incl pull-outs (as per Rinkey)

LMA790-3-LM 10 and Subsequent

APOLLO OPERATIONS HANDBOOK

LUNAR MODULE

LM 10 AND SUBSEQUENT

VOLUME I

SUBSYSTEMS DATA

Approved _____
Harlow K. Dunton, Ass't Program Director, Support

Approved _____
W. J. Everett, Program Manager, LM Publications Section

NAS 9-1100
Exhibit E Paragraph 10.4

TYPE I DOCUMENT

Prepared under direction of
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SPACECRAFT SYSTEMS BRANCH / FLIGHT CREW SUPPORT DIVISION

THIS PUBLICATION SUPERSEDES LMA790-3-LM 8 AND SUBSEQUENT DATED 15 JUNE 1970

GRUMMAN

LM PUBLICATIONS SECTION / PRODUCT SUPPORT DEPARTMENT / GRUMMAN AEROSPACE CORPORATION / BETHPAGE / NEW YORK

Box 082-34

1 APRIL 1971

ABBREVIATION LIST

A

A/D	Analog-to-digital
AAP	Abort autopilot
abs	Absolute
ac (a-c)	Alternating current
ACA	Attitude controller assembly
AEA	Abort electronics assembly
AEAA	Ascent engine arming assembly
AELD	Ascent engine latching device
AF	Audio frequency
AFC	Automatic frequency control
AGC	Automatic gain control
AGS	Abort guidance section
ALT	Altitude
amp	Ampere(s)
AMPL	Amplifier
ANT	Antenna
ANUN	Annunciator
AOT	Alignment optical telescope
APS	Ascent propulsion section
A_R	AOT reticle angle
ARS	Atmosphere revitalization section
A_S	AOT shaft angle
ASA	Abort sensor assembly
ASC	Ascent
ASD	Apollo standard detonator
ASI	Apollo standard initiator
ASSY	Assembly
A_T	AOT trunnion angle
ATA	Abort timing assembly
ATCA	Attitude and translation control assembly
ATM	Altimeter transmitter multiplier
ATT	Attitude
ATTEN	Attenuator
AUTO	Automatic
AUX	Auxiliary

B

BAL	Balance
BAT	Battery
BD	Band
biomed	Biomedical
BIPRPLNT	Bipropellant
BPF	Band-pass filter
BU	Backup

C

CW/FM	Continuous wave frequency-modulated
C/W	caution and warning
cb	Circuit breaker
CBW	Constant bandwidth
CBX	C-band transponder
CCRD	Computer control and reticle dimmer assembly
CDH	Constant delta altitude
CDR	Commander
CDU	Coupling data unit
CENTANG	Central angle of transfer
CES	Control electronics section
CFP	Coelliptic flight plan
cg	Center of gravity
CKT	Circuit
CL	Close
CLR	Clear
CMC	Command module computer
CMD(S)	Command(s)
CMPTR	Computer
COAS	Crewman optical alignment sight
COMM	Communications
COMP	Comparator
CONDR	Conditioner
CONT	Control
cont	continued
cos	Cosine
CO_2	Carbon dioxide
CPL	Couple
cps	Cycles per second
CPS	Cold plate section
CRSFD	Crossfeed
CS	Communications Subsystem
CSI	Coelliptic sequence initiation
CSM	Command and Service module
CSS	Computer subsection
CT	Control transformer
CTR	Counter reset
CTS	Counter set
CW	Continuous wave
CWEA	Caution and warning electronics assembly
CX	Control transmitter

D

D1, 2, 3, 4	Doppler spectrum signals
D/A	Digital-to-analog
DAP	Digital autopilot
db	Decibel
dc (d-c)	Direct current
DCA	Digital command assembly
DECA	Descent engine control assembly

ABBREVIATION LIST (cont)

D (cont)

DECR	Decrease
DEDA	Data entry and display assembly
DEG	Degree(s)
DEMOD	Demodulator
DES	Descent
DET	Detector
DFI	Developmental Flight Instrumentation
DFR	Deadface relay
DID	Display inertial data (discrete)
DIF	Differential
DISP	Display
DIST	Distribution
DN	Down
DNKRPT	Downlink interrupt
DPS	Descent propulsion section
DRB	Deadface relay box
DSEA	Data storage electronics assembly
DSKY	Display and keyboard
DUA	Digital uplink assembly
DVS	Doppler velocity sensor

E

E	Elevation angle
ECA	Electrical control assembly
ECI	Electrical circuit interrupter
ECS	Environmental Control Subsystem
ED	Explosive device
EDC	End detonator cartridge
EDS	Explosive Devices Subsystem
EKG	Electro-cardiograph
EL	Electroluminescent
EMI	Electromagnetic interference
EMP	Emphasis
EMU	Extravehicular mobility unit
ENG	Engine
ENTR	Enter
EOS	Emergency oxygen system
EPS	Electrical Power Subsystem
ERA	Electronic replaceable assembly
ERR	Error
EVA	Extravehicular astronaut
EVVA	Extravehicular visor assembly
E_X	X-component of attitude error
E_Y	Y-component of attitude error
E_Z	Z-component of attitude error

