POLITECNICO DI MILANO





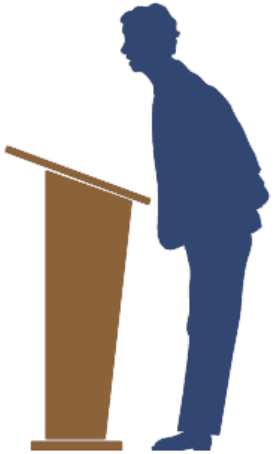
Apollo 11

I primi uomini sulla Luna

Davide Manca

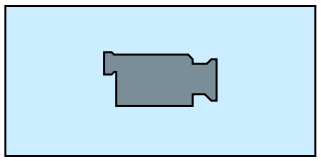
Struttura della presentazione

- Inquadramento storico
- La corsa allo spazio
- La progettazione del viaggio verso la luna
- Struttura dell'astronave
- Il razzo Saturno V
- Missione Apollo 11
- Gli uomini chiave
- Il computer



Apollo 11 – AS-506

L’idea propulsiva



John F. Kennedy – 25 Maggio 1961

First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth.

No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish. We propose to accelerate the development of the appropriate lunar space craft. We propose to develop alternate liquid and solid fuel boosters, much larger than any now being developed, until certain which is superior.

We propose additional funds for other engine development and for unmanned explorations--explorations which are particularly important for one purpose which this nation will never overlook: the survival of the man who first makes this daring flight. But in a very real sense, it will not be one man going to the moon--if we make this judgment affirmatively, it will be an entire nation. For all of us must work to put him there.

President John F. Kennedy, "Special Message to the Congress on Urgent National Needs", May 25, 1961

L’uomo chiave

Werner von Braun
(1912-1977)


Werner von Braun

Caratteristiche principali della missione

Qualche domanda…

- Ma quanto è grande la Terra?
- Ma quanto è grande la Luna?

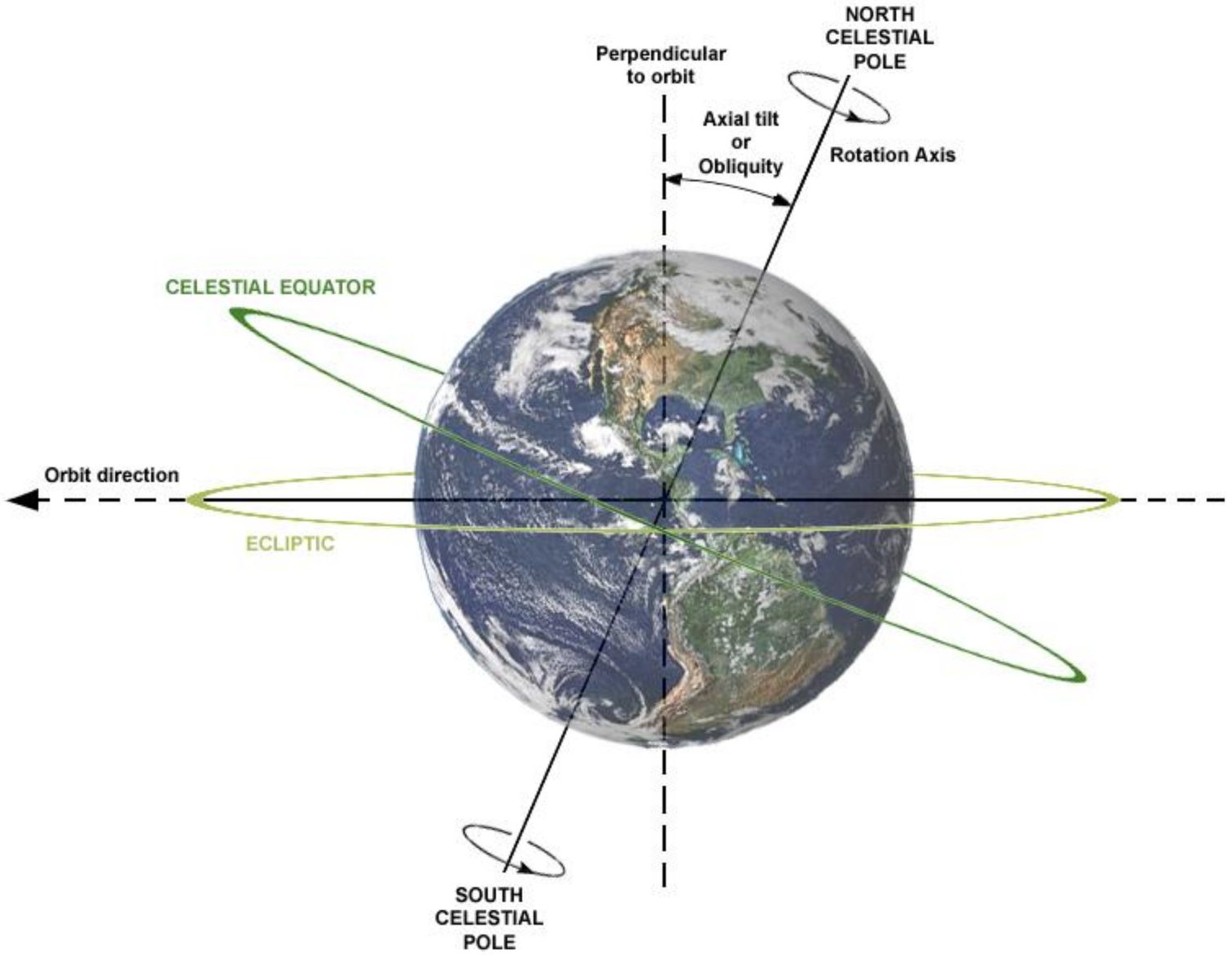
- Quanto è distante la Luna dalla Terra?

Alcuni dati

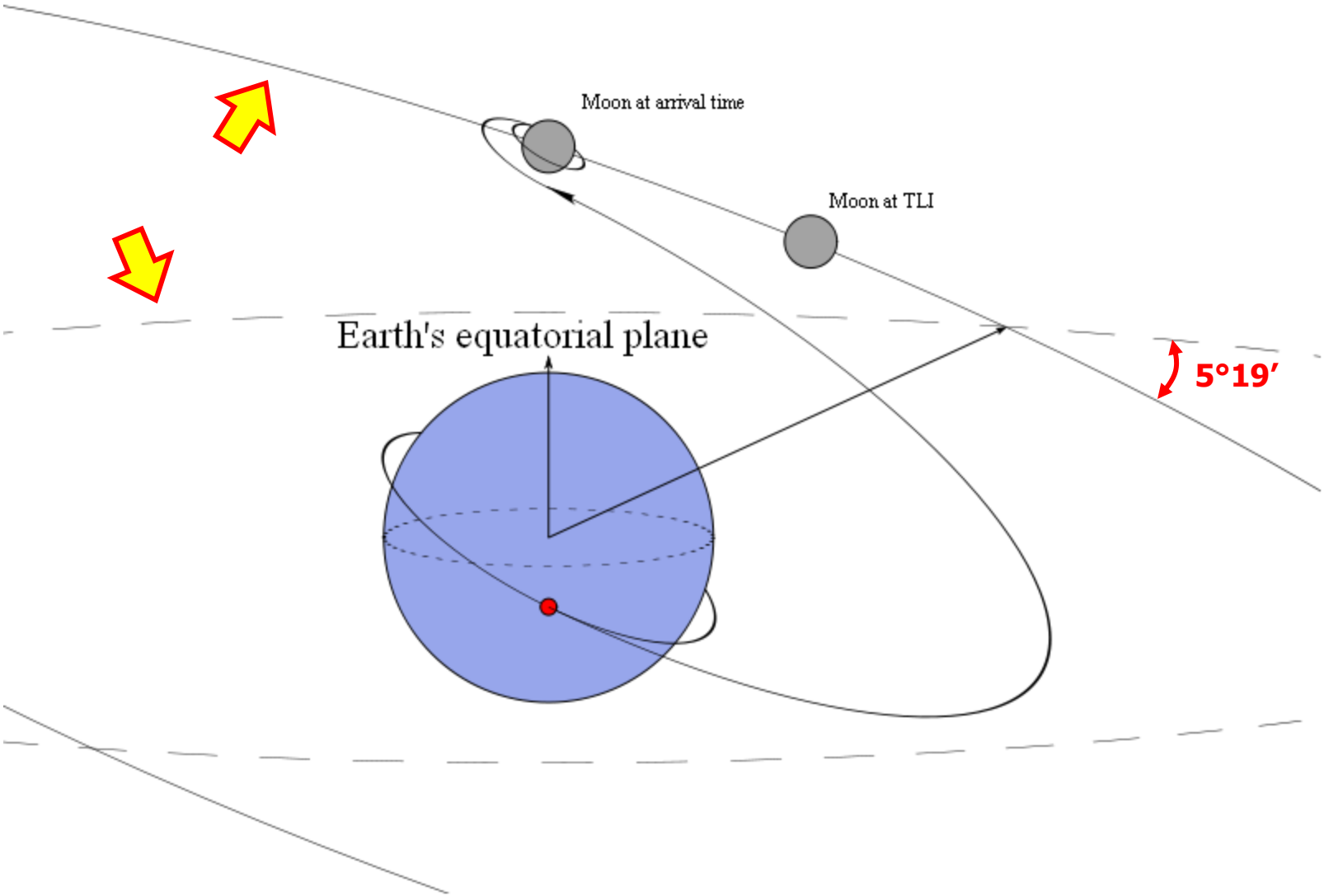
- Distanza media terra-luna: 384,400 km
- Tempo impiegato dalla luce a percorrere la distanza Terra Luna circa : 1.28 s
- La Luna non ha un'atmosfera propriamente detta
- Raggio lunare: 1,738 km
- Accelerazione di gravità: 1.622 m/s^2
- Gravità: circa 1/6 di quella terrestre (9.81 m/s^2)
- Velocità di fuga dalla luna: 2,380 m/s
- Velocità di fuga dalla terra: 11,200 m/s
- Pressione atmosferica: `3.E-10` Pa

- Diametro equatoriale terra = 12,756 km
- Diametro medio luna = 3,476 km
- La terra è 49.42 volte più grande della luna

Eclittica terrestre (23°27')



Orbite terrestri e lunari



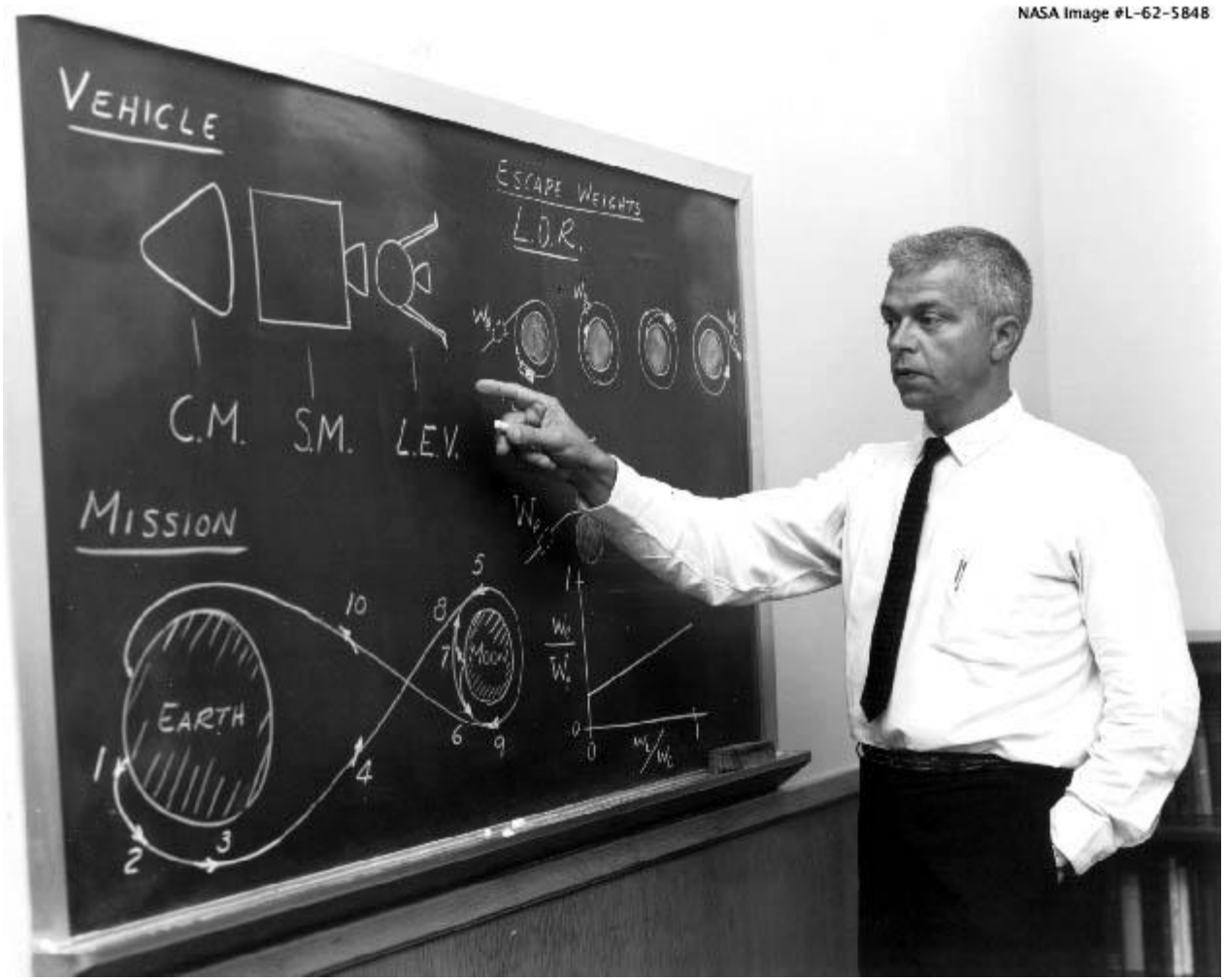
Il piano dell'orbita della Luna è inclinato di 5°19′ rispetto a quello dell'orbita della Terra intorno al Sole (*i.e.* il piano dell'eclittica)

Le alternative del volo

- **Volo diretto** terra-luna-terra
- **Rendezvous** in orbita intorno alla **terra**
- **Separazione** e successivo **rendezvous** in orbita intorno alla luna

- **Razzo vettore** inferiore + **astronave** superiore
- Soluzione ingegneristica dello **STAGING** basata su 3 stadi sequenziali del razzo vettore volti a minimizzare la massa trasportata nelle singole fasi del viaggio

John C. Houbolt



Quando il LEM tocca la superficie lunare Werner Von Braun si congratula con John Houbolt dicendogli che è stato grazie a lui se l'uomo è riuscito a raggiungere la luna. Houbolt aveva insomma ragione.

Struttura dell'astronave

Apollo 11

The Saturn V is the most powerful rocket ever created by the hand of Man.

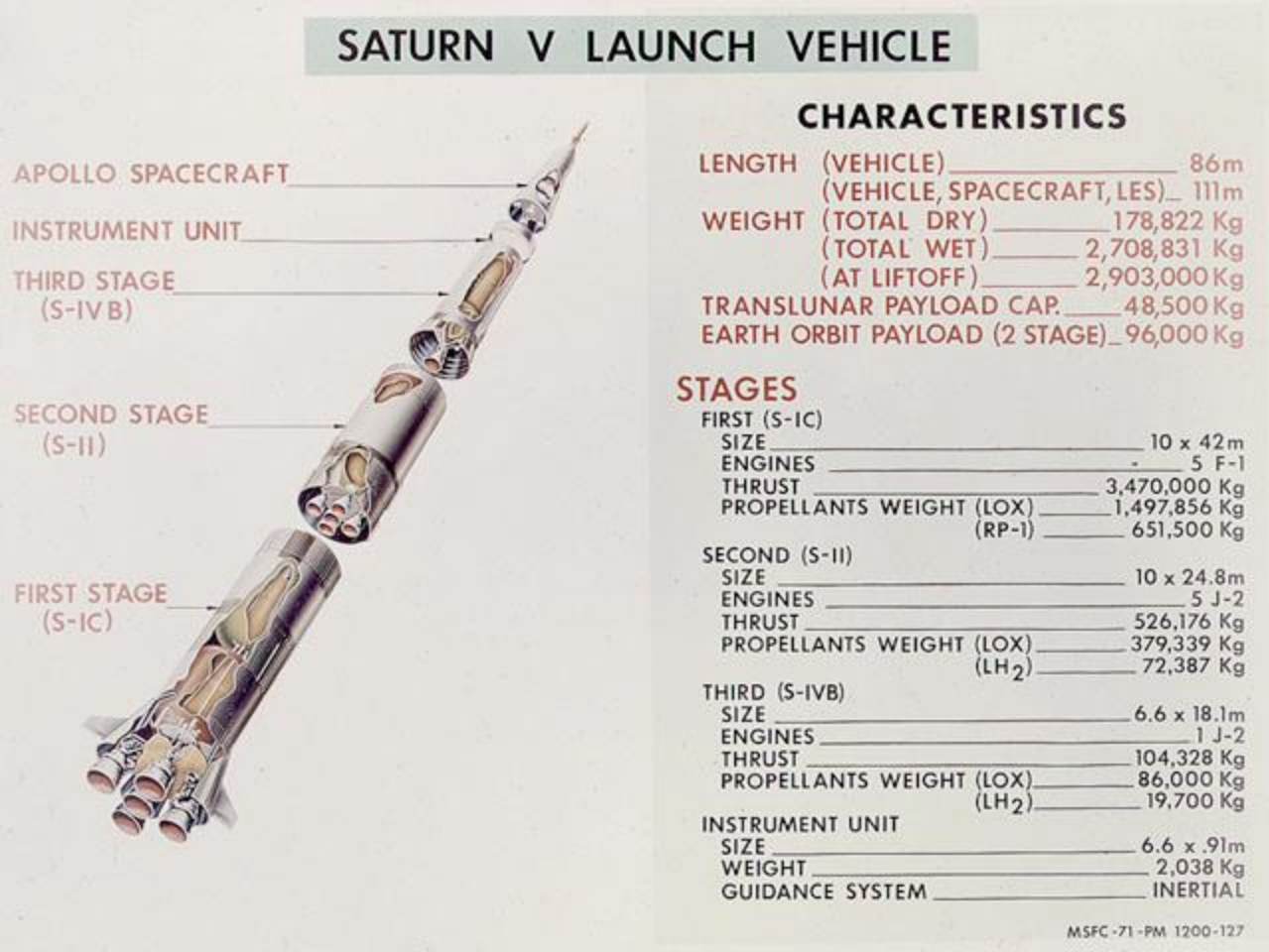
Altezza vettore (Saturn V): 281 ft = **86 m**

Altezza astronave: 82 ft = **25 m**

Altezza totale Apollo 11: 111 m

Altezza grattacielo Pirelli: 127 m
Altezza duomo di Milano (madonnina): 108 m
Altezza statua della libertà a New York: 93 m


USA
USA
1
1

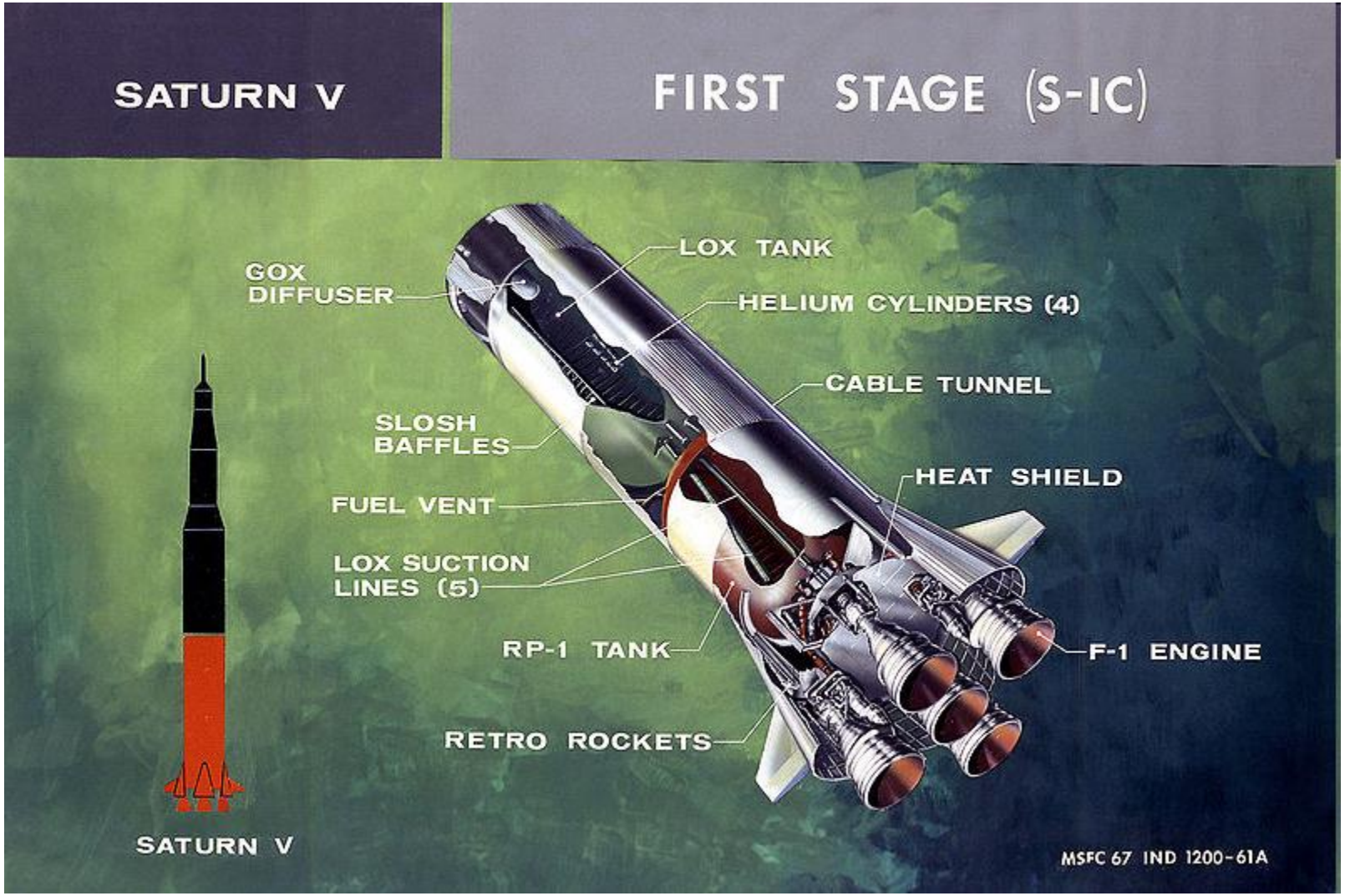


Saturno V costituito da 5,600,000 parti


SATURN V
APOLLO CAPSULE
LUNAR MODULE
LOX TANK
FUEL TANK
1 J-2 ENGINE
FUEL TANK
LOX TANK
5 J-2 ENGINES
LOX TANK
FUEL TANK
5 F-1 ENGINES
MSFC 67 PA-116

