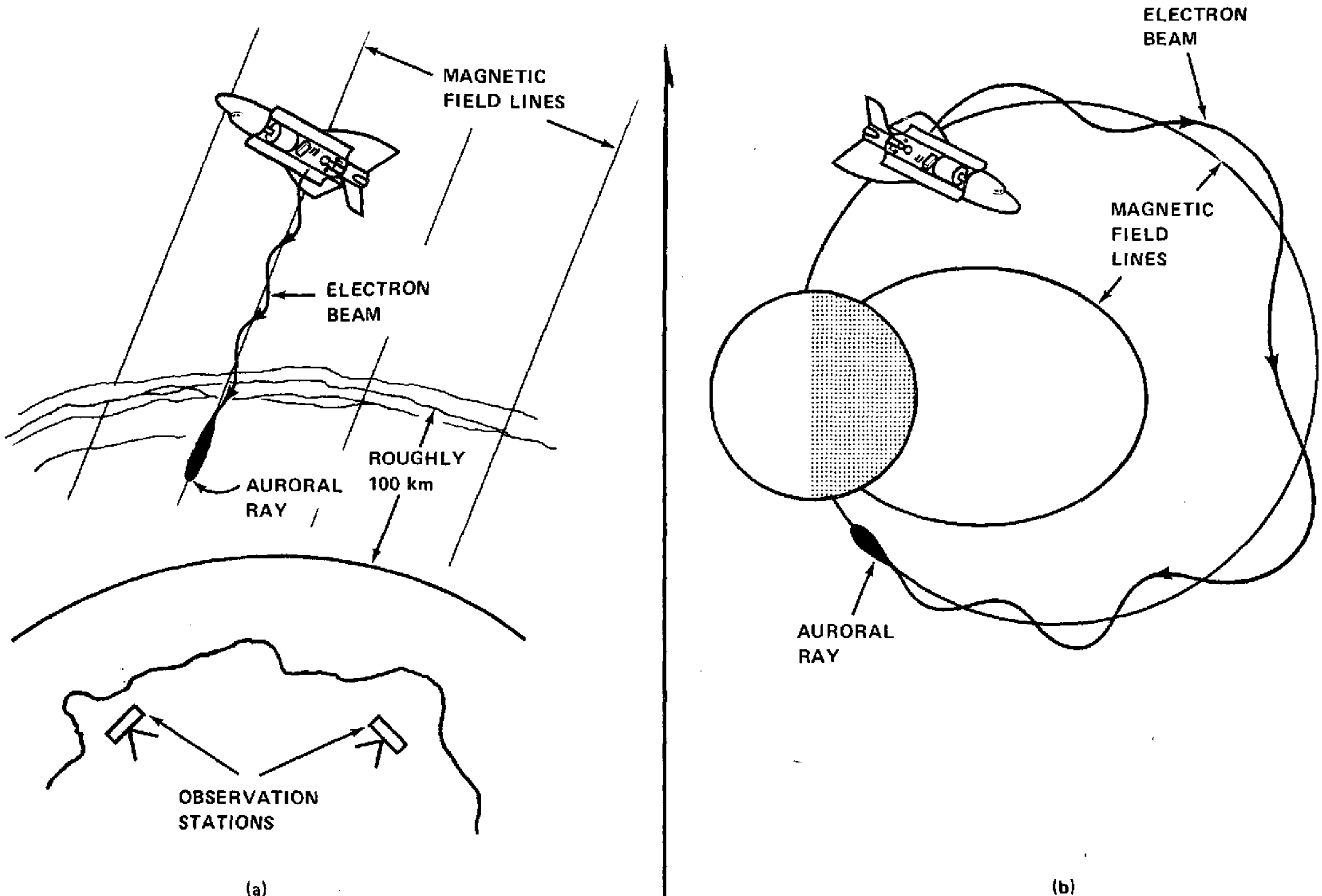


Figure 7-42. Artificial aurora.

7.4 GROUND OPERATIONS

7.4.1 Guidelines and Assumptions

The ground operations analysis was made under the following guidelines:

1. The AMPS will have dedicated sortie equipment.

2. Postflight and preflight systems tests will be conducted.

3. All experiment equipment except the remote sensing platform, the lidar, the accelerators, and the satellites will be refurbished intact with the sortie equipment.

4. The support unit simulator for preflight and postflight tests will be located at the AMPS integration site.

5. All the scientific equipment will be owned and refurbished by NASA.

6. The service module will be refurbished at the launch site.

7. All flight equipment will be flown on every flight.

7.4.2 Block Diagram

As indicated in Figure 7-43 and consistent with the guidelines, the AMPS payload will undergo both preflight and postflight systems tests at the integration site. Those elements requiring special refurbishment and calibration facilities (vacuum tank, dark room, etc.) will be removed, refurbished, and stored separately from the intact equipment. The AMPS shipping container will probably be used as a storage container for the intact equipment after the Spacelab and service equipment have been refurbished. The flight unit, backup science equipment, and special ground support equipment will be shipped together to and from the launch site and will be placed in bonded storage when not required for ground or flight operations.

7.4.3 Activities and Timelines

Tables 7-4 and 7-5 indicate the top level activities associated with the preflight and postflight activity at the integration site. The tables also indicate the activity precedence requirements necessary to construct a timeline. The resources indicated in the tables are ground crew requirements for each activity defined by the following:

Skill Type	Description
1	Handling
2	Warehouseman
3	Mechanical Engineer
4	Mechanical Technician
5	Electrical Engineer
6	Electrical Technician
7	Optical Engineer
8	Optical Technician
9	Software Engineer
10	Software Technician

Timelines for these activities are shown in Tables 7-6 and 7-7 and indicate a total time in working hours of 171 hours for the preflight MSFC activity and 184 hours for the postflight MSFC activity. The dots on the charts represent slack time, or the amount of time a job can be delayed without impacting the total completion time. Assuming one shift of 8 hours for 5 days each week, a total of about 9 weeks of activity is required at the integration site for both preflight and postflight operations, with 2 weeks at the launch site and 1 week on orbit implying a total turnaround of 12 weeks or four launches per year.

7.4.4 Manpower Requirements

The manpower requirements for each of the skill types described previously can be determined from the timelines in several ways. The largest estimate will be obtained if all the jobs begin as early as possible consistent with their precedent requirements. This estimate fluctuates with time for each skill type. A smoother, lower level manpower estimate can be obtained by delaying some of the jobs with slack time to a period where crew requirements are not as high. Even then some of the crew at this level will be idle a large portion of time. Cross-training of the crew to handle various percentages of activity will allow an even lower crew level to accomplish the work. Tables 7-8 and 7-9 show the manpower requirements for the 10 skill types previously described for several degrees of cross-training. Based on the charts with 5-percent of cross-training a prelaunch crew of 45 men and a postlaunch crew of 32 men will be required. This crew includes only the "hands-on-personnel" and does not include scientists, investigators, liaison personnel, tool crib operators, facilities personnel, clerks, typists, etc. Total requirements will probably be about twice the number indicated by the "hands-on" number.

7.4.5 Hardware Requirements

For each category of major equipment unique to AMPS there should exist the following kinds of hardware:

1. Flight equipment
2. Backup equipment
3. Training and mockup equipment
4. Spacelab control center equipment
5. Special ground support equipment

Figure 7-44 indicates the equipment activities and timelines for each category.

7.4.5.1 Flight Equipment

The flight units shall include all elements of the instruments, their Spacelab panel racks, cable kits, dust covers, and instrumentation kits. Also, a shipping and storage container for the intact equipment and for the separable items will be included.

7.4.5.2 Backup Flight Equipment

This equipment will consist of a complete duplicate of the flight equipment plus a shipping and storage container, lift slings for instrument changeout, dismounting and mounting guide bars to protect other equipment during changeout, and a changeout, checkout and verification kit.

7.4.5.3 Training and Mockup Equipment

This equipment shall consist of hardware sufficiently similar to the flight equipment and ground support equipment to adequately train both flight and ground crews in appropriate procedures for instrument operation, malfunction detection, installation, component changeout, checkout, packaging, shipping, storage, calibration, and all other appropriate training requirements.

7.4.5.4 Ground Control Center Panel Equipment

This equipment shall consist of that special equipment that will be required to modify and check out the Spacelab control center that will be supporting the AMPS flight equipment. It shall also service the ground software development and check out and support the integration tests.

7.4.5.5 Design Verification Units

These items of equipment shall consist of components sufficiently similar to the anticipated flight design to thoroughly verify the design. The equipment shall also include sufficient instrumentation to allow thorough verification.

7.4.5.6 Qualification Test Units

No distinct equipment is expected for this purpose; rather, the backup unit will be subjected to the required qualifications tests and refurbished for flight backup.

TABLE 7-4. MSFC PREFLIGHT AMPS ACTIVITY

SEQ	JOB	NAME	TIME	PRECEDENCE 1	2	3	4	5	RESOURCES 1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	BEGIN PRELAUNCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	MOVE RSP TO CALIBRAT	4	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
3	3	MOVE LIDAR TO CALIB	4	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
4	4	MOVE ACCELS TO CALIB	4	2	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
5	5	MOVE SATS TO CALIB	4	3	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
6	6	SETUP+CALIB RSP	40	2	0	0	0	0	1	0	1	1	1	1	1	0	1	1	0	0	0
7	7	SETUP+CALIB LIDAR	40	3	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0
8	8	SETUP+CALIB ACCEL	40	4	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	0	0
9	9	SETUP+CALIB SATS	40	5	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0
10	10	MOVE RSP TO INTEG	4	6	14	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
11	11	MOVE LIDAR TO INTEG	4	7	14	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
12	12	MOVE ACCEL TO INTEG	4	8	10	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
13	13	MOVE SATS TO INTEG	4	9	11	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
14	14	MOVE AMPS TO INTEG	8	1	0	0	0	0	4	2	1	1	1	1	1	1	0	0	0	0	0
15	15	DAMAGE INSP+RMV CAN	8	14	0	0	0	0	4	2	1	1	1	1	1	1	0	0	0	0	0
16	16	SECURE INTO STALL	4	15	0	0	0	0	4	0	1	1	1	1	1	1	0	0	0	0	0
17	17	MOUNT RSP	2	10	16	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
18	18	MOUNT LIDAR	2	11	17	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
19	19	MOUNT ACCELS	2	12	18	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
20	20	MOUNT SATS	2	13	19	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0
21	21	CHANGEOUT BATTERIES	4	20	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
22	22	MOD INSTRUMENTATION	16	20	0	0	0	0	1	0	0	0	2	2	0	0	0	0	0	0	0
23	23	SU SIM CALIBRATE	16	9	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	0	0
24	24	GSE CALIBRATE	16	9	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	0	0
25	25	SU SIM+GSE HOOKUP	4	21	22	23	24	0	1	0	1	1	1	1	0	0	0	0	0	0	0
26	26	CRYO FILL+CHILL	8	27	28	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
27	27	POWER,DATA,SOFTWARE	16	25	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0
28	28	ADJUST TARGETS	4	25	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
29	29	REMOVE BRACES,COVERS	2	26	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
30	30	LEAK CHECKS	3	29	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
31	31	INST,SELF CAL TESTS	4	30	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
32	32	RSP TESTS	3	31	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
33	33	LIDAR TESTS	3	32	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
34	34	ACCELERATOR TESTS	3	31	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
35	35	TRANSMITTERS TESTS	3	34	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
36	36	SATELLITES TESTS	3	31	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
37	37	BOOM TESTS	3	36	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
38	38	DEPLOY SYST TESTS	3	37	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
39	39	SPACELAB SYS TESTS	16	33	35	38	0	0	0	0	2	2	2	2	0	0	2	2	0	0	0
40	41	RETEST	2	40	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
41	40	INST CHANGEOUT 1	4	33	35	38	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
42	42	INST CHANGEOUT 2	4	41	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
43	43	RETEST 2	2	42	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
44	44	INST CHANGEOUT 3	4	43	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
45	45	RETEST 3	2	44	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
46	46	REPLACE BRACES+COVRS	3	39	45	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
47	47	DISCON CRYO+GSE+TARG	8	46	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
48	48	DISCON SU SIM	4	46	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
49	49	REFERB SU SIM	16	48	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
50	50	REFERB GSE	24	47	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
51	51	REFERB SHIP CANS	16	15	20	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
52	52	INSTALL AMPS IN CAN	8	47	48	51	0	0	4	1	1	1	1	1	1	1	0	0	0	0	0
53	53	PACK BACKUPS+SPC,GSE	8	51	0	0	0	0	2	1	1	1	1	1	1	1	0	0	0	0	0
54	54	LOAD EQUIP ON TRUCK	8	52	53	0	0	0	4	1	1	1	1	1	1	1	0	0	0	0	0
55	55	FINISH MSFC PRELAUNC	0	49	50	54	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 7-5. MSFC POSTFLIGHT AMPS ACTIVITY

SEQ	JOB	NAME	TIME	PRECEDENCE 1	2	3	4	5	RESOURCES 1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	ARRIVE INTEG SITE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	INTEG SITE R+I	4	1	0	0	0	0	4	2	1	0	1	0	1	0	0	0	0	0	0
3	3	MOVE TO STALL AREA	3	2	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0
4	4	LOAD INTO STALL	2	3	0	0	0	0	4	2	2	2	1	2	1	2	0	0	0	0	0
5	5	MOVE+REFRB CONTAINER	8	4	0	0	0	0	2	1	1	1	1	1	0	0	0	0	0	0	0
6	6	EQUIP INVENTORY+INSP	8	4	0	0	0	0	2	1	1	0	1	0	1	0	0	0	0	0	0
7	7	SU SIM CALIBRATE	16	1	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	0	0
8	8	GSE CALIBRATE	16	1	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	0	0
9	9	SU SIM+GSE HOOK UP	4	7	8	6	0	0	2	0	1	1	1	1	0	0	0	0	0	0	0
10	10	CRYO FILL,CHILL	8	9	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
11	11	POWER+DATA HOOK UP	4	6	0	0	0	0	0	0	0	0	1	2	0	0	1	1	0	0	0
12	12	ADJUST TARGETS,ETC	4	6	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
13	13	REMOVE BRACES,COVERS.	2	6	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
14	14	LEAK CHECKS	3	9	10	11	12	13	0	0	1	1	0	0	0	0	0	0	0	0	0
15	15	INST SELF CAL TESTS	4	14	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
16	16	RSP TESTS	3	15	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
17	17	LIDAR TESTS	3	16	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
18	18	ACCELERATOR TESTS	3	17	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
19	19	TRANSMITTERS TESTS	3	18	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
20	20	SATELLITE TESTS	3	19	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
21	21	BOOMS TESTS	3	20	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
22	22	DEPLOY SYST TESTS	3	21	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0
23	23	SPACE LAB SYS TESTS	16	22	0	0	0	0	0	0	2	2	2	2	0	0	1	1	0	0	0
24	24	REPLACE BRACES+COVRS	3	23	0	0	0	0	2	0	1	1	1	1	1	1	0	0	0	0	0
25	25	DISCONNECT SU SIM	4	24	0	0	0	0	2	0	1	1	1	1	1	0	0	0	0	0	0
26	26	DISCON.CRYO+GSE+TARG	8	24	0	0	0	0	2	0	1	1	1	1	1	1	0	0	0	0	0
27	27	DISC.RSP+LIDAR	4	25	26	0	0	0	2	0	1	1	1	1	1	1	0	0	0	0	0
28	28	DISC.ACCELS+SATS	4	27	0	0	0	0	2	0	1	1	1	1	1	1	0	0	0	0	0
29	29	REFERB SU SIM	16	25	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
30	30	REFERB AMPS GSE,TARG	24	26	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0
31	31	REFERB+STOW BOOMS	12	28	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
32	32	REF+STO DISPLAYS	12	31	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
33	33	REF+STO COMPUTERS	12	32	0	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0
34	34	REF+STO BATTERIES	12	33	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
35	35	REF+STO TRANSMTTTERS	8	34	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
36	36	REF+STO TV+CAMERAS	8	35	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
37	37	REF+STO DEPLOY SYST	12	36	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
38	38	SPACELAB REFERBISH	48	28	0	0	0	0	2	0	2	2	2	2	0	0	0	0	0	0	0
39	39	INSTALL STORAGE CANS	8	37	38	5	0	0	2	1	1	1	1	1	1	1	0	0	0	0	0
40	40	MOVE INTACT TO STORE	8	39	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0
41	41	REFERB+STORE RSP	8	27	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
42	42	REFERB+STORE LIDAR	8	41	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
43	43	REFERB+STORE ACCELS	8	28	42	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
44	44	REFERB+STORE SATS	8	43	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
45	45	FINISH POST FLT	0	29	30	40	44	46	0	0	0	0	0	0	0	0	0	0	0	0	0
46	46	DURATION	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 7-6. MSFC PREFLIGHT AMPS ACTIVITY TIMELINES

WATERFALL TOTAL TIME 171

JOB	NAME	START	DUR
1	BEGIN PRELAUNCH	0	0
46	DURATION	0	1
2	MOVE RSP TO CALIBRAT	0	4
3	MOVE LIDAR TO CALIB	0	4
14	MOVE AMPS TO INTEG	0	8
5	MOVE SATS TO CALIB	4	4
4	MOVE ACCELS TO CALIB	4	4
6	SETUP+CALIB RSP	4	40
7	SETUP+CALIB LIDAR	4	40
15	DAMAGE INSP+RMV CAN	8	8
8	SETUP+CALIB ACCEL	8	40
9	SETUP+CALIB SATS	8	40
16	SECURE INTO STALL	16	4
10	MOVE RSP TO INTEG	44	4
11	MOVE LIDAR TO INTEG	44	4
17	MOUNT RSP	48	2
12	MOVE ACCEL TO INTEG	48	4
13	MOVE SATS TO INTEG	48	4
23	SU SIM CALIBRATE	48	16
24	GSE CALIBRATE	48	16
18	MOUNT LIDAR	50	2
19	MOUNT ACCELS	52	2
20	MOUNT SATS	54	2
21	CHANGEOUT BATTERIES	56	4
22	MOD INSTRUMENTATION	56	16
51	REFERB SHIP CANS	56	16
25	SU SIM+GSE HOOKUP	72	4
53	PACK BACKUPS+SPC.GSE	72	8
28	ADJUST TARGETS	76	4
27	POWER,DATA,SOFTWARE	76	16
26	CRYO FILL+CHILL	92	8
29	REMOVE BRACES,COVERS	100	2
30	LEAK CHECKS	102	3
31	INST,SELF CAL TESTS	105	4
32	RSP TESTS	109	3
34	ACCELERATOR TESTS	109	3
36	SATELLITES TESTS	109	3
33	LIDAR TESTS	112	3
35	TRANSMITTERS TESTS	112	3
37	BOOM TESTS	112	3
38	DEPLOY SYST TESTS	115	3
40	INST CHANGOUT 1	118	4
39	SPACELAB SYS TESTS	118	16
41	RETEST	122	2
42	INST CHANGEOUT 2	124	4
43	RETEST 2	128	2
44	INST CHANGEOUT 3	130	4
45	RETEST 3	134	2
46	REPLACE BRACES+COVRS	136	3
48	DISCON SU SIM	139	4
47	DISCON CRYO+GSE+TARG	139	8
49	REFERB SU SIM	143	16
52	INSTALL AMPS IN CAN	147	8
50	REFERB GSE	147	24
54	LOAD EQUIP ON TRUCK	155	8
55	FINISH MSFC PRELAUNC	171	0

TABLE 7-7. MSFC POSTFLIGHT AMPS ACTIVITY TIMELINES

WATERFALL TOTAL TIME 184

JOB	NAME	START	DUR	
1	ARRIVE INTEG SITE	0	0	
46	DURATION	0	1	………
2	INTEG SITE R+I	0	4	X
7	SU SIM CALIBRATE	0	16	XXXXXXX.
8	GSE CALIBRATE	0	16	XXXXXXX.
3	MOVE TO STALL AREA	4	3	X
4	LOAD INTO STALL	7	2	X
5	MOVE+REFRB CONTAINER	9	8	XXXXX………
6	EQUIP INVENTORY+INSP	9	8	XXXXX
13	REMOVE BRACES,COVERS	17	2	X.....
9	SU SIM+GSE HOOK UP	17	4	XX
11	POWER+DATA HOOK UP	17	4	XX....
12	ADJUST TARGETS,ETC	17	4	XX....
10	CRYO FILL,CHILL	21	8	XXXX
14	LEAK CHECKS	29	3	XX
15	INST SELF CAL TESTS	32	4	XX
16	RSP TESTS	36	3	XX
17	LIDAR TESTS	39	3	X
18	ACCELERATOR TESTS	42	3	XX
19	TRANSMITTERS TESTS	45	3	XX
20	SATELLITE TESTS	48	3	X
21	BOOMS TESTS	51	3	XX
22	DEPLOY SYST TESTS	54	3	X
23	SPACE LAB SYS TESTS	57	16	XXXXXXXXX
24	REPLACE BRACES+COVRS	73	3	XX
25	DISCONNECT SU SIM	76	4	XX
26	DISCON.CRYO+GSE+TARG	76	8	XXXX
29	REFERB SU SIM	80	16	XXXXXXXXX………
27	DISC.RSP+LIDAR	84	4	XX
30	REFERB AMPS GSE,TARG	84	24	XXXXXXXXXXXXX………
28	DISC.ACCELS+SATS	88	4	XXX
41	REFERB+STORE RSP	88	8	XXXXX
31	REFERB+STOR BOOMS	92	12	XXXXXX
38	SPACELAB REFERBISH	92	48	XXXXXXXXXXXXXXXXXXXXXXXXXX………
42	REFERB+STORE LIDAR	96	8	XXXX
43	REFERB+STORE ACCELS	104	8	XXXX
32	REF+STO DISPLAYS	104	12	XXXXXXX
44	REFERB+STORE SATS	112	8	XXXXX………
33	REF+STO COMPUTERS	116	12	XXXXXX
34	REF+STO BATTERIES	128	12	XXXXXXX
35	REF+STO TRANSMITTERS	140	8	XXXX
36	REF+STO TV+CAMERAS	148	8	XXXX
37	REF+STO DEPLOY SYST	156	12	XXXXXXX
39	INSTALL STORAGE CANS	168	8	XXXX
40	MOVE INTACT TO STORE	176	8	XXXXX
45	FINISH POST FLT	184	0	

TABLE 7-8. MSFC PREFLIGHT AMPS ACTIVITY REQUIRED RESOURCE LEVELS

Skill Type	All Jobs Scheduled for Earliest Starts	Slack Jobs Rescheduled for Leveling	Leveling with 5-Percent Cross-Training	Leveling with 10-Percent Cross-Training	Leveling with 15-Percent Cross-Training
1	8	8	8	8	7
2	4	4	2	2	1
3	5	5	5	5	4
4	5	5	5	5	4
5	6	5	5	5	5
6	6	5	5	5	5
7	4	4	4	4	3
8	3	3	3	3	2
9	4	4	4	4	4
10	4	4	4	4	4
Total Crew	49	47	45	45	39

TABLE 7-9. MSFC POSTFLIGHT AMPS ACTIVITY REQUIRED RESOURCE LEVELS

Skill Type	All Jobs Scheduled for Earliest Jobs	Slack Jobs Rescheduled for Leveling	Leveling with 5-Percent Cross-Training	Leveling with 10-Percent Cross-Training	Leveling with 15-Percent Cross-Training
1	6	6	6	4	4
2	2	2	2	2	1
3	6	4	4	4	4
4	6	4	4	4	4
5	6	4	4	4	4
6	6	4	4	4	4
7	3	3	2	2	2
8	3	2	2	2	2
9	2	2	2	1	1
10	2	2	2	1	1
Total Crew	42	33	32	28	27

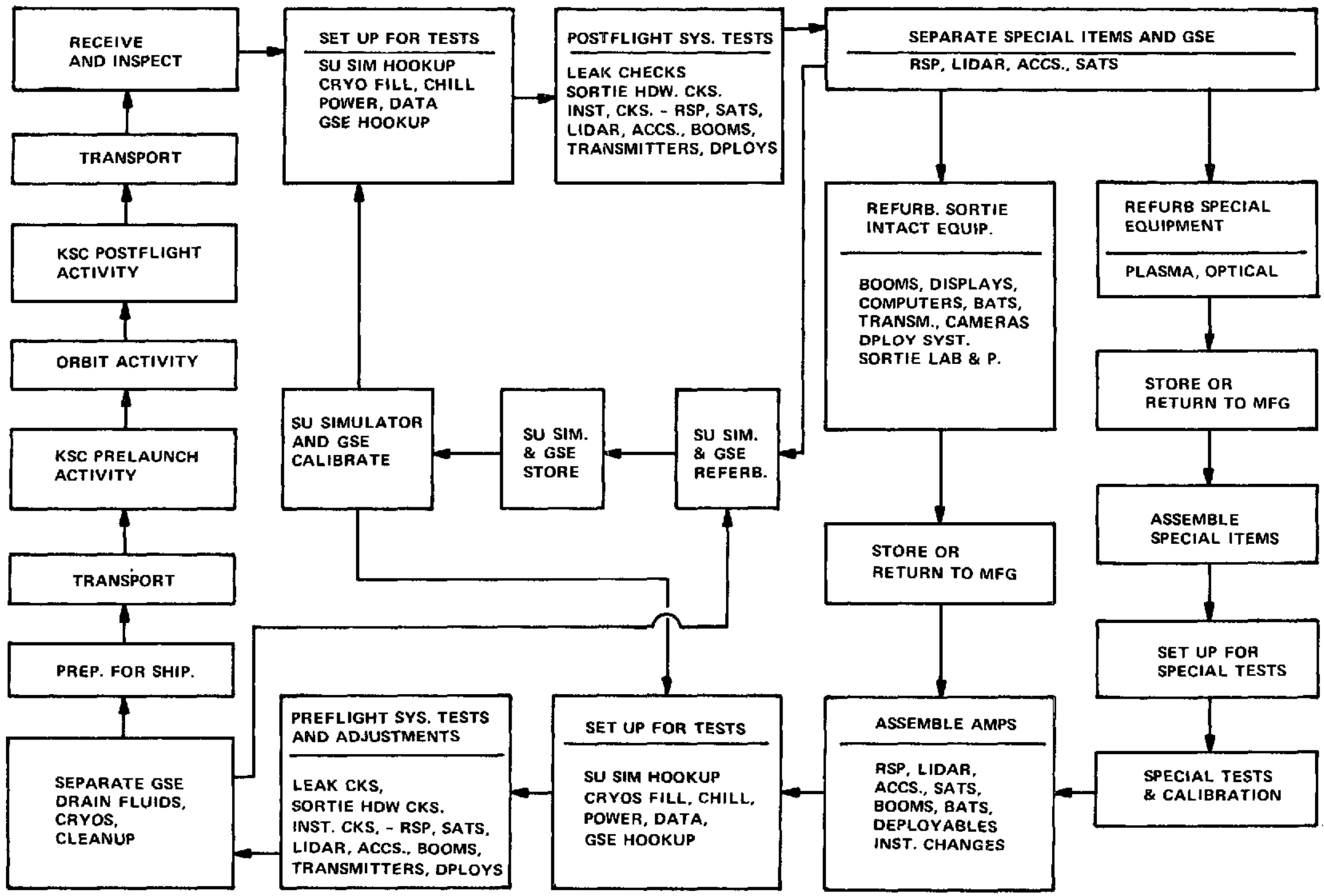


Figure 7-43. AMPS ground operations flow.

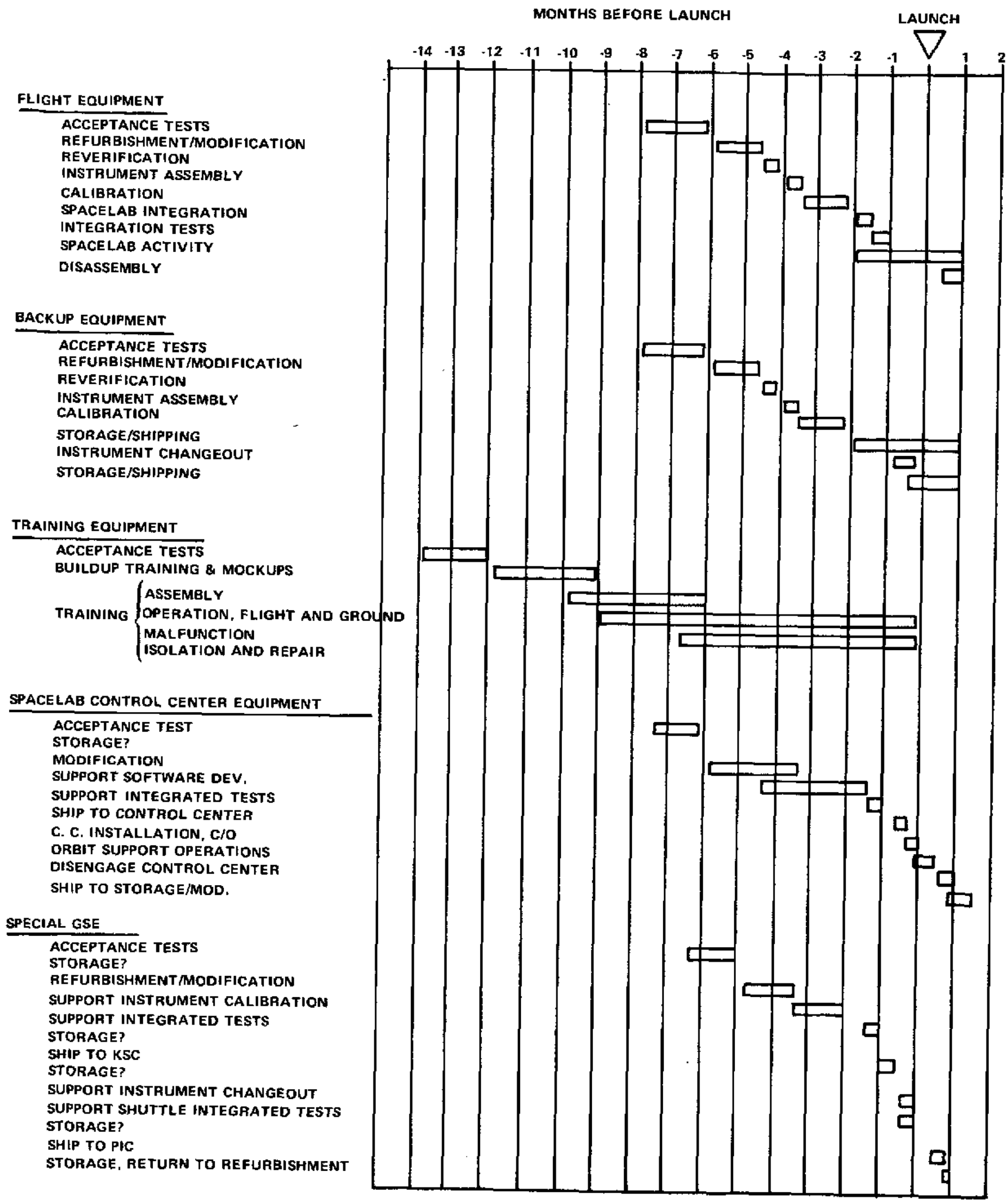


Figure 7-44. First dedicated AMPS equipment timelines.

7.5 PRELIMINARY TDRSS/STDN TRACKING COVERAGE ASSESSMENT

7.5.1 Introduction

The objective of the preliminary tracking coverage analysis is to assess the contact (line-of-sight) time statistics obtained for the Shuttle AMPS mission as covered by the Tracking and Data Relay Satellite System (TDRSS) and the Spaceflight Tracking and Data Network (STDN). Six ground-based STDN support stations are used to supplement the TDRSS subnet wherever the latter is constrained from the viewpoint of orbital operations because of upper altitude coverage limits and steering angle constraints. Some unique requirements for real-time analysis of observational data are emphasized for the AMPS mission. The preliminary coverage assessment is made available for possibly determining whether real-time control and evaluation could be best accomplished from the ground using the network of TDRSS/STDN, considering multiple polar orbits for the single mission. For effective experiment control planning, continuous global coverage with a high rate of data interchange with the TDRSS/STDN would be desirable. The feasibility, of course, depends on the TDRSS/STDN network capabilities.

The AMPS mission involves the following multiple orbits, inclined 90 deg to the Earth's equator, of the Shuttle Orbiter and its two subsatellites:

Orbiter	:	343 by 343 km circular
Subsatellite No. 1	:	343 by 1445 km elliptical ($1.13 \times$ Orbiter period)
Subsatellite No. 2	:	343 by 14816 km elliptical ($3.00 \times$ Orbiter period)

Aspects of launch to orbital insertion and deorbit are not considered in this analysis. The typical statistical data presented are essential for detailed mission timelining, orbital maneuver sequencing, and determination of ΔV requirements and may have an impact on the orbital operations of the subsatellites.

It should be emphasized that with the planned implementation of the TDRSS during the Shuttle time frame, the ground STDN subnet would be performing tracking functions above the TDRSS upper altitude coverage limits. However, in this coverage analysis, tracking of the AMPS mission is accomplished using both subnets of ground STDN and TDRSS for comparative purposes.

7.5.2 Assumptions

The basic ground rules and assumptions used in the study to satisfy the coverage requirements for the AMPS mission are provided.

7.5.2.1 TDRSS

The TDRSS subnet consists of two relay satellites, 130 deg apart in longitude and orbiting at the geosynchronous altitude, and a single ground terminal situated at White Sands, New Mexico. The White Sands terminal will be used to communicate with both relay satellites simultaneously. A multiple access system with one S-band array system to support 20 relatively low data rate spacecraft simultaneously is assumed to be the type of system capability employed for the Shuttle AMPS mission which happens to involve three spacecraft. The constraint imposed in this analysis is that the TDRS steering angle is assumed to be 26 deg. The upper altitude coverage limit with 100-percent orbital coverage is assumed to be 2000 km for the multiple access system (12 000 km for the single access system which tracks only one spacecraft).

7.5.2.2 STDN

The five 25.9-m antenna ground stations used to supplement the TDRSS subnet are situated at Fairbanks (Alaska), Goldstone (California), Madrid (Spain), Orroral Valley (Australia), and Rosman (North Carolina). A 9.1-m antenna station at Merritt Island (Florida) complements the six-station STDN subnet. In addition to the subnet, two stations at Tananarive (Malagasy Republic) (12-m antenna) and Bermuda (England) (9.1-m antenna) would be used for launch support only and are excluded from the coverage analysis. Antenna horizon coverage limits pertain to a minimum elevation angle of 5 deg for ground tracking.

7.5.2.3 Coverage Analysis

The preliminary evaluation technique used in this study is contact time (line-of-sight) statistical analysis which is confined to TDRSS, STDN, and communications line-of-sight between the Orbiter and either subsatellite when not occluded by Earth. Tracking simulation begins with orbital insertion of the Orbiter/payloads at the equator and an initial longitude of 39.96 deg East subsequent to separation of the two subsatellites from the Orbiter. Mission tracking duration is considered to be 31 hours. To present the pertinent data for the AMPS mission, the analysis assumes the TDRSS subnet to be tracking up to an altitude of 2000 km (1080 n. mi.) and the STDN subnet to be tracking above the 2000-km altitude. In the meantime, simulation takes the place of separate subnets for comparative purposes. The STDN coverage analysis uses an overlapping constraint for the ground-based stations which specifies that, in the event of multiple station overlapping, the station(s) with shorter contact time is eliminated from the evaluation so that the contact time accounting for only retained and unaffected stations is maintained.

7.5.3 Coverage Analysis

The objective of tracking coverage analysis is to assess preliminary real-time coverage results obtained from digital simulation in terms of contact (line-of-sight) times of three different spacecraft orbits as covered by the TDRSS/STDN network. The statistics are, thus, provided to determine whether the communications requirements can be satisfied in general, considering three spacecraft involved in the single mission. All spacecraft tracked are assumed to be treated as mass points in the simulation. The results cover contact times accumulated by each spacecraft throughout a mission duration of 31 hours as provided by:

- TDRSS when the spacecraft is within coverage of TDRS beams up to the altitude of 2000 km and outside the zone of exclusion (the area in which the coverage of low Earth orbits traversed by spacecraft cannot be provided by the TDRSS).
- STDN
- Communications line-of-sight between the Orbiter and either sub-satellite when not occluded by Earth.

Figures 7-45 through 7-47 are Mercator projections showing the world-wide coverage available from the TDRSS and the six ground remote sites. The circles shown on the maps represent coverage contour zones for the ground sites operating down to 5-deg antenna elevation for tracking and communications. The area (shadow zone) which is not covered by either TDRS on the projection is indicated by hachures. The zone of exclusion is shown in Figure 7-46 for an orbital altitude of 343 km. The spacecraft ground traces on the map are separated by the amount the Earth rotates plus the amount the orbital line of nodes regresses during one orbital revolution. The subsatellites are launched into higher elliptical orbits which are consequently longer in period.

A major portion of the Shuttle AMPS mission consists of the Orbiter operating in a 343-km circular orbit and its two subsatellites just released into two different elliptical polar orbits. Initial acquisition occurs as each spacecraft comes into line-of-sight with the STDN tracking stations or the TDRSS from an occluded part of its orbit. Since inception of spacecraft separation is over the equator, a combination of detailed coverage statistical sequences for TDRSS, STDN, and spacecraft communications line-of-sight in terms of contact times have been generated for each spacecraft and are plotted in Figure 7-48 for the first 15 of 31 flight hours. The bar graphs represent the data of contact intervals and time intervals between contacts for the initial 39.96-deg longitude affecting the communications coverage provided by the TDRSS and STDN. This figure is demonstrating whether each network and the Orbiter could provide continuous coverage without any gap for each subsatellite. In the TDRSS case, the missing gap is attributed to Earth occultation of the TDRS beam. Cross-hatches indicate that subsatellite No. 2 is out of the TDRS beam coverage while in its highly elliptical orbit. The two-TDRS system uses a combination of contact times achieved by each TDRS as shown on the figure. The TDRSS coverage limits are bounded by the phrase "$H \geqq 2000$ km". In the STDN case, the simulation generates the tracking times provided by the STDN of three spacecraft orbits, assuming the absence of the TDRSS. In the area of communications line-of-sight, the bars show the contact duration in which either subsatellite is in view of the Orbiter. After spacecraft separation, the distance of communications line-of-sight increases until the Earth occludes the part of orbit as the subsatellites are traversing in larger orbits. After reacquisition, the distance decreases until about the midpoint of the contact time interval, when the Orbiter and subsatellite are close to each other, and then increases until both spacecraft are out of line-of-sight. The maximum line-of-sight distance between the Orbiter and subsatellite No. 1 is determined to be approximately 6000 km and for the Orbiter and subsatellite No. 2, it is 21600 km. As shown in Figure 7-48, up/down oscillation of each subsatellite in an occultation results in many short and long gaps.

Spacecraft contact and gap statistics for the three orbits tracked by the six-station STDN subnet based on a minimum station elevation angle of 5 deg are depicted in Tables 7-10 through 7-12. Application of the station overlapping constraint, which deals with elimination of one or more overlapped stations with shorter contact times, is indicated by the phrase "overlapped; eliminated" in parentheses on the tables. The gap time in parentheses refers to a gap duration between the retained and unaffected stations. Table 7-13 provides the contact times that the spacecraft have accumulated with the TDRSS, satisfying the 100-km atmosphere constraint. Subsatellite No. 2 TDRSS contact times do not include the time the subsatellite spends outside the coverage of the TDRS beam.

Within the below/above 2000-km altitude constraint, the statistics summary covering ground and orbital coverage for the 31-hour duration is provided below:

Contact Conditions	Orbiter	Subsatellite No. 1	Subsatellite No. 2
Total Contact Time (TDRSS)	1758 min	1831 min	196 min
Total Contact Time (STDN)	-	-	1191 min
Percent of Contact Time (TDRSS + STDN)	94	98	74

Considering the TDRSS is absent, the STDN would accumulate a total contact of 116 min with the Orbiter for the same duration, 338 min with subsatellite No. 1, and 1224 min with subsatellite No. 2. It should be pointed out in the coverage statistics that, when two or more spacecraft happen to be in a view of a particular ground station at the same time, it is not necessary that the station track them simultaneously unless they happen to be within the same beamwidth of the station antenna. An examination of Figure 7-48 indicates the appearance of more than one spacecraft in a view of a particular station at several times while in different altitudes in the polar plane. In the situations involving the simultaneous tracking by the particular station, the mission timelining will dictate which spacecraft is to be tracked. Based on the constraint of TDRSS upper altitude limits, subsatellite No. 2 required a total of 18 handovers between STDN and TDRSS in the 31-hour period to ensure nearly continuous coverage. Thus, the problems of handover and slow/fast tracking rates of the TDRSS may maintain precedence of all-ground tracking for the subsatellite No. 2 mission. The all-ground tracking mode would produce 1224 min of contact with that subsatellite.