F

F	Fahrenheit; forward
FC	LR tracker reference frequency
FDAI	Flight director attitude indicator
FDBK	Feedback
FF	Flip-flop
FITH	Fire in the hole

F (cont)

FM	Frequency modulation
FR	Range frequency
FOV	Field-of-view
fps	Foot (feet) per second
ft	Foot (feet)
FWD	Forward

G

g	Gravity
GASTA	Gimbal angle sequencing transformation assembly
gc	Gigacycle(s)
GDA	Gimbal drive actuator
GEN	Generator
GET	Ground elapsed time
GETI	Ground elapsed time of ignition
GMBL	Gimbal
GN&CS	Guidance, Navigation, and Control Subsystem
GOX	Gaseous oxygen
GRD	Ground
GSE	Ground support equipment
GUID	Guidance

H

H/X	Heat exchanger
h	Altitude
$\dot{h}$	Altitude rate
Ha	Apogee
He	Helium
HEA	High-efficiency antireflection
HF	High frequency
Hg	Mercury
HI	High
HNDRPT	Hand interrupt
H_p	Perigee
HPF	High-pass filter
HTR	Heater
HTS	Heat transport section
HV	High voltage
H_2O	Water

I

IAM	Incidental amplitude modulation
ICS	Intercommunication system
ID	Identification
IF	Intermediate frequency
IGA	Inner gimbal axis
IMU	Inertial measurement unit
INCR	Increase
INV	Inverter
IOPS	Interim Oxygen Purge System
IRIG	Inertial reference integration gyro

ABBREVIATION LIST (cont)

I (cont)

IS	Instrumentation Subsystem
ISOL	Isolation
I_S	Specific impulse
ISS	Inertial subsection
ITMG	Integrated Thermal micrometeroid garment

K

K	Constant
kc	Kilocycle(s)
kmc	Kilomegacycle(s)
kpps	Kilopulse(s) per second
KYRPT	Key interrupt

L

L	Left
LAT	Lateral
LCA	Lighting control assembly
LCG	Liquid-cooled garment
LDG	Landing
LDR	LUT deadface relay
LF	Low frequency
LGC	LM guidance computer
LH	Left hand
LiOH	Lithium hydroxide
LLC	Low-level commutators
LLS	Low-level sensor
LM	Lunar Module
LMP	LM mission programmer; LM Pilot
LO	Low
LOR	Lunar orbital rendezvous; Lockout relay
LOS	Line of sight
LPD	Landing point designator
LPF	Low-pass filter
LR	Landing radar
LSD	Least significant digit
LTG	Lighting
LUT	Launch umbilical tower
LV	Low voltage

M

M	Mode discrete
MALF	Malfunction
MAN	Manual
MANF	Manifold
max	Maximum
mc	Megacycle(s)
MDF	Mild detonating fuse
MF	Medium frequency
MFC	Main feed contactor
MGA	Middle gimbal axis

M (cont)

min	Minimum
MISC	Miscellaneous
MKRPT	Mark interrupt
mm	Millimeter(s)
MOD	Modulation
MON	Monitor
MPS	Main Propulsion Subsystem
MPX	Multiplexer
MSD	Most significant digit
msec	Millisecond(s)
MSFN	Manned Space Flight Network
mv	Millivolt(s)
mw	Milliwatt(s)

N

N	Noun; noise factor
N/A	Not applicable
NB	Navigation base
NC	Normally closed
nm	Nautical mile(s)
NO	Normally open
No.	Number
NORM	Normal
NRZ	Nonreturn-to-zero
N_2H_4	Hydrazine
N_2O_4	Nitrogen tetroxide

O

O/C	Overcurrent
O/T	Overtemperature
OCR	Overcurrent relay
OCPS	Oxygen cabin pressure section
OGA	Outer gimbal axis
OPR	Operate
OPR ERR	Operator error
ORDEAL	Orbital rate display - earth and lunar
OSC	Oscillator
OSCPCS	Oxygen supply and cabin pressure control section
OSS	Optical subsection
OT	Operational test
OVBD	Overboard
OVHD	Overhead
OXID	Oxidizer
O_2	Oxygen

P

P	Program
P/O	Part of
p-p	Peak-to-peak
PA	Power amplifier
PAM	Pulse amplitude modulation

ABBREVIATION LIST (cont)

P (cont)