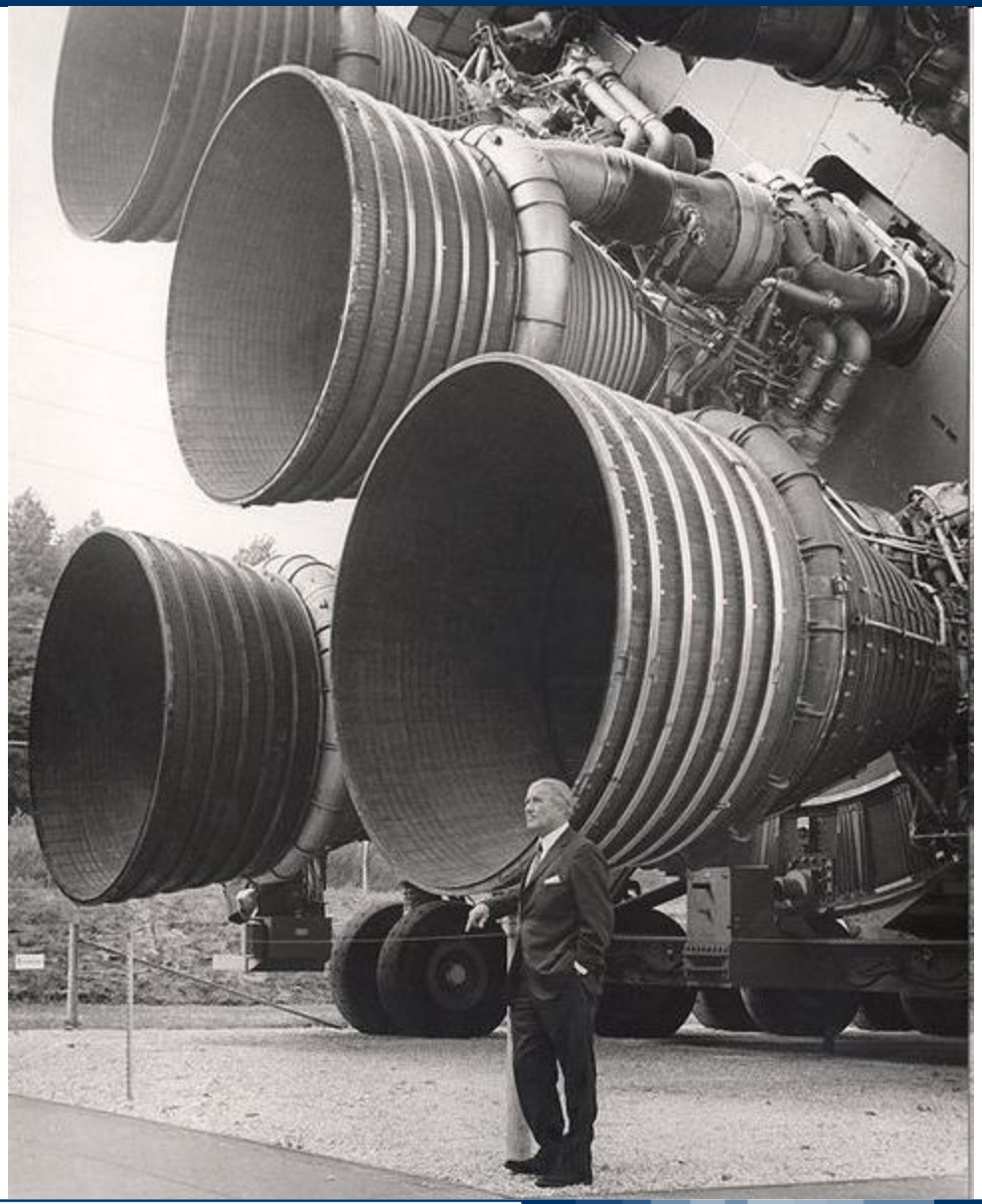
Primo stadio

Primo stadio: S-1C

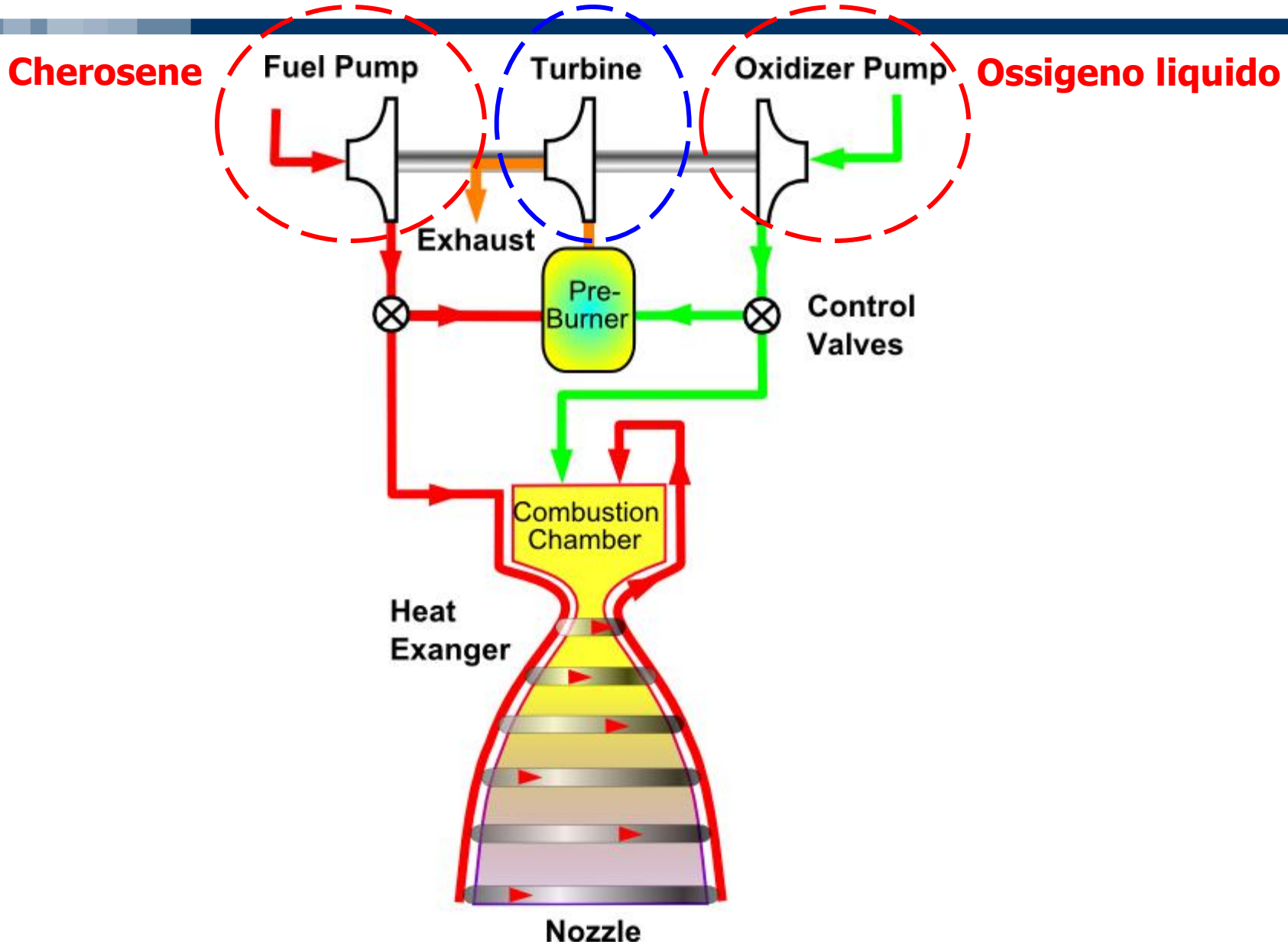


Diametro = 10.06 m **Altezza = 42.06 m** **Peso = 3,452,000 kg**

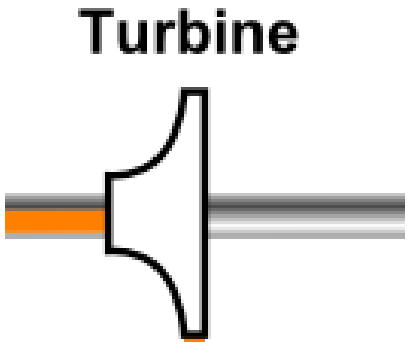
Motori F1 stadio S-1C e Von Braun



Schema motore F1



Motore Rocketdyne F-1



= 55,000 HP

Mercedes E55 AMG

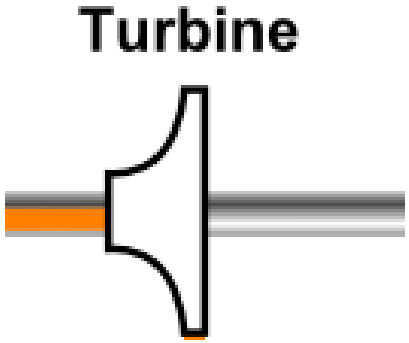
1 ×

= 550 HP

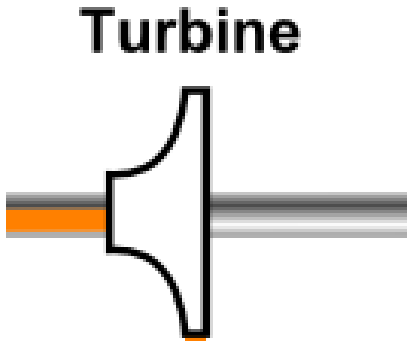
Motore Rocketdyne F-1

100 ×

=



Motore Rocketdyne F-1



- La turbina fa girare due pompe
  - Pompa combustibile (cherosene)
  - Pompa comburente (ossigeno liquido)
- Le pompe pompano 2,542 litri ogni secondo
- Il motore F-1 brucia ogni secondo:
  - 788 kg di combustibile RP-1 (cherosene)
  - 1,789 kg di ossigeno liquido

Test Firing of an F-1 Engine at Edwards Air Force Base

Nel corso dei primi test effettuati dalla ditta Rocketdyne i vetri delle finestre venivano rotti ad una distanza di 16 km.

Motore Rocketdyne F-1

= 200,000,000 HP

Spinta di 680,400 kg

Motore Rocketdyne F-1

200,000,000 HP ≡ 150,000 MW

150,000 MW ≡ 150 GW

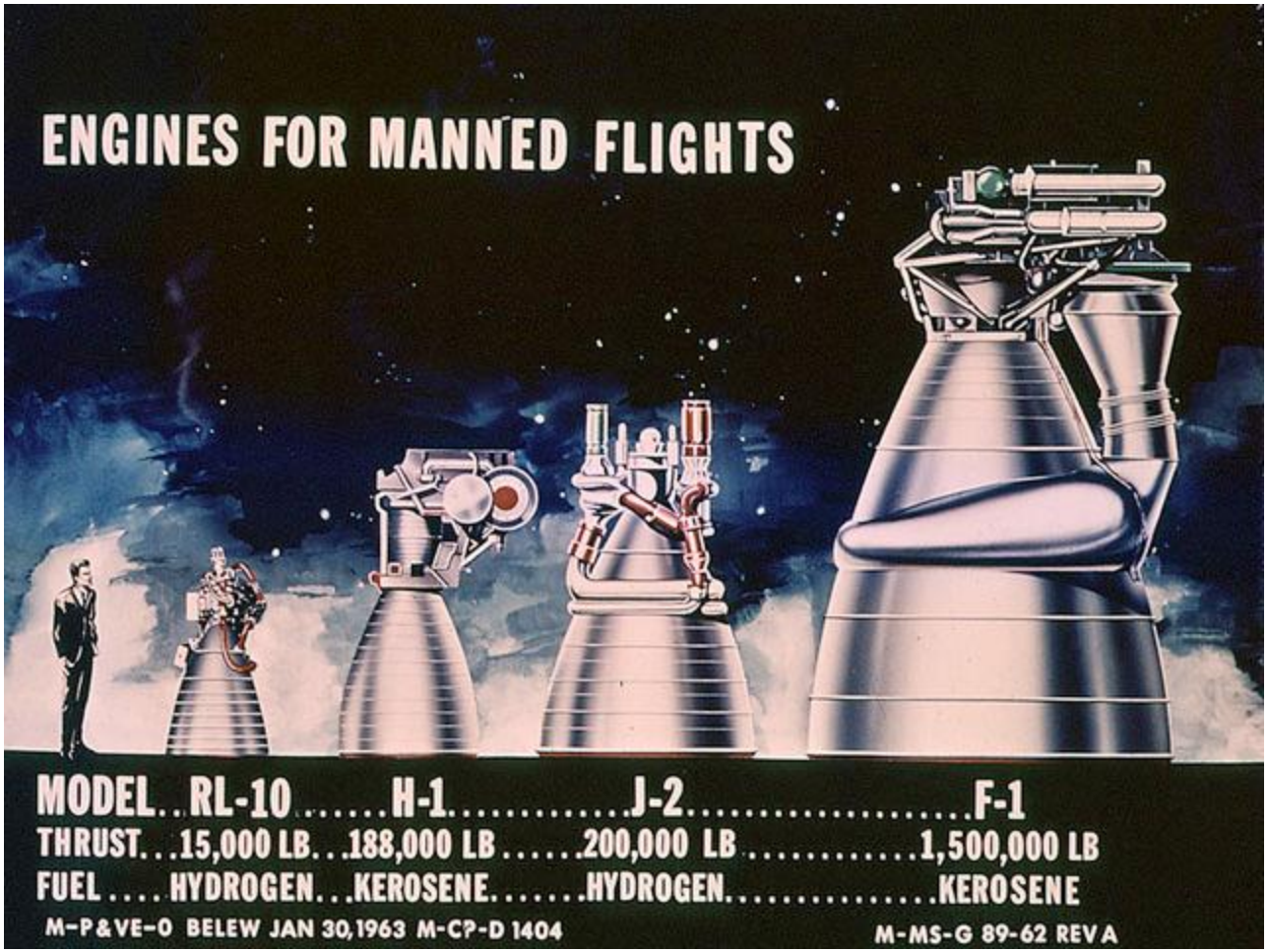
150 GW ≅ Potenza di 150 reattori nucleari

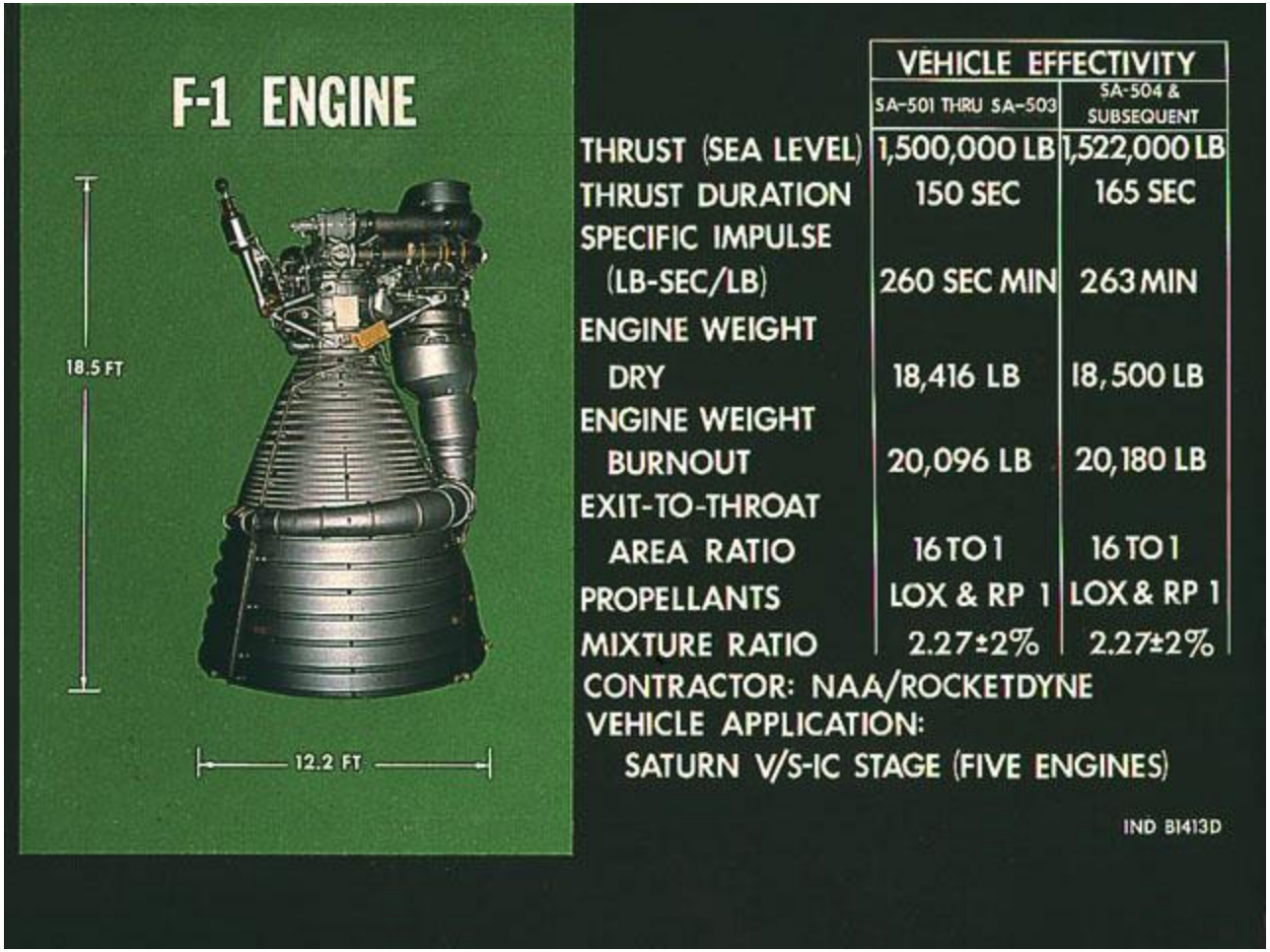
Motore Rocketdyne F-1

- I 5 motori F1 del primo stadio del Saturn V portavano l'astronave ad una velocità di 9,920 km/h (Mach 8.3) e ad un'altezza di 68 km.