Figure 7-49 depicts a typical Sun illumination history attained for the AMPS mission. The figure represents a midnight orbital insertion on September 2, 1982. The solid bars represent the time the spacecraft spends in the sunlight, whereas the gap between sunlights indicates time in the shadow. This figure can be used as an overlay for Figure 7-48. Based on the date of insertion, the sunlight time is decreasing very gradually during the mission, due to a change in Sun declination. The average time per orbit for the Orbiter orbit is 57 min or 63 percent of the nodal period; for the subsatellite No. 1 orbit, 72 min or 71 percent; and for the subsatellite No. 2 orbit, 251 min or 92 percent.

TABLE 7-10. SHUTTLE ORBITER CONTACT AND GAP STATISTICS, SIX-STATION STDN CONFIGURATION

Minimum 5-deg Station Elevation

Probe Altitude (km): 343 by 343 (185 by 185 n. mi) Probe Inclination (deg): 90

Initial Latitude (deg): 0 Initial Longitude (deg East): 39.96 Initial Azimuth (deg): 180

Orbital Revolution Number	Time Since Insertion (hr/min/sec)	Station Name	Contact Time (min/sec)	Time Between Contacts (min/sec)	
0	No Station Contact During This Revolution				
1	0/58/28	ULA	6/38	58/28	
2	2/32/6	ULA	2/34	86/59	
	2/47/59	MAD	7/7	13/18	
3	5/6/4	ORR	5/58	130/58	
4	No Station Contact During This Revolution				
5	7/22/45	ROS	5/34	130/42	(overlapped; eliminated)
	7/24/14	MIL	6/4	0/0 (132/11)	(overlapped; retained)
6	8/53/32	ROS	5/16	83/14	(overlapped; retained)
	8/56/6	MIL	3/18	0/0	(overlapped; eliminated)
7	10/17/42	ULA	2/34	78/17 (78/53)	
	10/23/42	GDS	7/9	3/26	
8	11/47/10	ULA	6/53	76/18	
9	13/18/4	ULA	6/35	84/0	
10	14/30/30	MAD	6/18	65/49	
11	16/45/13	ORR	7/5	128/24	
12	No Station Contact During This Revolution				
13	19/2/34	MIL	2/3	130/16	
	19/4/52	ROS	1/4	0/12	
14	20/31/25	MIL	5/18	85/29	(overlapped; eliminated)
	20/32/49	ROS	5/55	0/0 (86/53)	(overlapped; retained)
15	22/3/37	GDS	6/22	84/52	
	22/14/28	ULA	1/27	4/28	
16	23/41/57	ULA	6/28	86/1	
17	25/12/53	ULA	6/21	84/27	
18	27/2/10	MAD	7/1	102/55	
	27/50/12	ORR	4/27	41/0	
19	29/20/43	ORR	4/46	86/4	
20	No Station Contact During This Revolution				

NOTES: 1. Orbital revolution No. "0" is essentially 1/2 orbit.
2. Gap time in parentheses refers to a gap duration between the retained and unaffected stations.

TABLE 7-11. AMPS SUBSATELLITE NO. 2 CONTACT AND GAP STATISTICS, SIX-STATION STDN CONFIGURATION

Minimum 5-deg Station Elevation

Probe Altitude (km): 343 by 1445 (185 by 780 n. mi.) Probe Inclination (deg): 90

Initial Latitude (deg): 0 Initial Longitude (deg East): 39.96 Initial Azimuth (deg): 180

Orbital Revolution Number	Time Since Insertion (hr/min/sec)	Station Name	Contact Time (min/sec)	Time Between Contacts (min/sec)	
0	No Station Contact During This Revolution				
1	1/2/54	ULA	15/46	62/54	
	1/30/0	MAD	2/59	11/19	
	2/19/49	ORR	3/16	46/50	
2	2/47/36	ULA	13/18	24/30	
	3/9/43	MAD	8/36	8/48	
	3/56/12	ORR	17/36	37/52	
3	4/35/24	ULA	7/24	21/35	
	5/38/39	ORR	16/8	55/50	
4	No Station Contact During This Revolution				
5	8/18/20	ROS	8/9	143/32	(overlapped; retained)
	8/20/20	MIL	7/26	0/0	(overlapped; eliminated)
6	9/51/29	ULA	7/51	83/42 (85/0)	
	10/0/41	GDS	8/0	1/19	
7	11/33/35	ULA	10/32	84/54	
8	12/55/22	MAD	11/36	71/14	
	13/15/55	ULA	10/24	8/56	
9	14/33/20	MAD	17/30	67/0	
	14/58/27	ULA	7/25	7/36	
	15/28/25	ORR	4/19	22/33	
10	16/17/30	MAD	14/25	44/45	
	17/8/23	ORR	7/58	36/28	
11	18/2/9	ROS	9/16	45/47	
	19/36/19	MIL	18/11	84/53	(overlapped; retained)
12	19/38/37	ROS	17/41	0/0	(overlapped; eliminated)
	19/58/1	ULA	5/19	1/43 (3/31)	
13	21/20/48	MIL	14/2	77/26	(overlapped; eliminated)
	21/21/54	GDS	16/27	0/0 (88/32)	(overlapped; retained)
	21/22/25	ROS	14/57	0/0	(overlapped; eliminated)
	21/34/35	ULA	11/37	0/0	(overlapped; eliminated)
14	23/3/32	GDS	17/0	77/19 (85/09)	(overlapped; retained)
	23/13/43	ULA	14/55	0/0	(overlapped; eliminated)
15	24/55/28	ULA	15/32	86/49 (94/55)	
16	26/40/4	ULA	13/4	89/3	
	27/2/10	MAD	8/21	9/1	
	27/48/38	ORR	17/38	38/6	
17	28/27/51	ULA	7/8	21/35	
	29/30/55	ORR	16/34	55/55	
18	No Station Contact During This Revolution				

NOTES: 1. Orbital Revolution No. "0" is essentially 1/2 orbit.
2. Gap time in parentheses refers to a gap duration between the retained and unaffected stations.

TABLE 7-12. AMPS SUBSATELLITE NO. 2 CONTACT AND GAP STATISTICS, SIX-STATION STDN CONFIGURATION

Minimum 5-deg Station Elevation

Probe Altitude (km): 343 by 14816 (185 by 8000 n. mi) Probe Inclination (deg): 90

Initial Latitude (deg): 0 Initial Longitude (deg East): 39.96 Initial Azimuth (deg): 180

Orbital Revolution Number	Time Since Insertion (hr/min/sec)	Station Name	Contact Time (min/sec)	Time Between Contacts (min/sec)	
0	0/30/33	ORR	154/29	30/33	(overlapped; retained)
	1/55/1	GDS	119/36	0/0	(overlapped; eliminated)
1	2/16/48	ULA	117/43	0/0	(overlapped; eliminated)
	4/9/33	MAD	16/14	0/0 (64/31)	
	5/0/25	ORR	144/42	34/38	
2	7/58/8	ULA	54/32	33/01	(overlapped; retained)
	8/45/26	ROS	14/34	0/0	(overlapped; eliminated)
	8/46/40	GDS	11/50	0/0	(overlapped; eliminated)
	8/50/0	MIL	10/35	0/0	(overlapped; eliminated)
	9/36/56	ORR	34/55	36/21 (44/16)	
	11/12/42	MAD	117/32	60/51	(overlapped, retained)
3	12/48/59	ULA	38/41	0/0	(overlapped; eliminated)
	15/5/20	MAD	156/58	97/40 (115/06)	(overlapped; retained)
	15/48/55	MIL	107/55	0/0	(overlapped; eliminated)
4	15/56/14	ROS	103/49	0/0	(overlapped; eliminated)
	16/59/20	GDS	37/9	0/0	(overlapped; eliminated)
	17/2/11	ULA	52/6	0/0	(overlapped; eliminated)
	18/15/12	ORR	11/52	20/55 (32/54)	
	19/22/27	MIL	166/51	55/23	(overlapped; retained)
	19/31/1	ROS	161/28	0/0	(overlapped; eliminated)
	19/47/20	GDS	145/37	0/0	(overlapped; eliminated)
5	20/45/4	ULA	97/26	0/0	(overlapped; eliminated)
	23/16/43	ORR	127/8	54/13	(overlapped; eliminated)
	24/9/51	GDS	152/32	0/0 (120/33)	(overlapped; retained)
	24/53/34	ULA	121/19	0/0	(overlapped; eliminated)
6	26/50/42	MAD	17/53	0/0 (8/19)	
	27/41/41	ORR	157/20	33/06	
7	30/21/41	ULA	38/19	2/40	

NOTES: 1. Orbital Revolution No. "0" is essentially 1/2 orbit.
2. Gap time in parentheses refers to a gap duration between the retained and unaffected stations.

TABLE 7-13. TDRSS/SPACECRAFT CONTACT STATISTICS, SHUTTLE AMPS MISSION

Spacecraft: Initial Latitude (deg): 0 — Initial Longitude (deg East): 39.96 — Initial Azimuth (deg) = 180

TDRSS: Initial Latitude (deg): 0 — Initial Longitude (deg East): 189 (TDRS West) and 319 (TDRS East)

Orbiter: 343 by 343 km/90 deg				Subsatellite No. 1: 343 by 1445 km/90 deg				Subsatellite No. 2: 343 by 14816 km/90 deg			
TDRS West		TDRS East		TDRS West		TDRS East		TDRS West		TDRS East	
Time Since Insertion (hr/min/sec)	Contact Time (min/sec)	Time Since Insertion (hr/min/sec)	Contact Time (min/sec)	Time Since Insertion (hr/min/sec)	Contact Time (min/sec)	Time Since Insertion (hr/min/sec)	Contact Time (min/sec)	Time Since Insertion (hr/min/sec)	Contact Time[a] (min/sec)	Time Since Insertion (hr/min/sec)	Contact Time[a] (min/sec)
0/21/11	48/23	0/0/0	27/54	0/18/42	64/33	0/0/0	135/5	0/13/42	69/38	0/0/0	125/21
1/52/15	48/11	1/4/45	51/15	2/1/24	64/14	2/53/43	60/30	4/44/55	215/59	7/5/41	90/12
3/23/3	48/32	2/37/3	48/11	3/43/21	65/35	4/37/52	58/6	15/48/24	94/22	13/47/40	20/36
4/53/30	49/50	4/8/20	48/36	5/24/7	70/54	6/20/6	59/15	22/53/4	43/02	18/23/10	26/8
6/22/50	58/03	5/39/18	48/34	7/0/49	226/25	8/0/27	67/29	27/27/23	17/21	22/44/12	93/18
7/36/20	47/28	7/10/1	49/05	11/25/7	60/52	9/32/26	139/36			30/18/19	34/46
8/29/57	61/45	8/40/20	50/51	13/9/28	59/9	12/4/6	78/20				
10/10/44	50/21	10/8/57	47/39	14/51/49	59/3	13/55/28	66/55				
11/42/33	58/57	12/24/5	54/13	16/32/22	66/12	15/39/27	64/32				
13/13/44	48/32	13/58/31	49/28	18/5/53	142/7	17/22/9	64/14				
14/44/38	48/39	15/30/5	48/26	20/31/14	83/0	19/4/4	65/28				
16/15/16	49/23	17/1/10	48/12	22/26/44	67/16	20/44/46	71/4				
17/45/20	52/05	18/32/0	47/32	24/10/55	64/37	22/21/7	226/58				
19/12/8	104/17	20/2/30	49/38	25/53/41	64/12	26/46/14	60/41				
21/31/23	51/45	21/32/4	55/27	27/35/39	65/27	28/30/27	58/8				
23/4/10	49/02	22/51/11	109/58	29/16/28	70/17	30/12/46	47/14				
24/35/32	48/18	25/19/26	50/38	30/53/24	6/36						
26/6/32	48/13	26/51/25	49/1								
27/37/17	48/41	28/22/38	48/33								
29/7/38	50/21	29/53/33	48/37								
30/36/27	23/33										

a. For 343 by 14816 km/90 deg orbit, incremental times already deducted for spacecraft out of TDRS beam coverage.

NOTES: 1. Cutoff time at 31 hours.
2. TDRS Steering Angle, β = 26 deg.
3. 100-km atmosphere.

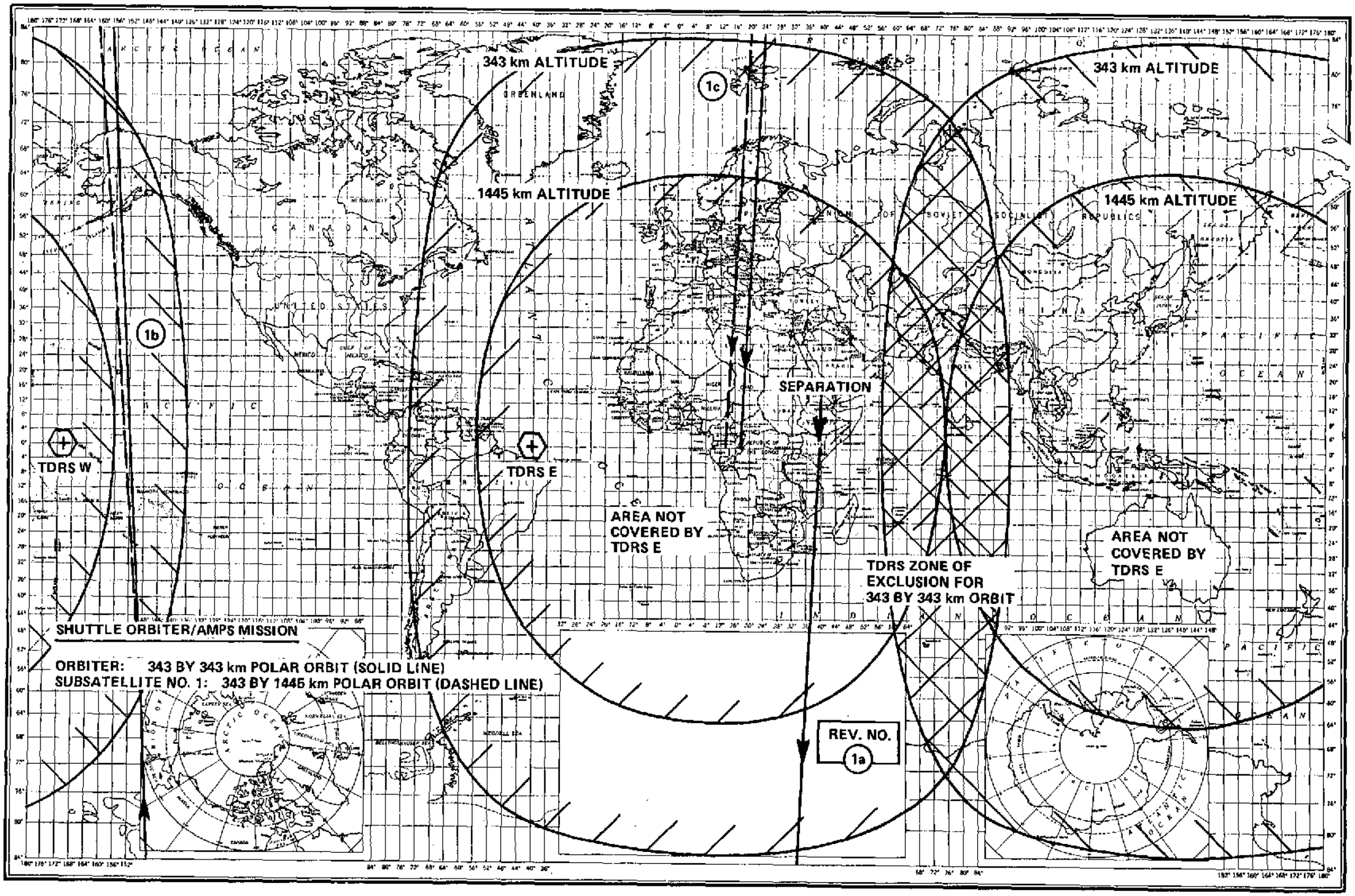


Figure 7-45. TDRSS tracking of Shuttle Orbiter and AMPS subsatellite No. 2, first orbit.

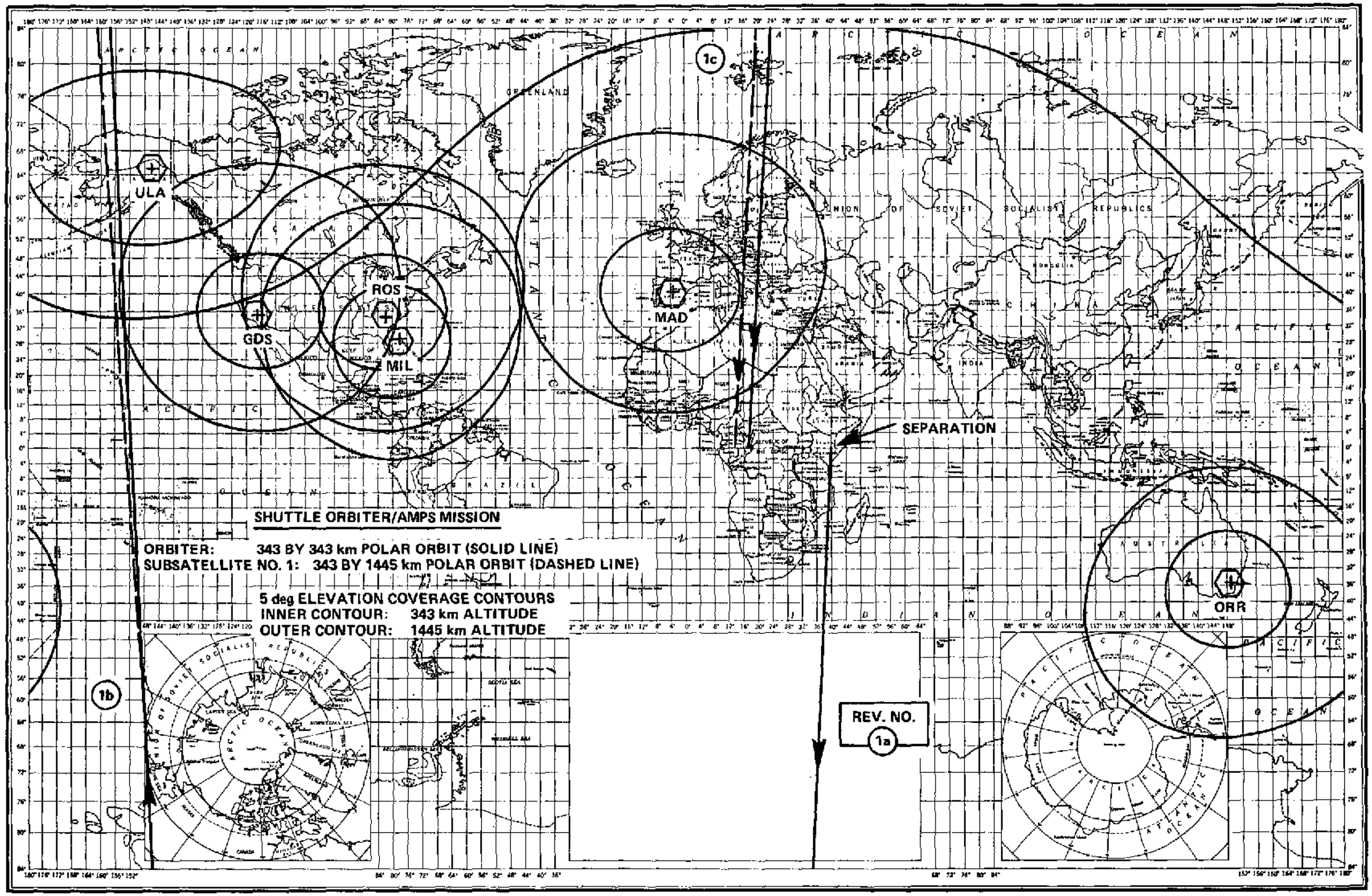


Figure 7-46. STDN tracking of Shuttle Orbiter and AMPS subsatellite No. 1, first orbit.

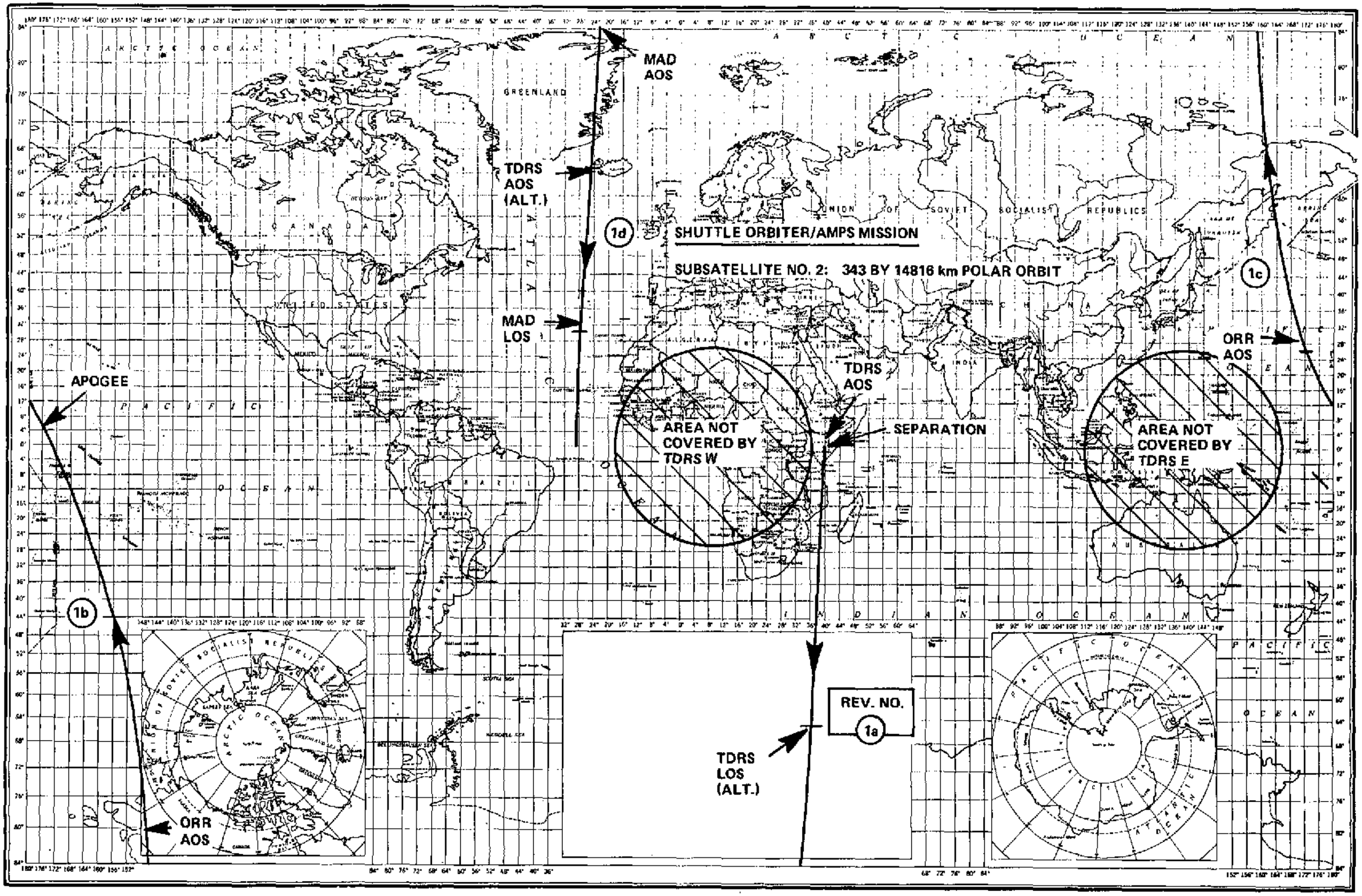


Figure 7-47. TDRSS/STDN tracking of AMPS subsatellite No. 2, first orbit.

SPACECRAFT	ORBITS
ORBITER	343 BY 343 km/90 deg
SUBSATELLITE NO. 1	343 BY 1445 km/90 deg
SUBSATELLITE NO. 2	343 BY 14816 km/90 deg

INIT. LAT. (deg): 0
INIT. LONG. (deg EAST): 39.96
INIT. AZ. (deg): 180
TDRS STEER ANG. (deg): 26

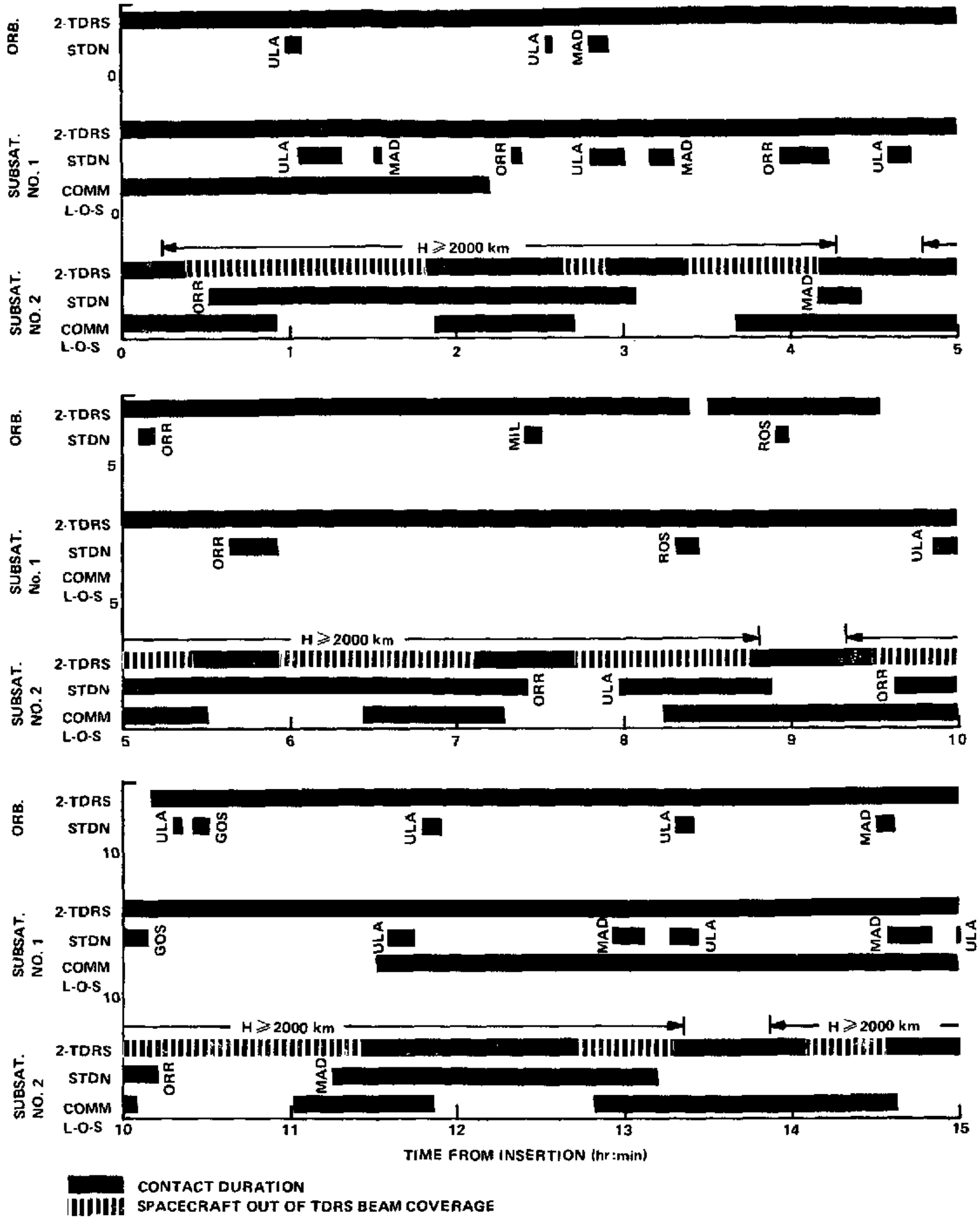


Figure 7-48. TDRSS/STDN coverage statistics, Shuttle AMPS mission.

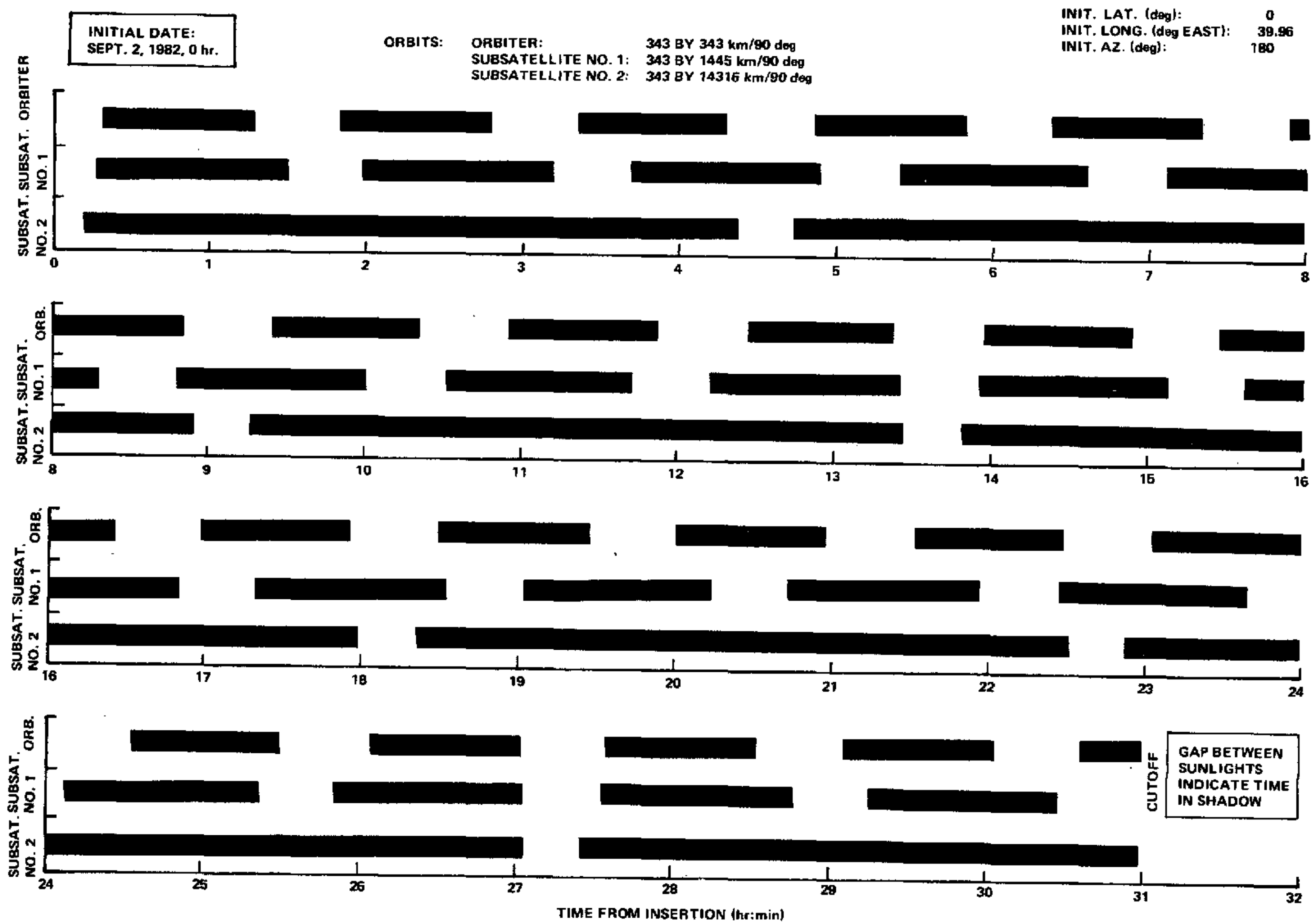


Figure 7-49. Sun illumination history for Shuttle AMPS mission.

SECTION 8.0 CREW SYSTEMS

8.0 CREW SYSTEMS

The systems integration effort in the Atmospheric Magnetospheric and Plasmas in Space (AMPS) study has been concentrated on better definition of the crew/systems interface. The first interface requirements examined were those for control and display (C&D). The panel area requirements derived from the Shuttle System Payload Description (SSPD) document grossly exceed the area available in the Orbiter flight deck (Table 8-1). Therefore, the AMPS mission should be flown with a pressurized module plus pallet or the controls and displays should be reduced an order of magnitude. Some of the volume allocated for C&Ds by the SSPD is inappropriate because it is assigned to stowage of photographic film, cameras, etc. (auxiliary equipment). Also, Spacelab will be providing some of the capabilities currently furnished by C&Ds listed in the SSPD. Finally, the SSPD contains some equipment redundancies.

To refine AMPS panel space requirements, a command function list (Fig. 8-1) was generated from the SSPD listing of AMPS instruments. It was punched out on computer cards to make it flexible. The function list was reviewed by several scientists at MSFC and their comments were documented. An experiment/instrument matrix was made and functional groups were defined (Fig. 8-2).

Revised panel space requirements were reflected on a preliminary layout of the AMPS pressurized module. The layout assumes discrete, dedicated controls and displays on each instrument (Fig. 8-3). The extent of use of automation and multifunction controls and displays is an issue worthy of extensive study. The approach depicted in Figure 8-3 represents a maximal panel space requirement. Using it as a point of departure, AMPS controls and displays can evolve into a more sophisticated facility without losing sight of the original requirements or capabilities. Since AMPS will be flying frequently and is a facility type payload, many operations may be candidates for automation.

The current concept verification testing plan (CVT) for the support module controls and displays (Fig. 8-4) depicts 2 deg of freedom hand controllers at two adjacent work stations. The CVT support module is supposed to represent the Spacelab support module. If a manual mode is required for controlling booms or for flying the subsatellite, a two-axis hand controller is inadequate. That would dictate serial operations which are too slow to be practical or safe.

The Atmosphere Explorer satellite, baselined for the study, was also investigated. As currently configured it has only a yaw thruster, two ΔV thrusters, two attitude control coils, and a momentum wheel for translation and attitude control (Fig. 8-5). Such controls may not be flexible or responsive enough to allow the subsatellite to play the active role during retrieval.

Recommendations made to date include:

1. Pressurized module should be used for AMPS due to current panel space requirements.

2. Experiment and support hardware should be grouped in the pressurized module for concurrent or staggered experiment operation.

3. A trade study should be done to determine applicability of multifunction displays and controls.

4. AMPS C&D requirements need to be coordinated with the labs.

5. Tracking and control requirements for deployable units should be better defined.

6. Subsatellites and their operations require better definition.

For the next few months, attention will be focused upon a preliminary failure mode effects analysis (FMEA), a task analysis, and a continuation of the C&D definition. Results from Skylab and ASSESS indicate that the primary roles of man in spacecraft should be to adapt the science to the situation on orbit and to enhance reliability by real-time troubleshooting and repair.

The FMEA should identify areas where repair tasks/redundancy would be beneficial on the short AMPS missions. The detailed task analysis should indicate functional relationships among tasks, equipment, and operational constraints.

TABLE 8-1. AMPS C&D PANEL SPACE REQUIREMENTS[a]

Ref. No.	Category	Area (ft^2)
Displays		
AP 801-816	General Displays	28
AP 817-824	Computing Equipment	21
AP 827-832	Auxiliary Equipment	18
AP 833-845	Remote Sensing Platform Controls	16
Subtotal		83
Controls		
AP 901-904	Transmitters	2.6
AP 905-908	Antennae	3.3
AP 909-911	Antenna Couplers	3.2
AP 912-925	Wave Analysis	17
AP 926-932	Accelerator Control	4.6
AP 933-937	Electron Beam	3.3
AP 938-942	MPD Arc	3.3
AP 943-955	Ambient Plasma Instrument Control	10
AP 956-960	Deployable Satellite	6.7
AP 961-963	Optical	4.3
AP 964-970	Projectiles	5.3
Subtotal		64
Total		147

a. Rack space allocated: $13 \times 1.8 \times 7.7 = 180\ ft^2$

Difference: 180-147 = 33

Rationale: Growth and packaging inefficiency

AP 100 REMOTE SENSING PLATFORM SYSTEM
AP 101 REMOTE SENSING PLATFORM
- GIMBAL CONTROLS
  - SECURE/RELEASE
- X-AXIS
  - ON/OFF
  - ANGLE SELECT
- Y-AXIS
  - ANGLE SELECT
  - ON/OFF
- TRACK MODE SELECT
  - MANUAL
  - INERTIAL
  - TARGET
  - SCAN
- SUN SHIELD
  - SECURE/RELEASE
  - EXTEND/RETRACT
- INSTRUMENT POWER
  - ON/OFF

AP 102 XUV NORMAL INCIDENCE SPECTROMETER
- ON/OFF
- VIDICON GAIN
- WAVELENGTH RANGE
- SCAN SPEED SELECT
- CAMERA INTEGRATION TIME
- CALIBRATION ENABLE/INHIBIT
- APERTURE DOOR

AP 103 UV-VISIBLE-NIR SCANNING SPECTROMETER
- ON/OFF
- WAVELENGTH RANGE
- SCAN SPEED SELECT
- SLIT WIDTH
- RESOLUTION
- SENSITIVITY
- SLIT HEIGHT
- DETECTOR SELECT
- GRATING SELECT
- COLLECTOR POSITION

AP 104 HIGH RESOLUTION FOURIER SWIR SPECTROMETER
- ON/OFF
- FIELD OF VIEW
- COOLER ON/OFF
- SCAN RATE
- CALIBRATION ENABLE/INHIBIT
- CALIBRATION TEMP. SELECT
- RESOLUTION
- INTEGRATION TIME

AP 105 CRYOGENIC IR FOURIER SPECTROMETER
- ON/OFF
- FIELD OF VIEW
- RESOLUTION
- INTEGRATION TIME
- CALIBRATION ENABLE/INHIBIT
- RANGE SELECT
- CALIBRATION TEMP. SELECT

AP 106 IR RADIOMETER
- ON/OFF
- FREQUENCY RANGE SELECT

AP 107 FABRY-PEROT INTERFEROMETER
- ON/OFF

AP 108 FILTER PHOTOMETER

Figure 8-1. Sample of command function list.