PBAT	Pyro battery
PBW	Proportional bandwidth
PCA	Program coupler assembly
PCM	Pulse code modulation
PCMTEA	Pulse-code-modulation and timing electronics assembly
PDA	Power distribution assembly
PGA	Pressure garment assembly
PGNCS	Primary guidance, navigation, and control section
PGNS	Primary guidance and navigation section
PIP	Pulse integrating pendulum
PIPA	Pulsed integrating pendulous accelerometer
PKG	Package
PLSS	Portable life support system
PM	Phase modulation
PMP	Premodulation processor
ppm	Pulse(s) per minute
pps	Pulse(s) per second
PQGS	Propellant quantity gaging system
PRA	Program reader assembly
PRE	Program reader electronics
PRESS	Pressure
PRF	Pulse repetition frequency
PRIM	Primary
PRM	Pulse ratio modulator
PRN	Pseudorandom noise
PRPLNT	Propellant
PS	Power Supply
PSA	Power and servo assembly
psi	Pound(s) per square inch
psia	Pound(s) per square inch absolute
psid	Pound(s) per square inch differential
PSK	Phase-shift keyed
PT	Pressure transducer
PTA	Pulse torque assembly
PTT	Push-to-talk
PVT	Pressure-volume-temperature
PWR	Power

Q

Q	Quotient
QI	Quantity indicator
QTY	Quantity
quad	Quadrant
QUAD	Quodrature

R

R1, 2, 3	DSKY registers 1, 2, and 3
R	Rankine; right
R/C	Reverse current

R (cont)

RC	Resistance-capacitance
RCCA	Rough combustion cutoff assembly
RCR	Reverse-current relay
RCS	Reaction Control Subsystem
RCVR	Receiver
RD	Relay driver
RDG	Range data good
RDNG	Range data no good
RDR	Radar
REF	Reference
REG	Regulator
RES	Resolver
RET	Return
RF	Radio frequency
r_f	Radial rate
RGA	Rate gyro assembly
RH	Right hand
RJB	Relay junction box
rms	Root mean square
RNDZ	Rendezvous
RNG	Range
ROD	Rate of descent
RR	Rendezvous Radar
RRE	Rendezvous radar electronics
RT	Resistance thermometer
RUPT	Interrupt
RZ	Return-to-zero

S

S+N	Signal + noise
S/S	Subsystem
S&C	Stabilization and control
SBASI	Single bridgewire Apollo standard initiator
SBPA	S-band power amplifier
SBX	S-band transponder
SC	Signal conditioner
SCEA	Signal-conditioning electronics assembly
SCERA	Signal conditioner electronic replaceable assembly
SCO	Signal-controlled oscillator
SE	Systems Engineer
sec	Second(s); secondary
SEL	Select
SENS	Sensitivity
SEP	Separator
SEQ	Sequence
SERVO-AMPL	Servoamplifier
SG	Signal generator
SHe	Supercritical helium
SHFT	Shaft
SIG	Signal
sin	sine

ABBREVIATION LIST (cont)

S (cont)

SLA	Spacecraft Lunar Module adapter
SMRD	Spin motor rotation detector
SOL	Solenoid
SOM	Stable orbit midcourse
SOR	Stable orbit rendezvous
SOV	Shutoff valve
SP	Static pressure
SPA	Signal-processing assembly
SPDT	Single-pole double-throw
SRR	Shift-register reset
SRS.	Shift-register set
SS	Speed sensor
SSB	Single sideband
ST	Strain/temperature signal conditioner
STAB/CONT	Stabilization and control
STBY	Standby
SW	Switch
SYS	System

T

T/R	Transmitter-receiver
T_Δ	Time to go until CDH maneuver
T_{AI}	Absolute time
TBS	To be supplied
t_f	Time of flight from tig until target is reached
Tig	Time of ignition
T_N	Trim negative
T_P	Trim positive
TC	Thermocouple
TCA	Thrust chamber assembly
TE	Timing electronics equipment
TEMP	Temperature
TFF	Time of free fall to 3,000 ft
TFI	Time from Tig
THR	Thrust
TL	Tracker look-on
TLE	Tracking light electronics
TM	Telemetry
TPF	Transfer phase final
TPI	Transfer phase initiation
TPM	Transfer phase midcourse
TRANSL	Translation
TRUN	Trunnion
TS	Temperature sensor
TT	Temperature transducer
TTCA	Thrust/translation controller assembly
TTI	Time to initiate
TTIg	Time to ignition
TV	Television
TX	Telemetry transmitter

U

UDMH	Unsymmetrical dimethylhydrazine
UHF	Ultrahigh frequency
UPRUPT	Uplink interrupt
usec	Microsecond(s)

