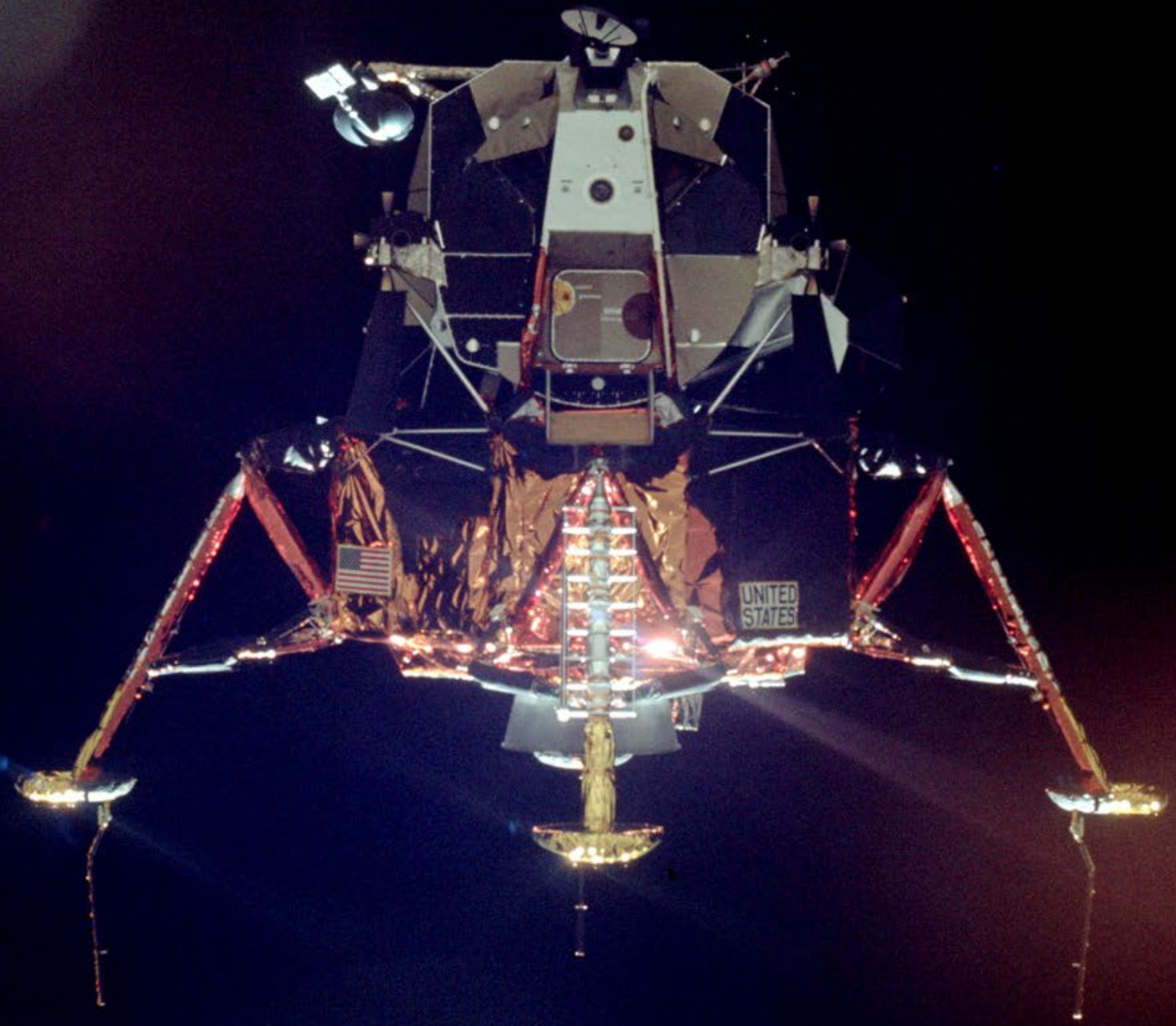


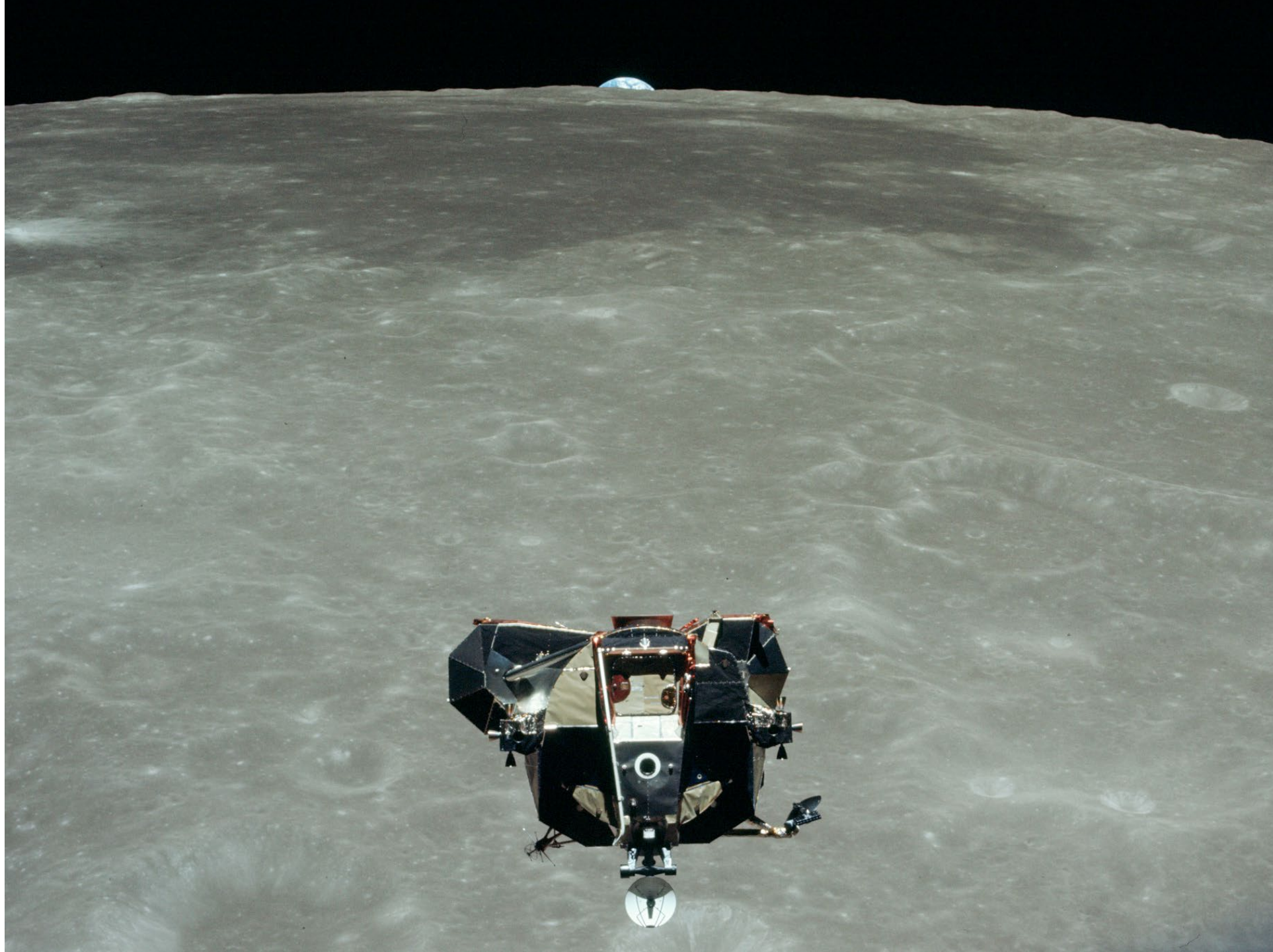
Lunar Module

HONR 269i

To the Moon and Back: The Apollo Program

