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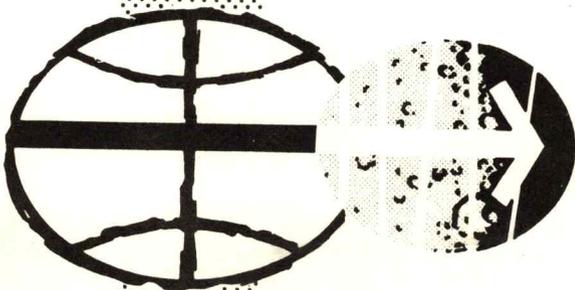
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME VI
CSM EXPERIMENTS DATA BOOK
FOR
J-MISSIONS

SD 70-284

SEPTEMBER 22, 1970



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

Volume VI

CSM Experiments Data Book for J-Missions

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DATA CHANGE NOTIFICATION FORM
CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

SNA-8-D-027

VOLUME VI PART 1

DATE 12/22/71

AMENDMENT 22

PAGE 1 OF 50

SHORT TITLE OF CHANGE See Below

CHANGE DESCRIPTION Remove or insert new or revised pages 3.1-1 through 3.1-13, 3.2-3 through 3.2-6, 3.3-3, 3.3-4, 3.4-5 through 3.4-8, 3.4-14, 3.4-15, 3.8-1 through 3.8-6, 3.9-1 through 3.9-4, 3.10-1 through 3.10-8 TAB and 3.13-1

This Amendment Consists of:

P. NO.	SHORT TITLE	CONTRACTOR SSM	NASA SSM
XP2-13	Ultraviolet Spec. Section	D. Patterson	Taylor/Hardee/Joslyn
XP2-43	Gamma-Ray Deployment Update	J. Potts	R. White
XP1-49	Gamma-Ray Spectrometer	D. Patterson	E. Stelly
XP1-51	X-Ray Spectrometer Update	D. Patterson	C. LeBlanc
XP1-52	Laser Altimeter Experiment	D. Patterson	Walters/Hardee
XP1-55	GRS Section Editorial Change	J. Potts	R. White
XP1-56	Lunar Sounder Constraints	D. Patterson	Speier/Panther
XP1-57	Pan Camera V/h Sensor Normal Select	D. Patterson	B. Mollberg
XP1-58	Alpha/X-Ray Constraints	D. Patterson	B. Mollberg
XP1-59	Subsatellite Constraints	D. Patterson	J. Johnson

CONTRACTOR SUBSYSTEM
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Volume VI
REVISIONS

REV LTR	AMEND NO.	DESCRIPTION	DATE	APPROVED
	1	Insert new or revised pages 3.1-3, 3.1-4, 3.1-5, 3.1-6, 3.2-3, 3.2-4, 3.2-7, 3.3-3, 3.3-4, 3.4-5, 3.4-6, 3.4-9, 3.4-10, 3.6-3, 3.6-4, 3.6-7, 3.6-8, 3.7-5, 3.7-6, 3.7-9, 3.8-3, 3.8-4, 3.8-5, 3.8-6, 3.9-3, 3.9-4, 3.9-5 and 3.9-6.	10/8/70	MOB
	2	Insert new or revised pages *-v-, 3.1-5, 3.1-6, 3.2-5, 3.2-6, 3.3-3, 3.3-4, 3.5-1, 3.5-2, 3.6-7, 3.6-8, 3.7-3 and 3.7-4.	11/6/70	MOB
	3	Insert new or revised pages 3.1-1, 3.1-2, 3.1-7, 3.4-3, 3.4-4, 3.4-5, 3.4-6, 3.6-3, 3.6-4, 3.7-5 and 3.7-6.	2/19/71	OAB
	4	Insert new or revised pages -v-, 3.1-1 through 3.1-4, 3.2-1 through 3.2-6, 3.3-1, 3.3-2, 3.4-3, 3.4-4, 3.5-1 through 3.5-4, 3.6-3, 3.6-4, 3.7-3, 3.7-4, 3.8-1, 3.8-2 and 3.9-3 through 3.9-6.	3/3/71	OAB
	5	Insert new or revised pages 3.1-1, 3.1-2, 3.1-3, 3.1-4, 3.6-1, 3.6-2, 3.9-3, 3.9-4, 3.9-5 and 3.9-6.	3/11/71	OAB
	6	Insert new or revised pages 2.2-1, 2.2-2, 3.2-1, 3.2-2, 3.2-5, 3.2-6, 3.4-1, 3.4-2, 3.4-5, 3.4-6, 3.6-1, 3.6-2, 3.7-1, 3.7-2, 3.9-1, 3.9-2 and TABS for Section 3.	3/25/71	OAB
	7	Insert new or revised pages 2.7-1, 2.8-1, 2.8-2, 3.6-1, 3.6-2, 3.6-5 and 3.6-6.	4/21/71	OAB

Volume VI
REVISIONS

REV LTR	AMEND NO.	DESCRIPTION	DATE	APPROVED
	18	Insert new or revised pages 2.4-1, 2.4-2, 3.4-5, 3.4-6, 3.4-14 3.4-15, 3.7-7 and 3.7-8.	7/26/71	OAB
	19	Insert new or revised pages 3.9-3 and 3.9-4.	8/3/71	OAB
	20	Remove and insert new or revised pages iii, iv, v, vi, vii, 1-1, 1-2, 2.1-1, 2.5-1, 2.5-2, 2.6-1, 2.6-2, 3.1-1, 3.1-1.1*, 3.3-3, 3.3-4*, 3.4-3, 3.4-4*, 3.4-14*, 3.4-15*, 3.6-9* through 3.6-12*, 3.7-5*, 3.7-6, 3.9-3, 3.9-3.1, 3.9-4, 3.12-1 through 3.12-4.	10/1/71	OAB
	21	Remove and insert new or revised pages 2.9-1, 2.9-2, 2.9-5, 2.9-6, 3.4-1 through 3.4-8, 3.4-14 and 3.4-15.	11/19/71	OAB
	22	Remove and insert new or revised pages 3.1-1 through 3.1-13, 3.2-3 through 3.2-6, 3.3-3, 3.3-4, 3.4-5 through 3.4-8, 3.4-14, 3.4-15, 3.8-1 through 3.8-6, 3.9-1 through 3.9-4, 3.10-1 through 3.10-8, TAB, and 3.13-1.	12/22/71	OAB

CONTENTS

Section	Page
1.0 INTRODUCTION	1-1
1.1 PURPOSE AND SCOPE	1-1
1.2 CONTENT	1-2
1.3 AMENDMENTS	1-3
1.4 SELECTED ABBREVIATIONS AND ACRONYMS	1-3
2.0 EXPERIMENTS SUMMARY	2.0-1
2.1 EXPERIMENT/CSM EFFECTIVITY	2.1-1
2.2 EXPERIMENTS INTERFACE MATRIX	2.2-1
2.3 ELECTRICAL POWER	2.3-1
2.4 INSTRUMENTATION AND DATA—GENERAL	2.4-1
2.4.1 Tape Recorder Characteristics	2.4-1
2.4.2 SDS Modulator	2.4-1
2.4.3 64-Kilobits-per-Second Data Processor	2.4-2
2.4.4 Timing Buffer Amplifier	2.4-2
2.5 POINTING ACCURACY AND POINTING KNOWLEDGE	2.5-1
2.5.1 Definition of Terms	2.5-1
2.5.2 Special Terms for Boom-Mounted Instruments	2.5-1
2.5.3 Sources of Attitude Uncertainties	2.5-2
2.5.4 Operational Considerations	2.5-2
2.6 EXPERIMENTS SUN-LINE LIMITATIONS	2.6-1
3.0 INDIVIDUAL EXPERIMENTS*	3.0-1
3.1 GAMMA-RAY SPECTROMETER	3.1-1
3.2 X-RAY FLUORESCENCE SPECTROMETER	3.2-1
3.3 ALPHA-PARTICLE SPECTROMETER	3.3-1
3.4 OPTICAL BAR PANORAMIC CAMERA	3.4-1
3.5 S-BAND TRANSPONDER	3.5-1
3.6 MASS SPECTROMETER	3.6-1
3.7 THREE-INCH LUNAR MAPPING CAMERA	3.7-1
3.8 LASER ALTIMETER	3.8-1
3.9 SUBSATELLITE	3.9-1
3.10 UV SPECTROMETER	3.10-1
3.11 IR SCANNING RADIOMETER	3.11-1
APPENDIX	
OUTLINE OF TYPICAL EXPERIMENT SECTION	A-1

*The standard format used for each experiment section is presented in the Appendix.

ILLUSTRATIONS

Figure		Page
2.6-1	Spacecraft Look Angles	2.6-2
2.6-2	Operating Experiment Sun-Avoidance Envelopes	2.6-3
2.6-3	Nonoperating Experiment Sun-Avoidance Envelopes	2.6-4
3.1-1	Gamma-Ray Spectrometer	3.1-6
3.1-2	Gamma-Ray Spectrometer Detector.	3.1-7
3.2-1	Alpha-Particle/X-Ray Fluorescence Spectrometers	3.2-7
3.4-1	Optical Bar Panoramic Camera	3.4-9
3.4-2	Panoramic Camera Thermal Surfaces	3.4-10
3.6-1	Mass Spectrometer	3.6-8
3.7-1	Three-Inch Mapping Camera and Laser Altimeter	3.7-9
3.8-1	DC Power Profile for Laser Altimeter	3.8-7
3.9-1	Subsatellite With Launching Mechanism	3.9-6

TABLES

Table		Page
2.1-1	Experiment/CSM Effectivity	2.1-1
2.2-1	Interface Matrix	2.2-2
3.2-1	Alpha and X-Ray DC Power Matrix	3.2-6
3.4-1	Panoramic Camera Power Matrix	3.4-8
3.7-1	Mapping Camera Subsystem Optical Characteristics	3.7-7
3.7-2	Mapping Camera DC Power Matrix	3.7-8
3.8-1	Laser Altimeter Characteristics	3.8-6

1.0 INTRODUCTION

of Volume VI

4.

J-Missions CSM experiments
the mission planning activities.
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mitations are included in this volume
ed experiment/SIM limitations that
M vehicle are presented in Volume I,

1.0 INTRODUCTION

The complete CSM/LM Spacecraft Operational Data Book series for the manned H- and J-Missions consists of six separate volumes:

Volume I. CSM Data Book

Part I. Constraints and Performance
Part II. Launch Mission Rule Redlines

Volume II. LM Data Book

Part I. Constraints and Performance
Part II. Launch Mission Rule Redlines

Volume III. Mass Properties Data Book

Volume IV. EMU Data Book

Volume V. ALSEP Data Book

Volume VI. CSM Experiments Data Book for J-Missions

A brief discussion of the purpose, scope, and content of Volume VI follows, together with the procedure for amending the data.

1.1 PURPOSE AND SCOPE

Volume VI of the Data Book contains the J-Missions CSM experiments performance and constraints data to support the mission planning activities. The experiments included are listed in Table 2.1-1.

Individual experiment-imposed limitations are included in this volume in the appropriate sections. Integrated experiment/SIM limitations that affect operations of the total CSM/SIM vehicle are presented in Volume I, Part 1, of the Data Book.

It is not the intent of this volume to present a physical description of experiment hardware except where necessary:

1. To identify the configuration for which performance characteristics are presented.
2. To provide information required to assure a correct understanding and proper use of the performance data.

Detailed descriptions of experiment hardware appear in the Apollo Operations Handbook, Volume I, Section 2.11.

Although the volume does not include operational procedures describing how to accomplish the various required functions, it does present the operational requirements for satisfactory instrument performance and acquisition of acceptable experiment data. Crew operational procedures appear in the J-Missions Operations Handbook, Volume II.

The data presented in this volume are not to be construed as imposing contractual hardware design requirements. Experiment design requirements are presented in the CSM Master End Item Specification, SID 64-1345, Appendix B; in the various instrument CEI specifications; in SD 69-315, Performance and Interface Specification; and in the various experiment ICD's contractually imposed by these documents.

1.2 CONTENT

The content of the various sections of this document is as follows:

Section 1.0, Introduction. Section 1.0 describes the scope of the overall data book and summarizes the content of the remaining sections of this volume.

Section 2.0, Experiments Summary. Section 2.0 contains an experiments summary and matrix to identify the various experiments with the individual missions and the interexperiment interfaces. This section also contains general information common to all of the experiments.

Section 3.0, Individual Experiments. Section 3.0 presents the physical characteristics and performance and constraints data for the individual experiments in a self-contained module or package.

1.3 AMENDMENTS

Amendments to this document will be made by page additions or replacements. Data changed by an amendment will be denoted by an amendment number and date in the upper right-hand corner of the page and a vertical bar in the page margin to locate the change. Where the entire page constitutes a new addition to the data book, no change bar will be placed in the margin.

A revision page showing the accumulative changes that have been made will be issued with each amendment. This revision page should be placed just behind the title page and will provide an up-to-date listing of all amendments.

1.4 SELECTED ABBREVIATIONS AND ACRONYMS

This section contains abbreviations and acronyms unique to this volume of the Data Book. For additional CSM acronyms, refer to Volume I, Part 1, Section 1.4, of this document.

AMU	Atomic mass units
CEI	Contract end item
DIDM	Data interface and decoupling module
FMC	Forward motion compensation
FOV	Field-of-view
GN ₂	Gaseous nitrogen
GRS	Gamma-ray spectrometer
Kev	Kilo (thousand) electronvolts
LVPS	Low-voltage power supply
MCC	Midcourse correction
Mev	Million electronvolts
MOM	Multiple operations module

PFN	Pulse forming network
PHA	Pulse height analyzer
PMP	Premodulation processor
PTC	Passive thermal control
RAD	Radiation absorbed dose at 100 ergs/gram
RH	Relative humidity
RSS	Root sum of squares
SCO	Subcarrier oscillator
SDS	Scientific data system
SIM	Scientific instrument module
SODB	Spacecraft Operational Data Book
TBS	To be supplied
TEC	Tranearth coast
TEI	Tranearth injection
TLC	Translunar coast
VGP	Vehicle ground point

cannot appropri-
Section 3.0.
ees:

2.0 EXPERIMENTS SUMMARY

2.0 EXPERIMENTS
SUMMARY

2.0-1

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2.0 EXPERIMENTS SUMMARY

This section provides experiment information which cannot appropriately be incorporated in the individual experiment subsections of Section 3.0. The data included in this section fulfill one or more of the following purposes:

1. Provide comparative visibility in one location for all experiments.
2. Provide information common to all experiments and thus avoid redundant presentations in Section 3.0.
3. Provide explanatory information to support Section 3.0 by aiding in the understanding and use of the data presented for each individual experiment.

2.1 EXPERIMENT/CSM EFFECTIVITY

Table 2.1-1 presents the CSM effectivity for each J-Mission experiment. The table also provides an index of all experiments presented in this volume including the experiment title, number, and location in Section 3.0. This document uses the section or paragraph numbers, rather than the experiment numbers, for reference to the various experiments contained herein.

Table 2.1-1. Experiment/CSM Effectivity
(See Section 2.1)

Experiment Title	Experiment No.	CSM Effectivity			
		Section No.	112	113	114
Gamma-ray spectrometer	S160	3.1	X	X	
X-ray fluorescence spectrometer	S161	3.2	X	X	
Alpha-particle spectrometer	S162	3.3	X	X	
Optical bar pan camera		3.4	X	X	X
S-band transponder	S164	3.5	X	X	X
Mass spectrometer	S165	3.6	X	X	
Three-inch mapping camera		3.7	X	X	X
Laser altimeter		3.8	X	X	X
Subsatellite					
Particles and fields	S173	3.9	X		X
Magnetometer	S174	3.9	X		X
S-band transponder	S164	3.9	X		X
UV spectrometer	S169	3.10 TBS			X
IR scanning radiometer	S171	3.11 TBS			X

2.2 EXPERIMENTS INTERFACE MATRIX

Table 2.2-1 identifies those experiments whose concurrent operation is either desired, required, or prohibited in order to satisfy the objectives of each experiment. A dash indicates that none of the three previous categories is applicable. More detailed information concerning a given experiment interface is presented in the applicable section of 3.0 under Interface Constraints.

2.2-1

SNA-8-D-027(VI)

Table 2.2-1. Interface Matrix (Lunar Orbit Phase)
(See Section 2.2)

Supporting Experiment	Experiment in Question						
	Gamma-Ray Spectrometer*	X-Ray Spectrometer	Alpha-Particle Spectrometer	Mapping Camera	Panoramic Camera	Laser Altimeter	Mass Spectrometer*
Gamma-ray spectrometer*	-	D	D	P	P	-	-
X-ray spectrometer	D	-	D	-	-	-	-
Alpha-particle spectrometer	D	D	-	-	-	-	-
Mapping camera	-	-	-	-	D	-	-
Panoramic camera	-	-	-	-	-	-	-
Laser altimeter	-	-	-	R	D	-	-
Mass spectrometer*	-	-	-	P	P	-	-

*With boom fully extended.

Legend: R = required D = desired P = prohibited

Note: During Pan Camera experiment operation, it is desirable to have Mapping Camera operation to support the Pan Camera objectives; however, for Mapping Camera operation it is not "desired" to have Pan Camera operation to support Mapping Camera objectives.

2.3 ELECTRICAL POWER

The spacecraft electrical equipment that uses ac or dc power and the power levels for each piece of CSM equipment (including scientific experiments) are shown in the master electrical equipment list (MEEL) in the appendixes of Volume I, Part 1, of the Data Book. Each electrical equipment list presents values of electrical power pertinent to the equipment in a specific spacecraft.

2.4 INSTRUMENTATION AND DATA - GENERAL

The scientific data system (SDS) is a basic Apollo data system with functional modifications as described in the following paragraphs:

2.4.1 TAPE RECORDER CHARACTERISTICS

1. Tape Recorder Rates:

PCM Bit Rate	Speed (ips)			Time (minutes)		
	Record	Playback	Rewind	Record	Playback	Rewind
High	7.5	7.5	60	60	60	8
Low	1.875	60	60	240	8	8

2. Tape Recorder Track Use:

Tracks	Function
1	Voice
1	LM PCM analog
1	Digital PCM: 51.2 or 1.6 kbps
1	Digital: 64 kbps
2	Scientific analog
3	Spare - analog

2.4.2 SDS MODULATOR

The SDS modulator duplicates the Apollo premodulation processor (PMP) operations with additional functional capabilities; it is activated during all SIM/experiment operations. The additional capabilities include the following:

1. Subcarrier Oscillators (SCO's). The SCO's are used as follows:

Frequency (kHz)	Function	Frequency Response (kHz)
165	Tape recorder playback (experiment analog)	0 to 5
225	Real-time transmission (experiment analog)	0 to 5

Frequency (kHz)	Function	Frequency Response (kHz)
300	Tape recorder playback (experiment analog)	0 to 9
400	Real-time transmission (experiment analog)	0 to 9

2. Biphase Modulators. The biphase modulators are used as follows:

Frequency (kHz)	Function	Frequency Response (kbps)
768	Real-time PCM (data processing)	64
576	Tape recorder playback (data processing)	64
1024*	Tape recorder playback (CSM data)	51.2

*51.2 kbps real-time data are transmitted via the PMP.

2.4.3 64-KILOBITS-PER-SECOND DATA PROCESSOR

The data processor accepts analog, discrete event, and digital data from the experiments and time multiplexes these data into a serial NRZ PCM format with a bit rate of 64,000 bits per second. The data processor is in the SIM.

2.4.4 TIMING BUFFER AMPLIFIER

The timing buffer amplifier distributes modified IRIG-B timing signals to the two cameras and a one-pulse-per-second timing signal to the laser altimeter. These signals are obtained from the central timing equipment located in the command module. The timing buffer amplifier is located in the SIM.

2.5 POINTING ACCURACY AND POINTING KNOWLEDGE

The following paragraphs clarify terminology used in Section 3.0 relative to attitude pointing performance requirements.

2.5.1 DEFINITION OF TERMS

Two major types of attitude pointing requirements are specified in Section 3 for each experiment's pointing accuracy and pointing knowledge. These terms are defined as follows:

1. Pointing Accuracy Requirement/Capability. The real-time accuracy to which a given instrument must/can be pointed relative to the desired direction.
2. Pointing Knowledge Requirement/Capability. The accuracy to which a given instrument pointing history must/can be derived from post-flight data reduction.

The only significant quantitative difference between pointing accuracy capability and pointing knowledge capability is the magnitude of the attitude hold deadband maintained in lunar orbit. The instantaneous position in the control deadband can be determined from the telemetered IMU gimbal angles, thus providing a more accurate post-flight pointing knowledge.

2.5.2 SPECIAL TERMS FOR BOOM-MOUNTED INSTRUMENTS

Each boom-mounted experiment presents a special pointing accuracy problem due to the additional sources of attitude uncertainty associated with the deployment mechanism and the boom itself. Hence, for the sake of convenience on these experiments, two types of pointing accuracy terms are frequently used:

1. Sensor Pointing Accuracy. Pointing accuracy related to the boom-mounted sensor, including uncertainties due to the extended boom and deployment mechanism.
2. SIM Pointing Accuracy. Pointing accuracy related to the interface of the SIM shelf and the deployment mechanism, excluding uncertainties due to the extended boom and deployment mechanism.

In that the angular uncertainties associated with the boom deployment of jettison mechanism are an order of magnitude larger than the control deadband, knowledge of the CSM attitude in the deadband is of negligible significance. Thus, for boom-mounted instruments, post-flight pointing knowledge is effectively the same as in-flight pointing accuracy.

2.5.3 SOURCES OF ATTITUDE UNCERTAINTIES

The following items constitute the various sources of attitude uncertainties which contribute to the total pointing knowledge capability of all non-boom-mounted experiments:

	Attitude Uncertainty (degrees)
Alignment in the instrument*	±0.50
SIM structural tolerances	±0.50
Instrument mounting	±0.20
SIM installation tolerance	±0.23
SIM-G&N navigation base boresighting	±0.05
Deviation from one g to zero g	±1.00
Thermal-induced variations	±0.33
IMU alignment accuracy	±0.03
IMU drift (assuming six hours)	±0.54
CMC local vertical program	±0.25
Root sum of squares (RSS) of random tolerances of these 10 items	±1.44

*Deviations to this 0.50-degree instrument design requirement may be granted for individual experiments and will be specified in the appropriate ICD's.

For non-boom-mounted experiments, the pointing accuracy capability is the 1.44 degrees plus the attitude control deadband (nominally ±0.5 degrees), or ±1.94 degrees. For the boom-mounted instruments, both pointing knowledge and pointing accuracy are further degraded by uncertainties in the deployment mechanism and the boom itself.

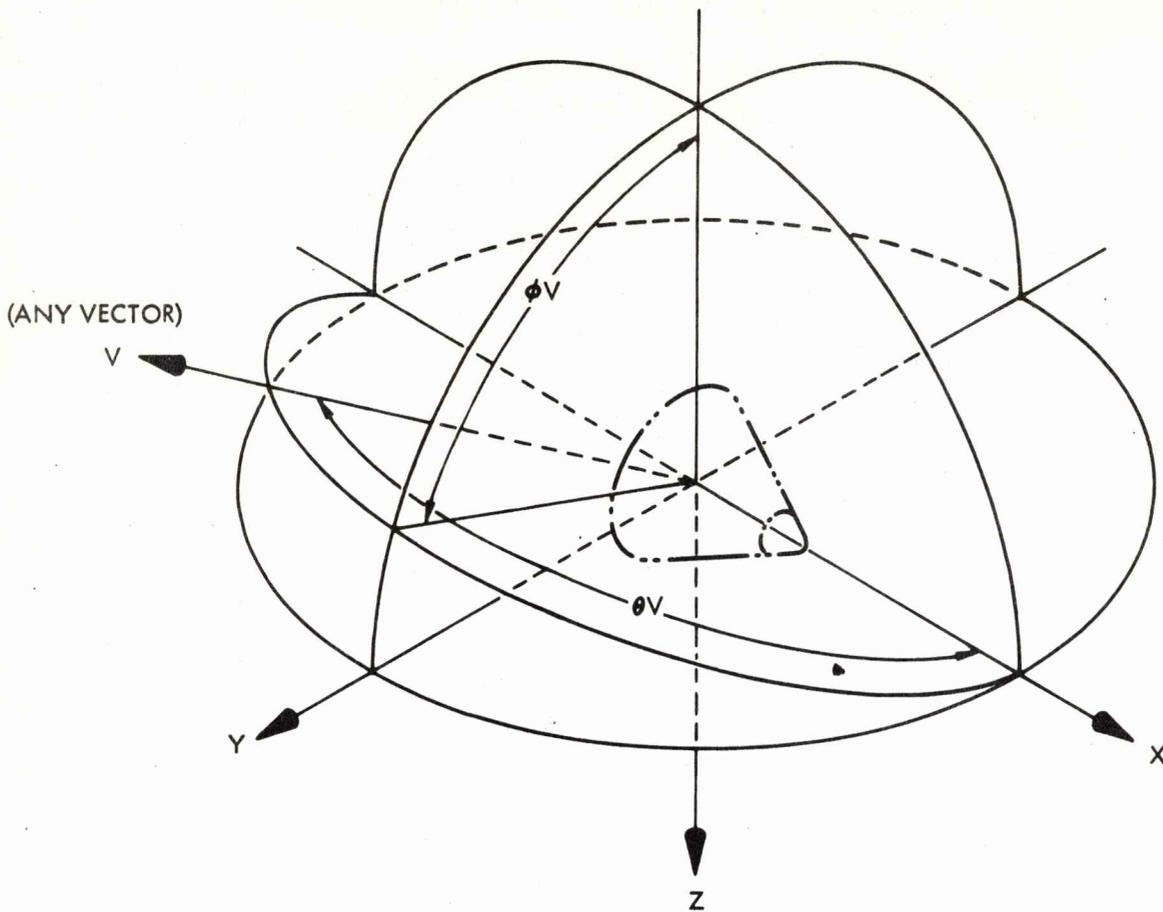
2.5.4 OPERATIONAL CONSIDERATIONS

Only one planning tool is available that significantly affects pointing accuracy capability, i. e., the selection of control deadband width. For those experiments that require a total pointing accuracy of ±2 degrees, a control deadband of ±0.5 degrees must be selected. During those experiment periods limited to operation of instruments that require a total pointing

accuracy of ± 5.0 degrees, the control deadband can be opened up to ± 3.5 degrees if desired. The IMU alignment interval can also be selected, but this selection has relatively little effect upon the total accuracy capability because of the RSS technique used in summing the ten errors listed in paragraph 2.5.3.