V

V	Verb
vac	Volts, alternating current
VCO	Voltage-controlled oscillator
V_{cx}	X-component of CSM velocity
V_{cy}	Y-component of CSM velocity
V_{cz}	Z-component of CSM velocity
VD	Velocity data
vdc	Volts, direct current
VDG	Velocity data good
VDNG	Velocity data no good
VEL	Velocity
VG	Magnitude of velocity to be gained
VGPS	Vehicle ground power supply
VHF	Very high frequency
VLV	Valve
VOL	Volume
VOX	Voice-operated relay
VPI	Valve position indicator
vrms	Volts root mean square
VSOM	Velocity sensor oscillator multiplier
V_x	X-component of LM velocity
V_{xa}	Altitude rate (landing radar)
V_y	Y-component of LM velocity
V_{ya}	Lateral velocity (landing radar)
V_z	Z-component of LM velocity
V_{za}	Forward velocity (landing radar)

W

W/B	Water boiler
WC	Weighted current
WCG	Weighted current gate
WMS	Water management section

X

XLUNAR	Translunar
XMTD	Transmitted
XMTR	Transmitter
XPNDR	Transponder
XTAL	Crystal
$\measuredangle$	Angle
Δh	Altitude differential

ABBREVIATION LIST (cont)

X (cont)		X (cont)	
ΔP	Pressure differential	ΔV_m	Measured ΔV magnitude
ΔR	Magnitude of difference between position state vectors before and after incorporation of mark data	$\Delta\phi c$	Gimbal angle change command
		$\Delta\phi g$	Change in gimbal angle
		ϕ	Phase
Δro	Differential altitude in co-elliptic orbit	Σ	Sum (summing)
		1X	One-speed resolver
ΔV	Velocity change (differential)	16X	Sixteen-speed resolver

2.9.4.5 Data Storage Electronics Assembly. (See figure 2.9-16.)

The DSEA is a single-speed, four-track, magnetic-tape recorder that stores voice and time-correlation data (TCD) (mission elapsed time). A maximum of 10 hours of recording time is provided (2.5 hours on each track) by driving the tape in one direction over the record head and, on completion of a pass, switching to the next track and reversing tape direction. The tape is supplied in a magazine, consisting of a supply reel and takeup reel. Once the magazine is properly placed in the DSEA and the control logic is placed in track No. 1 forward condition (reset), the DSEA is operated with the RECORDER switch on the COMMUNICATIONS portion of panel 12 in conjunction with the VOX trigger signal supplied by the signal-processing assembly (SPA) of the CS.

The DSEA operates in either a manual or semiautomatic mode. In the manual mode, the ICS T/R switch on the AUDIO portion of panel 8 or 12 is set to ICS T/R and the MODE switch on either panel is set to PTT. The PTT position bypasses the automatic voice sense circuits. The Commander or LM Pilot can close a push-to-talk switch (on the attitude controller assemblies or the umbilicals) and speak into a microphone. The push-to-talk switch energizes the VOX key relay, providing a ground for activation of the power control logic in the DSEA. In the energized state, this relay routes an enabling signal through the RECORDER switch and is applied to the recorder electronics. The audio signal generated by the astronaut is conditioned by the SPA and fed to the recorder for transfer to tape. For operation in the semiautomatic mode, the MODE switch is set to VOX. With the switch set to this position, the VOX trigger circuit is enabled. The VOX sense circuit senses voice input from within the cabin or from the communications receivers and feeds this signal to the VOX trigger circuit. When the two inputs are coincident, the trigger is activated. Setting the MOD switch to ICS/PTT results in a continuous key for the recorder. When operating in this mode, recorder operation is manually controlled with the RECORDER switch (panel 12). With the MODE switch in the ICS/PTT position, the RECORDER switch must be in the OFF position until voice is to be taped. The RECORDER TAPE talkback (panel 12) indicates tape motion during recording.

The DSEA consists of signal-conditioning electronics, a power supply, control logic, and a tape-motion amplifier. The signal-conditioning electronics accepts audio and TCD signals and conditions them before they are fed to the record head. Audio signals routed through the astronaut's intercommunications bus are applied to a voice amplifier that provides the band-pass filtering, impedance matching, and signal amplification required to drive the record head. Simultaneously with the voice input, TCD is supplied (as binary inputs) from the serial time code generator in the PCMTEA. A DSEA time-correlation data modulator accepts and converts serial binary-coded decimal data to frequency-coded data for recording. The binary input signals modulate a voltage-controlled oscillator to produce an output frequency of 4,175 cps, with a binary 1 input; 4,625 cps, with a binary 0 input. These voice and timing signals are mixed with the outputs of a reference oscillator that supplies a constant 5.2-kc signal for subsequent use in the DSEA test station, servoamplifiers, and a bias oscillator, which provides a 33-kc signal that eliminates nonlinear response in playback of voice and data. This permits recording multiplexed data on each of the four tracks. The control logic provides transport control, automatic track switching for the four tape passes, and starting and stopping of the DSEA. The tape transport uses a closed-loop capstan drive system with controlled tension in the record/reproduce head area. Dual capstans with a high angle of tape wrap provide sufficient driving friction without the use of pinch rollers. The drive motor in the tape transport is of the single-phase, 400-cycle, hysteresis, synchronous type with constant speed (+0.1% of input power). During recording, the reproduce head reads the recorded track and, through the tape-motion amplifier, supplies the signal that operates the TAPE talkback

