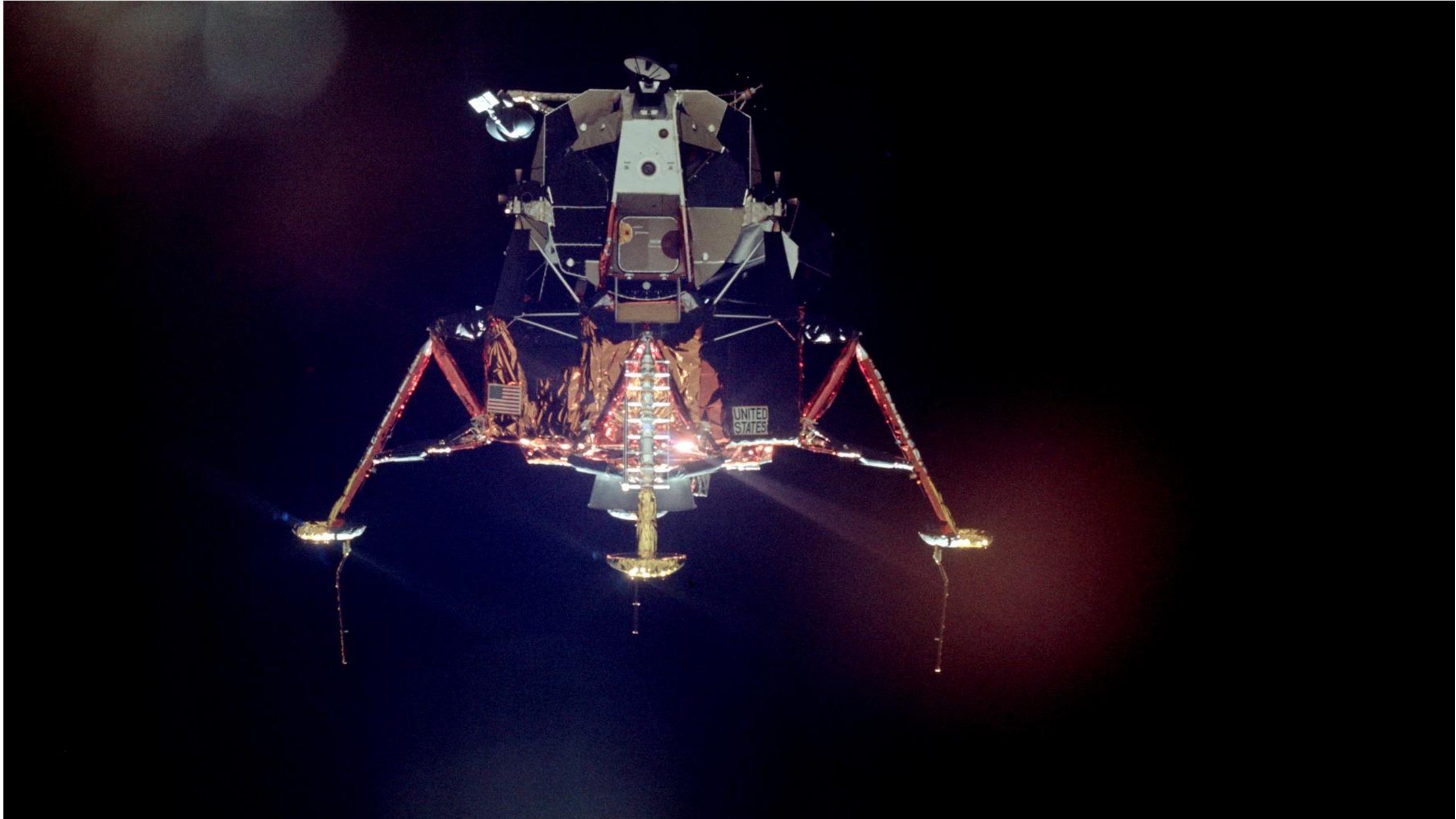
Lunar Module

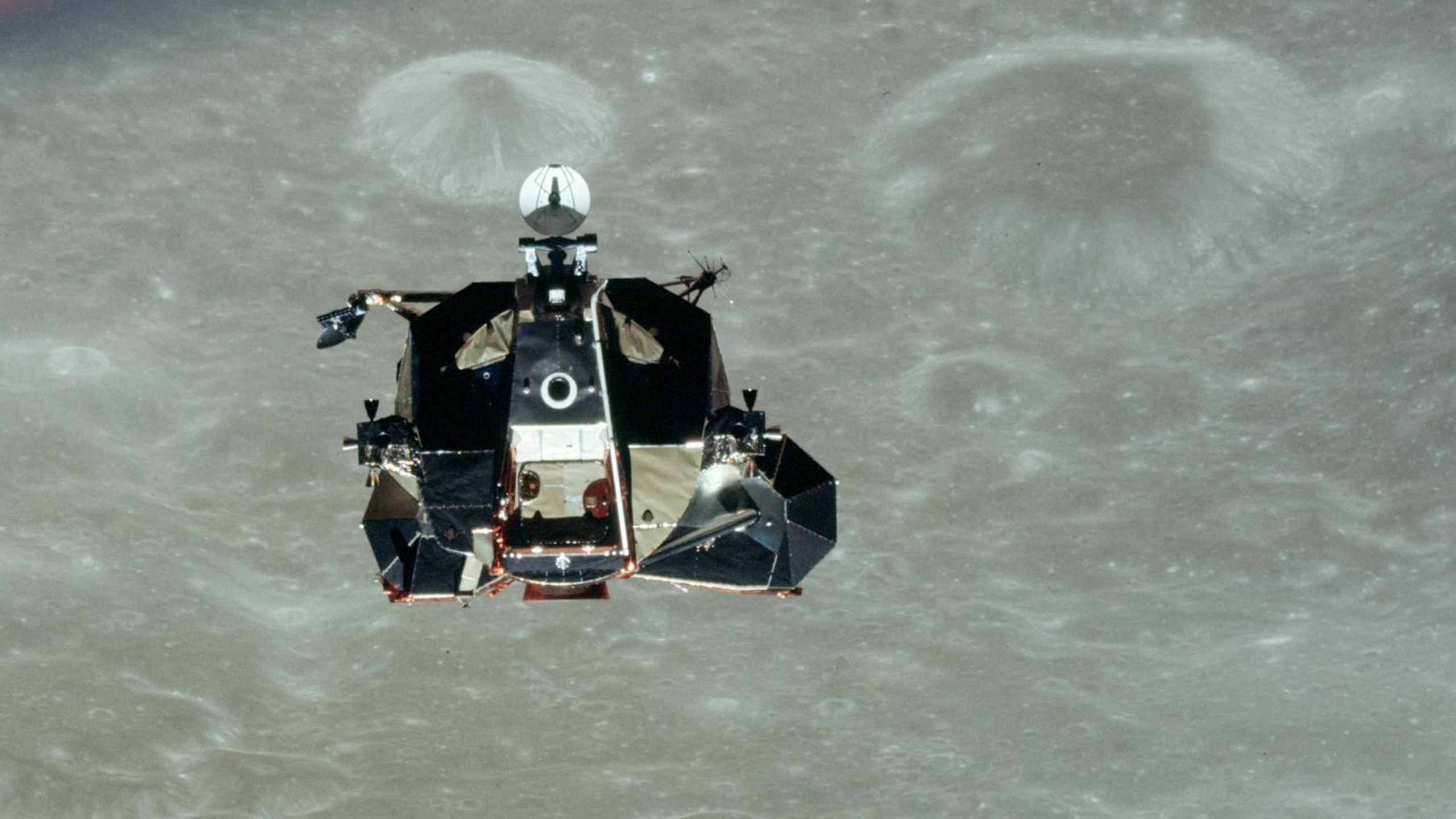
INST 154

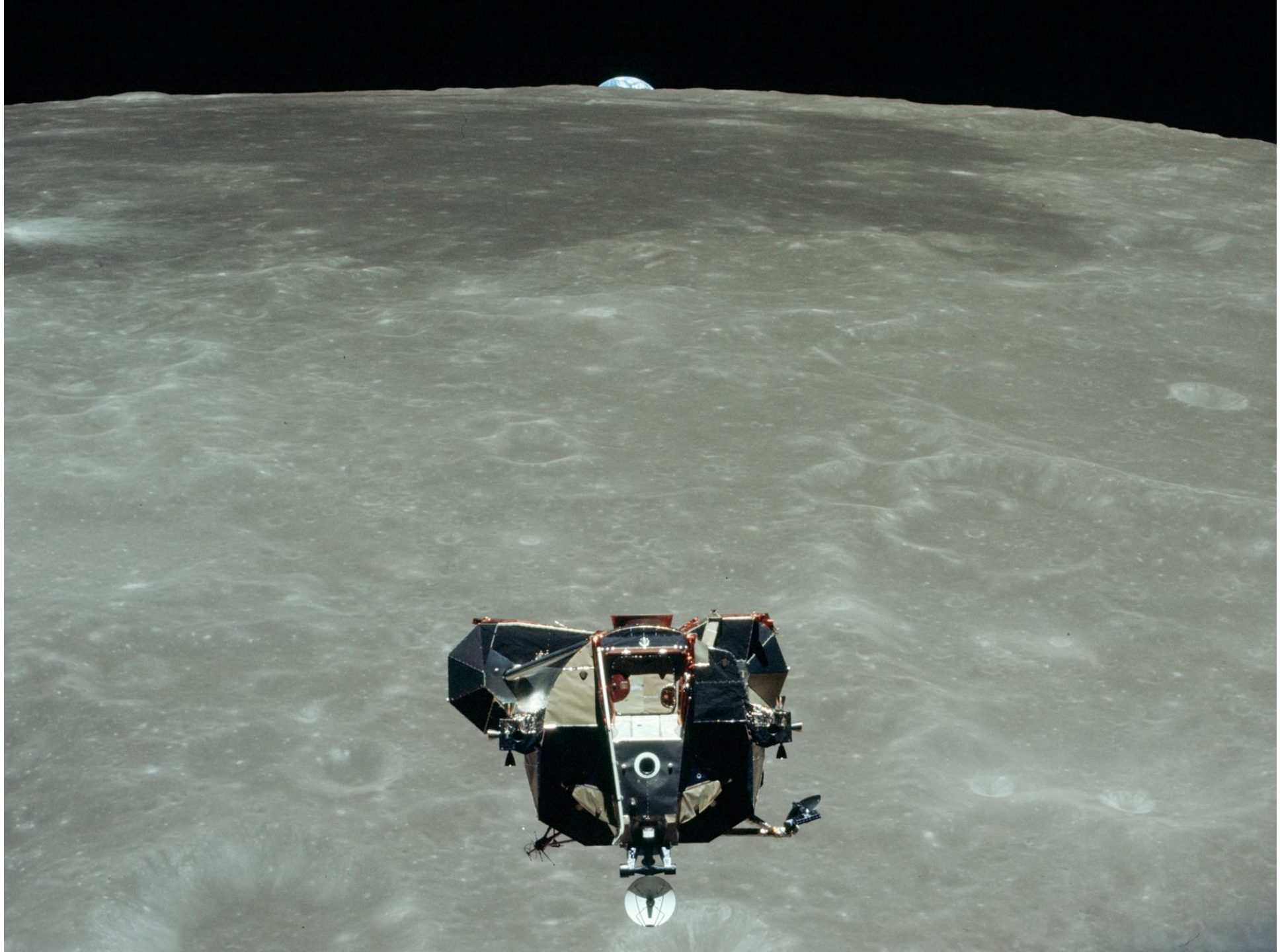