2.6 EXPERIMENTS SUN-LINE LIMITATIONS

Following SIM door jettison, the CSM attitude must be such that the sun-line vector is not permitted to fall within the look-angle envelope for the operating and nonoperating condition of each of the sun-sensitive experiment instruments as shown in Figures 2.6-2 and 2.6-3. These look angles are given in the theta (θ)-phi (ϕ) coordinate system as defined in Figure 2.6-1. If an experiment sun-avoidance restriction is time (duration) or mission phase limited, the individual experiment section will present such a limitation.



ϕ_V MEASURED FROM -Z BODY AXIS POSITIVELY ABOUT X BODY AXIS TO VECTOR PROJECTION IN YZ PLANE

θ_V SMALLEST ANGLE FROM +X BODY AXIS TO VECTOR

Figure 2.6-1. Spacecraft Look Angles

- NOTES: 1. SIM CENTERLINE AT $\theta = 90$ DEGREES, $\phi = 37.75$ DEGREES
2. PANORAMIC CAMERA (TBS)

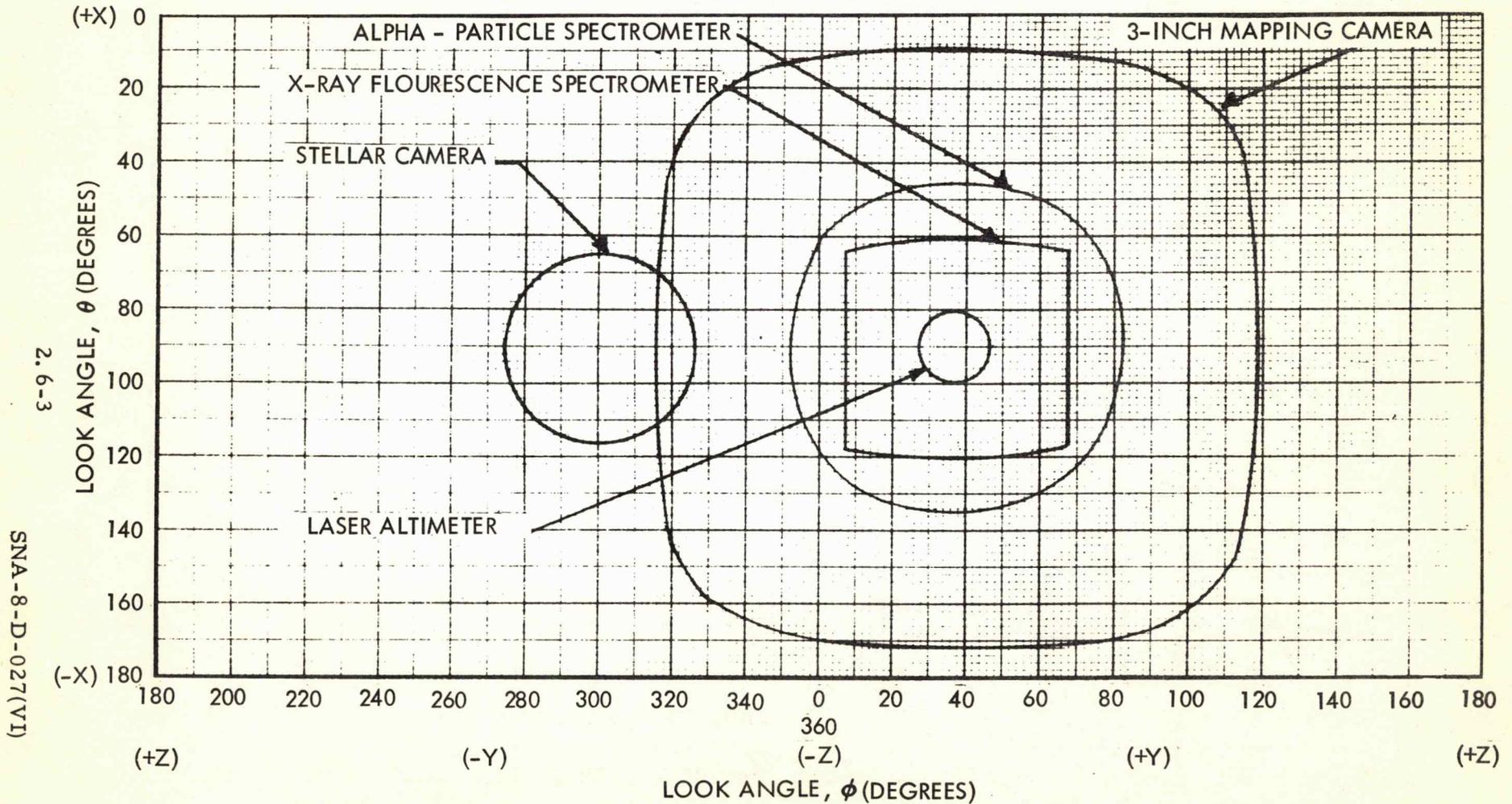


Figure 2.6-2. Operating Experiment Sun-Avoidance Envelopes

NOTE: SIM ζ AT $\theta = 90$ DEGREES, $\phi = 37.75$ DEGREES

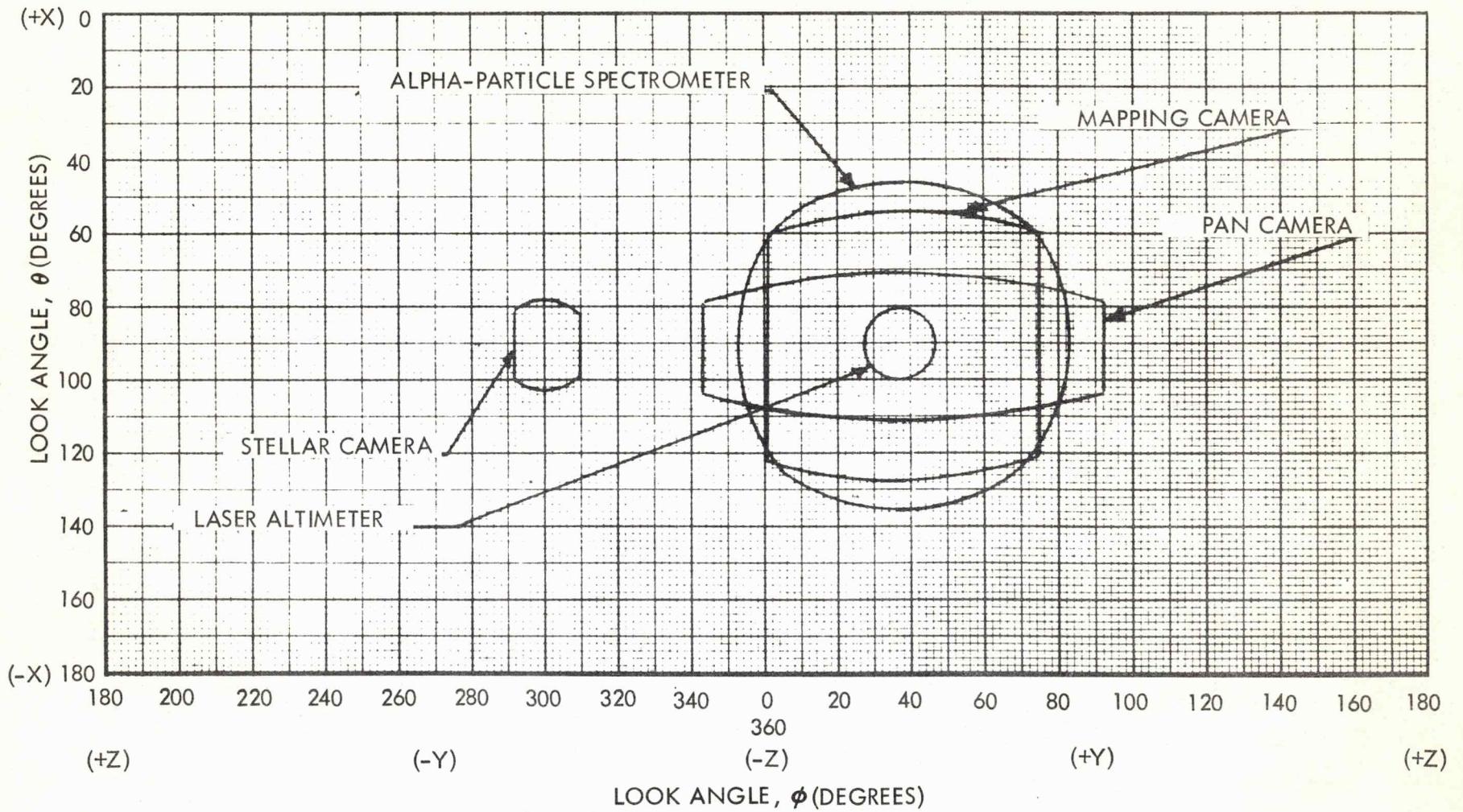


Figure 2.6-3. Nonoperating Experiment Sun-Avoidance Envelopes

2.6-4
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2.7 RADIATION ENVIRONMENT

To Be Supplied

2.8 SM-RCS Configuration Requirements

The SM-RCS configuration requirements to support the SIM instruments and EVA are identified in Table 2.8-1. An "X" in the appropriate column and row identifies those RCS jets which require disabling to support the indicated instrument or EVA operation. This table is applicable after SIM door jettison (Reference SODB, Vol. I, Part I, Section 2.0 for SIM door jettison characteristics) when the instruments are exposed (covers open) and are operated for data collection.

Table 2.8-1. SM-RCS Configuration Requirements
(See Paragraph 2.8)

SM-RCS Jets Operation	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4
	Gamma-Ray Spectrometer		X		X	X			X							
X-Ray Spectrometer		X		X	X			X								
Alpha Particle Spectrometer		X		X	X			X								
Laser Altimeter		X		X	X			X								
Pan Camera		X		X	X			X								
Mapping Camera		X		X	X			X								
Subsat Launch		X		X	X			X								
Mass Spectrometer		X		X	X			X	X		X					
EVA	X	X	X	X	X	X	X	X	X					X		

2.8-2

SNA-8-D-027 (VI)

Amendment 7
4/21/71

3.0 INDIVIDUAL EXPERIMENTS

Objectives, the physical characteristics, and
for each experiment. An outline of a
the appendix. If new experiments are
writing the new sections.

3.0 INDIVIDUAL EXPERIMENTS

3.0 INDIVIDUAL
EXPERIMENTS

-1

SNA-8-D-027(VI)

3.0 INDIVIDUAL EXPERIMENTS

Section 3.0 presents the objectives, the physical characteristics, and the performance and operational data for each experiment. An outline of a typical experiment section appears in the appendix. If new experiments are added, the format shown should be used in writing the new sections.

3.1 GAMMA-RAY SPECTROMETER

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0 inches in diameter
capable of extending

to the aft side of the SIM
establishes the instrument
90 degrees and a $\phi = 37.75$
appreciable effect on look angles.
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er experiment requires accumulation of data
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inal distances of 8 feet and 15 feet. To accom-
e set at 10 feet and 17 feet, respectively, from

retraction mechanism is capable of at least 150 com-
l rate of 2 ± 1 inches per second. Boom position
is provided at full extension, full retraction and jetti-
e boom positioning necessitates timing by the crew.

3.1 GAMMA-RAY SPECTROMETER (S160)

3.1.1 OBJECTIVES

The objectives are to determine the degree of chemical differentiation the moon has undergone during its development and to map possible differences between large-scale features.

3.1.2 PHYSICAL CHARACTERISTICS

3.1.2.1 Functional and Physical Description

The gamma-ray spectrometer (GRS) will obtain evidence on the origin and evolution of the moon by measuring the gamma radiation flux from the lunar surface. The gamma-ray energy range of interest is from 0.2 to 10 Mev.

The instrument is mounted at the end of an extendable/retractable/jettisonable boom operated by a deployment mechanism. The instrument consists of a gamma-ray detector and associated electronics. The detector, as depicted in Figure 3.1-2, has an omnidirectional field-of-view.

3.1.2.2 Envelope Dimensions and Weight (Approximate Values)

The deployment/jettison mechanism is 13 by 15 by 34 inches and weighs 69 pounds. The 21-pound GRS is contained in a cylinder 10 inches in diameter by 19 inches in length (see Figure 3.1-1). The boom is capable of extending to a maximum length of 25 feet from the SM mold line.

3.1.2.3 Installation in SIM

The boom deployment mechanism is attached to the aft side of the SIM shelf located at $X_S = 236.50$ in a manner which establishes the instrument alignment with a normal CSM look angle of $\theta = 90$ degrees and a $\phi = 37.75$ degrees. Boom deployment position has no appreciable effect on look angles. Refer to paragraph 2.5.3 for alignment accuracies.

3.1.2.4 Deployment Characteristics

At various times during the operation period, the spectrometer may require full or partial retraction to remove it from the cameras' fields-of-view. In addition, the gamma ray spectrometer experiment requires accumulation of data during TEC at two intermediate boom positions with the instrument extended beyond the spacecraft mold line by nominal distances of 8 feet and 15 feet. To accomplish this, boom positions are set at 10 feet and 17 feet, respectively, from the stowed positions.

The boom extension/retraction mechanism is capable of at least 150 complete cycles at a nominal rate of 2 ± 1 inches per second. Boom position monitoring capability is provided at full extension, full retraction and jettison only; intermediate boom positioning necessitates timing by the crew.

3.1.2.4 Deployment Characteristics (Continued)

Switch actuation times to reach the required intermediate boom positions of the GRS can be determined using the nomograms, shown in Figures 3.1-5 (10 ft. position) and 3.1-6 (17 ft. position) for CSM 113, and the procedures for the use of these nomograms as explained in the following paragraphs. Analysis of ground test data has indicated that extension from the fully-retracted to the 10-foot intermediate position or retraction from the fully-extended (approximately 27 ft) to the 17-foot intermediate position will provide the most accurate knowledge of the intermediate boom positions; therefore, two nomograms indicating these positions are provided for each CSM.

In-flight calibration of the boom mechanism should be performed in the same thermal environment as the intermediate positioning. This will minimize the effects of thermally induced variations in boom motion. This calibration consists of determining the time of each full extension (De) from the stowed position, or full retraction (Dr) from the fully extended position, and the bus voltage during each extension (Ve) or retraction (Vr). The ON time is measured from when the control switch is placed in the DEPLOY or RETRACT position to the time the talk-back changes from barber pole to gray. Using the bus voltage recorded from the in-flight calibration, locate the value on the V scale of the appropriate nomogram. A straight line from this value to the nomogram index point intersects the C scale at the corresponding ground calibration time. (The value at the intersection of the P scale is used below). The ratio (R) of the in-flight calibration time (D) to the ground calibration time (C) may be used as a correction factor to determine the boom position more accurately. It is recommended that at least three in-flight calibrations be performed and the ratio equation becomes:

$$R = \frac{1}{n} \sum_{j=1}^n \frac{D_j}{C_j}$$

where:

R = mean ratio of in-flight to ground calibration values

D = in-flight calibration time (De for DEPLOY or Dr for RETRACT)

C = ground calibration time (Ce for DEPLOY or Cr for RETRACT)

n = number of calibrations performed.

To determine the time required to position the boom at an intermediate position, the following procedure should be followed:

1. Determine the bus voltage (CC0207V) during boom motor operation. (This is the bus voltage before motor operation minus the voltage drop (≈ 0.1 volt) caused by motor operation).
2. Use the applicable nomogram with the voltage determined in Step 1 to find P for the desired intermediate position.
3. By using the value P determined from Step 2 and corrected by the in-flight calibration ratio \bar{R} , the time T required to place the boom in each position is determined by the equation:

$$T = \bar{R} \times P$$

4. Repeat the procedure for each intermediate position.

Figures 3.1-7 and 3.1-8 may be used to determine the timing required to extend or retract the boom to any intermediate position. Knowledge of the actual boom position is determined slightly less accurately than with the nomogram because of the inability to account for all variables when using the graphs.

3.1.2.5 Boom Jettison

Should the jettison of the gamma-ray spectrometer be required, 72 pounds of material would be jettisoned at 7.1 feet per second (nominal) in a direction of $\theta=90^\circ$ and $\phi=37.75^\circ$ with respect to spacecraft coordinates.

3.1.3 PERFORMANCE AND OPERATIONAL DATA

3.1.3.1 Electrical Power

3.1.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required.

3.1.3.1.2 Power Requirements

The power requirements for the five subsystems of the gamma-ray spectrometer are as follows:

Subsystem	Average (watts)	Maximum (watts)
Heaters	17.0	20.4
Electronics	1.2	1.4
Boom motor	82.5	206.0
Jettison A and B	92.0	102.0
Boom release A and B	99.5	109.5

3.1.3.1.3 Batteries

No batteries are used in the gamma-ray spectrometer.

3.1.3.2 Attitude and Orbital Geometry

3.1.3.2.1 Attitude Constraints

The gamma-ray spectrometer is nonsensitive to the CSM X-axis direction; therefore, the instrument can be operated with either the CSM positive X-axis or negative X-axis in the direction of the velocity vector.

The gamma-ray spectrometer is nonsensitive to direct sunlight and therefore imposes no sun-avoidance attitude constraints.

3.1.3.2.2 Orbital Geometry Constraints

The lunar orbital parameters are not constrained by the gamma-ray spectrometer.

3.1.3.3 Environment

3.1.3.3.1 Temperature Limitations

Temperature limits for operational telemetry thermal measurements are given in Table 3.1-1.

With the protective cover closed, the retracted instrument is capable of withstanding the convective heating resulting from a 20-second, continuous, simultaneous firing of SM RCS jets A4 and B4 after jettison of the SIM door.

3.1.3.3.2 Temperature Control

Thermal control of the gamma-ray spectrometer is achieved by the following methods:

1. A passive thermal control coating with solar absorptivity (α) and emissivity (ϵ) properties has been applied to all surfaces of the spectrometer.
2. The spectrometer is thermally isolated from the deployment boom.
3. Heaters are thermostatically controlled to turn on at 59 F and turn off at 61 F when the spectrometer is on.
4. The spectrometer is passively biased to the cold side of the thermal operating range.

3.1.3.3.3 Humidity Limitation

The maximum allowable relative humidity (RH) for the gamma-ray spectrometer is 60 percent.

3.1.3.3.4 Nuclear Radiation Limitation

Gamma-ray spectrometer data quality will not be degraded during operation, boom extended, if the background level of CSM inherent gamma-ray count does not exceed 0.05 counts per square centimeter per second for energies greater than 0.4 Mev measured at the extended boom position. Background radiation levels in excess of this could result in degraded data.

3.1.3.3.5 External Contaminant Limitations

Anticipated effluent dumps are not expected to affect the gamma-ray spectrometer. However, the GRS should be fully retracted (to insure that the instrument will have its protective cover closed) or fully extended during water and urine dumps, fuel-cell purges, and SM RCS A2, A4, B1 and B4 burns.

3.1.3.4 Crew Support Requirements

3.1.3.4.1 Pre-Experiment Operations

The temperature of the GRS will be monitored in real time on the ground. Since the thermal sensors on the GRS are not usable until the instrument is turned on, a SIM operational thermocouple in the vicinity of the boom is monitored to give an indication of the GRS temperature. MSFN will inform the crew when the temperature approaches a limit and recommend the procedure to maintain the GRS within temperature limits.

3.1.3.4.2 Experiment Operations

The GAIN-STEP control and the SHIELD ON-OFF control (a data signal veto function) shall be positioned as noted in the flight plan or as directed by MSFN in real time.

3.1.3.4.2.1 Lunar Orbit

The instrument must be operated in the fully extended position for the maximum allowable time in order to obtain optimum data.

To preserve operating stability for maximum quality data accumulation, the number of instrument OFF-ON cycles should be minimized.

3.1.3.4.2.2 Transearch Coast (TEC)

To obtain optimum background data, the instrument must be fully deployed and powered as soon as practicable after transearch injection (TEI).

For spectrometer data collection in intermediate boom positions, the crew will be required to time boom-travel (see paragraph 3.1.2.4 for extend/retract rates) in order to obtain an intermediate position, since intermediate position sensors are not provided.

The spectrometer may be in the deployed position while the CSM rolls in the passive thermal control mode.

3.1.3.4.3 Post-Experiment Operations

There are no post-experiment requirements.

3.1.3.5 Interface Constraints

The instrument boom must be fully retracted during subsatellite ejection.

The instrument boom must be retracted and the instrument turned OFF before any SPS maneuver. If the boom fails to retract, it must be jettisoned before SPS thrusting. After an SPS maneuver, the instrument may be turned ON and fully deployed as soon as practicable.

This instrument does not require concurrent operation of any other instrument, although concurrent operation of the alpha-particle and X-ray spectrometers is desirable. Refer to the Interface Matrix, Section 2.2.

During the collection of prime data in lunar orbit, the instrument boom must be in the fully extended position, and the mapping camera must be retracted and its protective cover closed to shield the GRS from mapping camera lens thorium radiation.

The mapping camera protective cover must be closed for instrument data collection during TEC to shield the GRS from mapping camera lens thorium radiations.

See paragraphs 3.4.3.5.1 and 3.7.3.5.1 for data on GRS interference into the cameras FOV.

Table 3.1-1. Gamma-Ray Spectrometer Temperature Limits (NASA Data Source)
(See Paragraph 3.1.3.3.1)

TELEMETRY MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION	OPERATING MODE (3)	MAXIMUM LIMITS (4)				REDLINE LIMIT (2) (5)		COMMENTS
			LOW	(1)	HIGH	(1)	LOW	HIGH	
			SL1085T	Detector Temp	Nonoperating	-4 °F	***	120°F	
	Operating	-4	S	120	S	*	*		
	Data Collection	-4	S	120	S	N/A	N/A		
SL1086T	Electronics Temp	Nonoperating	-4	***	120	***	-20**	140**	
	Operating	-4	S	120	S	*	*		
	Data Collection	-4	S	120	S	N/A	N/A	*This information is not available.	
								**Based upon chamber air temperature during off-limits testing of electronics package.	
								***Best engineering estimate.	

NOTES:

- 1 "S" designates limits established by specification; "Q" designates limits established by qualification test.
- 2 Source of redline values designated in "comments" column.
- 3 Data collection mode refers to operation for purposes of obtaining scientific data. This inherently implies that instrument performance is expected to be within specification (data degradation, if any, will be within acceptable limits).
- 4 Maximum Limits: Limits which if exceeded will result in the instrument's not performing within specification.
- 5 Redline Limits: Limits which if exceeded may result in permanent degradation of instrument (instrument will not recover to specification performance).