IS

2.9.4.5.1 Power Supply.

The DSEA power supply consists of a power converter and voltage regulator, which provide regulated d-c power for all DSEA electronics. The power converter conditions 115-volt, 400-cps, power supplied from control logic circuits, to voltage levels of +17 and -8 volts dc. The +17 volts operates relays in control logic and tape-motion monitor circuits. It is also applied to the voltage regulator, along with the -8 volts. A-C power for the capstan drive motor is supplied from a tap on the primary winding of a transformer (T1). The voltage regulator regulates the +17 and -8 volts dc from the power converter to +11.5 and -4.5 volts, respectively. These voltage levels are required for DSEA electronic circuitry.

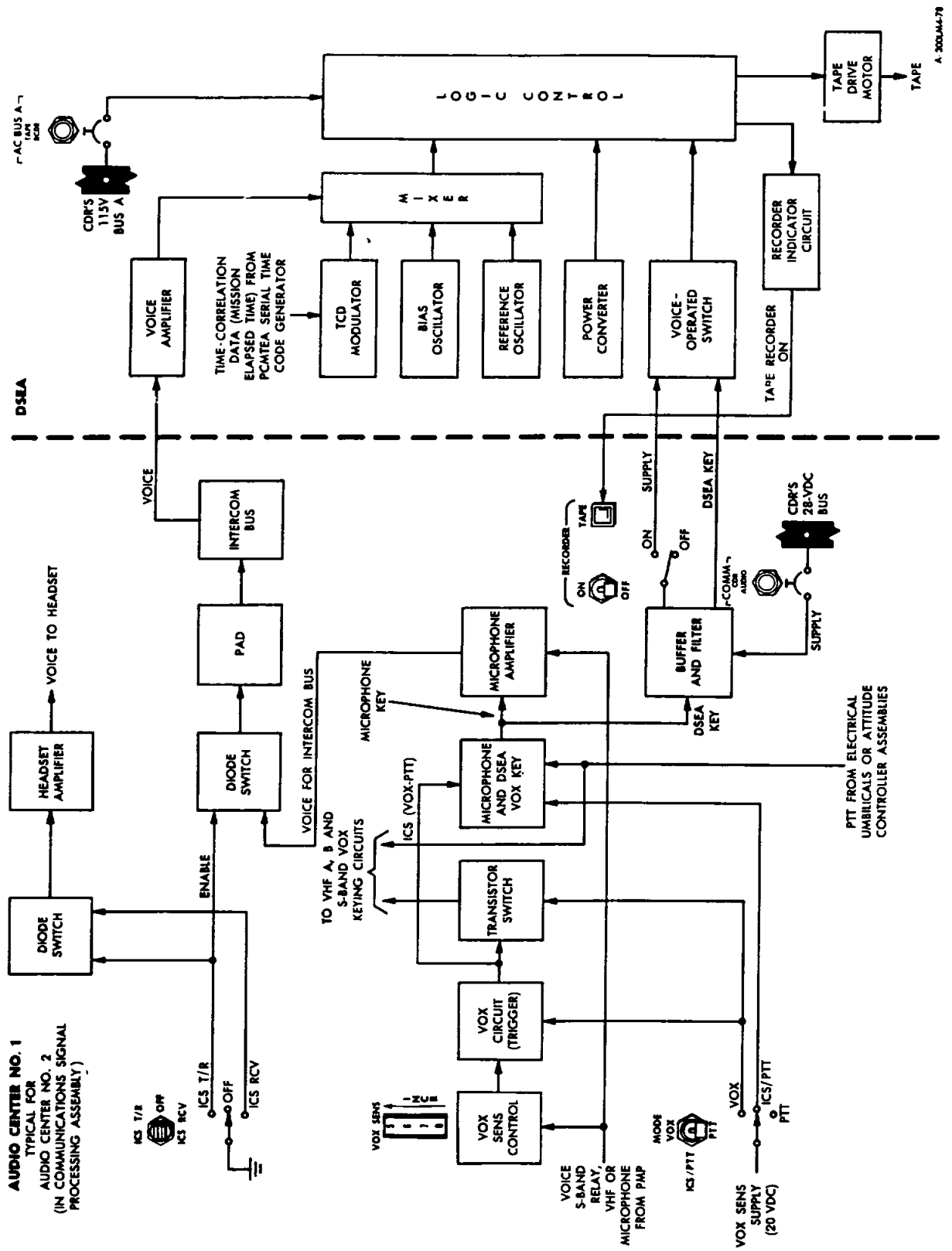

Figure 2.9-16. DSEA - Functional Block Diagram

2.9.5 PERFORMANCE AND DESIGN DATA.

The performance and design data for the IS are given in table 2.9-4.