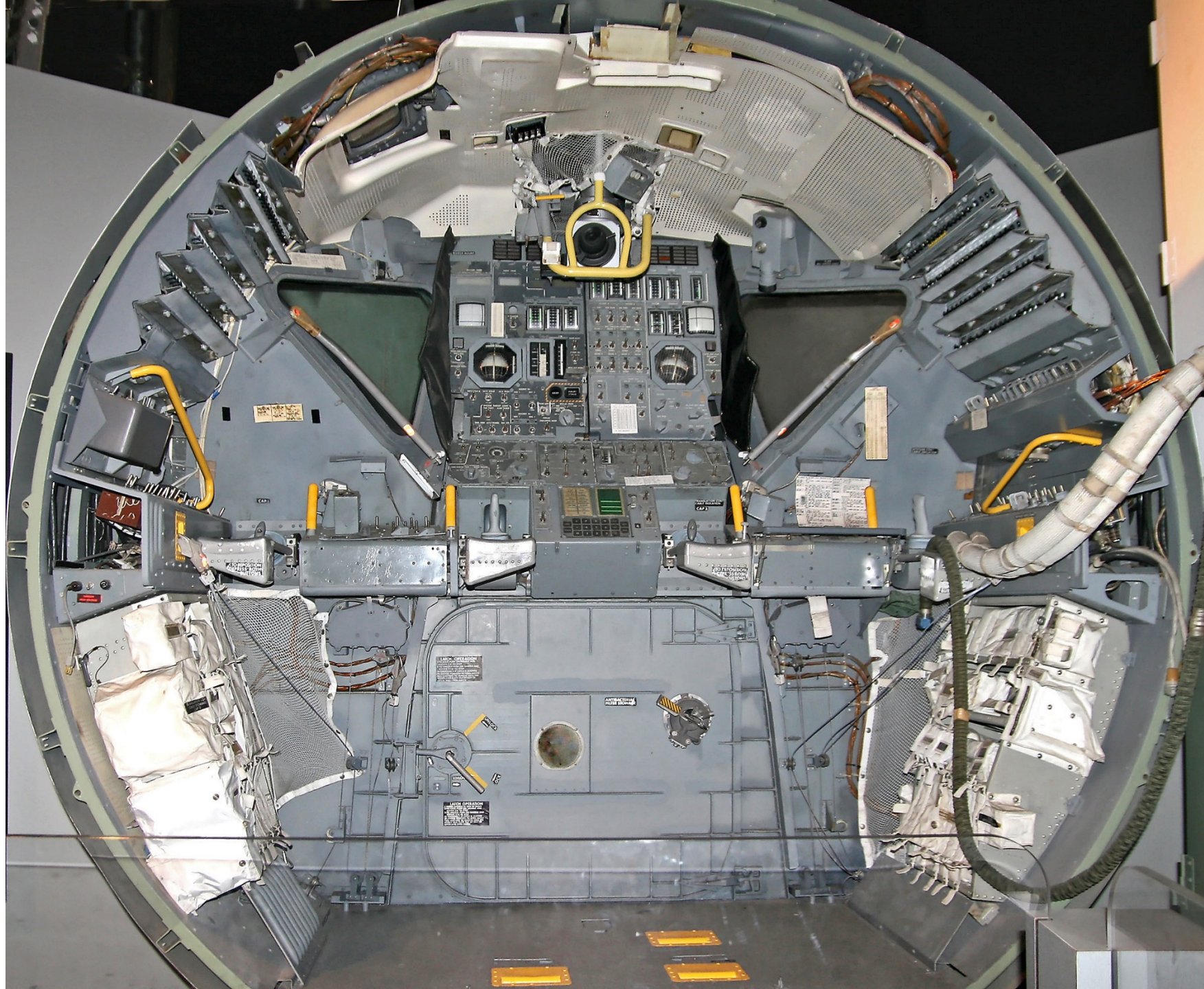


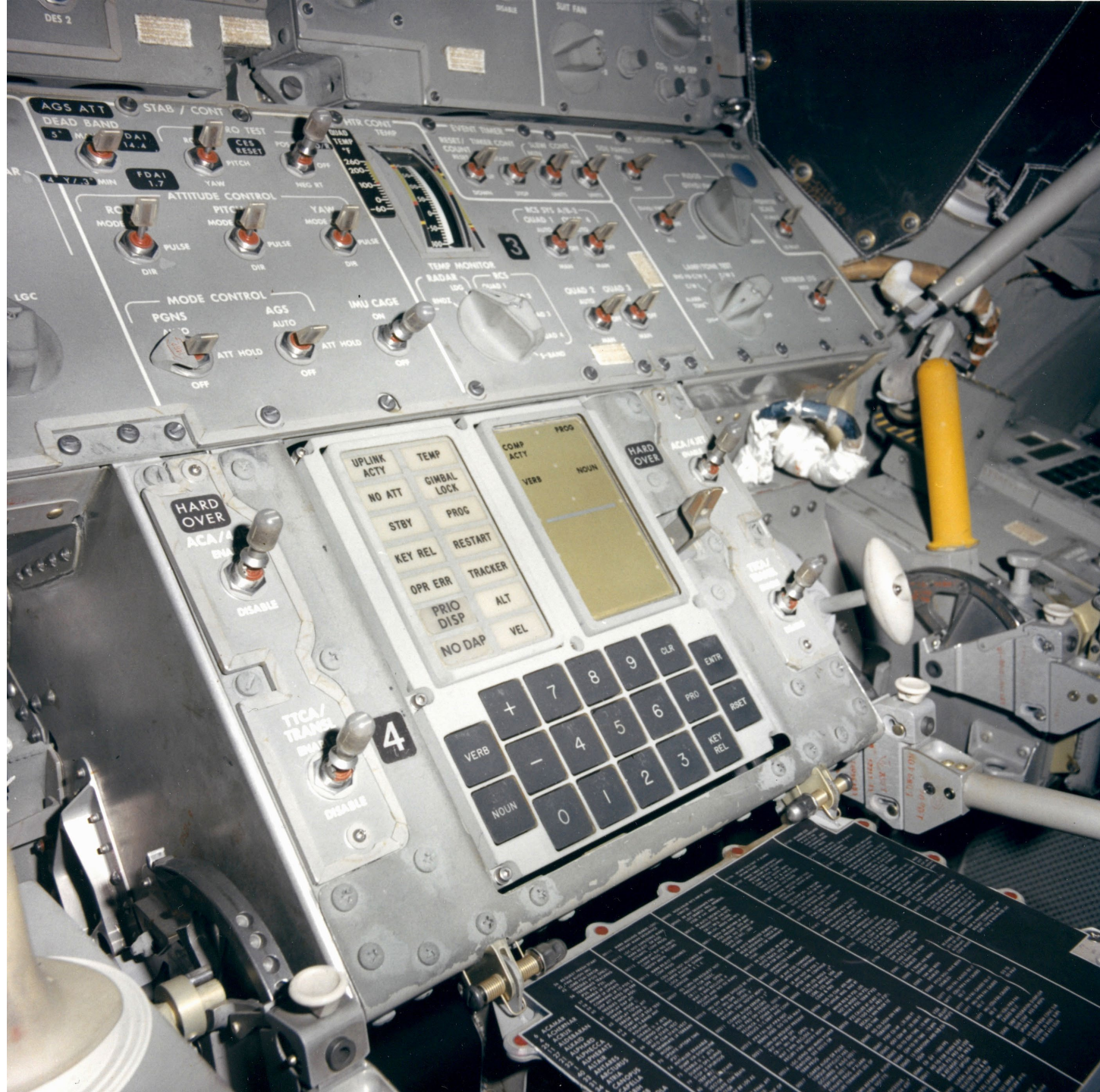


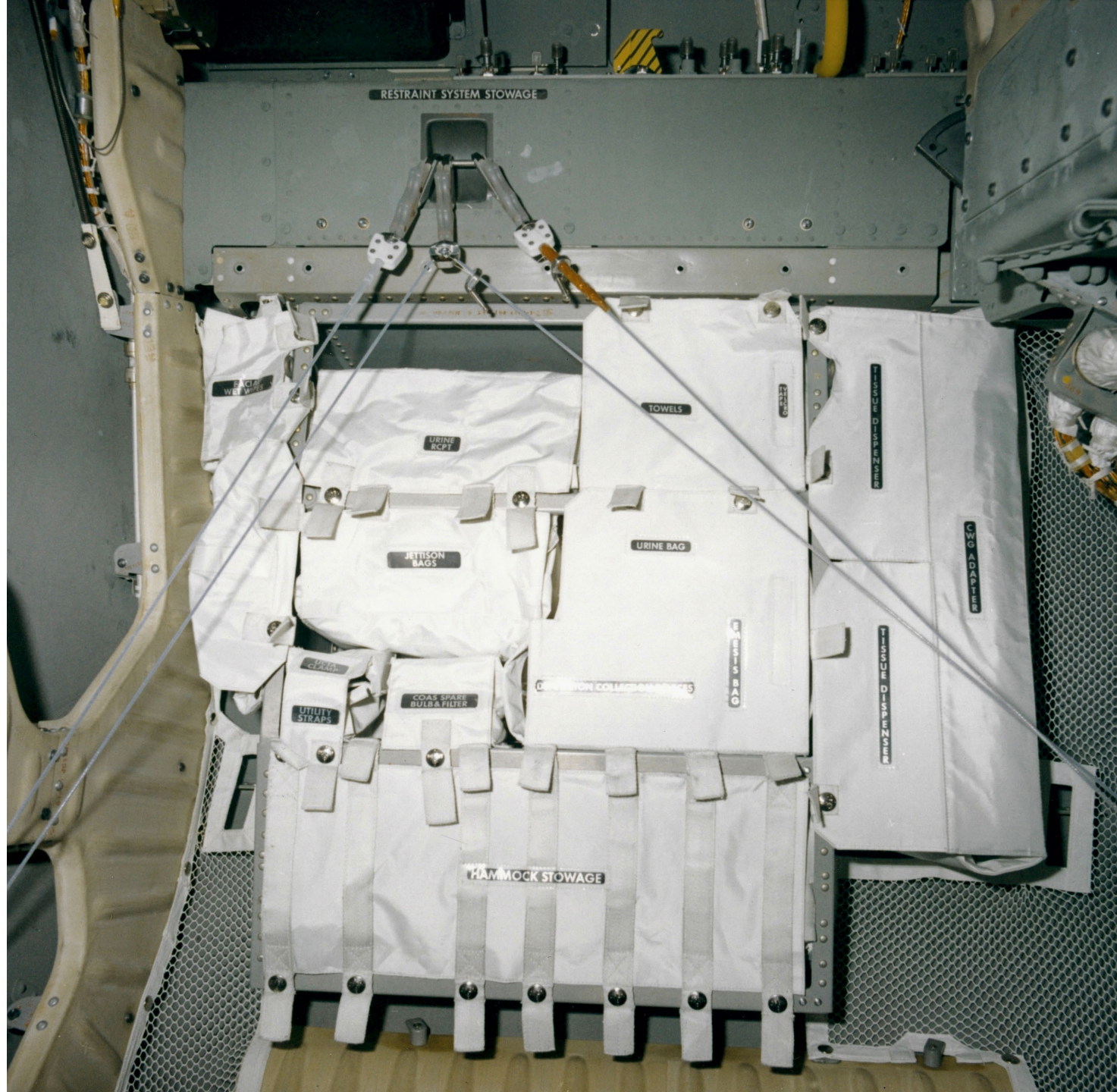