3.1-5.1

SNA-8-D-027 (VI)

Amendment 17
7/23/71

3.1-6

SNA-8-D-027(VI)

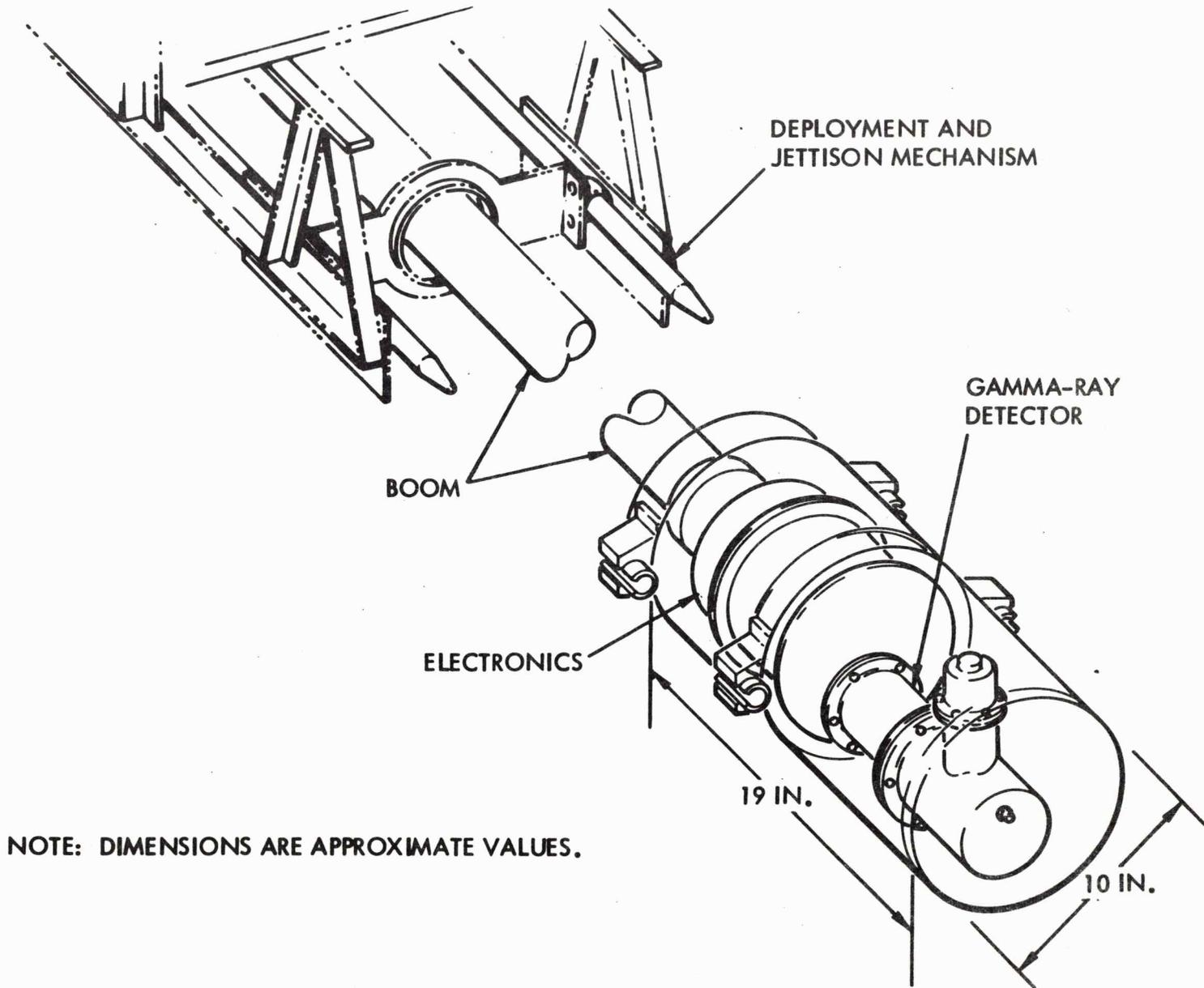


Figure 3.1-1. Gamma-Ray Spectrometer

Na I (Tl) CRYSTAL
HIGH EFFICIENCY FOR
GAMMA RAYS & CHARGED
PARTICLES

1.5 IN. PHOTOMULTIPLIER
TUBE

PHOTOSENSITIVE
SURFACE

HEATER

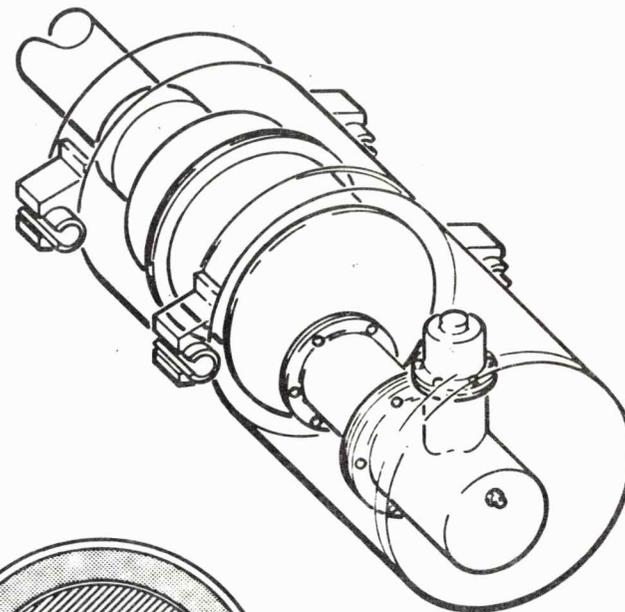
e⁻

3-IN. PHOTOMULTIPLIER
TUBE

VISIBLE RADIATION
SHIELD

Na I (Tl)
SCINTILLATOR

GAMMA RAY



PLASTIC SCINTILLATOR:
LOW EFFICIENCY FOR GAMMA
RAYS HIGH EFFICIENCY FOR
CHARGED PARTICLES

Na I (Tl)
(SODIUM
IODIDE)

PLASTIC ANTI-
COINCIDENCE
SHIELD (PILOT-B)

Figure 3.1-2 Gamma-Ray Spectrometer Detector
(See Paragraph 3.1.2.1)

3.1-7

SNA-8-D-027 (VI)

Figure 3.1-3. Deleted

Figure 3.1-4. Deleted

SN AAJ 6115

DEPLOYMENT TO 10 FEET - (120 INCHES) POSITION
FROM FULL RETRACTION (NOMINAL 8 FEET -
POSITION FROM MOLD LINE)

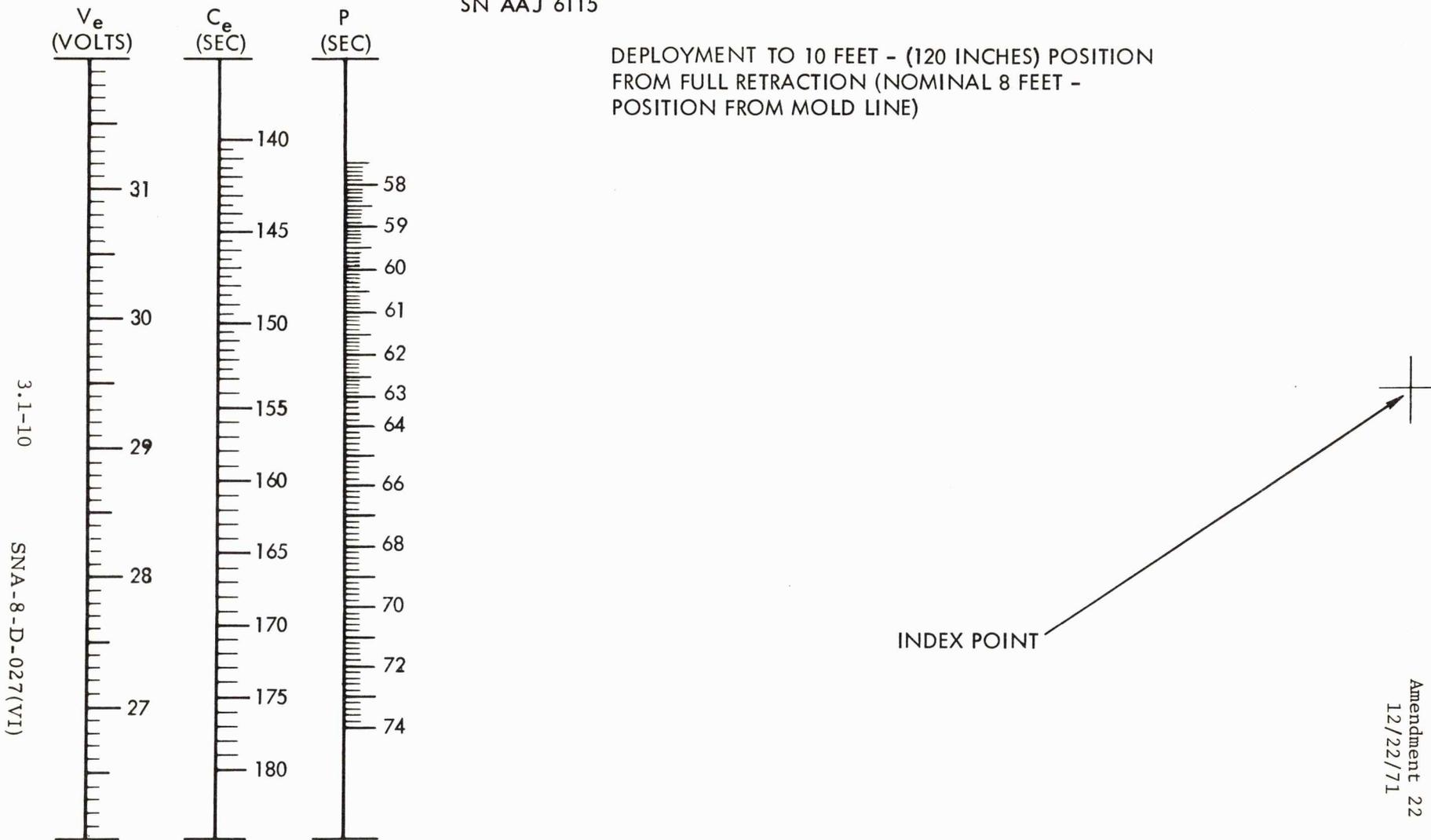
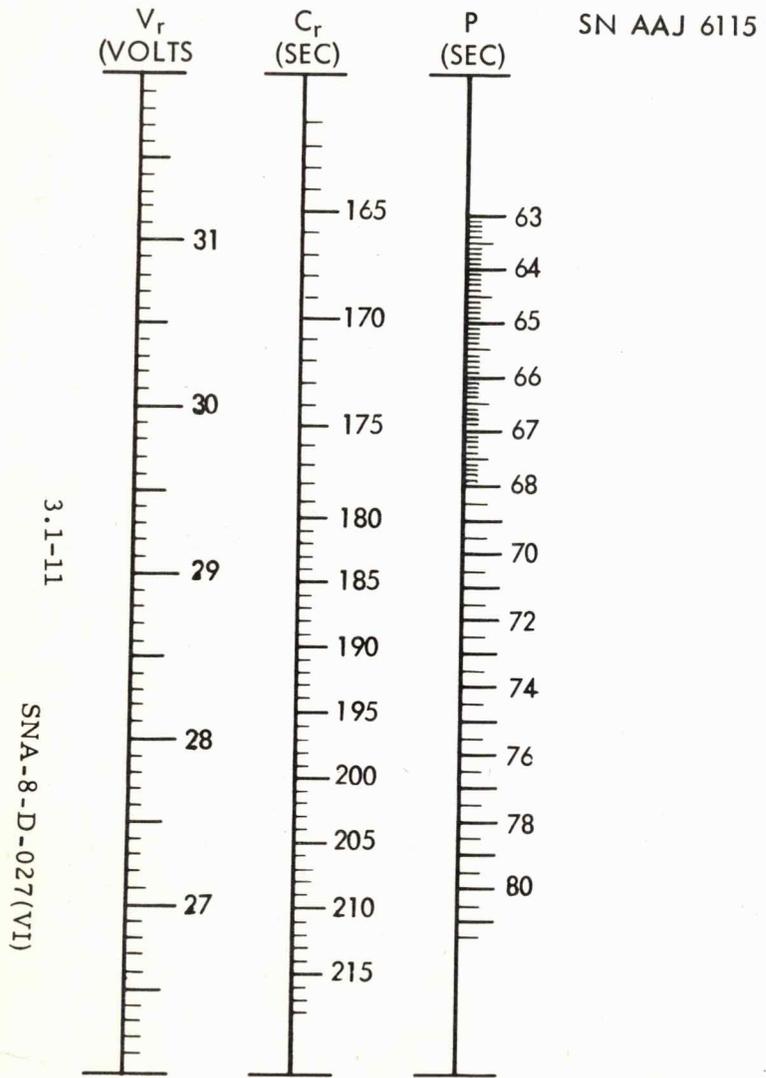
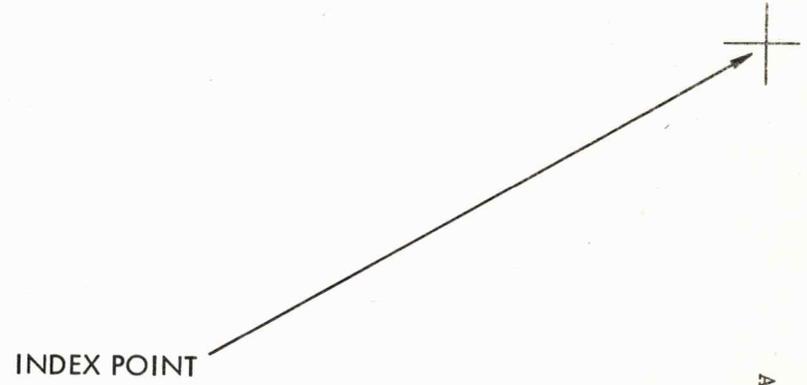


Figure 3.1-5. CSM 113 Gamma-Ray Spectrometer Boom Deployment Time Nomogram,
Extension to 10 Feet (See Paragraph 3.1.2.4)



RETRACTION TO 17 FEET - (204 INCHES) POSITION
FROM FULL EXTENSION (NOMINAL 15 FEET -
POSITION FROM MOLD LINE)



3.1-11
SNA-8-D-027(VI)

Figure 3.1-6. CSM 113 Gamma-Ray Spectrometer Boom Retraction Time Nomogram, Retraction to 17 Feet (See Paragraph 3.1.2.4)

Amendment 22
12/22/71

(S/N 6115)

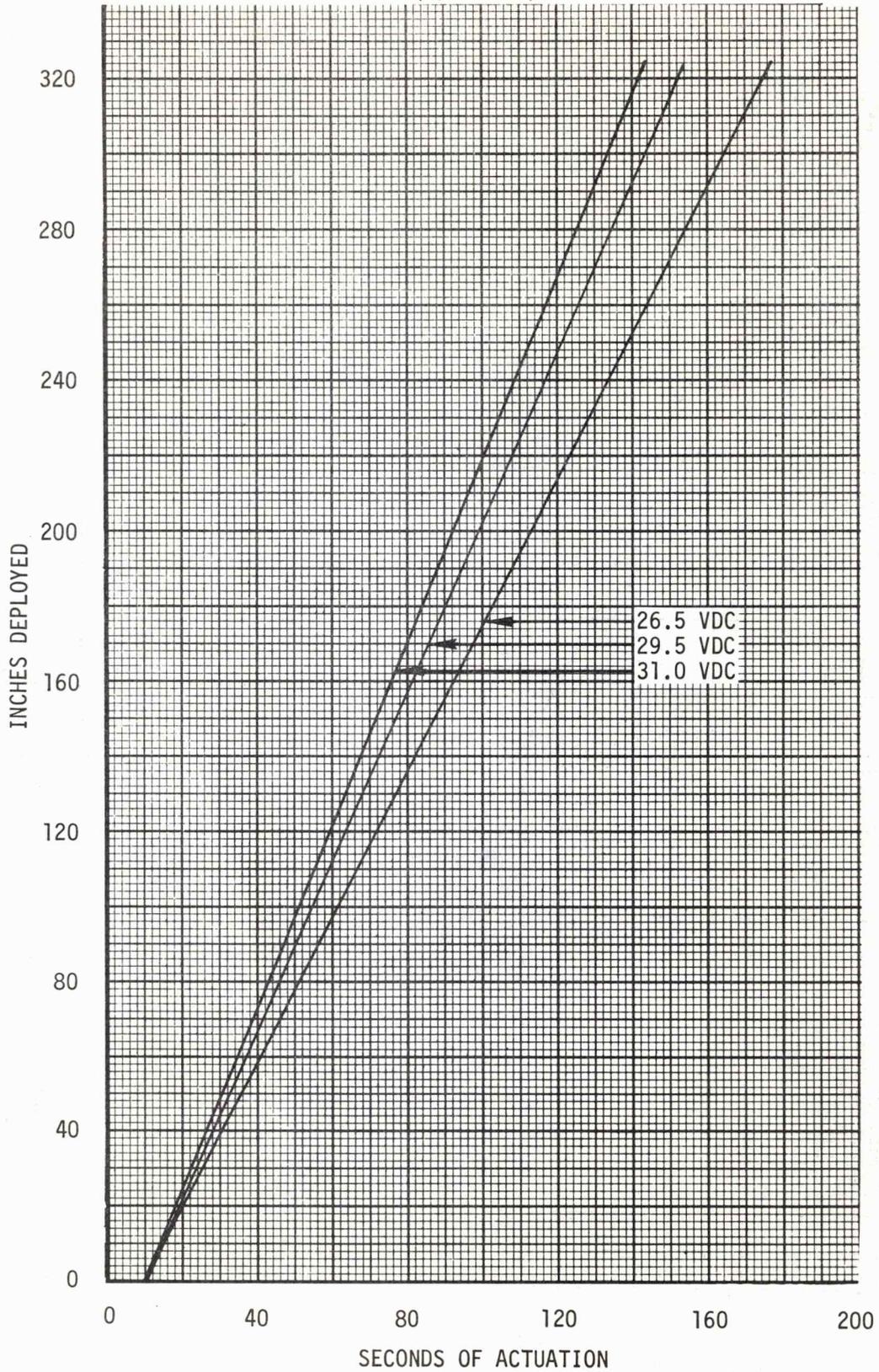


Figure 3.1-7. CSM 113 Gamma-Ray Mean Extension Data
(See Paragraph 3.1.2.4)

(S/N AAJ 6115)

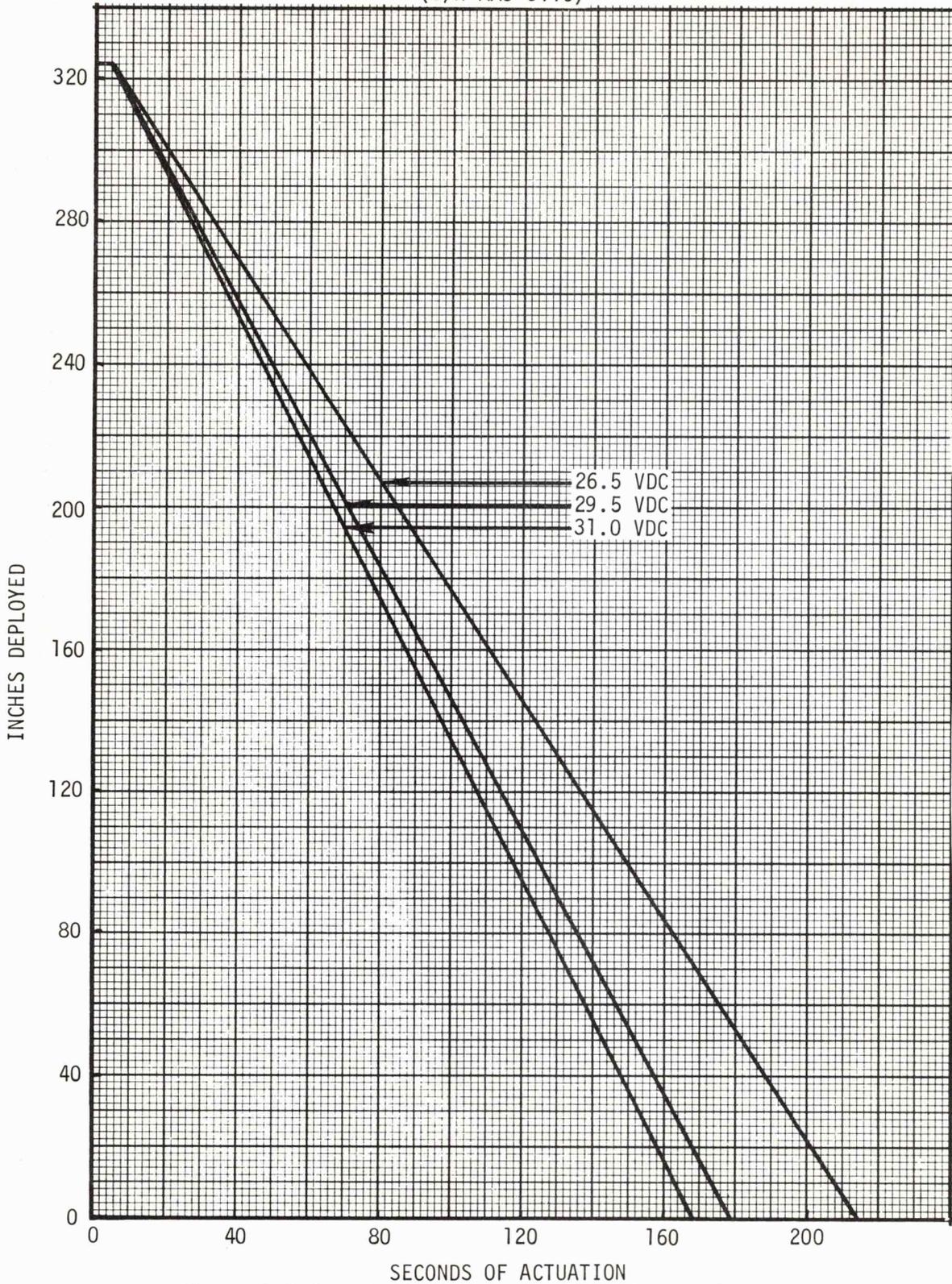


Figure 3.1-8. CSM 113 Gamma-Ray Mean Retraction Data
(See Paragraph 3.1.2.4)

3.2 X-RAY SPECTROMETER

degree
stry.

shaped to fit
slope. The solar
ads.

A shelf located at
to provide a nominal CSM
degrees. Refer to paragraph 2.5.3

3.2-1

SNA-8-D-027(VI)

3.2 X-RAY FLUORESCENCE SPECTROMETER (S161)

3.2.1 OBJECTIVES

The objective is to perform a compositional survey of the lunar surface. The experiment should provide data regarding the nature of the lunar surface material and should also measure surface homogeneity. By comparing these data with gamma-ray experiment data (Section 3.1), surface and subsurface similarities can be determined.

3.2.2 PHYSICAL CHARACTERISTICS

3.2.2.1 Functional and Physical Description

The X-ray instrument will measure the characteristic fluorescent X-rays in the 1- to 6-Kev range produced by the interaction of solar radiation with the lunar surface. The solar monitor will measure the solar X-ray flux, which induces the fluorescence.

The X-ray equipment consists of gas-filled proportional counters, passive filters, and supporting electronics contained in the same housing as the alpha-particle spectrometer (Section 3.3). In addition, a solar monitor is required as part of the X-ray experimental equipment. The instrument field-of-view of the X-ray experiment is a ± 30 -degree square (60-degree included angle), with the viewing direction as the axis of symmetry. The instrument field-of-view of the solar monitor is a ± 53 -degree cone (106-degree included angle), with the viewing direction as the conical axis of symmetry.

3.2.2.2 Envelope Dimensions and Weight (Approximate Values)

The combined 130-pound alpha/X-ray package has been shaped to fit the SIM shelf (Figure 3.2-1) in a 14- by 26- by 34-inch envelope. The solar monitor is 8 by 11 by 15 inches overall and weighs 22 pounds.

3.2.2.3 Installation in SIM

The combined package is mounted on the SIM shelf located at $X_g = 206.50$. The X-ray spectrometer is aligned to provide a nominal CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees. Refer to paragraph 2.5.3 for alignment accuracies.

The solar monitor is not mounted in the SIM but is located on the opposite side of the SM (Bay IV) for viewing in a direction 180 degrees to the X-ray spectrometer. The solar monitor installation provides a nominal CSM look angle of $\theta = 90$ degrees and $\phi = 217.75$ degrees.

3.2.2.4 Deployment Characteristics

Not applicable.

3.2.3 PERFORMANCE AND OPERATIONAL DATA

3.2.3.1 Electrical Power

3.2.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required

3.2.3.1.2 Power Requirements

The maximum dc power requirements of the alpha-particle and X-ray spectrometers will not exceed 47 watts. The average dc power will not exceed 40 watts. The allocation of power for various switch positions is presented in Table 3.2-1.

3.2.3.1.3 Batteries

No batteries are used in the X-ray spectrometer.

3.2.3.2 Attitude and Orbital Geometry

3.2.3.2.1 Attitude Constraints

The X-ray fluorescence spectrometer is nonsensitive to the CSM X-axis direction; therefore, the instrument can be operated with either the CSM positive X-axis or negative X-axis in the direction of the velocity vector.

The instrument deep-space calibration in lunar orbit requires that the CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees be aligned to within ± 45 degrees of the lunar zenith.

The X-ray spectrometer is sun-sensitive in the ON mode with the protective cover open. The operating mode sun-avoidance envelope is presented in Section 2.6.

3.2.3.2.2 Orbital Geometry Constraints

The lunar orbital parameters are not constrained by the X-ray spectrometer.

3.2.3.3 Environment

3.2.3.3.1 Temperature Limitations

Temperature limits for operational telemetry thermal measurements are given in Table 3.2-2.

3.2.3.3.2 Temperature Control

Thermal control of the X-ray spectrometer is achieved by the following methods:

1. A passive thermal control coating with solar absorptivity (α) and emissivity (ϵ) properties has been applied to the nadir facing surface.
2. Passive thermal control superinsulation with solar absorptivity (α) and emissivity (ϵ) properties has been provided on the SIM bay facing surfaces.
3. The spectrometer is thermally isolated from the SIM structure.

4. Heaters are thermostatically controlled to turn on at -5 F and turn off at 2 F when the spectrometer is in STANDBY or ON.
5. The spectrometer is passively biased to the cold side of the thermal operating range.

Thermal control of the solar monitor is achieved by the following methods:

1. A passive thermal control insulation with solar absorptivity (α) and emissivity (ϵ) properties has been provided on all surfaces.
2. The monitor is thermally isolated from the structure.
3. The monitor is passively biased to the cold side of the thermal operating range.

3.2.3.3.3 Humidity Limitation

The maximum allowable relative humidity (RH) is 60 percent for the X-ray fluorescence spectrometer and the solar monitor.

3.2.3.3.4 Nuclear Radiation Limitation

To prevent X-ray experiment degradation, the background radiation produced by sources on the spacecraft at the X-ray detectors should not exceed 10 counts per second up to energies of 50 Kev and 100 counts per second above 50 Kev.

3.2.3.3.5 External Contaminant Limitations

The X-ray/alpha particle spectrometer protective cover must be closed for effluent dumps (urine, waste water, fuel-cell purges, etc.) and when SM-RCS jets A2, A4, B1 and B4 are activated. The protective cover should remain closed for at least 15 minutes following an effluent dump, but the total closed time should be minimized for the maximum accumulation of data.

3.2.3.4 Crew Support Requirements

3.2.3.4.1 Pre-Experiment Operations

The X-ray solar monitor door is to be opened in lunar orbit before the initial operation of the instrument is started. Once the door is opened, it cannot be closed.

The protective cover over the spectrometer processor assembly in the SIM must also be open while data are being accumulated.