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data

Pulse-code-modulation and timing electronics assembly	
Height	6.72 inches
Width	5.12 inches
Length	19.75 inches
Weight	23.0 pounds (approximate)
Power requirements	
Excitation	20 to 32 volts dc
Consumption	11 watts
Operating temperature (ambient)	+30° to +130° F
Reliability	
Component calibration	Amplifiers, analog-to-digital converter, and all analog circuitry with functions common to 10 or more measurements
Calibration levels	4.250 volts, 0.750 volts
Accuracy	±9 millivolts on high level
High-level analog signals	
Number of channels	277
Normal bit rate (51.2 kilobits per second)	200 channels externally programmed, 77 channels internally redundant
Reduced bit rate (1.6 kilobits per second)	113 channels externally programmed, 41 channels internally redundant
Signal levels	0 to 5 volts
Analog error	0.5% (maximum)
Sampling rate	1, 10, 50, 100, or 200 samples per second
Bits formed per channel input	8
Parallel digital signals	
Number of channels	75
Normal bit rate	1, 10, 50, 100, or 200 samples per second
Reduced bit rate	1 sample per second

IS

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Pulse-code-modulation and timing electronics assembly (cont)	
Parallel digital signals (cont)	
Signal levels	
Binary 1	+3.5 to +10 volts
Binary 0	-0.5 to +1.5 volts
Bits per output word	8, 16, or 32
Sampling sequence for 8-, 16-, and 32-bit input words	Sequential, with eight most significant bits first
Serial digital signals	
Number of channels	2 channels, serial by bit
Signal levels	
Binary 1	+3.5 to +10 volts
Binary 0	-0.5 to +1.5 volts
Word length	One 24-bit channel One 40-bit channel
Normal bit rate	50 samples per second
Reduced bit rate	None
1,024-kpps input signals	
Type	Square wave
Amplitude	7±3 volts, peak to peak
NRZ output	
Bit rate	51.2 or 1.6 kilobits per second
Signal levels	
Binary 1	+6±0.5 volts
Binary 0	0.0 to +0.5 volt
RZ output	
Bit rate	51.2 or 1.6 kilobits per second
Signal levels	4.5±2 volts, peak to peak

Table 2.9 4 Instrumentation Subsystem - Performance and Design Data (cont)

Pulse-code-modulation and timing electronics assembly (cont)	
Data rate timing output	
Frequency	51.2 or 1.6 kpps (selected by remote switching)
Signal levels	4.5±2 volts, peak to peak
Subcarrier reference output	
Frequency	51.2 pps
Signal levels	
10-kilohm output load	0.0 to +0.5 volt and +6±0.5 volts
100-ohm output load	4.5±2 volts, peak to peak
Subframe sync pulse output	
Frequency	1 pps
Signal levels	4.5±2 volts, peak to peak
512-kpps timing output signals	
Frequency	512 kpps
Signal levels	0.0 to 0.5 volt and +3.0 ±0.5 volts
6.4-kpps timing output signals	
Frequency	6,400 pps
Signal levels	0.0 to 0.5 volt and +3.0 ±0.5 volts
1.6-kpps timing output signals	
Frequency	1,600 pps
Signal levels	0.0 to 0.5 volt and +3.0 ±0.5 volts
10-pps timing output signal	
Frequency	10 pps
Signal levels	0.0 to 0.5 volt and +3.0 ±0.5 volts
1024-kpps timing output signal	
Frequency	1024 kpps
Signal levels	0.0 to 0.5 volt and +3.0 ±0.5 volts
Time-correlation data	
40-bit serial start	
Frequency	1 pps
Signal level	4.5±1 volts, peak to peak

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Pulse-code-modulation and timing electronics assembly (cont)	
Time-correlation data (cont)	
40-bit serial stop	
Frequency	1 pps
Signal level	4.5±1 volts, peak to peak
40-bit serial sync	
Frequency	2 kpps
Signal level	4.5±1 volts, peak to peak
24-bit serial sync	
Frequency	1.2 kpps
Signal level	4.5±1 volts, peak to peak
24-bit serial stop	
Frequency	1 pps
Signal level	4.5±1 volts, peak to peak
Low-bit-rate split-phase data outputs	
Bit rate	1.6 kilobits per second
Signal levels	+6.0 ±0.5 volts (up level) +0.0 to 0.5 volt (down level)
Analog-to-digital conversion	
Each analog sample	8-bit binary word output
Full-scale input to ADC	11111110
Zero input	00000001
Greater than full scale	11111111
Less than zero	00000000
Signal-conditioning electronics assembly	
Height	8.0 inches
Width	5.25 inches
Length	23.90 inches
Weight	
ERA-1	35.44 pounds
ERA-2	35.25 pounds