5 ×  **= 1,000,000,000 HP**

2,400,000 kg di propellente in
152 s di funzionamento (2 min e 32 s)


ENGINES FOR MANNED FLIGHTS
MODEL..RL-10.....H-1.....J-2.....F-1
THRUST...15,000 LB...188,000 LB.....200,000 LB.....1,500,000 LB
FUEL....HYDROGEN...KEROSENE.....HYDROGEN.....KEROSENE
M-P&VE-O BELEW JAN 30,1963 M-CP-D 1404
M-MS-G 89-62 REV A

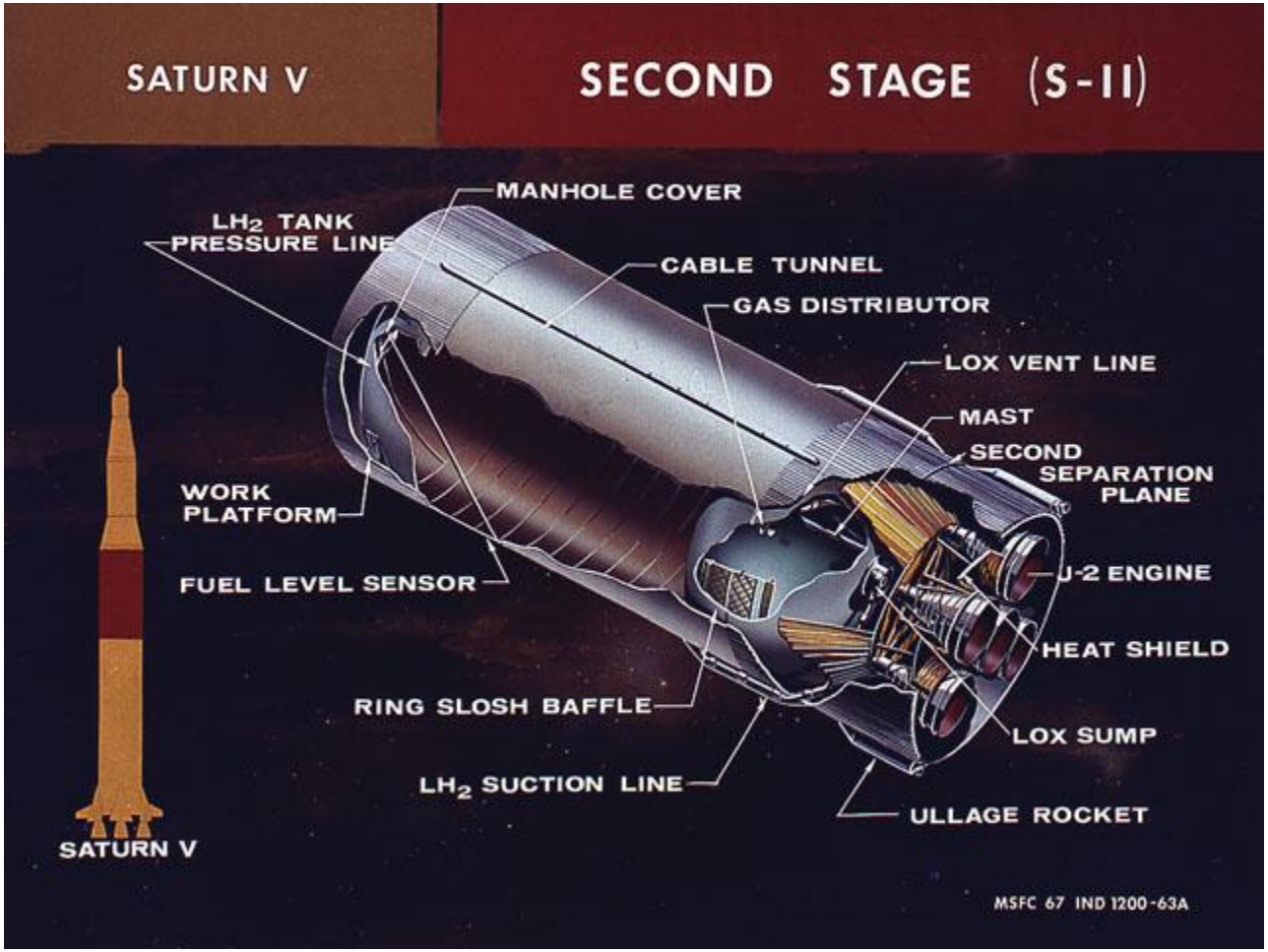


RP1 = kerosene

Motori F1 stadio S-1C

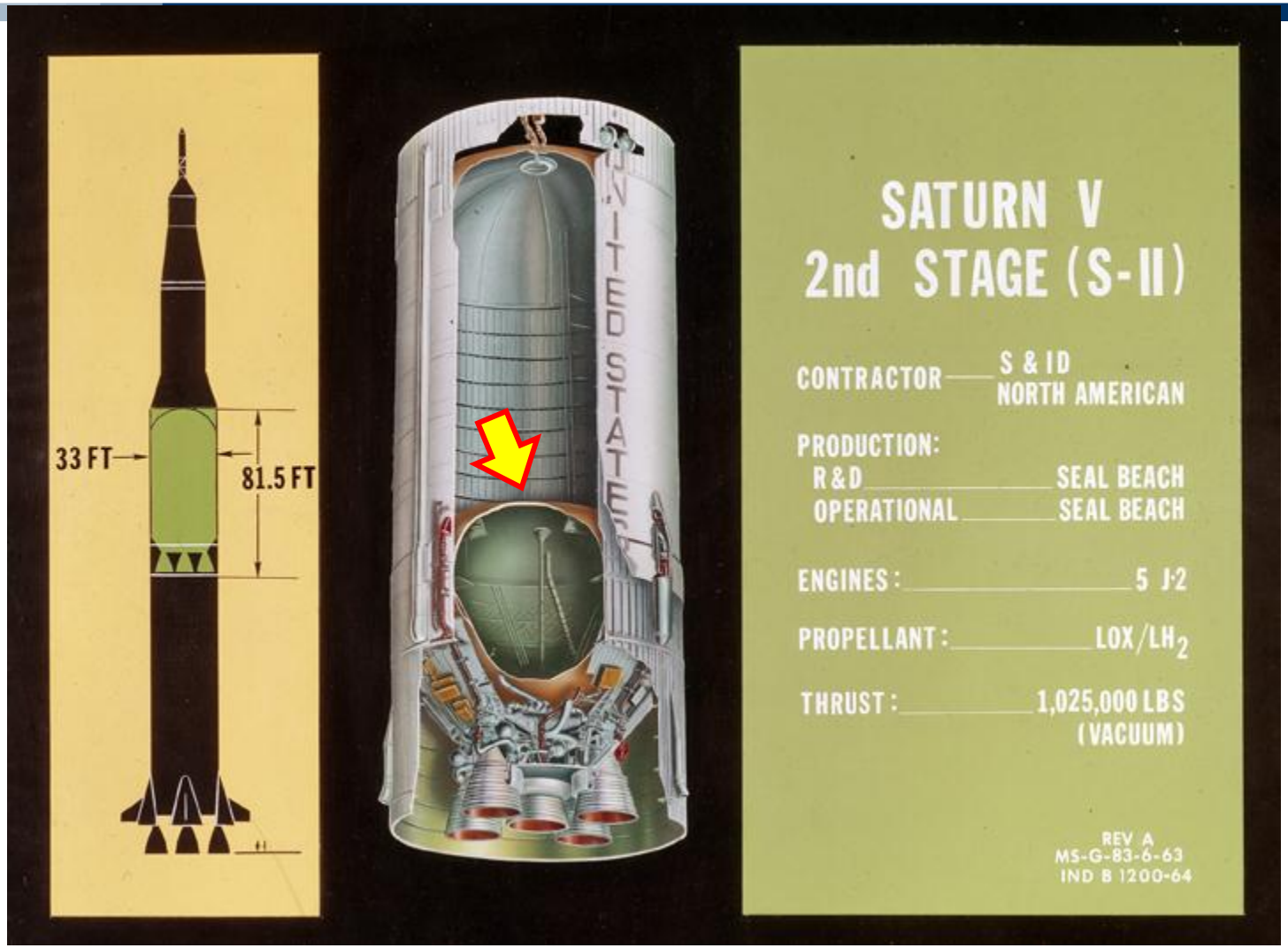
First stage S-1C

Secondo stadio

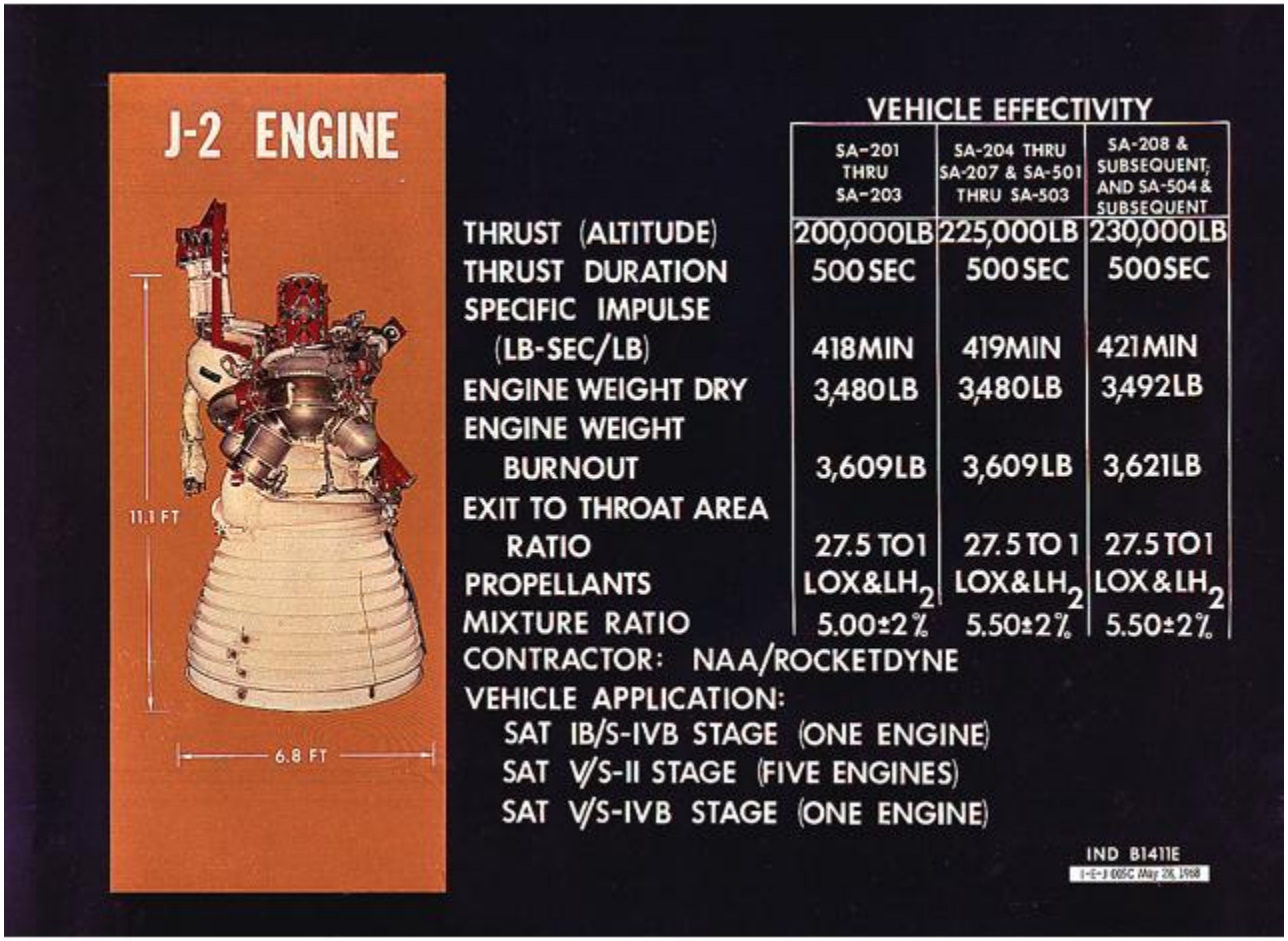


A 68 km di quota espulsione S-1C e ignizione stadio S-II. Spinta fino a quota 186 km e a 6.4 km/s

Tra S-1C e S-II per lasciare spazio ai 5 motori J-2 c'era un anello che ospitava **8 motori** a **propellente solido** per spingere il propellente liquido del S-II verso il basso dopo che lo stadio S-1C era stato gettato a mare



Lo Stadio 2 comprende 2 serbatoi H_2 e O_2 separati da un singolo strato di refrattario a nido d'ape basato sulla tecnologia dei surfer americani