Temperature in the vicinity of the X-ray spectrometer will be monitored in real time on the ground. If the possibility of the instrument reaching its low temperature limit appears imminent, the crew will be instructed to turn the instrument on.

3.2.3.4.2 Experiment Operations

3.2.3.4.2.1 Lunar Orbit. The spectrometer should operate continuously without interruption except for contingencies.

CAUTION: Sun entering the instrument while in the ON mode will degrade the instrument performance. If direct sunlight exposure is anticipated, the instrument will be switched to the STANDBY mode or the protective cover will be closed. Refer to paragraph 2.6 for a presentation of the sun-avoidance envelope.

Once each operating day, while on the dark side of the moon, the spectrometer must be calibrated by pointing the instrument at deep space for 15 minutes to obtain a background measurement. See paragraph 3.2.3.2.1 for the instrument calibration look angle and pointing attitude.

3.2.3.4.2.2 Transearth Coast. Simultaneous operation with the gamma-ray spectrometer (Section 3.1) is desired. The spectrometer should operate without interruption, except for contingencies, until the desired data collection is complete. Restrictions for sun rays entering the instrument FOV are the same as for lunar orbit (see paragraph 3.2.3.4.2.1) until the galactic sightings have been completed.

3.2.3.4.3 Post-Experiment Operations

None required.

3.2.3.5 Constraints

3.2.3.5.1 Interface Constraints

This experiment does not require concurrent operation of any other experiment, although concurrent operation with the gamma-ray spectrometer and the alpha-particle spectrometer is highly desirable. Refer to the Interface Matrix, Section 2.2.

*During SPS burns, the X-ray spectrometer should be in the OFF position to prevent damage due to vibration. The instrument may be turned on immediately after the burn is completed.

3.2.3.5.2 Operational Constraints

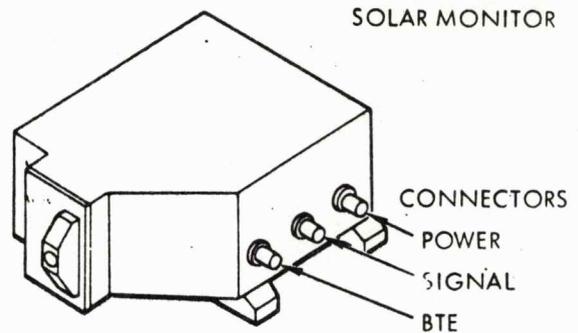
Limits for telemetry measurements are given in Table 3.2-3.

*NASA DATA SOURCE

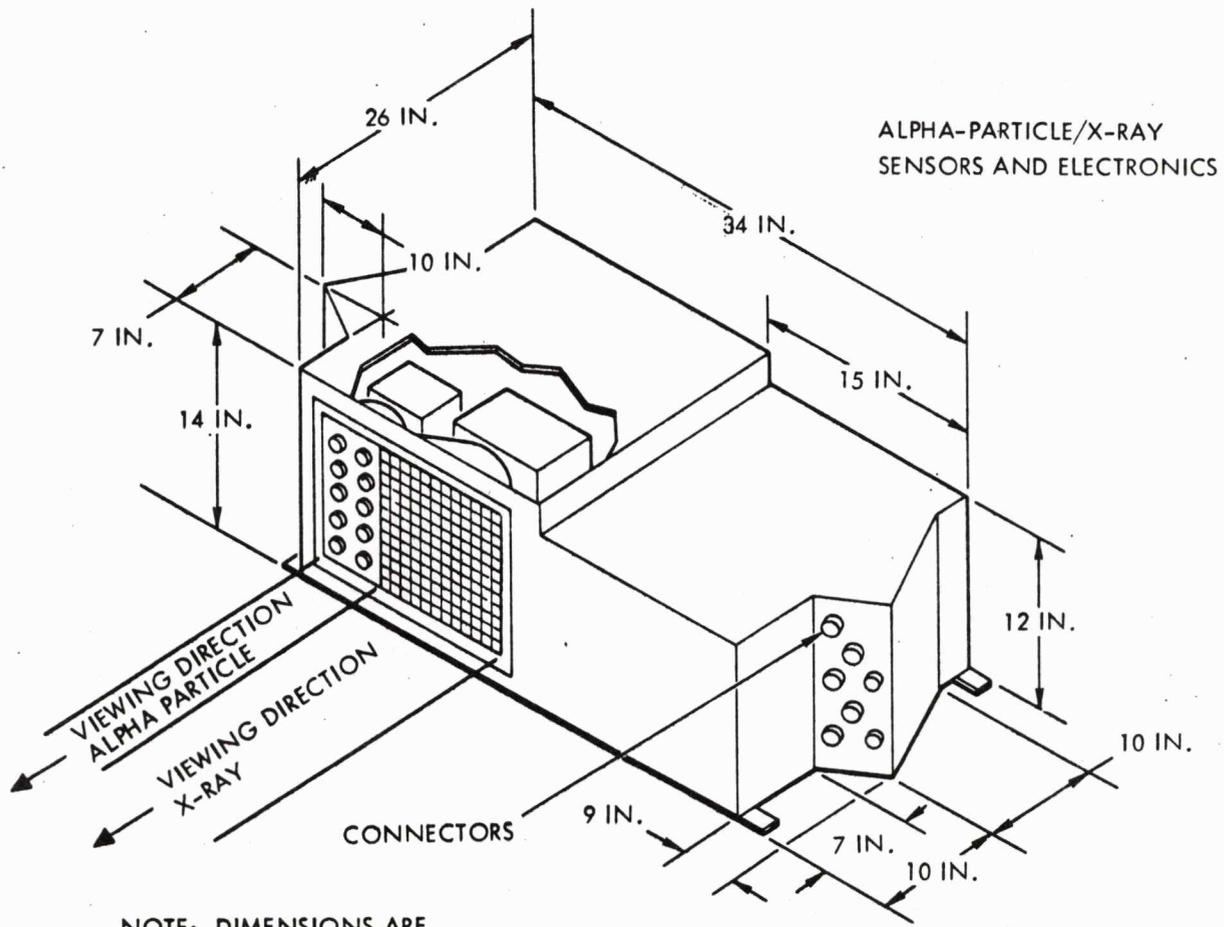
Table 3.2-1. Alpha and X-Ray DC Power Matrix for Apollo 15
(See Paragraph 3.2.3.1.2)

SWITCH POSITIONS						[2][3][4] DC POWER (WATTS)
X-RAY			ALPHA			
ON [3]	OFF	CAL. [1] DRIVE	STANDBY [3]	ON	OFF	
			X		X	20.48
X					X	20.48
X		X			X	24.84
X				X		29.49
X		X		X		33.85
	X			X		9.01

- [1] "CAL. DRIVE" is not a switch position. The calibration drive system is automatically energized when the X-ray system is turned on and has a duty cycle of 64 seconds every 16 minutes of experiment operation.
- [2] Electrical power reference: Acceptance Test Data, Alpha/X-Ray S/N 7498
- [3] Heater Power (6 watts) is not reflected in test data. Heaters are thermostatically controlled when the X-ray system is in the "ON" or "STANDBY" mode, heater cycling is dependent on the S/C thermal environment.
- [4] Power at 27.5 volts dc.



ENVELOPE (8 IN. BY 11 IN. BY 15 IN.)
INCLUDING INSULATION (NOT SHOWN)



NOTE: DIMENSIONS ARE
APPROXIMATE VALUES

Figure 3.2-1. Alpha-Particle/X-Ray Fluorescence Spectrometers

E SPECTROMETER (S162)

quantitative and spatial
by spectral analysis
daughter

3.3 ALPHA-PARTICLE SPECTROMETER

3.3 ALPHA-PARTICLE
SPECTROMETER

SNA-8-D-027(VI)

3.3 ALPHA-PARTICLE SPECTROMETER (S162)

3.3.1 OBJECTIVES

The objective is to obtain data pertaining to the quantitative and spatial distribution of thorium and uranium on the lunar surface by spectral analysis of the alpha particles emitted from these elements and their daughter products.

3.3.2 PHYSICAL CHARACTERISTICS

3.3.2.1 Functional and Physical Description

The alpha spectrometer will measure the intensity and energy spectrum of alpha particles emitted from the lunar surface. The alpha particle energy range of interest is approximately 4.7 to 9.3 Mev.

The alpha-particle equipment consists of an array of detectors and supporting electronics housed in the same enclosure as the X-ray experiment (Section 3.2). The instrument field-of-view is a ± 45 -degree cone (90-degree included angle), with the viewing direction as the conical axis of symmetry.

3.3.2.2 Envelope Dimensions and Weight (Approximate Values)

The combined 130-pound alpha/X-ray package has been shaped to fit the SIM shelf (Figure 3.2-2) in a 14- by 26- by 34-inch envelope.

3.3.2.3 Installation in SIM

The combined instruments are mounted on the SIM shelf located at $X_s = 206.50$. The alpha-particle spectrometer viewing axis is aligned to provide a nominal CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees. (Refer to paragraph 2.5.3 for alignment accuracies.)

3.3.2.4 Deployment Characteristics

Not applicable.

3.3.3 PERFORMANCE AND OPERATIONAL DATA

3.3.3.1 Electrical Power

3.3.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required.

3.3.3.1.2 Power Requirements

The power requirements for the alpha-particle spectrometer, which are shared with the X-ray spectrometer, are described in paragraph 3.2.3.1.2.

3.3.3.1.3 Batteries

No batteries are used in the alpha-particle spectrometer.

3.3.3.2 Attitude and Orbital Geometry

3.3.3.2.1 Attitude Constraints

The alpha-particle spectrometer is nonsensitive to the CSM X-axis direction; therefore, the instrument can be operated with either the CSM positive X-axis or negative X-axis in the direction of the velocity vector.

The instrument deep-space calibration in lunar orbit requires that the CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees be aligned to within ± 45 degrees of the lunar zenith.

The alpha-particle spectrometer is sun-sensitive. The sun-avoidance attitude envelope presented in Section 2.6 can be violated for the maximum exposure time defined in paragraph 3.3.3.4.1.1.

3.3.3.2.2 Orbital Geometry Constraints

The lunar orbit parameters are not constrained by the alpha-particle spectrometer.

3.3.3.3 Environment

3.3.3.3.1 Temperature Limitations

Temperature limits for operational telemetry thermal measurements are given in Table 3.3-1.

3.3.3.3.2 Temperature Control

Thermal control of the alpha-particle spectrometer is achieved by the following methods:

1. A passive thermal control coating with solar absorptivity (α) and emissivity (ϵ) properties has been applied to the nadir facing surface.
2. Passive thermal control superinsulation on the SIM facing surfaces with solar absorptivity (α) and emissivity (ϵ) properties, has been provided on the SIM bay facing surfaces.
3. The spectrometer is thermally isolated from the SIM structure.
4. The spectrometer is passively biased to the cold side of the thermal operating range.

3.3.3.3.3 Humidity Limitation

The maximum allowable relative humidity (RH) for the alpha-particle spectrometer is 60 percent.

3.3.3.3.4 Nuclear Radiation Limitation

An integrated particle dosage of 10^9 particles/cm² will cause degradation to the data from this experiment.

3.3.3.3.5 External Contaminant Limitations

The X-ray/alpha particle spectrometer protective cover must be closed for effluent dumps (urine, waste water, fuel-cell purges, etc.) and when SM-RCS jets A2, A4, B1 and B4 are activated. The protective cover should remain closed for at least 15 minutes following an effluent dump, but the total closed time should be minimized for the maximum accumulation of data.

3.3.3.4 Crew Support Requirements

3.3.3.4.1 Pre-Experiment Operations

The instrument protective cover must be open while data are being accumulated.

If the possibility of the instrument reaching its low temperature limit appears imminent, the crew will be instructed to turn the instrument on.

3.3.3.4.1.1 Lunar Orbit. The instrument is to be operated for the maximum available time within CSM operational requirements. It is desirable that this experiment be operated concurrently with the gamma-ray and X-ray experiments (Sections 3.1 and 3.2).

CAUTION: Sun entering the instrument (ON or OFF) must be limited to a period of five continuous minutes and to a cumulative time not to exceed 30 minutes. If direct sunlight exposure is anticipated, it is desirable to close the protective cover. Refer to paragraph 2.6 for presentation of the sun-avoidance envelope.

Once each operating day, while on the dark side of the moon, the spectrometer must be calibrated by pointing the instrument at deep space for 15 minutes to obtain a background measurement. (See paragraph 3.3.3.2.1 for the instrument calibration look angle and pointing attitude.)

3.3.3.4.1.2 Transearch Coast. Restrictions for sun rays entering the instrument FOV are the same as for lunar orbit (see paragraph 3.3.3.4.1.1) until the galactic sightings have been completed.

3.3.3.4.2 Post-Experiment Operations

None required.

3.3.3.5 Interface Constraints

This experiment does not require concurrent operation of any other experiment, although concurrent operation with the gamma-ray spectrometer and the X-ray spectrometer is desirable. (Refer to the Interface Matrix, Section 2.2.)

OPTICAL BAR PANORAMIC CAMERA

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3.4 PANORAMIC CAMERA

(VI)

3.4 OPTICAL BAR PANORAMIC CAMERA

3.4.1 OBJECTIVES

The objective is to obtain high-resolution stereo photography of potential landing sites and exploration areas and provide selective detailed information to support selenodetic/cartographic goals of the lunar mapping program.

3.4.2 PHYSICAL CHARACTERISTICS

3.4.2.1 Functional and Physical Description

This instrument will photograph the lunar surface at high resolution (135 lines/mm) from an orbiting vehicle.

The optical bar panoramic camera (Figure 3.4-1) consists of four major assemblies: the roll frame assembly, which rotates continuously in the scan direction (cross track) during operation; the gimbal assembly, which tilts fore and aft for stereo coverage and forward motion compensation; the main frame; and the GN₂ pressure vessel assembly.

Optics, camera, and film characteristics are described as follows:

1. Optics

- a. Field-of-view: 10°42' (conical)
- b. Aperture: f/3.5
- c. Focal length: 24 inches
- d. Field-flattened, double-folded, Petzval configuration

2. Camera

- a. Panoramic (108 by 39 degree field-of-view envelope)
- b. Stereoscopic (25-degree convergence angle)
- c. Scanning focal plane, variable slit shutter
- d. Forward motion compensation
- e. Automatic exposure control

3. Film

- a. Type: EK 3414
- b. Capacity: 6500 feet (165 minutes of operation)
- c. Width: 5 inches
- d. Format: 4.5 by 45.0 inches

The nitrogen (GN₂) system is used by both the panoramic camera and the mapping camera subsystems (paragraph 3.7.2.1). The panoramic camera uses the GN₂ to provide a gas bearing for selected film rollers. Major requirements for the GN₂ system are identified as follows:

1. Pressure: 25 ± 3 psig to camera
2. Supply temperature: between zero and 100 F
3. Quantity: 6.0 pounds of GN₂ (panoramic camera)
4. Flow rate: 1.55 lb/hr in operate mode (panoramic camera)

3.4.2.2 Envelope Dimensions and Weight (Approximate Values)

The camera assembly envelope is 25 by 29 by 60 inches and weighs 323 pounds (including film and cassette). The 72-pound film cassette is 19 inches in diameter by 7 inches wide. The GN₂ pressure vessel is a 12-inch-diameter sphere weighing 45 pounds (including gas).

3.4.2.3 Installation in SIM

The panoramic camera is mounted on rails that are attached to shelves in the SIM located at X_s = 299.50 and 236.50, with the centerline of the camera displaced 8.25 inches from the centerline of the SIM toward the positive Y coordinate. The optical axis (at center of format) is parallel to the SIM centerline, which provides a nominal CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees. (Refer to paragraph 2.5.3 for alignment accuracies.)

3.4.2.4 Deployment Characteristics

Not applicable.

3.4.3 PERFORMANCE AND OPERATIONAL DATA

3.4.3.1 Electrical Power

3.4.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts

2. Ac voltage = 115 ± 5 vac
3. Ac frequency = 400 ± 3 Hz, three phase

3.4.3.1.2 Power Requirements

The power requirements for the panoramic camera are presented in Table 3.4-1. A power profile for camera operation (watts versus time) at 28 vdc is presented in Figure 3.4-(TBS).

3.4.3.1.3 Batteries

No batteries are required for the panoramic camera experiment.

3.4.3.2 Attitude and Orbital Geometry

3.4.3.2.1 Attitude Constraints

The panoramic camera is a directional sensitive instrument, requiring the CSM positive X-axis to be in the direction of the velocity vector during camera operation.

The panoramic camera is sun-sensitive. (Refer to Section 2.6 for the sun-avoidance CSM look-angle attitude constraints for the operating and nonoperating modes.)

3.4.3.2.2 Orbital Geometry Constraints

The nominal mean lunar orbit altitude for which the V/h sensor electronics backup command signal is set is 60 nautical miles. The operating altitude capability of the camera (including an operational V/h system) is between 45 and 80 nautical miles to achieve specification quality photography. To assure the highest quality photography if the V/h signal is lost, the V/h electronics must be adjusted before launch if the planned mean lunar orbit altitude deviates from 60 nautical miles by more than 0.5 nautical mile.

3.4.3.3 Environment

3.4.3.3.1 Temperature Limitations

3.4.3.3.1.1 Nonoperating Conditions. The maximum allowable temperature range for the panoramic camera during nonoperating conditions is 10 to 120 F. A nonoperating condition refers to any period of the mission when the camera switches are in the OFF position. The maximum allowable temperature range for film cycling is 40 to 120 F. Film cycling period refers to the camera TEST mode only.

3.4.3.3.1.2 Operating Conditions. The temperature set point of the camera and lens assembly for specification level photography at the start of and during operating periods is 88 +2 F. For optimum resolution, the temperature of the camera and lens assembly should not be outside the limits of 85 to 96 F. Outside this range, photography will be degraded due to thermal gradients through the lens.

3.4.3.3.1.3 Film Temperature Limitations. Survival of the film (Eastman-Kodak series 3414 or equivalent), to the extent that satisfactory processing can be achieved after return to earth, is dependent upon the length of time that the film and film cassette are exposed to temperatures in excess of 90 F. The length of time for which the film can be exposed to a temperature of 90 F is 1000 hours (41.7 days). The maximum allowable temperature to which the film can be exposed is 125 F, and the maximum allowable duration of exposure at that temperature is 7.8 hours. The maximum allowable cumulative exposure to temperatures in excess of 90 F can be obtained from the following expression:

$$\text{Time at temperature} = \int_{t_0}^{t_r} 2^{(0.2)(T-90)} dt \leq 1000 \text{ hours}$$

where:

T = film temperature

t₀ = time corresponding to the start of the period when the temperature (T) exceeds 90 F.

t_r = time corresponding to the end of the period when the temperature (T) exceeds 90 F.

3.4.3.3.1.4 EVA Activity - Film Cassette Conditions. During retrieval from the SIM, direct exposure of the film cassette to any degree of solar radiation or deep-space sink temperature for a period of time equal to, or greater than, 40 minutes must be avoided.

7/26/71

3.4.3.3.2 Temperature Control

Thermal control of the panoramic camera is achieved by the following methods:

1. Passive thermal control coatings with solar absorptivity (α) and emissivity (ϵ) properties have been applied to the nadir facing surfaces defined in Figure 3.4-2.
2. A passive thermal control superinsulation with solar absorptivity (α) and emissivity (ϵ) properties has been provided on the SIM bay facing surfaces defined in Figure 3.4-2.
3. The camera is thermally isolated from the SIM structure.
4. Heaters are thermostatically controlled to turn on at 85.5 F and turn off at 86.5 F when the camera is in HEATER or OPERATE mode.
5. The camera is passively biased to the cold side of the thermal operating range.
6. The camera lens temperature is actively controlled by utilizing heaters for raising the temperature and an automatic lens stow control for lowering or raising the temperature. The lens stow logic will command the lens to stow down (pointed outboard) only when the lens temperature is greater than 93 F and the outside thermal control surface is less than 90 F. The POWER switch must be in the ON position and the MODE switch must be in the STBY position to permit lens stow.

3.4.3.3.2.1 Pan Camera Sun Avoidance Constraints (Lens Stowed Inboard).*

The jettisoning of the SIM bay door prior to lunar orbit requires definition of the solar constraints for the pan camera closeout panel and lens barrel such that the inner mylar insulation is maintained below 250°F.

The pan camera solar avoidance envelope that was determined maintains the inner mylar temperature below 250°F. This envelope is defined in Figure 3.4-3. With the spacecraft sun angle θ between 60° and 150°, the spacecraft must pass through the envelope within a 13-minute period (equivalent to 1.5 rph) to maintain the mylar insulation temperature below 250°F.

3.4.3.3.3 Humidity Limitation

There are no significant humidity limitations for the panoramic camera. The relative humidity (RH) to which the film cassette can be exposed is 60 percent maximum.

*NASA Data Source

3.4.3.3.4 Nuclear Radiation Limitation

There are no significant nuclear radiation exposure limitations related to the panoramic camera or the film cassette.

3.4.3.3.5 External Contaminant Limitation

Panoramic camera performance will be degraded by the presence of external contaminants, either on the camera lens or in the camera field-of-view. Significant contaminant sources are urine, waste water dumps and SM RCS by-products. All scheduled contaminant emissions must be restricted to times other than from three hours before to immediately after panoramic camera operations. The camera lens should be stowed-in during maximum contamination activity to prevent lens contamination.

3.4.3.4 Crew Support Requirements

3.4.3.4.1 Pre-Experiment Operations

Since thermal stabilization is variable and dependent upon the SIM thermal environment, a warmup period is required for the camera to stabilize at the specification operating temperature (see paragraph 3.4.3.3.1.2).
* SIM bay temperature levels greater than or less than expected require real-time determination of allowable pan camera warmup period. Final warmup of the pan camera, if required, will be accomplished after SIM door jettison (see Figure 3.4-6 for required warmup periods).

The camera must be cycled (momentary test switch) once every 24 ± 6 hours following flight film loading to prevent film set (five frames advanced automatically; no warmup required). Loading and cycling consumes 350 feet of film.

3.4.3.4.2 Experiment Operations

3.4.3.4.2.1 Lunar Orbit. Deployed instruments that present objectionable obstructions to the field-of-view must be retracted before camera operation (see paragraph 3.4.3.5). The crew will monitor the camera talk-back indicator for camera status (if barber-pole remains, camera is NO-GO). The camera is direction-, attitude-, and sun-sensitive (refer to paragraph 3.4.3.2.1 for the attitude constraints). Cycling of the camera must be accomplished once each 24 ± 6 hours to prevent film set during nonoperational periods.

The pan camera should not be operated for longer than 30 minutes on any one data pass to prevent dc motor brush overheating.

During camera passes, the CSM attitude must be maintained in accordance with the limitations identified in paragraph 3.4.3.2.1.

Limitations on effluent dumps must be observed in accordance with the constraints identified in paragraph 3.4.3.3.5.

3.4.3.4.2.1.1 V/h Sensor Nominal Select. The V/h override switch allows for an active V/h sensor operation when in the center position. In the event of sensor malfunction, the V/h sensor may be overridden by selecting one of two nominal V/h rates. One position is identified as "HI ALT" and the other position is identified as "LO ALT".

The "LO ALT" setting sets a fixed V/h rate into the camera logic centered at 15.13 milliradians per second (55 n mi altitude) and overrides any input from the V/h sensor. At this setting, the camera may be operated at altitudes ranging from 53.4 to 57 n mi with no degradation to photography (See Figure 3.4-5). However, this setting may be used over the range of 49 to 65 n mi with up to 2-meter degradation in GRD (ground resolved distance) outside the limits previously specified.

The "HI ALT" setting also overrides the V/h sensor and sets a fixed V/h rate into the camera of 13.76 milliradians per second (60 n mi) at this setting, the camera may be operated at altitudes ranging from 57 to 64 n mi with no degradation to photography (See Figure 3.4-5). This setting may also be used over the range of 55 to 75 n mi with degradation up to 2-meters GRD outside the 57 to 64 n mi range.

3.4.3.4.2.2 Transearch Coast. An astronaut will retrieve the film cassette via EVA.

3.4.3.4.3 Post-Experiment Operations

Following EVA retrieval, the film cassette will be stowed in the CM for return to earth.

3.4.3.5 Constraints

3.4.3.5.1 Interface Constraints

If the gamma-ray and mass spectrometer booms are not retracted during pan camera operations, the interference in the camera FOV will be as shown in Figure 3.4-4.

This experiment does not require concurrent performance of any other experiment. However, it is desirable that the mapping camera (Section 3.7) be operated during panoramic camera operation. (Refer to the Experiments Interface Matrix, Section 2.2.)

3.4.3.5.2 Operational Constraints

Limits for telemetry measurements are given in Table 3.4-4.