Apollo at 50

Agenda

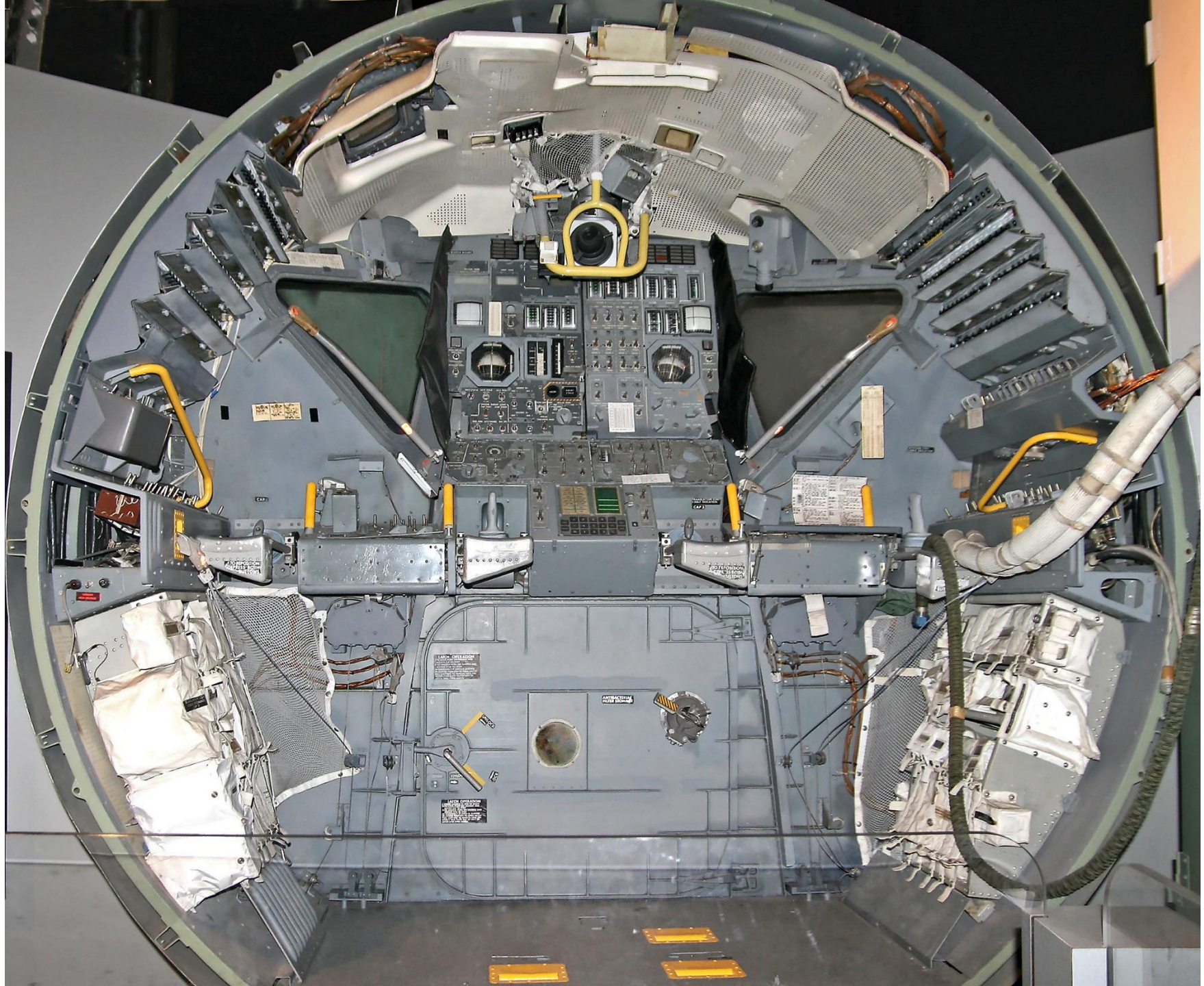
- Lunar Module
- Apollo Spacesuit
- Risk Management
- (Discussion groups)
- Case study papers