LM SIMULATOR







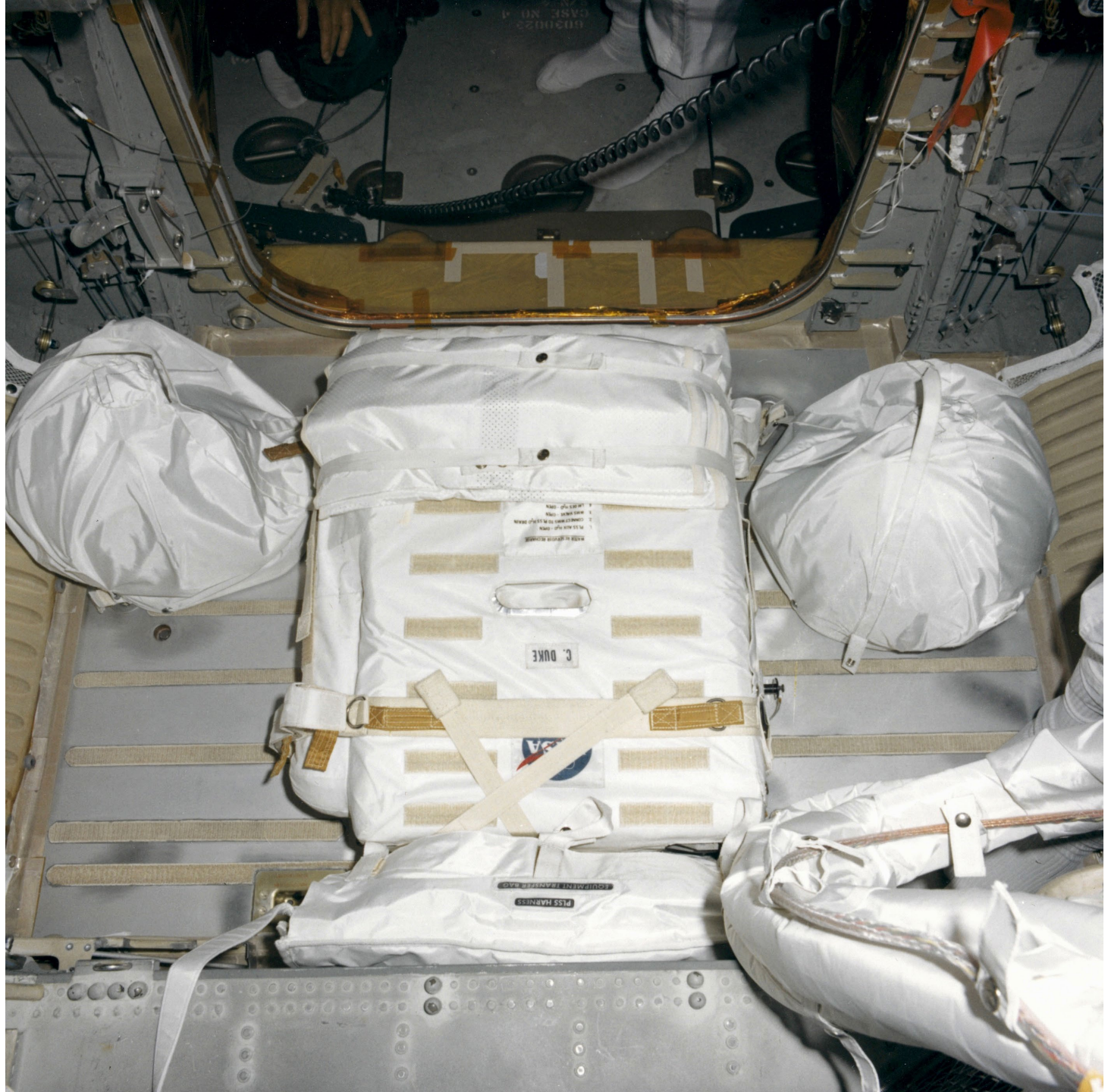


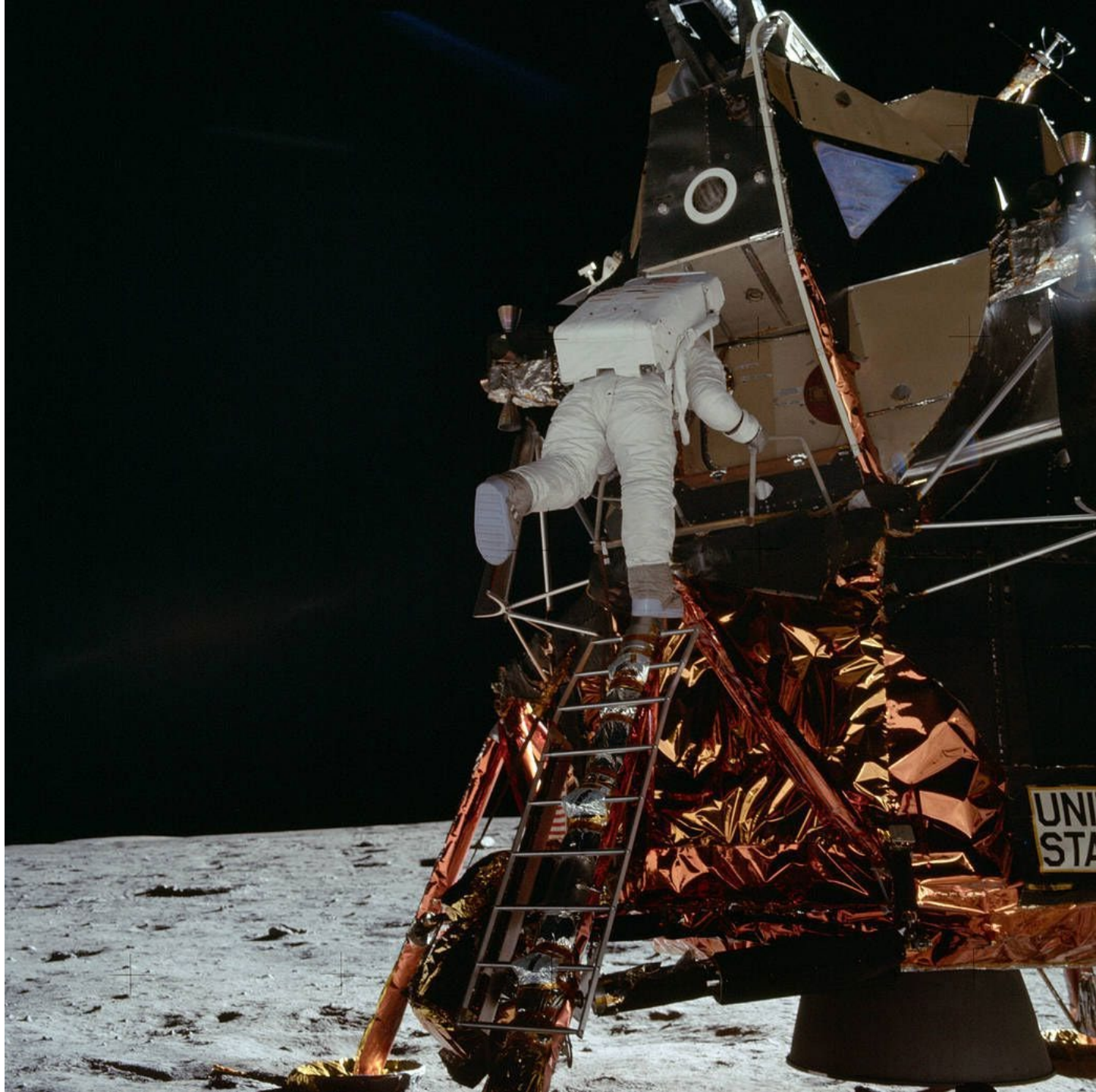
FLIGHT DATA FILE

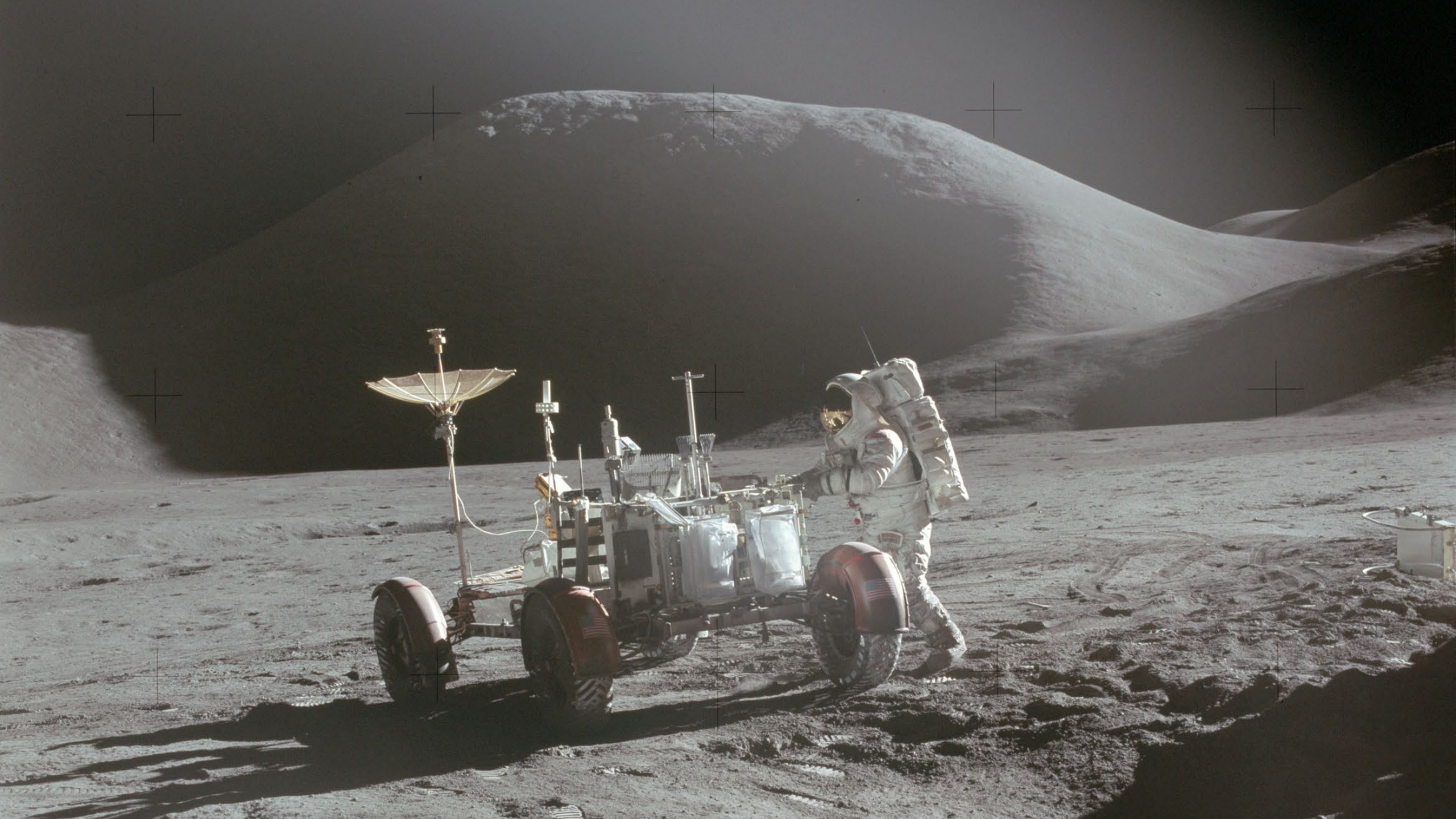