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Signal-conditioning electronics assembly (cont)	
Power requirements	
Excitation	28 volts dc
Consumption	
ERA-1	16.04 watts
ERA-2	14.23 watts
Thermal characteristics	An efficient thermal path exists between heat-producing sources within subassemblies and an external heat sink.
Environmental limits	
Vibration	8.1g rms from 20 to 2,000 cps
Acceleration	8g
Shock	15g sawtooth
Temperature	
Operating	+30° to +130° F
Nonoperating	-65° to +160° F
D-C amplifiers	
Inputs	
Unipolar mode	0 to 200 millivolts dc and 0 to 5 volts dc
Bipolar mode	-100 millivolts to -2.5 volts dc and +100 millivolts to +2.5 volts dc
Output	0 to 5 volts dc (four single channels)
Attenuators	
Inputs	
Unipolar mode	0 to 5 volts dc (minimum attenuation) 0 to 40 volts dc (attenuation of 8)
Bipolar mode	-2.5 to +2.5 volts dc and -20 to +20 volts dc
Output	0 to 5 volts dc (four single channels)
AC-to-dc converters	
Input frequency	380 to 840 cps
Output	0 to 5 volts dc (three single channels)
Analog signal isolating buffer	
Input	0 to 5 volts dc
Output	0 to 5 volts dc (four single channels)

IS

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Signal-conditioning electronics assembly (cont)	
Discrete signal isolating buffers	
504-2	
Turn-on voltage	0.5 to 2.5 volts dc
Output voltage	0.to 5 volts dc (10 dual channels)
504-3-4	
Output voltage	0 to 5 volts dc (12 dual channels)
504-5	
Output voltage	0 to 5 volts dc (12 single channels)
Frequency-to-dc converter	
Input frequency	380 to 420 cps
Output	0 to 5 volts dc
Resistance-to-dc converters	
Resistance changes	665 to 2, 795 ohms (-200° to +500° F)
Output	0 to 5 volts dc (four dual channels)
Phase-sensitive demodulators	
Output	0 to 5 volts dc
Caution and warning electronics assembly	
Height	7.0 inches
Width	6.750 inches
Length	11.750 inches
Weight	19.75 pounds (approximate)
Power requirements	
Excitation	28 volts dc
Consumption	13 watts
Internally generated	+4, +23, +12, +9, -3, +7, and 16.3 volts dc, rectified
	Three 34-volt, zero-to-peak, 10-kc, center-tapped square waves
	One 15.5-volt, zero-to-peak, 10-kc, center-tapped square wave
	Two 10-kc reference signals

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Caution and warning electronics assembly (cont)	
Environmental limits	
Temperature	
Operating	+35° to +135° F
Nonoperating	-65° to +160° F
Vibration	8.1g rms from 20 to 2,000 cps
Shock	15g sawtooth
Acceleration	8g
Input signals	
Caution	
Discrete	26
Analog	23
Inhibit	3
Enable	4
Warning	
Discrete	10
Analog	22
Inhibit	7
Enable	2
Indicator reset	
Caution	10
Warning	1
Thrust chamber assembly (TCA) logic	
Command (discrete or analog)	16
Response (discrete)	16
Output signals	
Caution light	17
Warning light	14
Component caution light	2
Talkback	8
MASTER ALARM pushbutton/light	2

IS

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Caution and warning electronics assembly (cont)	
Inputs	
Analog signals	0.5 to 5.0 volts dc
Discrete, malfunction	3.4 to 6.0 volts dc
Discrete, no malfunction	0 to 0.5 volt dc
Out-of-limit inputs	Delay time (input to output): 0.5 second maximum
Telemetry output	
Malfunction	Relay contacts open
No malfunction	Relay contacts closed
Voltage limits	
Upper	Output signal generated when preset voltage is exceeded
Lower	Output signal generated when preset voltage is exceeded
Data storage electronics assembly	
Height	2.05 inches
Width	4.0 inches
Length	6.22 inches
Weight	38 ounces
Power requirements	
Power supply input	115±2.5 volts rms, 400 cps, single phase
Reset command	28±4 volts dc
VOX command input	28+4-8 volts dc
Output	+17 volts dc unregulated, +11.5 volts dc regulated 26.0 volts rms
Magnetic heads	Two record/reproduce heads to provide four tracks
Voice record amplifier	
Input level	-3 to +7 dbm
Frequency response	300 cps to 3,000 cps ±3 db
Bias oscillator	
Output frequency	33 kc ±10%
Output level	5±1 milliamperes

Table 2.9-4. Instrumentation Subsystem - Performance and Design Data (cont)