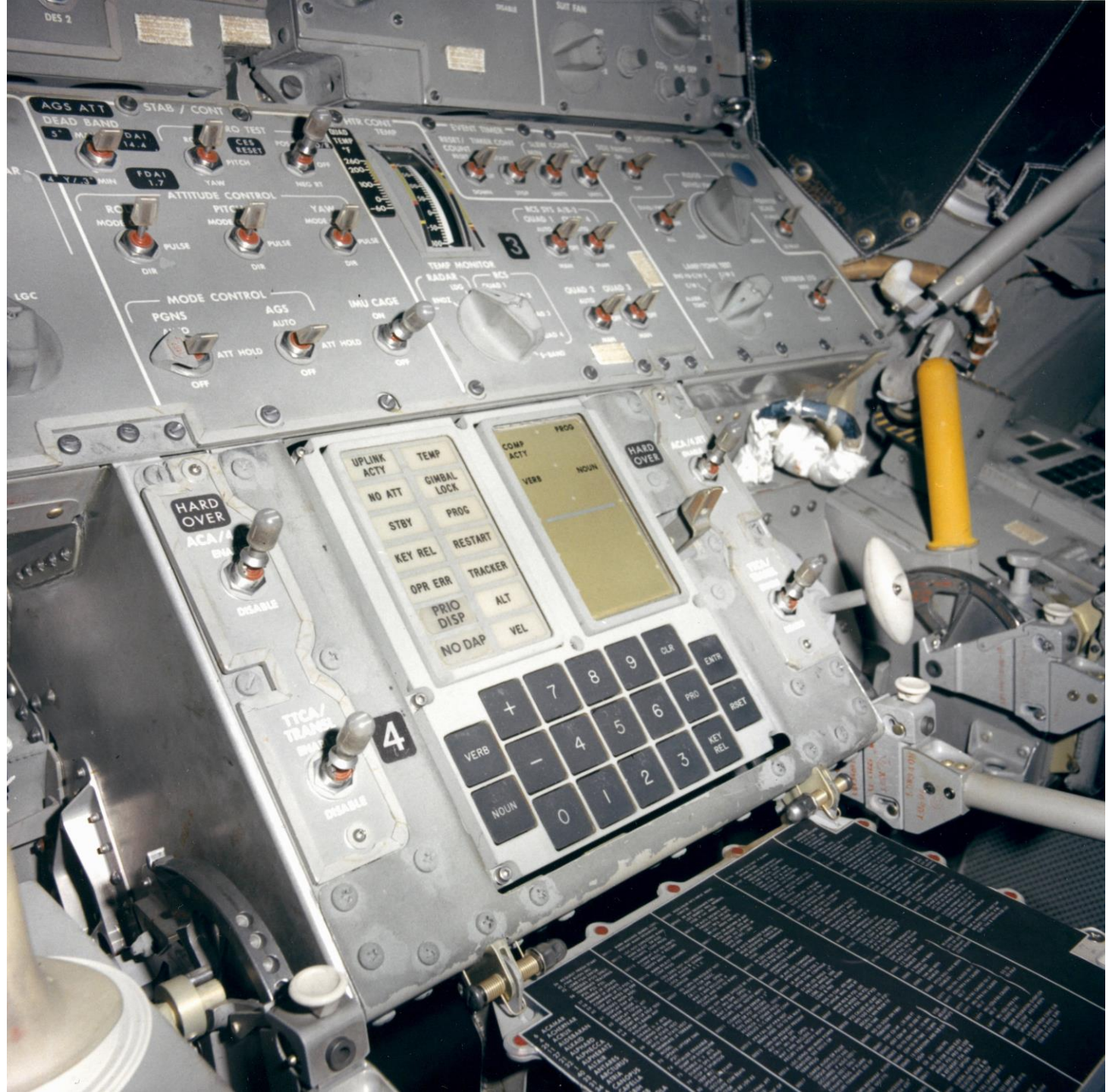

UNITED
STATES

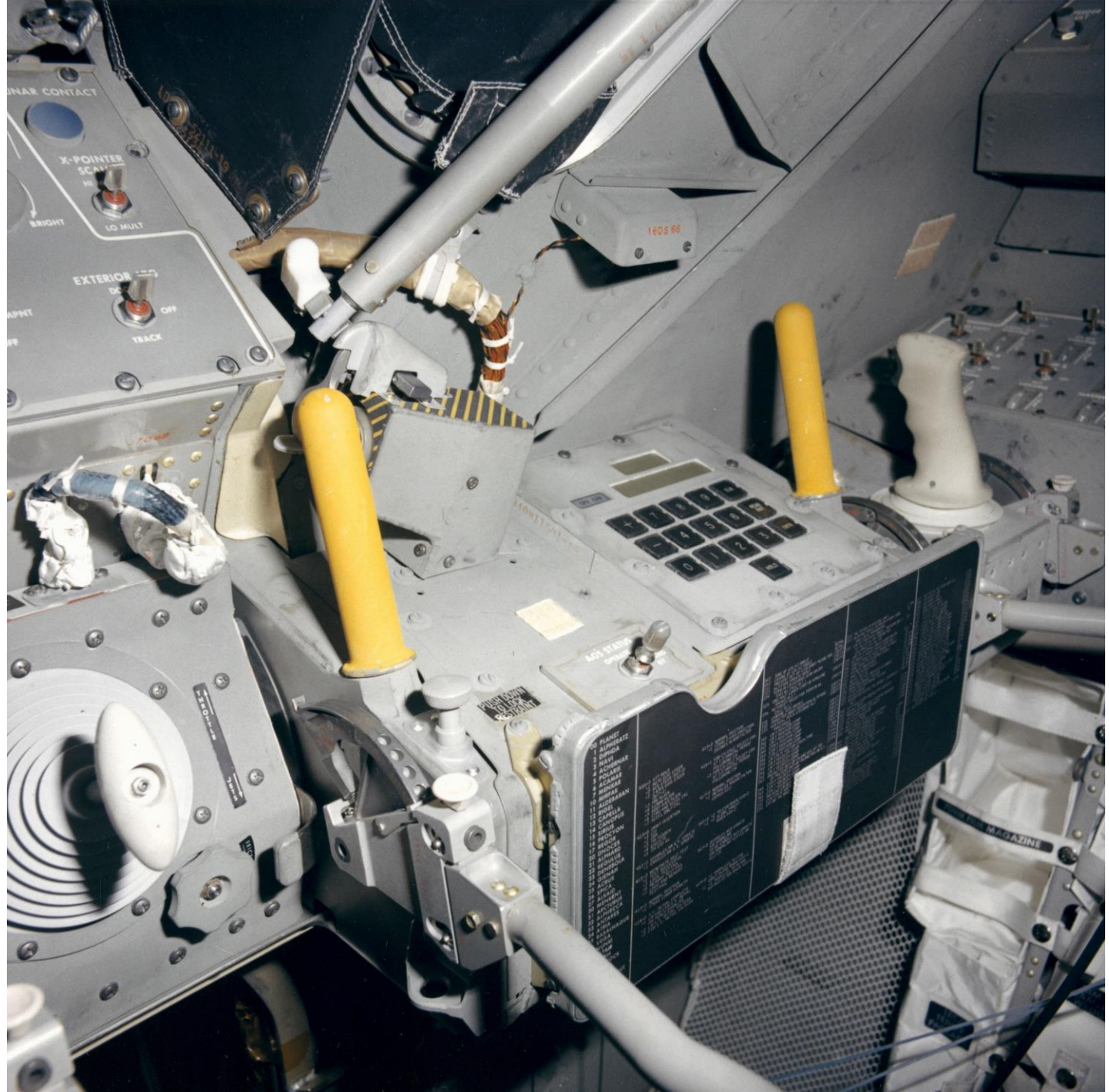


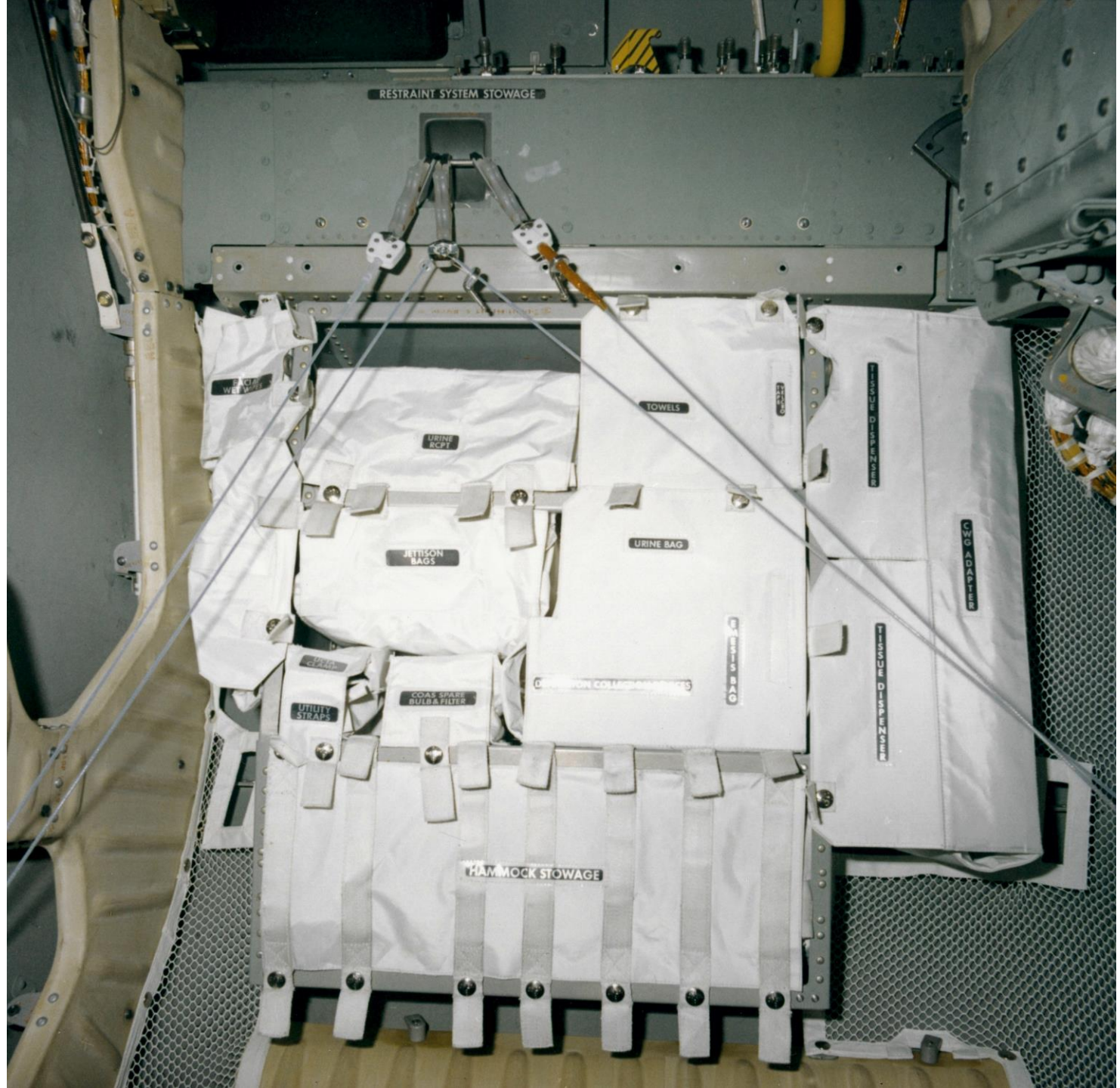



LM SIMULATOR



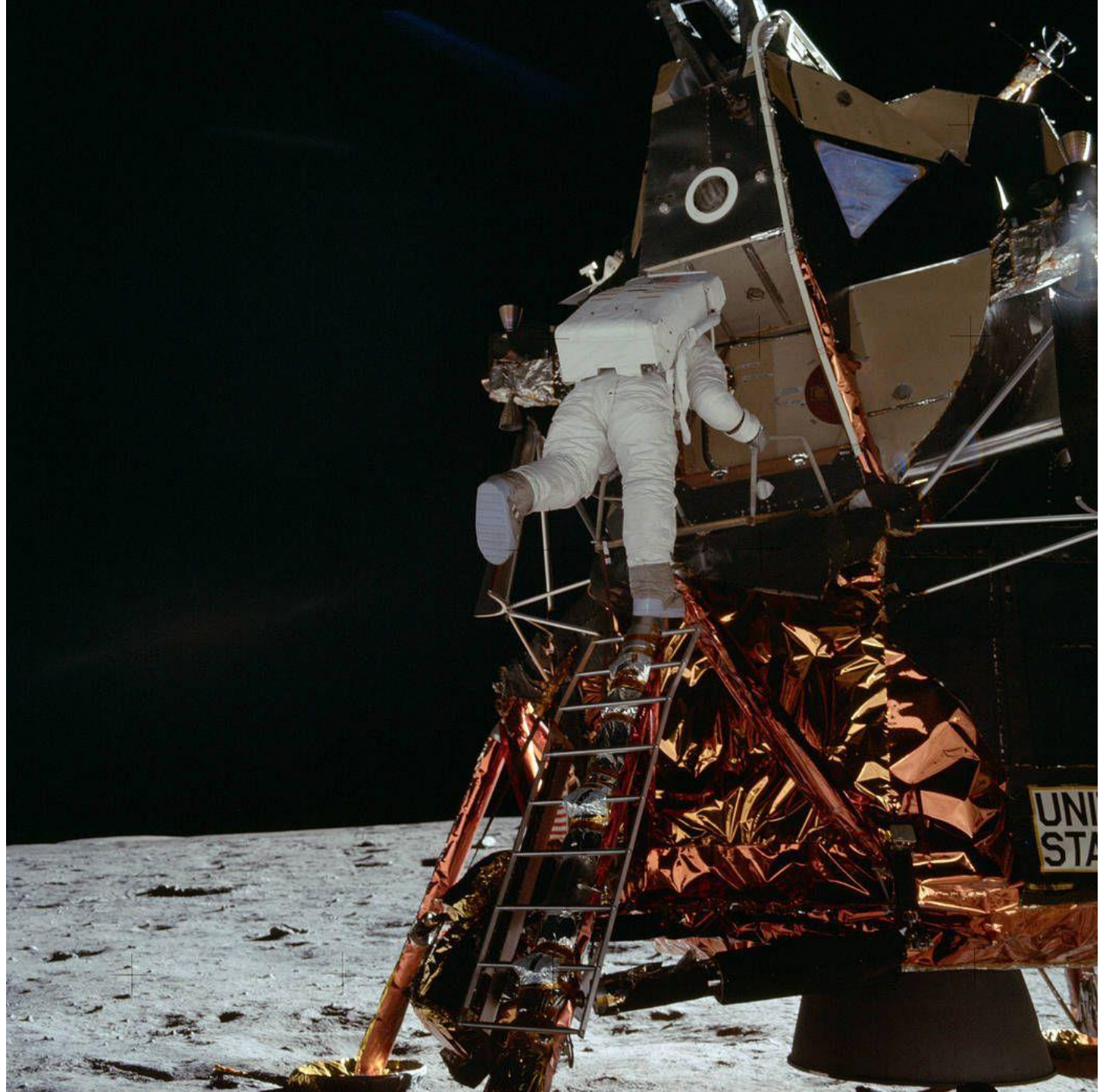

AGS ATT
STAB / CONT
DEAD BAND
ATTITUDE CONTROL
MODE CONTROL
PGNS
AGS
IMU CAGE
ATT HOLD
OFF
TEMP MONITOR
RADAR
HARD OVER
DISABLE
UPLINK ACTY
TEMP
NO ATT
GIMBAL LOCK
STBY
PROG
KEY REL
RESTART
OPR ERR
TRACKER
PRIO DISP
ALT
NO DAP
VEL
COMP ACTY
VERB
NOUN
CLR
ENTR
RSET
KEY REL
TTCA/ THC
4