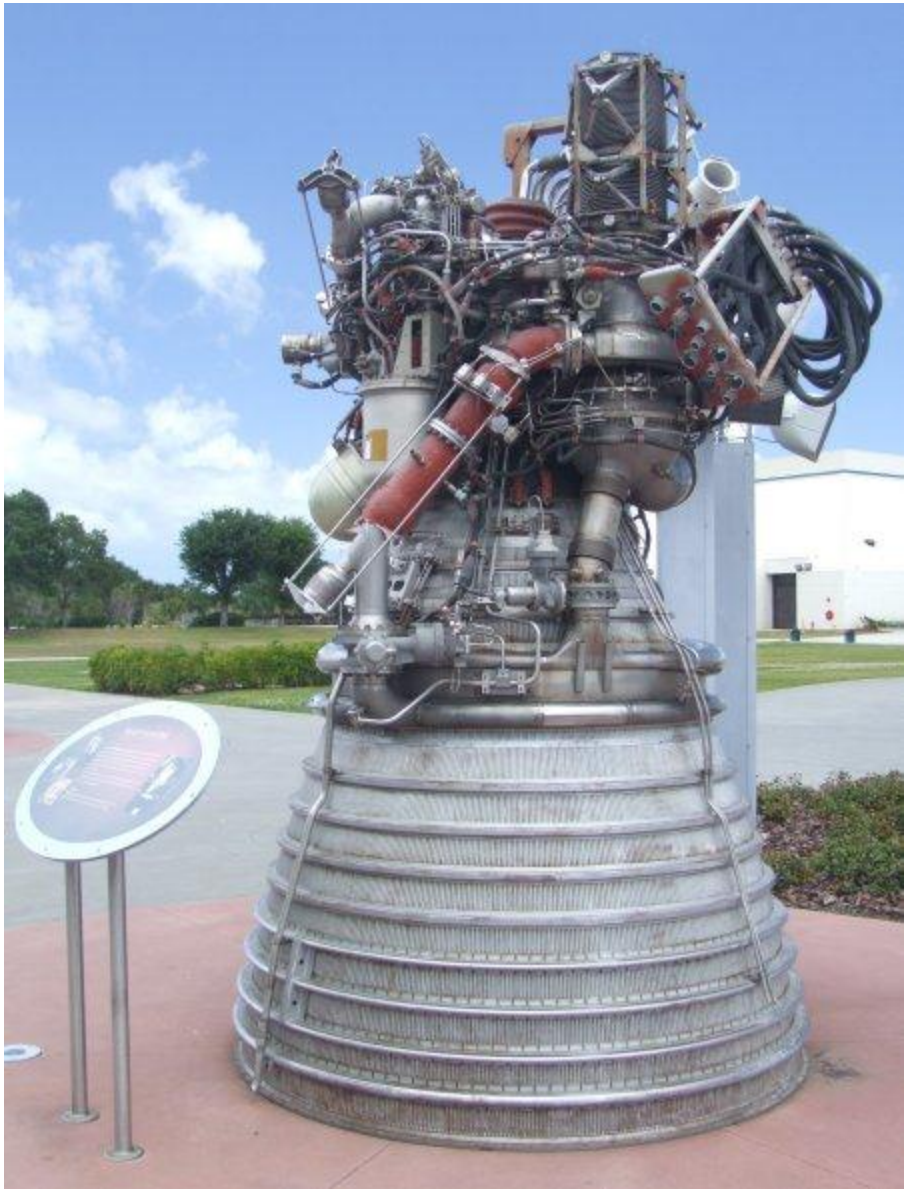


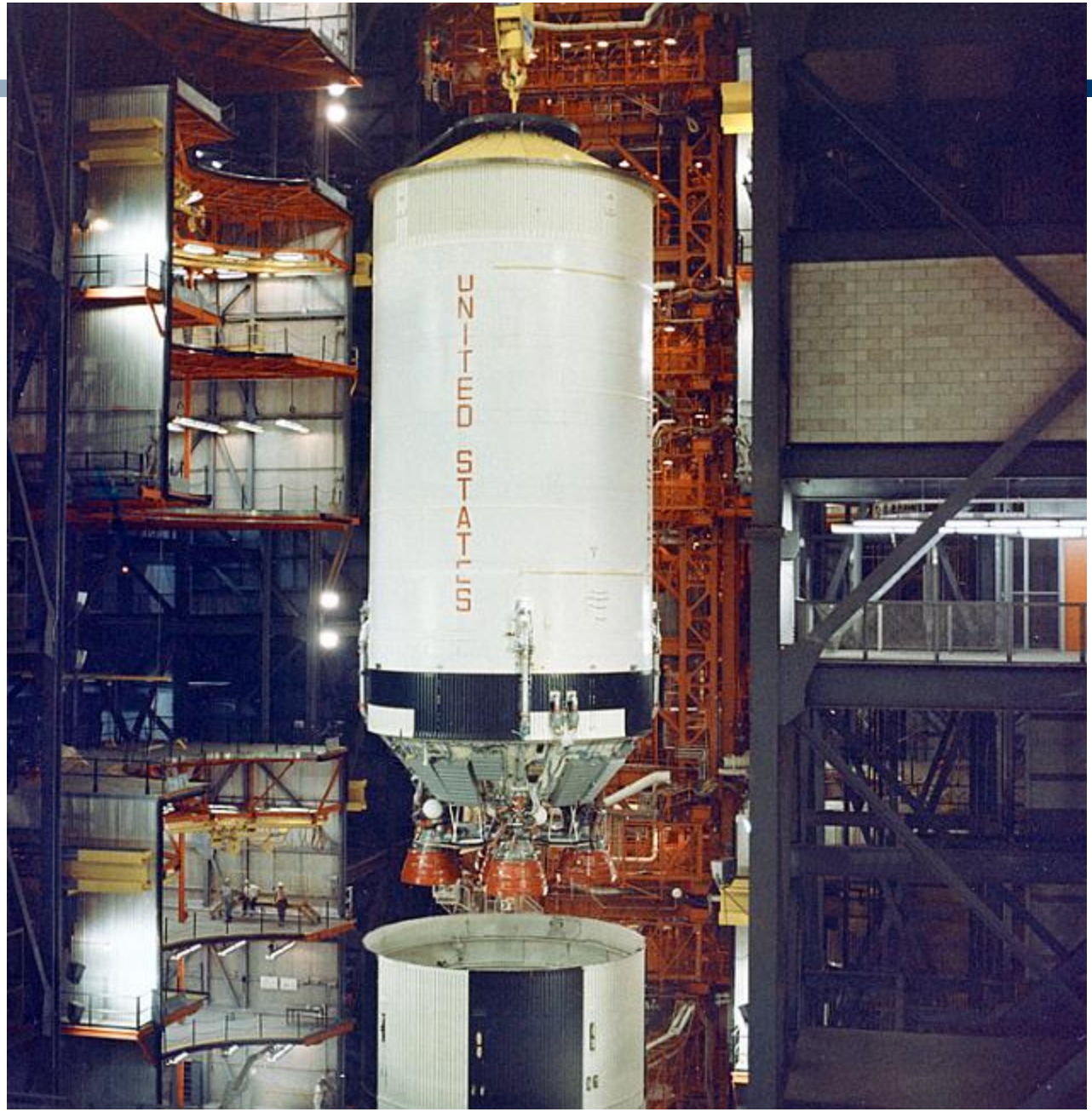
Ossigeno liquido T_{eb} −182.96 °C

Idrogeno liquido Teb = −252.87 °C

ΔT = 70 °C

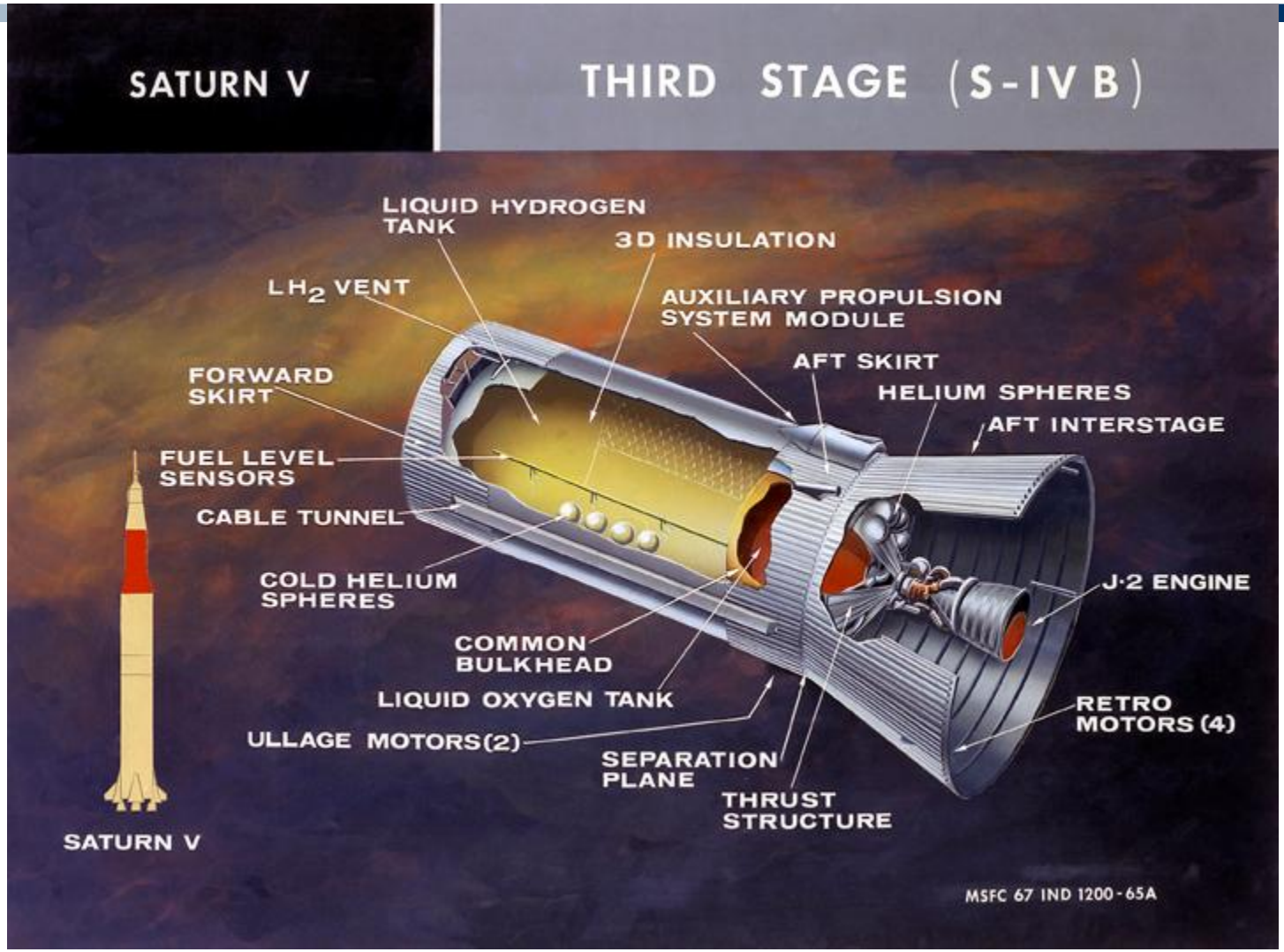
Rocketdyne J-2 engine



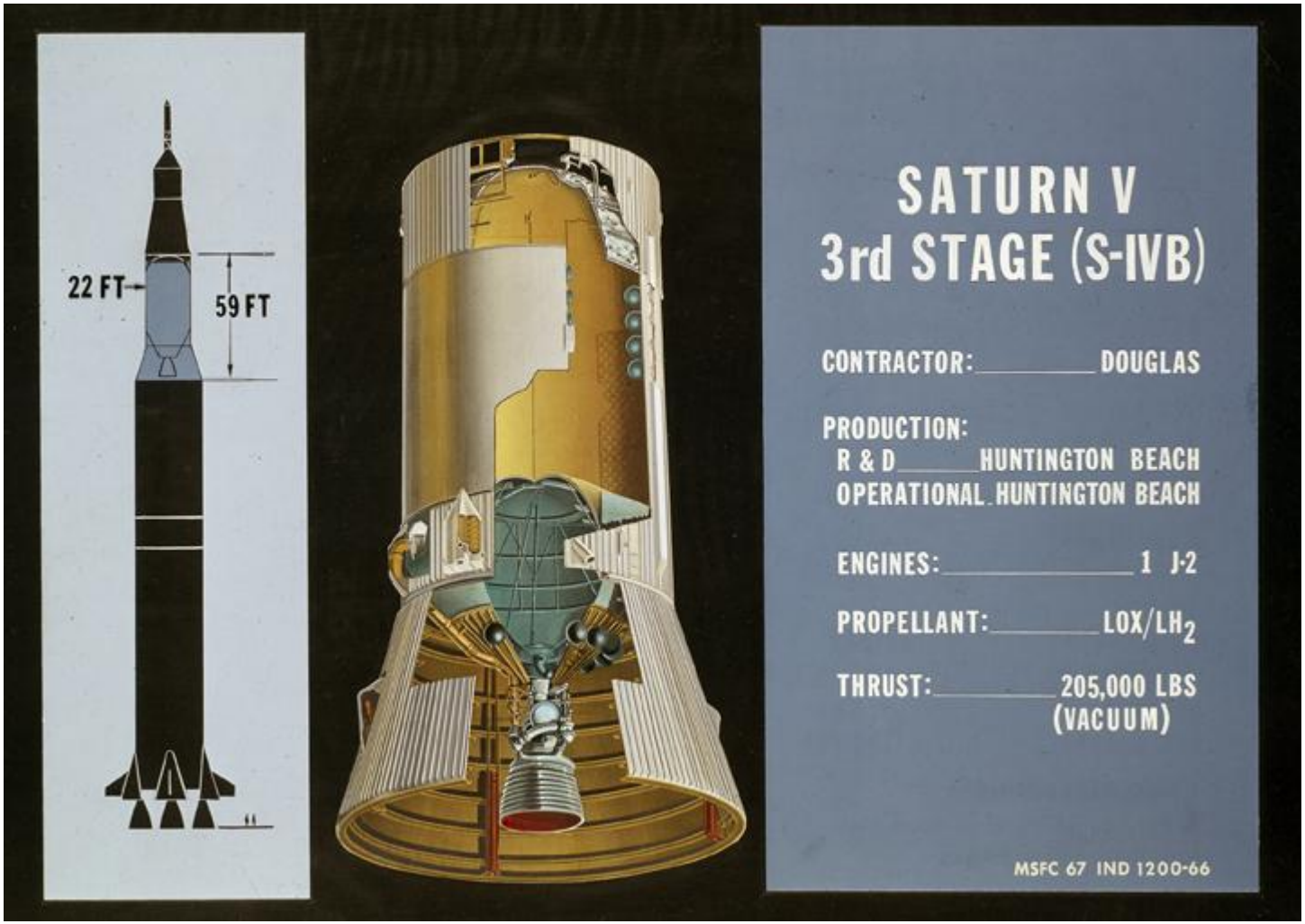


Second stage S-II

Terzo stadio



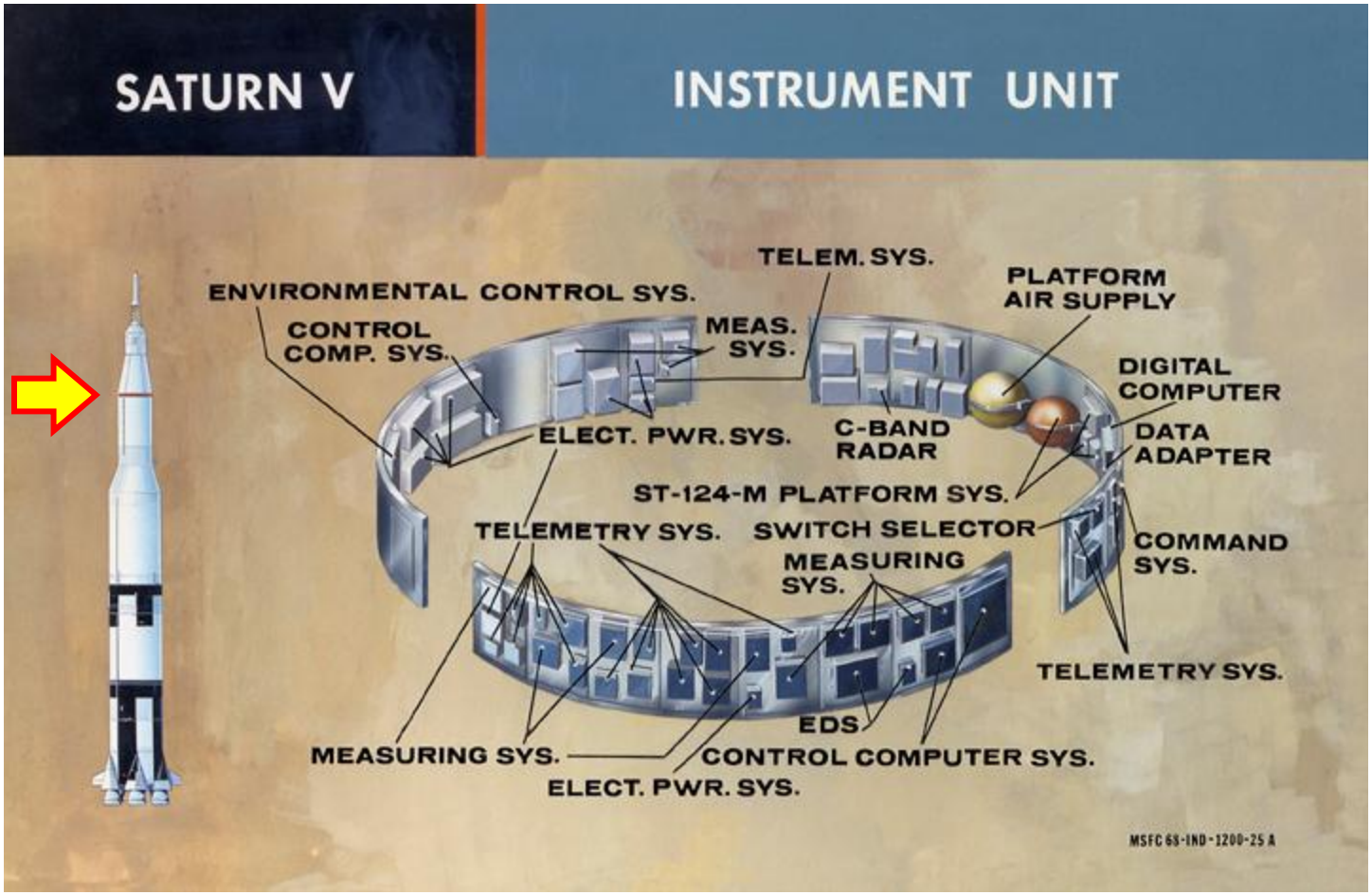
Compito del terzo stadio S-IVB era quello di condurre l'astronave dapprima in orbita terrestre e successivamente fuori dell'orbita terrestre nel viaggio verso la Luna (**TLI**)



Il tronco di cono di raccordo tra stadio 2 e stadio 3 restava attaccato allo stadio 2 e gettato a mare al momento del distacco dello stadio 2

The **S-IVB third stage** is moved into position for mating

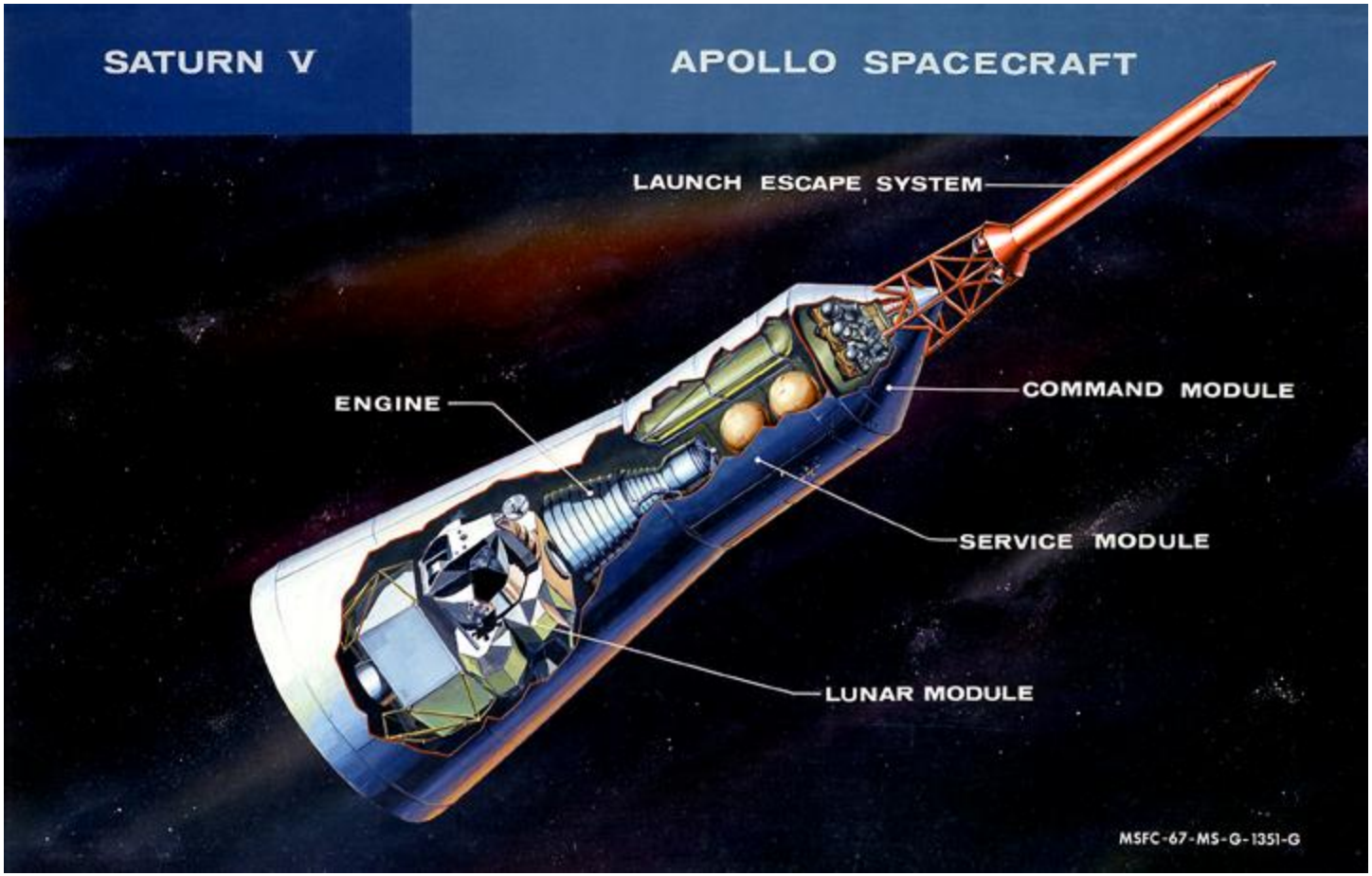
Unità di controllo e strumentazione

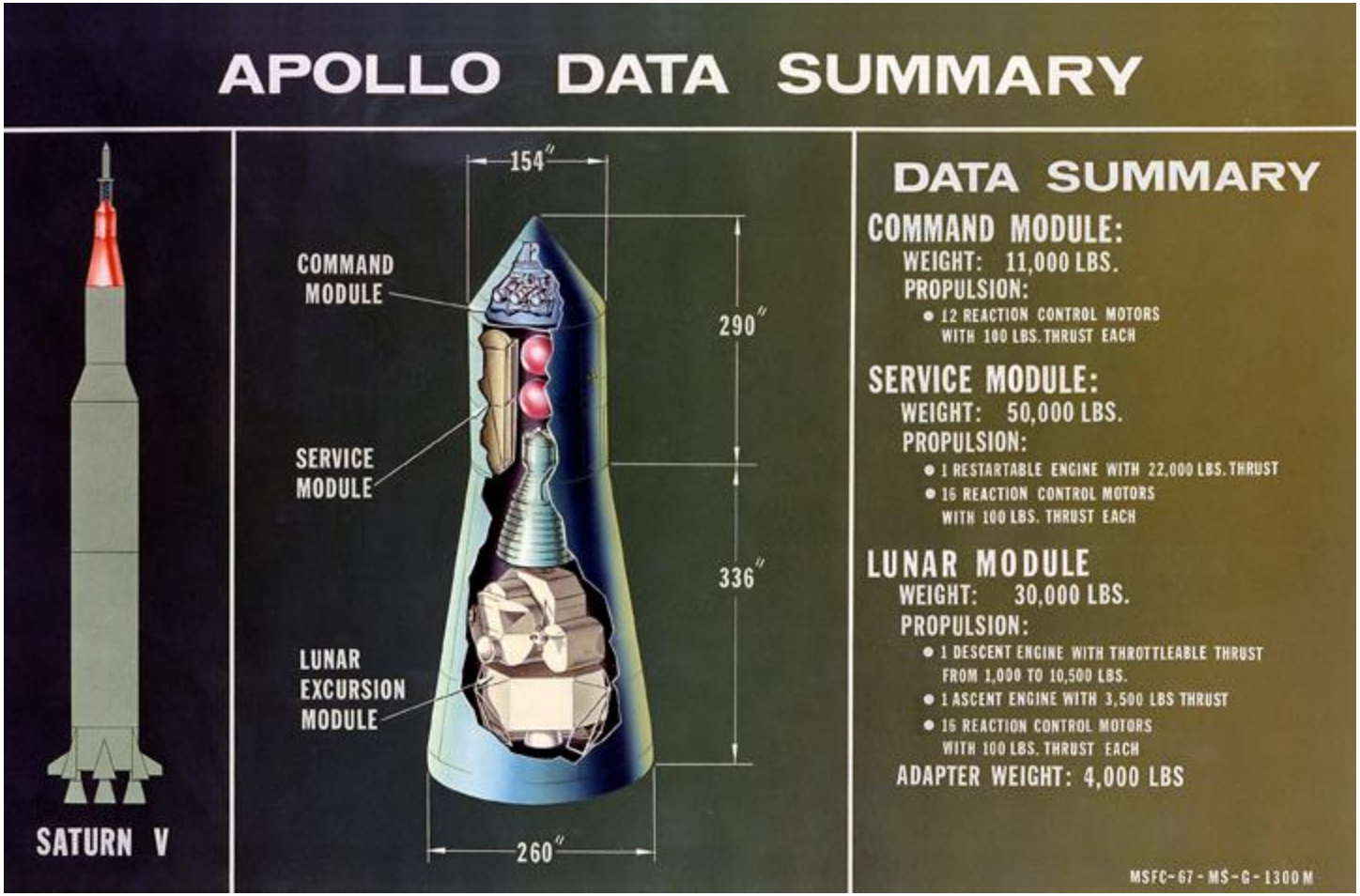


Definito lo stadio più importante in quanto contiene il sistema di guida autonoma per tutto il Saturn V

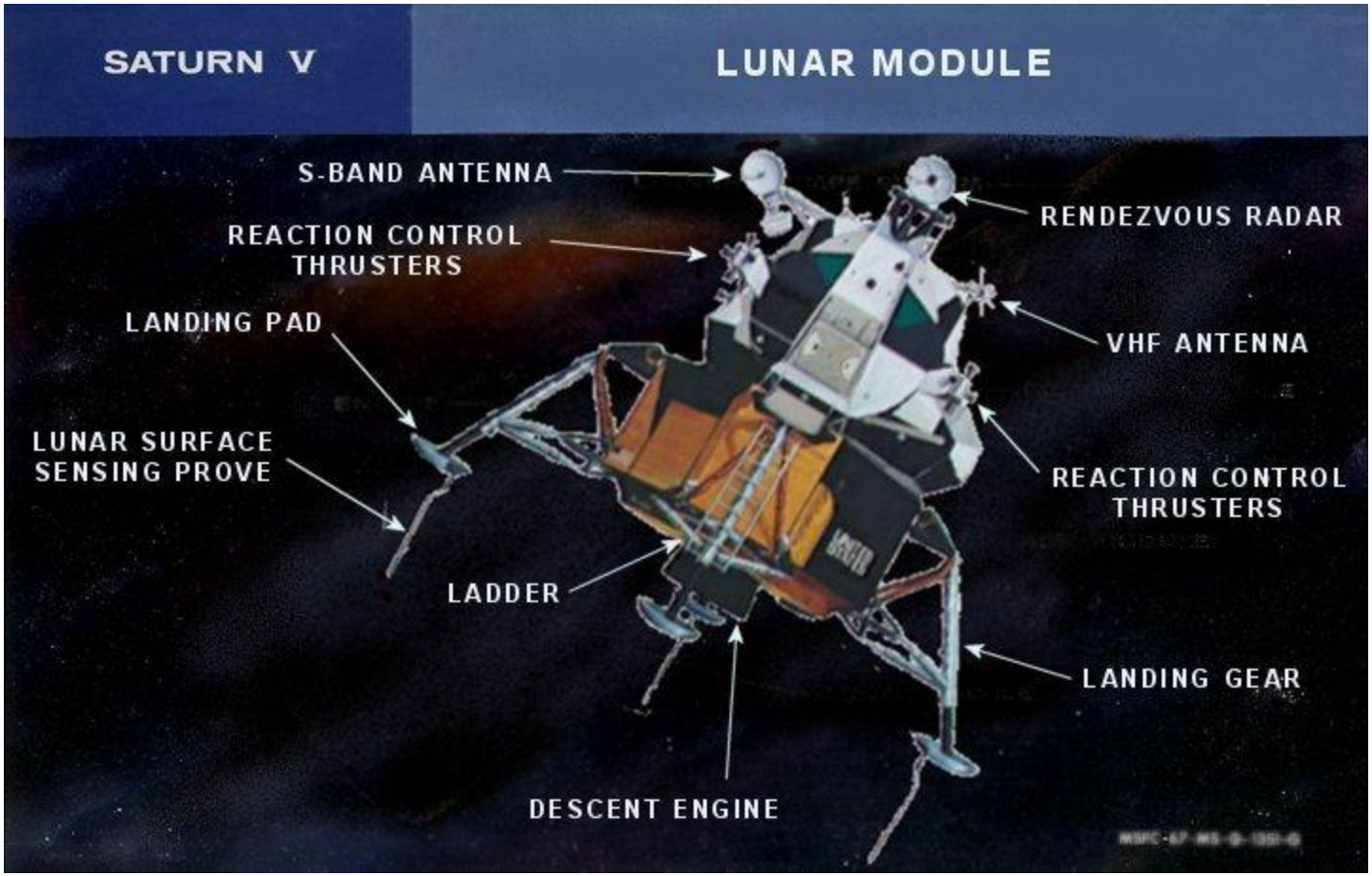
Instrument Unit

L’astronave


SATURN V
APOLLO SPACECRAFT
LAUNCH ESCAPE SYSTEM
COMMAND MODULE
ENGINE
SERVICE MODULE
LUNAR MODULE
MSFC-67-MS-G-1351-G

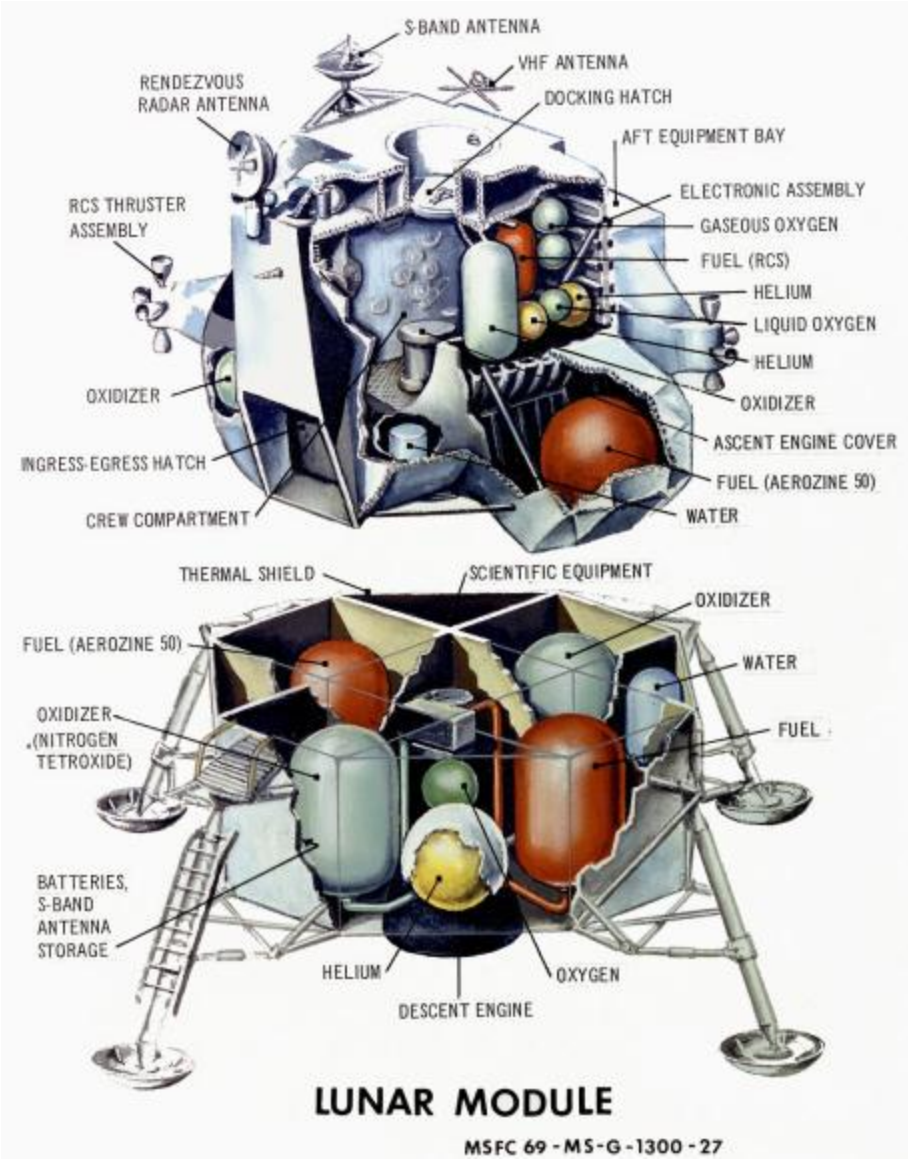

APOLLO DATA SUMMARY
SATURN V
154″
COMMAND MODULE
SERVICE MODULE
LUNAR EXCURSION MODULE
290″
336″
260″
DATA SUMMARY
COMMAND MODULE:
WEIGHT: 11,000 LBS.
PROPULSION:
• 12 REACTION CONTROL MOTORS WITH 100 LBS. THRUST EACH
SERVICE MODULE:
WEIGHT: 50,000 LBS.
PROPULSION:
• 1 RESTARTABLE ENGINE WITH 22,000 LBS. THRUST
• 16 REACTION CONTROL MOTORS WITH 100 LBS. THRUST EACH
LUNAR MODULE
WEIGHT: 30,000 LBS.
PROPULSION:
• 1 DESCENT ENGINE WITH THROTTLEABLE THRUST FROM 1,000 TO 10,500 LBS.
• 1 ASCENT ENGINE WITH 3,500 LBS THRUST
• 16 REACTION CONTROL MOTORS WITH 100 LBS. THRUST EACH
ADAPTER WEIGHT: 4,000 LBS
MSFC-67-MS-G-1300M