Table 3.4-1. Panoramic Camera Power Matrix
(See Paragraph 3.4.3.1.2)

SM/AC		Power			Mode		Function			DC Power (watts)		AC Power (watts)	
Off	On	On	Off	Boost	Operate	Standby	Test	Off	Heaters	Average	Peak	Average	Peak
**	X		X		X			X		0	0	12.5	12.5
**	X		X			X		X		0	0	12.5	12.5
X			X			X		X		0	0	0	0
X				X		X		X		20.0	20.0	0	0
	X			X		X			X	101.3	182.5	12.5	12.5
	X	X				X	X			194.0	260.0	82.0	82.0
	X		X			X			X	81.3	162.5	12.5	12.5
	X	X			X			X		194.0	260.0	82.0	82.0
										234.0	341.3*	82.0	82.0
	X	X				X		X		80.0	80.0	33.0	33.0
	X	X				X			X	161.3	242.5	45.5	45.5

*Worst case

NOTE:

1. Ac power was calculated by using a 0.75 power factor.

**2. This condition exists when the laser altimeter/mapping camera is on and the pan camera is off.

3.4-8

SNA-8-D-027 (VI)

Amendment 15
7/16/71

3.4-9

SNA-8-D-027(VI)

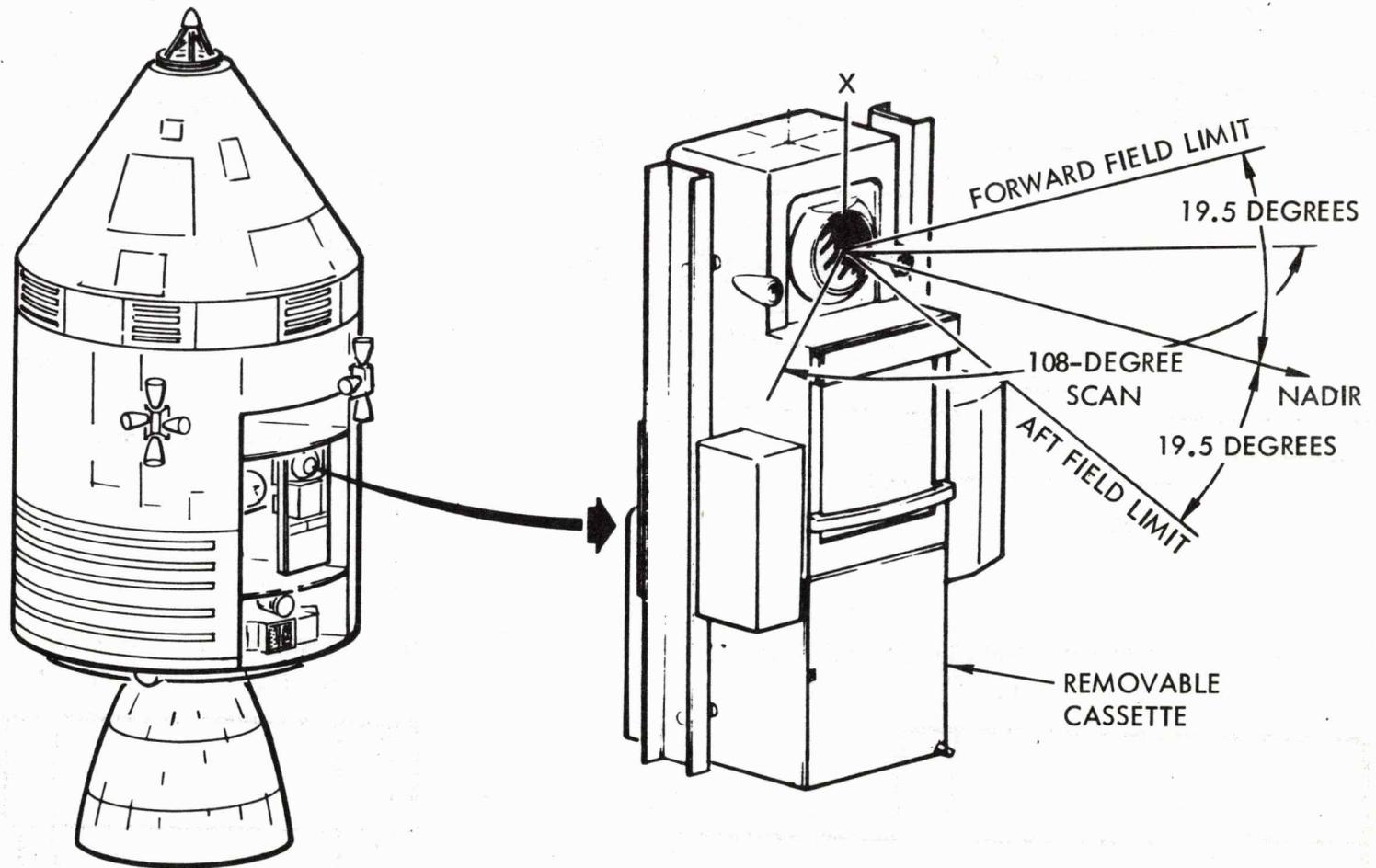
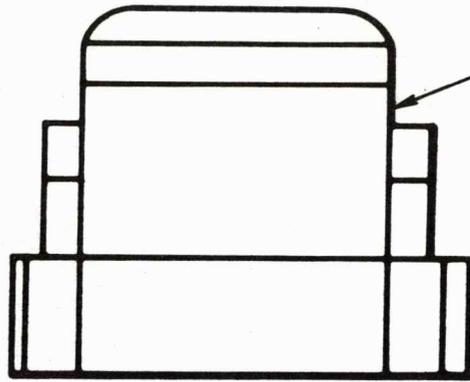
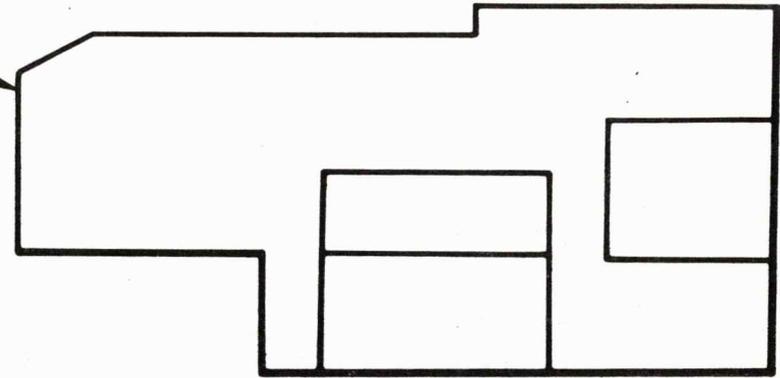


Figure 3.4-1. Optical Bar Panoramic Camera

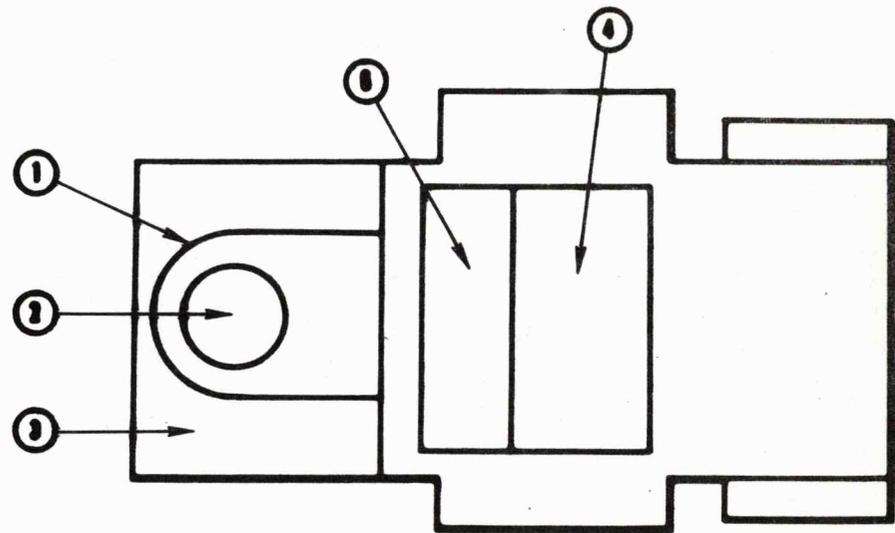


SIM FACING SIDE OF CAMERA
VIEW LOOKING AFT ALONG -X AXIS



SIM FACING SIDE OF CAMERA
VIEW IN Y-Z PLANE, PARALLEL TO X AXIS

- ① LENS THERMAL SHIELD
- ② LENS 1
- ③ THERMAL BAFFLES
- ④ THERMAL CONTROL SURFACE
- ⑤ SIM-FACING SUPERINSULATION
- ⑥ HEAT-SINK PLATE

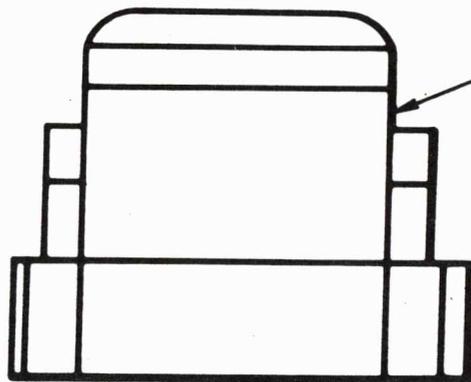


NADIR FACING SIDE OF CAMERA
VIEW LOOKING FORWARD ALONG +X AXIS

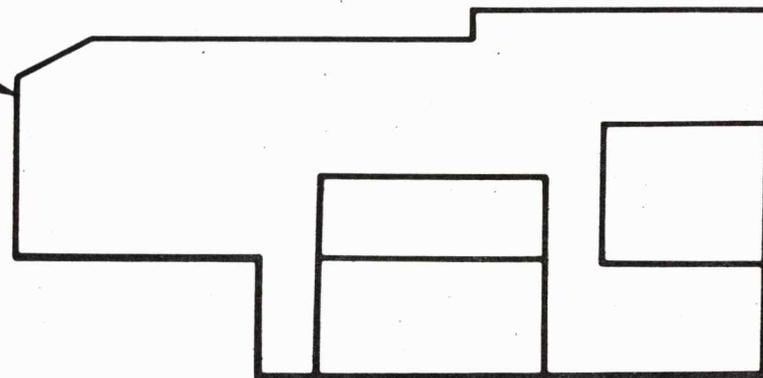
Figure 3.4-2. Panoramic Camera Thermal Surfaces

3.4-10

SNA-8-D-027(VI)

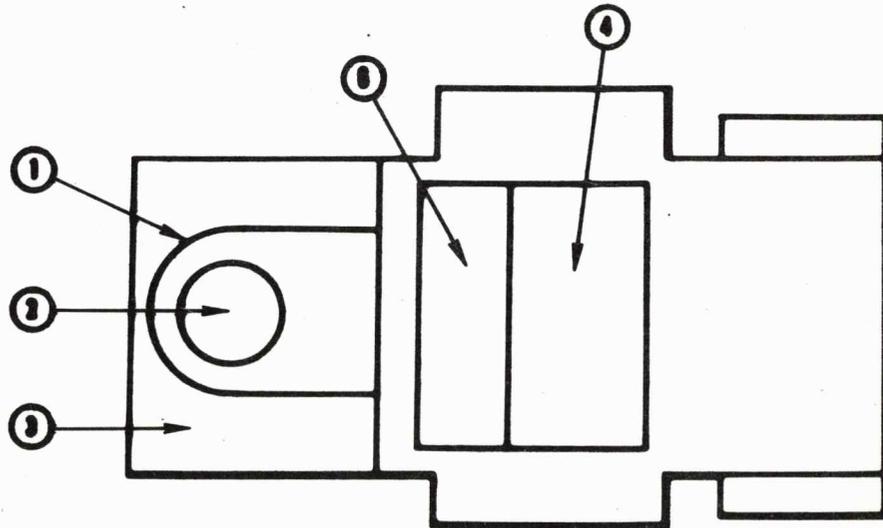


SIM FACING SIDE OF CAMERA
VIEW LOOKING AFT ALONG -X AXIS



SIM FACING SIDE OF CAMERA
VIEW IN Y-Z PLANE, PARALLEL TO X AXIS

- ① LENS THERMAL SHIELD
- ② LENS 1
- ③ THERMAL BAFFLES
- ④ THERMAL CONTROL SURFACE
- ⑤ SIM-FACING SUPERINSULATION
- ⑥ HEAT-SINK PLATE



NADIR FACING SIDE OF CAMERA
VIEW LOOKING FORWARD ALONG +X AXIS

3.4-11

SNA-8-D-027(VI)

Figure 3.4-2. Panoramic Camera Thermal Surfaces

3.4-14

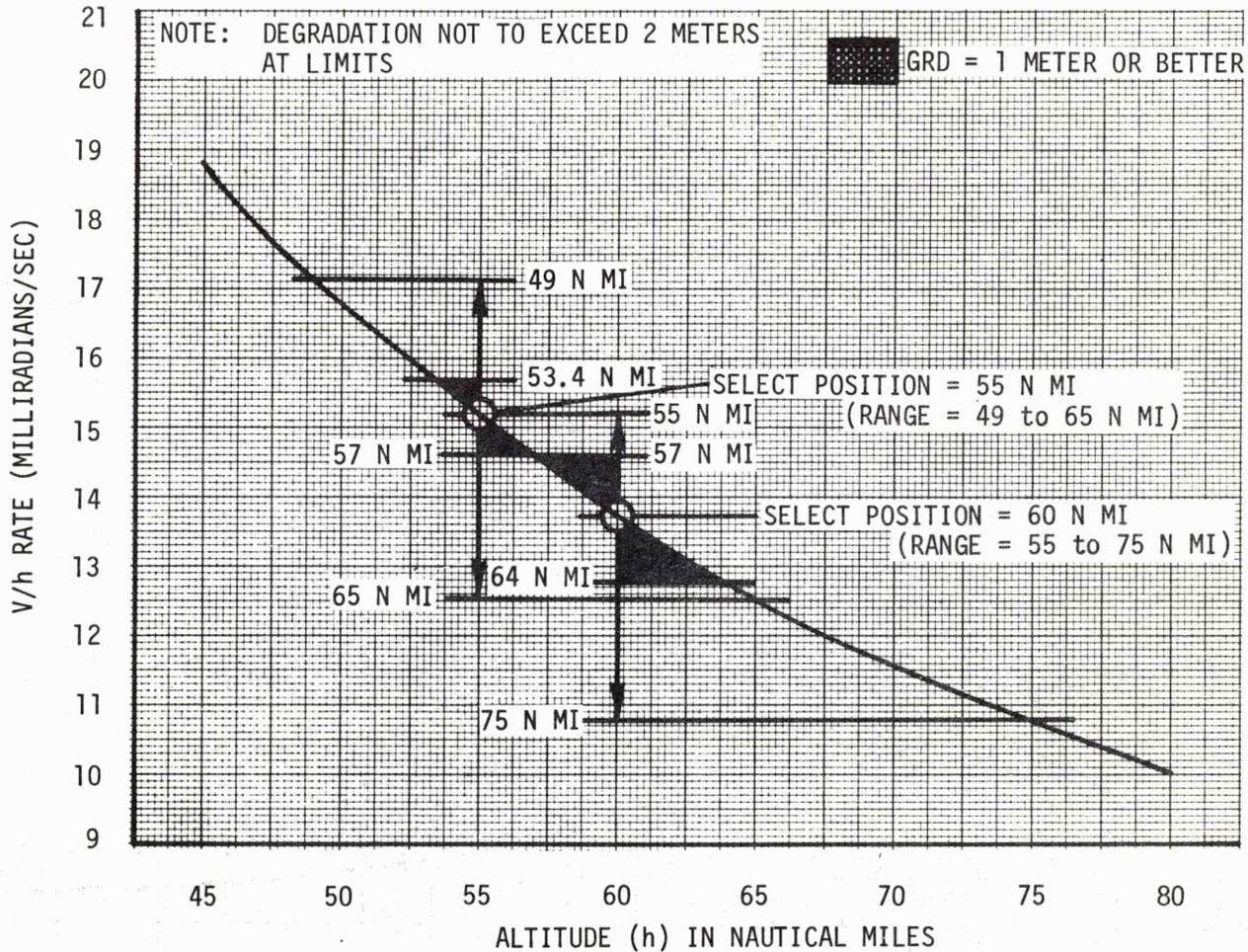


Figure 3.4-5. V/h Sensor Nominal Select (Override) for Elliptical Orbit, 49 to 75 Nautical Miles (Or Near Circular of 53.4 x 64 N MI) (See Paragraph 3.4.3.4.2.1.1)

(NASA DATA SOURCE)

NOTE: SIM BAY DOOR OFF

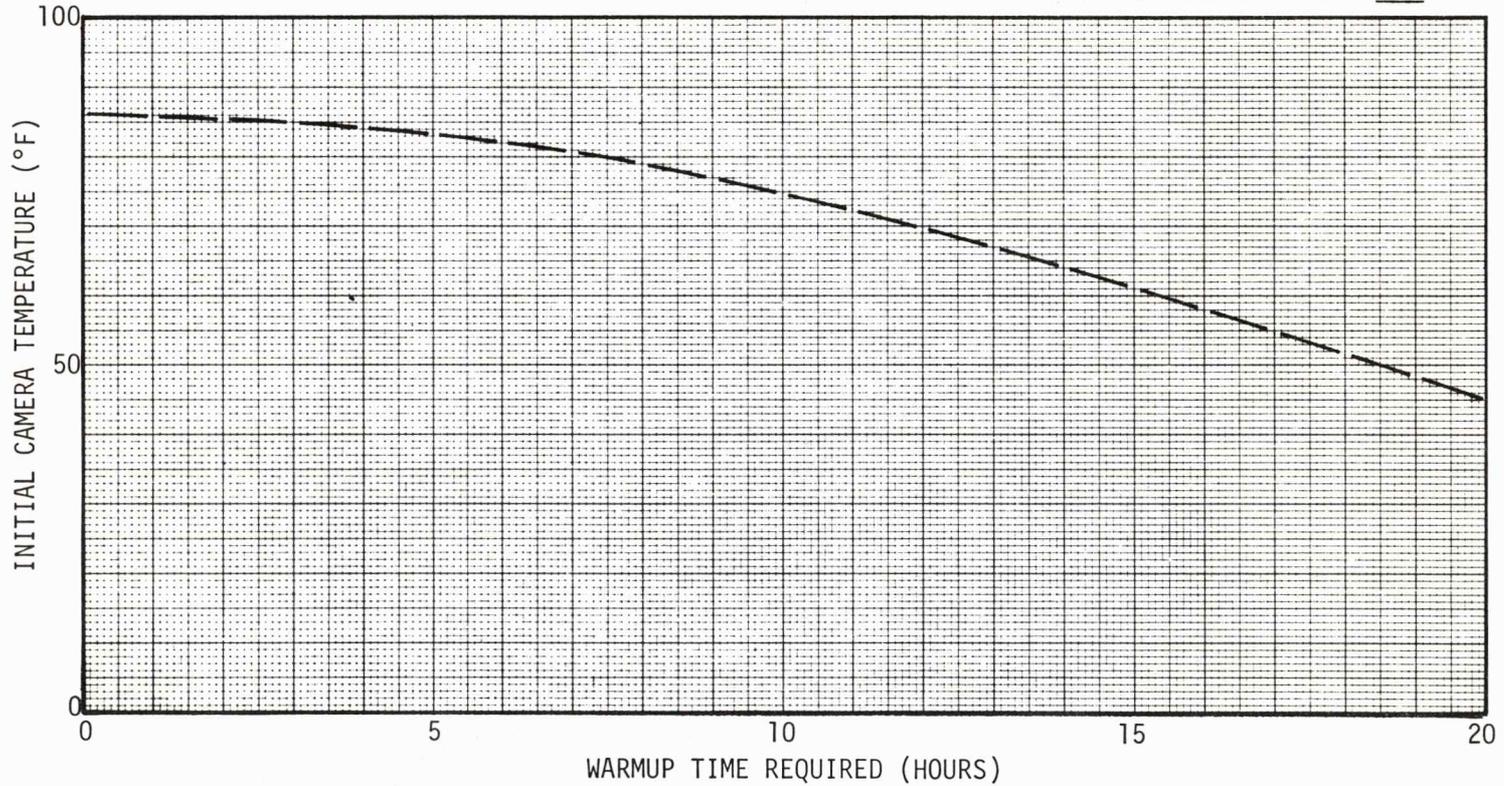


Figure 3.4-6. Panoramic Camera Warmup Requirement
(Time for Center Lens Element to Reach 88 ± 2 F)
(See Para. 3.4.3.4.1)

3.4-15

SNA-8-D-027 (VI)

Amendment 18
7/26/71

S-BAND TRANSPONDER (S164)*

Experiment is to track the CSM in lunar orbit by
measurements during periods of relative CSM
for an enhanced lunar gravity field

uses that will be used to
model for lunar structure

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3.5 S-BAND TRANSPONDER (S164)*

3.5.1 OBJECTIVES

The objective of this experiment is to track the CSM in lunar orbit by means of S-band Doppler measurements during periods of relative CSM quiescence and then reduce the data for an enhanced lunar gravity field determination.

3.5.2 PHYSICAL CHARACTERISTICS

3.5.2.1 Functional and Physical Description

The experiment will provide data for analyses that will be used to define a lunar mass model and provide a basic model for lunar structure and origin studies.

Existing CSM S-band equipment (Volume I, Part 1, Section 4.7, of the Data Book) is used to obtain measurement data.

3.5.2.2 Envelope Dimensions and Weight

Existing CSM equipment is used. No additional requirements are necessary.

3.5.2.3 Installation in SIM

Not applicable.

3.5.2.4 Deployment Mechanism

Not applicable.

3.5.3 PERFORMANCE AND OPERATION DATA

3.5.3.1 Electrical Power

Existing CSM equipment is used. No additional requirements are necessary.

*This subsection covers the CSM-related portion of the S-band transponder experiment only. See Section 3.9 for the subsatellite-related portion of this experiment. The LM-related portion is not included in this volume.

3.5.3.2 Attitude and Orbital Geometry

3.5.3.2.1 Attitude Constraints

During lunar orbit operation while scheduled S-band Doppler measurements are being taken, the CSM attitude is confined to an inertial attitude hold, which minimizes motion of the high-gain antenna relative to MSFN tracking station on earth.

For this experiment, there are no SIM pointing accuracy or pointing knowledge requirements.

The S-band transponder experiment is nonsensitive to direct sunlight and therefore imposes no sun-avoidance attitude constraints.

3.5.3.2.2 Orbital Geometry Constraints

The lunar orbital parameters are not constrained by the S-band transponder experiment.

3.5.3.3 Environment

Existing CSM equipment is used. No additional requirements are necessary.

3.5.3.4 Crew Support Requirements

3.5.3.4.1 Pre-Experiment Operation

None required.

3.5.3.4.2 Experiment Operations

The CSM operational attitude constraints are presented in paragraph 3.5.3.2. Attitude control during the data collection period is maintained by use of balanced SM RCS couples. All functions that cause CSM translation (water pump, purges, water boiler operation, etc.) must be inhibited.

3.5.3.4.3 Post-Experiment Operations

None required.

3.5.3.5 Interface Constraints

The CSM S-band transponder prime experiment phase occurs before SIM door jettison; therefore, no SIM experiment interface exists.

Table 3.5-1 Deleted

3.6 MASS SPECTROMETER

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spectrometer and the gamma-ray
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nted 31.5 degrees from the SIM centerline
he boom deploys along a nominal look angle
.25 degrees. The instrument is mounted on
t plenum is on the side away from the spacecraft
Figure 3.6-1. Refer to paragraph 2.5.3 for

3.6 MASS SPECTROMETER (S165)

3.6.1 OBJECTIVES

The objective is to obtain data on the composition of the lunar ambient atmosphere (classic exosphere) and the distribution of gases in the atmosphere.

3.6.2 PHYSICAL CHARACTERISTICS

3.6.2.1 Functional and Physical Description

The instrument will collect data regarding the lunar atmosphere to aid in the understanding of the atmospheric origin and the transport properties of planetary exospheres. The range of interest for mass is in the 12- to 28-AMU and 28- to 66-AMU regions.

The spectrometer is mounted on an extendable/retractable/jettisonable boom such that the inlet plenum is on the side away from the CSM and facing aft. The instrument is a magnetic sector-field mass spectrometer with a Nier type of thermionic electron bombardment ion source. The instrument field-of-view is a 2π solid angle hemisphere with respect to a plane through the inlet plenum face.

3.6.2.2 Envelope Dimensions and Weight (Approximate Values)

The boom-mounted spectrometer is 9 by 12 by 12 inches and weighs a maximum of 25 pounds. The deployment mechanism (including the jettison mechanism) is 13 by 17 by 33 inches and weighs 90 pounds. The boom will place the instrument 24 feet from the SM mold line when fully deployed to obtain an unobstructed FOV between the mass spectrometer and the gamma-ray spectrometer (also boom deployed). The spectrometer is illustrated in Figure 3.6-1.

3.6.2.3 Installation in SIM

The boom deployment mechanism is attached to the aft side of the SIM shelf located at $X_s = 236.50$, canted 31.5 degrees from the SIM centerline toward the positive Y-axis. The boom deploys along a nominal look angle of $\theta = 90$ degrees and $\phi = 69.25$ degrees. The instrument is mounted on the boom such that the inlet plenum is on the side away from the spacecraft and facing aft as shown in Figure 3.6-1. Refer to paragraph 2.5.3 for alignment accuracies.

3.6.2.4 Deployment Characteristics

At various times during the operation period, the spectrometer may require full or partial retraction to remove it from camera field-of-view. Boom position monitoring capability is supplied to the extent of full deployment, retraction, or jettison only, and partial retraction will necessitate timing by the crew. The deployment/retraction rate is 2 ± 1 inches per second. The boom deployment/retraction mechanism is capable of 150 deployment/retraction cycles. The spectrometer nominal look angle is not changed for any boom deployment/retraction position.

3.6.2.5 Boom Jettison

Should the jettison of the mass spectrometer be required, 76 pounds of material would be jettisoned at 8 feet per second in a direction of $\theta = 90^\circ$ and $\phi = 69.25^\circ$ with respect to spacecraft coordinates.

3.6.3 PERFORMANCE AND OPERATIONAL DATA

3.6.3.1 Electrical Power

3.6.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required

3.6.3.1.2 Power Requirements

The power requirements for the mass spectrometer are as follows:

Subsystem	Power (watts)	Maximum Power (watts)
Electronics and heater		
STANDBY	15 (maximum)	
OPERATE	15 (nominal)	20
Boom motor	TBS	TBS
Jettison A and B*	180 (nominal)	200
Boom release*	180 (nominal)	200

*30- to 150-msec duration

3.6.3.1.3 Batteries

No batteries are required for the mass spectrometer experiment.