X-POINTER SCAN
BRIGHT
LO MULT
EXTERIOR
OFF
TRACK
MAGAZINE


RESTRAINT SYSTEM STOWAGE
TOWELS
URINE RCPT
URINE BAG
JETTISON BAGS
TISSUE DISPENSER
CWG ADAPTER
TISSUE DISPENSER
COAS SPARE BULB & FILTER
UTILITY STRAPS
HAMMOCK STOWAGE


PULL AND TURN
FLIGHT DATA FILE
NASA
J. YOUNG
J. YOUNG
J. YOUNG


PLSS HARNESS
EQUIPMENT TRANSFER BAG
C. DUKE


UNI
STA

Learning as You Go

- Seats?
  - Too heavy, too far from the windows
- Forward docking port?
  - Too small to exit with a PLSS backpack
- Fuel cells?
  - Too late
- Descent engine throttling
  - Parallel development, but both worked
- Ascent engine injector
  - No parallel development until 1967, but it was needed!

Subcontracted LM Components

CALIFORNIA (56)
Abort Electronics Assembly
Absolute and Differential Pressure Transducers
Absolute Pressure Switch
Actuator Bellows Assembly
Air Filter
Ambient Helium Tanks
Ascent - GOX Tanks Ascent Helium Storage
Ascent Engine - Injector and Combustion Chamber
Ascent Propellant Tanks
Bulkhead Feedthrough Connectors
Burst Disk
Cable Cutter Explosive Devices
Circular Connectors
Coaxial Switches and Connectors
Coupling Disconnects
Coupling Test Points
Data Storage
Data Entry Display Assembly
Descent Engine
Diplexer
Disconnect
Disconnect. Flight Half
Descent Propellant Tanks (LM 6 and later)
Docking Lights
End Detonator Cartridges
Explosive Nut and Bolt Assembly
Explosive Valves
Gimbal Drive Actuators

CALIFORNIA (contd.)
Helium Explosive Valves
Helium Filter
Helium Pressure Valve
Helium Quad Check Valve
Helium Relief Valve
Helium Valve - Descent Regulator
High Pressure O2 Control Assembly
Initiator
Interstage Disconnect
Landing Gear Uplock Cutter Assembly
Latching Valve
Oxygen Fill Disconnect
Potentiometer
Pressure Relief Valve
Propellant Filter
Propellant Quantity Measuring Device
Propellant Solenoid Valve
Quad Check Valve
RCS Explosive Cartridge
Reaction Control Subsystem
Regulating Valve
Steam Vent Divider
Suit Loop Switch
Supercritical Helium Tanks
Surge Tank Disconnect
Transducer
TTCA Transducer
Universal Ball Joint

NEW YORK (21)
Ascent Engine - Skirt Bell and Valves
Caution and Warning Electronic Assembly
Control Electronic Section
Exterior Tracking Light
H20 Bacteria Filter
Heater Assembly (RCS)
Helium Filter Aircraft
Lighting Control Assembly
Mission Timer
Panel Overlay
PLSS Condensate Collector
Program Reader Assembly
Propellant Filters
Propellant Level Detectors
Propellant Tanks
Relays
Sensor Probe
Signal Conditioning Electronics Assembly
Waste Management System
Window Panel Assembly
Windows

MASSACHUSETTS (9)
Attitude and Translation Control Assembly
Descent Engine Control Assembly
Discrete Transducers
Event Timer
Landing Radar and Rendezvous Radar Subsystem
Miniature Switch
Mission Timer
Toggle Switch
Transistors

Subcontracted LM Components

NEW JERSEY (8)
Communication Subsystem
Helium Temperature Pressure indicator
Propellant Quantity indicator
Range/Altitude Indicator
Rotary Switch
Rough Combustion Cutoff
Solenoid Valve
Synchros

CONNECTICUT (7)
Caution and Warning
C02 Sensor
Component Caution
Environmental Control Subsystem
Inverter
Pressure Garment Assembly 02 Connectors
Waveguides

MINNESOTA (7)
Attitude Control Assemblies
Flag indicators (Talkbacks)
Pushbutton Switch
Self-Luminous Devices
Signal Strength Meters
Target Assembly
X (Cross) Pointers

MICHIGAN (6)
Circuit Breakers
Flight Director Attitude Indicators
Gimbal Angle Sequencing Transformation Assembly
Helium Latch Valve
Relief Valve
Time Delay

OHIO (4)
Digital Uplink Assembly
Electroluminescent Lamps
Interior Floodlight
Portable Utility Light

ARIZONA (3)
Circuit Interrupter
Fire-in-The-Hole (FITH) Connector
Interrupter

VIRGINIA (3)
C-Band Transponder
Electrical Control Assembly
RF Signal Sampling Sensor