INSTRUMENTS	EXPERIMENT CATEGORY	GENERAL PLASMA PHYSICS IN SPACE XAP 108	ENERGETIC PARTICLES AND TRACERS XAP 104	MAGNETOSPHERIC MODIFICATION XAP 107	BEAM-PLASMA INTERACTIONS XAP 103	WAVE AND SHEATH EXPERIMENTS XAP 105	PROPULSION AND DEVICES XAP 106	WAVE-PARTICLE INTERACTIONS XAP 102	WAVE CHARACTERISTICS XAP 101	ION AND NEUTRAL MASS DISTRIBUTIONS XAP 306	LASER EXCITATION XAP 308	IR SPECTRAL DISTRIBUTION XAP 303	XUV SPECTRAL DISTRIBUTION XAP 301	VISIBLE LINE SPECTRA XAP 302
REMOTE SENSING PLATFORM	101	X	X	X	X	X	X	X	X	X	X	X	X	X
XUV NORMAL INCIDENCE SPECTROMETER	102	X	X	X	X						X		X	
UV-VISIBLE-NIR SCANNING SPECTROMETER	103	X	X	X	X						X	X	X	X
HIGH-RESOLUTION FOURIER SWIR SPECTROMETER	104	X	X	X	X						X	X		
CRYOGENIC IR FOURIER SPECTROMETER	105	X	X	X	X						X	X		
IR RADIOMETER	106	X	X	X	X						X	X		
FABRY-PEROT INTERFEROMETER	107	X	X	X	X						X	X	X	X
FILTER PHOTOMETER	108	X	X	X	X						X	X	X	X
UV-VISIBLE DOCUMENTATION CAMERAS	109	X	X	X	X								X	X
ION MASS SPECTROMETER (G1)	110	X	X	X	X	X	X	X	X	X				
NEUTRAL MASS SPECTROMETER (G2)	111	X	X	X	X	X	X	X	X	X				
ELECTROSTATIC ANALYZER (G3)	112	X	X	X	X	X	X	X	X	X				
MAGNETIC ANALYZER (G4)	113	X	X	X	X	X	X	X	X	X				
KeV MeV PARTICLE DETECTOR (G5)	114	X	X	X	X	X	X	X	X	X				
TOTAL ENERGY DETECTOR (G6)	115	X	X	X	X	X	X	X	X	X				
CYLINDRICAL PROBE (G9)	116	X	X	X	X	X	X	X	X	X				
SEGMENTED PLANAR PROBE (G10)	117	X	X	X	X	X	X	X	X	X				
RF PROBE (G11)	118	X	X	X	X	X	X	X	X	X				
PLANAR PROBE (G12)	119	X	X	X	X	X	X	X	X	X				
TRANSMITTER/RECEIVER	201	X									X			
MOUNT, COMPUTER CONTROLLED	202	X									X			
ION ACCELERATOR (A-1)	301	X	X	X	X									
STORAGE BANKS 2-5 KILOJOULES - HV (A-2)	302	X	X	X	X									
GIMBALED ELECTRON ACCELERATOR (A-3)	303	X	X	X	X									
MPD ARC, INCLUDING CONDENSER BANK (A-4)	304	X	X	X	X		X							
TRANSMITTER/COUPLER (10 kW .2 TO 2 MHz) (T1)	401	X		X										
TRANSMITTER/COUPLER (10 kW 2 TO 20 MHz) (T2)	402	X		X										
TRANSMITTER/COUPLER (1 kW .3 TO 200 kHz) (T3)	403	X		X		X								
DIPOLE ELEMENT - 330 METER	404	X		X		X								
50-METER BOOM A (BA)	501	X	X	X	X	X	X	X	X	X				
GIMBALED PLATFORM (BA1)	502	X	X	X	X	X	X	X	X	X				
5-METER BOOM K (BA2)	503	X	X	X	X	X	X	X	X	X				
ONE METER LOOP (BA3)	504	X	X	X	X	X	X	X	X	X				
SHORT ELECTRIC DIPOLE (BA4)	505	X	X	X	X	X	X	X	X	X				
TRIAXIAL SEARCH COIL (BA5)	506	X	X	X	X	X	X	X	X	X				
5-METER BOOM L (BA6)	507	X	X	X	X	X	X	X	X	X				
RUBIDIUM MAGNETOMETER (BA7)	508	X	X	X	X	X	X	X	X	X				
TRIAXIAL FLUXGATE (BA8)	509	X	X	X	X	X	X	X	X	X				
33-METER ELECTRIC DIPOLE - EXTENDIBLE (BA9)	510	X	X	X	X	X	X	X	X	X				
POWER SUPPLY (BA10)	511	X	X	X	X	X	X	X	X	X				
DATA SYSTEM (BA11)	512	X	X	X	X	X	X	X	X	X				
ALIGNMENT TV (BA12)	513	X	X	X	X	X	X	X	X	X				
ION MASS SPECTROMETER (BA13)	514	X	X	X	X	X	X	X	X	X				
SPHERICAL ION PROBE (BA14)	515	X	X	X	X	X	X	X	X	X				
CYLINDRICAL ION PROBE (BA15)	516	X	X	X	X	X	X	X	X	X				
PLANAR SEGMENTED PROBE (BA16)	517	X	X	X	X	X	X	X	X	X				
NEUTRAL MASS SPECTROMETER (BA17)	518	X	X	X	X	X	X	X	X	X				
TRIAXIAL HEMISPHERICAL ANALYZER (BA18)	519	X	X	X	X	X	X	X	X	X				
PLANAR ELECTRON TRAP (BA19)	520	X	X	X	X	X	X	X	X	X				
50-METER BOOM B (BB)	521	X				X								
WAVE GENERATOR (BB1)	522	X						X	X					
TARGET (BB2)	523	X				X								
BARIUM CANISTER, 100 gm (DBC1)	601	X	X											
BARIUM CANISTER, 1 kg (DBC2)	602	X	X											
BARIUM CANISTER, 10 kg (DBC3)	603	X	X											
SHAPED CHARGE, 1 kg (DSC1)	610	X	X											
SHADED CHARGE, 5 kg (DSC2)	611	X	X											
SHADED CHARGE, 10 kg (DSC3)	612	X	X											
BALLOON-SPHERICAL INSULATED (DB1)	620	X				X								
BALLOON-SPHERICAL CONDUCTING (DB2)	621	X				X								
DEPLOYABLE SATELLITE SYSTEM	700	X	X	X	X	X	X	X	X	X				

Figure 8-2. Instrument/experiment matrix.

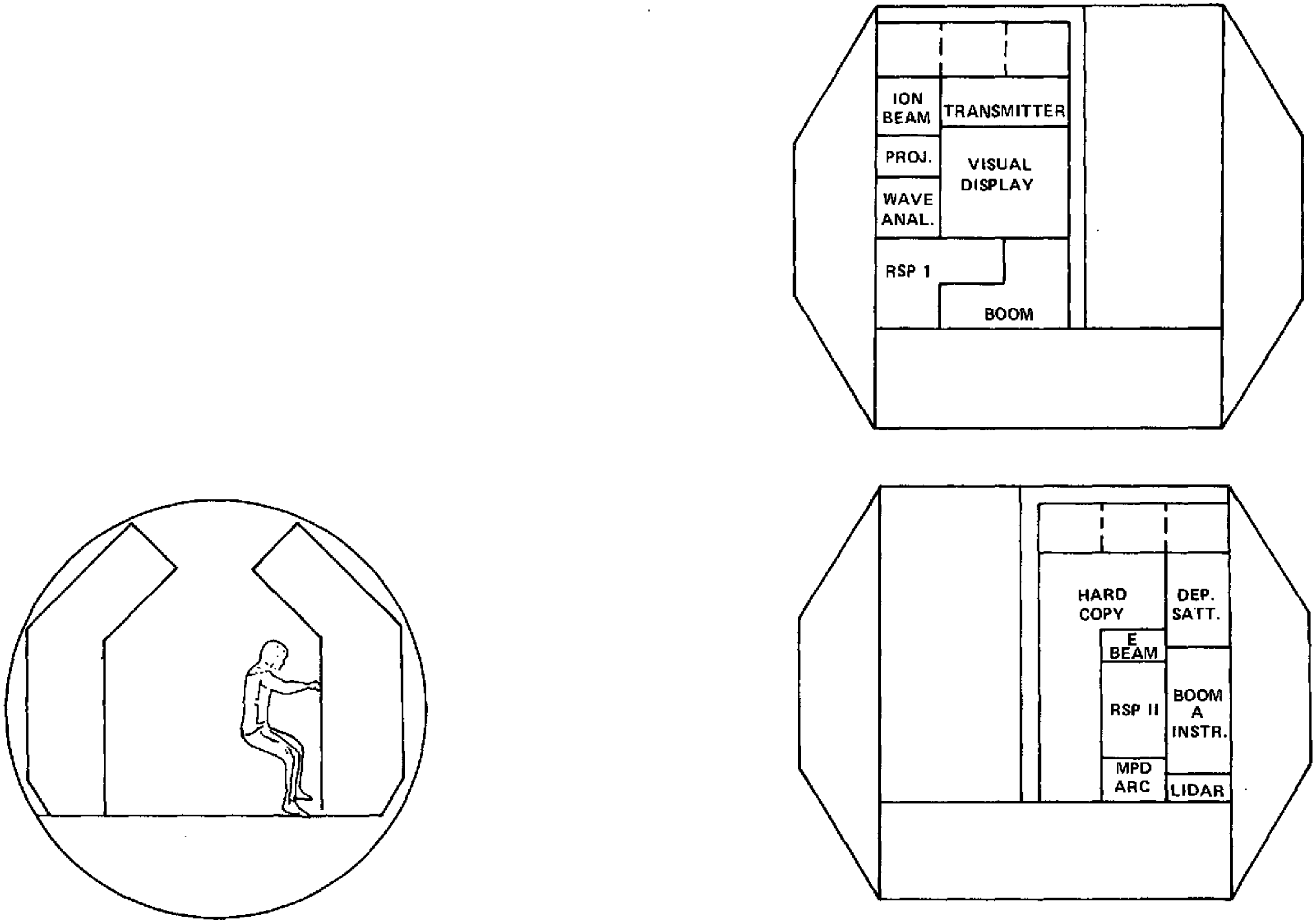
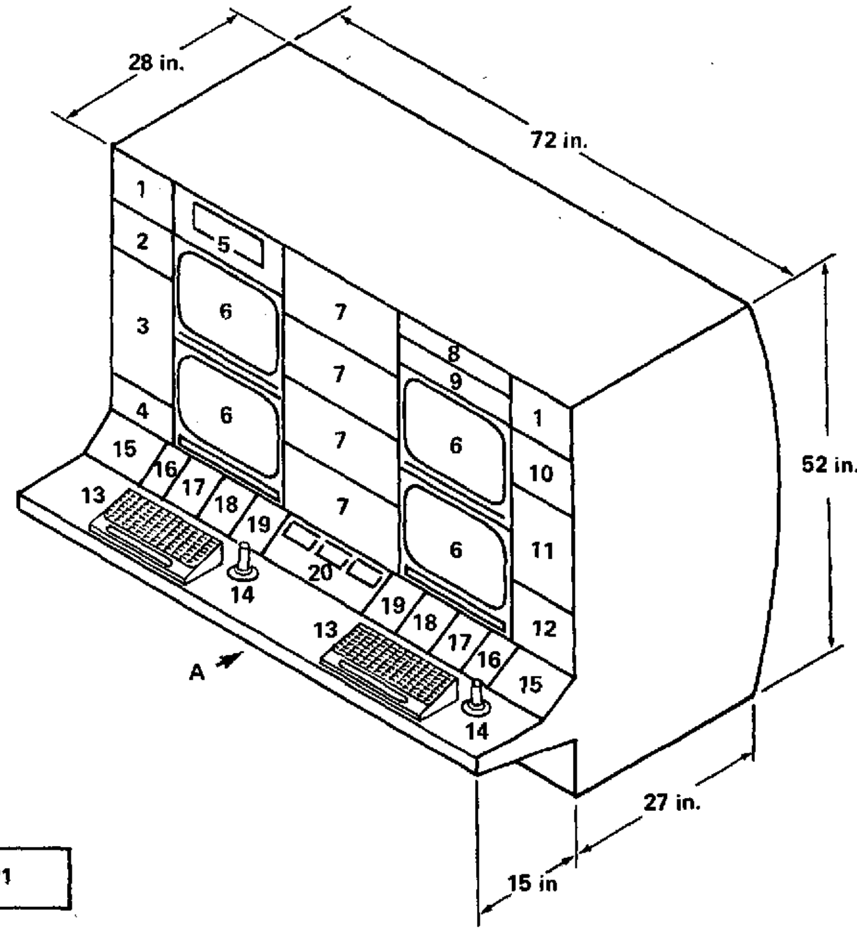
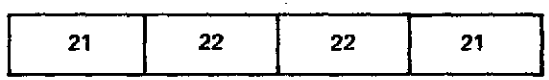


Figure 8-3. Inboard layout of Spacelab.

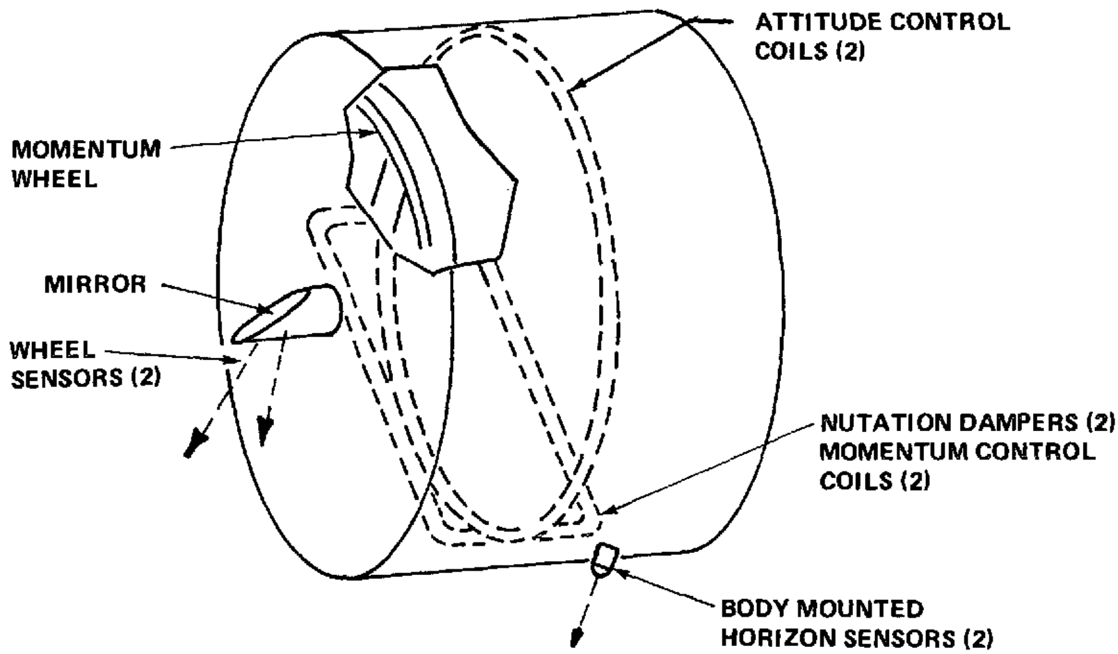
1. VIDEO SWITCHING UNIT
2. COMPUTER CONTROLS
3. ELECTRICAL POWER SUBSYSTEM DEDICATED C&D
4. CONSOLE CIRCUIT BREAKERS
5. ADVISORY PANEL
6. CRT DISPLAY INDICATOR UNIT
7. EXPERIMENT DEDICATED C&D
8. CAUTION & WARNING
9. TBD
10. DATA ACQUISITION DEDICATED C&D
11. ENVIRONMENT CONTROL SUBSYSTEM DEDICATED C&D
12. STABILITY & ATTITUDE CONTROL SUBSYSTEM DEDICATED C&D
13. ALPHANUMERIC KEYBOARD
14. HAND CONTROLLER
15. TAPE RECORDER CONTROLS
16. MICROFILM TO VIDEO CONVERTER CONTROLS
17. AUDIO UNIT
18. CCTV CONTROLS
19. VIDEO SWITCHING CONTROLS
20. TIME DISPLAY UNIT
21. MULTIFUNCTION DISPLAY SYMBOL GENERATOR
22. MICROFILM TO VIDEO CONVERTER



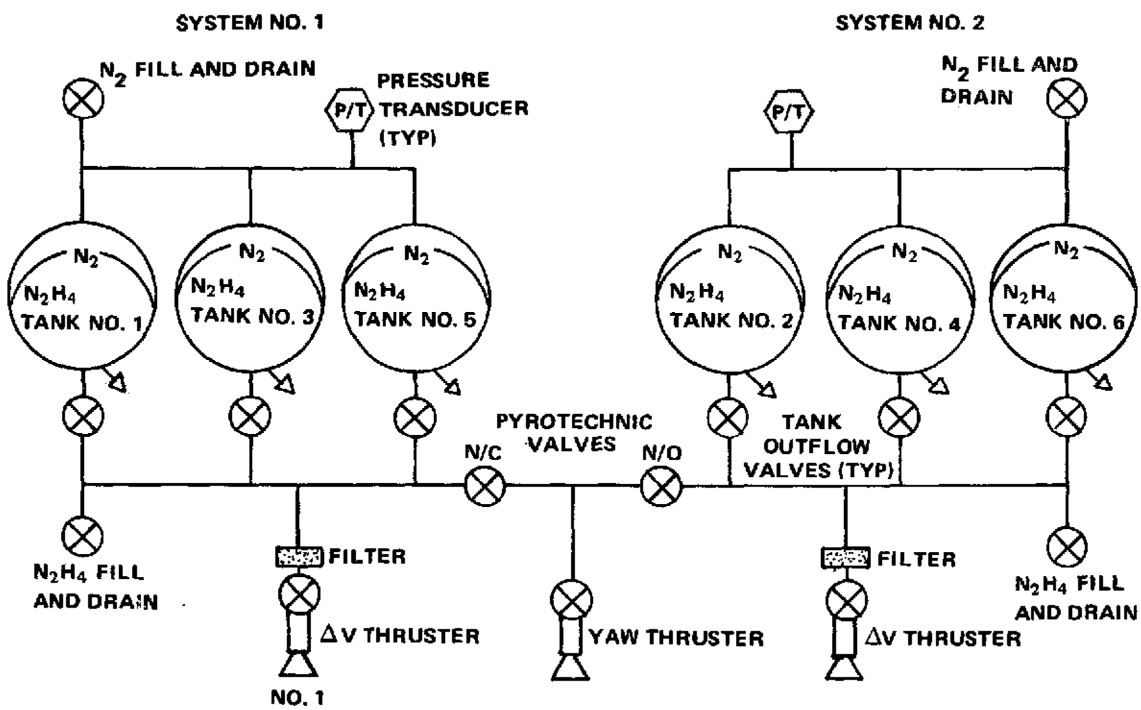


A-A

Figure 8-4. Support Module C&D.



a. Attitude control components.



b. Propulsion subsystem schematic.

Figure 8-5. Atmosphere Explorer satellite configuration.

SECTION 9.0 CONCLUSIONS AND RECOMMENDATIONS

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

The Atmospheric, Magnetospheric and Plasmas in Space (AMPS) payload baselined for the Phase A Study is a complex scientific laboratory facility which utilizes the full capabilities of the Space Shuttle and Spacelab and requires a flexibility and adaptability in design not required in space flight heretofore. It has become apparent that AMPS must evolve into a facility of scientific and support systems which are to support not only the program objectives currently being identified but also the advanced instrumentation concepts and experimental techniques of the future. The ability to adapt to a variety of scientific and economic environments must be the hallmark of the AMPS program.

A major input to this study was the Shuttle System Payload Descriptions (SSPD) Level B data on the AMPS payload (AP-06-S). Those data provided the initial scientific instrument descriptions and interface requirements and, for the most part, remained unchanged throughout the study. It is anticipated that the AMPS Scientific Working Group will have identified, in the near future, instrumentation characteristics and experimental procedures which will more closely resemble the ultimate AMPS facility. An update to this document, reflecting the recommendations of the Working Group, is planned.

The following observations are some of the more significant ones which have been identified in the Phase A Study.

9.1.1 Configuration

It was determined that the Spacelab configuration most suited to the Phase A baseline payload was one consisting of the 2.7 m core pressurized module segment with three 3 m pallet segments. A number of configuration options were addressed, most of which are discussed in Section 4. Because of an understandable lack of experiment definition and because of the physical size of the payload, there remains some concern about the capability of the core segment to house the necessary controls and displays and about the consistency of the payload with Orbiter center of gravity of mass constraints. These concerns, although not of major significance at this time, are currently being addressed through close interaction with the Working Group and through involvement with the development of Spacelab and Orbiter accommodations.

9.1.2 Structures

Emphasis in the structural design and analysis area was placed on the 50 m booms and the 600 m (tip-to-tip) dipole antenna. It seems that the wake and sheath experiments drive the design of the booms since they may require rapid movement with large accelerations. Analytical studies have indicated that the assumed boom deflection limit (±0.5 deg relative to the base of boom) is exceeded during some portions of the experiment. Methods for reducing these errors (e.g., more optimum wake tracing pattern) will be investigated in subsegment study of the boom system. Recent discussions with AMPS Science Working Group members and additional analysis (not contained here) indicate that the assumed boom deflection limit and scan pattern are unnecessarily restrictive and that the analytically proven boom system performed is quite acceptable.

The mechanism assumed for radiating energy from the transmitter/coupler system is a 600 m (tip-to-tip) dipole antenna. Both dynamic and thermal deflections have been investigated. It is felt that thermal deflections can be brought within an acceptable range. The dynamics deflections, however, resulting from Orbiter limit cycling with the possibility of frequency coupling suggest that experiments which utilize the antennas be clustered so that the antenna can be extended only when needed.

9.1.3 Thermal Control

For the orbital parameters and heat loads assumed (consistent with the baseline reference design), no thermal difficulties were identified. All pallet mounted instruments can be passively controlled on-orbit except the particle accelerators, the lidar, and the transmitter/coupler which appear to require active cooling from the fluid loop. The thermal response of the instruments during ascent and reentry was determined. No out-of-tolerance conditions arose.

9.1.4 Pointing and Control

It is felt at this time that, except for the remote sensing platform (RSP), all pointing and control requirements can be satisfied by the Orbiter (0.16 deg accuracy). It was assumed that the lidar system included a computer controlled mount. Seven gimbal systems, of various sizes, are required for the remote sensing platform, for both booms, for the instrument platform at the end of the passive boom, for the accelerator system (three accelerators controlled by the same set of gimbals) for the lidar, and for the star tracker (double gimbaled). The pointing requirements of the RSP instruments dictate the inclusion of a three-axis gyro reference unit. Analyses indicate that the 3 arc min accuracy requirement can be met (1.5 arc min demonstrated analytically) with existing technology. The 2 arc sec stability and 0.2 arc sec stability rate requirements are very difficult to satisfy and their need should be more clearly defined. On the full complemented AMPS reference configuration, attitude reference is provided by a double gimbaled star tracker and the RSP gyros. During missions when the RSP is not flown, attitude reference will probably be assisted by a separate, pallet mounted, gyro package possibly similar to the RSP gyros.

9.1.5 Communication and Data Management

Analyses to date indicate that the Orbiter/Spacelab command and voice system is adequate to satisfy the assumed AMPS requirements. The real-time downlink transmission requirement of approximately 2 MBPS (mostly lidar data) cannot be accommodated by the Orbiter as currently defined. Proposed Orbiter changes now being evaluated include a 50 MBPS digital and a 10 MHz downlink through the Tracking and Data Relay Satellite System (TDRSS). An RF command and data transfer system for the 50 m passive boom is feasible but is somewhat more complex and heavier than a corresponding hardwire data bus approach.

The AMPS subsatellites [e.g., Atmosphere Explorer (AE) type] are currently quoted as requiring a 400 kbs digital data rate which is to be received by the Orbiter. The Orbiter can accpet only 16 kbs. A separate AMPS-provided receiver/antenna system has been proposed for location on the pallet to satisfy this requirement. A 1 m parabolic antenna can accept 400 kbs from a redesigned AE communications system (existing AE transmits at 16 kbs) at distances up to approximately 1200 km.

The data management system provided by Spacelab is judged adequate to satisfy AMPS requirements except possibly for computer data processing. A need for a somewhat faster machine has been suggested.

9.1.6 Electrical Power Subsystem

Electrical power for AMPS is provided by an Orbiter dedicated fuel cell with approximately 4.0 kW available for the science payload. The large power users such as the lidar, transmitter, and the particle accelerators will interface with a capacitor bank. Based on the experiment operational timeline, the average power required by AMPS scientific instruments is approximately 2.5 kW (380 kW-h).

The range of voltage requirements [500 V for the magnetoplasmadynamic (MPD) arc, 20 kV for ion accelerator] suggests the use of two different capacitor banks. For the transmitter/coupler, the electron accelerator, and the lidar, a 300 lb, 20 kJ, 100 μF capacitor was chosen, whereas for the MPD arc a 1200 lb, 100 kJ, 0.8 F unit seems most appropriate.

9.1.7 Controls and Displays

The control and display (C&D) systems located within the Spacelab pressurized module are the primary means for real-time control and interaction by the onboard experimenters with the experiment performed via the pallet mounted instruments. Considering the need for ground-based/laboratory-like experimenter involvement and the need for extreme flexibility in control and display system design to adapt to the various payload complements, preliminary data management and human engineering analyses were performed to arrive at control and display system design characteristics for the individual instruments and the complete, flight-dedicated, AMPS payload. The Spacelab multifunction display system is utilized whenever practical.

These studies have indicated a need for approximately 9.3 m^2 (100 ft^2) of panel area. The 2.7 m Spacelab core module can accommodate up to six payload-dedicated racks for a total area of approximately 8.82 m^2 (94.9 ft^2). Although additional panel space is desirable, it is concluded at this point that the Spacelab core module can accommodate the AMPS controls and displays.

9.1.8 Subsatellite Flight Mechanics

Two types of subsatellites are being considered to support AMPS experiments operations: (1) A subsatellite designed to operate in the near vicinity of the Orbiter (less than 50 km) and (2) a subsatellite designed to operate in non-co-orbit with respect to the Orbiter.

With regard to operation in the near vicinity of the Orbiter, results have been obtained to indicate how the relative movement of the subsatellite can be controlled by the initial selection of impulse direction and magnitude.

Suggested candidate spacecraft configurations to satisfy the non-co-orbiting subsatellite requirements (e.g., operate in orbits with periods several times that of the Orbiter) are: (1) AE type spacecraft and (2) a spacecraft which uses the third stage of the Scout launch vehicle as the major propulsion system. The AE spacecraft propulsion system can provide a ΔV of 2000 ft/sec. The AE is capable of attaining orbits with periods up to 1.1 times those attainable by the Orbiter, and up to 1.25 times orbit period of the Orbiter, if the spacecraft is not returned. If the third stage of the Scout is used then periods of 1.3 and 1.9 times those of the Orbiter can be obtained for spacecraft return and no-return, respectively.

9.1.9 Experiment/Crew Timelines

Experiment operational timelines and crew activities timelines have been developed for a polar and a low inclination AMPS mission. A basic assumption was made that only one experiment is performed at a time. These timelines have been used to assist in the sizing of support systems (power, data) and in assessing the compatibility of experiment/instrument requirements. These timelines are dynamic and will continue to be updated and refined as better information on experiment operations is developed.

9.1.10 Ground Operations

A major objective in this area was to develop a reasonable ground operations plan that is consistent with Shuttle and Spacelab operations. The block flow design has been established for routine AMPS ground operation. AMPS equipment descriptions have been compiled for most items based on the assumption that each item is similar to some piece of hardware flown in the past. For estimating manpower and ground support equipment requirements it is not essential that precise characteristics and capabilities of the equipment be known; consequently, the information compiled from historical data is adequate for operations studies.

9.1.11 Tracking Analysis

The objective of the preliminary tracking coverage analysis is to assess the contact (line-of-sight) time statistics obtained for the AMPS mission as covered by the TDRSS. The type of statistical data developed is essential for detailed mission timelining, orbital maneuver sequencing, and determination of

ΔV requirements and may have an impact in the orbital operation of subsatellites. Contact time statistics for each orbit as covered by the TDRSS/Spaceflight Tracking and Data Network (STDN) have been obtained and plotted. These parametric data are essential for the planned detailed studies of AMPS orbital operations.

9.1.12 Crew Systems

The number and type of AMPS payload specialists and the activities which they will perform within the Spacelab pressurized module are directly dependent upon mission objective, the instrumentation carried, the type of experiments performed, and the degree of interaction required between the payload specialist (onboard experimenter) and the experiment. The Atmospheric Science and Space Physics community indicates a desire for a high degree of experiment controllability by the payload specialist.

A preliminary listing of instrument/experiment command, control and display interface requirements has been developed. The corresponding C&D panel layout has been developed. This preliminary information is expected to serve as a sound basis for more detailed studies based on the recommendations of the AMPS Working Group.

9.2 RECOMMENDATIONS

It shall be mandatory that further AMPS-related studies be appropriately coordinated with the activities and recommendations of the AMPS Science Working Group. The following are some of the more significant items identified in the Phase A Study as requiring additional study:

1. With regard to programmatics, an evolutionary approach to AMPS program buildup must be constructed. This approach must support the development of an AMPS facility characterized by flexibility and adaptable to unknown instrument requirements and experimental techniques.

2. To support the need for maximum science return for minimal cost, the applicability of standard off-the-shelf designs and hardware must be seriously investigated. In particular, the use of NIM, CAMAC and ARINC standard electronics modules for instrument/experiment control must be studied.

3. AMPS scientific instrument and experiment support and interface requirements must be thoroughly reviewed to identify and justify the need for support equipment other than that provided by Spacelab. In particular, the need for long booms, gimbal mounts, subsatellites, and energy storage devices should be investigated from both a scientific and economic viewpoint. Alternate means for satisfying the requirements must be studied.

APPENDIX

SHUTTLE SYSTEM PAYLOAD DESCRIPTIONS, LEVEL B DATA

SORTIE PAYLOAD
DEFINITION AND REQUIREMENTS DATA
LEVEL B

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

PAYLOAD NO. AP-06-S

SHEET NO.	TITLE
S-1	MISSION DEFINITION PARAMETERS
S-2	OBJECTIVES
S-3	EXPERIMENT/EQUIPMENT MATRIX
S-4	EXPERIMENT EQUIPMENT CHARACTERISTICS
S-5	SKETCHES - PRESSURIZED EQUIPMENT
S-6	SKETCHES - UNPRESSURIZED EQUIPMENT
S-7	INTERFACE DIAGRAM(S)
S-8	EXPERIMENT EQUIPMENT - POWER & DATA
S-9	IN-FLIGHT EXPERIMENT EQUIPMENT ENVIRONMENTAL LIMITS: NON-OPERATING
S-10	IN-FLIGHT EXPERIMENT EQUIPMENT ENVIRONMENTAL LIMITS: OPERATING
S-11	IN-FLIGHT CONTAMINATION CONTROL CRITERIA
S-12	ORIENTATION, POINTING AND STABILITY REQUIREMENTS
S-13	FLIGHT OPERATIONS
S-14	EXPERIMENT OPERATIONAL CYCLE
S-15	PAYLOAD OPERATIONAL TIMELINE
S-16	PAYLOAD PERSONNEL SKILLS AND EVA/IVA REQUIREMENTS
S-17	PAYLOAD MISSION CONSUMABLES
S-18	PAYLOAD ELECTRICAL POWER REQUIREMENTS
S-19	DATA ACQUISITION AND MANAGEMENT
S-20	DATA DISPOSITION AND COMMUNICATIONS
S-21	PAYLOAD IN-FLIGHT ENVIRONMENTAL LIMITS
S-22	LAUNCH/LANDING SUPPORT REQUIREMENTS
S-23	GROUND FACILITY REQUIREMENTS
S-24	GROUND ENVIRONMENTAL LIMITS
S-25	PAYLOAD SAFETY ANALYSIS

MISSION DEFINITION PARAMETERS

DATA SHEET NO. S-1 PAYLOAD NO. AP-06-S

DATE JUN 11 1974 REV DATE ____ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC & PLASMAS IN SPACE (AMPS)

1. Discipline ATMOSPHERIC & SPACE PHYSICS
2. Cognizant Scientist/Engineer E. Schmerling/R. Chase
3. Development Agency NASA/OSS
4. Initial Launch Date (Year) 1981

5. No. of Sets of Mission Equipment in Program — Development: 1
6. No. of Sets of Mission Equipment in Program — Operations: 6
7. No. of Sortie Flights in Program: 30
8. Nominal Flight Duration (N), days: 7

LAUNCH SCHEDULE:

Data Item No:	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
Year:	79	80	81	82	83	84	85	86	87	88	89	90	91
No. Launches:	___	___	1	1	1	1/2	1/2	2/2	1/2	2/2	1/2	2/2	1/2
Mission Code Letter:	___	___	A	B	B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B

ORBIT PARAMETERS:

	A	B	C	D	E	F
APOGEE, km						
22. Desired	435	340				
23. Minimum	400	320				
24. Maximum	500	360				
PERIGEE, km						
25. Desired	435	340				
26. Minimum	400	320				
27. Maximum	500	360				
INCLINATION, deg						
28. Desired	28.5	90				
29. Minimum	28.5	55				
30. Maximum	28.5	105				
31. Launch Site(s)	ETR	WTR				

(Mission code letter columns A–F.)

32. Launch Window Center N/A (Initial Launch Date/Time)
33. Launch Window Duration, hr. N/A

PAYLOAD SUMMARY DATA:

34. Payload weight at launch, kg 5381
35. Weight of expended consumables and P/L Equipment not returned to earth, kg 725
36. Consumables weight at launch, kg 85
37. Pressurized equipment volume, m^3 3.2
38. Estimated pallet length, m 7.6
39. No. of subsatellite deployments per flight 2
40. No. of subsatellite retrievals per flight 2
41. No. of planned EVAs per flight 0
42. Average duration of each EVA, hr N/A
43. Preferred accommodation mode:

☐ Pallet only: on-orbit control ☐ ; control from ground ☐

☐ Lab only

☒ Lab plus pallet

44. Payload Model Date October 1973
45. P/L Code No. PHY-7

46. REFERENCE DOCUMENTS:

(1) Final Report of the Space Shuttle Payload Planning Working Groups – Atmospheric and Space Physics, May 1973; NASA, GSFC

(2) AMPS Detailed Timeline, 28.5 deg orbit, March 1974; NASA, MSFC

(3) Final Report, Contract NAS8-28047 - Plasma Physics and Environmental Perturbation Laboratory, May 1973; NASA, MSFC

(4) Preliminary Design Study for an Atmospheric Science Facility, Dec. 1972; NASA, JSC

(5) Manned Auroral and Magnetospheric Observatory System, Sept. 1972; NASA, JSC

(6) NASA Woods Hole Summer Study, Atmospheric and Space Physics Working Group Report, Preliminary Data, August, 1973.

(7) Opportunities for Participation in the Scientific Definition of Space Shuttle Missions for Atmospheric, Magnetospheric, and Plasmas In Space (AMPS) Payloads, November 1973; NASA, Hq.

47. COMMENTS:

SORTIE PAYLOAD
OBJECTIVES

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-2 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

1. SUMMARY: This payload consists of a variety of active and passive instrumentation designed to observe and artificially perturb the space environment and upper atmosphere. Multipurpose controls, displays and data processing equipment are included to permit effective interaction among on-orbit investigators and experiments. Major assmeblies requiring external mounting include a Remote Sensing Platform, housing both optical instrumentation and field and particle sensors; a Laser Radar (LIDAR); long (50 m) booms for remote measurements of the ambient environment and for wake studies; transmitters and particle accelerators for stimulation of the ionosphere and magnetosphere; subsatellites; and a variety of deployable devices, including those designed to release chemicals into the upper ionosphere and magnetosphere. The AMPS payload is designed to make maximum use of this core equipment to perform a great variety of experiments. Additional special-purpose instruments may be added as needed to accomplish specific mission objectives. Two mission classes are presently defined--low inclination (Type A) and high inclination (Type B), with 60% of the missions flown at high inclination.

2. MISSION OBJECTIVES: Overall, the objectives of the AMPS payload, as expressed by the Space Shuttle Payload Planning Working Group, are

- To investigate the detailed mechanisms which control the near-space environment of the earth
- To perform plasma physics investigations not feasible in ground-based laboratories
- To conduct investigations which are important in understanding planetary and cometary phenomena.

These are to be accomplished by conducting (predominately active) controlled experiments, stimulating and modifying the upper atmosphere and magnetosphere and observing the consequences.

3. RELATIONSHIP TO DISCIPLINE OBJECTIVES:

Atmospheric Science - The AMPS payload will provide a full complement of instruments for remote sensing of the stratosphere, mesosphere, and lower thermosphere, using both active and passive systems with large apertures, high spectral resolution and improved signal-to-noise ratios.

Magnetospheric Physics - Controlled geophysical experiments will be conducted with the objective of "breaking into the atmosphere-ionosphere-magnetosphere feed-back loops". The magnetosphere will be stimulated by injection of energetic particles, injection of plasma beams, release of chemicals, and injection of waves. These experiments are particularly suited to sortie missions.

Space Plasma Physics - The AMPS payload provides the opportunity to study fundamental and applied plasma physics problems that cannot be studied in terrestrial laboratories, where there are limitations due to scale length, collisions, wall effects, and the short duration of discharges.

EXPERIMENTS

4. No.	5. Title	6. Objectives
XAP410	Wave Characteristics	Study dispersion relations, wave generation behavior of wave packets in a dispersive medium.
XAP420	Wave/Particle Interactions	Measure scale sizes, characteristic growth times and propagation velocities of wave instabilities and associated particle motions, using artificial waves.
XAP430	Wake and Sheath Experiments	Analyze disturbed region around a body placed in a plasma, to infer characteristics of solar wind interaction with planets, comets, asteroids. Measure geometry, stability, and instrument effects.
XAP440	Propulsion and Devices	Study problems of electric probes in space, new techniques for measuring small plasma drifts, MPD arcs in large volumes, plasma propulsion.
XAP450	Global Emission Survey	Measure atmospheric radiation in 0.03 to 150 micrometer wavelength intervals with passive and active systems. Determine properties of aurora, anglow, aerosols, etc.
XAP460	Energetic Particle Stability	Study mechanisms by which charged particles are accelerated in earth's magnetosphere; inject energetic particles and observe effects in atmosphere.
XAP470	Magnetospheric Topology	Employ tracers to determine magnetosphere structure in outlying regions, measure convection parameters, trace large-scale particle motions.
XAP480	Plasma Dynamics	Study neutral-plasma interactions, generalized ohm's law, plasma confinement devices, behavior of conductors in wall-less plasma, antenna properties, etc.