Data storage electronics assembly (cont)	
Tape	
Speed	0.6 inch per second
Total recording time	10 hours (maximum)
Length of tape between sensor strips	450 feet (minimum)
Power Source	
AC	115±2.5 volts rms
DC	28 volts dc
DSEA transport	
Speed error	0.05 of input power deviation
Start time	100 milliseconds after receipt of VOX trigger
Stop time	300 milliseconds after cessation of VOX trigger
Record time	Total of 10 hours
End of tape	Automatically sensed
Time-correlation data	
Input	Serial NRZ-C (100 bits per second)
Input levels	
Binary 1	6±1 volts
Binary 0	-0.5 to 1.5 volts

IS

2.9.6 OPERATIONAL LIMITATIONS AND RESTRICTIONS.

The operational limitations and restrictions for the IS are as follows:

- The PCMTEA, SCEA, and signal sensors (for preconditioned transducers) must be warmed up for 5 minutes after coolant-loop stabilization, before use. If the 5-minute warmup period is not allowed, the accuracy of data will be uncertain.
- Total recording time (voice keyed) for the DSEA voice tape recorder is 10 hours. The DSEA will not record voice after 10-hour use.

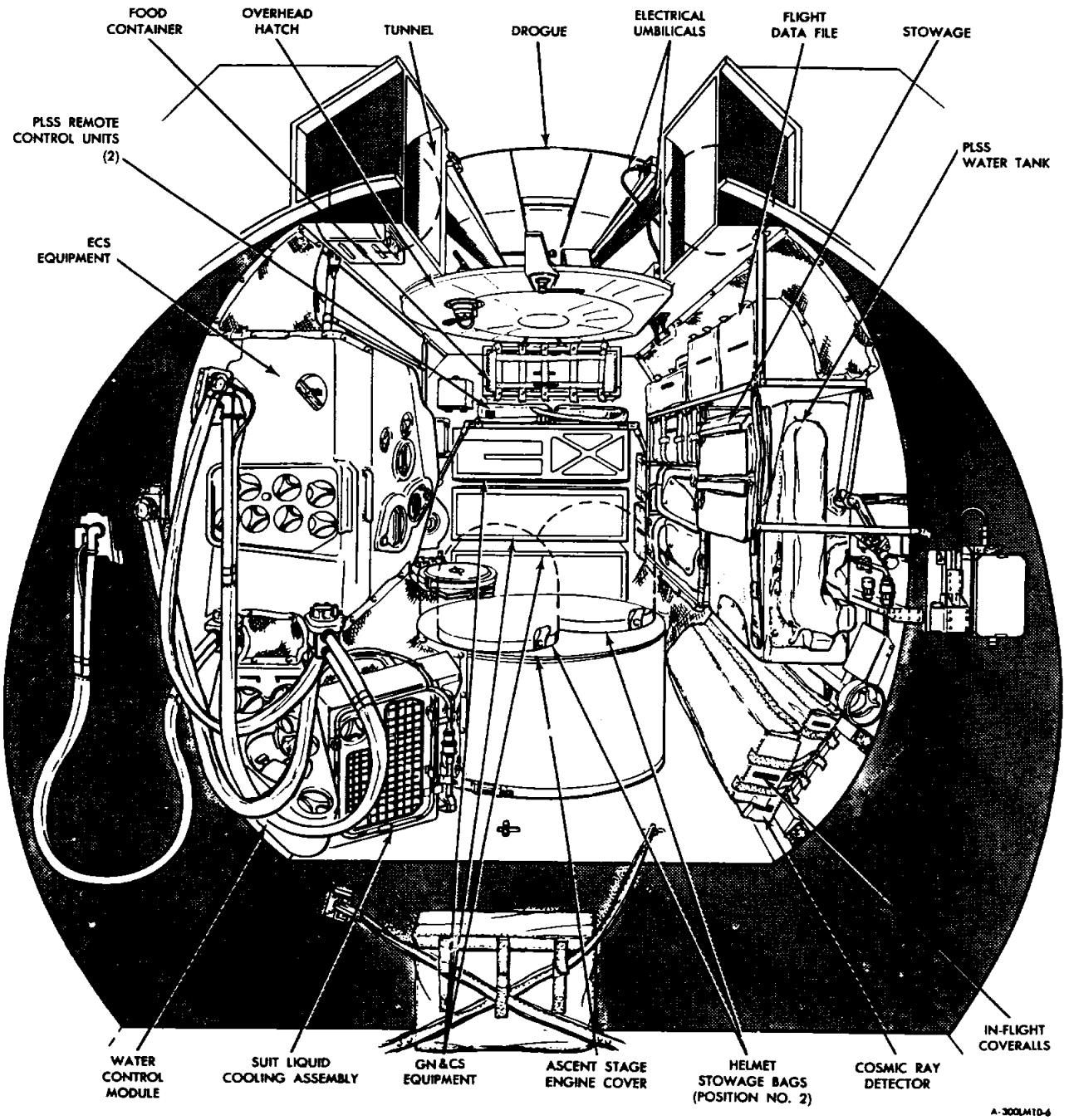

Figure 2.11-19. LM Cabin Interior, Aft View

CPE