FLORIDA (2)
Pulse Code Modulation/Timing Electronic Assembly

INDIANA (2)
Descent Propellant Tanks (LM4 and 5)
Heat Exchanger Discrete

MISSOURI (2)
Ascent and Descent Batteries
Bacteria Filter

VERMONT (2)
Retractable Cable
Wire

IOWA (1)
Thrust/Weight Indicator

MAINE (1)
Propellant Quantity Gaging System

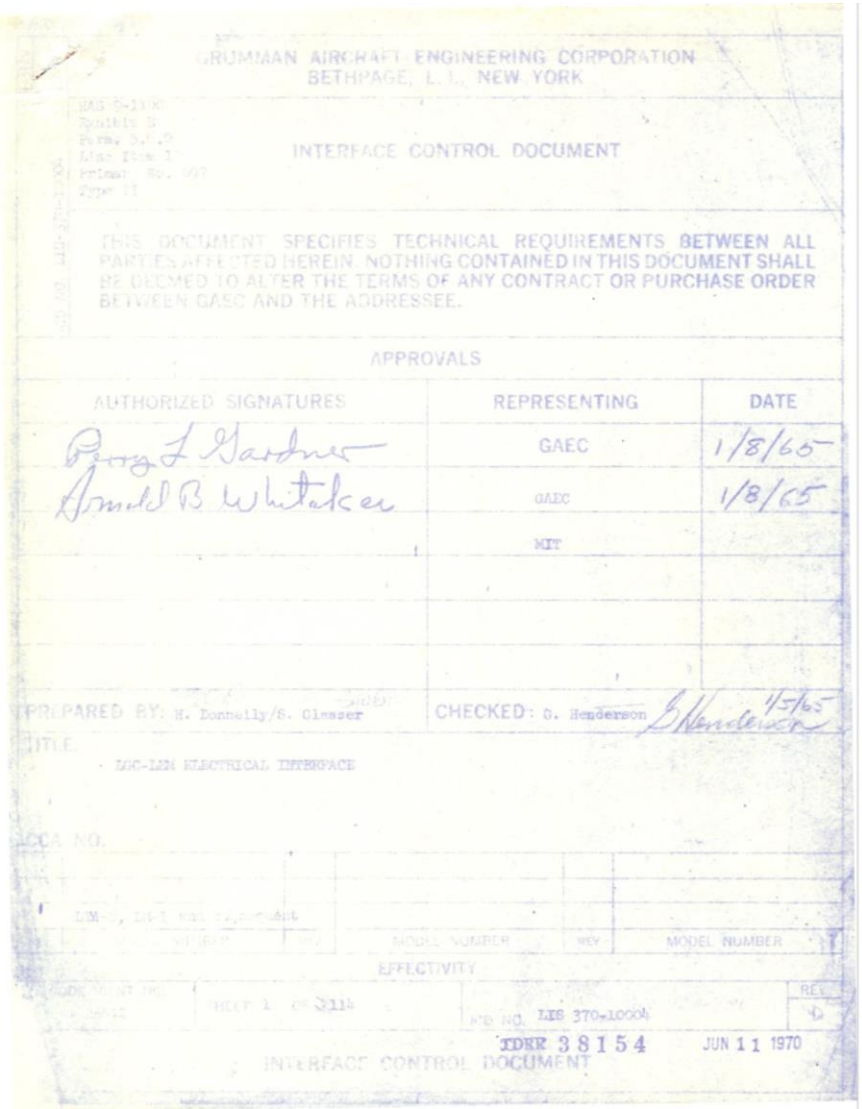
MARYLAND (1)
Oxygen Hose

NORTH CAROLINA (1)
Pyro Battery

RHODE ISLAND (1)
Flex Lines

TENNESSEE (1)
Cold Plate Assembles

Interface Control Documents



GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, L. I., NEW YORK

INTERFACE CONTROL DOCUMENT

THIS DOCUMENT SPECIFIES TECHNICAL REQUIREMENTS BETWEEN ALL PARTIES AFFECTED HEREIN. NOTHING CONTAINED IN THIS DOCUMENT SHALL BE DEEMED TO ALTER THE TERMS OF ANY CONTRACT OR PURCHASE ORDER BETWEEN GAEC AND THE ADDRESSEE.

APPROVALS

AUTHORIZED SIGNATURES	REPRESENTING	DATE
Doug L Gardner	GAEC	1/8/65
Arnold B Whitaker	GAEC	1/8/65
	MIT	

PREPARED BY: H. Donnelly/S. Glesser CHECKED: S. Henderson 1/5/65

TITLE: LGC-LEM ELECTRICAL INTERFACE

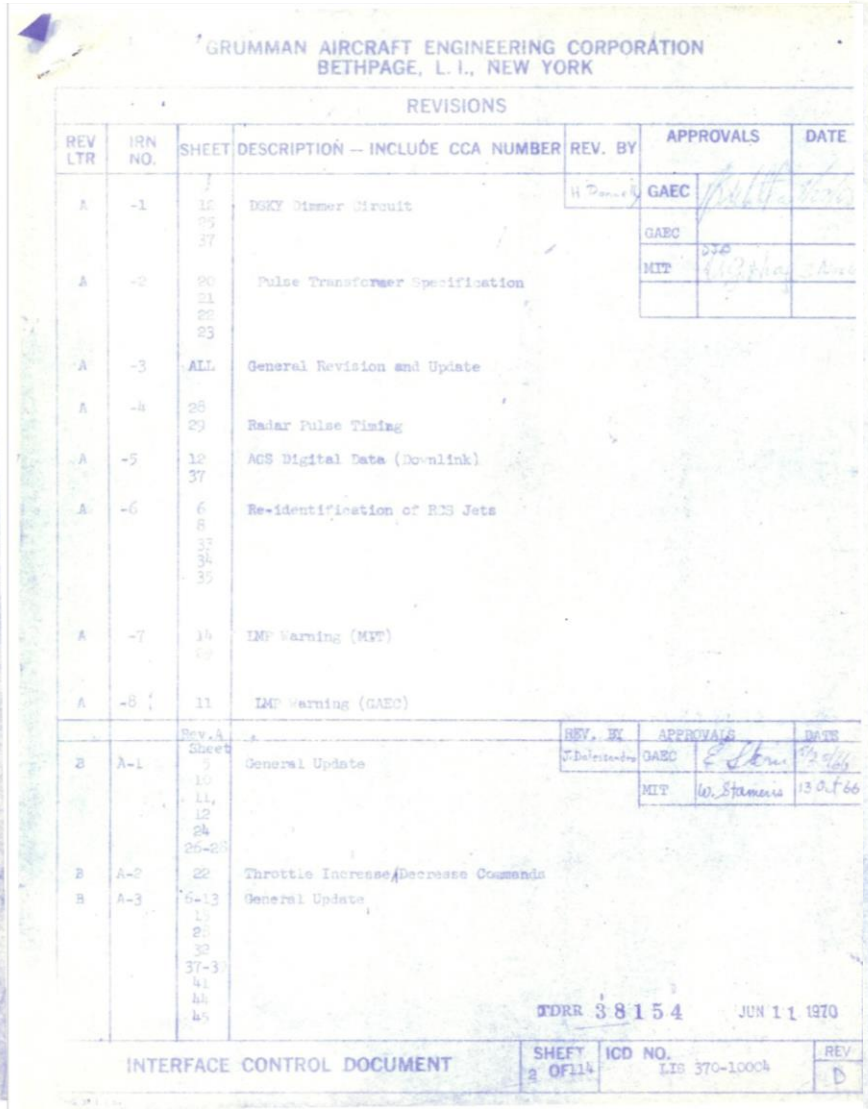
CCA NO.

EFFECTIVITY

SHEET 1 OF 114 ICD NO. LIS 370-10004 REV D

IDRR 38154 JUN 11 1970

INTERFACE CONTROL DOCUMENT



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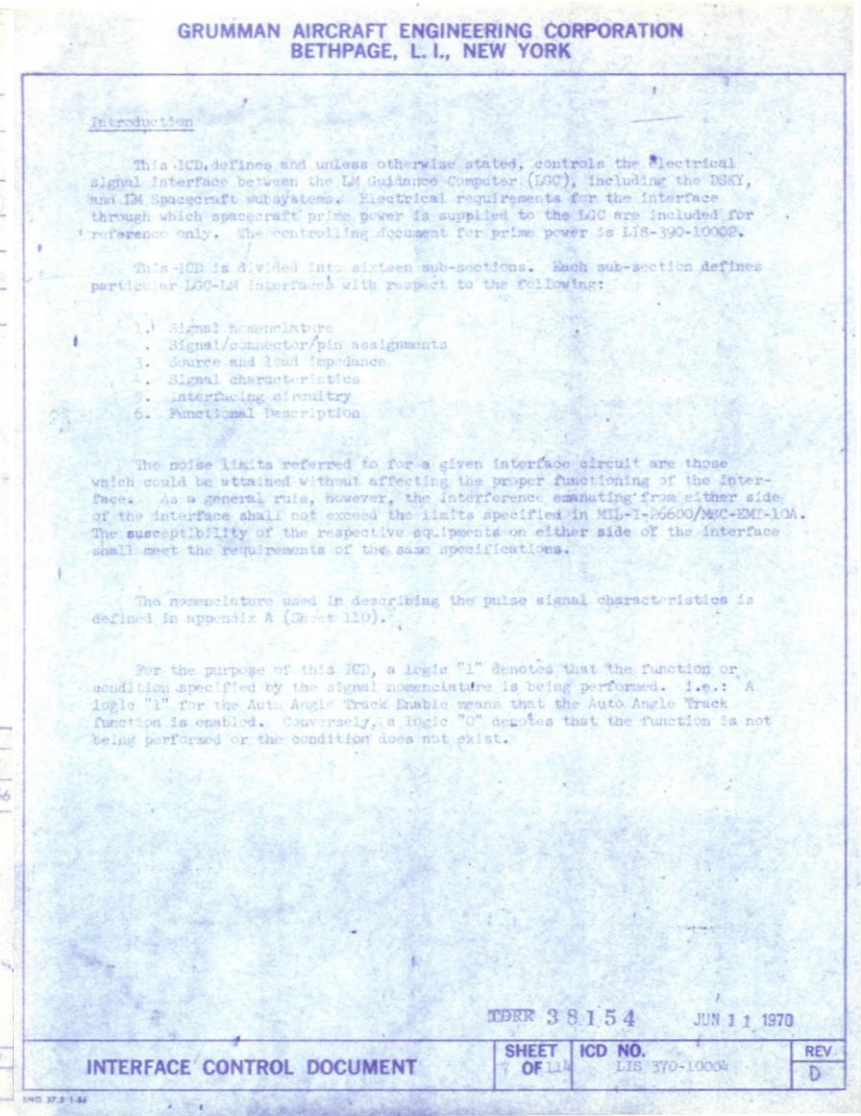
REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION — INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
A	-1	15	DSKY Dimmer Circuit	H Donnelly	GAEC		
		36			GAEC		
		37					
A	-2	20	Pulse Transformer Specification		MIT		
		21					
		22					
		23					
A	-3	ALL	General Revision and Update				
A	-4	28					
		29	Radar Pulse Timing				
A	-5	12	AGS Digital Data (Downlink)				
		37					
A	-6	6	Re-identification of RCS Jets				
		8					
		33					
		34					
		35					
A	-7	14	LMP Warning (MIT)				
		69					
A	-8	11	LMP Warning (GAEC)				