Modulo lunare


SATURN V
LUNAR MODULE
S-BAND ANTENNA
REACTION CONTROL THRUSTERS
LANDING PAD
LUNAR SURFACE SENSING PROVE
LADDER
DESCENT ENGINE
RENDEZVOUS RADAR
VHF ANTENNA
REACTION CONTROL THRUSTERS
LANDING GEAR

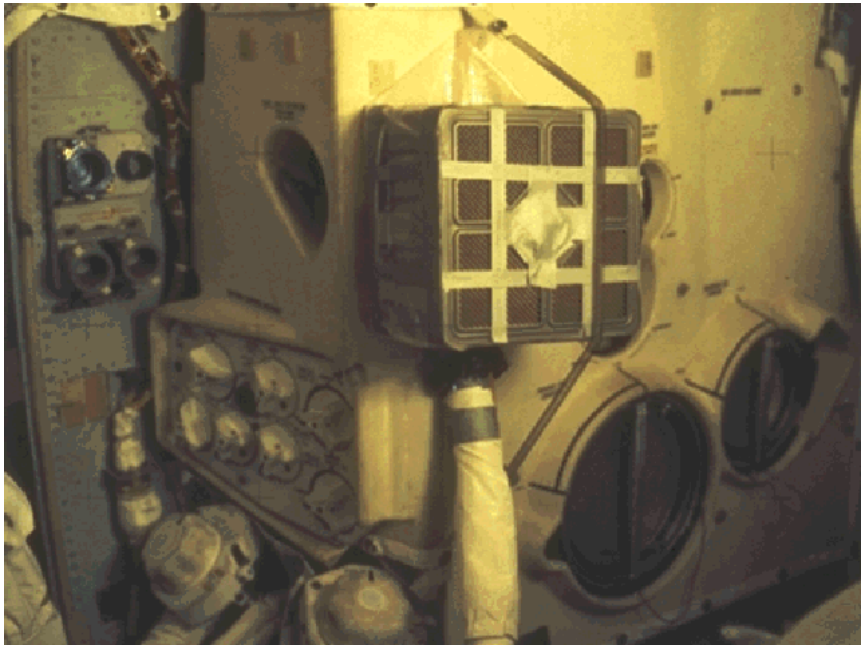
Ascent stage

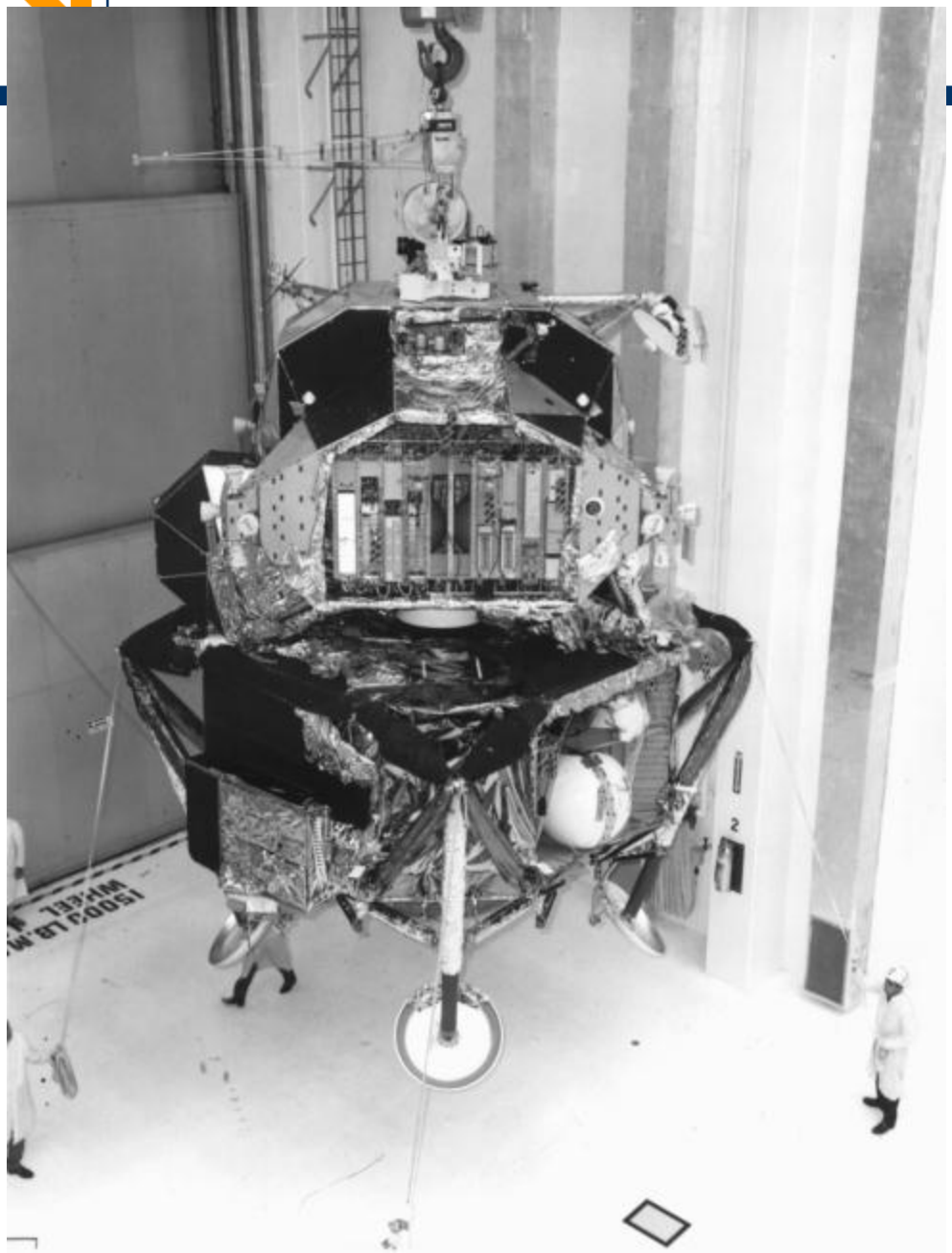
Descent stage



Lunar Module

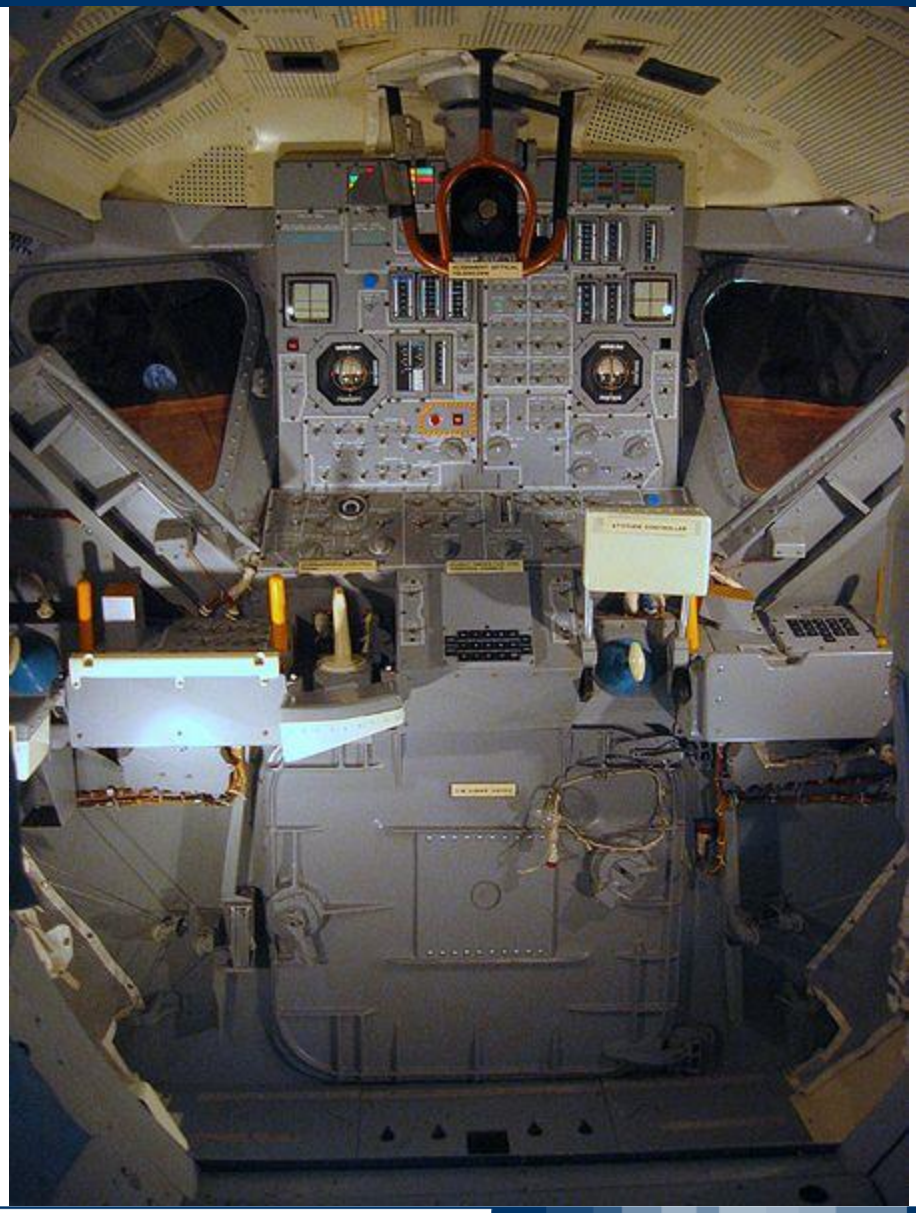
- Il LM era progettato per ospitare (e quindi far sopravvivere) due astronauti per un totale di 50 ore. Nel corso dell'Apollo 13 il LM ospitò tre astronauti per 100 ore. Fondamentali i filtri al litio per bloccare la CO_2 respirata, di sezione quadrata nel CSM e di sezione circolare nel LM. Per ovviare all'incompatibilità, utilizzarono come adattatore un tubo spiralato presente nella navicella spaziale e dedicato alla respirazione degli astronauti.





LM-5 is prepared for placement in the Apollo 11 spacecraft adapter

Cabina di comando del modulo lunare



Motore di ascesa LM

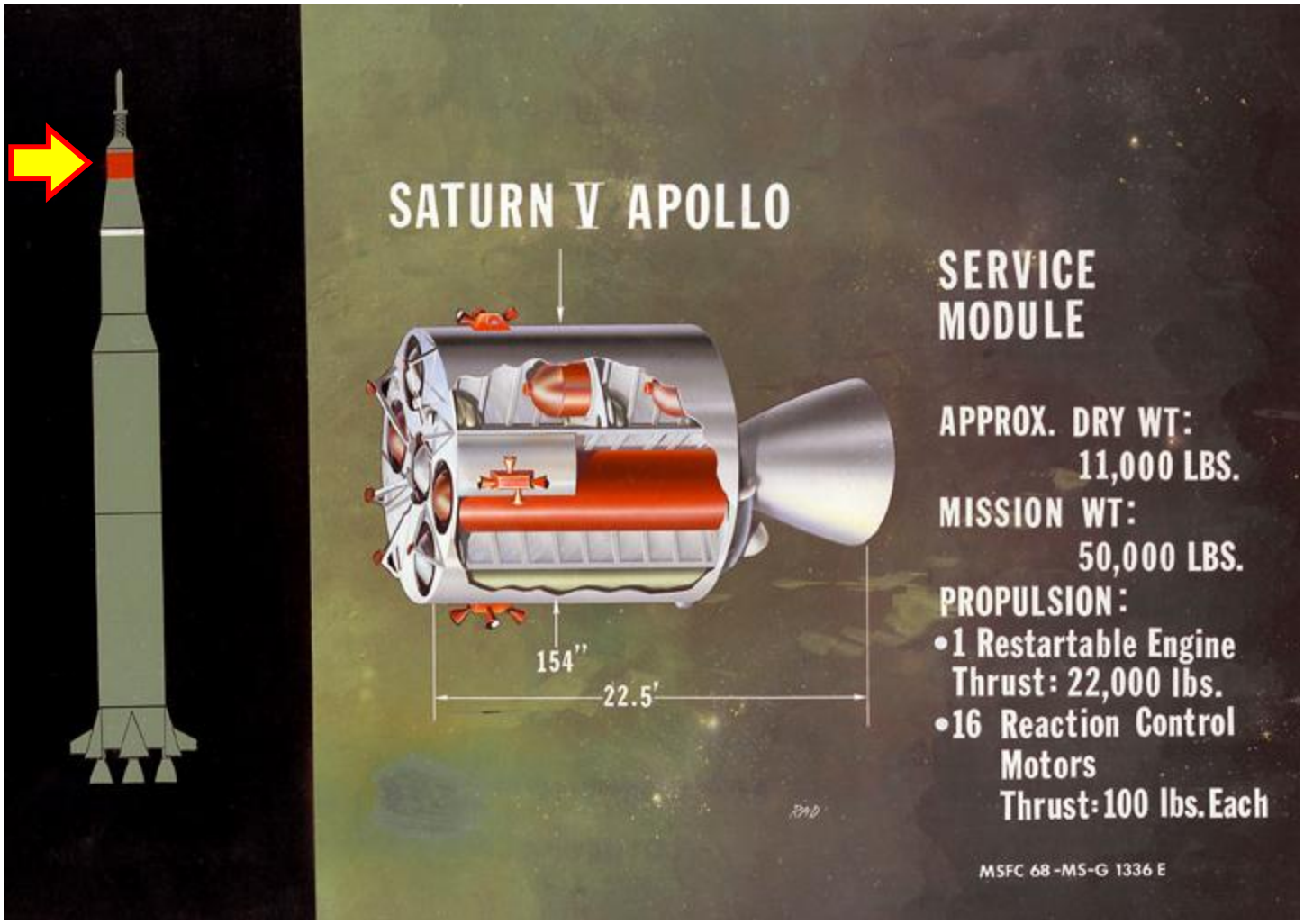
Propellente ipergolico molto corrosivo ed estremamente tossico (bastano 5 ppm per emorragia polmonare). Materiale dell'ugello ablato nel corso del funzionamento. Motore definitivo per la missione Apollo 11 mai testato causa corrosione.

Problema instabilità combustione risolto con progetto congiunto affidato da **Grumman** a **Bell Aerosystems** in collaborazione con **Rocketdyne**.

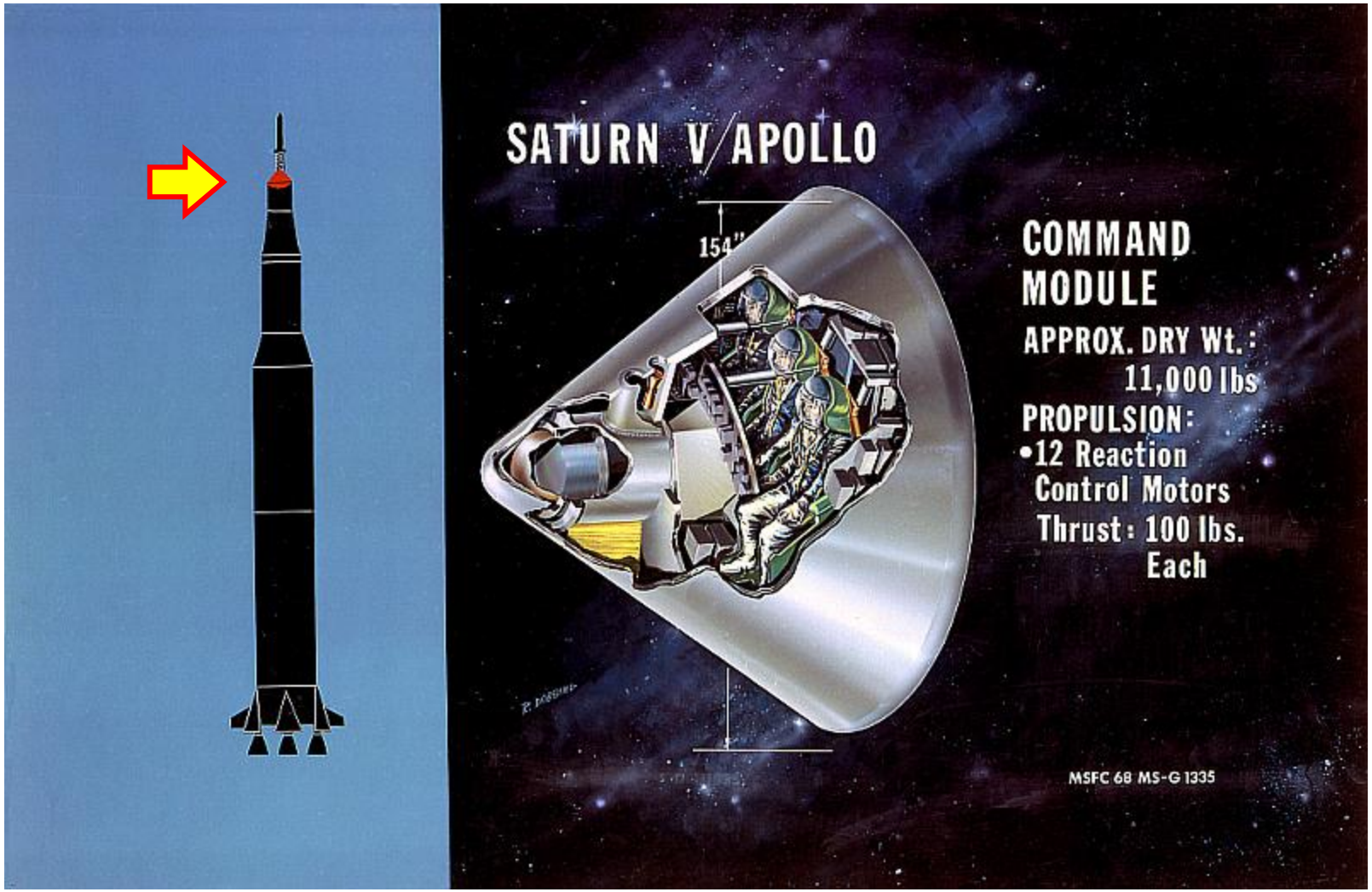
Hypergolic engines

The **fuel** component in the hypergolic engines used in the Apollo program (*e.g.*, the descent and ascent engines of the lunar module) was composed of **hydrazine** and **dimethylhydrazine** in approximately 50-50 proportions by weight. The associated **oxidizer** was **nitrogen tetroxide**.

Modulo di servizio


SATURN V APOLLO
SERVICE MODULE
APPROX. DRY WT: 11,000 LBS.
MISSION WT: 50,000 LBS.
PROPULSION:
•1 Restartable Engine Thrust: 22,000 lbs.
•16 Reaction Control Motors Thrust: 100 lbs. Each
154"
22.5'
MSFC 68-MS-G 1336 E

Modulo di comando


SATURN V/APOLLO
154"
COMMAND MODULE
APPROX. DRY Wt.:
11,000 lbs
PROPULSION:
•12 Reaction Control Motors
Thrust: 100 lbs. Each
MSFC 68 MS-G 1335

Atmosfera respirata

- Dopo l'incidente avvenuto in un test a terra all'interno del Command Module dell'Apollo 1 si passò da una atmosfera al 100% di ossigeno con pressione di 16 psi (rispetto ai 14.7 psi atmosferici esterni) ad una atmosfera al 60% di ossigeno e 40% di azoto.
  A valle del decollo una volta in orbita terrestre si purgava progressivamente l'azoto presente nell'ambiente del Command Module passando al 100% di ossigeno ma ad una pressione ridotta a soli 5 psi (per avvicinarsi al 20% di ossigeno dell'atmosfera terrestre usualmente respirato).
  Per compensare la rapida depressurizzazione del Command Module una volta arrivati in orbita terrestre ed evitare la sindrome del sommozzatore, gli astronauti respiravano ossigeno puro per 3 ore prima del decollo (al fine di eliminare l'azoto ancora disciolto nel sangue).