3.6.3.2 Attitude and Orbital Geometry

3.6.3.2.1 Attitude Constraints

The mass spectrometer is a directional sensitive instrument. During lunar orbit, normal mass spectrometer data collections must be performed with the CSM negative X-axis in the direction of the velocity vector. During background contamination data collection in lunar orbit, the instrument must be operated with the CSM positive X-axis in the direction of the velocity vector. In TEC, background contamination data collection can be performed with the CSM in any orientation, including PTC.

The mass spectrometer is nonsensitive to the sun and therefore imposes no sun-avoidance attitude constraints.

3.6.3.2.2 Orbital Geometry Constraints

The desired nominal lunar orbital altitude is 60 nautical miles.

3.6.3.3 Environment

3.6.3.3.1 Temperature Limitations

3.6.3.3.1.1 Nonoperating Conditions. The allowable temperature range for the mass spectrometer during nonoperating conditions is -60 to +180 F for the electronics section and -80 to +180 F for the analyzer section. A nonoperating condition refers to any period of the mission when both the spectrometer and the ion source are in OFF or STANDBY mode.

The retracted instrument is capable of withstanding the convective heating resulting from a 20-second, continuous, simultaneous firing of SM RCS jets A4 and B4 with the SIM door jettisoned.

3.6.3.3.1.2 Operating Conditions. The allowable temperature range for the mass spectrometer during operating conditions is -20 to +160 F for the electronics section and -65 to +160 F for the analyzer section. An operating condition refers to any period of the mission when both the spectrometer and the ion source are ON.

3.6.3.3.2 Temperature Control

Thermal control of the mass spectrometer and the ion source is achieved by the following methods:

1. A passive thermal control coating with solar absorptivity (α) and emissivity (ϵ) properties has been applied to the instrument surfaces.
2. The spectrometer is thermally isolated from the deployment boom.
3. The instrument electronic heater is thermostatically controlled to turn on at 32 F and turn off at 43 F when the spectrometer is in the STANDBY or ON mode.
4. The spectrometer is passively biased to the cold side of the thermal operating range.

3.6.3.3.3 Humidity Limitation

The relative humidity (RH) limitation to which the mass spectrometer can be exposed is 60-percent maximum.

3.6.3.3.4 Nuclear Radiation Limitation

There are no significant nuclear radiation exposure limitations related to the mass spectrometer.

3.6.3.3.5 External Contaminant Limitations

The following contaminant restrictions during the lunar orbit and transearth coast mission phases must be observed.

3.6.3.3.5.1 Lunar Orbit.

3.6.3.3.5.1.1 Ion Source Heater.* Nominally, effluent dumps (urine, waste water, fuel cell purges, etc.) must be inhibited one hour before and one hour after ion source heater operation. In an off-nominal situation, if a dump is required during the heater operation period, the heater must be turned off 15 minutes before the dump and left off for one hour after completion of the dump. The instrument must remain in a fully deployed position during the heater-off time.

*NASA Data Source

3.6.3.3.5.1.2 Mass Spectrometer. Optimum instrument operation requires that no effluent dumps occur during or within five hours immediately preceding, nor within five minutes immediately following, any mass spectrometer data collection period.

Minimum acceptable instrument operation requires that no effluent dump occur during or within two hours immediately preceding, nor within five minutes immediately following, any spectrometer data collection period.

In addition to inhibiting SM RCS jets A2, A4, B1, and B4, (see Volume I, Part 1, of the Data Book), jets C1 and C3 must always be inhibited when the spectrometer is not in the fully retracted position to prevent jet plume impingement upon the spectrometer.

3.6.3.3.5.2 Transearch Coast. The lunar orbit limitations (paragraph 3.6.3.3.5.1) also apply to this mission phase.

3.6.3.4 Crew Support Requirements

3.6.3.4.1 Pre-Experiment Operations (Ion Source Heater)

During the pre-experiment operations, the CSM effluent dumps and propulsion system operation must be limited in accordance with paragraph 3.6.3.3.5 and the operational constraints in the following subsections. There are no known CSM attitude limitations during this mission phase.

3.6.3.4.1.1 Lunar Orbit. Prior to the initial data collection period, the ion source heaters must be operated with the instrument fully deployed for a minimum cumulative time of six hours. If ion source heater operation is interrupted, as for a boom retraction or an effluent dump, 30 minutes of heater operation must be added to the six hour cumulative time for each interruption. One hour minimum of continuous heater operation is required immediately preceding the initial data collection period.

Prior to each subsequent data collection period, the ion source heaters must be operated for 30 minutes continuous with the instrument in the fully deployed position.

3.6.3.4.1.2 Transearch Coast. Operation of the instrument during TEC requires ion source heater operation for three hours (cumulative) before data collection, with the instrument in a half to fully deployed position, as limited by other mission constraints. If a boom retraction or an effluent dump is necessary during heater operation, 30 minutes of heater operation must be added to the three-hour cumulative time for each required boom retraction or effluent dump. A minimum of one hour of continuous heater operation is required immediately before the TEC data collection.

3.6.3.4.2 Experiment Operations

Crew support must be provided for operation of the CM control switches during (1) the first hour and the final hour of each data collection period in which the negative X-axis is in the direction of the velocity vector, (2) the entire data collection time in which the positive X-axis is in the direction of the velocity vector, (3) all periods of ion source heater operation, and (4) the entire TEC data collection interval. Additional support may be required as identified in the following subparagraphs.

During these data collection periods, the CSM attitude must be maintained in accordance with the limitations identified in paragraph 3.6.3.2.1.

Limitations on CSM effluent dumps and propulsion system operation during data collection periods must be constrained in accordance with the constraints identified in paragraph 3.6.3.3.5.

3.6.3.4.2.1 Lunar Orbit. Optimum operation will consist of data collection during the entire time that the negative X-axis is in the direction of the velocity vector.

Discriminator/multiplier settings during spectrometer operation will be on an as-required basis upon direction from MSFN.

A minimum background contamination data collection period consisting of one revolution is required near the end of the experiment phase, but it must not compromise the attainment of the primary data collection objective. The attitude required for the background contamination data collection period is defined in paragraph 3.6.3.2.1.

3.6.3.4.2.2 Transearth Coast. All other boom-deployed instruments must be in the same mechanical configuration as that during operation of the mass spectrometer in lunar orbit, within other mission constraints.

3.6.3.4.3 Post-Experiment Operations

None required.

3.6.3.5 Interface Constraints

During panoramic camera and/or mapping camera operation, the mass spectrometer boom must be retracted to the extent necessary to avoid interference in the optical field-of-view of either camera. The instrument must be fully retracted before any SPS maneuvers are performed. If the boom fails to retract, it must be jettisoned before SPS thrusting.

This experiment does not require concurrent operation of any other experiment. Refer to Interface Matrix, Section 2.2.

MASS SPECTROMETER

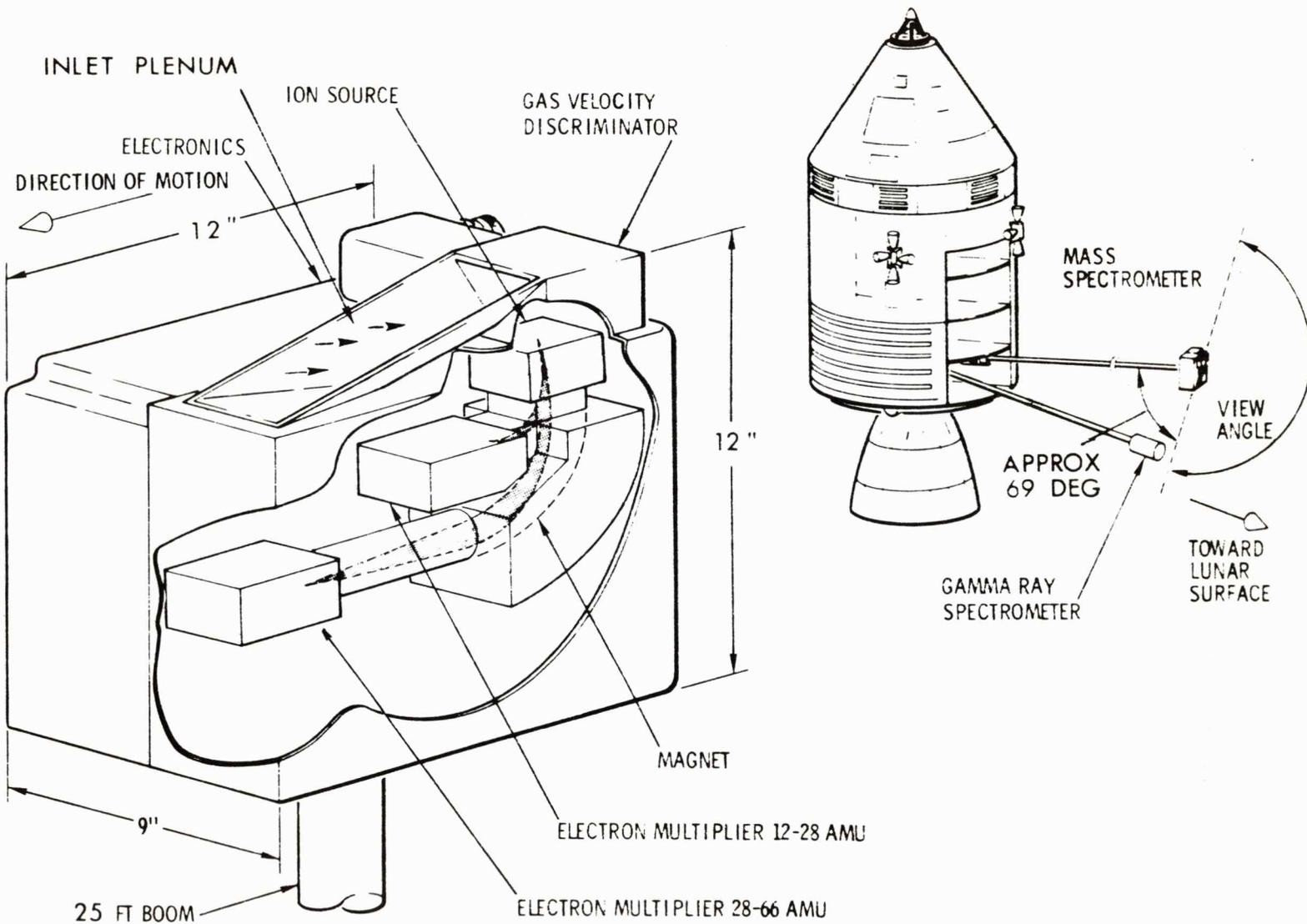


Figure 3.6-1. Mass Spectrometer (See Paragraph 3.6.2.2)

3.6-8

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3.6-9
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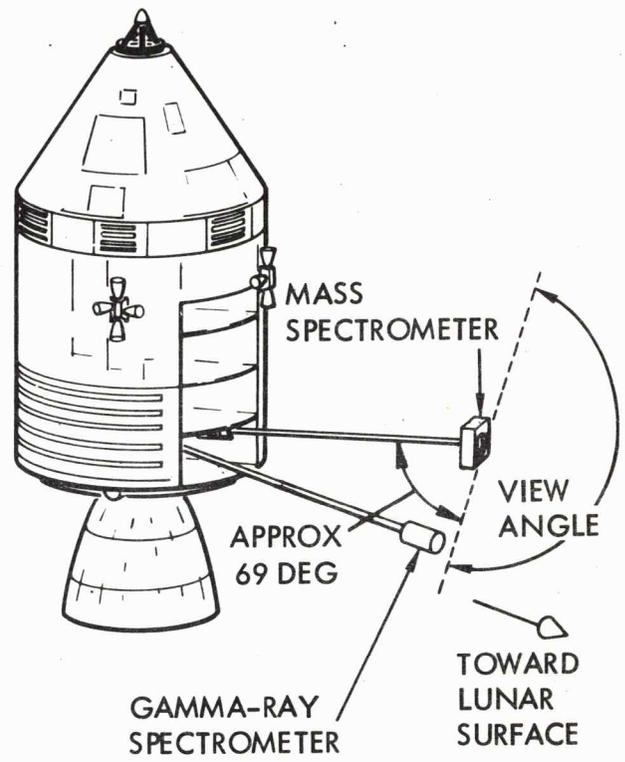
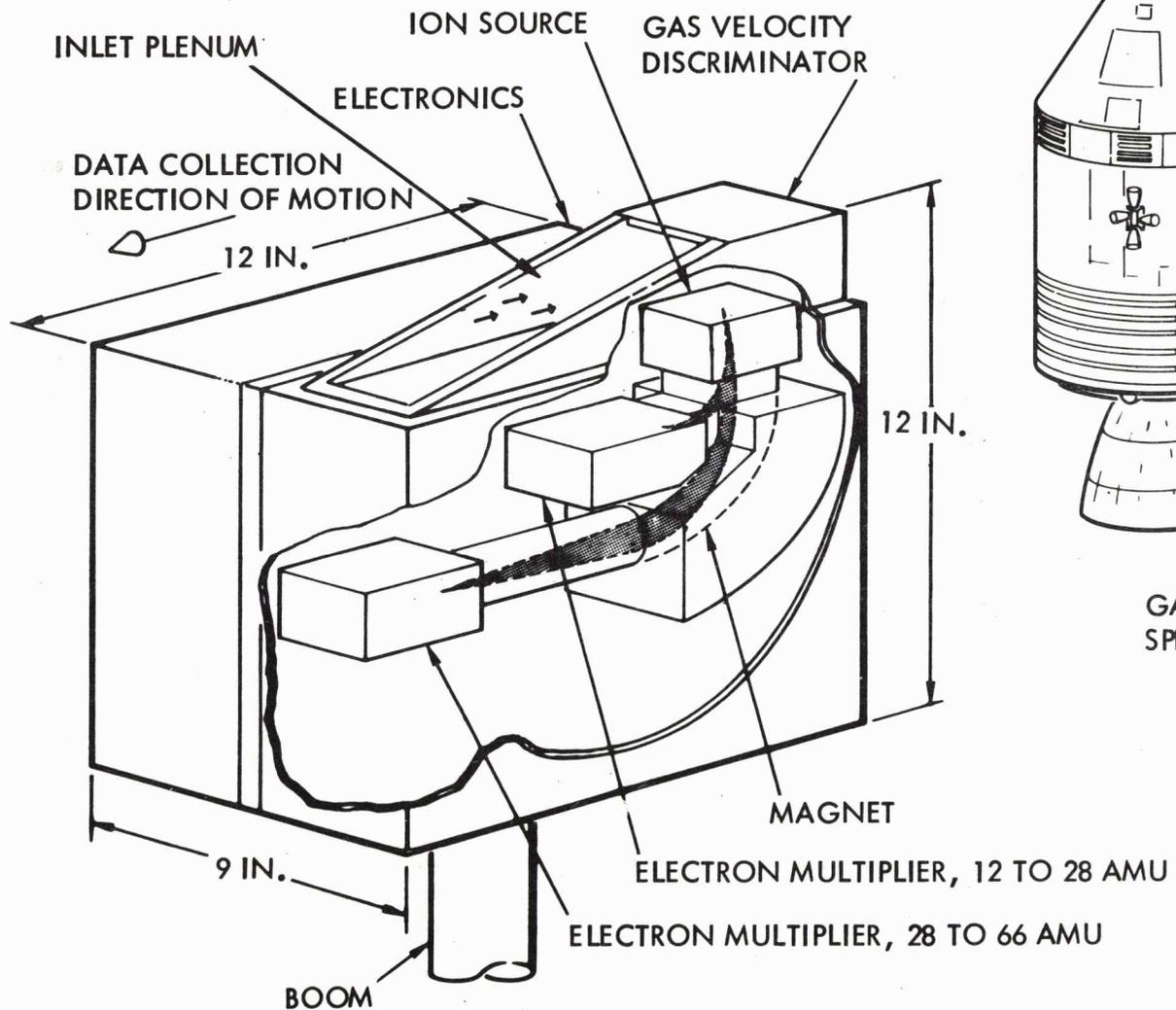


Figure 3.6-1. Mass Spectrometer

lunar

3.7 MAPPING CAMERA

3.7 MAPPING CAMERA

re

re recoverable

es at 62.5 feet of
(based on 60-nm orbit)

forward overlap
= 60 minutes

X 3401
: 510 feet

3.7 THREE-INCH LUNAR MAPPING CAMERA

3.7.1 OBJECTIVES

The objective is to obtain high-quality metric photographs of the lunar surface from lunar orbit combined with time-correlated stellar photography for selenodetic/cartographic control.

3.7.2 PHYSICAL CHARACTERISTICS

3.7.2.1 Functional and Physical Description

The mapping camera experiment will provide a selenodetic network which can only be achieved through the use of photogrammetry. The mapping camera will provide the lunar-surface photography; the stellar camera will furnish the necessary attitude information; and the laser altimeter (Section 3.8) will provide the range data necessary for altitude determination.

The mapping camera subsystem is composed of two optical instruments: a mapping camera and a stellar camera. The two cameras are manufactured and assembled with the required optical axis relationship to provide the necessary attitude correlation. The laser altimeter (Section 3.8) is hard-mounted to the mapping camera subsystem (see Figure 3.7-1) and pre-aligned parallel to the mapping camera optical axis with the required accuracy.

The optical characteristics of the mapping camera subsystem are presented in Table 3.7-1.

The exposed film for both cameras is contained in a single recoverable record container. The film characteristics are as follows:

1. Mapping Camera

Type: EK 3400

Length: 1500 feet

Width: 5 inches

Format: 4.5 by 4.5 inches

*Capability: 24 daylight passes at 62.5 feet of
film/pass** (based on 60-nm orbit)

*Based on 78-percent forward overlap

**One daylight pass = 60 minutes

2. Stellar Camera

Type: EK 3401

Length: 510 feet

Width: 35 mm

Format: 1.25-inch diameter with 0.96-inch flats.

***Capability: 24 passes at 21.25 feet of film/pass†
(based on 60-nm orbit)

***Based on mapping camera specification

†One daylight pass = 60 minutes

The mapping camera subsystem requires a supply of gaseous nitrogen (GN₂) and will use the same pressure vessel assembly as the panoramic camera, as described in paragraph 3.4.2.1. The GN₂ provides an inert and pressurized atmosphere in the cameras to minimize potential static electrical corona discharge which could cause exposed areas on the film. The subsystem has a nominal requirement of 0.5 pound and uses the GN₂ at a rate of 0.02 pound per hour during mapping operations.

3.7.2.2 Envelope Dimensions and Weight (Approximate Values)

The mapping camera subsystem is 18 by 22 by 51 inches and weighs 280 pounds (maximum), including film, record container, laser altimeter, and deployment mechanism.

The record container is 11 inches in diameter (with protruding handle) by 9 inches in width (with protruding drive shafts) and weighs 23 pounds when it contains all of the exposed film.

3.7.2.3 Installation in SIM

The mapping camera subsystem is mounted on the forward side of the SIM shelf at $X_s = 299.50$ and is aligned to provide a nominal CSM look angle of the mapping camera optical axis of $\theta = 90$ degrees and $\phi = 37.75$ degrees. Refer to paragraph 2.5.3 for the alignment accuracies.

3.7.2.4 Deployment Characteristics

The mapping camera subsystem and laser altimeter equipment are deployed at an angle of 30 degrees with the SIM centerline in a manner which maintains a parallel relationship between the mapping camera optical axis and the SIM centerline and provides a nominal CSM look angle of $\theta = 90$ degrees and $\phi = 37.75$ degrees. Deployment provides the stellar lens with a clear view of the star field (clear of both lunar horizon and SM mold line). Deployment can be accomplished in four minutes maximum. In the event camera deployment cannot be accomplished, after the lens cover door is opened, photographs may be taken and the laser altimeter may be operated; no stellar camera data will be obtained. When operated in the non-deployed position, camera and laser temperatures must be monitored to insure maximum operating temperature limits are not exceeded.

3.7.3 PERFORMANCE AND OPERATIONAL DATA

3.7.3.1 Electrical Power

3.7.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required.

3.7.3.1.2 Power Requirements

The power requirements for the mapping camera subsystem are presented in Table 3.7-2. A power profile (watts versus time) for camera operation at 28 vdc is presented in Figure 3.7-(TBS).

3.7.3.1.3 Batteries

No batteries are required for the mapping camera experiment.

3.7.3.2 Attitude and Orbital Geometry

3.7.3.2.1 Attitude Constraints

The mapping camera is a directional sensitive instrument, requiring the CSM positive X-axis to be in the direction of the velocity vector during camera operation.

The mapping camera is sun-sensitive. Refer to Section 2.6 for the sun-avoidance CSM look-angle attitude constraints for the operate and nonoperate modes.

3.7.3.2.2 Orbital Geometry Constraints

The desired nominal lunar altitude is 60 nautical miles; however, the camera has a capability of operating from 40 to 80 nautical miles. For the 60-nautical-mile altitude, the V/h compensation altitude range is 50 to 70 nautical miles. The V/h compensation system should be adjusted before launch if other than a 60-nautical-mile nominal altitude is planned.

3.7.3.3 Environment

3.7.3.3.1 Temperature Limitations

3.7.3.3.1.1 Nonoperating Conditions. The allowable range for the mapping camera subsystem during non-photographic periods is 40 to 90 F. A non-photographic period refers to any portion of the mission when photographic data is not required. Non-photographic portions of the mission will be those times when the camera is in the off or standby mode, or when the camera is operated for film advancement purposes only.

3.7.3.3.1.2 Operating Conditions. The temperature range for specification level photography during operating conditions is 60 to 80 F.

3.7.3.3.1.3 Film Temperature Limitations. Survival of the film (Eastman-Kodak series 3400 or equivalent) so that it can be satisfactorily processed after return to earth is dependent upon the length of time that the film and film cassette are exposed to temperatures in excess of 90 F. The length of time for which the film can be exposed to a temperature of 90 F is 4000 hours (166.7 days). The maximum allowable temperature to which the film can be exposed is 125 F, and the maximum allowable duration of exposure at that temperature is 7.8 hours. The maximum allowable cumulative exposure to temperatures in excess of 90 F may be obtained from the following expression.

$$\text{Time at temperature} = \int_{t_0}^{t_r} 2^{(0.2)(T-90)} dt \leq 4000 \text{ hours}$$

where

T = film temperature

t_0 = time corresponding to start of period when the temperature (T) exceeds 90 F.

t_r = time corresponding to end of period when the temperature (T) exceeds 90 F.

3.7.3.3.1.4 EVA Activity - Film Cassette Conditions. During retrieval from the SIM, direct exposure of the film cassette to any degree of solar radiation or deep-space sink temperature for a period of time equal to or greater than 40 minutes must be avoided.

3.7.3.3.2 Temperature Control

Thermal control of the mapping camera is achieved by the following methods:

1. Passive thermal control superinsulation with solar absorptivity (α) and emissivity (ϵ) properties has been provided on all surfaces.
2. The camera is thermally isolated from the SIM structure.
3. During the boost phase and TLC, the pre-set heater thermostats are controlled to turn on at 67 F and turn off at 72 F when the camera is in the STANDBY or ON mode.
4. The camera is passively biased to the cold side of the thermal operating range.

3.7.3.3.3 Humidity Limitation

There is no significant humidity limitation relative to the mapping camera.

The relative humidity (RH) limitation to which the film cassette can be exposed is 50-percent maximum.

3.7.3.3.4 Nuclear Radiation Limitation

There are no significant nuclear radiation exposure limitations related to the mapping camera or the film cassette.

3.7.3.3.5 External Contaminant Limitation

Mapping camera performance will be degraded by the presence of external contaminants either on the camera lens or in the camera field-of-view. Significant contaminant sources are urine and waste water dumps. All scheduled contaminant emissions must be restricted to times other than from 3 hours before to immediately after mapping camera operations.

3.7.3.4 Crew Support Requirements

3.7.3.4.1 Pre-Experiment Operations

The time required for camera warmup before operation is 25 hours, providing the optical system temperature at the beginning of the warmup period is between 40 and 60 F. The STANDBY mode is also required during launch, translunar injection, and all SPS-powered flight phases which occur before film retrieval to prevent slack loops. The camera must be cycled once every 24 ± 6 hours following flight film loading to prevent film set (no warmup required). The camera must be extended to the operating position to assure clear fields of view for both mapping and stellar cameras. The boom-deployed instruments which present objectionable intrusions into the optical field-of-view of the cameras must be retracted before mapping phases (See paragraph 3.7.3.6).

3.7.3.4.2 Experiment Operations

3.7.3.4.2.1 Lunar Orbit. The laser altimeter (Section 3.8) will operate synchronously upon a signal from the mapping camera to supply the altitude data when power is supplied to both systems.

Crew support, as identified by the flight plan or MSFN direction, will provide ON-OFF operation, STANDBY operation, and V/h setting changes.

During mapping passes, the CSM attitude must be maintained in accordance with the limitations identified in paragraph 3.7.3.2.1.

Limitations on CSM effluent dumps must be observed in accordance with the constraints identified in paragraph 3.7.3.3.5.

3.7.3.4.2.2 Transearch Coast. Camera operation during this phase is not required. An astronaut will retrieve the record container via EVA.

3.7.3.4.3 Post-Experiment Operations

Following EVA retrieval, the film cassette will be stowed in the CM for return to earth.

3.7.3.6 Interface Constraints

This experiment requires the concurrent operations of the laser altimeter experiment (Section 3.8). Refer to the Experiment Interface Matrix, Section 2.2.

Boom constraints are TBS.