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

DATA SHEET NO. S-3a PAYLOAD NO. AP06S

DATE JUN 24 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

1. No.	2. Title (EXPERIMENTS / Equipment Inv. No. and Name)	3. AP100 REMOTE SENSING PLATFORM SYS.	4. AP101 Platform, Remote Sensing	5. AP102 Spectrometer, XUV Normal Incidence	6. AP103 Spectrometer, UV-Vis-NIR Scanning	7. AP104 Spectrometer, Hi-Resol. Fourier SWIR	8. AP105 Spectrometer, Cryogenic IR Fourier	9. AP106 Radiometer, IR	10. AP107 Interferometer, Fabry-Perot	11. AP108 Photometer, Filter (Narrow Band)	12. AP109 Camera(s), UV-Vis. Documentation	13. AP114 Detector, KeV-MeV Particle	14. AP115 Detector, Total Energy	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics																													
XAP420	Wave/Particle Interaction									4	2																			
XAP430	Wake and Sheath Experiments									4																				
XAP440	Propulsion and Devices																													
XAP450	Global Emission Survey		1	1	1	1	1	1	1	4	2																			
XAP460	Energetic Particle Stability									4	2	1	1																	
XAP470	Magnetospheric Topology									4	2	1																		
XAP480	Plasma Dynamics																													

SSPD (S-3) 3-15-74 NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3a

SORTIE PAYLOAD

EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE

DATA SHEET NO. S-3[b] PAYLOAD NO. AP06S

DATE JUN 24 1974 REV DATE ______ LTR ____

1. No.	2. Title	3. AP200 LIDAR SYSTEM	4. AP201 Transmitter/Receiver, Lidar	5. AP202 Mount, Lidar, Computer Controlled	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics																													
XAP420	Wave/Particle Interaction																													
XAP430	Wake and Sheath Experiments																													
XAP440	Propulsion and Devices																													
XAP450	Global Emission Survey		1	1																										
XAP460	Energetic Particle Stability																													
XAP470	Magnetospheric Topology																													
XAP480	Plasma Dynamics																													

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3[b]

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3c PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ____

EXPERIMENTS / Equipment Inv. No. and Name

1. No.	2. Title	3. AP300 GIMBALED ACCELERATOR SYSTEM	4. AP301 Accelerator, Ion	5. AP302 Storage Banks, 2-5 Kilojoules, HV	6. AP303 Accelerator, Electron, Gimbaled	7. AP304 MPD-ARC, with Condensor Banks	8. AP305 Accelerator, Gimbal System	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics																													
XAP420	Wave/Particle Interaction																													
XAP430	Wake and Sheath Experiments																													
XAP440	Propulsion and Devices					1																								
XAP450	Global Emission Survey																													
XAP460	Energetic Particle Stability		1	1	1	1	1																							
XAP470	Magnetospheric Topology		1	1	1		1																							
XAP480	Plasma Dynamics		1	1	1		1																							

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3c

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME. ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3d PAYLOAD NO. AP06S
DATE JUN 21 1974 REV DATE ______ LTR ____

1. No.	2. Title	3. TRANSMITTER/COUPLER SYSTEM AP400	4. Transmitter/Coupler (10 kW, 0.2-2MHz) AP401	5. Transmitter/Coupler (10 kW, 2-20 MHz) AP402	6. Transmitter/Coupler (1 kW, 0.3-200 kHz) AP403	7. Dipole Element, 330 Meters AP404	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics		1	1	1	2																								
XAP420	Wave/Particle Interaction		1	1	1	2																								
XAP430	Wake and Sheath Experiments		1	1																										
XAP440	Propulsion and Devices																													
XAP450	Global Emission Survey																													
XAP460	Energetic Particle Stability																													
XAP470	Magnetospheric Topology																													
XAP480	Plasma Dynamics			1																										

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3d

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3e PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ______

1. No.	2. Title	3. AP500 BOOM SYSTEM	4. AP501 Boom A, 50-Meter	5. AP502 Platform, Gimbaled	6. AP503 Boom, 5-Meter	7. AP504 Loop Antenna, One-Meter	8. AP505 Dipole, Short Electric	9. AP506 Search Coil, Triaxial	10. AP507 Boom, 5-Meter	11. AP508 Magnetometer, Rubidium	12. AP509 Fluxgate, Triaxial	13. AP510 Electric Dipole, 33-Meter Extendable	14. AP511 Power Supply	15. AP512 Data System	16. AP513 Television, Alignment	17. AP514 Spectrometer, Ion Mass	18. AP515 Probe, Spherical Ion	19. AP516 Probe, Cylindrical Ion	20. AP517 Probe, Planar Segmented	21. AP518 Spectrometer, Neutral Mass	22. AP519 Analyzer, Triaxial Hemispherical	23. AP520 Electron Trap, Planar	24. AP521 Boom B, 50-Meter	25. AP522 Wave Generator	26. AP523 Target(s) Boom B	27. AP524 Artificial Light Source Calib. Boom A	28.	29.	30.	31.
XAP410	Wave Characteristics		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1						
XAP420	Wave/Particle Interaction		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1								
XAP430	Wake and Sheath Experiments		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1		2					
XAP440	Propulsion and Devices		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1								
XAP450	Global Emission Survey																									1				
XAP460	Energetic Particle Stability		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1								
XAP470	Magnetospheric Topology		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1								
XAP480	Plasma Dynamics		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1								

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3e

SORTIE PAYLOAD

EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3f PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ______

1. No.	2. Title	3. AP600 DEPLOYABLE UNITS SYSTEM	4. AP601 Canister, Barium (100 gm)	5. AP602 Canister, Barium (1 kg)	6. AP603 Canister, Barium (10 kg)	7. AP610 Charge, Shaped (1 kg)	8. AP611 Charge, Shaped (5 kg)	9. AP612 Charge, Shaped (15 kg)	10. AP620 Balloon, Spherical Insulated	11. AP621 Balloon, Spherical Conducting	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics																													
XAP420	Wave/Particle Interaction																													
XAP430	Wake and Sheath Experiments								1	1																				
XAP440	Propulsion and Devices																													
XAP450	Global Emission Survey																													
XAP460	Energetic Particle Stability		2	2	1	2	1	1																						
XAP470	Magnetospheric Topology		2	2		2																								
XAP480	Plasma Dynamics																													

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3 f

SORTIE PAYLOAD

EXPERIMENT/EQUIPMENT MATRIX

DATA SHEET NO. S-38 PAYLOAD NO. AP06S

DATE JUN 24 1974 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE PAYLOADS (AMPS)

1. No.	2. Title	3. AP700 DEPLOYABLE SATELLITE SYSTEM	4. AP701 Subsatellite	5. AP702 Television System (1)	6. AP703 Magnetometer, 3-Axis Fluxgate (1)	7. AP704 Magnetometer, Search Coil (1)	8. AP705 Probe, Electric, Cylinder (1)	9. AP706 Planar Trap, Segmented (1)	10. AP707 Spectrometer, Ion Mass (1)	11. AP708 Analyzer, Triaxial Hemispherical (1)	12. AP709 Receiver, VLF (1)	13. AP710 Meter, E-Field (1)	14. AP711 Ejection Mech, & Interface-Sat/Pallet	15. AP712 Transponder, Telemetry & Ranging (1)	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP410	Wave Characteristics																													
XAP420	Wave/Particle Interaction		1	1	1	1	1	1	1	1	1	1	1	1																
XAP430	Wake and Sheath Experiments		2		1	1	1	1	1	1	1	1	2	1																
XAP440	Propulsion and Devices		1	1	1	1	1	1	1	1	1	1	1	1																
XAP450	Global Emission Survey		1	1	1	1	1	1	1	1	1	1	1	1																
XAP460	Energetic Particle Stability		1	1	1	1	1	1	1	1	1	1	1	1																
XAP470	Magnetospheric Topology		1	1	1	1	1	1	1	1	1	1	1	1																
XAP480	Plasma Dynamics		1	1	1	1	1	1	1	1	1	1	1	1																

NOTE: (1) Number shown is per subsatellite.

NOTE: Enter in box the quantity of each equipment item for each experiment.

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3h PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ____ LTR ____

EXPERIMENTS 1. No.	2. Title	3. AP800 DISPLAY SYSTEM	4. AP802 EXPERIMENT TV DISPLAY	5. AP803 SPECTRUM ANALYZER	6. AP804 MULTI-CHANNEL ANALYZER	7. AP805 WAVE ANALYZER	8. AP806 WAVE ANALYZER	9. AP807 COAXIAL PATCH PANEL	10. AP808 FREQUENCY COUNTER	11. AP809 AUTOMATIC DISPLAY GENERATOR *	12. AP810 CAMERA (35 mm film)	13. AP811 X-Y RECORDER	14. AP812 STRIP CHART RECORDER	15. AP813 8-CHANNEL RECORDER
XAP410	Wave Characteristics		1	1	1	1	1	1	1	1	1	1	1	1
XAP420	Wave/ Particle Interaction		1	1	1	1	1	1	1	1	1	1	1	1
XAP430	Wake and Sheath Experiments		1	1	1	1	1	1	1	1	1	1	1	1
XAP440	Propulsion and Devices		1	1	1	1	1	1	1	1	1	1	1	1
XAP450	Global Emission Survey		1	1	1	1	1	1	1	1	1	1	1	1
XAP460	Energetic Particle Stability		1	1	1	1	1	1	1	1	1	1	1	1
XAP470	Magnetospheric Topology		1	1	1	1	1	1	1	1	1	1	1	1
XAP480	Plasma Dynamics		1	1	1	1	1	1	1	1	1	1	1	1

EXPERIMENTS 1. No.	2. Title	16. AP815 OSCILLOSCOPE	17. AP832 TIME CODE GENERATOR	18. COMPUTATION EQUIPMENT	19. AP817 TAPE RECORDER DIGITAL	20. AP818 COMPUTER	21. AP819 KEYBOARD DISPLAY TERMINAL	22. AP820 STATUS PANEL	23. AP821 SPECIAL DATA ACQUISITION PANEL	24. AUXILLIARY EQUIPMENT	25. AP814 TAPE RECORDER ANALOG	26. AP827 POWER SUPPLY MONITOR	27.	28.	29.	30.	31.
XAP410	Wave Characteristics	1	1		1	1	1	1	1		1	1					
XAP420	Wave/ Particle Interaction	1	1		1	1	1	1	1		1	1					
XAP430	Wake and Sheath Experiments	1	1		1	1	1	1	1		1	1					
XAP440	Propulsion and Devices	1	1		1	1	1	1	1		1	1					
XAP450	Global Emission Survey	1	1		1	1	1	1	1		1	1					
XAP460	Energetic Particle Stability	1	1		1	1	1	1	1		1	1					
XAP470	Magnetospheric Topology	1	1		1	1	1	1	1		1	1					
XAP480	Plasma Dynamics	1	1		1	1	1	1	1		1	1					

* Spacelab provided

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3h

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3 i PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

1. No.	2. Title	3. AP900 CONTROLS SYSTEM	4. Transmitters	5. AP901 10 KW-0.2 to 2 MHz	6. AP902 10 KW-2 to 20 MHz	7. AP903 1 KW-0.3 to 200 KHz	8. AP904 Electrostatic Wave	9. Antennas	10. AP905 Long 330 m Dipole	11. AP906 Short VLF Dipole	12. AP907 Loop-IM	13. AP908 RF Antenna	14. Antenna Couplers	15. AP909 0.2 to 2 MHz	16. AP910 2 to 20 MHz	17. AP911 0.3 to 200 KHz	18. Wave Analysis	19. AP912 Bandpass Filter	20. AP913 Pulse-C.W. Modes	21. AP914 Patch Panels	22. AP915 Amplifiers, Wave	23. AP916 Frequency Synthesizer	24.	25.	26.	27.	28.	29.	30.	31.
XAP 410	Wave Characteristics			1	1	1	2		2	1				1	1	1		2	1	5										
XAP 420	Wave/Particle Ineraction			1	1	1	2		2	1				1	1	1				5										
XAP 430	Wake and Sheath Experiments			1	1				2	1				1	1					5										
XAP 440	Propulsion and Devices								2	1										5	1	2								
XAP 450	Global Emission Survey										1									5										
XAP 460	Energetic Particle Stability								2	1										5										
XAP 470	Magnetospheric Topology									1		1								5										
XAP 480	Plasma Dynamics														1					5										

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3 i

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3 i PAYLOAD NO. AP-06-6
DATE JUN 07 1974 REV DATE ______ LTR ______

EXPERIMENTS 1. No.	2. Title	3. MAIN BOOM	4. AP917 Main Boom A Control	5. AP918 Platform Boom A Control	6. AP919 Main Boom B Control	7. AP920 Alignment TV	8. AP921 Gimballed Platform Contr.	9. AP922 5M Boom Control	10. AP923 Boom A Power Supply and Data System	11. AP924 Boom B Target (inflation, deflat, eject	12. AP990 Boom A Artificial Lt. source con	13. ION BEAM ACCELER. CONTROLS
XAP 410	Wave Characteristics		1	1	1	1	1	1	1	2	1	
XAP 420	Wave/Particle Interaction		1	1	1	1	1	1	1	2	1	
XAP 430	Wake and Sheath Experiments		1	1	1	1	1	1	1	2	1	
XAP 440	Propulsion and Devices		1	1	1	1	1	1	1	2	1	
XAP 450	Global Emission Survey										1	
XAP 460	Energetic Particle Stability		1	1	1	1	1	1	1	2	1	
XAP 470	Magnetospheric Topology											
XAP 480	Plasma Dynamics											

No.	14. AP925 Acceleration-Deceleration	15. AP926 Discharge, Fil. Heater	16. AP927 Discharge Potential	17. AP928 Pulse Sequence and Burst Length	18. AP929 Gas Selection and Pressure	19. AP930 Neutralize Emission and Bias	20. AP931 Charge Exch. Channel Actuator	21. AP932 Beam Current Monitor	22. ELECTRON BEAM	23. AP933 Beam Voltage; Heater Current	24. AP934 Burst Length; Burst Magnitude	25. AP935 Expansion Lens	26. AP936 Beam Current Monitor	27. AP937 I, Φ, I	28. MPD-ARC	29. AP938 Voltage Level	30. AP939 Burst Current and Duration	31. AP940 Pulse Sequencer
XAP 410																		
XAP 420																		
XAP 430	1	1	1	1	1	1	1	1		1	1	1	1	1		1	1	1
XAP 440																		
XAP 450																		
XAP 460	1	1	1	1	1	1	1	1		1	1	1	1	1		1	1	1
XAP 470	1	1	1	1	1	1	1	1		1	1	1	1	1		1	1	1
XAP 480	1	1	1	1	1	1	1	1		1	1	1	1	1		1	1	1

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3 i

SORTIE PAYLOAD
EXPERIMENT/EQUIPMENT MATRIX

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-3k PAYLOAD NO. AP-06-S
DATE JUN 27 1974 REV DATE ______ LTR ______

1. No.	2. Title	3. AP941 Beam Current Monitor	4. AP942 Gas Selection and Pressure	5. AMBIENT PLASMA	6. AP943 Spherical Ion Probe	7. AP944 Cylindrical Ion Probe	8. AP945 Planar Electron Probe	9. AP946 RF Probe	10. AP947 Ion Mass Spectrometer	11. AP948 Neutral Mass Spectrometer	12. AP949 Triaxial Fluxgate	13. AP950 Segmented Planar Probe	14. AP951 Rubidium Magnetometer	15. AP952 Triaxial Search Coil	16. AP953 Amplifiers (Pulse) Particle Detect.	17. AP954 HV Supplies-Particle Detector	18. AP955 Triaxial Hemisph. Analyz. Control	19. DEPLOYABLE SATELLITE	20. AP956 TV System	21. AP957 Telemetry & Ranging	22. AP958 Location and Orientation	23. AP959 Instrument Control and Housekeeping	24. AP960 Ejection Mechanism	25. OPTICAL	26. AP961 Photometer HV Supply	27. AP962 Photometer Amplifiers	28. AP963 TV System Control-Image Intens. Opt.	29. AP964 Canister Ejection	30. AP965 Camera	31. AP966 Canister Monitor
XAP 410	Wave Characteristics				1		1	1	1	1		1	1	1	1	1									1	2	1			
XAP 420	Wave/Particle Interaction				1		1			1			1	1					1	1	1	1	1		4	4	1			
XAP 440	Propulsion and Devices				1		1			1			1	1					1	1	1	1	1				1			
XAP 450	Global Emission Survey				1	1	1	1	1	1	1	1	1	1	1	1	1										2			
XAP 460	Energetic Particle Stabilit.	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1		4	4	1	1	1	2
XAP 470	Magnetospheric Topology	1	1																1	1	1	1	1		4	4		1	1	1
XAP 480	Plasma Dynamics	1	1																1	1	1	1	1							
XAP 430	Wake and Sheath Experiments	1	1																1	1	1	1	2		4	4				

SSPD (S-3) 3-15-74

NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-3k

SORTIE PAYLOAD

EXPERIMENT/EQUIPMENT MATRIX

DATA SHEET NO. S-31 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

1. No.	2. Title	3. AP967 Shaped Charge Ejection	4. AP968 Shaped Charge Monitor	5. AP969 Balloon Ejection	6. AP970 Gas Control System	7. REMOTE SENSING PLATFORM	8. AP971 Gimbal Control (AP101)	9. AP972 XUV Normal Incidence Spect	10. AP973 UV-Visible NIR Scanning Spectrometer	11. AP974 Hi-Resolution Fourier SWIR Spectrometer	12. AP975 Cryogenic IR Fourier Spectrometer	13. AP976 IR Radiometer	14. AP977 Fabrey-Perot Interferometer	15. AP978 UV-Visible Documentation Cameras	16.	17.	18. AP981 KeV-MeV Particle Detector	19. AP982 Total Energy Detector	20. AP983 Lidar and Gimbal Platform Monitor	21. AP984 Filter Photometer	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
XAP 410	Wave Characteristics						1	1	1	1	1	1	1	1			1	1		4										
XAP 420	Wave/Particle Interaction													2					1	4										
XAP 430	Wake and Sheath Experiments			1	1															4										
XAP 440	Propulsion and Devices																													
XAP 450	Global Emission Survey						1	1	1	1	1	1	1	2			1	1	1	4										
XAP 460	Energetic Particles Stability	1	1	1	1		1	1	1	1	1	1	1	2			1	1		4										
XAP 470	Magnetospheric Topology													2			1			4										
XAP 480	Plasma Dynamics																													

SSPD (S-3) 3-15-74 NOTE: Enter in box the quantity of each equipment item for each experiment.

DATA SHEET NO. S-31

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-4 a PAYLOAD NO. AP0oS
DATE [illegible] REV DATE ______ LTR ____

EQUIPMENT 1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	Location Code① 5 Operating	Access Code② 6 Setup	Access Code② 7 Operating	UNIT SIZE, (m) 8 W or D	9 H	10 L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	FIELD OF VIEW (deg) Instantaneous 13 W or D	14 L	Total 15 W or D	16 L	MANNED ACCESS REQUIREMENTS 17 Primary Reason?	18 How Often?	CONSUMABLES 19 Type	Use Rate 20 Qty.	21 Units	How Sup'd 22 Payload	23 Spacelab	How Disp'd 24 Ret'd to Earth	25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP100	REMOTE SENSING PLATFORM SYSTEM																								
AP101	Platform, Remote Sensing	1	1	1	0	0	2.5	2.3	4.0	23.0	590.0	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					Includes cryogen dewar
AP102	Spectrometer, XUV Normal Incidence	1	1	1	0	0	0.24	0.9	0.79	0.017	11.4	10.0	-	10.0	-	N/A	N/A	None	N/A	N/A					
AP103	Spectrometer, UV-Vis-NIR Scanning	1	1	1	0	0	0.55	0.37	1.3	0.265	86.0	TBD	-	TBD	-	N/A	N/A	Film	20	kg	X		X		
AP104	Spectrometer, High Resolution Fourier SWIR	1	1	1	0	0	0.52	0.70	0.30	0.109	46.0	TBD	-	TBD	-	N/A	N/A	Cryogenics	8	kg					
AP105	Spectrometer, Cryogenic IR Fourier	1	1	1	0	0	0.90	0.90	0.75	0.608	114	TBD	-	TBD	-	N/A	N/A	Cryogenics	20	kg	X			X	
AP106	Radiometer, IR	1	1	1	0	0	0.30	0.30	0.90	0.081	22.8	10.0	-	10.0	-	N/A	N/A	Cryogenics	2	kg	X			X	
AP107	Interferometer, Fabry-Perot	1	1	1	0	0	0.30	0.30	0.90	0.081	22.8	TBD	-	TBD	-	N/A	N/A	None	N/A	N/A					
AP108	Photometer, Filter (Narrow Band)	4	1	1	0	0	0.25	0.25	0.75	0.047	4.6	1.0	-	1.0	-	N/A	N/A	None	N/A	N/A					
AP109	Camera, UV-Visible Documentation	2	1	1	0	0	0.30	0.30	0.30	0.027	2.3	30.0	30.0	30.0	30.0	N/A	N/A	Film	9.5	kg	X		X		
AP114	Detector, keV-MeV Particle	1	1	1	0	0	0.30	0.30	0.30	0.027	5.0	20.0	-	20.0	110.0	N/A	N/A	None	N/A	N/A					
AP115	Detector, Total Energy	1	1	1	0	0	0.30	0.30	0.30	0.027	2.0	30.0	-	30.0	120.0	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 100									24.457	923.0														

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______

Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE

DATA SHEET NO. S-4b PAYLOAD NO. AP06S
DATE JUN 2[illegible] 19[illegible] REV DATE ____ LTR ____

EQUIPMENT			Location Code①		Access Code②		UNITSIZE, (m)			11	12	FIELD OF VIEW (deg)				MANNED ACCESS REQUIREMENTS		CONSUMABLES							26
												Instantaneous		Total				19	Use Rate		How Supl'd		How Disp'd		Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	Unit Vol (m³)	Unit Dry Wt (kg)	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	Type	20 Qty.	21 Units	22 Payload	23 Spacelab	24 Ret'd to Earth	25 Release	
AP200	LIDAR SYSTEM																								
AP201	Transmitter/Receiver, Lidar	1	1	1	0	0	0.50	-	2.0	0.393	100	0.057	0.057	0.057	0.057	N/A	N/A	None	N/A	N/A					
AP202	Mount, Lidar Computer Controlled	1	1	1	0	0	0.50	-	1.5	0.663	149	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 200									1.056	249														

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ____ 28 Unpressurized ____ 29 Total: ____
Volume, m³: 30 Pressurized ____ 31 Unpressurized ____ 32 Total: ____
33 Total weight of experiment equipment items left in orbit, kg ____

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4b

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE

DATA SHEET NO. S-4 c PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ____

EQUIPMENT: 1 Inv. No.	EQUIPMENT: 2 Name	3 Qty	Location Code①: 4 Storage	Location Code①: 5 Operating	Access Code②: 6 Setup	Access Code②: 7 Operating	UNITSIZE, (m): 8 W or D	UNITSIZE, (m): 9 H	UNITSIZE, (m): 10 L	11 Unit Vol (m^3)	12 Unit Dry Wt (kg)	FIELD OF VIEW (deg) Instantaneous: 13 W or D	FIELD OF VIEW (deg) Instantaneous: 14 L	FIELD OF VIEW (deg) Total: 15 W or D	FIELD OF VIEW (deg) Total: 16 L	MANNED ACCESS REQUIREMENTS: 17 Primary Reason?	MANNED ACCESS REQUIREMENTS: 18 How Often?	CONSUMABLES: 19 Type	CONSUMABLES Use Rate: 20 Qty.	CONSUMABLES Use Rate: 21 Units	How Supl'd: 22 Payload	How Supl'd: 23 Spacelab	How Disp'd: 24 Ret'd to Earth	How Disp'd: 25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP300	GIMBALED ACCELERATOR SYSTEM																								
AP301	Accelerator, Ion	1	1	1	0	0	0.60	1.00	1.00	0.60	150	10.0	-	10.0	90.0	N/A	N/A	None	N/A	N/A					
AP302	Storage Banks 2-5 kilojoules HV	1	1	1	0	0	1.00	1.00	1.0	1.00	200	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP303	Accelerator, Electron	1	1	1	0	0	1.00	-	2.00	1.57	15	10.0	-	10.0	90.0	N/A	N/A	None	N/A	N/A					
AP304	MPD-ARC with Condensor Banks	1	1	1	0	0	1.4	1.0	1.4	1.96	300	20.0	-	20.0	-	N/A	N/A	None	N/A	N/A					
AP305	Gimbal System, Accelerator, Electron/Ion	1	1	1	0	0	1.0	1.0	1.0	1.00	45	N/A	-	N/A	-	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 300									6.130	710														

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ Volume, m^3: 30 Pressurized ______
28 Unpressurized ______ 31 Unpressurized ______
29 Total: ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-4 d PAYLOAD NO. AP06S
DATE [illegible] REV DATE ______ LTR ______

EQUIPMENT 1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	5 Operating	Access Code② 6 Setup	7 Operating	UNIT SIZE, (m) 8 W or D	9 H	10 L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	FIELD OF VIEW (deg) Instantaneous 13 W or D	14 L	Total 15 W or D	16 L	MANNED ACCESS REQUIREMENTS 17 Primary Reason?	18 How Often?	CONSUMABLES 19 Type	Use Rate 20 Qty.	21 Units	How Supl'd 22 Payload	23 Spacelab	How Disp'd 24 Ret'd to Earth	25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP400	TRANSMITTER/COUPLER SYSTEM																								
AP401	Transmitter/Coupler (10 kW, 0.2-2.0 MHz)	1	1	1	0	0	0.40	0.40	0.50	0.08	70	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP402	Transmitter/Coupler (10 kW, 2.0-20.0 MHz)	1	1	1	0	0	0.40	0.40	0.50	0.08	50	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP403	Transmitter/Coupler (1 kW, 0.3-200 kHz)	1	1	1	0	0	0.20	0.50	0.50	0.05	50	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP404	Dipole Element, 330-Meter	1	1	1	0	0	0.20	0.40	0.15	0.012	20	N/A	-	N/A	-	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 400									0.222	190														

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ Volume, m³: 30 Pressurized ______
28 Unpressurized ______ 31 Unpressurized ______
29 Total: ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4d

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

DATA SHEET NO. S-4e PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

EQUIPMENT			Location Code①		Access Code②		UNIT SIZE, (m)			11	12	FIELD OF VIEW (deg)				MANNED ACCESS REQUIREMENTS		CONSUMABLES							26
												Instantaneous		Total				19	Use Rate		How Supl'd		How Disp'd		
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	Unit Vol (m³)	Unit Dry Wt (kg)	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	Type	20 Qty.	21 Units	22 Payload	23 Specelab	24 Ret'd to Earth	25 Release	Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP500	BOOM SYSTEM																								
AP501	Boom A, 50 Meters	1	1	1	0	0	0.60	-	1.90	0.537	235	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP502	Platform, Gimbaled	1	1	1	0	0	1.00	-	0.30	0.236	8														
AP503	Boom, 5-Meter	1	1	1	0	0	0.1	-	0.2	0.0016	0.2														
AP504	Loop Antenna, One-Meter	1	1	1	0	0	1.00	-	0.2	0.157	0.4														
AP505	Dipole, Short Electric	1	1	1	0	0	0.10	-	1.00	0.0078	1.0														
AP506	Search Coil, Triaxial	1	1	1	0	0	0.30	-	0.30	0.027	1.5														
AP507	Boom, 5-Meter	1	1	1	0	0	0.10	-	0.20	0.002	0.2														
AP508	Magnetometer, Rubidium	1	1	1	0	0	0.30	-	0.30	0.021	2.0														
AP509	Fluxgate, Triaxial	1	1	1	0	0	0.20	0.20	0.20	0.008	1.5														
AP510	Electric Dipole, 33-Meter Extendable	2	1	1	0	0	0.30	-	0.50	0.035	4.0														
AP511	Power Supply	1	1	1	0	0	0.20	0.20	0.30	0.012	4.0														
AP512	Data System	1	1	1	0	0	0.20	0.20	0.20	0.008	2.0	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP513	Television, Alignment	1	1	1	0	0	0.20	0.20	0.30	0.012	5.0	10.0	-	10.0	360.0	N/A	N/A	None	N/A	N/A					
AP514	Spectrometer, Ion Mass	1	1	1	0	0	0.20	0.20	0.30	0.012	5.0	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP515	Probe, Spherical	1	1	1	0	0	0.10	-	0.30	0.0023	2.0	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______
Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-4f **PAYLOAD NO.** AP0?S

DATE [illegible] **REV DATE** ______ **LTR** ______

1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	Location Code① 5 Operating	Access Code② 6 Setup	Access Code② 7 Operating	Unit Size (m) 8 W or D	Unit Size (m) 9 H	Unit Size (m) 10 L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)
AP516	Probe, Cylindrical Ion	1	1	1	0	0	0.20	-	0.20	0.0062	1.5
AP517	Probe, Planar Segmented	1	1	1	0	0	0.20	0.20	0.20	0.008	2.5
AP518	Spectrometer, Neutral Mass	1	1	1	0	0	0.20	0.20	0.20	0.008	8.0
AP519	Analyzer, Triaxial Hemispherical	1	1	1	0	0	0.30	0.30	0.30	0.027	2.0
AP520	Electron Trap, Planar	1	1	1	0	0	0.20	0.20	0.20	0.008	2.5
AP521	Boom B, 50-Meter	1	1	1	0	0	0.60	-	1.90	0.537	235
AP522	Wave Generator	1	1	1	0	0	0.30	-	0.30	0.021	1.0
AP523	Target(s)	2	1	1	0	0	0.20	0.20	0.20	0.008	2.0
AP524	Light Source, Artificial (Boom A)	1	1	1	0	0	0.30	0.30	0.30	0.5	0.5
	SUBTOTAL AP 500									2.245	532.8

1 Inv. No.	Field of View (deg) Instantaneous 13 W or D	Instantaneous 14 L	Total 15 W or D	Total 16 L	Manned Access Requirements 17 Primary Reason?	18 How Often?	Consumables 19 Type	Use Rate 20 Qty.	Use Rate 21 Units	How Supl'd 22 Payload	How Supl'd 23 Spacelab	How Disp'd 24 Ret'd to Earth	How Disp'd 25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP516	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP517	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP518														
AP519														
AP520														
AP521														
AP522														
AP523														
AP524	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______

Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4 1

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

DATA SHEET NO. S-4 g PAYLOAD NO. AP06S
DATE JUN 2[illegible] 19[illegible] REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

EQUIPMENT			Location Code ①		Access Code ②		UNIT SIZE, (m)			11	12	FIELD OF VIEW (deg)				MANNED ACCESS REQUIREMENTS		CONSUMABLES							26
												Instantaneous		Total				19	Use Rate		How Supl'd		How Disp'd		
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	Unit Vol (m³)	Unit Dry Wt (kg)	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	Type	20 Qty.	21 Units	22 Payload	23 Spacelab	24 Ret'd to Earth	25 Release	Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP600	DEPLOYABLE UNITS																								
AP601	Canister, Barium (100 gm)	2	1	1	0	0	0.13	-	0.13	0.0017	1.3	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP602	Canister, Barium (1kg)	2	1	1	0	0	0.20	-	0.20	0.0062	3														
AP603	Canister, Barium (10 kg)	1	1	1	0	0	0.30	-	0.38	0.027	15														
AP610	Charge, Shaped (1 kg)	2	1	1	0	0	0.20	-	0.60	0.019	30														
AP611	Charge, Shaped (5 kg)	1	1	1	0	0	0.35	-	1.03	0.099	150														
AP612	Charge, Shaped (15 kg)	1	1	1	0	0	0.55	-	1.63	0.387	450														
AP620	Balloon, Spherical Insulated	1	1	1	0	0	0.20	-	0.38	0.012	4														
AP621	Balloon, Spherical Conducting	1	1	1	0	0	0.25	-	0.50	0.025	7	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 600									0.604	694.6														

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______
Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE

DATA SHEET NO. S-4h PAYLOAD NO. AP06S

DATE JUN 2? 1974 REV DATE ______ LTR ____

1 Inv. No.	2 Name	3 Qty	4 Location Code (1) Storage	5 Location Code (1) Operating	6 Access Code (2) Setup	7 Access Code (2) Operating	8 Unit Size (m) W or D	9 Unit Size (m) H	10 Unit Size (m) L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	13 Field of View (deg) Instantaneous W or D	14 Field of View (deg) Instantaneous L	15 Field of View (deg) Total W or D	16 Field of View (deg) Total L	17 Manned Access Requirements Primary Reason?	18 Manned Access Requirements How Often?	19 Consumables Type	20 Consumables Use Rate Qty.	21 Consumables Use Rate Units	22 How Supl'd Payload	23 How Supl'd Spacelab	24 How Disp'd Ret'd to Earth	25 How Disp'd Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP700	SUBSATELLITE SYSTEM																								
AP701	Subsatellite	2	1	1	0	0	1.36	-	1.09	1.583	600	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP702	Television System	2	1	1	0	0	0.30	-	0.30	0.021	5.0	TBD	-	TBD	-	N/A	N/A	None	N/A	N/A					
AP703	Magnetometer, 3-Axis Fluxgate	2	1	1	0	0	0.20	-	0.20	0.006	1.5	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
AP704	Magnetometer, Search Coil	2	1	1	0	0	0.30	-	0.30	0.021	1.5	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP705	Probe, Electric Cylinder	2	1	1	0	0	0.20	-	0.20	0.006	2.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP706	Planar Trap, Segmented	2	1	1	0	0	0.20	0.20	0.20	0.008	2.5	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP707	Spectrometer, Ion Mass	2	1	1	0	0	0.20	0.20	0.30	0.012	5.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP708	Analyzer, Triaxial Hemispherical	2	1	1	0	0	0.30	0.30	0.30	0.027	2.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP709	Receiver, VLF	2	1	1	0	0	0.20	0.20	0.30	0.012	4.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP710	Meter, E-Field	2	1	1	0	0	0.20	0.20	0.30	0.012	2.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP711	Ejection Mechanism and Interface - Satellite/Pallet	2	1	1	0	0	0.68	-	0.56	0.203	30.0	↓	↓	↓	↓	↓	↓	↓	↓	↓					
AP712	Transponder, Telemetry and Ranging	2	1	1	0	0	0.30	0.20	0.3	0.018	22.7	N/A	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A					
	SUBTOTAL AP 700									3.858	1356.4														

PREPARATION INSTRUCTIONS

(1) Location Code: 0 = pressurized
1 = unpressurized

(2) Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______

Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4h

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

DATA SHEET NO. S-4i PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ____ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

EQUIPMENT			Location Code(1)		Access Code(2)		UNIT SIZE, (m)			11	12	FIELD OF VIEW (deg)				MANNED ACCESS REQUIREMENTS		CONSUMABLES							26
												Instantaneous		Total				19	Use Rate		How Supl'd		How Disp'd		Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	Unit Vol (m³)	Unit Dry Wt (kg)	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	Type	20 Qty.	21 Units	22 Payload	23 Spacelab	24 Ret'd to Earth	25 Release	(shaded) Spacelab provided
AP800	DISPLAYS																								
AP802	Experiment TV Display	2	0	0	1	1	.483	.850	.425	.1712	20					Equip. Oper.	Cont.	0							
AP803	Spectrum Analyzer	4	↑	↑	↑	↑	.483	.176	.574	.0478	7					↑	↑	↑							
AP804	Multi-Channel Analyzer	1					.483	.425	.425	.0860	20														
AP805	Wave Analyzer	1					.483	.225	.425	.0453	6														
AP806	Wave Analyzer	1					.483	.225	.425	.0453	8														
AP807	Coaxial Patch Panel	8					.483	.125	.425	.0251	2														
AP808	Frequency Counter	1					.483	.176	.425	.0354	4							↓							
AP809	Automatic Display Generator	1					.483	.125	.425	.0251	5							0							
AP810	Camera (35 mm film)	1					.483	.125	.198	.0117	5							Film			X		X		Consumables included in unit weight
AP811	X-Y Recorder	2					.483	.524	.198	.0491	8							Paper Sheet			X		X		
AP812	Strip Chart Recorder	2					.483	.524	.379	.0931	2							Paper Tape			X		X		↓
AP813	8-Channel Recorder	2					.483	.524	.379	.0931	35							Paper Tape			X		X		
AP825	TV Camera	1					.152	.102	.304	.0050	2														
AP815	Oscilloscope	2	↓	↓	↓	↓	.483	.131	.524	.0324	8					↓	↓	0							
AP832	Time Code Generator	1	0	0	1	1	.483	.176	.250	.0208	6					Equip. Oper.	Cont.	0							

PREPARATION INSTRUCTIONS
(1) Location Code: 0 = pressurized
1 = unpressurized
(2) Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ____ 28 Unpressurized ____ 29 Total: ____
Volume, m³: 30 Pressurized ____ 31 Unpressurized ____ 32 Total: ____
33 Total weight of experiment equipment items left in orbit, kg ____

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4 i

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-4i PAYLOAD NO. AP-06-S

DATE 6/24/74 REV DATE ______ LTR ______

EQUIPMENT			Location Code①		Access Code②		UNIT SIZE, (m)			Unit Vol (m³)	Unit Dry Wt (kg)	FIELD OF VIEW (deg) Instantaneous		FIELD OF VIEW (deg) Total		MANNED ACCESS REQUIREMENTS		CONSUMABLES			How Supl'd		How Disp'd		Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	11	12	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	19 Type	20 Use Rate Qty.	21 Use Rate Units	22 Payload	23 Spacelab	24 Ret'd to Earth	25 Release	26
	COMPUTATION EQUIPMENT																								Spacelab provided
AP817	Tape Recorder, Digital	2	0	0	1	1	.483	I. 232	.396	.2312	20					Equip Oper.	Cont.	Mag. Tape	15	Kg	X		X		
AP818	Computer	2	↕	↕	↕	↕	.483	.30	.61	.0867	50					↕	↕	0							
AP819	Keyboard Display Terminal	1	↕	↕	↕	↕	.483	.351	.425	.0706	25					↕	↕	0							
AP820	Status Panel	2	↕	↕	↕	↕	.483	.351	.425	.0706	10					↕	↕	0							
AP821	Special Data Acquisition Panel	1	0	0	1	1	.483	.351	.425	.0706	15					Equip. Oper.	Cont.	0							
	AUXILIARY EQUIPMENT																								
AP814	Tape Recorder, Analog	1	0	0	1	1	.483	.61	.61	.1763	102					Equip. Oper.	Cont.	Mag. Tape	10	Kg	X		X		
AP827	Power Supply Monitor	1	0	0	1	1	.483	.250	.375	.0444	50					Equip. Oper.	Cont	0							
	SUBTOTAL AP800									1.162	194														

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ Volume, m³: 30 Pressurized ______
28 Unpressurized ______ 31 Unpressurized ______
29 Total: ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4i

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

DATA SHEET NO. S-4k PAYLOAD NO. AP-06-S

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT			Location Code ①		Access Code ②		UNIT SIZE, (m)					FIELD OF VIEW (deg)				MANNED ACCESS REQUIREMENTS		CONSUMABLES							26
												Instantaneous		Total				19	Use Rate		How Supl'd		How Disp'd		Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
1 Inv. No.	2 Name	3 Qty	4 Storage	5 Operating	6 Setup	7 Operating	8 W or D	9 H	10 L	11 Unit Vol (m^3)	12 Unit Dry Wt (kg)	13 W or D	14 L	15 W or D	16 L	17 Primary Reason?	18 How Often?	Type	20 Qty.	21 Units	22 Payload	23 Spacelab	24 Ret'd to Earth	25 Release	
AP900	CONTROLS																								
	TRANSMITTERS																								
AP901	10KW - 0.2 to 2 MHz	1	0	0	1	1	.483	.076	.406	.0149	2					Equip. Oper.	Cont.	0	N/A	N/A					
AP902	10KW - 2 to 20 MHz	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP903	1 KW - 0.3 to 200 KHz	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP904	Electrostatic Wave	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
	ANTENNAS																								
AP905	Long 330 m Dipole	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP906	Short VLF Dipole	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP907	Loop - 1M	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP908	RF Antenna	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
	ANTENNA COUPLERS																								
AP909	0.2 to 2 MHz	1	↕	↕	↕	↕	.483	.076	.406	.0149	3					↕	↕	↕	↕	↕					
AP910	2 to 20 MHz	1	↕	↕	↕	↕	.483	.076	.406	.0149	3					↕	↕	↕	↕	↕					
AP911	0.3 to 200 KHz	1	0	0	1	1	.483	.076	.406	.0149	3					Equip. Oper.	Cont.	0	N/A	N/A					

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ Volume, m^3: 30 Pressurized ______
28 Unpressurized ______ 31 Unpressurized ______
29 Total: ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-41 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	Location Code① 5 Operating	Access Code② 6 Setup	Access Code② 7 Operating	Unit Size, (m) 8 W or D	9 H	10 L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	Field of View (deg) Instantaneous 13 W or D	14 L	Total 15 W or D	16 L	Manned Access Requirements 17 Primary Reason?	18 How Often?	Consumables 19 Type	Use Rate 20 Qty.	21 Units	How Supl'd 22 Payload	23 Spacelab	How Disp'd 24 Ret'd to Earth	25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
	WAVE ANALYSIS																								
AP912	Bandpass Filter	2	0	0	1	1	.483	.152	.406	.0298	4					Equip. Oper.	Cont.	0	N/A	N/A					
AP913	Pulse - C. W. Modes	1	↕	↕	↕	↕	.483	.152	.406	.0298	2					↕	↕	↕	↕	↕					
AP914	Patch Panels	5	↕	↕	↕	↕	.483	.152	.406	.0298	2					↕	↕	↕	↕	↕					
AP915	Amplifiers, Wave (dc)	1	↕	↕	↕	↕	.483	.152	.406	.0298	15					↕	↕	↕	↕	↕					
AP916	Frequency Synthesizer	2	↕	↕	↕	↕	.483	.076	.406	.0149	12					↕	↕	↕	↕	↕					
	MAIN BOOM																								
AP917	Main Boom A Control	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					Spacelab provided
AP918	Platform Boom A Control	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP919	Main Boom B Control	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP920	Alignment TV	1	↕	↕	↕	↕	.483	.229	.406	.0447	50					↕	↕	↕	↕	↕					
AP921	Gimbaled Platform Controls	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP922	SM Boom Control	1	↕	↕	↕	↕	.483	.076	.406	.0149	2					↕	↕	↕	↕	↕					
AP923	Boom A Power Supply and Data System	1	↕	↕	↕	↕	.483	.076	.406	.0149	1					↕	↕	↕	↕	↕					
AP924	Boom B Target (Inflation, deflation, ejection)	1	↕	↕	↕	↕										↕	↕	↕	↕	↕					
AP990	Boom A Artificial Light Source Control	1	↕	↕	↕	↕										Equip. Oper.	Cont.	0	N/A	N/A					

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______
Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-41

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

DATA SHEET NO. S-4m PAYLOAD NO. AP-06-S

DATE JUN 24 '74 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

1 Inv. No.	2 Name	3 Qty	4 Location Code① Storage	5 Location Code① Operating	6 Access Code② Setup	7 Access Code② Operating	8 Unit Size (m) W or D	9 Unit Size (m) H	10 Unit Size (m) L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	13 Field of View (deg) Instantaneous W or D	14 Instantaneous L	15 Total W or D	16 Total L	17 Manned Access Requirements Primary Reason?	18 How Often?	19 Consumables Type	20 Use Rate Qty.	21 Use Rate Units	22 How Supl'd Payload	23 How Supl'd Spacelab	24 How Disp'd Ret'd to Earth	25 How Disp'd Release	Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
	ACCELERATOR CONTROLS - ION BEAM																								
AP926	Discharge Filament Heater	1	0	0	1	1	.483	.304	.406	.1468	16					Equip. Oper.	Cont.	None							AP926-AP929 on one panel
AP927	Discharge Potential																								
AP928	Pulse Sequence and Burst Length																								
AP929	Gas Selection and Pressure																								
AP925	Acceleration-Deceleration	1	0	0	1	1	.483	.304	.406	.1468	16														AP925, AP930-932 on 1 panel
AP930	Neutralized Emission and Bias																								
AP931	Charge Exchange Channel Actuator																								
AP932	Beam Current Monitor																								
	ELECTRON BEAM																								
AP933	Beam Voltage; Heater Current	1	0	0	1	1	.483	.380	.406	.1961	20														AP933-AP937 on one panel
AP934	Burst Length; Burst Magnitude																								
AP935	Expansion Lens																								
AP936	Beam Current Monitor																								
AP937	Ø, θ, I	1	0	0	1	1										Equip. Oper.	Cont.	None							