The Apollo 11 CSM being moved from work stand for mating

Motori missione Apollo

N.B.: rispetto alla durata totale della missione Apollo (**8 giorni per Apollo 11**) il tempo totale di accensione dei motori era di circa **15 minuti**

Sistema di sicurezza per espulsione rapida

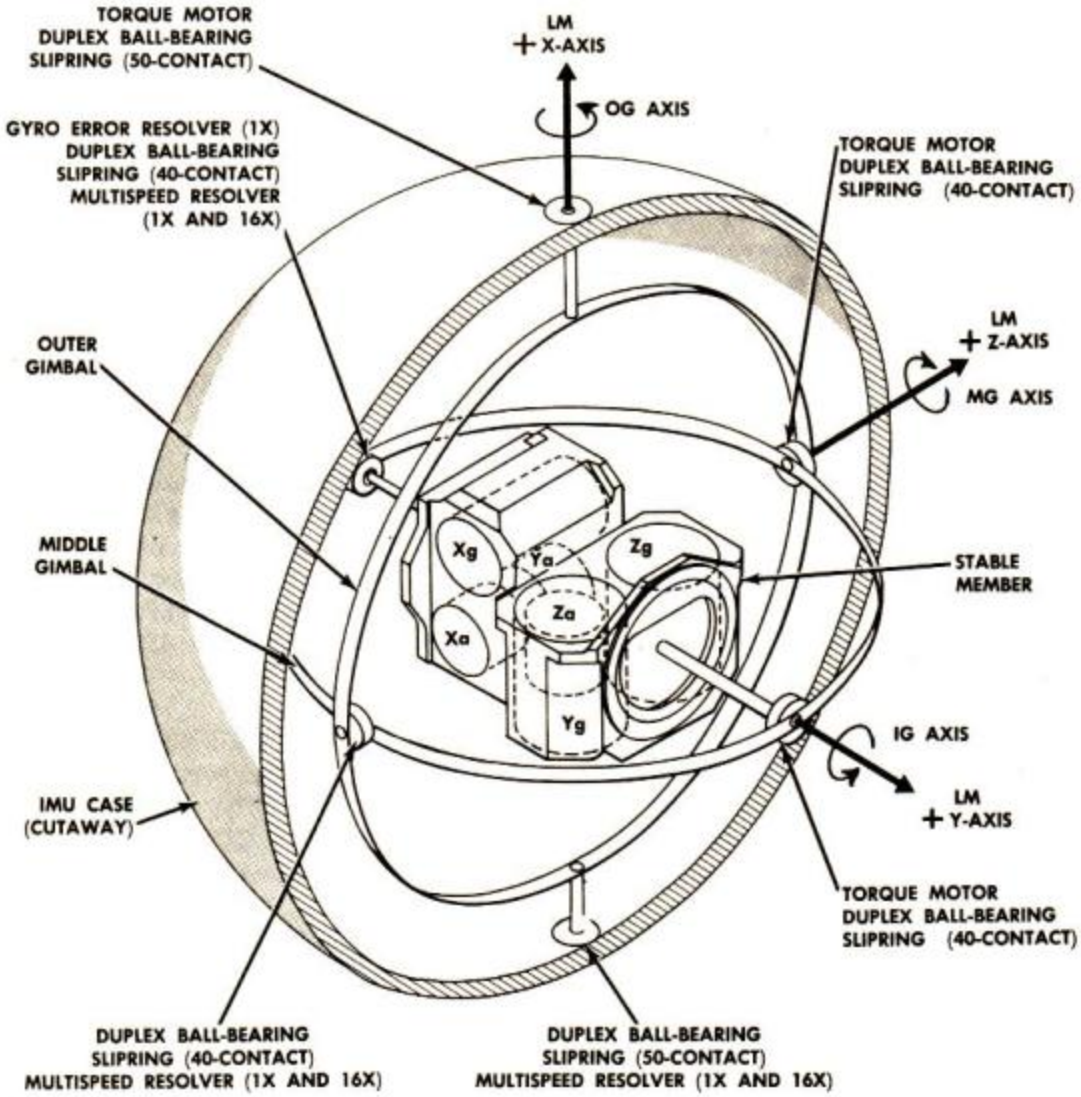
Launch Escape Assembly

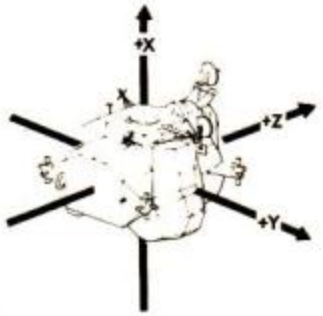
Launch Escape Assembly

Launch escape system

Sistema di guida inerziale

IMU = Inertial Measurement Unit

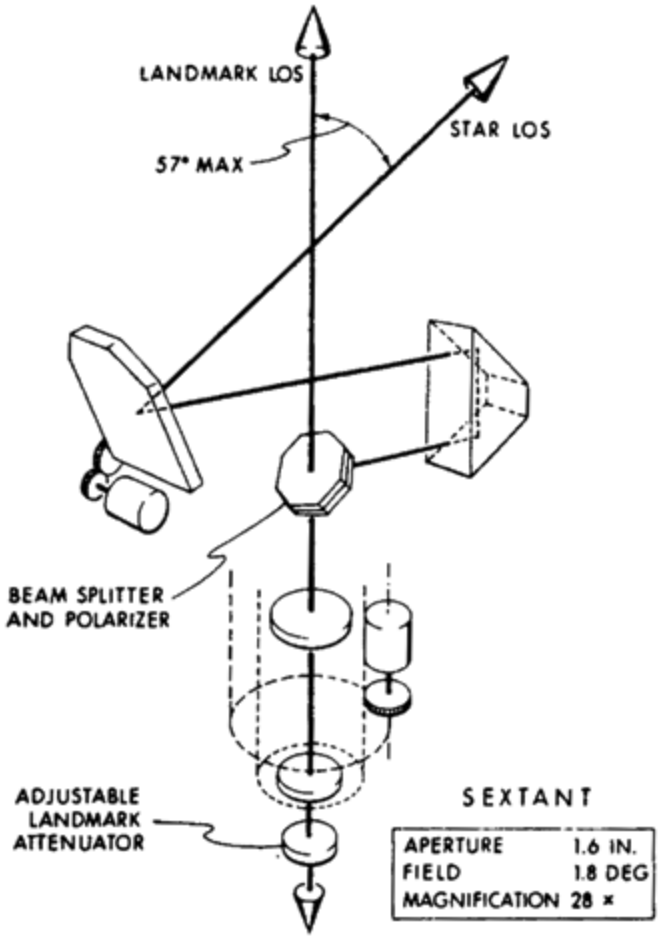




Note:
Xg — X IRIG; Xa — X PIP
Yg — Y IRIG; Ya — Y PIP
Zg — Z IRIG; Za — Z PIP

300LM4-152

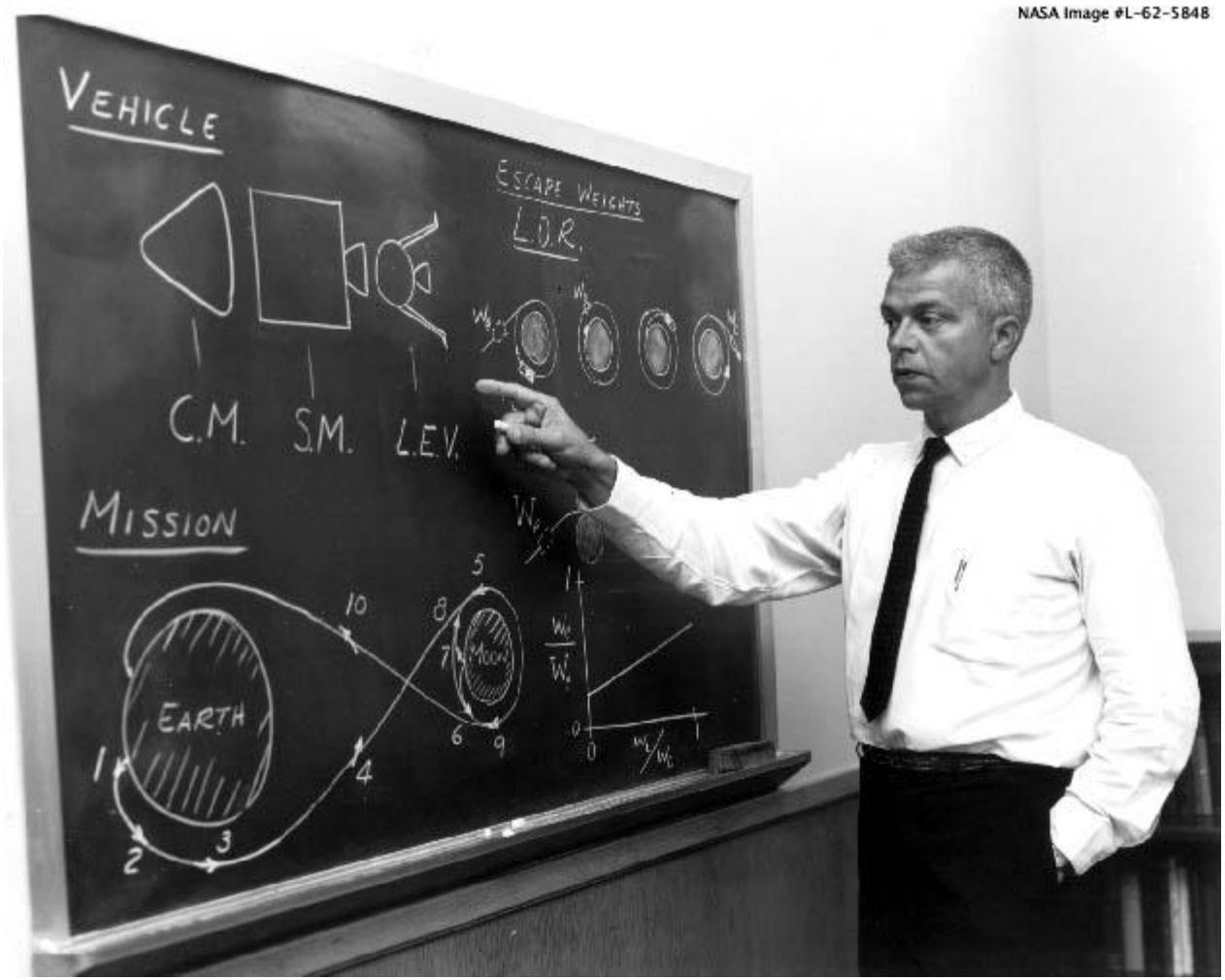
Charles Draper – MIT Instrumentation laboratory


LANDMARK LOS
STAR LOS
57° MAX
BEAM SPLITTER AND POLARIZER
ADJUSTABLE LANDMARK ATTENUATOR
SEXTANT
APERTURE 1.6 IN.
FIELD 1.8 DEG
MAGNIFICATION 28 ×

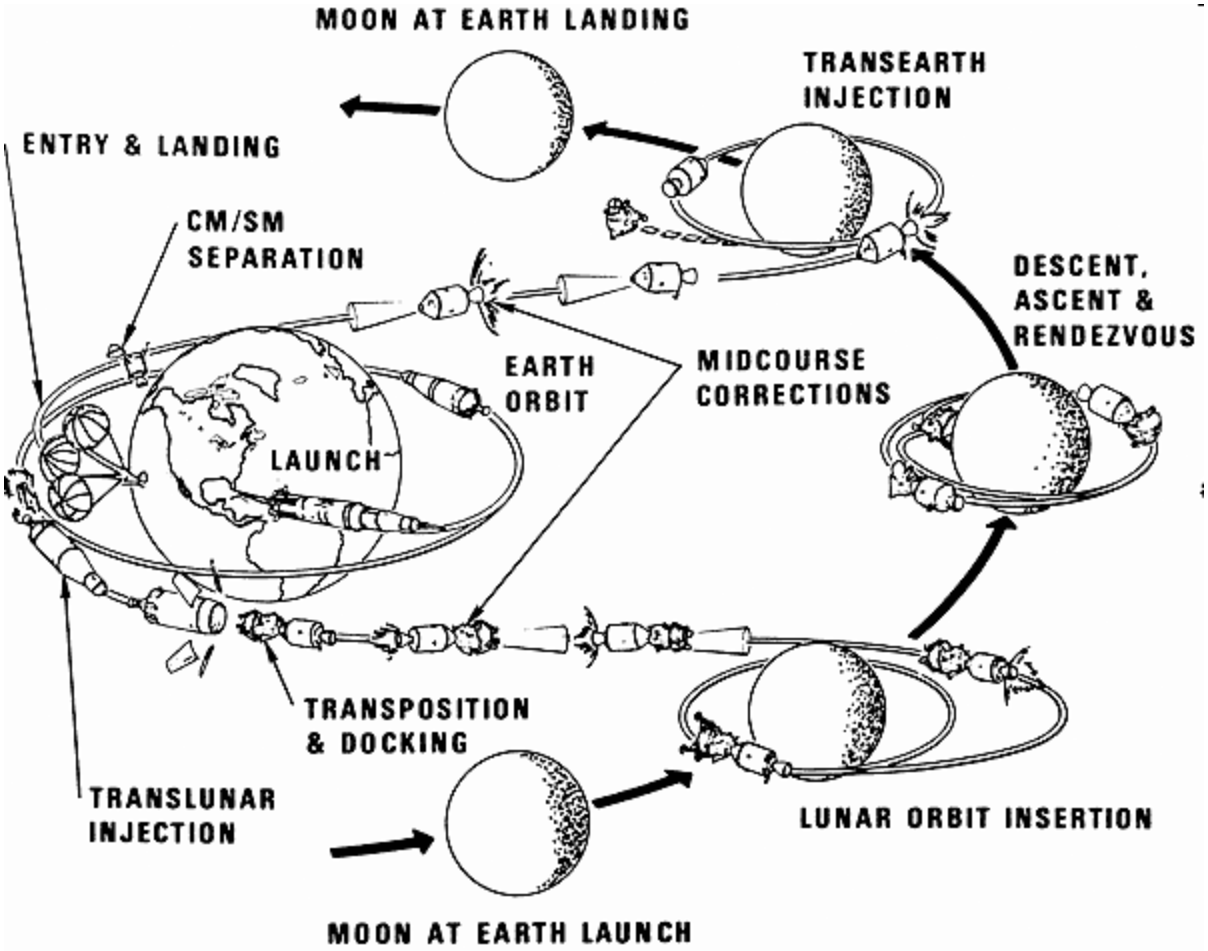

28x Sextant
Scanning Telescope

Sequenza operativa della missione

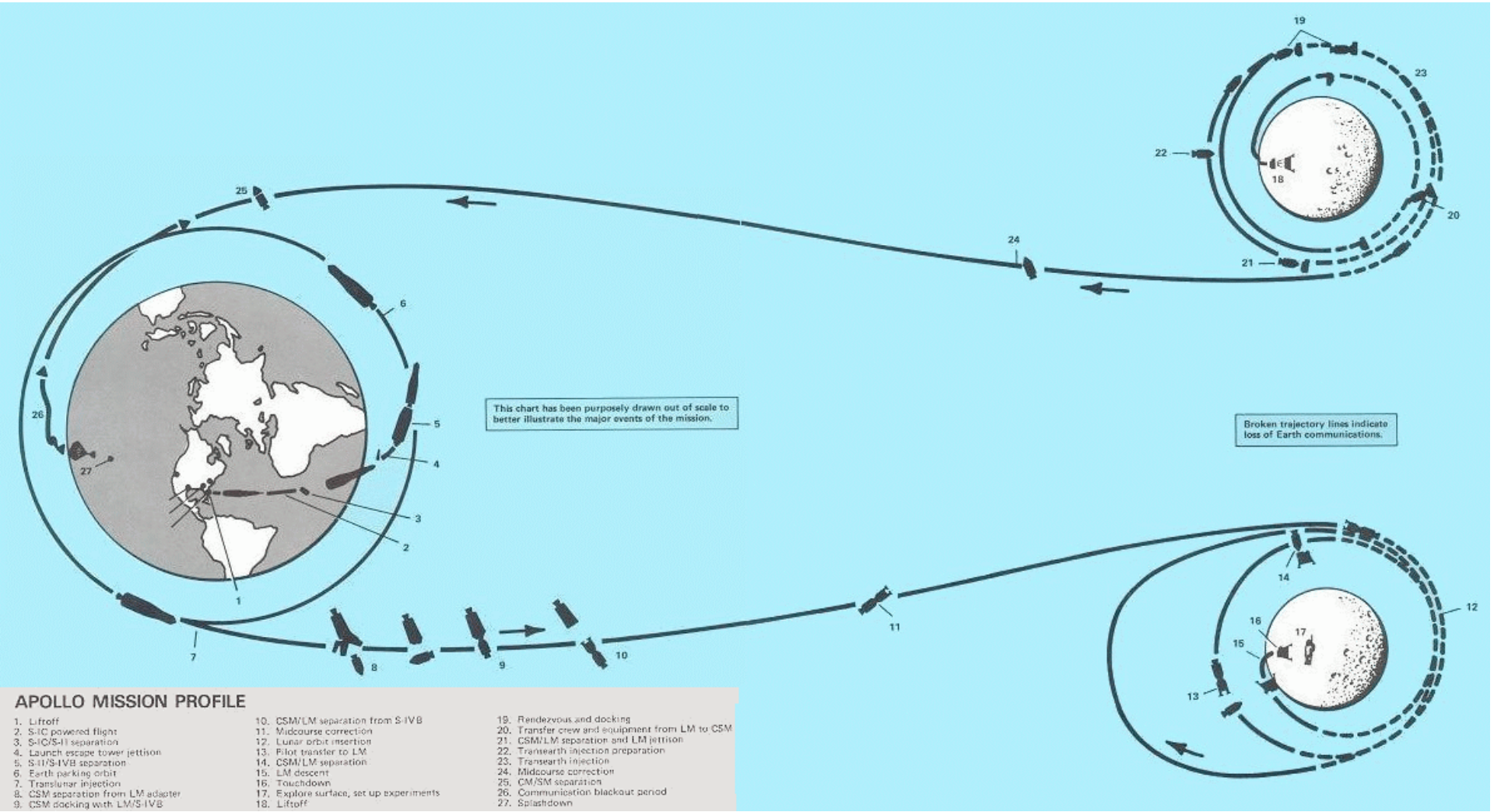
John C. Houbolt



Quando il LEM tocca la superficie lunare Werner Von Braun si congratula con John Houbolt dicendogli che è stato grazie a lui se l'uomo è riuscito a raggiungere la luna. Houbolt aveva insomma ragione.

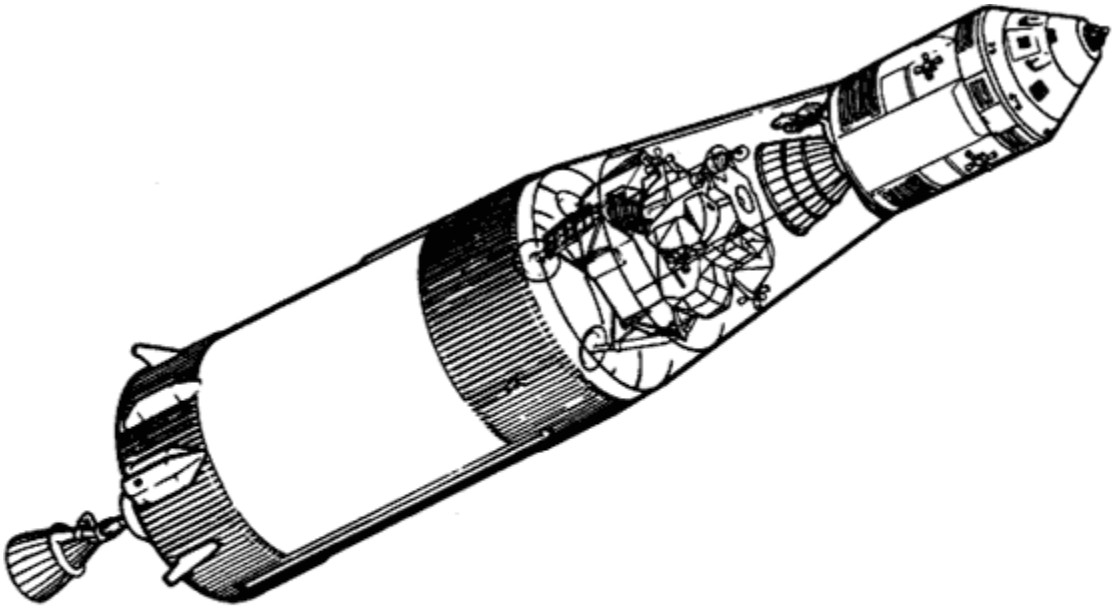


APOLLO LUNAR MISSION



APOLLO MISSION PROFILE

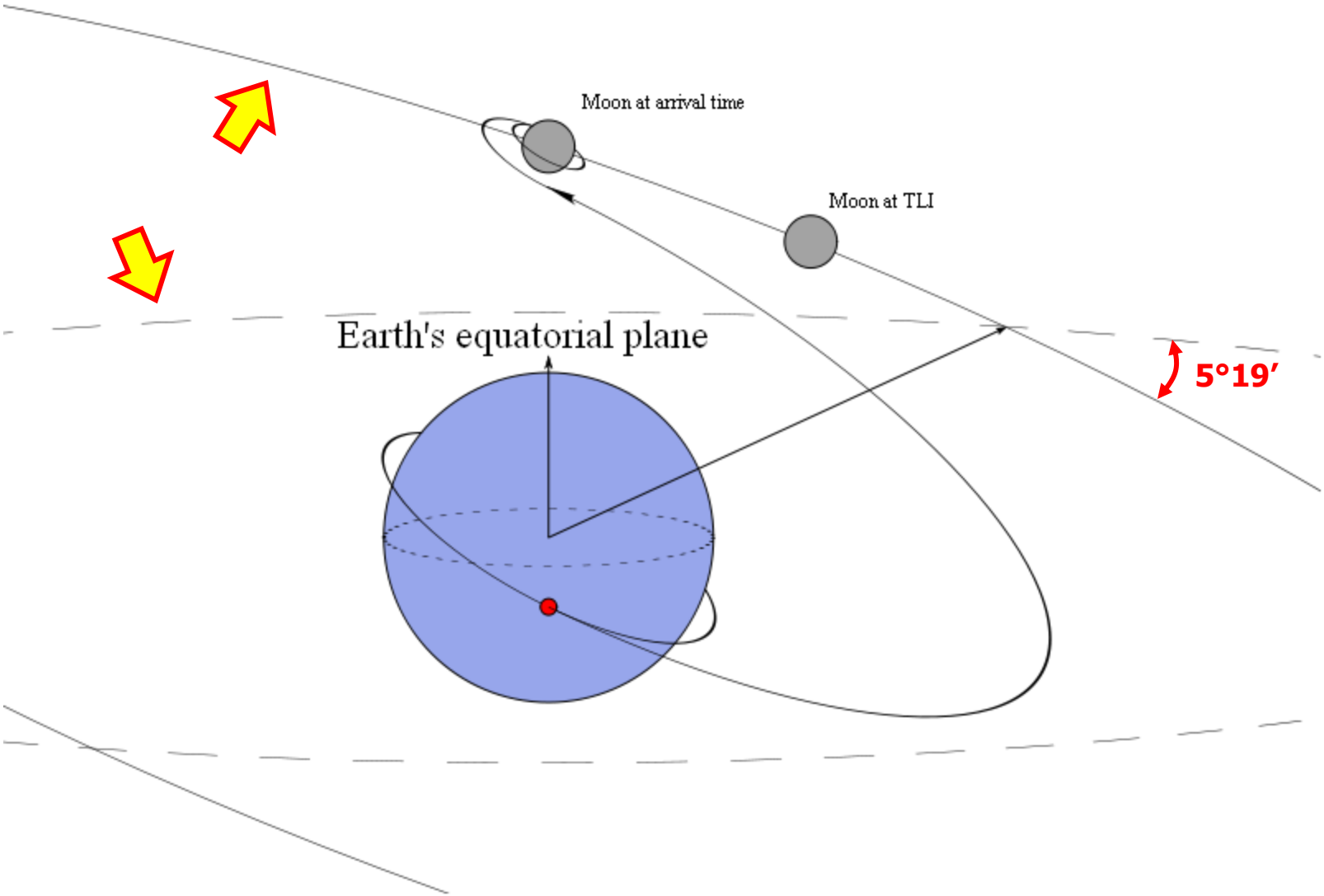
1. Liftoff
2. S-IC powered flight
3. S-IC/S-II separation
4. Launch escape tower jettison
5. S-II/S-IVB separation
6. Earth parking orbit
7. Translunar injection
8. CSM separation from LM adapter
9. CSM docking with LM/S-IVB
10. CSM/LM separation from S-IVB
11. Midcourse correction
12. Lunar orbit insertion
13. Pilot transfer to LM
14. CSM/LM separation
15. LM descent
16. Touchdown
17. Explore surface, set up experiments
18. Liftoff
19. Rendezvous and docking
20. Transfer crew and equipment from LM to CSM
21. CSM/LM separation and LM jettison
22. Transearth injection preparation
23. Transearth injection
24. Midcourse correction
25. CM/SM separation
26. Communication blackout period
27. Splashdown