				REV. BY	APPROVALS		DATE
		Rev. A					
B	A-1	Sheet 9	General Update	J. Dalessandro	GAEC	E Stern	9/2/66
		10					
		11, 12			MIT	W. Stameris	13 Oct 66
		24					
		26-28					
B	A-2	22	Throttle Increase/Decrease Commands				
B	A-3	6-13	General Update				
		17					
		28					
		32					
		37-3					
		41					
		44					
		45					

IDRR 38154 JUN 11 1970

INTERFACE CONTROL DOCUMENT | SHEET 2 OF 114 | ICD NO. LIS 370-10004 | REV D



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Introduction

This ICD defines and unless otherwise stated, controls the electrical signal interface between the LM Guidance Computer (LGC), including the DSKY, and LM Spacecraft subsystems. Electrical requirements for the interface through which spacecraft prime power is supplied to the LGC are included for reference only. The controlling document for prime power is LIS-390-10008.

This ICD is divided into sixteen sub-sections. Each sub-section defines particular LGC-LM interfaces with respect to the following:

1. Signal nomenclature
2. Signal/connector/pin assignments
3. Source and load impedance
4. Signal characteristics
5. Interfacing circuitry
6. Functional Description

The noise limits referred to for a given interface circuit are those which could be attained without affecting the proper functioning of the interface. As a general rule, however, the interference emanating from either side of the interface shall not exceed the limits specified in MIL-I-26600/MSC-EMI-10A. The susceptibility of the respective equipments on either side of the interface shall meet the requirements of the same specifications.

The nomenclature used in describing the pulse signal characteristics is defined in appendix A (Sheet 110).

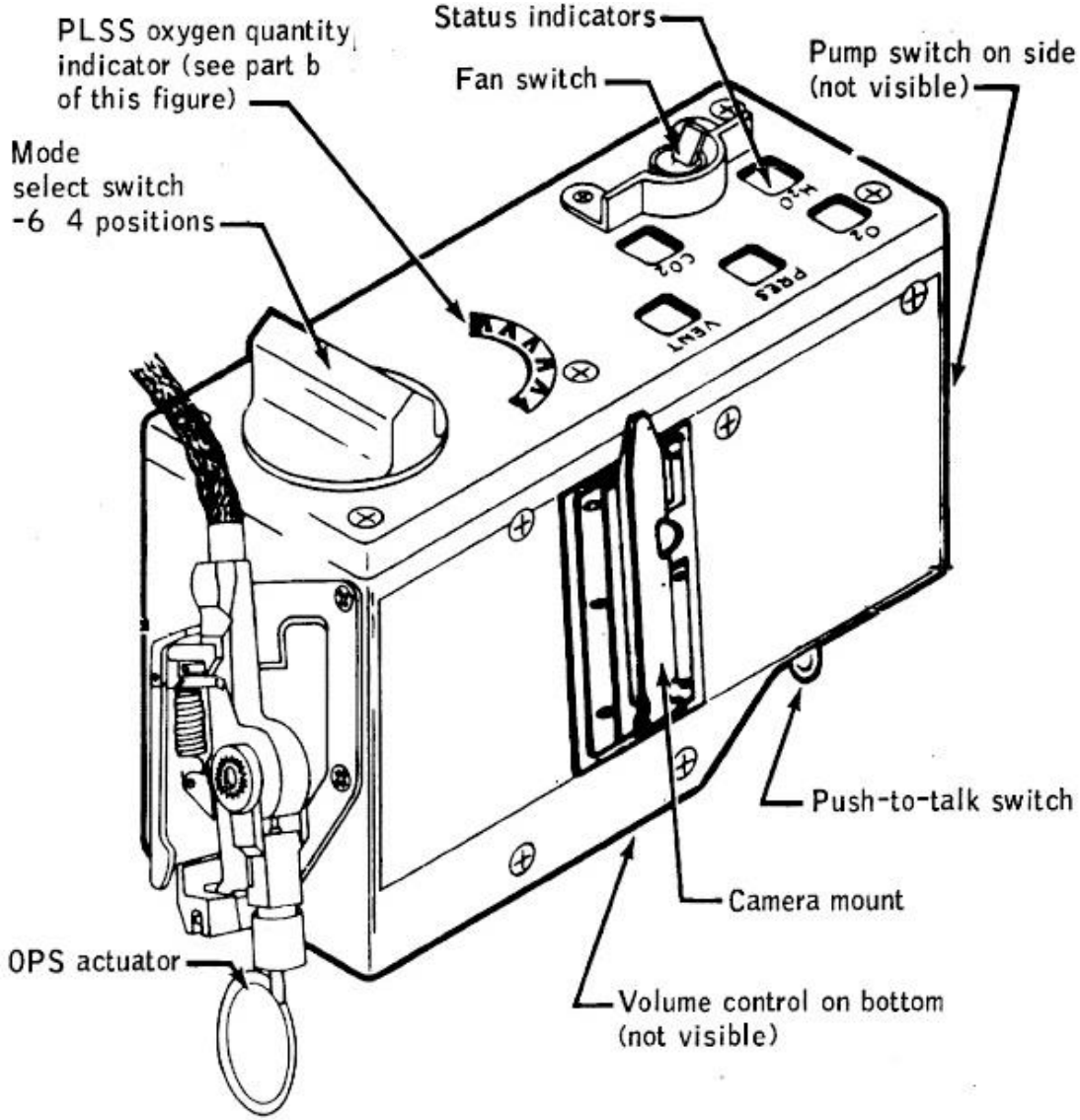
For the purpose of this ICD, a logic "1" denotes that the function or condition specified by the signal nomenclature is being performed. I.e.: A logic "1" for the Auto Angle Track Enable means that the Auto Angle Track function is enabled. Conversely, a logic "0" denotes that the function is not being performed or the condition does not exist.