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______

Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-4n PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	Location Code① 5 Operating	Access Code② 6 Setup	Access Code② 7 Operating	Unit Size (m) 8 W or D	Unit Size (m) 9 H	Unit Size (m) 10 L	11 Unit Vol (m^3)	12 Unit Dry Wt (kg)	Field of View (deg) Instantaneous 13 W or D	Field of View (deg) Instantaneous 14 L	Field of View (deg) Total 15 W or D	Field of View (deg) Total 16 L	Manned Access Requirements 17 Primary Reason?	Manned Access Requirements 18 How Often?	Consumables 19 Type	Consumables Use Rate 20 Qty.	Consumables Use Rate 21 Units	How Supl'd 22 Payload	How Supl'd 23 Special	How Disp'd 24 Ret'd to Earth	How Disp'd 25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
	MPD ARC																								
AP938	Voltage Level	1	0	0	1	1	.483	.380	.406	.1961	20					Equip. Oper.	Cont.	None							
AP939	Burst Current & Duration	1																							
AP940	Pulse Sequencer	1																							
AP941	Beam Current Monitor	1																							
AP942	Gas Selection and Pressure	1																							
	AMBIENT PLASMA																								
AP943	Spherical Ion Probe	1					.483	.076	.406	.0149	5														
AP944	Cylindrical Ion Probe	1					.483	.076	.406	.0149	5														
AP945	Planar Electron Probe	1					.483	.076	.406	.0149	5														
AP946	RF Probe	1					.483	.076	.406	.0149	5														
AP947	Ion Mass Spectrometer	1					.483	.152	.406	.0298	3														
AP948	Neutral Mass Spectrometer	1					.483	.076	.406	.0149	3														
AP949	Triaxial Fluxgate	1					.483	.076	.406	.0149	3														
AP950	Segmented Planar Probe	1					.483	.076	.406	.0149	5														
AP951	Rubidium Magnetometer	1	0	0	1	1	.483	.152	.406	.0298	3					Equip. Oper.	Cont.	None							

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______

Volume, m^3: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______

33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-4o PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	3 Qty	Location Code① 4 Storage	5 Operating	Access Code② 6 Setup	7 Operating	Unit Size, (m) 8 W or D	9 H	10 L (1)	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	Field of View (deg) Instantaneous 13 W or D	14 L	Total 15 W or D	16 L	Manned Access Requirements 17 Primary Reason?	18 How Often?	Consumables 19 Type	Use Rate 20 Qty.	21 Units	How Supl'd 22 Payload	23 Spacelab	How Disp'd 24 Ret'd to Earth	25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP952	Triaxial Search Coil	1	0	0	1	1	.483	.076	.406	.0149	3					Equip. Oper.	Cont.	None							(1) ARINC 404 max. standard
AP953	Amplifiers (Pulse) Particle Detection	1	↑	↑	↑	↑	.483	.076	.406	.0149	10					↑	↑	↑							
AP954	HV Supplies - Particle Detection	1					.483	.076	.406	.0149	10														
AP955	Triaxial Hemispherical Analytical Controls	3	↓	↓	↓	↓	.483	.076	.406	.0149	5					↓	↓	↓							
	DEPLOYABLE SATELLITE																								
AP956	TV System	1	↑	↑	↑	↑	.483	.152	.406	.0298	10					↑	↑	↑							
AP957	Telemetry and Ranging	1					.483	.076	.406	.0149	10														
AP958	Location and Orientation	1					.483	.076	.406	.0149	10														
AP959	Instrument Control and Housekeeping	1					.483	.076	.406	.0149	10														
AP960	Ejection Mechanism	1	↓	↓	↓	↓	.483	.076	.406	.0149	5					↓	↓	↓							
	OPTICAL																								
AP961	Photometer HV Supply	1	↑	↑	↑	↑	.483	.076	.406	.0149	10					↑	↑	↑							
AP962	Photometer Amplifiers	2					.483	.076	.406	.0149	10														
AP963	TV System Control - Image Intensifier, Optical	2	↓	↓	↓	↓	.483	.076	.406	.0149	26(2)					↓	↓	↓							(2) TV camera (7 kg) provided by payload; remainder provided by Spacelab
	RELEASES																								
AP964	Canister Ejection	1	0	0	1	1	.483	.076	.406	.0149	5					Equip. Oper.	Cont.	None							

PREPARATION INSTRUCTIONS
① Location Code: 0 = pressurized
1 = unpressurized
② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ 28 Unpressurized ______ 29 Total: ______
Volume, m³: 30 Pressurized ______ 31 Unpressurized ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-4P PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

1 Inv. No.	2 Name	3 Qty	4 Location Code (1) Storage	5 Location Code (1) Operating	6 Access Code (2) Setup	7 Access Code (2) Operating	8 Unit Size (m) W or D	9 H	10 L	11 Unit Vol (m^3)	12 Unit Dry Wt (kg)	13 Field of View Instantaneous W or D	14 Instantaneous L	15 Total W or D	16 Total L	17 Manned Access Primary Reason?	18 How Often?	19 Consumables Type	20 Use Rate Qty.	21 Units	22 How Supl'd Payload	23 Spacelab	24 How Disp'd Ret'd to Earth	25 Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP965	Camera	1	0	0	1	1	.483	.076	.406	.0149	2					Equip. Oper.	Cont.	None							
AP966	Canister Monitor	1					.483	.076	.406	.0149	3														
AP967	Shaped Charge Ejection	1					.483	.076	.406	.0149	3														
AP968	Shaped Charge Monitor	1					.483	.076	.406	.0149	3														
AP969	Balloon Ejection	1					.483	.076	.406	.0149	3														
AP970	Gas Control System	1					.483	.076	.406	.0149	3														
	REMOTE SENSING PLATFORM																								
AP971	Gimbal Control	1					.483	.076	.406	.0149	2														Spacelab provided
AP972	XUV Normal Incidence Spectrometer	1					.483	.152	.406	.0298	6														
AP973	UV-Visible NIR Scanning Spectrometer	1					.483	.229	.406	.0447	6														
AP974	High-Resolution Fourier SWIR Spectrometer	1					.483	.152	.406	.0298	6														
AP975	Cryogenic IR Four ier Spectrometer	1					.483	.152	.406	.0298	6														
AP976	IR Radiometer	1					.483	.152	.406	.0298	6														
AP977	Fabry-Perot Interferometer	1					.483	.152	.406	.0298	6							None							
AP978	UV-Visible Documentation Camera	1					.483	.152	.406	.0298	2							Film	TBD	Frame	X		X		

PREPARATION INSTRUCTIONS
(1) Location Code: 0 = pressurized
1 = unpressurized
(2) Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:
Weight, kg: 27 Pressurized ______ Volume, m^3: 30 Pressurized ______
28 Unpressurized ______ 31 Unpressurized ______
29 Total: ______ 32 Total: ______
33 Total weight of experiment equipment items left in orbit, kg ______

SSPD (S-4) 3-15-74

DATA SHEET NO. S-4P

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT CHARACTERISTICS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-49 PAYLOAD NO. AP-06-S

DATE JUN 11 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	3 Qty	4 Location Code① Storage	5 Location Code① Operating	6 Access Code② Setup	7 Access Code② Operating	8 Unit Size (m) W or D	9 H	10 L	11 Unit Vol (m³)	12 Unit Dry Wt (kg)	13 Field of View (deg) Instantaneous W or D	14 Instantaneous L	15 Total W or D	16 Total L	17 Manned Access Requirements Primary Reason?	18 How Often?	19 Consumables Type	20 Use Rate Qty.	21 Use Rate Units	22 How Sup'l'd Payload	23 How Sup'l'd Spacelab	24 How Disp'd Ret'd to Earth	25 How Disp'd Release	26 Special Characteristics: Identify items requiring air locks, booms (state length), vacuum ports, etc. Identify items left in orbit
AP981	KeV-MeV Particle Detector	1	0	0	1	1	.483	.076	.406	.0149	6					Equip. Oper.	Cont.	None							
AP982	Total Energy Detector	1	↓	↓	↓	↓	.483	.076	.406	.0149	6					↓	↓	↓							
AP983	LIDAR and Gimbal Platform Monitor	1	↓	↓	↓	↓	.483	.229	.406	.0447	25					↓	↓	↓							
AP984	Filter Photometer	4	↓	↓	↓	↓	.483	.076	.406	.0149	7					Equip. Oper.	Cont.	None							
AP900	SUBTOTAL									2.012	446.0														

PREPARATION INSTRUCTIONS

① Location Code: 0 = pressurized
1 = unpressurized

② Access Code: 0 = manned access not required
1 = manned access is required

NOTE: Enter totals in Items 27-33 only on final sheet S-4 for this payload.

The unit weights and volumes multiplied by the quantities indicated above are:

Weight, kg: 27 Pressurized 640.0 — 28 Unpressurized 4655.8 — 29 Total: 5295.8

Volume, m³: 30 Pressurized 3.174 — 31 Unpressurized 38.572 — 32 Total: 41.746

33 Total weight of experiment equipment items left in orbit, kg 695

SORTIE PAYLOAD
SKETCHES - PRESSURIZED EQUIPMENT

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC, AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-5 PAYLOAD NO. AP-06-S
DATE JUN 24 1974 REV DATE ____ LTR ____

PRESSURIZED EQUIPMENT CONFIGURATION ----TBD

PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Indicate type and location of physical interfaces.
4. Indicate special manned access requirements, where applicable.
5. Indicate relative flight path direction, where applicable.
6. Use continuation sheet(s) as required.

SSPD (S-5) 3-15-74

DATA SHEET NO. S-5

SORTIE PAYLOAD

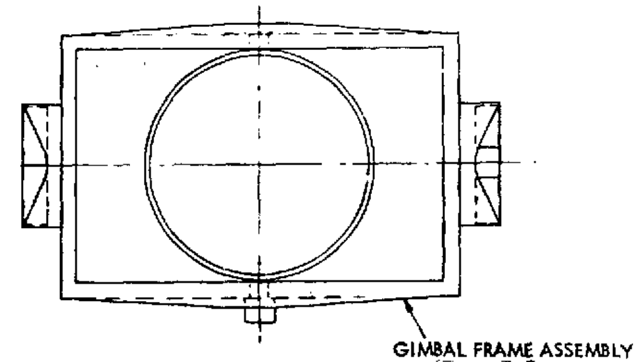
SKETCHES - UNPRESSURIZED EQUIPMENT

DATA SHEET NO. S-6a PAYLOAD NO. AP-06-S

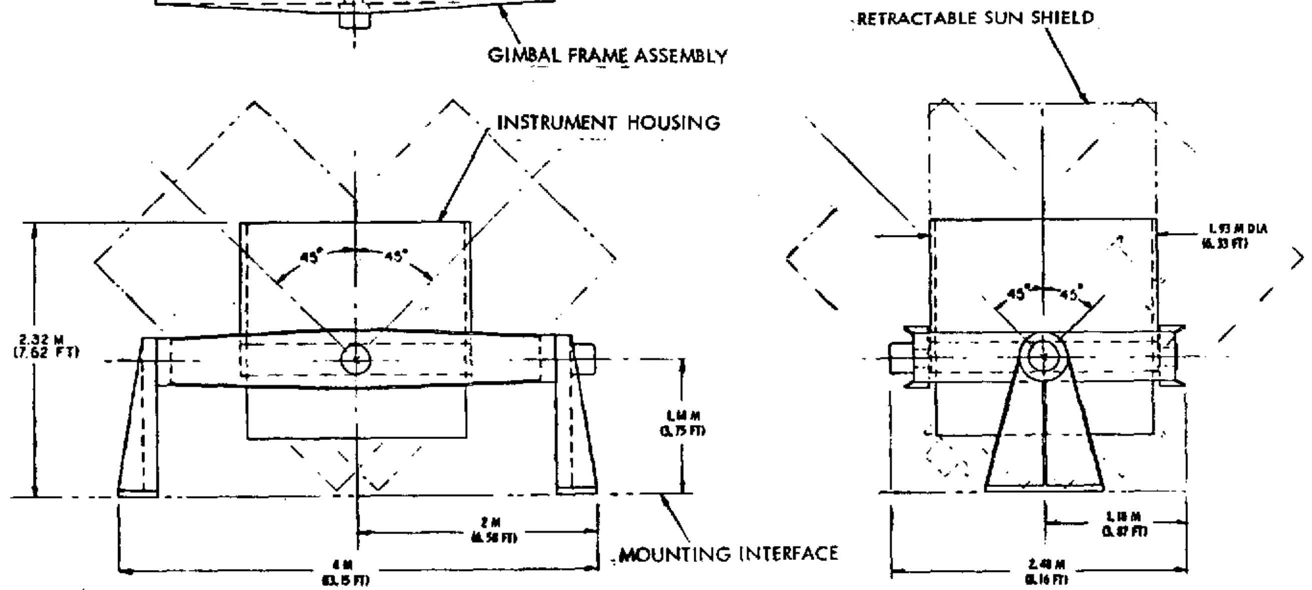
DATE JUN 07 1974 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

AP100 REMOTE SENSING PLATFORM SYSTEM



AP100 REMOTE SENSING PLATFORM SYSTEM
- AP101 REMOTE SENSING PLATFORM
- AP102 XUV NORMAL INCIDENCE SPECTROMETER
- AP103 UV-VISIBLE-NIR SCANNING SPECTROMETER
- AP104 HIGH-RESOLUTION FOURIER SWIR SPECTROMETER
- AP105 CRYOGENIC IR FOURIER SPECTROMETER
- AP106 IR RADIOMETER
- AP107 FABRY-PEROT INTERFEROMETER
- AP108 FILTER PHOTOMETER
- AP109 UV-VISIBLE DOCUMENTATION CAMERAS
- AP114 KEV-MEV PARTICLE DETECTOR
- AP115 TOTAL ENERGY DETECTOR



PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SORTIE PAYLOAD

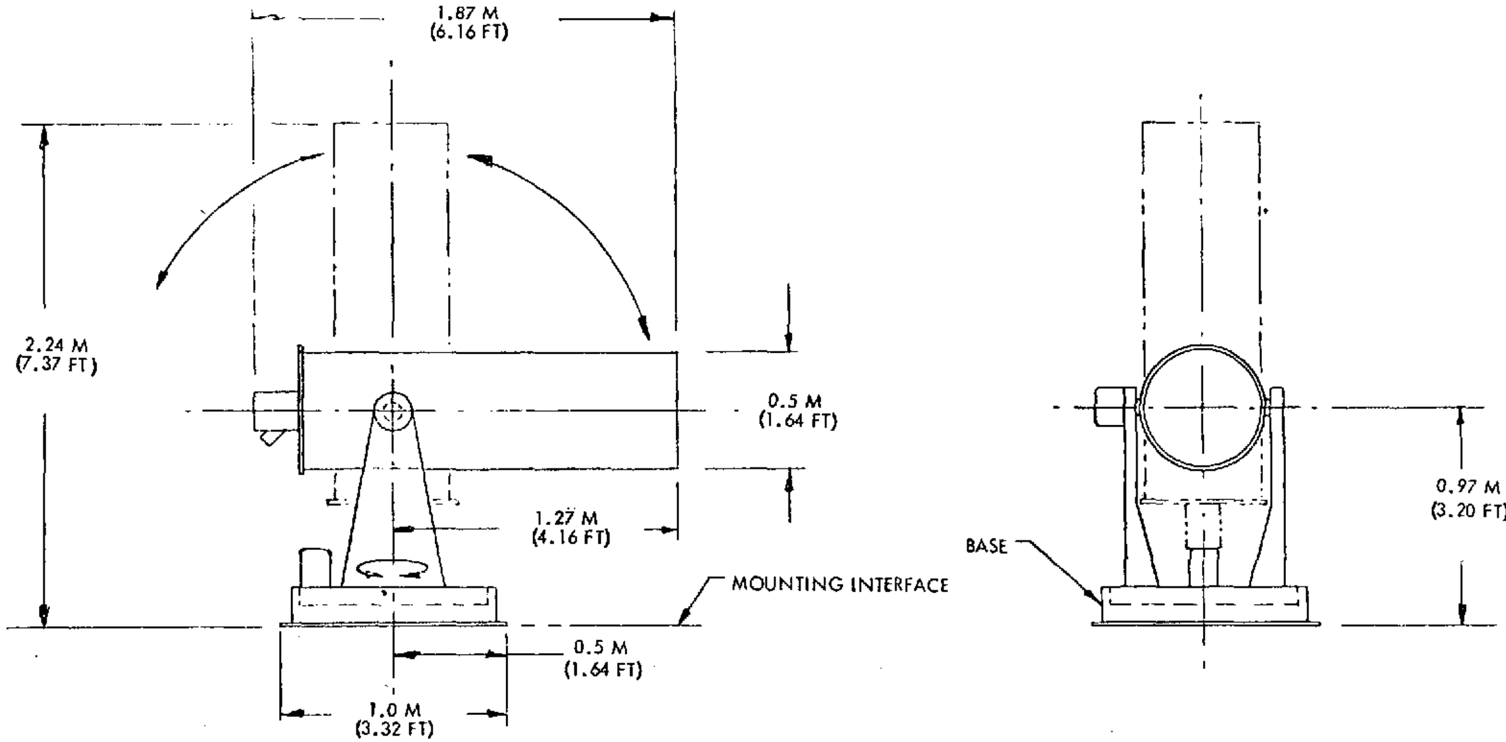
SKETCHES - UNPRESSURIZED EQUIPMENT

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-6b PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

AP200 LIDAR SYSTEM



PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SSPD (S-6) 3-15-74

DATA SHEET NO. S-6b

SORTIE PAYLOAD

SKETCHES - UNPRESSURIZED EQUIPMENT

DATA SHEET NO. S-6c PAYLOAD NO. AP-06-S

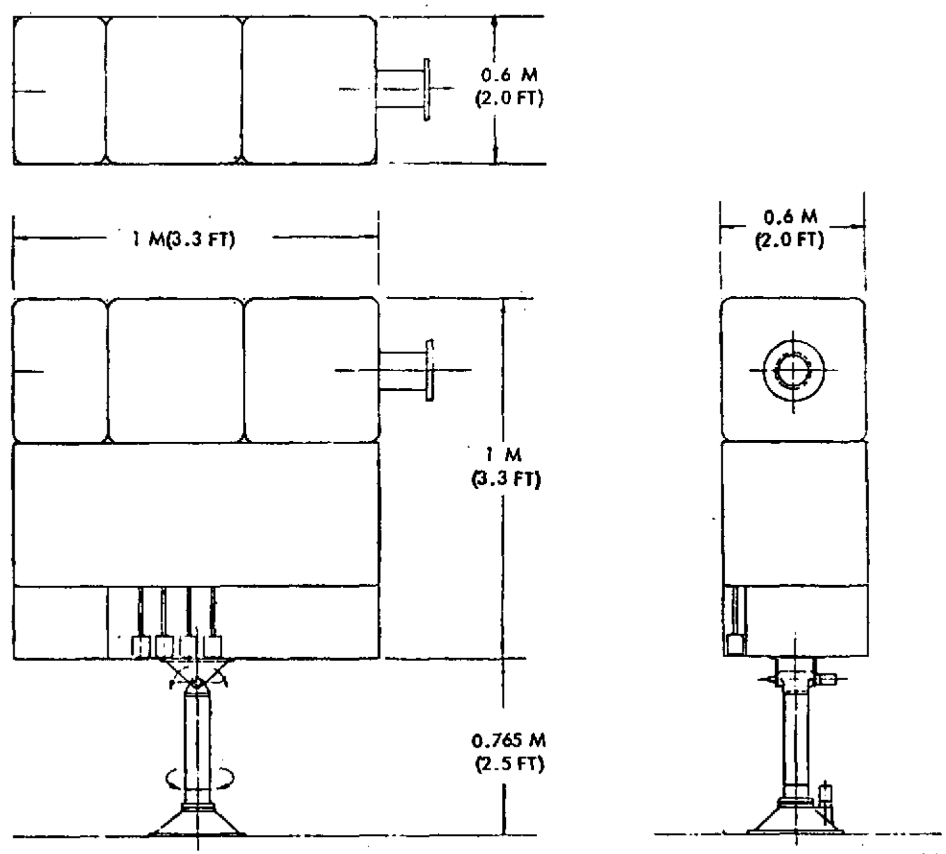
DATE JUN 07 1974 REV DATE ____ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

AP300 GIMBALED ACCELERATOR SYSTEM

AP301 ION ACCELERATOR Shown

NOT TO SCALE



PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SORTIE PAYLOAD

SKETCHES - UNPRESSURIZED EQUIPMENT

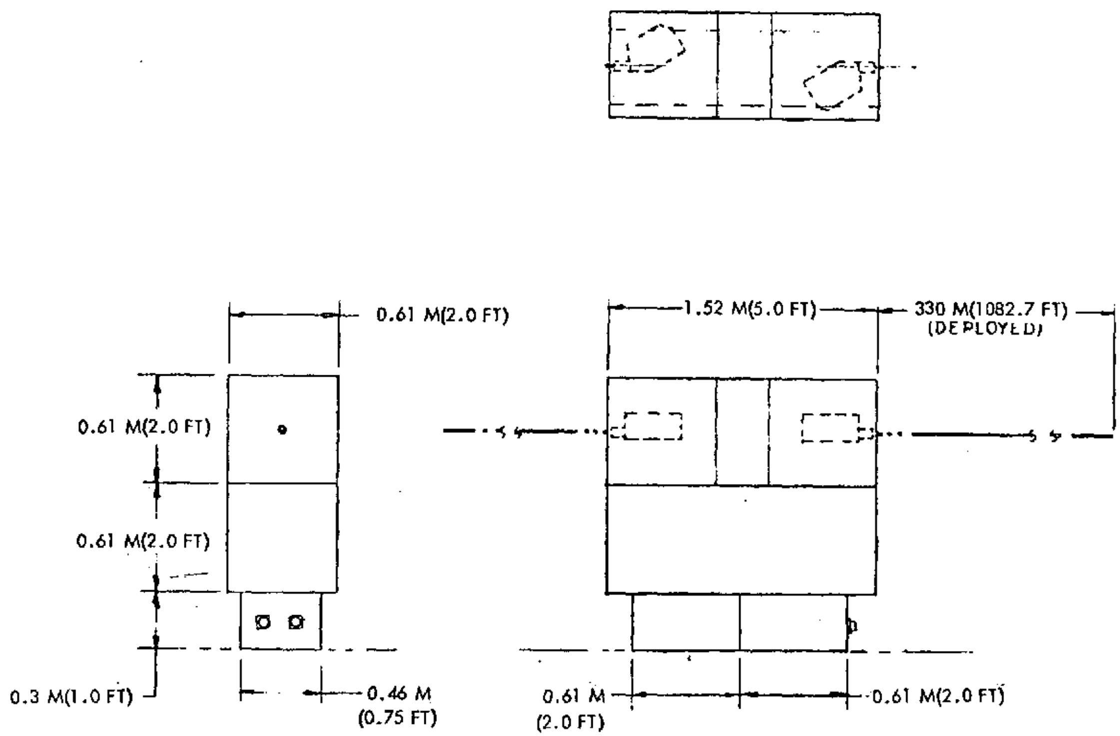
PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-6d PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

AP400 : TRANSMITTER/COUPLER SYSTEM

NOT TO SCALE



PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SSPD (S-6) 3-15-74

SORTIE PAYLOAD

SKETCHES - UNPRESSURIZED EQUIPMENT

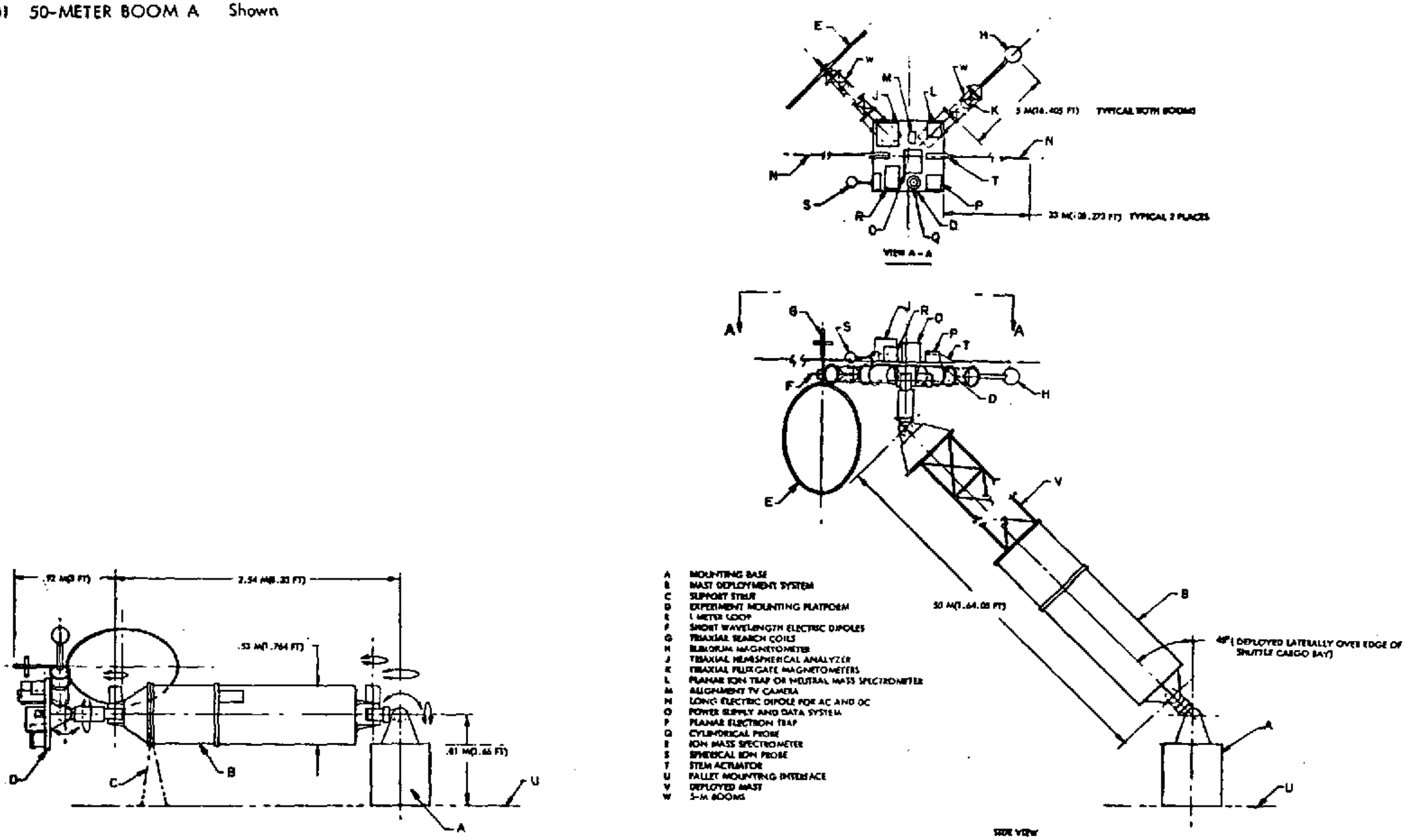
DATA SHEET NO. S-6e PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

AP500 BOOM SYSTEM

AP501 50-METER BOOM A Shown



PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SORTIE PAYLOAD

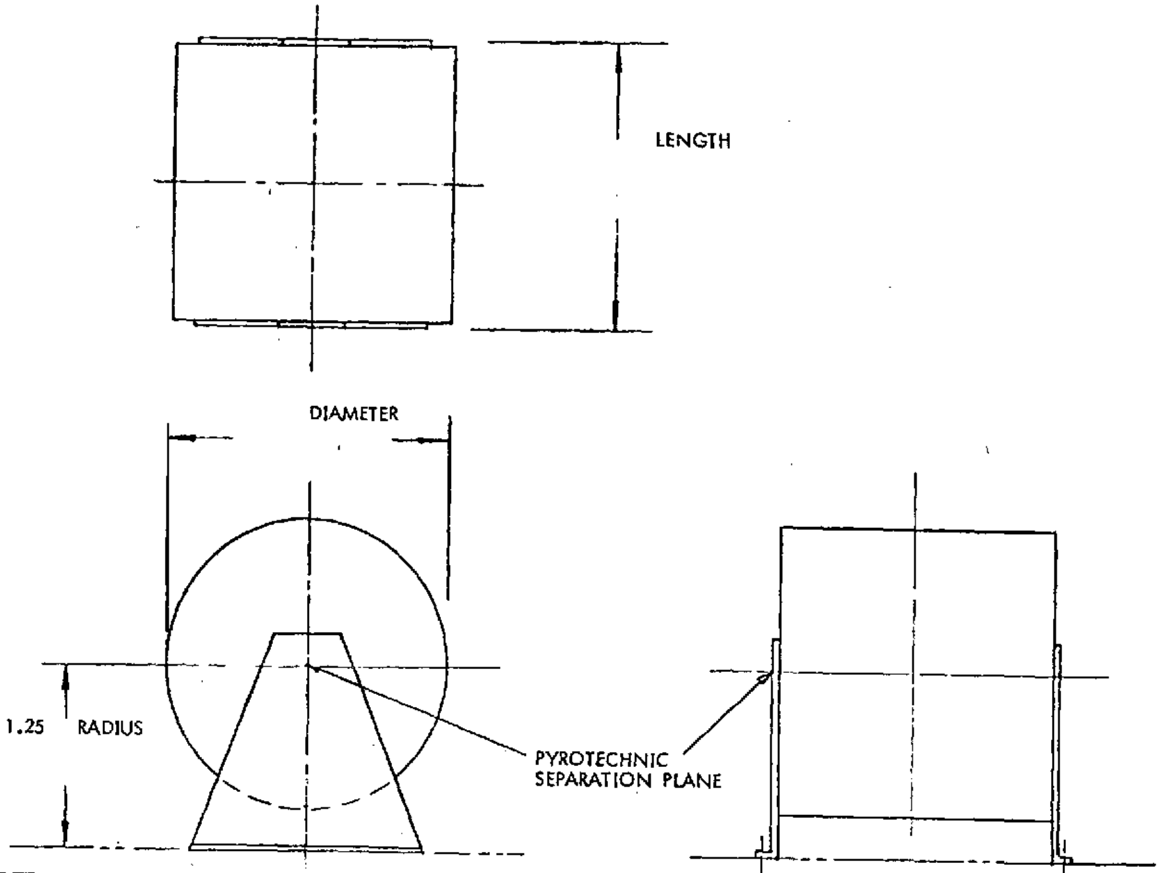
SKETCHES - UNPRESSURIZED EQUIPMENT

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-6 f PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

AP600 DEPLOYABLE UNITS



ITEM NUMBER	EQUIPMENT NAME	DIA.	LENGTH
AP601	Barium Canister, 100 gm	0.125 (0.415)	0.125 (0.415)
AP602	Barium Canister, 1 kg	0.198 (0.66)	0.198 (0.66)
AP603	Barium Canister, 10 kg	0.3 (1.0)	0.375 (1.25)
AP610	Shaped Charge, 1 kg	0.198 (0.66)	0.61 (2.0)
AP611	Shaped Charge, 5 kg	0.350 (1.165)	1.03 (3.42)
AP612	Shaped Charge, 15 kg	0.549 (1.83)	1.63 (5.42)
AP620	Balloon - Spherical Insulated	0.198 (0.66)	0.375 (1.25)
AP621	Balloon - Spherical Conducting	0.25 (0.833)	0.498 (1.66)

NOTE: TYPICAL FOR BARIUM CANISTERS AND BALLOON DEPLOYMENT DEVICES.

PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SORTIE PAYLOAD

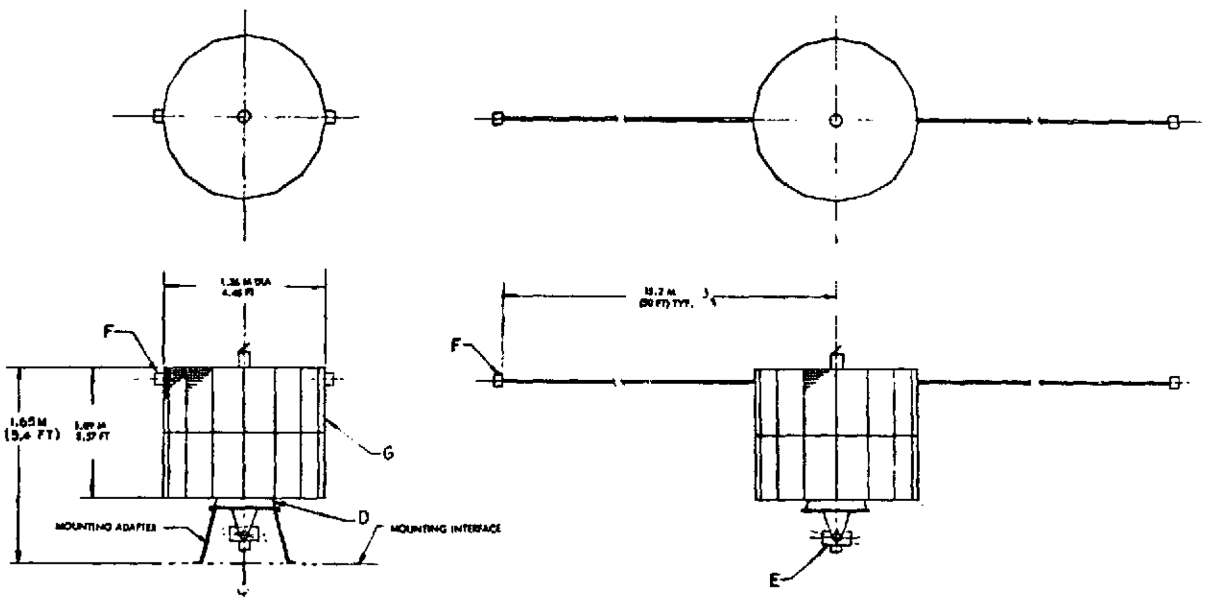
SKETCHES - UNPRESSURIZED EQUIPMENT

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-6.8 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

AP700 DEPLOYABLE SATELLITE SYSTEM



DEPLOYED CONFIGURATION

AP700 DEPLOYABLE SATELLITE SYSTEM
- AP701 SATELLITE
- AP702 TV SYSTEM
- AP703 MAG 3-AXIS FLUXGATE
- AP704 MAG SEARCH COIL
- AP705 CYL ELEC PROBE
- AP706 SEGMENTED PLANAR TRAP
- AP707 ION MASS SPECTROMETER
- AP708 TRIAXIAL HEMISPH. ANALYZER
- AP709 VLF RECEIVER
- AP710 E-FIELD METER
- AP711 SATELLITE/PALLET INTERFACE & EJECTOR MECHANISM
- AP712 TRANSPONDER, TELEMETRY & RANGING

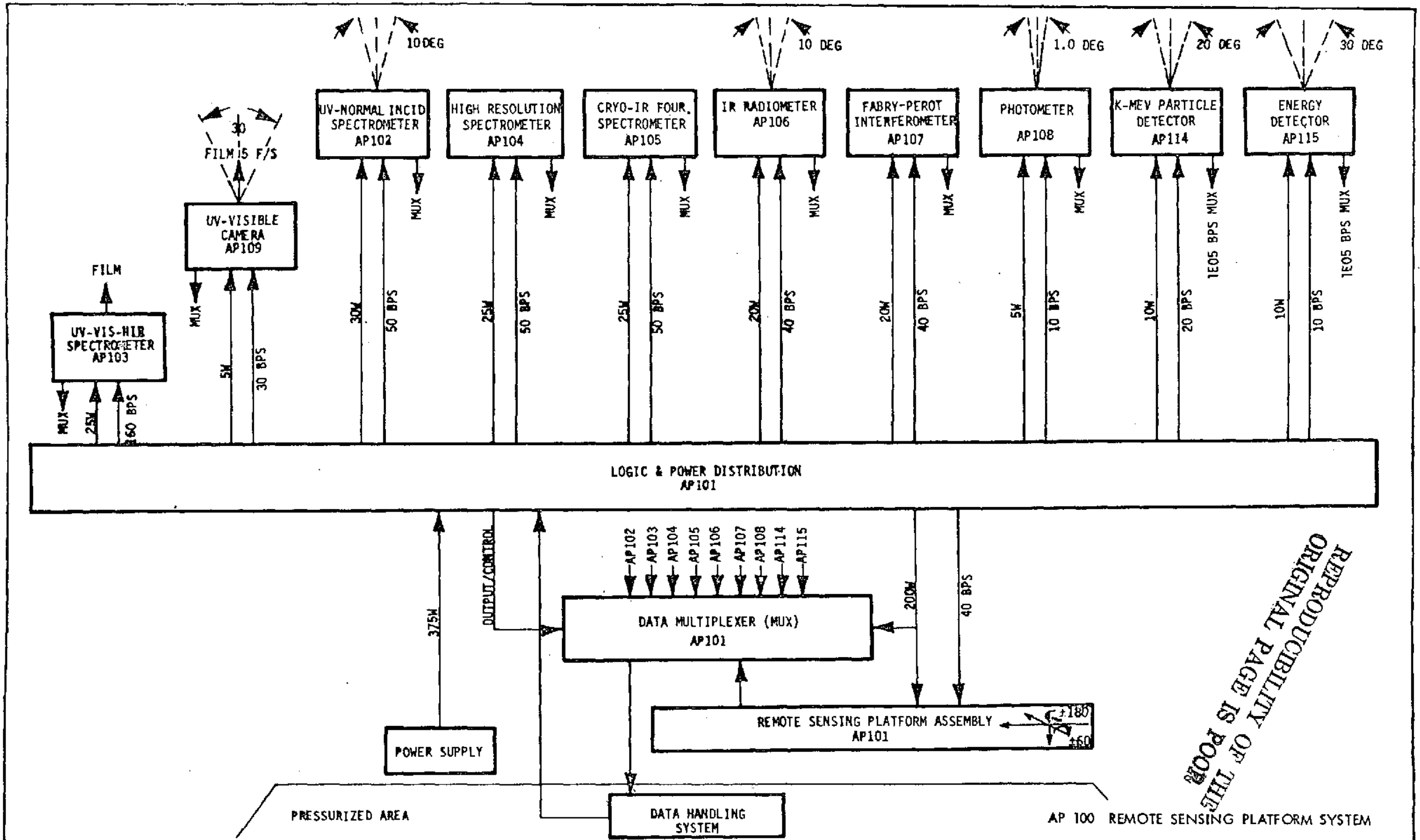
PREPARATION INSTRUCTIONS:

1. Identify each item by inventory number and name.
2. Use an isometric sketch and give envelope dimensions.
3. Show both stowed and deployed configurations, where applicable.
4. Indicate type and location of physical interfaces.
5. Indicate special manned access requirements, where applicable.
6. Indicate relative flight path direction, where applicable.
7. Use continuation sheet(s) as required.

SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

DATA SHEET NO. S-7 a PAYLOAD NO. AP-06-S Ⓐ
DATE JUN 24 1974 REV DATE 7/30/74 LTR A

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC, AND PLASMAS IN SPACE (AMPS)

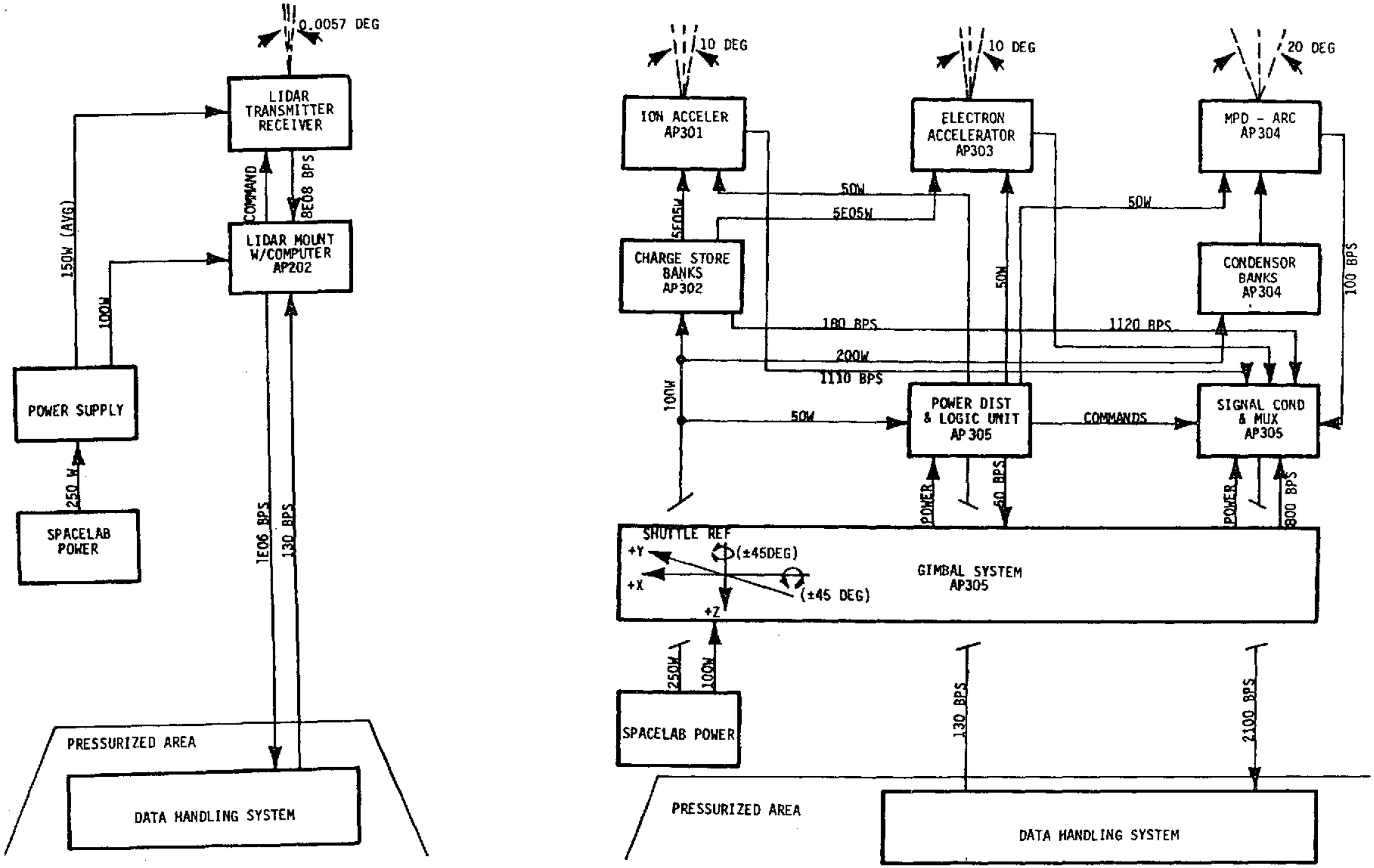


REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

DATA SHEET NO. S-7 b PAYLOAD NO. AP-06-S Ⓐ
DATE JUN 24 1974 REV DATE 7/30/74 LTR A

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)



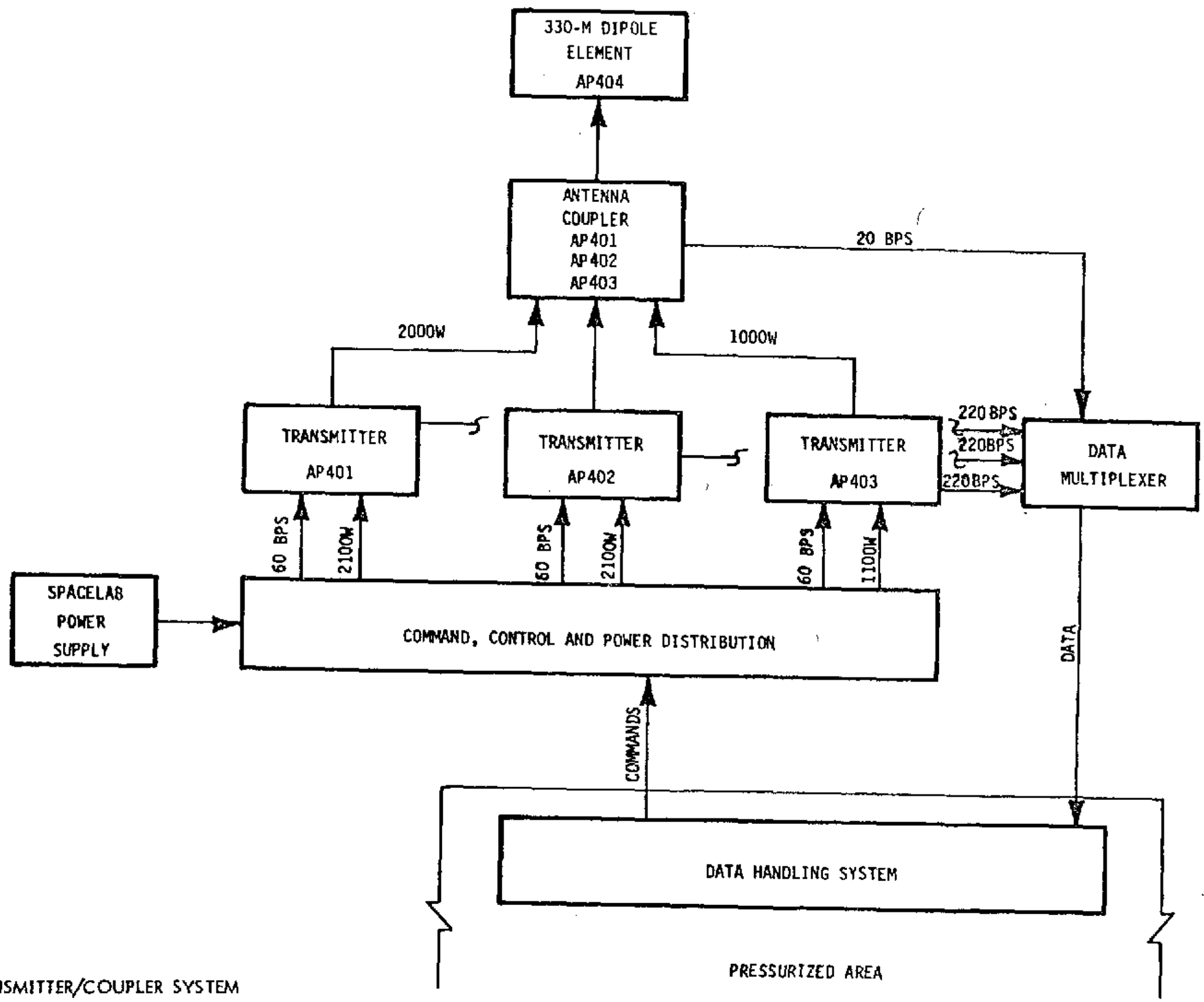
AP 200 LIDAR SYSTEM

AP 300 GIMBALED ACCELERATOR SYSTEM

SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

PAYLOAD NAME ATMOSPHERIC MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-7c PAYLOAD NO. AP-06-S
DATE [illegible] REV DATE ______ LTR ______

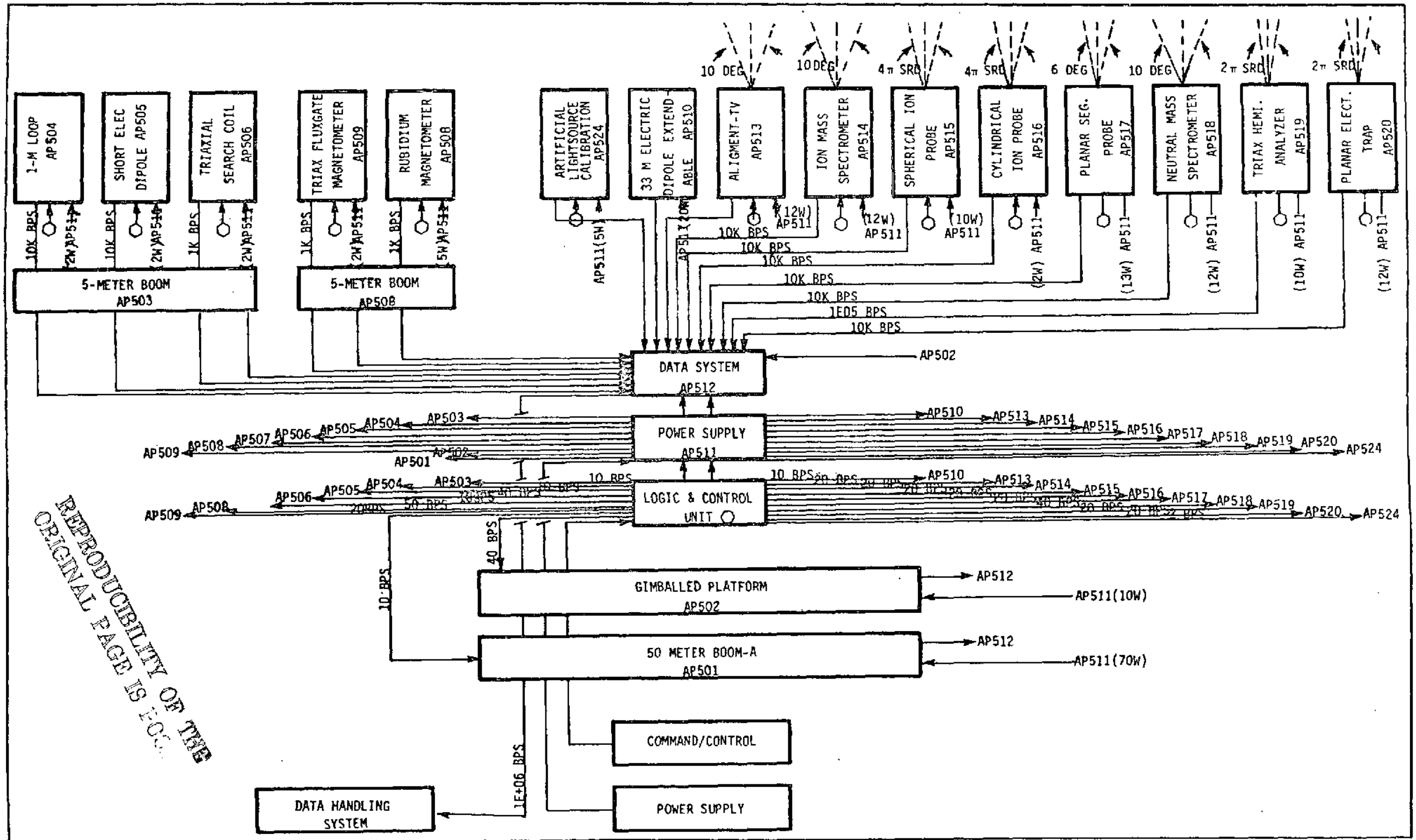


AP 400 TRANSMITTER/COUPLER SYSTEM

SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

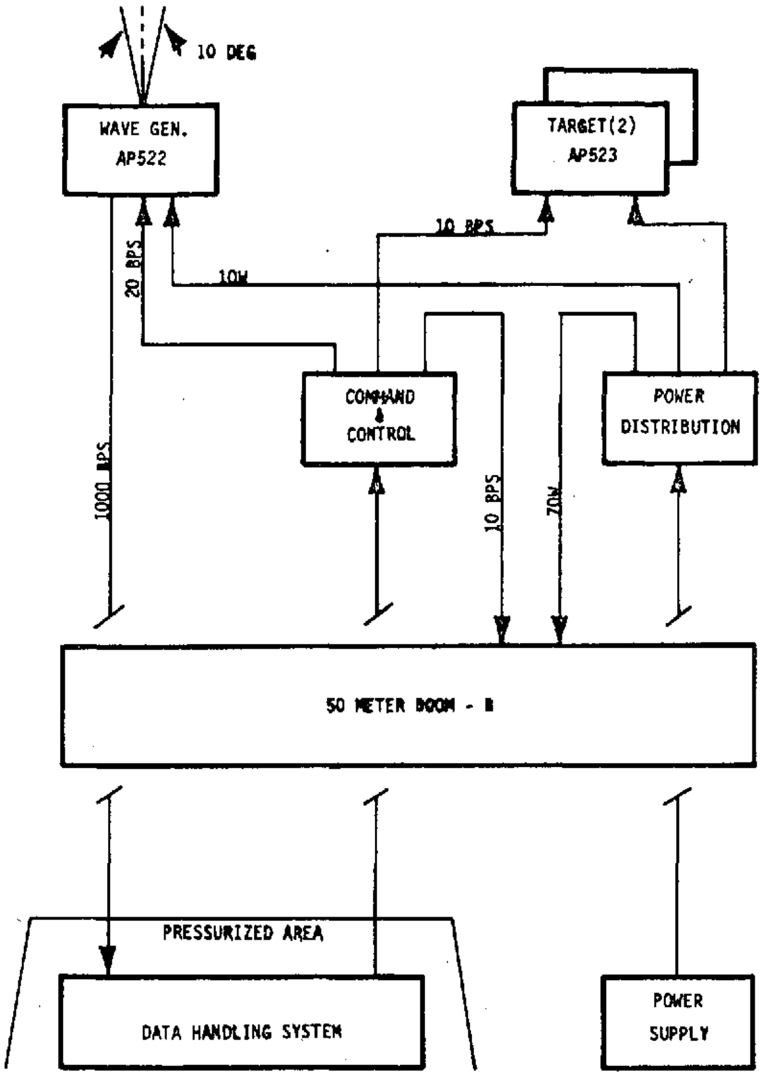
DATA SHEET NO. S-7 d PAYLOAD NO. AP-06-S
DATE JUN 24 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)



SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

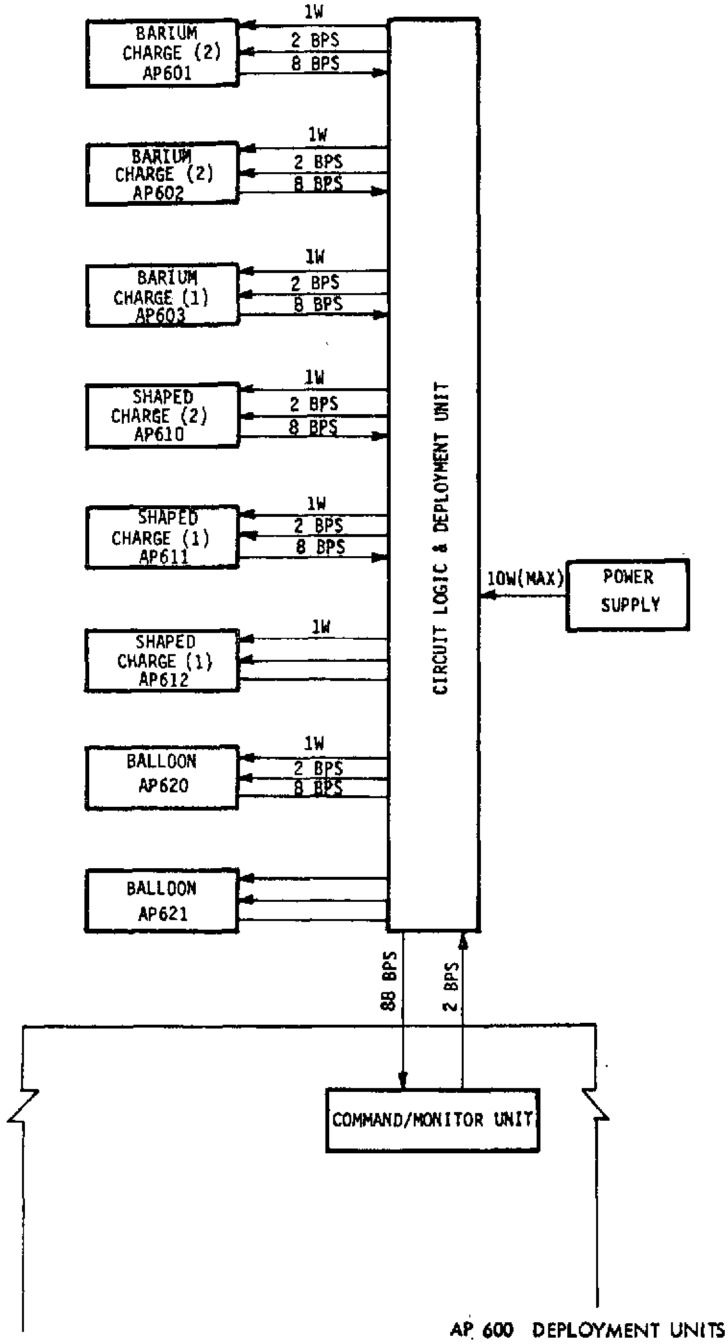
PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)



AP 500 BOOM SYSTEM (continued)

SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

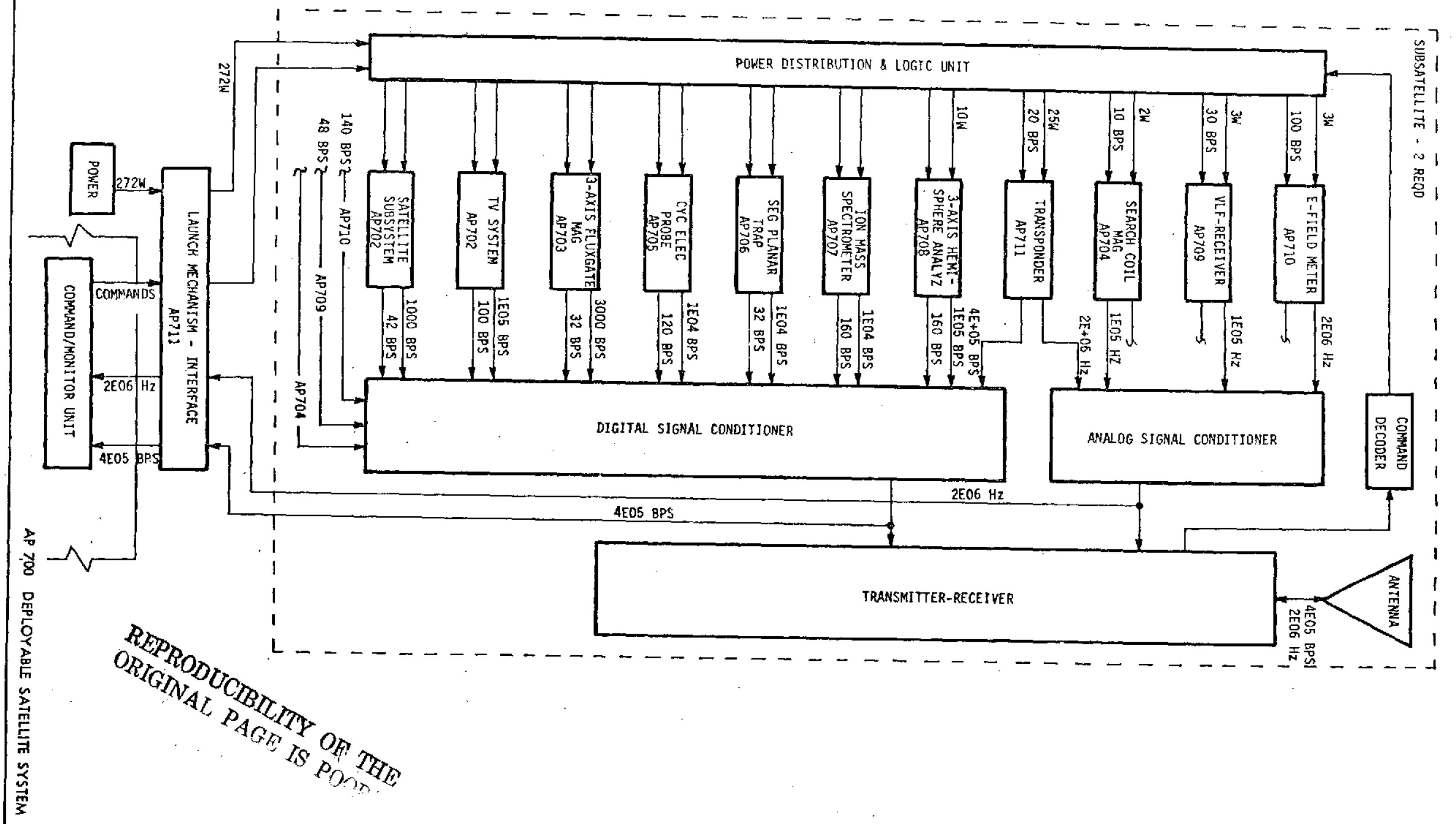
PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)



SORTIE PAYLOAD
INTERFACE DIAGRAM(S)

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-7 9 PAYLOAD NO. AP-06-S
DATE JUN 24 1974 REV DATE ____ LTR ____



SSPD (S-7) 3-15-74

DATA SHEET NO. S-7 9

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8a PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER														DATA				Input Commands	
			DC						AC								Output					
			Voltage						Freq (Hz)		Voltage						Science		Housekeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP100	Remote Sensing Platform System													(1)				(1)				(4)
AP101	Remote Sensing Platform	1							400		110	10	TBD	200					D	800 bps	Discrete D	2 40 bps
AP102	X UV Normal Incidence Spectrometer								400		110	10	TBD	30			D	.5E + 04	D	110	Discrete D	3 50
AP103	UV-Visible-NIR Scanning Spectrometer	1							400		110	10	TBD	25			F	125 frames/roll	D	160	Discrete D	1 160
AP104	High Resolution Fourier SWIR Spectrometer	1							400		110	10	TBD	25			D		D	110	Discrete D	3 50
AP105	Cryogenic IR Fourier Spectrometer	1							400		110	10	TBD	25			D		D	110	Discrete D	3 50
AP106	IR Radiometer	1							400		110	10	TBD	20			D	1E + 04	D	300	Discrete D	2 40
AP107	Fabry-Perot Interferometer	1							400		110	10	TBD	20			D		D	100	Discrete D	2 40
AP108	Filter-Photometer	4							400		110	10	TBD	5			D	1E + 03	D	130	Discrete D	2 10
AP109	UV-Visible Documentation Cameras	2																				
AP114	KeV-MeV Particle Detector (G5)	1							400		110	10	TBD				D	1E + 05	D	100	Discrete D	1 20
AP115	Total Energy Detector (G6)	1							400		110	10	TBD				D	1E + 05	D	100	Discrete D	1 10

24. NOTES:
(1) System total power requirement and data output is function of experiment requirements.
(2) Experiment supplied condensor bank provides 500 kilowatts peak internal power.
(3) Experiment supplied condensor bank provides 25 megawatts peak internal power.
(4) 10 bit words, 2 words per second.

25. COMMENTS:

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8 b PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER – DC							UNIT ELECTRICAL POWER – AC								DATA – Output – Science		DATA – Output – Housekeeping		DATA – Input Commands	
1. Inv. No.	2. Name	3. Qty	4. Voltage Nom (V)	5. Voltage Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. Freq (Hz) f_{low}	11. Freq (Hz) f_{high}	12. Voltage Nom (V)	13. Voltage Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP200	LIDAR System (Phased Array)	1	28	10		100			400		110	10	100				D	1.01E+06	D	1180	Discrete D	6 130
AP201	Transmitter/Receiver	1							400		110	10	100	1E + 04			D	1E+06 (1)	D	380	Discrete D	3 80
AP202	Mount, Computer Controlled	1	28	10		100											D	1E + 04	D	800	Discrete D	3 50
AP300	Gimbaled Accelerator System													(2)				(2)				
AP301	Ion Accelerator	1							400		110	10	50	50					D	1110	Discrete D	2 80
AP302	Storage Banks, 2-5 Kilojoules HV	1							400		110	10	100	(3)					D	180	Discrete	1
AP303	Gimballed Electron Accelerator	1							400		110	10	50	200					D	1120	Discrete D	2 80
AP304	MPD ARC, Including Condenser Bank	1							400		110	10	250	(4)					D	100	Discrete D	2 40
AP305	Gimbal System, Accelerator, Ion/Electron	1	28	10		100											D	1E+04	D	800	Discrete	2 50

24. NOTES:

(1) System is conceived to include an A/D converter at 100 MHz sampling, 8 bits per sample, output data rate reflects internal data compression from 8E+08 bps acquisition rate.
(2) System total power requirement and data output is function of experiment requirements.
(3) Experiment supplied condenser bank provides 500 kilo watts peak internal power.

25. COMMENTS: NONE.

(4) Experiment supplied condenser bank provides 25 megawatts peak internal power.

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT – POWER AND DATA

DATA SHEET NO. S-8c PAYLOAD NO. AP-06-S

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATE JUN 0? 1974 REV DATE ______ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER														DATA				Input Commands	
			DC						AC								Output					
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP400	Transmitter/Coupler System					(1)								(1)				(1)				
AP401	Transmitter/Coupler (10KW 0.2 to 2 MHz)	1							400		110	10	50	1E +04					D	220	Discrete D	2 60
AP402	Transmitter/Coupler (10KW 0.2 to 2MHz)	1							400		110	10	50	1E +04					D	220	Discrete D	2 60
AP403	Transmitter/Coupler (1KW 0.3 to 200 KHz)	1							400		110	10	50	1000					D	220	Discrete D	2 60
AP404	Dipole Element -330-meters	1	28	10	0	10	N/A	N/A	-										D	20	Discrete D	1 10
AP500	Boom System					(1)																
AP501	50-Meter Boom A	1	28	1	0	70	70	TBD											D	20	Discrete D	1 10
AP502	Gimbaled Platform (2, 3)	1	28	1	0	10	10	TBD											D	800	Discrete D	2 40
AP503	5-Meter Boom (2, 3)	1	28	1	0	0	3	0.028											D	20	Discrete D	1 10
AP504	One-Meter Loop (2, 3)	1	28	1	0	2	2	TBD									D	IE + 04	D	20	Discrete	2
AP505	Short Electric Dipole (2, 3)	1	28	1	0	2	2	TBD									D	1E + 04	D	20	Discrete D	1 10
AP506	Triaxial Search Coil (2, 3)	1	28	0.1	0	2	2	TBD									D	1000	D	180	Discrete D	2 40
AP507	5-Meter Boom (2, 3)	1	28	1	0	0	3	0.028											D	20	Discrete D	1 10
AP508	Rubidium Magnetometer (2, 3)	1	28	0.1	0	5	5	TBD									D	1000	D	450	Discrete D	1 50
AP509	Triaxial Fluxgate (2, 3)	1	28	0.1	0	2	2	TBD									D	1000	D	32	Discrete D	2 20
AP510	33-Meter Electric Dipole-Extendable (BA9) (2, 3)	1	28	1	0	2	4	0.125									D	1E + 04	D	20	Discrete D	1 10

24. NOTES: (1) System total power requirement and data output is function of experiment requirement.
(2) AP511 Power Supply delivers electrical power to AP502 through AP520 and AP524. Power requirement shown for AP511 is allowance for losses. Total power output requirement for AP511 is function of experiment requirements.
(3) All Boom A instruments interface with AMPS through AP512 Data System. Data rate shown for AP512 is maximum output rate.

25. COMMENTS:

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8d PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Housekeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP511	Power Supply (2)	1	28	10	0	10	10										---	---	D	180	Discrete D	1 10
AP512	Data System (3)	1	28	10	0	10	10										D	1E + 06	D	48	Discrete D	3 50
AP513	Alignment TV (2, 3)	1	28	10	0	20	20										D	1E + 05	D	100	Discrete D	7 20
AP514	Ion Mass Spectrometer (2, 3)	1	28	10	0	12	12										D	1E + 04	D	160	Discrete D	3 20
AP515	Spherical Ion Probe (2, 3)	1	28	10	0	10	10										D	1E + 04	D	100	Discrete D	1 20
AP516	Cylindrical Ion Probe (2, 3)	1	28	10	0	2	2										D	1E + 04	D	100	Discrete D	1 20
AP517	Planar Segmented Probe (2, 3)	1	28	10	0	13	13										D	1E + 04	D	120	Discrete D	1 20
AP518	Neutron Mass Spectrometer (2, 3)	1	28	10	0	12	12										D	1E + 04	D	160	Discrete D	3 40
AP519	Triaxial Hemispherical Analyzer (2, 3)	1	28	10	0	10	10										D	1E + 05	D	160	Discrete D	2 20
AP520	Planar Electron Trap (2, 3)	1	28	10	0	12	12										D	1E + 04	D	160	Discrete D	1 20
AP521	50-Meter Boom B	1	28	10	0	70	70												D	120	Discrete D	1 10
AP522	Wave Generator	1	28	10	0	10	10										D	1000	D	110	Discrete D	1 20
AP523	Target	2	28	10	0	0	0										---	---	D	16	Discrete D	2 10
AP524	Artificial Light Source Calibration (Boom A) (2, 3)	1	28	10	0	5	5										---	---	D	32	Discrete	1

24. NOTES: (2) AP511 Power System delivers electrical power to AP502 through AP520 and AP524. Power requirement shown for AP511 is allowance for losses. Total power output requirement for AP511 is function of experiment requirements.

(3) All Boom A instruments interface with AMPS through AP512 Data System. Data rate Shown for AP512 is maximum output rate.

25. COMMENTS:

SSPD (S-8) 3-15-74

DATA SHEET NO. S-8 d

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT – POWER AND DATA

DATA SHEET NO. S-8c PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

EQUIPMENT			UNIT ELECTRICAL POWER														DATA				Input Commands	
			DC						AC								Output					
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP600	Deployable Units																					
AP601	Barium Canister, 100 gm	2	28	10													---	---	D	8 bps	Discrete	2
AP602	Barium Canister, 1 kg	2	28	10													---	---	D	8	Discrete	2
AP603	Barium Canister, 10 Kg	1	28	10													---	---	D	8	Discrete	2
AP610	Shaped Charge, 1 Kg	2	28	10													---	---	D	8	Discrete	2
AP611	Shaped Charge, 5 Kg	1	28	10													---	---	D	8	Discrete	2
AP612	Shaped Charge, 20 Kg	1	28	10													---	---	D	8	Discrete	2
AP620	Balloon-Spherical Insulated	1	28	10													---	---	D	8	Discrete	2
AP621	Balloon-Spherical Conducting	1	28	10													---	---	D	8	Discrete	2
AP700	Deployable Satellite System					(1)												(1)				
AP701	Satellite	2	28	10		200														42	Discrete D	2 10
AP702	TV System	1	28	10		20											D	1E + 05	D	100	Discrete D	7 110
AP703	Magnetometer 3-Axis Fluxgate	1	28	1		2											D	3000	D	32	Discrete D	2 10
AP704	Magnetometer, Search Coil	1	28	1		2											A	1E + 05	D	32	Discrete D	2 10
AP705	Electric Probe, Cyindrical	1	28	10		2											D	1E + 04	D	120	Discrete D	1 10
A P706	Planar Trap, Segmented	1	28	10		13											D	1E + 04	D	32	Discrete D	2 10

24. NOTES:
(1) System total power requirement and data output is function of experiment requirements.

25. COMMENTS:

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8f PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER: DC						UNIT ELECTRICAL POWER: AC								DATA: Output: Science		DATA: Output: Housekeeping		Input Commands	
1. Inv. No.	2. Name	3. Qty	4. Voltage Nom (V)	5. Voltage Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. Freq (Hz) f_{low}	11. Freq (Hz) f_{high}	12. Voltage Nom (V)	13. Voltage Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP707	Ion Mass Spectrometer	1	28	10		12											D	1E + 04	D	160	Discrete	3 100
AP708	Hemispherical Analyzer, Triaxial	1	28	10		10											D	1E + 05	D	160	Discrete D	2 20
AP709	Receiver, VLF	1	28	10		3											A	1E + 05	D	48	Discrete D	3 30
AP710	E-Field Meter	1	28	10		3											A	2E + 06	D	140	Discrete D	4 100
AP711	Satellite/Pallet Interface and Ejection Mechanism	2	28	10													---	---	D	80	Discrete D	2 20
AP712	Transponder, Telemetry and Ranging	1	28	10		25											D A	4E + 05 2E + 06	D	24	Discrete D	1 20

24. NOTES:

25. COMMENTS:

SSPD (S-8) 3-15-74

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

DATA SHEET NO. S-8g PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7 Oper. Power Level (W)	8. Peak Power Level (W)	9 Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14 Stdby Power Level (W)	15 Oper Power Level (W)	16 Peak Power Level (W)	17 Peak Duration (hr)	18 Form, D, A, Film, etc	19 Rate, bps, Hz, fps, etc	20 Form, D, A, Discrete, etc	21 Rate, bps, Hz, pps, etc.	22 Form, D, A, Discrete, etc.	23 Rate, bps, Hz, pps, etc.
AP800	Displays																					
AP802	Experiment TV Display	2												10								
AP803	Spectrum Analyzer	4												50					D	32		
AP804	Multi-Channel Analyzer	1												50					D	16		
AP805	Wave Analyzer	1												40					D	16		
AP806	Wave Analyzer	1												50					D	16		
AP807	Coaxial Patch Panel	8												0					D	16		
AP808	Frequency Counter	1												5					N/A	0		
AP809	Automatic Display Generator	1												10					D	16		
AP810	Camera (35 mm film)	1				2								20					D	16		
AP811	X-Y Recorder	2												45					D	16		
AP812	Strip Chart Recorder	2											10	100					D	16		
AP813	8-Channel Recorder	2											20	200					D	16		
AP825	TV Camera	1												10					D	16		
AP815	Oscilloscope	2												40					D	16		
AP832	Time Code Generator	1												10					D	16		
	Computation Equipment																					
AP817	Tape Recorder Digital	2												200					D	16		

24. NOTES:

25. COMMENTS:
Provided by Spacelab

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8h PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ____ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Housekeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP818	Computer	2											50	80			N/A	N/A	D	80	N/A	N/A
AP819	Keyboard Display Terminal	1												50			N/A	N/A	P/O AP818	-	N/A	N/A
AP820	Status Panel	2												25			N/A	N/A	P/O AP818	-	N/A	N/A
AP821	Special Data Acquisition Panel	1												25			N/A	N/A	N/A	N/A	N/A	N/A
	Auxiliary Equipment																					
AP814	Tape Recorder Analog	1											20	200			N/A	N/A	D	16	N/A	N/A
AP827	Power Supply Monitor	1												50			N/A	N/A	D	16	N/A	N/A

24. NOTES:

25. COMMENTS:

(shaded) Provided by Spacelab

A-55

SSPD (S-8) 3-15-74

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8i PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER														DATA				Input Commands	
			DC						AC								Output					
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP900	Controls System																					
	Transmitters																					
AP901	10 Kw -0.2 to 2 MHz	1			0	2																
AP902	10 Kw -2 to 20 MHz	1			0	2																
AP903	1 Kw -0.3 to 200 KHz	1			0	2																
AP904	Electrostatic Wave	1			0	2																
	Antennas																					
AP905	Long 330 m Dipole	1			0	10																
AP906	Short VLF Dipole	1			0	10																
AP907	Loop-1M	1			0	10																
AP908	RF Antenna	1			0	10																
	Antenna Couplers																					
AP909	0.2 to 2 MHz	1			0	10																
AP910	2 to 20 MHz	1			0	10																
AP911	0.3 to 200 KHz	1			0	10																
	Wave Analysis																					
AP912	Bandpass Filter	2			0	0																
AP913	Pulse - C.W. Modes	1			0	2																

24. NOTES:

25. COMMENTS:

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8i PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ____ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP914	Patch Panels	5			0	0																
AP915	Amplifiers, Wave (dc)	1			0	5																
AP916	Frequency Synthesizer	2											20	20								
	Main Boom																					
AP917	Main Boom A Control	1			0	5																
AP918	Platform Boom A Control	1			0	5																
AP919	Main Boom B Control	1			0	5																
AP920	Alignment TV	1											0	10								
AP921	Gimbaled Platform Controls	1			0	5																
AP922	5M Boom Control	1			0	5																
AP923	Boom A Power Supply and Data System	1											0	25								
AP924	Boom B Target (inflation, deflation, ejection)	1			0	5																
AP990	Boom A Artificial light source control	1			0	0																
	Ion Beam Accelerator Controls																					
AP925	Accel-Decelerate	1			0	5																
AP926	Discharge Filament Heater	1			0	5																
AP927	Discharge Potential	1			0	1																
AP928	Pulse Sequence and Burst Length	1			0	1																

24. NOTES:

25. COMMENTS:

A-57

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8K PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Houskeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP929	Gas Selection and Pressure	1			0	1																
AP930	Neutralizer Emission and Bias	1			0	1																
AP931	Charge Exchange Channel Actuator	1			0	1																
AP932	Beam Current Monitor	1			0	2																
	Electron Beam																					
AP933	Beam Voltage ; Heater Current	1			0	1																
AP934	Burst Length; Burst Magnitude	1			0	1																
AP935	Expansion Lens	1			1	1																
AP936	Beam Current Monitor	1			0	2																
AP937	φ, θ, I	1			0	1																
	MPD-ARC																					
AP938	Voltage Level	1			0	1																
AP939	Burst Current and Duration	1			0	1																
AP940	Pulse Sequencer	1			0	1																
AP941	Beam Current Monitor	1			0	1																
AP942	Gas Selection and Pressure	1			0	1																
	Ambient Plasma																					
AP943	Spherical Ion Probe	1			2	5																

24. NOTES:

25. COMMENTS:

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-81 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ____ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER: DC						AC								DATA: Output – Science		Output – Housekeeping		Input Commands	
1. Inv. No.	2. Name	3. Qty	Voltage 4. Nom (V)	Voltage 5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	Freq (Hz) 10. f_{low}	Freq (Hz) 11. f_{high}	Voltage 12. Nom (V)	Voltage 13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP944	Cylindrical Ion Probe	1			2	5																
AP945	Planar Electron Probe	1			2	5																
AP946	R. F. Probe	1			2	5																
AP947	Ion Mass Spectrometer	1			2	5																
AP948	Neutral Mass Spectrometer	1			2	5																
AP949	Triaxial Fluxgate	1			5	5																
AP950	Segmented Planar Probe	1			2	5																
AP951	Rubidium Magnetometer	1			5	5																
AP952	Triaxial Search Coil	1			5	5																
AP953	Amplifiers (Pulse) Particle Detection	1			10	10																
AP954	HV Supplies - Particle Detection	1			10	10																
AP955	Triaxial Hemispherical Analytical Controller	3			10	15																
	Deployable Satellite																					
AP956	TV System	1											0	10								
AP957	Telemetry and Ranging	1			0	10																
AP958	Location and Orientation	1			0	10																
AP959	Instrument Control and Housekeeping	1			0	10																
AP960	Ejection Mechanism	1			2	10																

24. NOTES:

25. COMMENTS:

SORTIE PAYLOAD
EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8m PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Housekeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
	Optical																					
AP961	Photometer HV Supply	1			5	5																
AP962	Photometer Amplifiers	2			2	2																
AP963	TV System Control - Image Intensifier, Optional	2			5	12																
	Releases																					
AP964	Canister Ejection	1			0	20																
AP965	Camera	1			0	0																
AP966	Canister Monitor	1			0	10																
AP967	Shaped Charge Ejection	1			0	10																
AP968	Shaped Charge Monitor	1			0	20																
AP969	Balloon Ejection	1			0	20																
AP970	Gas Control System	1			0	20																
	Remote Sensing Platform																					
AP971	Gimbal Control	1			0	5																
AP972	XUV Normal Incidence Spectrometer	1			5	10																
AP973	UV - Visable - NIR Scanning Spectrometer	1			5	10																
AP974	High-Resolution Fourier SWIR Spectrometer	1			5	10																
AP975	Cryogenic IR Fourier Spectrometer	1			5	10																

24. NOTES:

25. COMMENTS:

SSPD (S-8) 3-15-74

SORTIE PAYLOAD

EXPERIMENT EQUIPMENT – POWER AND DATA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-8n PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ____ LTR ____

EQUIPMENT			UNIT ELECTRICAL POWER														DATA					
			DC						AC								Output				Input Commands	
			Voltage						Freq (Hz)		Voltage						Science		Housekeeping			
1. Inv. No.	2. Name	3. Qty	4. Nom (V)	5. Tol (±%)	6. Stdby Power Level (W)	7. Oper. Power Level (W)	8. Peak Power Level (W)	9. Peak Duration (hr)	10. f_{low}	11. f_{high}	12. Nom (V)	13. Tol (±%)	14. Stdby Power Level (W)	15. Oper Power Level (W)	16. Peak Power Level (W)	17. Peak Duration (hr)	18. Form, D, A, Film, etc	19. Rate, bps, Hz, fps, etc	20. Form, D, A, Discrete, etc	21. Rate, bps, Hz, pps, etc.	22. Form, D, A, Discrete, etc.	23. Rate, bps, Hz, pps, etc.
AP976	IR Radiometer	1			5	10																
AP977	Fabry-Perot Interferometer	1			5	10																
AP978	UV-Visible Documentation Cameras	1			0	1																
AP981	KeV-MeV Particle Detector	1				10																
AP982	Total Energy Detector	1				10																
AP983	LIDAR and Gimbal Platform Monitor													25								
AP984	Filter Photometer	4			2	2																

24. NOTES:

25. COMMENTS:

SSPD (S-8) 3-15-74

DATA SHEET NO. S-8n

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT — ENVIRONMENTAL LIMITS
NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9a PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT: 1 Inv. No.	EQUIPMENT: 2 Name	Location Code ①: 3 Storage	Location Code ①: 4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	Temp. Limits, (°K): 8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m^2): 10 Min.	Allowable Pressure, (N/m^2): 11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg. s)	Radiation: 14 Total Dose (J/kg)	EMI LIMITS (1) Conducted: Freq. Range (Hz) 15 f_{low}	EMI LIMITS (1) Conducted: Freq. Range (Hz) 16 f_{high}	EMI LIMITS (1) Conducted: 17 Level ③ (dBμV)	EMI LIMITS (1) Radiated: Freq. Range (Hz) 18 f_{low}	EMI LIMITS (1) Radiated: Freq. Range (Hz) 19 f_{high}	EMI LIMITS (1) Radiated: 20 Level ④ (dBW/m^2)	21 Magnetic Field (0–30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
	OPTICAL SENSORS	1	1	140	4			0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
												THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN									
AP109	UV-Visible Documentation Camera					273	276														
	ELECTRO-OPTICAL SENSORS	1	1	140	4			0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP102	Normal Incidence Spectrometer, XUV					273	276														
AP104	Fourier SWIR Spectrometer, High Resolution					273	298														77°K Detector Coolant
AP105	IR Fourier Spectrometer, Cryogenic					273	298														4°K Detector Coolant
AP106	IR Radiometer					273	298					THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN									
AP107	Interferometer, Fabry-Perot					TBD	TBD														
AP108	Filter Photometer					273	276														
AP201	Transmitter/Receiver					253	293														
AP513	Alignment TV					273	285														
AP702	TV System					273	285														
AP103	UV-Visible-NIR Scanning Spectrometer					273	276														
	MAGNETIC FIELDS	1	1	140	4			0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP506	Search Coil, Triaxial					TBD	TBD														

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 $\mu N/m^2$.