VEHICLE EARTH PARKING ORBIT CONFIGURATION

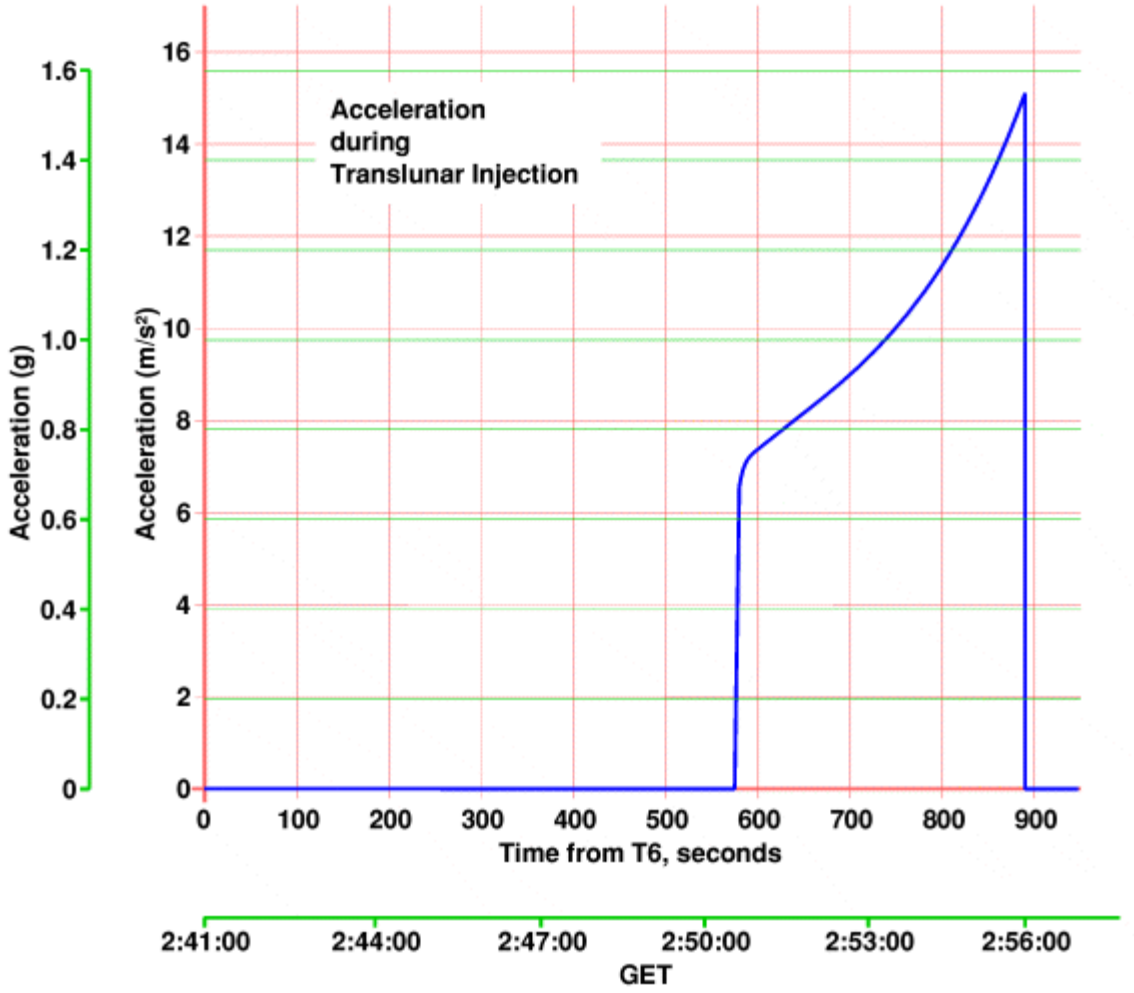
(SATURN V THIRD STAGE AND INSTRUMENT UNIT, APOLLO SPACECRAFT)

Orbite terrestri e lunari

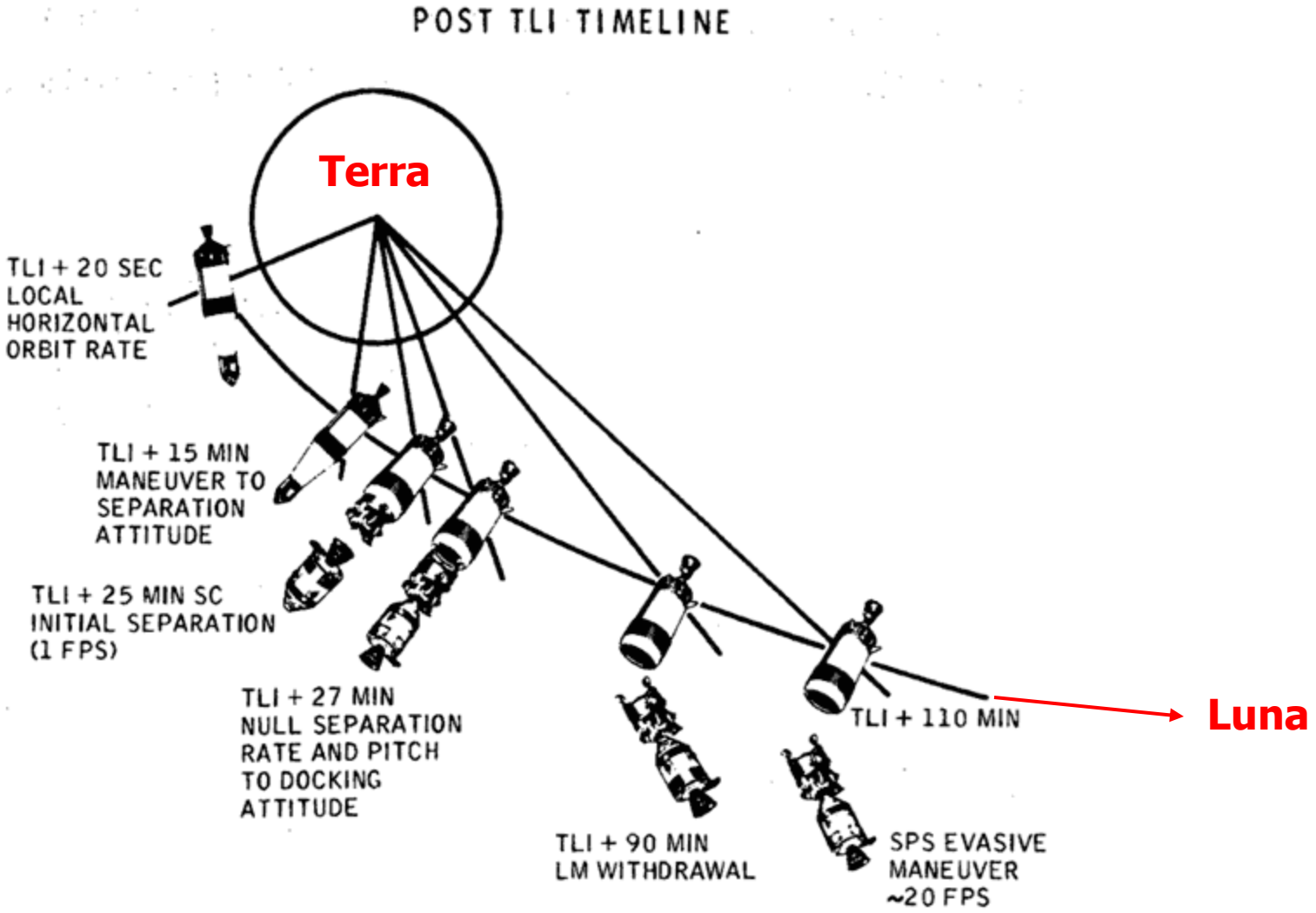


Il piano dell'orbita della Luna è inclinato di 5°19′ rispetto a quello dell'orbita della Terra intorno al Sole (*i.e.* il piano dell'eclittica)