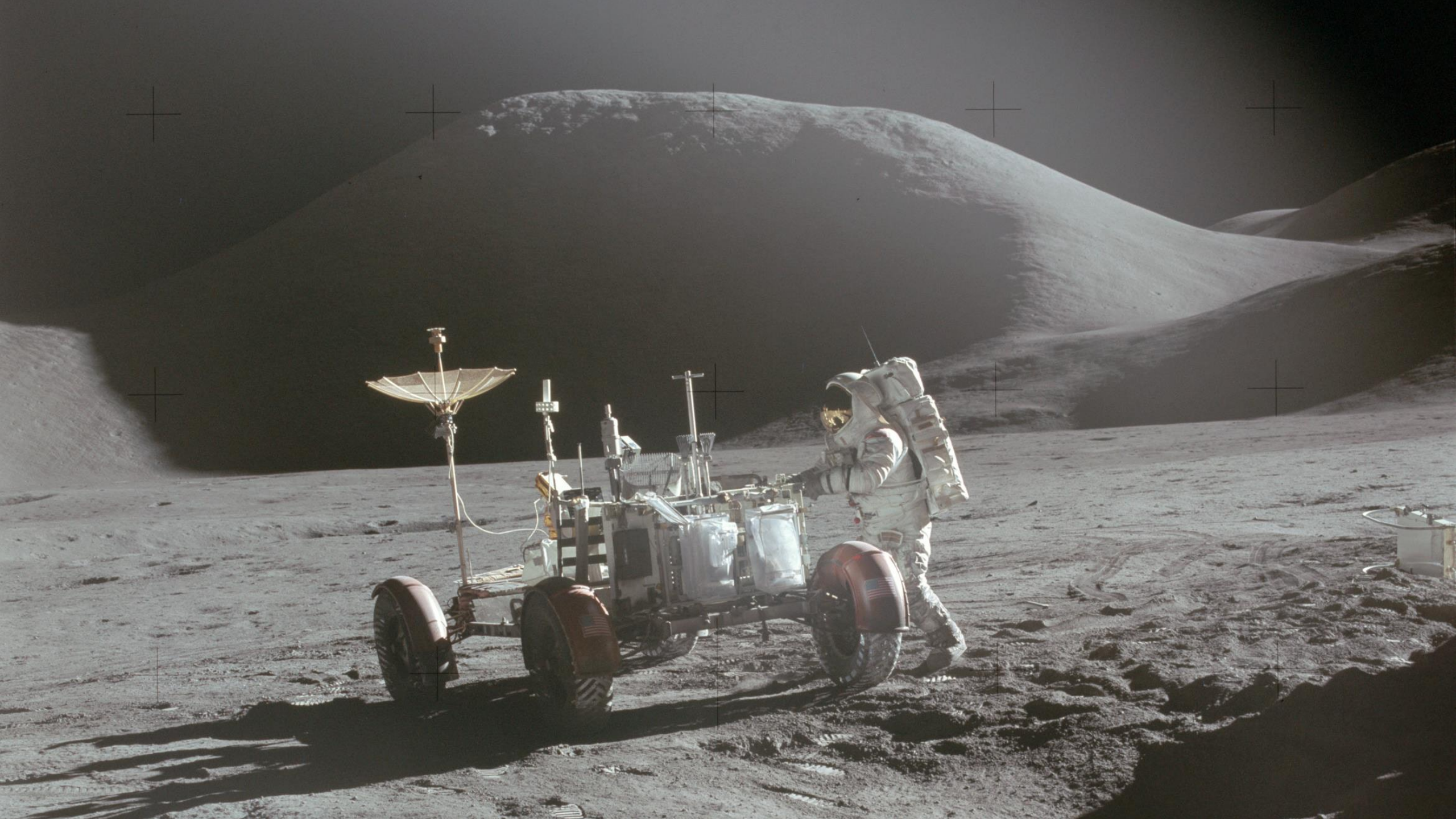
IDRR 38154 JUN 11 1970

INTERFACE CONTROL DOCUMENT | SHEET 7 OF 114 | ICD NO. LIS 370-10004 | REV D


ARMSTRONG

PLSS Remote Control Unit

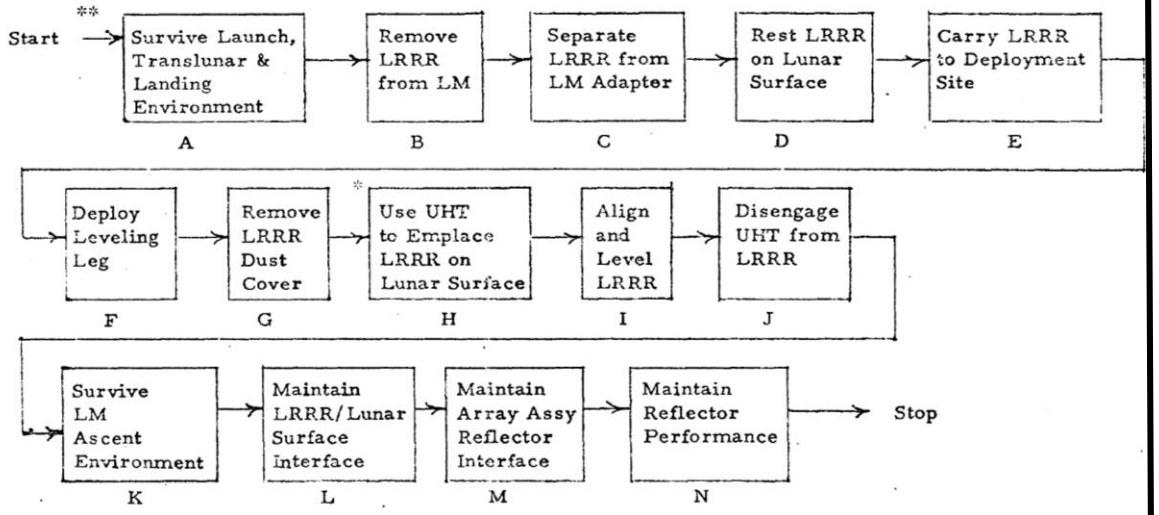




Risk Management

- Schedule risk vs. safety risk
- Qualitative vs. quantitative
- Failure Modes and Effects Analysis
- Critical Items List
  - Criticality 1: Loss of life or vehicle if the component fails
  - Criticality 2: Loss of mission if the component fails
  - Criticality 3: All others
- Exception, Waiver or Retention Rationale
  - Design, Test, Inspection, History, Use

Failure Modes and Effects Analysis (FMEA)



* UHT is implaced in UHT Socket Interface prior to removal of LRRR Dust Cover

** The loss of corners due to environmental stress during transportation to the lunar surface would result in a linear degradation of the return signal to earth. A design safety factor has been included in the Array to preclude the probability of corners fracturing due to environmental stress.

Figure 1 Mission Functions for LRRR

TABLE I (cont)
SUMMARY OF LRRR FAILURE MODES AND EFFECTS

Mission Function	Sym.	Hardware	Statement of Assumed Failure	Seriousness	Probability of Occurrence	Detectable During	Contingencies
Deploy Leveling Leg	F	Pull Pin	Stuck Pin	Significant	Negligible	Functional Tests	In the event astronaut cannot remove pull pin to deploy leveling leg, he should use lunar soil or lunar rock and bubble leveler to deploy LRRR.
		Latching Mechanism	Spring Failure	Significant	Negligible	Functional Tests	In the event of spring failure in latching mechanism, astronaut should use lunar soil or lunar rock and bubble leveler to deploy LRRR.

Discussion Groups

- Moon Machines video (“The Lunar Module”)
  - An overview of LM development
- Brooks Chapter 6 (“Lunar Module”)
  - The view from NASA, focused on preliminary design
- Kelly Chapter 5 (“Engineering a Miracle”)
  - The view form Grumman, focused on preliminary design
- Lutz Report (“Development of the Extravehicular Mobility Unit”)
  - An “Apollo Experience Report” focused on the spacesuit and PLSS