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m^2

23. NOTES:
(1) Susceptibility only, emissions as per MIL-STD-461
(2) 0-3000 Hz

24. COMMENTS:

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT — ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9b PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT: 1 Inv. No.	2 Name	Location Code ①: 3 Storage	4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²): 10 Min.	11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg-s)	14 Total Dose (J/kg)	EMI LIMITS, Conducted, Freq. Range (Hz): 15 f_{low}	16 f_{high}	17 Level ③ (dBμV)	Radiated, Freq. Range (Hz): 18 f_{low}	19 f_{high}	20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP508	Rubidium Magnetometer					TBD	TBD														
AP509	Triaxial Fluxgate					198	393														
AP703	Magnetometer, 3-Axis Fluxgate					198	393														
AP704	Mag., Search Coil					TBD	TBD														
	ELECTRIC FIELDS	1	1	140	4	TBD	TBD	0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP710	E-Field Meter																				
	ELECTROMAGNETIC FIELDS	1	1	140	4	TBD	TBD	0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP401	Transmitter/Coupler (10 kw, 0.2 to 2 MHz)																				
AP402	Transmitter/Coupler (10 kw, 2 to 20 MHz)																				
AP403	Transmitter/Coupler (1 kw, 0.3 to 200 kHz)																				
AP709	VLF Receiver																				
AP712	Transponder, Telemetry, & Ranging																				

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN (stamped across the rows AP509–AP704)

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN (stamped across the ELECTRIC FIELDS group)

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN (stamped across the rows AP402–AP712)

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

24. COMMENTS:

SSPD (S-9) 3-15-74

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT – ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9c PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity	Allowable Pressure, (N/m²)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS Conducted			EMI LIMITS Radiated			21 Magnetic Field (0-30 Hz) Limit Level,	22 Primary Thermal Control Method(e.g., forced air cold plate, liquid loop, radiation, etc.)
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.	(% RH)	10 Min.	11 Max.		13 Rate (J/kg·s)	14 Total Dose (J/kg)	15 Freq. Range (Hz) f_{low}	16 Freq. Range (Hz) f_{high}	17 Level ③ (dBμV)	18 Freq. Range (Hz) f_{low}	19 Freq. Range (Hz) f_{high}	20 Level ④ (dBW/m²)	(Tesla)	
	ELECTRICAL/ ELECTRONIC EQUIP.	1	1		4	TBD	TBD	0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP302	Storage Banks, 2-5 kilo-joules-HV (A-2)																				
AP504	One-Meter Loop			TBD																	
AP511	Power Supply			140																	
AP512	Data System			140																	
AP522	Wave Generator			140																	
	ELECTRO-MECHANICAL EQUIP.	1	1	140	4	TBD	TBD	0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP101	Remote Sensing Platform																				
AP202	Mount, Computer Controlled																				
AP404	Dipole Element 330-Meter																				
AP501	50-Meter Boom A																				
AP502	Gimbaled Platform																				
AP503	5-Meter Boom																				

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

24. COMMENTS:

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT — ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9d PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS Conducted			EMI LIMITS Radiated			21 Magnetic Field (0-30 Hz) Limit Level,	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.		10 Min.	11 Max.		13 Rate (J/kg·s)	14 Total Dose (J/kg)	Freq. Range (Hz) 15 f_{low}	16 f_{high}	17 Level ③ (dBμV)	Freq. Range (Hz) 18 f_{low}	19 f_{high}	20 Level ④ (dBW/m²)	(Tesla)	
AP507	5-Meter Boom			140																	
AP510	33-Meter Electric Dipole - Extendable			↓																	
AP521	50-Meter Boom B			↓																	
AP523	Target			N/A																	
AP601	Barium Canister, 100 gm			TBD																	
AP602	Barium Canister, 1 kg			↓																	
AP603	Barium Canister, 10 kg			↓																	
AP610	Shaped Charge, 1 kg			↓																	
AP611	Shaped Charge, 5 kg			↓																	
AP612	Shaped Charge, 20 kg			↓																	
AP620	Balloon-Spherical Insulated			140																	
AP621	Balloon-Spherical Conducting			↓																	
AP701	Satellite			↓																	
AP711	Satellite/Pallet Interface and Ejection Mechanism			↓																	
AP505	Short Electric Dipole			↓																	

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

24. COMMENTS:

SSPD (S-9) 3-15-74

DATA SHEET NO. S-9d

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT — ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9e PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity	Allowable Pressure, (N/m²)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS						21 Magnetic Field (0–30 Hz) Limit Level,	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
														Conducted			Radiated				
												13 Rate	14 Total Dose	Freq. Range (Hz)		17 Level ③	Freq. Range (Hz)		20 Level ④		
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.	(% RH)	10 Min.	11 Max.		(J/kg·s)	(J/kg)	15 f_{low}	16 f_{high}	(dBμV)	18 f_{low}	19 f_{high}	(dBW/m²)	(Tesla)	
	ENERGETIC PARTICLES	1	1	140	4	233	333	0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP114	KeV-MeV Particle Detector																				
AP115	Total Energy Detector																				
	PLASMA DEVICES & MASS SPECTROMETERS	1	1	140	4	233		0	1.1E +05	TBD	Nitrogen	1.4E -10	1.1E -04	5E +04	4E +08	0	30	3E +04	0	7E -05	
AP514	Ion Mass Spectrometer																				
AP515	Spherical Ion Probe																				
AP516	Cylindrical Ion Probe																				
AP517	Planar Segmented Probe																				
AP518	Neutral Mass Spectrometer																				
AP519	Triaxial Hemispherical Analyzer																				

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

24. COMMENTS:

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT — ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-9 f PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m^2)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS Conducted			EMI LIMITS Radiated			21 Magnetic Field (0–30 Hz) Limit Level,	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.		10 Min.	11 Max.		13 Rate (J/kg·s)	14 Total Dose (J/kg)	Freq. Range (Hz) 15 f_{low}	16 f_{high}	17 Level ③ (dBμV)	Freq. Range (Hz) 18 f_{low}	19 f_{high}	20 Level ④ (dBW/m^2)	(Tesla)	
AP520	Planar Electron Trap																				
AP705	Cyl. Elec. Probe																				
AP706	Segmented Planar Trap																				
AP707	Ion Mass Spectrometer																				
AP708	Triaxial Hemis. Analyzer																				
AP301	Ion Accelerator																				
AP303	Gimbaled Electron Accelerator																				
AP304	MPD ARC Including Condensor Bank																				

THESE VALUES APPLY TO ALL INSTRUMENTS IN THE GROUP EXCEPT WHERE SHOWN

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 $\mu N/m^2$.

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m^2

23. NOTES:

24. COMMENTS:

SSPD (S-9) 3-15-74

DATA SHEET NO. S-9 f

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT – ENVIRONMENTAL LIMITS

NON-OPERATING

DATA SHEET NO. S-9 9 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS Conducted Freq. Range (Hz)		17 ③ Level	EMI LIMITS Radiated Freq. Range (Hz)		20 Level ④	21 Magnetic Field (0-30 Hz) Limit Level,	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.		10 Min.	11 Max.		13 Rate (J/kg·s)	14 Total Dose (J/kg)	15 f_{low}	16 f_{high}	(dBμV)	18 f_{low}	19 f_{high}	(dBW/m²)	(Tesla)	
AP800	DISPLAYS SYSTEM	0	0	140	4																
AP802	Experiment TV Display					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
AP815	Oscilloscope					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
AP803	Spectrum Analyzer					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP804	Multi-Channel Analyzer					↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	
AP805	Wave Analyzer																				
AP806	Wave Analyzer																				
AP808	Frequency Counter																				
AP809	Automatic Display Generator																				
AP820	Status Panel																				
AP821	Special Data Acquisition Panel																				
AP827	Power Supply Monitor					↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		
AP832	Time Code Generator					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)		
AP810	Camera (35 mm film)					TBD	TBD	40	0.5E +05	TBD	N/A	4.1E -08	0.02	30	4E+ 08	60	30	3E+ 04	20(1)		
AP811	X-Y Recorder					273	328	95(2)	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	↓	
AP812	Strip Chart Recorder					|	|	|	|	|	|	|	|	|	|	|	|	|	|	TBD	

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

1. Minimum at 30,000 Hz
2. at 40° C

24. COMMENTS:

Provided by Spacelab

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT – ENVIRONMENTAL LIMITS

NON-OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-9h PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

EQUIPMENT: 1 Inv. No.	2 Name	Location Code ①: 3 Storage	4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²): 10 Min.	11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg·s)	14 Total Dose (J/kg)	EMI LIMITS, Conducted: Freq. Range (Hz): 15 f low	16 f high	17 Level ③ (dBμV)	EMI LIMITS, Radiated: Freq. Range (Hz): 18 f low	19 f high	20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP813	8-Channel Recorder					273	328	95(1)	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP825	TV Camera					258	298	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
AP817	Tape Recorder Digital					244	TBD	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP814	Tape Recorder Analog					244	TBD	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP818	Computer					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP819	Keyboard Display Terminal					273	328	95	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP900	Controls System	0	0																		
	ALL AP900 EQUIPMENT ITEMS	0	0	140	4	273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1 μV.

④ 0dB Ref. = 1 W/m²

23. NOTES:

1. Minimum at 30,000 Hz
2. at 40° C

24. COMMENTS:

Provided by Spacelab.

SSPD (S-9) 3-15-74

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-10a PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	Location Code ① 3 Storage	4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K) 7 Min.	8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²) 10 Min.	11 Max.	12 Controlled Atmosphere Gas Type	Radiation 13 Rate (J/kg. s)	14 Total Dose (J/kg)	EMI LIMITS Conducted Freq. Range (Hz) 15 f low	16 f high	17 Level ③ (dBμV)	Radiated Freq. Range (Hz) 18 f low	19 f high	20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
	OPTICAL SENSORS	1	1	120	1.0			0	0	1.1E +05	nitrogen	6.1E -08	0.032	5E + 04	4E + 08		30	3E + 04	140 (4)	10E-04	
AP109	UV/Visible Documentation Cameras					(6) 273	(6) 276									(3) 64					
	ELECTRO-OPTICAL SENSORS	1	1	120	1.0				0	1.1E + 05	nitrogen	6.1E -08	0.032	5E + 04	4E + 08	30 (1)	30	3E + 04	140 (4)		
AP102	Normal Incidence Spectrometer, XUV					(6) 273	(6) 276													10E-04	
AP104	Fourier SWIR Spectrometer, High Resolution					(7) 273	(7) 298														77 K detector coolant
AP105	IR Fourier Spectrometer, Cryogenic					(7) 273	(7) 298														4 K detector coolant
AP106	IR Radiometer					(7) 273	(7) 298														
AP107	Interferometer, Fabry-Perot					TBD	TBD														
AP108	Filter Photometer					(6) 273	(6) 276													10E-04	
AP201	Transmitter/Receiver					253	293														
AP513	Alignment TV					(8) 273	(8) 285	(11) 95													
AP702	TV System					(8) 273	(8) 285														
AP103	UV/Visible - NIR Scanning Spectrometer					(6) 273	(6) 276									30 (1)					

PREPARATION INSTRUCTIONS:
① Location Code: 0 = pressurized
1 = unpressurized
② 0dB Ref. = 20 $\mu N/m^2$.
③ 0dB Ref. = 1. μV.
④ 0dB Ref. = 1. W/m^2

23. NOTES:
(1) Assumes allowable tolerance of ± .001 v over 1 v range
(4) 140 dB w/m^2 max at 30 Hz, declining linearly to 20 dB w/m^2 at 30,000 Hz
(5) Susceptibility only; emissions as per MIL-STD-461
(3) Assumes ±3 V over 28 V range.

24. COMMENTS:
(6) Assumes LiF optics
(7) Assumes Si optics
(8) Assumes SiO_2 optics

(11) At 313 K

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-10b PAYLOAD NO. AP-06-S
DATE [illegible] REV DATE ____ LTR ____

EQUIPMENT		[3] Location Code ①		[5] Max. Acoustic Overall Level ②	[6] Max. Acceleration	Temp. Limits, (°K)		[9] Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²)		[12] Controlled Atmosphere Gas Type	Radiation		EMI LIMITS						[21] Magnetic Field (0–30 Hz) Limit Level,	[22] Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
														Conducted			Radiated				
												[13] Rate	[14] Total Dose	Freq. Range (Hz)		[17] Level ③	Freq. Range (Hz)		[20] Level ④		
[1] Inv. No.	[2] Name	[3] Storage	[4] Operating	(dB)	(g)	[7] Min.	[8] Max.		[10] Min.	[11] Max.		(J/kg. s)	(J/kg)	[15] f_{low}	[16] f_{high}	(dBμV)	[18] f_{low}	[19] f_{high}	(dBW/m²)	(Tesla)	
	MAGNETIC FIELDS	1	1	120	1.0	TBD	TBD	0	0	1.1E + 05	nitrogen	6.1E-08	0.032	5E + 04	4E + 08	40 (2)	30	3E + 04	140 (4)		
AP506	Search Coil, Triaxial																			TBD	
AP508	Rubidium Magnetometer																			1E-09	
AP509	Triaxial Fluxgate																			2E-10	
AP703	Magnetometer, 3-Axis Fluxgate																			1E-09	
AP704	Magnetometer, Search Coil																			TBD	
	ELECTRIC FIELDS	1	1	120	4.5	TBD	TBD	0	0	1.1E + 05	nitrogen	6.1E-08	0.032	5E + 04	4E + 08	40 (2)	30	3E + 04	140 (4)	TBD	
AP710	E-Field Meter																				
	ELECTROMAGNETIC FIELDS	1	1	120	4.5	TBD	TBD	0	0	1.1E + 05	nitrogen	6.1E-08	0.032	5E + 04	4E + 08	40 (2)	30	3E + 04	140 (4)	TBD	
AP401	Transmitter/Coupler (10 kW, 0.2 to 2 MHz)																				
AP402	Transmitter/Coupler (10 kW, 2 to 20 MHz)																				
AP403	Transmitter/Coupler (1 kW, 0.3 to 200 kHz)																				

PREPARATION INSTRUCTIONS:
① Location Code: 0 = pressurized
1 = unpressurized
② 0dB Ref. = 20 μN/m².
③ 0dB Ref. = 1. μV.
④ 0dB Ref. = 1. W/m²

23. NOTES:
(2) Assumes allowable tolerance of 0.1 v over 10 v range

24. COMMENTS:

SSPD (S-10) 3-15-74

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

4-72

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-10c PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

1 Inv. No.	2 Name	Location Code ① 3 Storage	Location Code ① 4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K) 7 Min.	Temp. Limits, (°K) 8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²) 10 Min.	Allowable Pressure, (N/m²) 11 Max.	12 Controlled Atmosphere Gas Type	Radiation 13 Rate (J/kg.s)	Radiation 14 Total Dose (J/kg)	EMI Limits Conducted Freq. Range (Hz) 15 f_{low}	EMI Limits Conducted Freq. Range (Hz) 16 f_{high}	EMI Limits Conducted 17 Level ③ (dBµV)	EMI Limits Radiated Freq. Range (Hz) 18 f_{low}	EMI Limits Radiated Freq. Range (Hz) 19 f_{high}	EMI Limits Radiated 20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP709	VLF Receiver																				
AP712	Transponder, Telemetry and Ranging																				
	ELECTRICAL/ELECTRONIC EQ.	1	1	120	4.5	TBD	TBD	0	0	1.1E 05	nitrogen						30	3E + 04	140(4)	TBD	
AP302	Storage Banks, 2-5 kilojoules -HV											TBD	TBD	5E + 04	4E + 08	40(2)					
AP504	One-Meter Loop											N/A	N/A	30	5E + 04	40(2)					
AP511	Power Supply											6.1E-08	0.032	30	5E + 04	40(2)					
AP512	Data System											6.1E-08	0.032	30	5E + 04	40(2)					
AP522	Wave Generator											6.1E-08	0.032	30	5E + 04	40(2)					
	ELECTROMECHANICAL EQUIP.	1	1	120	4.5	TBD	TBD	0	0	1.1E 05	nitrogen						30	3E + 04	140(4)		
AP101	Remote Sensing Platform											1.93E -06	1	30	5E + 04	64(3)				TBD	
AP202	Mount, Computer-Controlled											6.1E-08	0.032	30	5E + 04	40(2)				TBD	
AP404	Dipole Element 330-Meter																				

PREPARATION INSTRUCTIONS:
① Location Code: 0 = pressurized
1 = unpressurized
② 0dB Ref. = 20 µN/m².
③ 0dB Ref. = 1.µV.
④ 0dB Ref. = 1.W/m²

23. NOTES:
(2) Assumes allowable tolerance of 0.1 V over 10 V range.
(3) Assumes ±3 V over 28 V range.
(4) 140 dB w/m² max at 30 Hz, declining linearly to 20 dB w/m² at 30,000 Hz.

24. COMMENTS:

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE

DATA SHEET NO. S-10d PAYLOAD NO. AP-06-S
DATE JUN 07 197_ REV DATE ______ LTR ______

EQUIPMENT: 1 Inv. No.	2 Name	Location Code ①: 3 Storage	4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²): 10 Min.	11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg.s)	14 Total Dose (J/kg)	EMI LIMITS, Conducted, Freq. Range (Hz): 15 f_{low}	16 f_{high}	17 Level ③ (dBμV)	EMI LIMITS, Radiated, Freq. Range (Hz): 18 f_{low}	19 f_{high}	20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP501	50-Meter Boom A											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP502	Gimbaled Platform											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP503	5-Meter Boom											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP507	5-Meter Boom											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP510	33-Meter Electric Dipole - Extendable											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP521	50-Meter Boom B											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP523	Target											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP601	Barium Canister, 100 gm											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP602	Barium Canister, 1 kgm											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP603	Barium Canister, 10 kgm											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP610	Shaped Charge, 1 kgm											1.93E -06	1	30	5E +04	40 (2)				TBD	
AP611	Shaped Charge, 5 kgm											1.93E -06	1	30	5E +04	40 (2)					
AP612	Shaped Charge, 20 kgm											1.93E -06	1	30	5E +04	40 (2)					
AP620	Balloon - Spherical Insul.											TBD	TBD	30	5E +04	40 (2)					
AP621	Balloon - Spherical Conducting											TBD	TBD	30	5E +04	40 (2)					
AP505	Short Electric Dipole																				

PREPARATION INSTRUCTIONS:
① Location Code: 0 = pressurized
1 = unpressurized
② 0dB Ref. = 20 μN/m².
③ 0dB Ref. = 1. μV.
④ 0dB Ref. = 1. W/m²

23. NOTES:
(2) Assumes allowable tolerance of 0.1 V over 10 V range.

24. COMMENTS:

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-10 e PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT: 1 Inv. No.	EQUIPMENT: 2 Name	Location Code ①: 3 Storage	Location Code ①: 4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	Temp. Limits, (°K): 8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²): 10 Min.	Allowable Pressure, (N/m²): 11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg. s)	Radiation: 14 Total Dose (J/kg)	EMI Limits, Conducted, Freq. Range (Hz): 15 f low	EMI Limits, Conducted, Freq. Range (Hz): 16 f high	EMI Limits, Conducted: 17 Level ③ (dBμV)	EMI Limits, Radiated, Freq. Range (Hz): 18 f low	EMI Limits, Radiated, Freq. Range (Hz): 19 f high	EMI Limits, Radiated: 20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP701	Satellite											6.1E-08	0.032	30	5E + 04	40 (2)					
AP711	Satellite/Pallet Interface and Ejection Mechanism											1.93E-06	1	30	5E + 04	40 (2)					
	ENERGETIC PARTICLE	1	1	120	1.0	TBD	TBD	0	0	1.1E +05	nitrogen	6.1E-08	0.032	5E + 04	4E + 08	40 (2)	30	3E + 04	140 (4)	10E-04	
AP114	KeV-MeV Particle Detector																				
AP115	Total Energy Detector																				
	PLASMA DEVICES AND MASS SPECTROMETERS	1	1	120	1.0	TBD		0	0	1.1E +05	nitrogen	6.1E-08	0.032			40 (2)	30	3E + 04	140 (4)	10E-04	

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 $\mu N/m^2$.

③ 0dB Ref. = 1. μV.

④ 0dB Ref. = 1. W/m^2

23. NOTES:

24. COMMENTS:

SORTIE PAYLOAD

IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS

OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE

DATA SHEET NO. S-10f PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTP ______

EQUIPMENT: 1 Inv. No.	EQUIPMENT: 2 Name	Location Code ①: 3 Storage	Location Code ①: 4 Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	Temp. Limits, (°K): 7 Min.	Temp. Limits, (°K): 8 Max.	9 Max. Rel. Humidity (% RH)	Allowable Pressure, (N/m²): 10 Min.	Allowable Pressure, (N/m²): 11 Max.	12 Controlled Atmosphere Gas Type	Radiation: 13 Rate (J/kg. s)	Radiation: 14 Total Dose (J/kg)	EMI Limits, Conducted, Freq. Range (Hz): 15 f_low	EMI Limits, Conducted, Freq. Range (Hz): 16 f_high	EMI Limits, Conducted: 17 Level ③ (dBμV)	EMI Limits, Radiated, Freq. Range (Hz): 18 f_low	EMI Limits, Radiated, Freq. Range (Hz): 19 f_high	EMI Limits, Radiated: 20 Level ④ (dBW/m²)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP514	Ion Mass Spectrometer						TBD							30	5E + 04						
AP515	Spherical Ion Probe						TBD							30	5E + 04						
AP516	Cylindrical Ion Probe						TBD							30	5E + 04						
AP517	Planar Segmented Probe						TBD							30	5E+04						
AP518	Neutral Mass Spectrometer						311							30	5E + 04						
AP519	Triaxial Hemispherical Analyzer						TBD							30	5E + 04						
AP520	Planar Electron Trap						TBD							30	5E + 04						
AP705	Cyl. Elec. Probe						TBD							30	5E + 04						
AP706	Segmented Planar Trap						TBD							30	5E + 04						
AP707	Ion Mass Spectrometer						311							30	5E + 04						
AP708	Triaxial Hemis. Analyzer						TBD							30	5E + 04						
AP301	Ion Accelerator						TBD							30	5E + 04						
AP303	Gimbaled Electron Accelerator						TBD							30	5E + 04						
AP304	MPD ARC Including Condensor Bank						TBD							30	5E + 04						

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1.μV.

④ 0dB Ref. = 1.W/m²

23. NOTES:

24. COMMENTS:

SSPD (S-10) 3-15-74

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-10g PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ____

EQUIPMENT		Location Code ①		5 Max. Acoustic Overall Level ②	6 Max. Acceleration	Temp. Limits, (°K)		9 Max. Rel. Humidity	Allowable Pressure, (N/m²)		12 Controlled Atmosphere Gas Type	Radiation		EMI LIMITS Conducted			EMI LIMITS Radiated			21 Magnetic Field (0-30 Hz) Limit Level,	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
1 Inv. No.	2 Name	3 Storage	4 Operating	(dB)	(g)	7 Min.	8 Max.	(% RH)	10 Min.	11 Max.		13 Rate (J/kg.s)	14 Total Dose (J/kg)	15 Freq. Range (Hz) f_{low}	16 Freq. Range (Hz) f_{high}	17 Level ③ (dBμV)	18 Freq. Range (Hz) f_{low}	19 Freq. Range (Hz) f_{high}	20 Level ④ (dBW/m²)	(Tesla)	
AP800	DISPLAYS SYSTEM	0	0	120	4.5																Spacelab provided
AP802	Experiment TV Display					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
AP815	Oscilloscope					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
A803	Spectrum Analyzer					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP804	Multi-Channel Analyzer																				
AP805	Wave Analyzer																				
AP806	Wave Analyzer																				
AP808	Frequency Counter																				
AP809	Automatic Display Generator																				
AP820	Status Panel																				
AP821	Special Data Acquisition Panel																				
AP827	Power Supply Monitor																				
AP832	Time Code Generator					273	323	TBD	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)		
AP810	Camera (35 mm film)					TBD	TBD	40	0.5E +05	TBD	N/A	4.1E -08	0.02	30	4E+ 08	60	30	3E+ 04	20(1)		
AP811	X-Y Recorder					273	328	95(2)	0.5E +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)		
AP812	Strip Chart Recorder																			TBD	

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 μN/m².

③ 0dB Ref. = 1.μV.

④ 0dB Ref. = 1.W/m²

23. NOTES:

1. Minimum at 30,000 Hz
2. at 40° C

24. COMMENTS:

SORTIE PAYLOAD
IN-FLIGHT EXPERIMENT EQUIPMENT-ENVIRONMENTAL LIMITS
OPERATING

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-10 h PAYLOAD NO. AP-06-S
DATE 6/24/74 REV DATE ______ LTR ______

1 Inv. No.	2 Name	3 Location Code ① Storage	4 Location Code ① Operating	5 Max. Acoustic Overall Level ② (dB)	6 Max. Acceleration (g)	7 Temp. Limits, (°K) Min.	8 Temp. Limits, (°K) Max.	9 Max. Rel. Humidity (% RH)	10 Allowable Pressure, (N/m^2) Min.	11 Allowable Pressure, (N/m^2) Max.	12 Controlled Atmosphere Gas Type	13 Radiation Rate (J/kg. s)	14 Radiation Total Dose (J/kg)	15 EMI Conducted Freq. Range (Hz) f_{low}	16 EMI Conducted Freq. Range (Hz) f_{high}	17 EMI Conducted Level ③ (dBμV)	18 EMI Radiated Freq. Range (Hz) f_{low}	19 EMI Radiated Freq. Range (Hz) f_{high}	20 EMI Radiated Level ④ (dBW/m^2)	21 Magnetic Field (0-30 Hz) Limit Level, (Tesla)	22 Primary Thermal Control Method (e.g., forced air cold plate, liquid loop, radiation, etc.)
AP813	8-Channel Recorder					273	328	95(2)	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP825	TV Camera					258	298	TBD	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	6E-04	
AP817	Tape Recorder Digital					244	TBD	TBD	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP814	Tape Recorder Analog					244	TBD	TBD	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP818	Computer					273	323	TBD	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP819	Keyboard Display Terminal					273	328	[illegible]	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	
AP900	Controls System	0	0																		
	ALL AP900 EQUIPMENT ITEMS			70	4.5	273	323	TBD	0.5 +05	TBD	N/A	6.1E -08	0.032	30	4E+ 08	60	30	3E+ 04	20(1)	TBD	

PREPARATION INSTRUCTIONS:

① Location Code: 0 = pressurized
1 = unpressurized

② 0dB Ref. = 20 $\mu N/m^2$.

③ 0dB Ref. = 1.μV.

④ 0dB Ref. = 1.W/m^2

23. **NOTES:**

1. Minimum at 30,000 Hz
2. at 40° C

24. **COMMENTS:**

Provided by Spacelab.

SSPD (S-10) 3-15-74

SORTIE PAYLOAD
IN-FLIGHT CONTAMINATION CONTROL CRITERIA

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-11 PAYLOAD NO. AP-06-S
DATE 6/24/74 REV DATE ____ LTR ____

EQUIPMENT		LAUNCH & ASCENT *				ON-ORBIT OPERATIONS *				DESCENT & LANDING *				SPECIAL INDIVIDUAL INSTRUMENT REQUIREMENTS			18. NOTES (Provide elaboration on specific requirements wherever possible)
1. Inv. No.	2. Name	3. 5,000 Class Incoming Air†	4. 15 ppm VCM With Inlet Air†	5. Surface Cleanliness Control Level 300††	6. Surface Cleanliness Control NVR Level A††	7. Column Density 10^{12} Molecules/cm^2	8. Scattered Light Background < 20 Mag/sec^2	9. Less than 1 Particle > 5μm in FOV per Orbit**	10. Deposition on Surface of Instrument (One Monolayer)	11. Incoming Air 5,000 Class†	12. 15 ppm VCM With Inlet Air†	13. Surface Cleanliness Control Level 300††	14. Surface Cleanliness Control NVR Level A††	15. Instrument Inert Gas Purge	16. Cleanliness Class Above Bay Cleanliness †	17. Contamination Protection Covers	
	Optical Sensors	0	0	0	0	0	0	0	0	N/A	0	0	0	N/A	50,000 (2) ↓	Yes (1)	
	Electro-Optical Sensors	↓	↓	0	0	0	↓	↓	0	N/A	N/A	0	0	N/A		Yes (1)	
	Magnetic Field Sensors			↓	↓	↓			↓	N/A	N/A	↓	↓	N/A		No	
	Electric Field Sensors									N/A	N/A			N/A		No	
	Electromagnetic Field Sensors									N/A	N/A			N/A		No	
	Electrical/Electronic Equipment									N/A	N/A			N/A		No	
	Electromechanical Equipment									N/A	N/A			N/A		No	
	Energetic Particle									N/A	N/A			N/A		Yes (1)	
	Plasma Devices and Mass Spectrometers									N/A	N/A			N/A		Yes (1)	
	Display System									0	0			N/A	N/A	No	
	Controls System									0	0			N/A	N/A	No	

PREPARATION INSTRUCTIONS: *Key: Enter 0 or 1 for Items 3 through 14
0 means required control is ≤ than the value specified.
1 means required control is > than the value specified.
** Within 10 km.

†Ref. Fed. Std. No. 209A
††Ref. MIL-STD-1246A, Table 1.
VCM = Volatile Condensible Material
NVR = Non-Volatile Residue

19. COMMENTS:
(1) Included in weight and size of Sheet 4
(2) External to Instrument

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-12a PAYLOAD NO. AP-06-S

DATE JUN 24 1974 REV DATE 7/30/74 LTR A

EQUIPMENT		3. ORIENTATION OR TARGET(S)	4. ① Axis	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ② (1) Ⓐ					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY Ⓐ				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name			5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP100	REMOTE SENSING PLATFORM SYSTEM		X,Y															
			Z															
AP101	Platform, Remote Sensing		X,Y	1.0	0.5	1.0	0.5	0.1	0.05	0.5	2	0.5	0.2					
			Z						0.05	0.5	2	0.5	0.2					
AP102	Spectrometer, XUV Nominal Incidence		X,Y						N/A	N/A	N/A		N/A					
			Z											0.05	0.5	2	0.5	0.2
AP103	Spectrometer, UV-Vis.-NIR Scanning		X,Y															
			Z															
AP104	Spectrometer, High Resolution Fourier SWIR		X,Y															
			Z															
AP105	Spectrometer, Cryogenic IR Fourier		X,Y															
			Z															
AP106	Radiometer, IR		X,Y															
			Z															
AP107	Interferometer, Fabry-Perot		X,Y															
			Z															
AP108	Photometer, Filter (Narrow Band)		X,Y															
			Z															
AP109	Camera, UV-Visible Documentation		X,Y															
			Z															
AP114	Detector, keV-MeV Particle		X,Y															
			Z															
AP115	Detector, Total Energy		X,Y	1.0	0.5	1.0	0.5	0.1	N/A	N/A	N/A	0.5	N/A	0.05	0.5	2	0.5	0.2
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
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			X,Y															
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			Z															
			X,Y															
			Z															
			X,Y															
			Z															

PREPARATION NOTES:

① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.

② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:

Requirements shown apply to X, Y, and Z axes.

(1) These are accuracies provided to sensors by the payload-supplied gimbal system. Ⓐ

SSPD (S-12) 4-16-74

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS).

DATA SHEET NO. S-12[b] PAYLOAD NO. AP-06-S

DATE JUN 24 1974 REV DATE 7/30/74 LTR A

EQUIPMENT 1. Inv. No.	2. Name	3. ORIENTATION OR TARGET(S)	4. (1) Axis	SHUTTLE POINTING REQUIREMENT — Accuracy — 5. Level (deg)	6. Duration (hr)	Stability — 7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	MOUNT POINTING REQUIREMENT (2) (1) (A) — Accuracy — 10. Level (sec)	11. Duration (hr)	Stability — 12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	FINAL INTERNAL INSTRUMENT POINTING CAPABILITY (A) — Accuracy — 15. Level (sec)	16. Duration (hr)	Stability — 17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP200	LIDAR SYSTEM		X, Y															
			Z															
AP201	Transmitter/Receiver, Lidar		X, Y	1.0	0.5	1.0	0.5	0.1	N/A	N/A	N/A	0.5	N/A	180	0.5	TBD	0.5	TBD
			Z															
AP202	Mount, Lidar Computer Controlled		X, Y						1800	0.5	180	0.5	TBD	N/A	N/A	N/A	N/A	N/A
			Z															
			X, Y															
			Z															
			X, Y															
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PREPARATION NOTES:

(1) Axis Reference: Items 5–8, Use Shuttle Coordinate Axes. Items 9–16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.

(2) Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:

Requirements shown apply to X, Y, and Z axes.

(1) These are accuracies provided to the sensors by the payload-supplied mount. (A)

SORTIE PAYLOAD
ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-12 c PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ____ LTR ____

EQUIPMENT		3.	4.	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name	ORIENTATION OR TARGET(S)	① Axis	5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP300	GIMBALED ACCELERATOR FOR SYSTEM		X,Y															
			Z															
AP301	Accelerator, Ion		X,Y	1.0	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	3600	0.1	360	0.1	360
			Z															
AP302	Storage Banks, 2-5 kilojoules HV		X,Y											N/A	N/A	N/A	N/A	N/A
			Z															
AP303	Accelerator, Electron, Gimbaled		X,Y															
			Z											3600	0.1	360	0.1	360
AP304	MPD-ARC with Condensor Banks		X,Y	1.0	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Z															
AP305	Gimbal Syst., Accelerator, Ion/Electron		X,Y	1.0	0.1	0.1	0.1	0.1	TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
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			Z															

PREPARATION NOTES:
① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.
② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:
Requirements shown apply to X, Y, and Z axes.

SSPD (S-12) 4-16-74

DATA SHEET NO. S-12 c

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

DATA SHEET NO. S-12d PAYLOAD NO. AP06S

DATE JUN 24 1974 REV DATE ______ LTR ____

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

EQUIPMENT		3. ORIENTATION OR TARGET(S)	4. ① Axis	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name			5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP400	TRANSMITTER COUPLER SYSTEM		X, Y															
			Z															
AP401	Transmitter/Coupler (10 kW, 0.2 - 2.0 MHz)		X, Y	10	0.1	1.0	0.1	0.1	N/A	N/A	N/A	N/A	N/A	3.6E+04	0.1	3600	0.1	360
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	↓	↓
AP402	Transmitter/Coupler (10 kW, 2.0 - 20.0 MHz)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	3.6E+04	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	↓	↓
AP403	Transmitter/Coupler (1 kW, 0.3 - 200 kHz)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	3.5E+04	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	↓	↓
AP404	Dipole Element, 330-Meter		X, Y	10	0.1	1.0	0.1	0.1	N/A	N/A	N/A	N/A	N/A	3.5E+04	0.1	3600	0.1	360
			Z															

PREPARATION NOTES:
① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.
② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:
Requirements shown apply to X, Y, and Z axes.

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-12e PAYLOAD NO. AP06S
DATE JUN 24 1974 REV DATE ______ LTR ____

EQUIPMENT		3. ORIENTATION OR TARGET(S)	4. ① Axis	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name			5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP500	BOOM SYSTEM		X, Y Z															
AP501	Boom, 50-Meter		X, Y Z	0.5	0.5	0.1	0.5	0.1	TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
AP502	Platform, Gimbaled		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP503	Boom, 5-Meter		X, Y Z	↓	↓	↓	↓	↓	TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
AP504	Loop Antenna, One Meter		X, Y Z	↓	↓	↓	↓	↓	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
AP505	Dipole, Short Electric		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP506	Search Coil, Triaxial		X, Y Z	↓	↓	↓	↓	↓	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
AP507	Boom, 5-Meter		X, Y Z	↓	↓	↓	↓	↓	TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
AP508	Magnetometer, Rubidium		X, Y Z	↓	↓	↓	↓	↓	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
AP509	Fluxgate, Triaxial		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP510	Electric Dipole, 33-Meter Extendable		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	1800	0.5	360	0.5	360
AP511	Power Supply		X, Y Z	↓	↓	↓	↓	↓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AP512	Data System		X, Y Z	↓	↓	↓	↓	↓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AP513	Television, Alignment		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	1800	0.5	360	0.5	360
AP514	Spectrometer, Ion Mass		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP515	Probe, Spherical		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP516	Probe, Cylindrical Ion		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP517	Probe, Planar Segmented		X, Y Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP518	Spectrometer, Neutral Mass		X, Y Z	0.5	0.5	0.1	0.5	0.1	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360

PREPARATION NOTES:
① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.
② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:

Requirements shown apply to X, Y, and Z axes.

SSPD (S-12) 4-16-74

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

DATA SHEET NO. S-12 PAYLOAD NO. AP06S

DATE JUN 24 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

EQUIPMENT		3.	4.	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability		9.	Accuracy		Stability		14.	Accuracy		Stability		19.
1. Inv. No.	2. Name	ORIENTATION OR TARGET(S)	① Axis	5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	Stability Rate (sec/sec)
AP519	Analyzer, Triaxial Hemispherical		X,Y	0.5	0.5	0.1	0.5	0.1	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
			Z															
AP520	Electron Trap, Plasma		X,Y						N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
			Z															
AP521	Boom B, 50-Meter		X,Y						TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
			Z															
AP522	Wave Generator		X,Y						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Z															
AP523	Target(s)		X,Y											1800	0.5	360	0.5	360
			Z															
AP524	Light Source, Artificial		X,Y	0.5	0.5	0.1	0.5	0.1	N/A	N/A	N/A	N/A	N/A	1800	0.5	360	0.5	360
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
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			Z															
			X,Y															
			Z															
			X,Y															
			Z															

PREPARATION NOTES:
① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.
② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:
Requirements shown apply to X, Y, and Z axes.