J. YOUNG

NASA RESEARCH RECORD

1. PLS ASK AG - OPEN
2. CONNECT WING TO PLS AG BRAN
3. WING VALVE - OPEN
4. UN DES SUP - OPEN
5. CONNECT WING TO PLS AG FALL KEPT (CONNECT WING SUP AND LIGHT BLAST)
6. PLS FOR 5 MINUTES
7. CONNECT WING TO PLS PRIME VENT FOR 10 RECORDS
8. CONNECT WING TO PLS AG VENT FOR 10 RECORDS
9. WING VALVE - CLOSE, STOP WING INFL
10. PLS ASK AG - CLOSE, STOP WING INFL
11. DISCONNECT AND STOP WING INFL

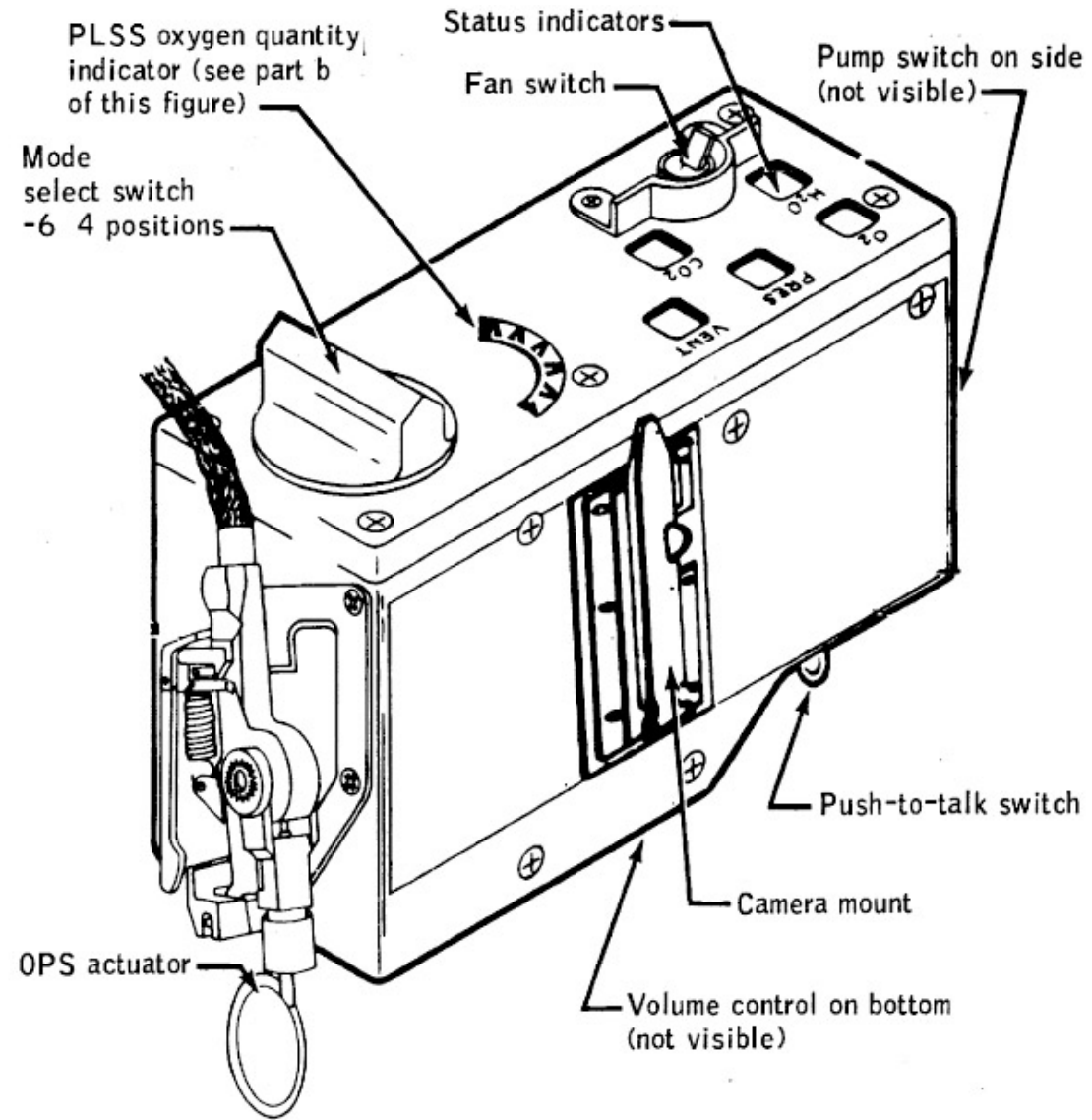








PLSS Remote Control Unit



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!