Table 3.7-1. Mapping Camera Subsystem Optical Characteristics
(See Paragraph 3.7.2.1)

Item	Mapping Camera	Stellar Camera
Focal length	3 inches	3 inches
Aperture	f/4.5	f/2.8
Shutter	Rotary	Rotary
Optical field-of-view	93-degree cone with flats (74 by 74 degrees)	24-degree cone with flats (18 degrees vertical by 24 degrees horizontal)
Image motion compensation (V/h manual input and adjustment)	3-percent accuracy 0.01 to 0.04 radians per second	N/A

Table 3.7-2. Mapping Camera DC Power Matrix
(See Paragraph 3.7.3.1.2)

Mission Phase	Switch Positions				Heaters (watts)		Electronics (watts)		Notes
	STBY	OPER	EXTEND	RETRACT	Peak	Average	Average	Peak	
Launch and powered flight	X			X	35	15	5	5	/
Film advance		X		X	35	15	100	150	1
Camera warmup	X			X	35	35	5	5	2
Deployment	X		X		35	/	60	60	3
Photographic pass		X	X		35	15	100	150	4
Between photographic passes	X		X		35	15	5	5	4
Retraction	X			X	35	/	60	60	5

Notes:

- Two-minute operation each 24 hours.
- Heater average power is for 45-degree orbit (worst-case) camera warmup period, 25-hour maximum before photographic period.
- For deployment time only—approximately 0.1 hour.
- Fifteen-watt heater power average per orbit is worst case.
- For retract time only—approximately 0.1 hour.

3.7-8

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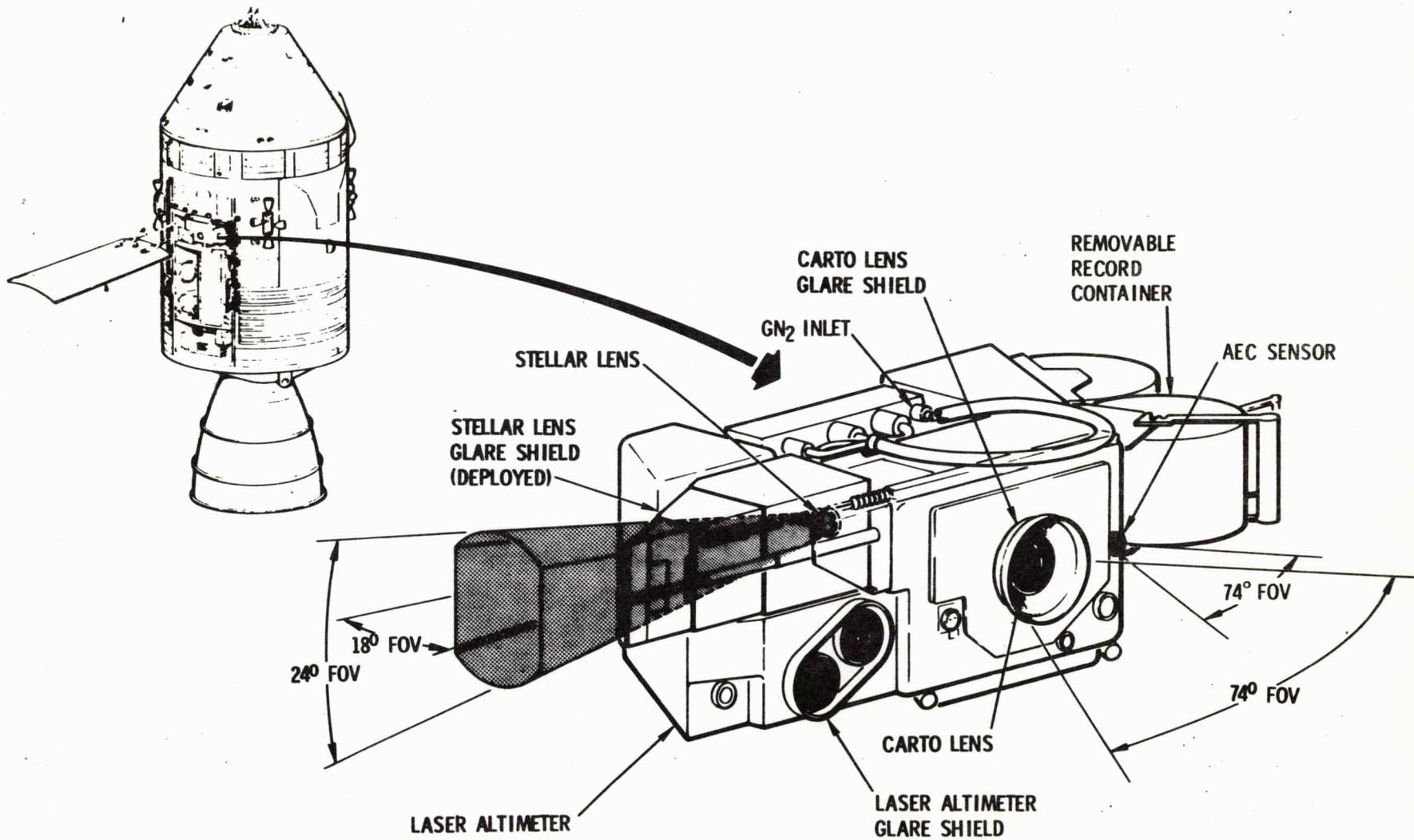


Figure 3.7-1. Three-Inch Mapping Camera and Laser Altimeter

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3.8 LASER ALTIMETER

3.8 LASER ALTIMETER

voltage limitations at the

3.8-1

SNA-8-D-027(VI)

3.8 LASER ALTIMETER

3.8.1 OBJECTIVES

The objectives are to measure altitude with high precision and high ground resolution specifically for mapping camera reference and to relate the topography to the lunar shape as determined from orbital data.

3.8.2 PHYSICAL CHARACTERISTICS

3.8.2.1 Functional and Physical Description

The laser altimeter will obtain altitude (or range) data by measuring the elapsed time between transmission and receipt of the laser pulse. The instrument is hard-mounted and aligned (boresighted) to the mapping camera (Section 3.7). It is essentially a slant-ranging device dependent upon CSM attitude obtained from the mapping camera subsystem (Section 3.7) for data reduction. Characteristics of the instrument are given in Table 3.8-1.

3.8.2.2 Envelope Dimensions and Weight (Approximate Values)

The laser altimeter envelope is approximately 16 by 17 by 22 inches, and the weight is 50 pounds.

3.8.2.3 Installation in SIM

The laser altimeter is hard-mounted to the mapping camera. See paragraph 3.7.2.3 for mapping camera subsystem installation.

3.8.2.4 Deployment Characteristics

See paragraph 3.7.2.4.

3.8.3 PERFORMANCE AND OPERATIONAL DATA

3.8.3.1 Electrical Power

3.8.3.1.1 Voltage Limitations

Based on design criteria, the experiment voltage limitations at the experiment interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts

2. Ac voltage = 110 to 120 volts

3. Ac frequency = 400 Hz \pm 3 Hz, three phase (ϕ)

3.8.3.1.2 Power Requirements

The power requirements for the laser altimeter are presented in Table 3.8-2. A power profile for laser operation (peak watts versus time) is presented in Figure 3.8-1.

3.8.3.1.3 Batteries

There are no batteries used in the laser altimeter.

3.8.3.2 Attitude and Orbital Geometry

3.8.3.2.1 Attitude Constraints

The laser altimeter is not sensitive to rotation about its optical axis and may be operated with the CSM positive or negative X-axis in the direction of the velocity vector.

The laser altimeter is sun-sensitive. Refer to Section 2.6 for the sun-avoidance CSM look-angle attitude constraints.

3.8.3.2.2 Orbital Geometry Constraints

The operating range capability of the laser altimeter is between 40 and 80 nautical miles.

3.8.3.3 Environment

3.8.3.3.1 Temperature Limitations

Temperature limits for operational telemetry thermal measurements are given in Table 3.8-3.

3.8.3.3.2 Temperature Control

Thermal control of the laser altimeter is achieved by the following methods:

1. Passive thermal control coating with solar absorptivity (α) and emissivity (ϵ) properties has been provided on all except optical surfaces.
2. The instrument is thermally isolated from the SIM structure.
3. The altimeter is passively biased to the cold side of the thermal operating range.

3.8.3.3.3 Humidity Limitation

Dry nitrogen is used in two modules of the laser altimeter:

1. The laser module, containing the laser cavity, Q-switch and trigger circuitry, uses dry nitrogen gas pressurization to protect the internal optical cavity finish, prevent condensation on the optical surfaces, and prevent high-voltage flashover (corona discharge).
2. The telescope module, containing optics for the laser altimeter transmitter and receiver, uses gaseous nitrogen to maintain a clean environment for the optics. An exhaust valve is opened before launch, and the internal pressure is vented during boost.

3.8.3.3.4 Nuclear Radiation Limitation

No significant nuclear radiation exposure limitations related to the laser altimeter have been established.

3.8.3.3.5 External Contaminant Limitation

Laser altimeter performance may be degraded by the presence of external contaminants either on the altimeter lens or in the altimeter field-of-view. The range accuracy is not degraded unless the contaminants directly or indirectly reduce the intensity of the return light beam below the level required to trigger the range counter. The mapping camera/laser altimeter protective cover must be closed prior to operation of SM RCS jets A2, A4, B1 and B4 to minimize lens contamination.

3.8.3.4 Crew Support Requirements

3.8.3.4.1 Pre-Experiment Operations

To obtain valid range data, the laser cavity temperature must be consistent with the operating temperature specified in Table 3.8-3.

3.8.3.4.2 Experiment Operations

3.8.3.4.2.1 Lunar Orbit. The laser altimeter can be operated independently or with the mapping camera subsystem.

During independent operation, the instrument automatically fires to provide range data at 20-second intervals while in the ON mode. The mapping camera must not be in the ON mode.

During combined operation, the laser altimeter and mapping camera must both be in the ON mode. In this mode, the altimeter is electrically slaved or triggered by the camera (data request pulse) to provide range data for the center of exposure for each mapping camera photographic frame.

During laser altimeter operations, the CSM attitude must be maintained in accordance with the limitations identified in paragraph 3.8.3.2.1.

Limitations on CSM effluent dumps must be observed in accordance with the constraints identified in paragraph 3.8.3.3.5.

3.8.3.4.2.2 Transearch Coast. No operation required.

3.8.3.4.3 Post-Experiment Operations

None required.

3.8.3.5 Constraints

3.8.3.5.1 Interface Constraints

The laser altimeter can be operated independently; however, this experiment must be performed concurrently with the mapping camera experiment (Section 3.7). Refer to the Experiments Interface Matrix, Section 2.2.

The laser altimeter should not be operated with the protective cover door closed. Laser energy reflected by the door will endanger the receiver's photomultiplier tube.

When operation of the CSM or SIM instruments require pointing the SIM centerline away from lunar nadir in a 60 nautical mile orbit, the laser altimeter will provide the slant range from the CSM if the SIM centerline is within $\pm 40^\circ$ of the lunar nadir. Altitude data can be derived from the slant range data using the CSM attitude data.

3.8.3.5.2 Operational Constraints

Limits for telemetry measurements are given in Table 3.8-4.

Table 3.8-1. Laser Altimeter Characteristics
(See Paragraph 3.8.2.1)

Item	Characteristics
Laser	Ruby, mechanically Q-switched
Operating wavelength	6943 Angstroms (nominal)
Transmitter beam	300 μ radian
Receiver field-of-view	200 μ radian
Pulse	
Energy	250 millijoules (nominal)
Duration	13 nanosecond (half power duration)
Range resolution	1 meter
Rep. rate	
Synchronized	3.75/minute (maximum in CAMERA mode)
Independent	3/minute (AUTOMATIC mode)

Table 3.8-2 Laser Altimeter Electrical Power
(See Paragraph 3.8.3.1.2)

Power Requirements	DC Power ⁽¹⁾ (Watts at 27.5V)	AC (1) (2)
Average	31.7	3.3 VA/ ϕ
Peak	68.7	3.3 VA/ ϕ

(1) Electrical power reference: Acceptance Test Data
(3-22-71)
Laser Altimeter S/N 0004
(P/N 2364000)

(2) AC power is to be calculated by using a power factor
of 0.5.

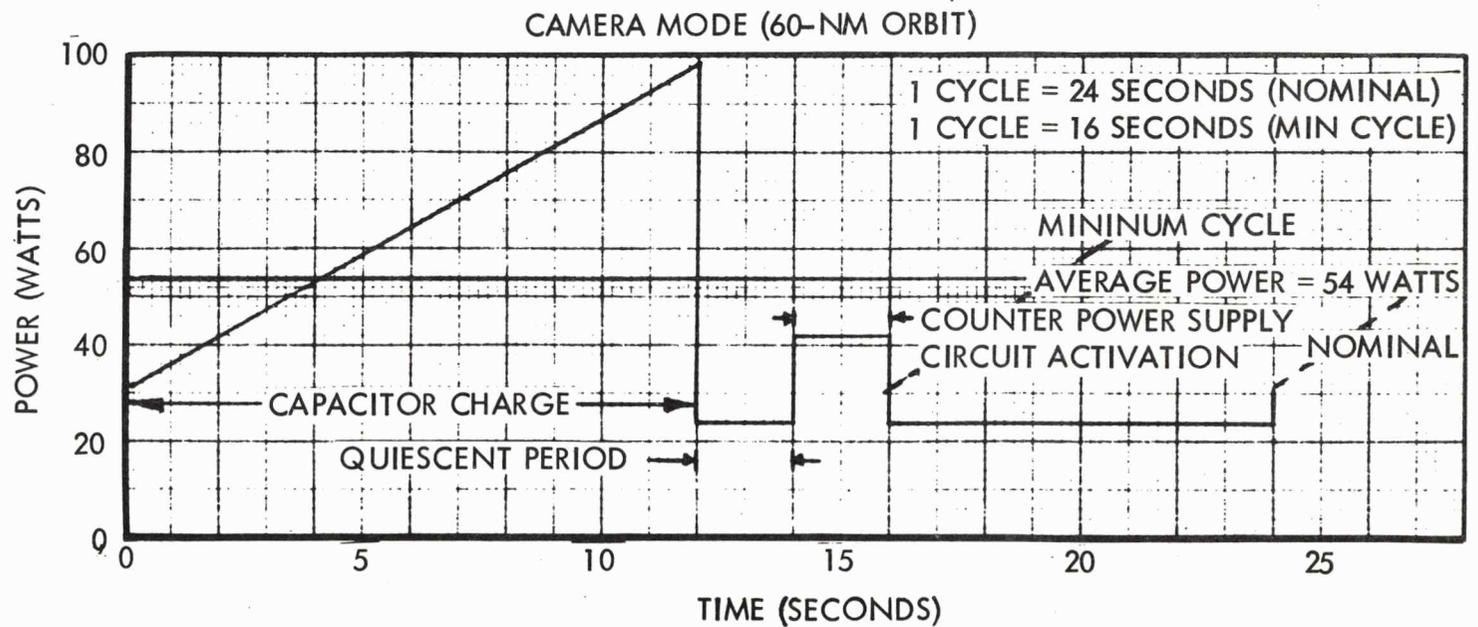
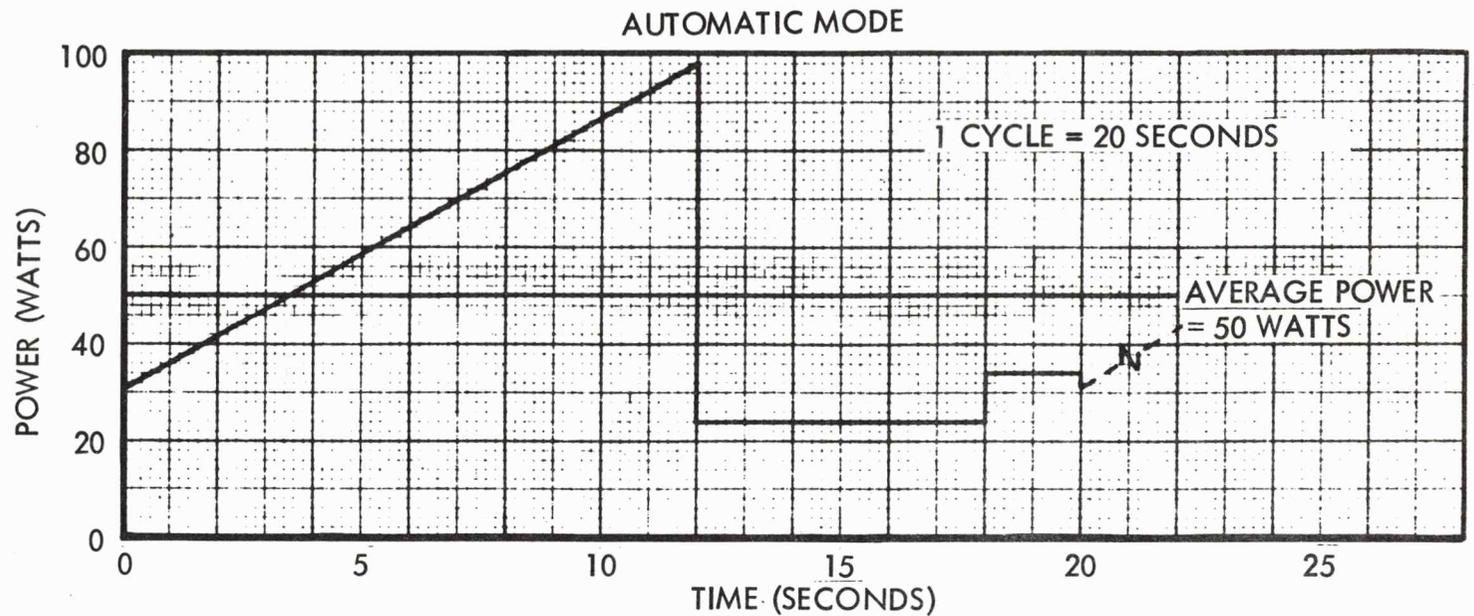


Figure 3.8-1. DC Power Profile for Laser Altimeter

3.8-7

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SUBSATELLITE (S173, S174, S164)

investigate the formation and dynamics of the
wind boundary layer as it flows over
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3.9 SUBSATELLITE

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3.9 SUBSATELLITE (S173, S174, S164)

3.9.1 OBJECTIVES

The objectives are to investigate the formation and dynamics of the earth's magnetosphere and the solar wind boundary layer as it flows over the moon and to obtain S-band doppler measurements over an extended period of time (approximately one year) without velocity correction disturbances.

3.9.2 PHYSICAL CHARACTERISTICS

3.9.2.1 Functional and Physical Description

The experiment is designed to study wave particle interactions while in lunar orbit, to study the formation of the earth's magnetosphere and solar wind boundary layer over the moon, to study the magnetic field interaction with the moon, to measure particle flux in and near the plasma sheet, to monitor solar flare electron events, and to provide S-band source for lunar gravity gradient measurements. Following launch from the CSM into lunar orbit, the subsatellite remains in a standby mode until given a command from the ground following the completion of LM/MSFN communication.

The experiment equipment consists of the deployment mechanism, the launch platform, and the subsatellite. The subsatellite contains charged particle detectors, a magnetometer, a data storage unit, a solar cell-battery power system, and a S-band communications subsystem. Three 5-foot-long articulated booms are attached, as shown in Figure 3.9-1, and weighted to provide spin stabilization of the subsatellite. One boom is also used to support the magnetometer, thus reducing the effect of the subsatellite on the magnetic field measurements.

3.9.2.2 Envelope Dimensions and Weight

The subsatellite is hexagonal in shape with three booms folded for storage along the side and latched at both ends. The subsatellite is approximately 30 inches long and has a 12-inch long S-band antenna. As stowed, the antenna is on the inboard end and protrudes through the center of the launch platform. The installation envelope is approximately 17 inches in diameter by 43 inches in length. The subsatellite system weight is 95 pounds (80 pounds for the subsatellite and 15 pounds for the launch platform).

3.9.2.3 Installation in SIM

The deployment mechanism provides the means for attaching the subsatellite system to the SIM. The subsatellite is clamped to the launch platform, and the launch platform is attached to the deployment mechanism.

The deployment mechanism is attached to the forward side of the SIM shelf located at $X_S = 236.50$. The spin axis is located at approximately $X_S = 248.5$ and is oriented to $\theta = 90$ degrees and $\phi = 12.75$ degrees.

As installed in the SIM, the subsatellite is enclosed within a protective cover, the door of which opens upon initiation of the subsatellite launch sequence and closes when the deployment mechanism is retracted.

3.9.2.4 Deployment and Launch Characteristics

Activation of the EXTEND/LAUNCH switch initiates a series of automatic sequences culminating in the launch of the subsatellite. The subsatellite is launched and ready for operation, with booms fully extended, 11.2 ± 2.0 seconds following activation of the EXTEND/LAUNCH switch. Details of deployment and launch characteristics are presented in paragraph 2.10.

3.9.3 PERFORMANCE AND OPERATIONAL DATA

3.9.3.1 Electrical Power

3.9.3.1.1 Voltage Limitations

Based on design criteria, the voltage limitations at the experiment launch platform interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required.

3.9.3.1.2 Prelaunch Power Requirements

Electrical power to operate the subsatellite after launch will be provided by a self-contained power system. The CSM will supply power to operate the deployment mechanism and data signal. The CSM power requirement for deployment, launch and retraction is 56 watts maximum (1036 watt seconds maximum) per cycle.

3.9.3.1.3 Operational Power Requirements (NASA Data Source)

For the power consumed by the subsatellite in various modes of operation see Table 3.9-1.

3.9.3.1.4 CSM Batteries for the Subsatellite (NASA Data Source)

There are no batteries in the CSM specifically for the subsatellite or its launch platform.

3.9.3.1.5 Subsatellite Battery

The 10 ampere-hour battery cell pack consists of eleven sealed, silver cadmium cells which provide a nominal 15.5 volts. Associated with the battery pack are overcharge protection circuits for each cell, and the charging circuitry. The battery circuitry is designed so that no short or open circuit battery failure will impair the performance of the subsatellite when loads are being supplied by the solar array. The battery is designed to operate within temperature limits shown in Table 3.9-2.

3.9.3.1.5.1 Subsatellite Battery Operational Constraints (NASA DATA SOURCE)

During the first six months of operation the battery can be considered to have a capacity of 10 ampere-hours. During the next six months of operation the battery capacity should be considered to be no more than seven ampere-hours.

If required, 75% of the battery capacity may be removed before being returned to full charge, i.e., during first six months, 7.5 ampere hours; during second six months, 5.2 ampere-hours.

Immediately before entering into a flight mode which will lead to the deep discharge, the battery should be returned to the fully charged condition.

Immediately following an operational mode which resulted in deep discharge, the battery should be returned to the fully charged state as soon as possible.

The battery should be subjected to no more than two deep discharges per month throughout the satellite life.

When operating the battery below 50% remaining capacity, the battery operating characteristics (voltage and current) should be monitored as nearly continuously as possible. Should battery load voltage fall below a level equivalent to one volt per cell, the mode of flight should be changed to allow battery recharge to full capacity.

3.9.3.2 Attitude and Orbit Geometry

3.9.3.2.1 Attitude Constraints

Operation of the subsatellite requires that its spin axis remain normal to the plane of the ecliptic. Maximum permissible deviation is 35 degrees after one year in lunar orbit. To satisfy this requirement, the spin axis of the subsatellite must be within 5 degrees of nominal just after launch. Because of CSM uncertainties (see section 2.5.3) and launch dynamics, this necessitates that the CSM be in narrow dead band (0.5 degrees).

The long-time limit on spin axis precession (cited above) requires that the angular momenta of spacecraft and subsatellite be additive. Hence, launcher design provides for a northward launch of the subsatellite.

The CSM attitude must not permit the sun to impinge upon the sun-sensitive instruments in the SIM bay (see Section 2.6 for sun-avoidance envelopes).

3.9.3.2.2 Orbit Constraints

The CSM orbit at the time of launch is constrained by the timing sequence built into the subsatellite automatic data transmission mode. This mode employs a timer set for an orbital period of 7104 seconds ± 0.04 percent. A minimum of 20 minutes during a frontside pass is required to accommodate acquisition of signal and transmission of stored data.

To minimize the likelihood of later collision between CSM and sub-satellite, launch should occur within ten minutes of crossing the moon-centered ecliptic. For the same reason, northward launch should be from the ascending node.

3.9.3.3 Environment

3.9.3.3.1 Temperature Limitations

3.9.3.3.1.1 Temperature Limits in SIM

A passive thermal control system maintains subsatellite temperature-critical components within a temperature range compatible with the SIM structure before SIM door jettison. Temperature limitations following SIM door jettison are 0°F and 90°F.

3.9.3.3.1.2 Operational Temperature Limits (NASA Data Source)

Temperature limits following launch of the subsatellite from the CSM into lunar orbit are shown in Table 3.9-2.

3.9.3.3.2 Temperature Control

Thermal control of the subsatellite is achieved by the following methods:

1. A passive thermal control coating with selected solar absorptivity (α) and emissivity (ϵ) properties has been applied to the instrument surfaces.
2. The conductance value between the subsatellite system and the SIM environment with the door in place is 0.83 Btu/hour-°F.

3.9.3.3.3 Humidity Limitation

The maximum allowable relative humidity (RH) limit for the sub-satellite is 60 percent.

3.9.3.3.4 Nuclear Radiation and Magnetic Field Limitations

The maximum radiation dose to which the subsatellite can be exposed while in the SIM is 1×10^4 rad (reference silicon).

The dc magnetic field at the surface of the subsatellite must not exceed 2.0 gauss at any time.

3.9.3.4.2 Experiment Operations (Launch of Subsatellite)

The crew will activate the subsatellite DEPLOY/LAUNCH switch to launch the subsatellite. (When separation occurs, the talkback will turn gray and the event will be transmitted via PCM). Visual observation through a CM window may also provide launch monitoring capability.