SSPD (S-12) 4-16-74

DATA SHEET NO. S-12

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-12g PAYLOAD NO. AP06S

DATE JUN 2? 1974 REV DATE ______ LTR ______

EQUIPMENT		3.	4.	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name	ORIENTATION OR TARGET(S)	① Axis	5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP600	DEPLOYABLE UNITS SYSTEM		X, Y															
			Z															
AP601	Canister, Barium (100 gm)		X, Y	1.0	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	3600	0.1	360	0.1	360
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP602	Canister, Barium (1 kg)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP603	Canister, Barium (10 kg)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP610	Charge, Shaped (1 kg)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP611	Charge, Shaped (5 kg)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP612	Charge, Shaped (20 kg)		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP620	Balloon, Spherical Insulated		X, Y	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
			Z	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
AP621	Balloon, Spherical Conducting		X, Y	1.0	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	3600	0.1	360	0.1	360
			Z															
			X, Y															
			Z															
			X, Y															
			Z															
			X, Y															
			Z															
			X, Y															
			Z															
			X, Y															
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			X, Y															
			Z															
			X, Y															
			Z															
			X, Y															
			Z															

PREPARATION NOTES:

① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.

② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:

Requirements shown apply to X, Y, and Z axes.

SORTIE PAYLOAD

ORIENTATION, POINTING & STABILITY REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMA IN SPACE (AMPS)

DATA SHEET NO. S-12h PAYLOAD NO. AP06S

DATE JUN 21 1974 REV DATE ______ LTR ______

EQUIPMENT		3.	4.	SHUTTLE POINTING REQUIREMENT					MOUNT POINTING REQUIREMENT ②					FINAL INTERNAL INSTRUMENT POINTING CAPABILITY				
				Accuracy		Stability			Accuracy		Stability			Accuracy		Stability		
1. Inv. No.	2. Name	ORIENTATION OR TARGET(S)	① Axis	5. Level (deg)	6. Duration (hr)	7. Level (deg)	8. Duration (hr)	9. Stability Rate (deg/sec)	10. Level (sec)	11. Duration (hr)	12. Level (sec)	13. Duration (hr)	14. Stability Rate (sec/sec)	15. Level (sec)	16. Duration (hr)	17. Level (sec)	18. Duration (hr)	19. Stability Rate (sec/sec)
AP700	SUBSATELLITE SYSTEM		X,Y															
			Z															
AP701	Satellite		X,Y	0.5	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	1800	0.1	360	0.1	360
			Z															
AP702	Television System		X,Y															
			Z															
AP703	Magnetometer, 3-Axis Fluxgate		X,Y															
			Z															
AP704	Magnetometer, Search Coil		X,Y															
			Z															
AP705	Probe, Electric Cylinder		X,Y															
			Z															
AP706	Planar Trap, Segmented		X,Y															
			Z															
AP707	Spectrometer, Ion Mass		X,Y															
			Z															
AP708	Analyzer, Triaxial Hemispherical		X,Y															
			Z															
AP709	Receiver, VLF		X,Y															
			Z															
AP710	Meter, E-Field		X,Y						N/A	N/A	N/A	N/A	N/A	1800	0.1	360	0.1	360
			Z															
AP711	Ejection Mechanism and Interface, Satellite/Pallet		X,Y						TBD	TBD	TBD	TBD	TBD	N/A	N/A	N/A	N/A	N/A
			Z															
AP712	Transponder, Telemetry and Ranging		X,Y	0.5	0.1	0.1	0.1	0.1	N/A	N/A	N/A	N/A	N/A	1800	0.1	360	0.1	360
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
			Z															
			X,Y															
			Z															

PREPARATION NOTES:

① Axis Reference: Items 5-8, Use Shuttle Coordinate Axes.
Items 9-16, Z is line-of-sight axis; X and Y are mutually perpendicular to Z.

② Pointing Required at Inner Gimbal.

20. GENERAL COMMENTS:

Requirements shown apply to X, Y, and Z axes.

SORTIE PAYLOAD

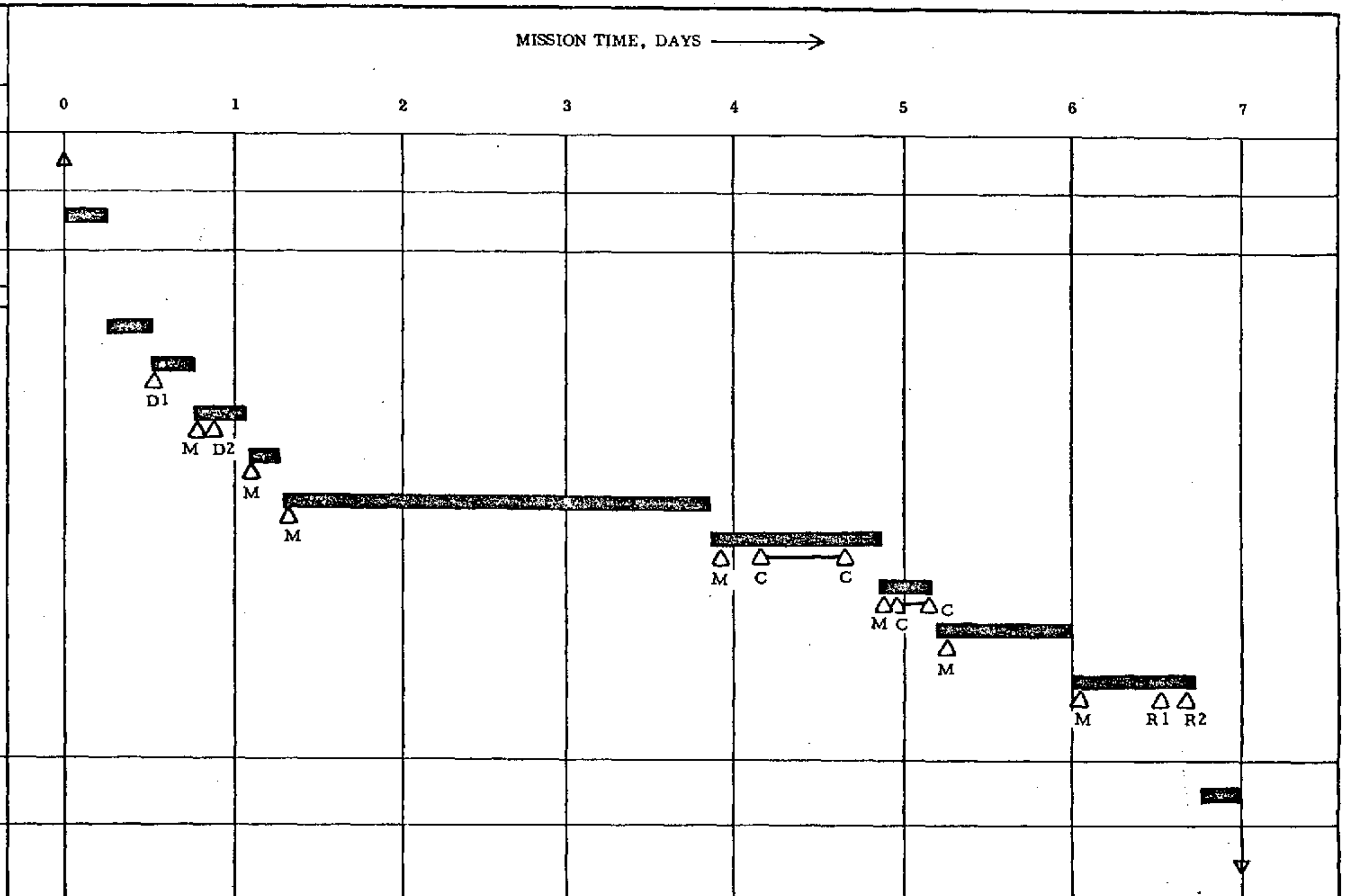
FLIGHT OPERATIONS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC & PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-13 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

Phase No.	FLIGHT OPERATION Description	
1.	Lift-off	
2.	Ascent & Operational Preparation	
3.	On-Orbit Experiment Operations	
	No.	Title
	XAP410	Wave Characteristics
	XAP420	Wave Particle Interactions
	XAP430	Wake and Sheath Experiments
	XAP440	Propulsion and Devices
	XAP450	Global Emission Survey
	XAP460	Energetic Particle Stability
	XAP470	Magnetospheric Topology
	XAP480	Plasma Dynamics
		Repeated Experiments
4.	Mission Termination & Descent	
5.	Landing	



PREPARATION INSTRUCTIONS:

1. For mission duration other than 7 days, change to appropriate time scale.

COMMENTS:

Δ Δ Δ
D, M, R = Deploy, Maneuver and retrieve Subsatellite

Δ
C = Concurrent ground-based observations required.

SORTIE PAYLOAD
EXPERIMENT OPERATIONAL CYCLE

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-14 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

EXPERIMENT		INITIAL SETUP		REPETITIVE CYCLE							TERMINATION		TYPICAL TARGET ② OBSERVATION SEQUENCE				18 Notes
									Repetition Rate								
1 No.	2 Title	3 Function	4 Time (hr)	5 Setup & Deploy Time (hr)	6 Expt. or Observ. Dur. (hr)	7 Shut-down & Retrieve Time (hr)	8 Data Eval. Time (hr)	9 Total Cycle Time (hr)	10 No. of Cycles/ Per Day	11 No. of Cycles Per N Day Mission ①	12 Function	13 Time (hr)	14 Target Type Code ③	15 Latitude or Rt. Ascen. (deg/min/sec)	16 Longitude or Declin. (deg/min/sec)	17 Dur. Per Observ (hr)	Include viewing constraints, sun inclination angle reqmts, special slewing, etc.
XAP410	Wave Characteristics	Align antenna Position booms	0.6	N/A	2.4	0.1	0.5	3.0	N/A	1	See Comment 3		N/A	N/A	N/A	N/A	
XAP420	Wave-Particle Interactions	Activate systems Align subsatellite Align antenna	0.3	N/A	3.7	0.1	1.5	5.3	N/A	1	See Comment 3		O	See Comment 1			
XAP430	Wake and Sheath Experiments	Inflate target Align boom Calibrate instrum's	4.0	N/A	2.0	1.0	0.5	3.5	N/A	1	See Comment 3		O	See Comment 1			
XAP440	Propulsion and Devices	Deploy subsat's Deploy boom	1.0	N/A	2.0	1.0	1.0	4.0	N/A	1	See Comment 3		O	See Comment 1			
XAP450	Global Emission Survey	Activate systems Deploy subsat's Orient and calib.	11.0	0.1	5.1	0.1	4.6	9.9	N/A	6	See Comment 3		E	See Comment 2			
XAP460	Energetic Particle Stability	Position subsat. Align accelerator and antennas	1.5	0.5	1.5	0.1	1.0	3.1	N/A	6	See Comment 3		O	See Comment 1			
XAP470	Magnetospheric Topology	Position sub-satellite	1.0	0.5	0.5	0.1	0.5	1.6	N/A	5	See Comment 3		O	See Comment 1			
XAP480	Plasma Dynamics	Align booms Maneuver sub-satellites	0.7	0.1	1.0	0.1	0.5	1.7	N/A	12	See Comment 3		O	See Comment 1			

PREPARATION INSTRUCTIONS:

① Mission duration N = 7 days.
② Specify a typical 4 to 8 orbit sequence.
③ Target Type Code:
- E = Earth; location is given in latitude & longitude.
- S = Stellar; location is given in right ascension and declination.
- O = Other (Specify in Item 19).

19. COMMENTS: (Include statements of simultaneous operation requirements, predecessor/successor relationships, etc.):

(1) XAP420, 430, 440, 460, 470, 480 require observation of vicinity of subsatellite, barium release, etc.

(2) XAP450 observes earth limb and high latitude areas.

(3) Termination requires 4 hours at end of mission for all devices.

SORTIE PAYLOAD

PAYLOAD OPERATIONAL TIMELINE

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC, AND PLASMAS IN SPACE (AMPS) MISSION DAY NO. 2

DATA SHEET NO. S-15a PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ____ LTR ____

Time, hours → 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Experiments

No.	Title
XAP430	Wake & Sheath Experiments
	Map area in wake
	Reorient ball and boom
	Record variations with sep.
	Cleanup, prepare next experiment
XAP440	Propulsion and Devices
	Deploy subsatellites
	Deploy diagnostic boom
	Boom measurements
	Operate arc - 10 kev, 1A
	Operate arc - 20 kev, 1A
	Operate arc - 30 kev, 1A
	Operate arc - 10 kev, 5A
	Operate arc - 20 kev, 5A
	Cleanup, prepare next experiment

Continued on sheet S-15b.

Skills Role/Field

See Sheet S-15b

Time-Dependent Functions

Power Profile (kW) (at payload/Spacelab interface) See Sheet S-15b	AC
	DC
Data Profile† See Sheet S-15b (at payload/Spacelab interface)	D
	A

SSPD (S-15) 3-15-74 †Indicate Real Time data downlink transmission using double-width line and flag with "RT".

DATA SHEET NO. S-15a

SORTIE PAYLOAD

PAYLOAD OPERATIONAL TIMELINE

MISSION DAY NO. 2

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC, AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-15b PAYLOAD NO. AP-06-S

DATE JUN 24 1974 REV DATE ______ LTR ______

Time, hours →

Experiments

No.	Title
XAP450	Global Emission Survey
	Activate equipment
	Deploy subsatellite to test area
	Set scan rate of instruments
	Calibrate instruments
	Orient remote sensing platform
	Collect data in occult mode

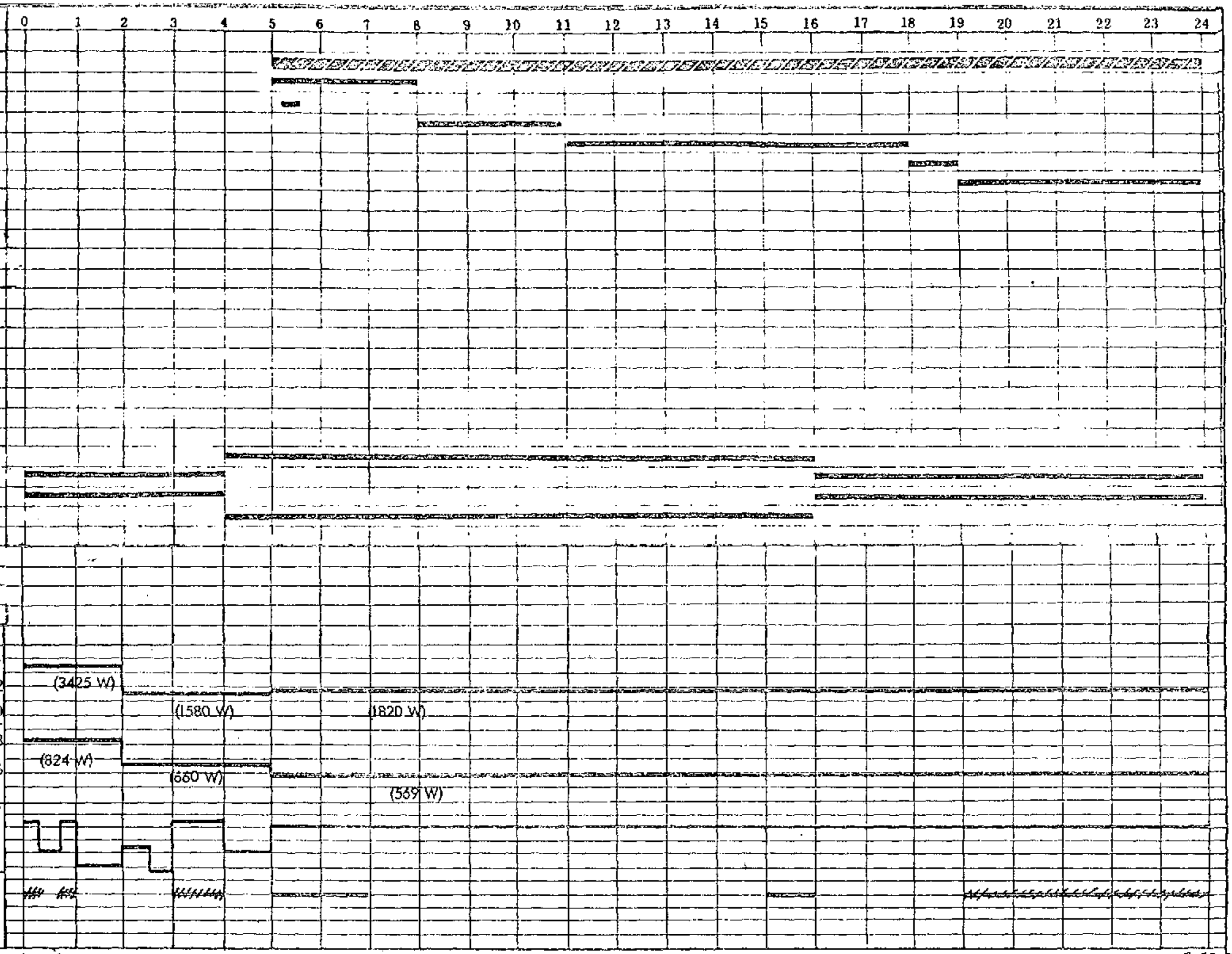
Skills Role/Field

Exprt/Phys, Plasma, Part-Flds
Invtr/Phys, Plasma, Part-Flds
Tech/Phys, Plasma, Part-Flds
Tech/Phys, Plasma, Part-Flds

Time-Dependent Functions

Power Profile (kW) (at payload/Spacelab interface): AC, DC

Data Profile† (at payload/Spacelab interface): D 1E0X, A MHz



†Indicate Real Time data downlink transmission using double-width line and flag with "RT".

SORTIE PAYLOAD

PAYLOAD PERSONNEL SKILLS & EVA/IVA REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-16 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

EXPERIMENT		3.	SKILL TYPES		P/L Personnel Time			PLANNED EVA AND IVA REQUIREMENTS				13.	14.
1. No.	2. Title	Functions	4. Role	5. Scientific or Technical Field	6. Hrs/Run/Skill	7. Hrs/Day/Skill	8. Tot Hrs/Mission/Skill *	9. E or I†	10. Tasks	11. Duration (hr)	12. Freq	Contingency EVA? yes/no	Notes
XAP410	Wave Characteristics	Experiment operations							None				
XAP420	Wave Particle Interaction	Experiment operations							None				
XAP430	Wake and Sheath Experiments	Experiment operations							None				
XAP440	Propulsion and Devices	Experiment operations	Experimenter	Physics, Plasmas, Particles and Fields	N/A	12	78		None				
XAP450	Global Emission Survey	Experiment operations	Investigator	Physics, Plasmas, Particles and Fields	N/A	12	78		None				
XAP460	Energetic Particle Stability	Experiment operations	Technician	Physics, Plasmas, Particles and Fields	N/A	24	156		None				
XAP470	Magnetospheric Topology	Experiment operations							None				
XAP480	Plasma Dynamics	Experiment operations											

PREPARATION INSTRUCTIONS:

* Based on mission duration (N) = 7 days.
†E = EVA, I = IVA

15. Total skill hours per day (Σ Col. 7) = 48 hr
16. Total skill hours per mission (Σ Col. 8) = 312 hr
17. No. of planned EVAs per mission = 0
18. Average duration per EVA = N/A hr

SORTIE PAYLOAD

PAYLOAD MISSION CONSUMABLES
(ON-BOARD)

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-17 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

EXPERIMENT		3 TYPE OF CONSUMABLE	USE RATE			STORAGE REQUIREMENT				11 Portion of initially stored consumables not returned to Earth (kg)	12 Notes
1 No.	2 Title		4 Wt. per Operation (kg)	5 Wt. per Day (kg)	6 Wt. per N Day Mission (kg)	7 Method, e.g., compressed gas cylinders, storage lockers, liquid vessel, self contained (in exp. equip.) etc.	8 Provided by E or S†	9 Weight at Launch (kg)	10 Weight at Landing (kg)		
XAP420	Wave Particle Interaction	Film	2.27	2.27	2.27	Film Magazine	E	2.27	2.27	0	
XAP450	Global Emission Survey	Film	13.62	5.45	13.62	Film Magazine	E	13.62	13.62	0	
	(AP104, 105, and 106)	LN_2	TBD	TBD	30	Dewar	E	30	0	30	
XAP460	Energetic Particle Stability	Film	9.08	9.08	9.08	Film Magazine	E	9.08	9.08	0	
XAP470	Magnetospheric Topology	Film	4.54	4.54	4.54	Film Magazine	E	4.54	4.54	0	
	All Experiments	Magnetic Tape			25	Tape Locker	S	25	25	0	
	All Experiments	Paper, Chart Recorder	TBD	TBD	30	Tape Locker	E	30	30	0	

PREPARATION INSTRUCTIONS:
†Code E = Provided by experiment equipment,
S = Provided by Spacelab.

13 Total weight of consumables at Launch (Σ Col. 9) = 84.5 kg.
14 Total weight of consumables not returned to Earth (Σ Col. 11) = 30 kg.

SORTIE PAYLOAD

PAYLOAD ELECTRICAL POWER REQUIREMENTS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-18 PAYLOAD NO. AP-06-S
DATE 6/24/74 REV DATE ______ LTR ______

REQUIREMENT PARAMETER / MISSION PHASE	1 Mission Phase Duration (hr)	D.C. POWER: Voltage 2 Nom. (V)	3 Tol. (±%)	Avg. Power 4 Level (W)	5 Dur. (hr)	Peak Power 6 Level (W)	7 Dur. (hr)	8 Repetition Rate	9 Energy per Day (kWh)	A.C. POWER: 10 Source Freq. (Hz)	Voltage 11 Nom. (V)	12 Tol. (±%)	Avg. Power 13 Level (W)	14 Dur. (hr)	Peak Power 15 Level (W)	16 Dur. (hr)	17 Repetition Rate	18 Energy per Day (kWh)	19 Total Energy per Day (kWh)	20 Mission Total Energy (kWh)	21 Notes
Launch Pad/Liftoff	Appx. 48	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	(1) Launch pad/liftoff, ascent, descent and landing/post-landing power requirements are for payload provided control, display, computation and data storage equipment.
Ascent	6.0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
On-Orbit Operations ①										50											
	156	28	10	602	24	824	2	1/day	14.44	60	110	5	1923	24	3425	2	1/day	46.17	60.61	394	
										400											
Descent	6.0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
Landing/Post-Landing (While in Orbiter)	Appx. 36	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	

PREPARATION NOTES:

① Power and energy requirements are based upon profile shown in Sheet S-15.

22 Total in-flight energy (ascent through descent), kWh 394

SORTIE PAYLOAD

DATA ACQUISITION AND MANAGEMENT

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-19 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ______

Req'ment Param / Mission Phase	SCIENCE [HOUSEKEEPING] DATA ACQUISITION* 1. Output Form - D,A,TV, Film, Voice, etc.)	2. Output Rate (bps, Hz, fps, Time, etc.) (2)	3. No. of Channels or Film Size	Operations 4. Duration per Run or Obs. (hr)	Repetition Rate 5. Operations per Orbit	Repetition Rate 6. Operations per Day	7. Daily Total Data Quantity, D: (bits) A: (time & b.w.) TV, Voice: (Time) Film: (Frames)	CONTROL & DISPLAY 8. Personnel Stations	9. Image Displays	Experiment Controls 10. Type & Qty	Experiment Controls 11. Rate, (Opers per Hour)	Experiment Monitors 12. Type & Qty	Experiment Monitors 13. Rate, (Opers per Hour)	COMPUTER SUPPORT 14. Functions; e.g., Data Formatting, Stored Commands, Data Processing, G&N Computations, Pointing Control, etc.	Memory Size (Words) 15. Rapid Access	Memory Size (Words) 16. Bulk	17. Word Length (bits)	18. Opers per Sec.
Launch Pad/ Liftoff	[D]	[1000 bps]	TBD	N/A	N/A	[Cont.]	[2.16E + 07]			0	0	C/W-8	Cont.	0				
Ascent	[D]	[1000 bps]	TBD	N/A	N/A	[Cont.]	[1.08E + 07]			0	0	C/W-8	Cont.	0				
On-Orbit Operations	D	1.4E+ 06	TBD	N/A	N/A	N/A	6.33E + 10	2	2	Bi-level 14	TBD	CRT-2	Cont.	General Processing	1000	30000	32	5000
	A	4E + 06	TBD	N/A	N/A	N/A	9.7 Hrs/4E + 06					Oscillo-scope.-2		Spectrum Analysis	1000	10000	32	5000
	Voice	32000 bps	TBD	Cont.	N/A	N/A	Continuous			Multi-position 21	TBD	(1) Counters -40	Cont.	Display Generation	320	2500	32	32000 (4)
	Film	TBD	TBD	N/A	N/A	N/A	TBD							Performance Monitoring	1000	5000	32	10000
	[D]	[7000]	TBD	N/A	N/A	[Cont.] (3)	[5.79E+ 08]					Recorder -6 (non-magnetic)	Cont.	Data Reduction	300	3000	32	5000
	A (video)	2E + 06	TBD	N/A	N/A	8								Prediction Analysis	1000	50000	32	5000
	D Sate.	4E+05 bps	2	N/A	N/A	N/A	TBD					(1) Position-Indicator -30	Cont.	Pointing calculations	500	1000	32	2500
	A Sate.	2E+06 Hz	1	N/A	N/A	N/A	TBD							Real time data storage (10% of Scientific data)	4000	12000	32	N/A
												C/W -8	Cont.					
Descent	[D]	[1000]	TBD	N/A	N/A	[Cont.]	[1.08E+07]			0	0	C/W-8	Cont.	0				
Landing/ Post Landing (While in Orbiter)	None																	

ADDITIONAL ON-ORBIT OPERATIONAL REQUIREMENTS

19. Timing Accuracy Required, m sec TBD

Orbit Determination Accuracy Required:

20. Position, km TBD

21. Velocity, m/sec TBD

22. Attitude Determination Accuracy Required, deg TBD

23. Notes

(1) Prelim. Estimate

(2) Maximum data rate

(3) Hours/day

(4) Includes refresh rate of 20 frames/sec.

SSPD (S-19) 3-15-74

*Make separate entries for science and housekeeping data; include housekeeping data in brackets.

DATA SHEET NO. S-19

SORTIE PAYLOAD

DATA DISPOSITION AND COMMUNICATIONS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-20 PAYLOAD NO. AP-06-S
DATE 6/24/74 REV DATE 7/30/74 LTR A

Req'ment Parameter / Mission Phase	1 Output Form D, A, TV Film, Voice	TRANSMITTED TO GROUND: Real Time: Digital: 2 Rate (bps)	3 Time (hr per Oper)	Analog: 4 BW (Hz)	5 Time (hr per Oper)	6 TV BW (Hz) & Time (hr per Oper)	7 Voice (hr per Oper)	On-Orbit Dump: Within One Orbit: 8 D (bits)	9 A&TV BW (Hz) Time (hr)	Within One Day: 10 D (bits)	11 A&TV BW (Hz) Time (hr)	Shuttle/Spacelab Storage and Return Reqm'ts For an N Day Mission: 12 Total D (M bits)	13 Total A BW (Hz) & Time (hr)	14 Total TV BW (Hz) & Time (hr)	Film Frames: 15 Size(s)	16 Total No.	UPLINK: 17 Data Type and Rate	18 TV (hr per Day)	19 Voice (hr per Day)	ADDITIONAL ON-ORBIT OPERATIONAL REQUIREMENTS
Launch Pad/ Liftoff	D	1.4E+06	48	4E+06	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20 Minimum acceptable contact time (min) TBD
Ascent	D	1000	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21 Maximum acceptable gap time (min) TBD
On-Orbit Operations	D	25,000	6.5 per day					0		0		3.8 E+05					N/A			22 Minimum acceptable playback pass duration (min) TBD
	A			4E+06	(1) 6.5 per day				0		0		4E+06 TBD (A)				N/A			23 Will ground timing updates be required? Yes ☒ No ☐ (A)
	TV					0			0		0			2E+06 52 (A)				N/A		24 Does payload description assume use of TDRS? Yes ☐ No ☒ (A)
	Film														TBD	TBD	N/A			
	Voice						cont												Cont	25 Does payload require direct rf communication with ground facilities? Yes ☐ No ☐
																				26 If 25 = Yes, describe RF link(s): TBD
Descent	D	1000	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(1) Hours/day
Landing/ Post Landing (While in Orbiter)	None																			

SORTIE PAYLOAD

PAYLOAD IN-FLIGHT ENVIRONMENTAL LIMITS

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

DATA SHEET NO. S-21 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE 7/30/74 LTR A

Operational Status	Location	① 1. Max Acoustic Level (dB)	Maximum Acceleration 2. Translation (g)	Maximum Acceleration 3. Rotation (deg/sec²)	Temperature Limits (°K) 4. Min	Temperature Limits (°K) 5. Max	6. Max Rel Hum (% RH)	Allowable Pressure (N/m²) 7. Min	Allowable Pressure (N/m²) 8. Max	9. Controlled Atmosphere Gas Type	Radiation 10. Max Rate (J/kg-s)	Radiation 11. Total Dose (J/kg)	EMI Limits Conducted Freq. Range (Hz) 12. f_{low}	EMI Limits Conducted Freq. Range (Hz) 13. f_{high}	EMI Limits Conducted 14. ② Level (dBμV)	EMI Limits Radiated Freq. Range (Hz) 15. f_{low}	EMI Limits Radiated Freq. Range (Hz) 16. f_{high}	EMI Limits Radiated 17. ③ Level (dBW/m²)	18. Magnetic Field (0-30Hz) Limit Level (Tesla)	19. Notes
Operating	Pressurized	70	TBD	TBD	273	298	TBD	0.5E +05	TBD	N/A	4.1E-08	0.02	30	4E+08	60	30	3E+04	20	6E-04	
Ⓐ Operating	Unpressureized	N/A	TBD	TBD	273	276 Ⓐ		N/A	N/A		6.1E -08	0.032	30	4E +08	30	30	3E +04	140	10E -04	
Non-Operating	Pressurized	70	4	TBD	273	298	40	0.5E +05	TBD	N/A	4.1E -08	0.02	30	4E +08	60	30	3E +04	20	6E -04	
Ⓐ Non-Operating	Unpressurized	140	TBD	TBD	273	276 Ⓐ		N/A	N/A		6.1E -08	0.032	30	4E +08	30	30	3E +04	140	10E -04	

PREPARATION INSTRUCTIONS:
① 0dB Ref. = 20 μN/m²
② 0dB Ref. = 1. μV
③ 0dB Ref. = 1. W/m²

20. COMMENTS:

SORTIE PAYLOAD
LAUNCH/LANDING SUPPORT REQUIREMENTS

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

DATA SHEET NO. S-22 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

MISSION PHASE	1. Functional Requirements	Min. Access Time (hours) (Specify for time-critical functions only) 2. Duration	3. Time Before Launch	4. Time After Landing	SPECIAL SUPPORT EQUIPMENT REQUIREMENTS 5. Equipment description; e.g., performance capabilities, size, weight, power and other utilities, etc.	6. Equipment to be provided by:	7. Notes
Launch Pad/Liftoff	Installation of AMPS into Orbiter	1 day	5 days		Mobile crane	Launch site	
	AMPS/Orbiter interface checkout in checkout building	3 days	4 days		Electrical and electronic diagnostic equipment	TBD	
Landing/Post-Landing (While in Orbiter)	Remove and/or dump acquired data	1 day		8 hrs	Electrical and electronic equipment, tape recorders	TBD	
	Remove AMPS from Orbiter	1 day		2 days	Mobile crane	Landing site	

SORTIE PAYLOAD
GROUND FACILITY REQUIREMENTS

DATA SHEET NO. S-23 PAYLOAD NO. AP-06-S
DATE JUN 07 1974 REV DATE ______ LTR ____

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas in Space (AMPS)

Location	1. Description	SIZE 2. Area (m^2)	3. Min Height (m)	UTILITIES Power 4. Form (AC, DC Voltage, etc.)	5. Level (kW)	6. Liquid/Gases	7. Other	8. Special Handling	9. Notes
Launch Site	Assembly/Test Area	465	10	110v ac 60/400Hz 28 vdc	TBD TBD	LN_2 GN_2 H_2O Subsatellite fuel	Fire and other safety equipment	Yes	Spare modular units for consoles and displays Tapes for recorders, repair/refurbishment stores Tools, etc.
	Shuttle Assembly Building		LIMITS WILL BE SET BY SHUTTLE REQUIREMENTS						
	Shuttle Checkout Building		LIMITS WILL BE SET BY SHUTTLE REQUIREMENTS						
Landing Site	Shuttle/Payload Remote Building		LIMITS WILL BE SET BY SHUTTLE REQUIREMENTS						
	Payload Disassembly Area	465	10	110v ac 60/400Hz	TBD	GN_2	Fire and other safety equipment	Yes	
	Storage Room	465	10	110v ac 60/400Hz	TBD TBD		Fire and other safety equipment	Yes	
Other (Specify)									

SORTIE PAYLOAD

GROUND ENVIRONMENTAL LIMITS

DATA SHEET NO. S-24 PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ______ LTR ______

PAYLOAD NAME ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)

EQUIPMENT		PRELAUNCH											POST-LANDING										
		Temperature/Humidity						Contamination Limits					Temperature/Humidity						Contamination Limits				
		Non-Operating			Operating			Surf.Clean. Cont.(Ref. MIL-STD -1246A)		Inert Gas Purge		13. Protective Covers Req'd? Yes/No	Non-Operating			Operating			Sur.Clean. Cont.(Ref. MIL-STD -1246A)		Inert Gas Purge		24. Protective Covers Req'd? Yes/No
		Temp (°K)		5. Max Rel. Hum (%)	Temp (°K)		8. Max Rel. Hum (%)						Temp (°K)		16. Max Rel Hum (%)	Temp (°K)		19. Max Rel Hum (%)					
1. Inv. No.	2. Name	3. Min.	4. Max.		6. Min.	7. Max.		9. Particulate (Table Ia)	10. NVR (Tbl Ib)	11. Type of Gas	12. Cleanliness Class		14. Min.	15. Max.		17. Min.	18. Max.		20. Particulate (Table Ia)	21. NVR (Tbl Ib)	22. Type of Gas	23. Cleanliness Class	
	Optical Sensors	273	276	0	273	276	0	300	A	Nitrogen (1)	1000	Yes	273	276	0	N/A	N/A	0	300	A	Nitrogen (1)	1000	Yes
	Electro-Optical Sensors	273	298	0	273	298	0	300	A	Nitrogen (1)	1000	Yes	273	298	0	N/A	N/A	0	300	A	Nitrogen (1)	1000	Yes
	Magnetic Field Sensors	212	393	0	272.9	273.1	0	1000	J	Nitrogen (1)	5000	No	212	393	0	N/A	N/A	0	1000	J	Nitrogen (1)	5000	No
	Electric Field Sensors	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No	TBD	TBD	0	N/A	N/A	0	1000	J	Nitrogen (1)	5000	No
	Electromagnetic Field Sensors	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No
	Electrical/Electronic Equip.	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No
	Electro-Mechanical Equip.	TBD	TBD	0	TBD	TBD	0	1000	J	Nitrogen (1)	5000	No	TBD	TBD	0	N/A	N/A	0	1000	J	Nitrogen (1)	5000	No
	Energetic Particles	233	333	0	TBD	TBD	0	300	A	Nitrogen (1)	1000	Yes	233	333	0	N/A	N/A	0	300	A	Nitrogen (1)	1000	Yes
	Plasma Devices & Mass Spectrometers	233	311	0	TBD	311	0	300	A	Nitrogen (1)	1000	Yes	233	311	0	N/A	N/A	0	300	A	Nitrogen (1)	1000	Yes
	Display System	273	298	95	273	298	95	1000	J	0	0	No	273	298	95	273	298	95	1000	J	0	0	No
	Controls System	273	298	95	273	298	95	1000	J	0	0	No	273	298	95	273	298	95	1000	J	0	0	No

25. NOTES:

26. COMMENTS:

(1) Shuttle cargo bay is pressurized above ambient except during on-orbit operation.

SORTIE PAYLOAD

PAYLOAD SAFETY ANALYSIS

DATA SHEET NO. S-25a PAYLOAD NO. AP-06-S
DATE JUN 0, 1974 REV DATE ______ LTR ______

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas In Space (AMPS)

PAYLOAD EQUIPMENT		POTENTIAL HAZARDOUS CONDITION		5. Control Action Taken (By Payload)	Caution & Warning Req'd?		Safing & Arming Req'd?		10. Notes
1. Inv. No.	2. Name	3. Description	4. Effect		6. Yes	7. No	8. Yes	9. No	
AP101	Platform, Remote Sensing	Movable platform	Serious injury or damage	Platform gimbals locked	X			X	
AP201	LIDAR Transmitter/Receiver	1. High voltage 2. Laser light	Shock, burns Eye damage	Operational safing and interlocks	X			X	
AP202	LIDAR Mount, Computer Controlled	Movable platform	Possible injury to test personnel	Platform gimbals locked	X			X	
AP302	Storage Banks, 2-5 kilo-joule HV	High capacity storage condensers	Shock, burns	Load status warning	X		X		
AP304	MPD-ARC Including Condenser Bank	High capacity storage condensers	Shock, burns	Load status warning	X		X		
AP401	Transmitter/Coupler (10 kw 0.2-2 MHz)	High power electronics	Shock, burns	Status warning	X			X	
AP402	Transmitter/Coupler (10 kw 2-20 MHz)	High power electronics	Shock, burns	Status warning	X			X	
AP403	Transmitter/Coupler (1 kw 0.3-200 kHz)	High power electronics	Shock, burns	Status warning					
AP501	50-Meter Boom A	Extendable boom arms	Serious injury or damage	Boom extender mechanism locked until on orbit and doors opened	X		X		
		Emergency Separation Mechanism	Serious injury	Status Warning	X		X		
AP502	Gimbaled Platform	Movable platform	Serious injury or damage	Platform gimbals locked	X			X	
AP503	5-Meter Boom	Extendable boom arms	Serious injury or damage	Boom extender mechanism locked until on orbit and doors opened	X		X		
					X		X		
AP513	Alignment TV	Internal high voltage	Shock, burns	None	X			X	
AP521	50-Meter Boom B	Extendable boom arms	Serious injury or damage	Boom extender mechanism locked until on orbit and doors opened	X		X		

PREPARATION INSTRUCTIONS:

11. COMMENTS:

SORTIE PAYLOAD

PAYLOAD SAFETY ANALYSIS

PAYLOAD NAME Atmospheric, Magnetospheric and Plasmas In Space (AMPS)

DATA SHEET NO. S-25b PAYLOAD NO. AP-06-S

DATE JUN 07 1974 REV DATE ____ LTR ____

PAYLOAD EQUIPMENT		POTENTIAL HAZARDOUS CONDITION		5. Control Action Taken (By Payload)	Caution & Warning Req'd?		Safing & Arming Req'd?		10. Notes
1. Inv. No.	2. Name	3. Description	4. Effect		6. Yes	7. No	8. Yes	9. No	
AP601	Barium Canister, 100 gm	Ejection Mechanism	Serious injury or damage		X		X		
AP602	Barium Canister, 1 kg	Ejection mechanism	Serious injury or damage		X		X		
AP603	Barium Canister, 100 kg	Ejection Mechanism	Serious injury or damage		X		X		
AP610	Shaped Charge, 1 kg	Explosive charge	Serious injury or damage		X		X		
AP611	Shaped Charge, 5 kg	Explosive charge	Serious injury or damage		X		X		
AP612	Shaped Charge, 20 kg	Explosive charge	Serious injury or damage		X		X		
AP620	Balloon-spherical insulated	Activation and ejection	Serious injury or damage		X		X		
AP621	Balloon-spherical conducting	Activation and ejection	Serious injury or damage		X		X		
AP702	TV System	High voltage	Shock, burns		X			X	
AP711	Satellite/Pallet Interface and Ejection Mechanism	Ejection mechanism	Serious injury or damage		X		X		
	Cryogenics	Supercold liquid (LN_2)	Serious injury or damage		X			X	
	High Pressure Gas Bottles	High pressure gas	Serious injury or damage		X			X	

PREPARATION INSTRUCTIONS:

11. COMMENTS:

SSPD (S-25) 3-15-74

DATA SHEET NO. S-25b

APPROVAL

PHASE A CONCEPTUAL DESIGN STUDY OF THE ATMOSPHERIC, MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS) PAYLOAD

By Program Development

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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