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)



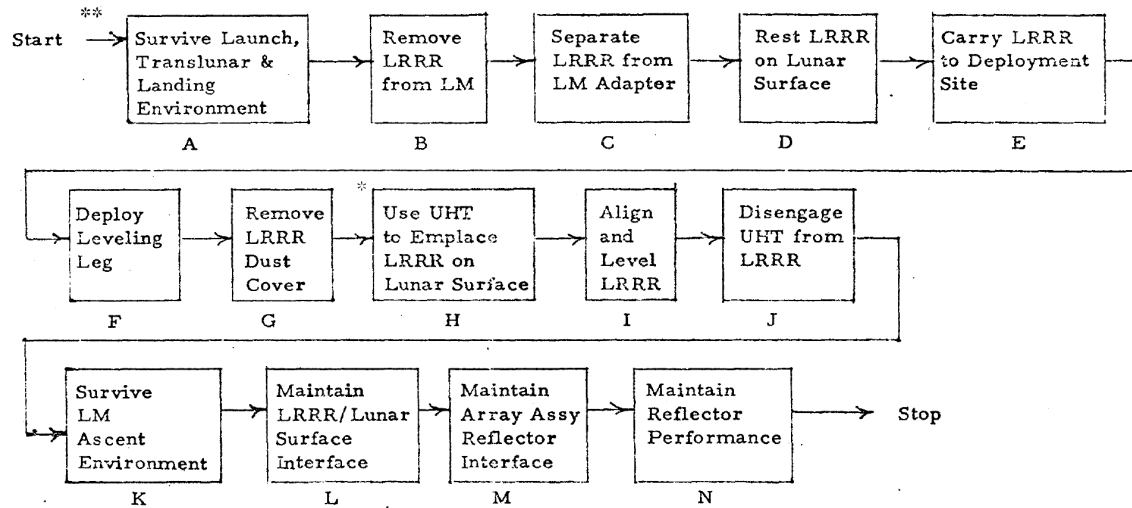
Failure Modes and Effects Analysis - LRRR

NO. ATM 86P Rev. NO. A
PAGE 6 OF 11
DATE 20 August 1970



Failure Modes and Effects Analysis - LRRR

NO. ATM 868 Rev. A
PAGE 8 OF 11
DATE 20 August 1970



* 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.

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.

Figure 1 Mission Functions for LRRR

Interface Control Documents

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

FORM 8-2100
Rev. 3-6-65
Proc. 3-6-65
Inst. 1-1-65
Prin. No. 997
Type II

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

Perry L Gardner
Arnold B Whitaker

GAEC

1/8/65

GAEC

1/8/65

MIT

PREPARED BY: H. Donnelly/S. Glasser

CHECKED: G. Henderson

4/5/65

G Henderson

TITLE

IGC-LM ELECTRICAL INTERFACE

CCA NO.

LM-1, IM-1 and associated

EFFECTIVITY

FORM NO. 8-2100

SHEET 1 OF 114

ICD NO. LIS 370-10004

REV

D

IDRR 38154

JUN 11 1970

INTERFACE CONTROL DOCUMENT

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

REVISIONS

REV LTR	IRN NO.	SHEET	DESCRIPTION - INCLUDE CCA NUMBER	REV. BY	APPROVALS		DATE
A	-1	16 25 37	DSKY Dimmer Circuit	H Donnelly	GAEC	<i>[Signature]</i>	
A	-2	20 21 22 23	Pulse Transformer Specification		GAEC	<i>[Signature]</i>	
A	-3	ALL	General Revision and Update		MIT	<i>[Signature]</i>	
A	-4	28 29	Radar Pulse Timing				
A	-5	12 37	ACS Digital Data (Downlink)				
A	-6	6 8 33 34 35	Re-identification of EBS Jets				
A	-7	14 2	IMP Warning (MIT)				
A	-8	11	IMP Warning (GAEC)				
B	A-1	Rev. A Sheet 3 10 11, 12 24 25-28	General Update	J. Balasandro	GAEC	<i>[Signature]</i>	12/9/66
B	A-2	22	Throttle Increase/Decrease Commands		MIT	<i>[Signature]</i>	13 Oct 66
B	A-3	6-13 15 25 32 37-39 41 44 45	General Update				

IDRR 38154

JUN 11 1970

INTERFACE CONTROL DOCUMENT

SHEET
2 OF 114

ICD NO.
LIS 370-10004

REV
D

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

Introduction

This ICD defines and unless otherwise stated, controls the electrical signal interface between the LM Guidance Computer (IGC), including the DSKY, and LM Spacecraft subsystems. Electrical requirements for the interface through which spacecraft prime power is supplied to the IGC are included for reference only. The controlling document for prime power is LIS-390-10002.

This ICD is divided into sixteen sub-sections. Each sub-section defines particular IGC-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

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
H2O 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
CO2 Sensor
Component Caution
Environmental Control Subsystem
Inverter
Pressure Garment Assembly O2 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 Assemblies

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 from Grumman, focused on preliminary design
- Lutz Report (“Development of the Extravehicular Mobility Unit”)
 - An “Apollo Experience Report” focused on the spacesuit and PLSS

Activity: Case Studies

- James Webb
- Werner Von Braun
- Boris Chertok
- Max Faget
- Margaret Hamilton
- Katherine Johnson
- Gene Kranz
- Gunter Wendt
- Valentina Tereshkova
- Alan Sheppard
- Jim Lovell