If the talkback and PCM do not verify subsatellite separation, the deployment mechanism may be retracted and the launch sequence repeated.

3.9.3.4.3 Post-Launch Operations

None required.

3.9.3.5 Interface Constraints

No other SIM experiment can be in the data collection mode during the deployment and launch phase of the subsatellite experiment due to the CSM unique attitude requirements imposed by this experiment.

Spacecraft maneuver rates shall be minimized and after spacecraft stabilization the RCS quads shall be disabled immediately prior to subsatellite DEPLOY/LAUNCH. Upon subsatellite launch RCS quads may be enabled.

Following launch, or an unsuccessful attempt to launch, the deployment mechanism must be fully retracted into the SIM bay.

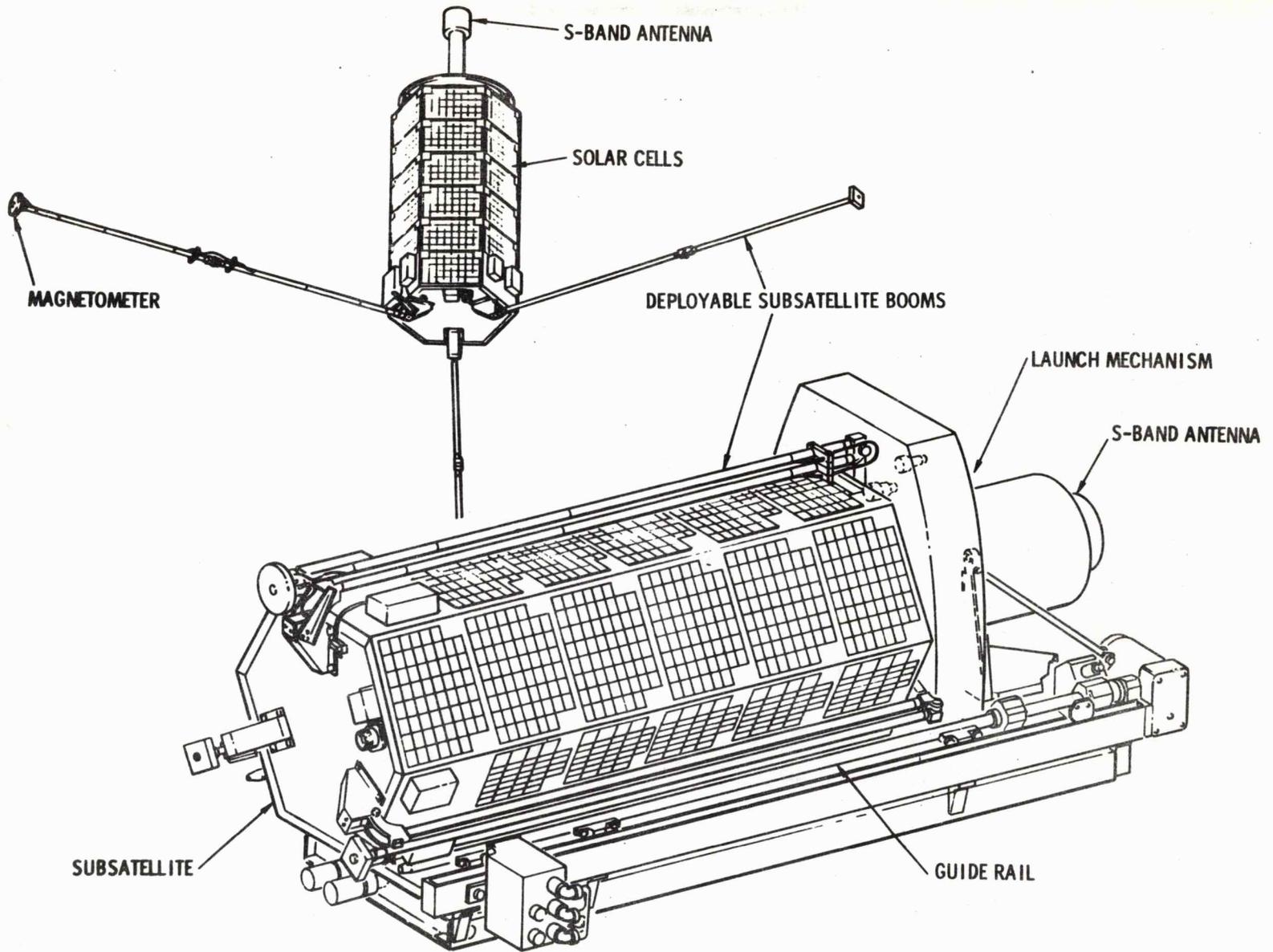
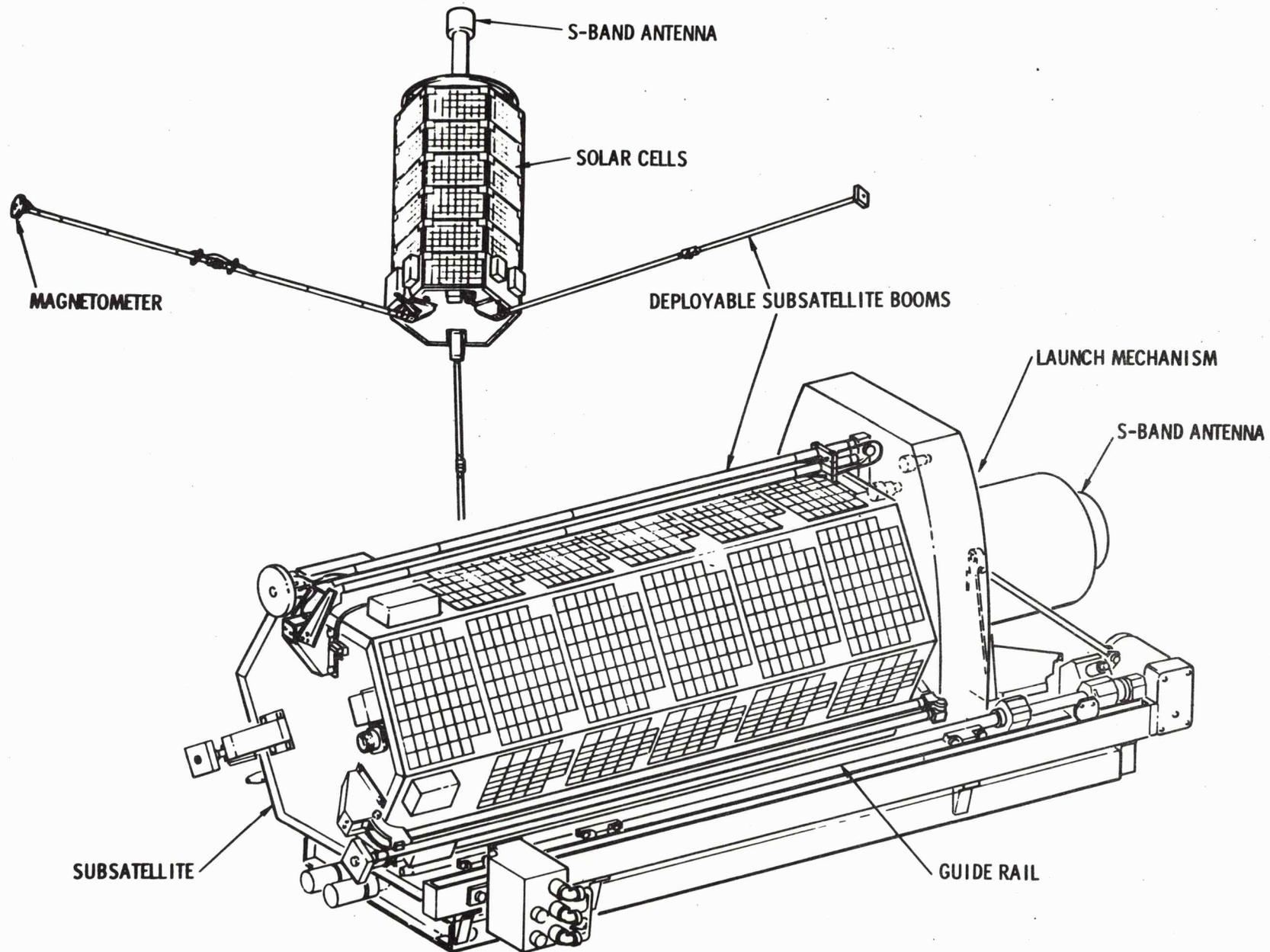


Figure 3.9-1. Subsatellite With Launching Mechanism

3.9-6

SNA-8-D-027(VI)

NASA—MSC



3.9-7

SNA-8-D-027 (VI)

Figure 3.9-1. Subsatellite With Launching Mechanism

3.10 ULTRAVIOLET SPECTROMETER

are to determine the lunar atmosphere atomic
height for each constituent.

are to: 1) measure the temporary atmosphere
cent engines, 2) measure the UV albedo and
by the dark side fluorescence, 4) measure
study the atomic hydrogen distribution

on

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3.10 UV SPECTROMETER

3.10 ULTRAVIOLET SPECTROMETER

3.10.1 OBJECTIVES

The primary objectives are to determine the lunar atmosphere atomic composition, density and scale height for each constituent.

The secondary objectives are to: 1) measure the temporary atmosphere created by the LM descent and ascent engines, 2) measure the UV albedo and its geographic variations, 3) study the dark side fluorescence, 4) measure the UV galactic emission, and 5) study the atomic hydrogen distribution between the earth and the moon.

3.10.2 PHYSICAL CHARACTERISTICS

3.10.2.1 Functional and Physical Description

The ultraviolet spectrometer (UVS) will determine the composition of the lunar atmosphere by detection of the resonance re-radiation of ultraviolet energy in the 1180A to 1680A region.

The instrument is a 1/2 meter focal length Ebert spectrometer consisting of an external baffle, entrance and exit slits, Ebert mirror, oscillating diffraction grating, synchronous motor with cam, photoelectric sensor, and associated electronics.

The external baffle is a multiple-angled horn which limits the instrument to a 12 by 20 degree field-of-view in the longitude and transverse planes, respectively, and centered about the optical axis. To minimize data degradation caused by the entrance of reflected light into the instrument, the UVS requires that the installation in the SIM provide a total unobstructed field-of-view of 60 degrees longitudinal by 90 degrees transverse and centered about the optical axis. Light originating from sources outside the 12° by 20° data field-of-view but within the 60° by 90° unobstructed field-of-view (guard-band) is greatly attenuated due to multiple reflection within the baffle before it passes through the entrance slit. Where intrusion into the guard-band is unavoidable, those surfaces must be optically non-reflective.

3.10.2.2 Envelope Dimensions and Weight

The main housing containing the optical system is approximately 9.5 x 12.25 x 23.5 inches. Attached to one end of the main housing are the electronics module, approximately 9 x 6 x 8 inches, and the multi-angled rectangular shaped external baffle, approximately 19 inches long. The UV spectrometer is illustrated in Figure 3.10-1. The instrument weighs a maximum of 40 pounds.

3.10.2.3 Installation in SIM

The UVS is attached to a support bracket which mounts the instrument to the SIM shelf at $X_S = 206.50$ next to Beam 6. The UVS is inclined towards

the positive X-axis at an angle of 25 degrees and canted towards Beam 6 at an angle of 18 degrees from the SIM centerline.

The optical axis is offset within the instrument such that it establishes a nominal look angle of $\theta = 66.783$ degrees and $\phi = 19.75$ degrees with respect to spacecraft coordinates. Refer to paragraph 2.5.3 for alignment accuracies.

3.10.2.4 Deployment Characteristics

Not applicable.

3.10.2.5 Protective Covers

The UVS installation in the SIM includes a contamination cover which covers the entrance of the external baffle. This cover, when closed, protects the instrument from SM RCS jet firings, effluent dumps, and solar radiation effects described in paragraph 2.10.3.2.1. A thermal protective shield over the electronics module is provided in addition to the baffle cover to protect the assembly from the SM RCS jet ullage firings. Refer to Section 2.10 for the description and operation of the protective devices.

3.10.3 PERFORMANCE AND OPERATIONAL DATA

3.10.3.1 Electrical Power

3.10.3.1.1 Voltage Limitations

Based on design criteria, the voltage limitations at the instrument interface are as follows:

1. Dc voltage = 27.5 ± 2.5 volts
2. Ac voltage = No ac power required

3.10.3.1.2 Power Requirements

Typical power requirements for all UV spectrometer systems based upon a nominal bus voltage of 27.5 Vdc are as follows:

<u>Subsystem</u>	<u>Nominal Power (Watts)</u>	<u>Maximum Power (Watts)</u>
Protective Cover Motor (Logic Bus A)	52.8	77.0
UV Spectrometer	TBS	12.0

3.10.3.1.3 Batteries

No batteries are required for the UV spectrometer.

3.10.3.2 Attitude and Orbital Geometry

3.10.3.2.1 Attitude Constraints

The UVS is a direction sensitive instrument and must be operated in both a nominal local vertical attitude and an inertial hold attitude. Refer to Sections 3.10.3.2.1.1 through 3.10.3.2.1.4 for specific attitude constraints for each mode of operation.

The UVS is sun-sensitive when the instrument protective cover is open. Data degradation will result whenever the sun enters the 60° by 90° FOV with complete loss of data whenever the sun enters within 30° of the optical axis. Refer to Section 2.6 for the sun-avoidance CSM look-angle attitude constraints for when the protective cover is open. There is no attitude constraint when the UVS protective cover is closed.

The UV spectrometer is nonsensitive to CSM drift rates and imposes no CSM attitude control maneuver rate constraints.

3.10.3.2.1.1 Mode I Attitude

The CSM velocity vector must be along the +X axis and the SIM bay centerline aligned to nadir.

3.10.3.2.1.2 Mode II Attitude

The CSM velocity vector must be along the -X axis and the SIM bay centerline aligned to nadir.

3.10.3.2.1.3 Mode III Attitude

For Mode III lunar operation, the CSM must be constrained such that the instrument's optical axis maintains an angle of 100 ±5 degrees to the CSM sun line. The optical axis must also be fixed within 30 degrees of the plane of the orbit so that the spectrometer scans the illuminated lunar surface after the CSM has crossed the longitude of the subsolar point.

For Mode III TEC calibration, the CSM must be confined to an inertial hold attitude to duplicate the inertial space attitude established during Mode III operation in lunar orbit to within 2 degrees.

3.10.3.2.1.4 Mode IV Attitude

During Mode IV TEC operation, the CSM must be rolled in passive thermal control mode with the CSM X-axis perpendicular to the moon-earth-sun plane.

3.10.3.2.2 Orbital Geometry Constraints

The desired nominal lunar orbital altitude is 60 nautical miles. The UV spectrometer, however, has the capability of operating at other orbital altitudes.

3.10.3.3 Environment

3.10.3.3.1 Temperature Limitations

Temperature limits for operational telemetry thermal measurements are given in Table 3.10-1.

3.10.3.3.2 Temperature Control

Thermal control of the UV spectrometer is achieved by the following methods:

1. Passive thermal control multi-layer insulation with specific solar absorptivity (α) and emissivity (ϵ) properties has been applied to all surfaces of the instrument.
2. The instrument is passively biased to the cold side of the thermal operating range.
3. The spectrometer is protected from RCS jet plume thermal heating by a protective cover and thermal shield with selected solar absorptivity and emissivity properties.
4. A portion of the energy absorbed by the external baffle is radiatively interchanged with the SIM walls.

3.10.3.3.3 Humidity Limitation

The maximum relative humidity (RH) to which the UV spectrometer can be exposed is 60 percent.

3.10.3.3.4 Radiation Limitations

The ambient spacecraft electromagnetic and nuclear radiation levels as presently defined will not limit the UV spectrometer operation. Any change of the defined ambient radiation, RF, or lighting levels will require an analysis on the effects to the instrument.

3.10.3.3.5 External Contaminant Limitations

The UV spectrometer performance will be degraded by the presence of external contaminants. Contaminant emissions such as urine, waste water and fuel-cell purges must be restricted to times other than from two hours before to immediately after any Mode III data collection or calibration. Contaminant emissions are to be as far removed as possible from all other UVS data collection periods.

The SM RCS jets to be inhibited during instrument data collection are specified in Section 2.8. The UV spectrometer must be turned off and the protective cover closed whenever these SIM impinging RCS jets are not inhibited.

3.10.3.4 Crew Support Requirements

3.10.3.4.1 Pre-Experiment Operations

During the pre-experiment phase the CSM effluent dumps must be constrained in accordance with the requirements of paragraph 3.10.3.3.5. The instrument may be activated with the protective cover closed as long as the temperature limits of paragraph 3.10.3.3.1 are maintained. There are no known CSM attitude limitations during this mission phase.

3.10.3.4.2 Experiment Operations

Crew support is required for operation of the instrument ON-OFF switch and the protective cover OPEN-CLOSE switch.

During all data collection periods, the CSM attitude must be maintained in accordance with the limitations specified in paragraph 3.10.3.2.1.

Limitations on CSM effluent dumps and propulsion system operation during data collection periods must be in accordance with the constraint identified in paragraph 3.10.3.3.5.

3.10.3.4.3 Post-Experiment Operations

None required.

3.10.3.5 Constraints

3.10.3.5.1 Interface Constraints

This experiment does not require operation of any other experiment. Refer to the Experiment Interface Matrix, Section 2.2.

3.10.3.5.2 Operational Constraints

Limits for telemetry measurements are given in Table 3.10-2. Sun entering the instrument while the protective cover is open will degrade the instrument performance or result in permanent damage. Refer to paragraph 2.6 for a presentation of the sun-avoidance envelope. The protective cover must be closed whenever the sun enters within 20 degrees of the optical axis.

Table 3.10-1. UV Spectrometer Temperature Limits
(See paragraph 3.10.3.5.2)

Telemetry Measurement Number	Measurement Description	Operating Mode	Nominal Values		Redline Limits*	
			Low °F	High °F	Low °F	High °F
SL1101T	UVS Housing Temperature	OFF	N/A	N/A	-67	180**
		ON	10	110	-13	131
SL1102T	UVS Motor Temperature	OFF	N/A	N/A	-67	180**
		ON	10	120	-40	180

*Redline boundary limits are those which, if exceeded, will result in, or will likely be the result of, catastrophic failure to the UVS system.

**The 180°F temperature is permitted for 10 hours maximum. Exposure at a maximum of 125°F is permissible for an indefinite duration.

3.10-6

SNA-8-D-027 (VI)

Amendment 22
12/22/71

Table 3.10-2. UV Spectrometer Telemetry Measurement Limits
(See paragraph 3.10.3.5.2)

Telemetry Measurement Number	Measurement Description	Nominal Operating Range		Nominal Value	Redline Limits*		Data Units
		Low	High		Low	High	
SL1100K	UVS Spectrum Count	0	65535	N/A	N/A	N/A	Counts/Sample
SL1103V	UVS Input Voltage	23.5	28.5	26.0	21	32	Vdc
SL1104C	UVS Input Current	300	400	365	200	1000	mA
SL1105V	UVS PMT Hi Voltage	3000	3800	3400	2000	4000	Vdc
SL1106V	UVS Regulated Voltage	4.8	5.2	5.0	4.0	6.0	Vdc

*Redline boundary limits are those which, if exceeded, will result in, or will likely be the result of, catastrophic failure to the UVS system.

3.10-7

SNA-8-D-027 (VI)

Amendment 22
12/22/71

3.10-8

SNA-8-D-027 (VI)

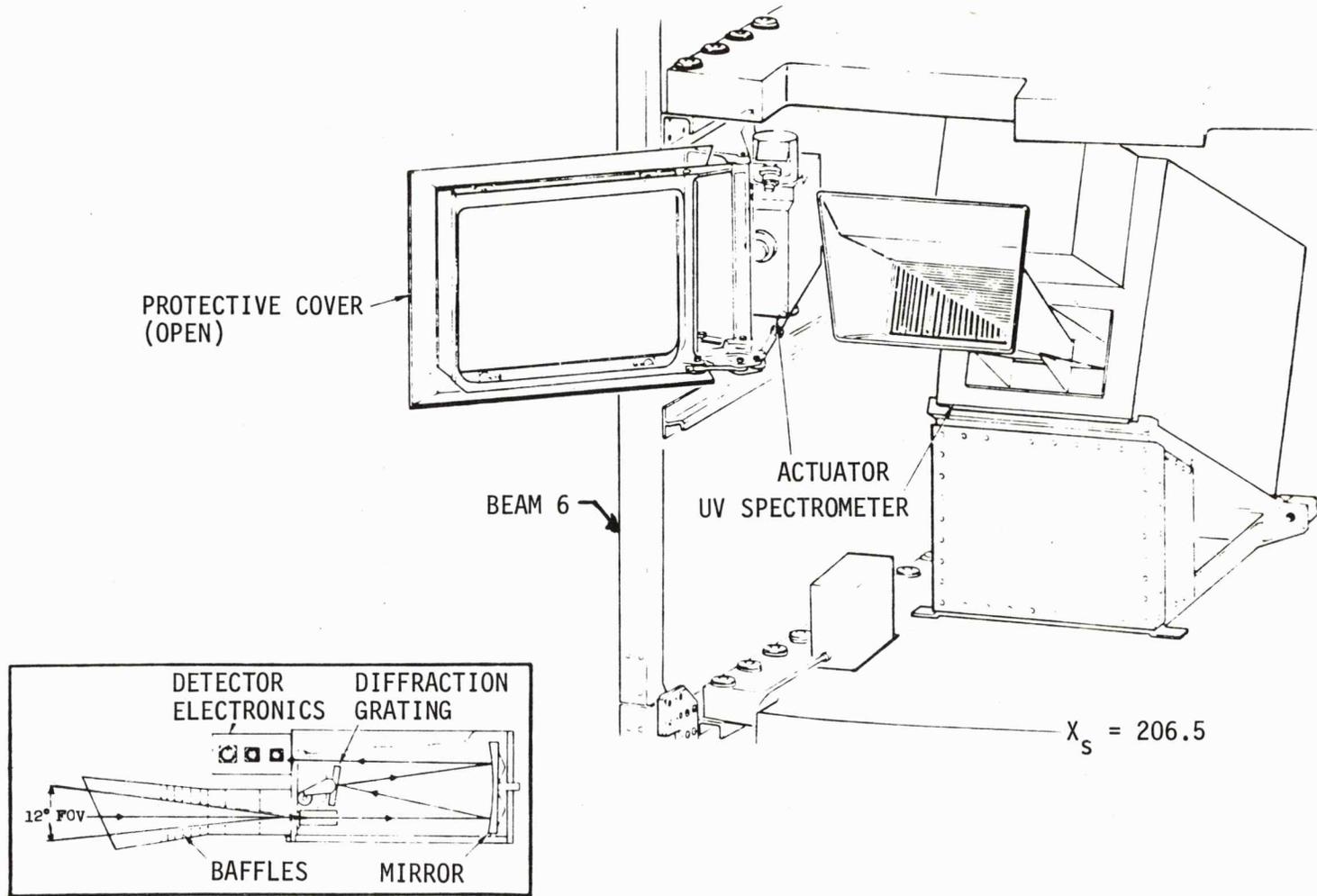


Figure 3.10-1. UV Spectrometer (See Paragraph 3.10.2.2)

3.11 IR SCANNING RADIOMETER (S171)

To Be Supplied

3.11-1

SNA-8-D-027 (VI)

3.13 LUNAR SOUNDER

ot be operated when the CSM is
imately 1000 ft.) to, the lunar
ne inadvertent firing of the LM

3.13 LUNAR SOUNDER

To Be Supplied

3.13.3.5 Interface Constraints

The lunar sounder transmitter shall not be operated when the CSM is mated with, or in close proximity (approximately 1000 ft.) to, the lunar module prior to LM descent to prevent the inadvertent firing of the LM pyrotechnics.

APPENDIX

LINE OF TYPICAL EXPERIMENT SECTION

ent format for individual experiments is as follows:

EXPERIMENT TITLE AND NUMBER

CHARACTERISTICS

Physical Description
Dimensions and Weight

Characteristics

ADDITIONAL DATA

Dimensions
Weights

Prints

APPENDIX

APPENDIX

APPENDIX

OUTLINE OF TYPICAL EXPERIMENT SECTION

The standard content format for individual experiments is as follows:

3. X EXPERIMENT TITLE AND NUMBER

3. X. 1 OBJECTIVES

3. X. 2 PHYSICAL CHARACTERISTICS

3. X. 2. 1 Functional and Physical Description

3. X. 2. 2 Envelope Dimensions and Weight

3. X. 2. 3 Installation in SIM

3. X. 2. 4 Deployment Characteristics

3. X. 3 PERFORMANCE AND OPERATIONAL DATA

3. X. 3. 1 Electrical Power

3. X. 3. 1. 1 Voltage Limitations

3. X. 3. 1. 2 Power Requirements

3. X. 3. 1. 3 Batteries

3. X. 3. 2 Attitude and Orbital Geometry

3. X. 3. 2. 1 Attitude Constraints

3. X. 3. 2. 2 Orbit Geometry Constraints

3. X. 3. 3 Environment

3. X. 3. 3. 1 Temperature Limitations

3. X. 3. 3. 2 Temperature Control

3. X. 3. 3. 3 Humidity Limitation

3. X. 3. 3. 4 Nuclear Radiation Limitation

3. X. 3. 3. 5 External Contaminant Limitation

3. X. 3. 4 Crew Support Requirements

3. X. 3. 4. 1 Pre-Experiment Operations

3. X. 3. 4. 2 Experiment Operations

3. X. 3. 4. 3 Post-Experiment Operations

3. X. 3. 5 Interface Constraints