TLI = Translunar injection

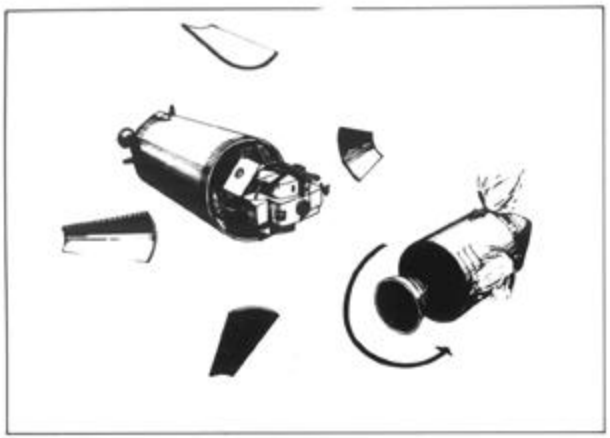


TLI = Translunar injection

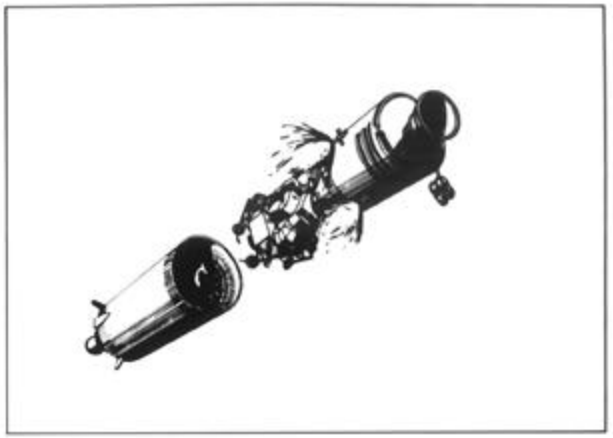


LOI = Lunar Orbit Insertion

APOLLO 11 — Translunar Flight

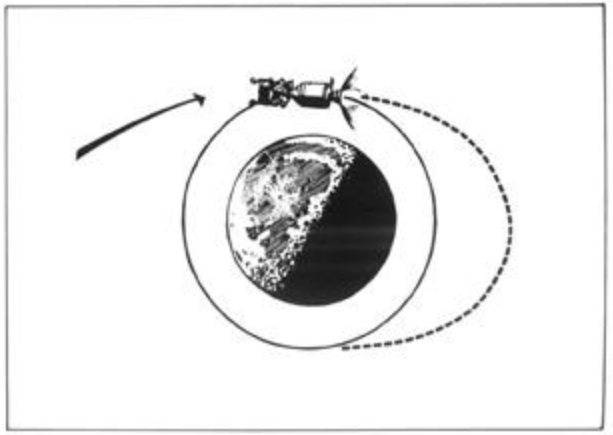


Transposition Maneuver



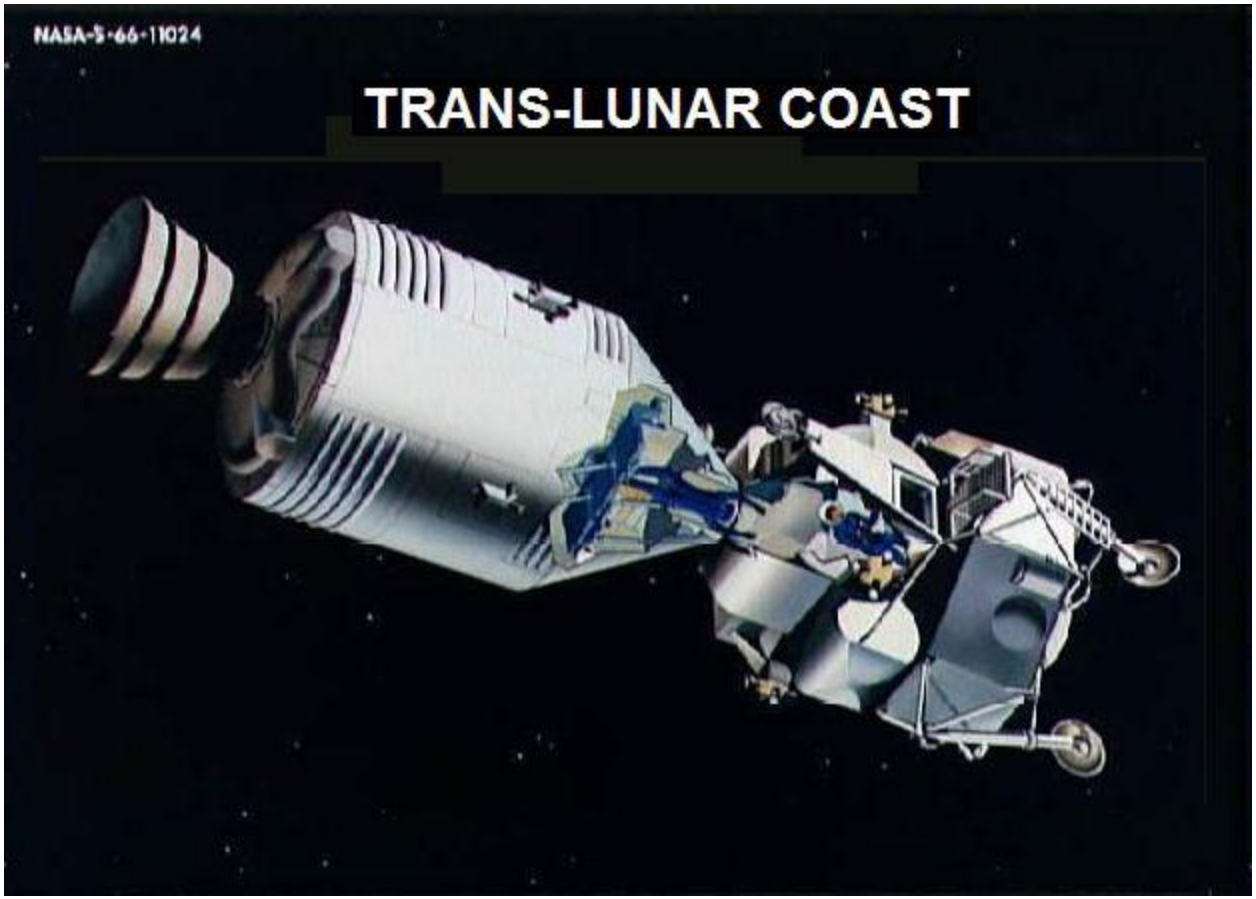
Extraction Of Lunar Module

Navigation Check

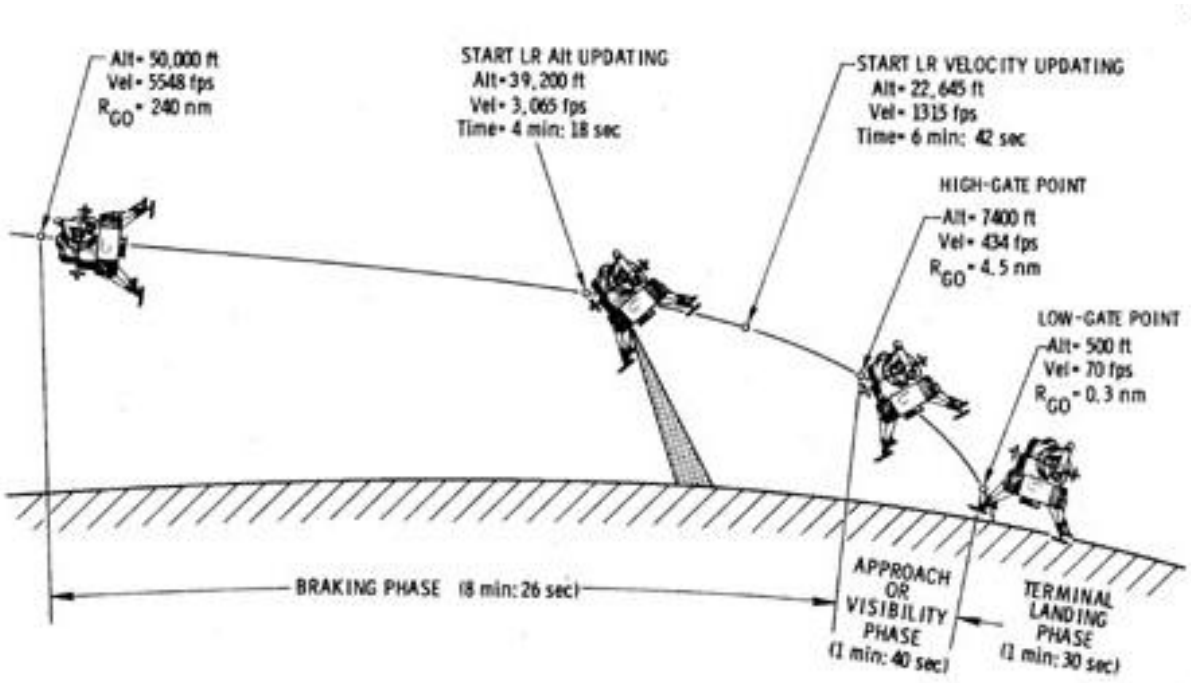


Lunar Orbit Insertion

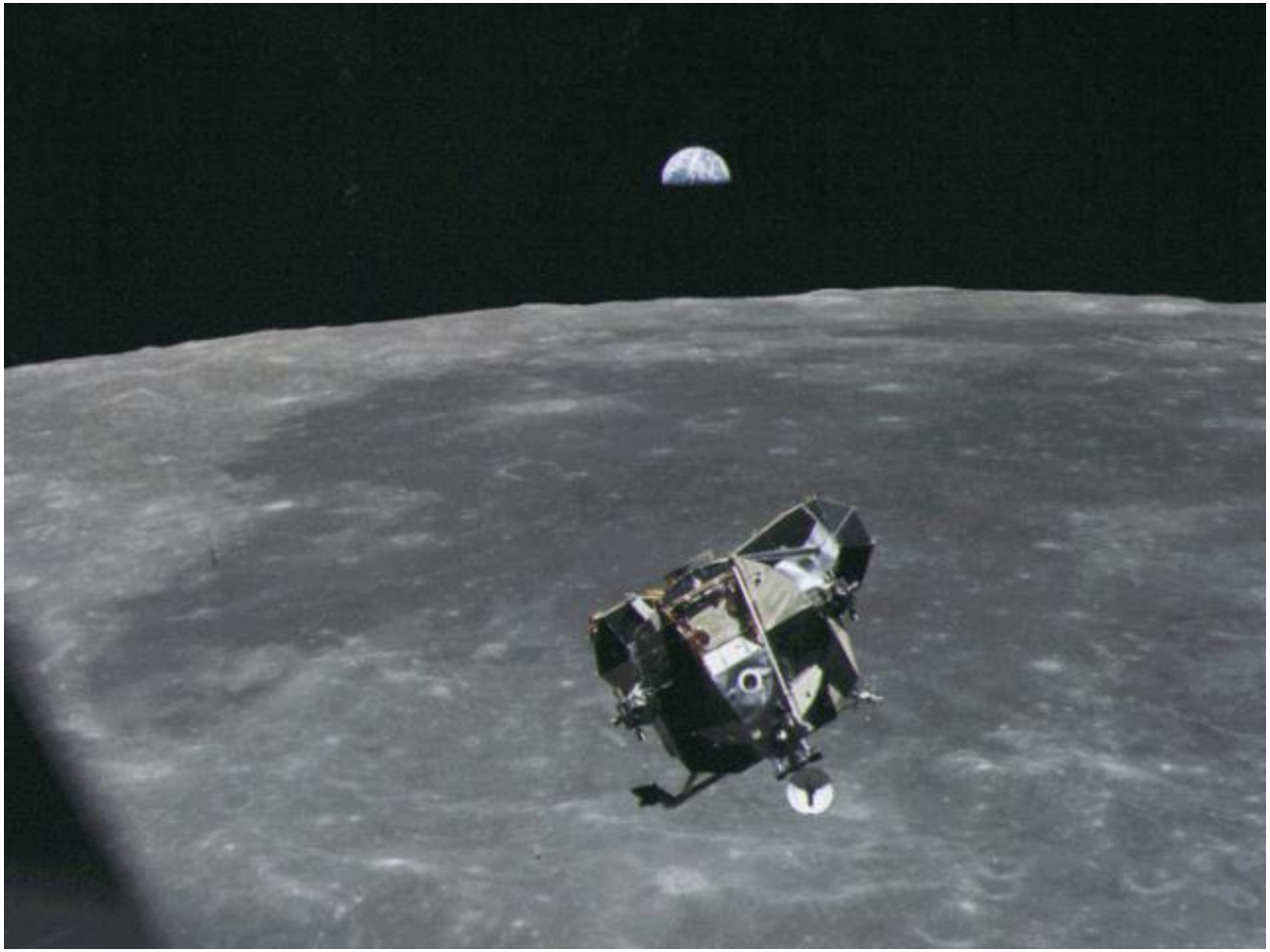
Accoppiamento CSM e LM



Sequenza di allunaggio



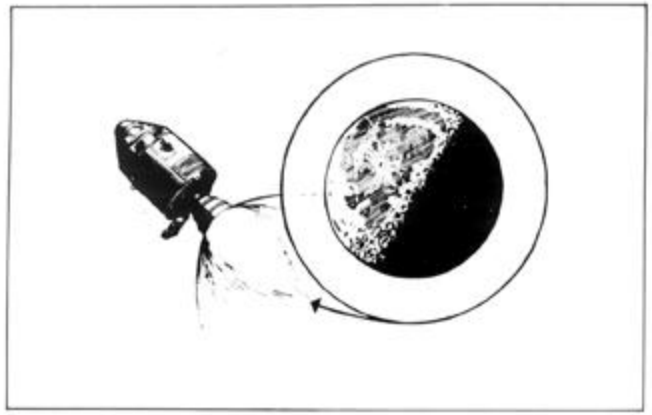
Sequenza di allunaggio



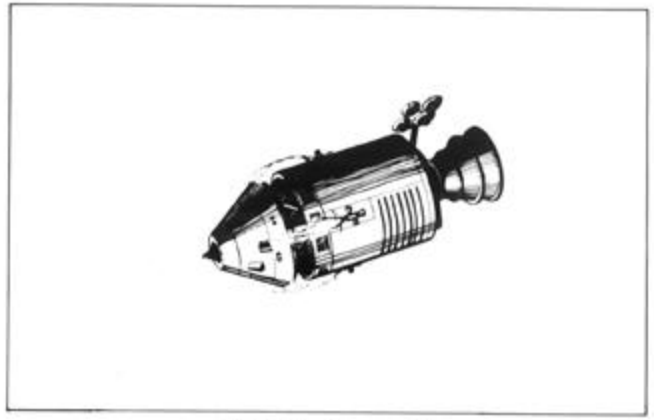
Il CSM resta da solo…

TEI = Transearth injection

APOLLO 11 — Transearth Injection And Recovery



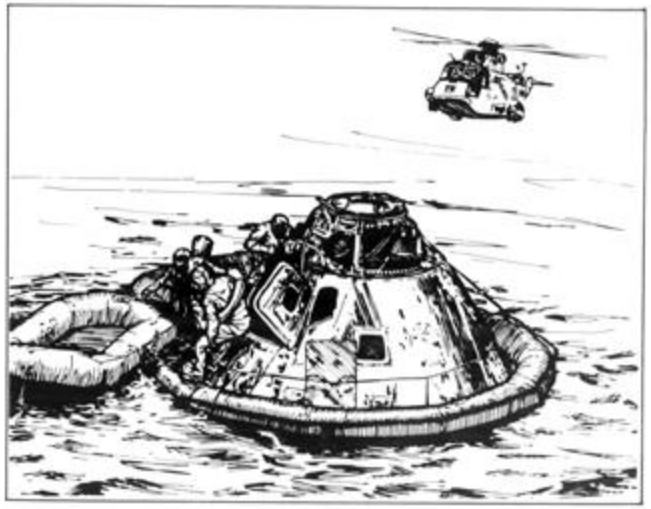
Transearth Injection



CM/SM Separation

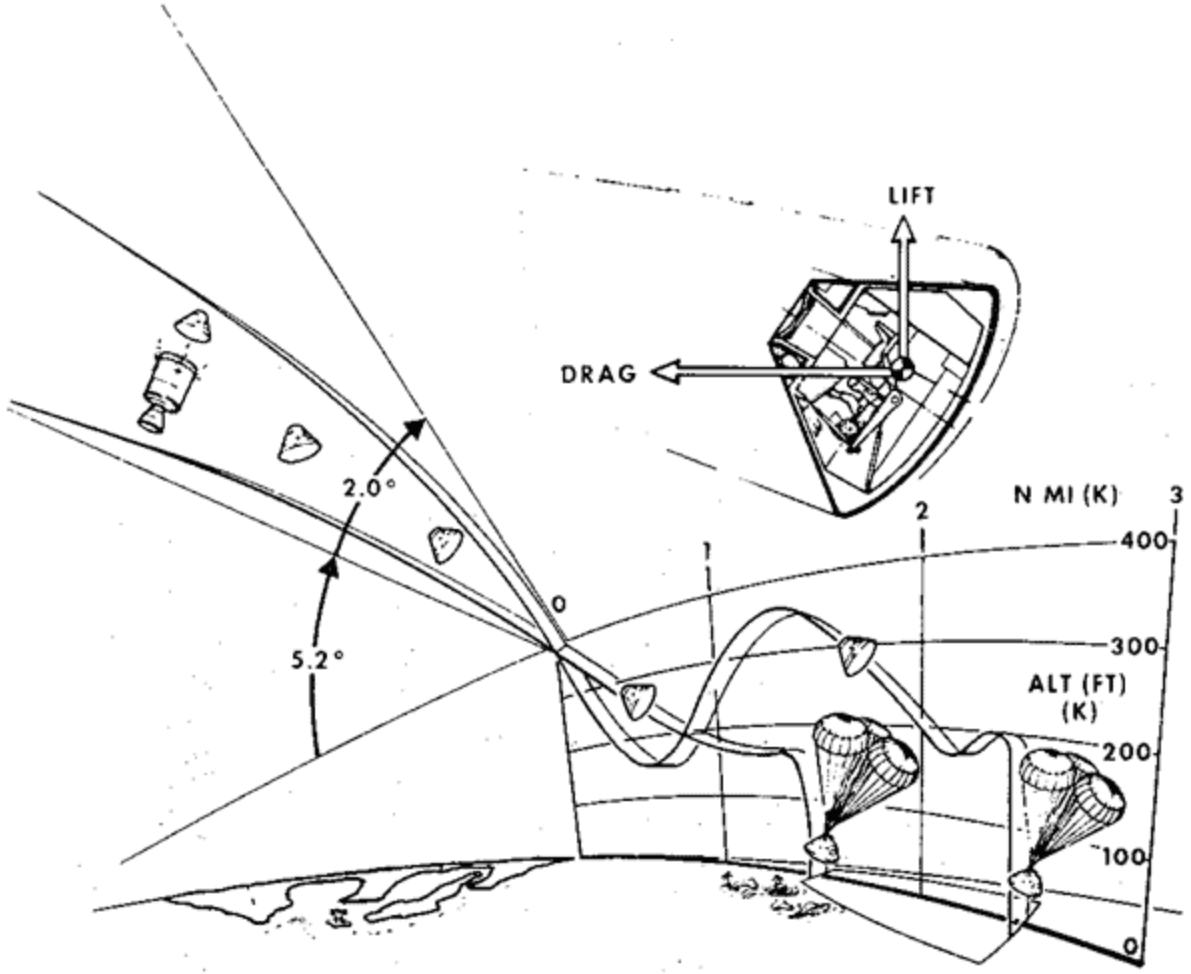
Reentry

Splashdown

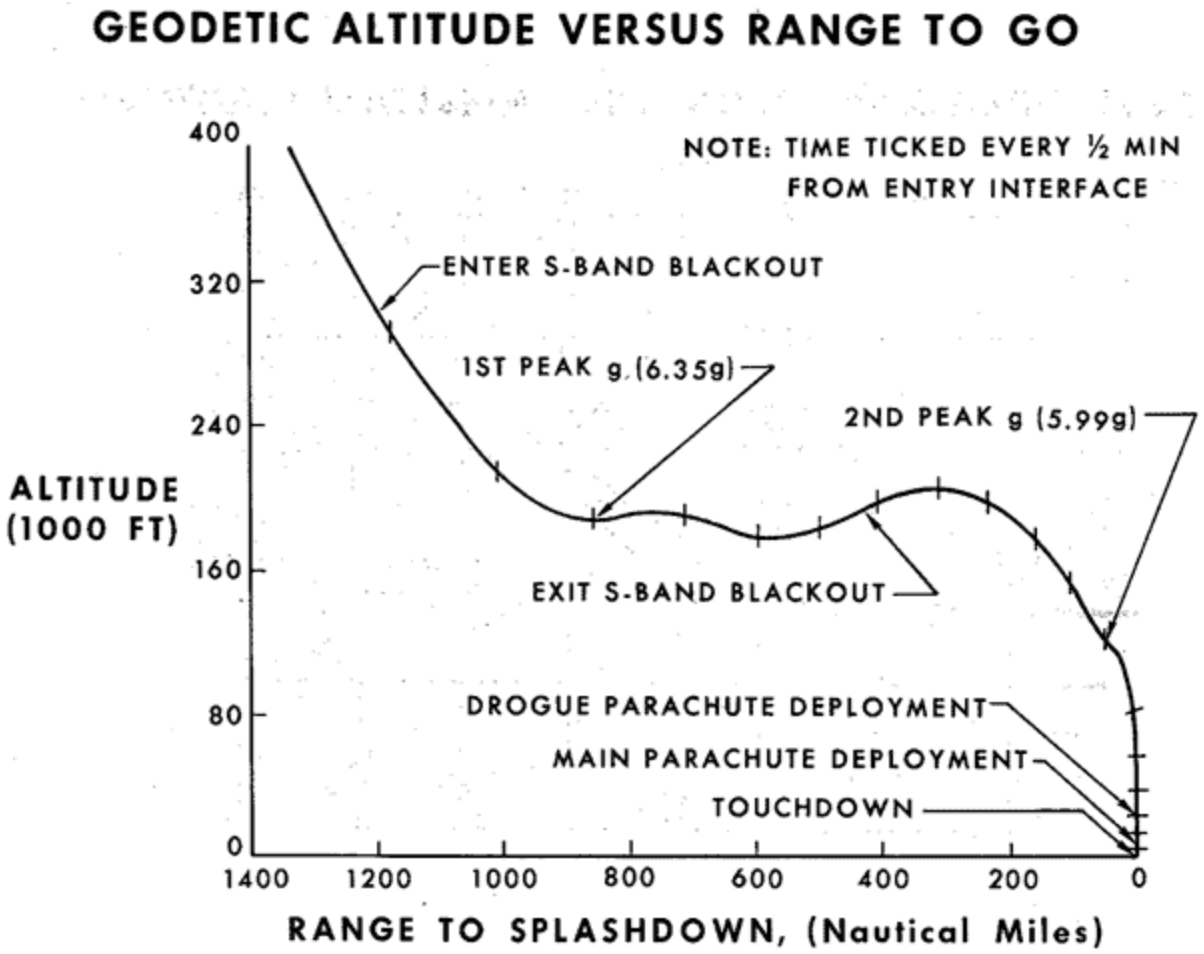


Recovery

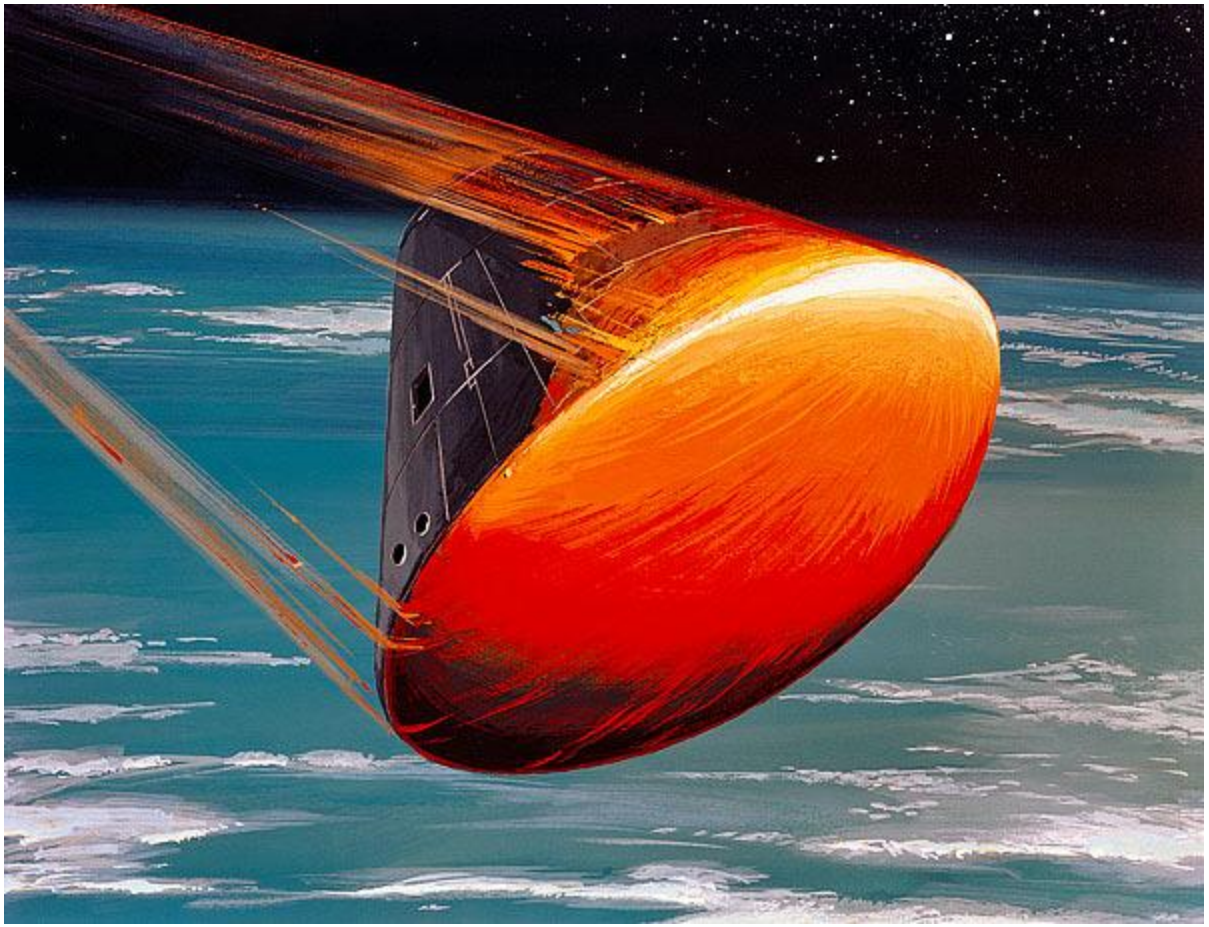
Rientro in atmosfera



Rientro in atmosfera

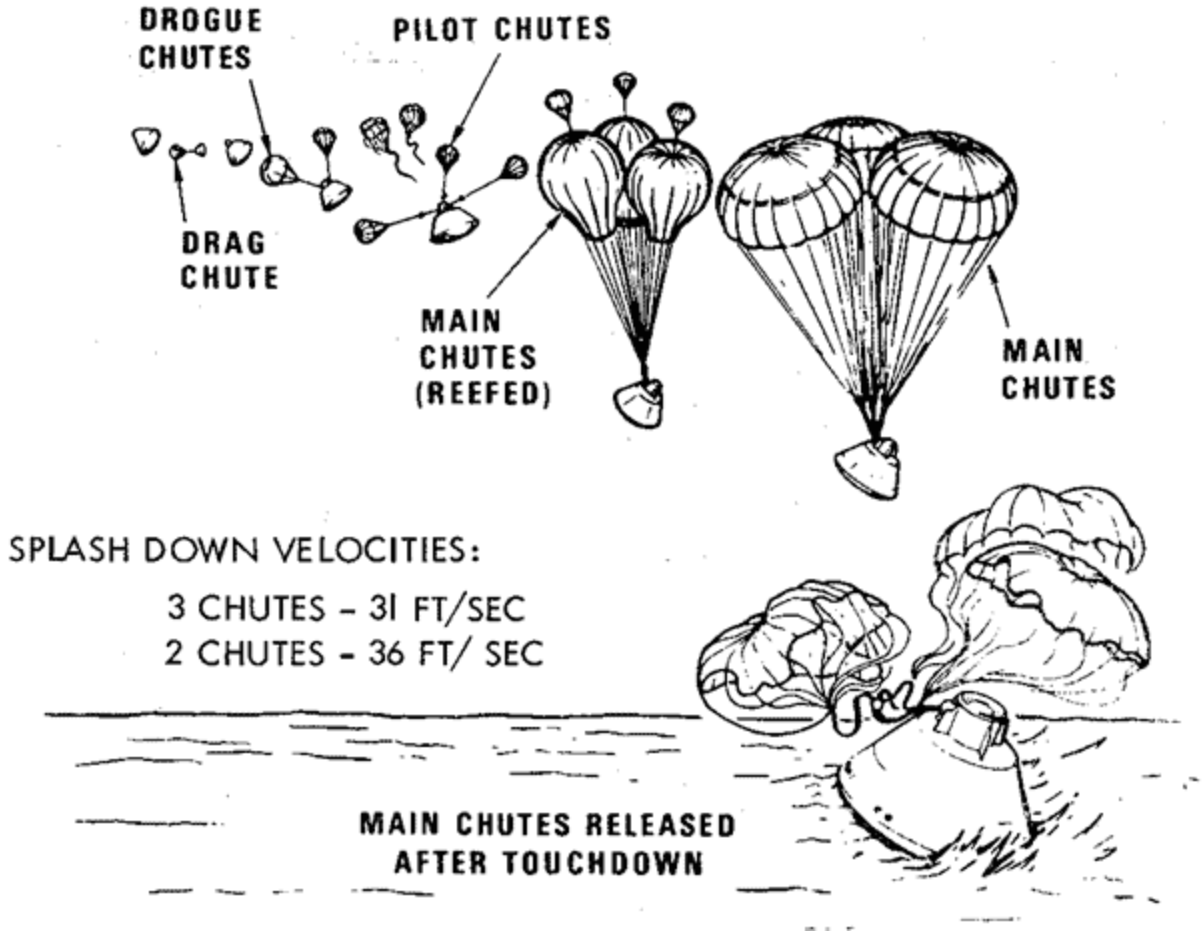


Rientro in atmosfera



Velocità di rientro in atmosfera: 40,200 km/h = 11.2 km/s ≅ Mach 34 (più di 13 volte quella di un proiettile)
Ablazione dell'isolante in resina fenolica, epossidica con struttura a nido d'ape in fibra di vetro

Apertura paracaduti ed ammaraggio

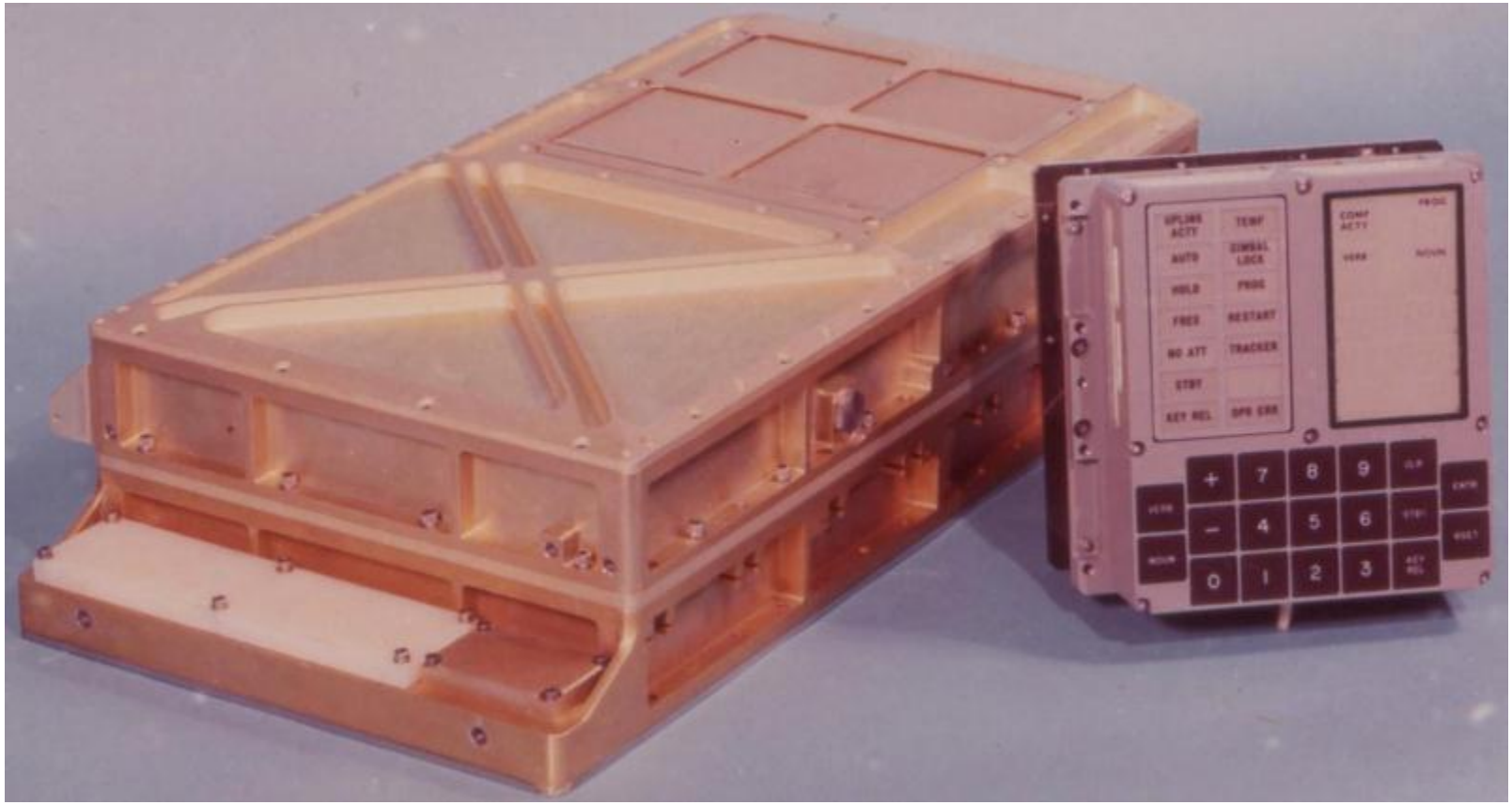


Ogni paracadute ~2100 m^2 di naylon compresso, 2 milioni di punti, 2400 m di fili di sospensione

Ammaraggio a circa 34 km/h

Il computer: hardware e software

Il computer e l'unità DSKY



1 ft^3

La memoria

Memoria non in byte ma in WORD.

1 WORD = 15 + 1 bit

Il computer AGC (Apollo Guidance Computer) disponeva di:

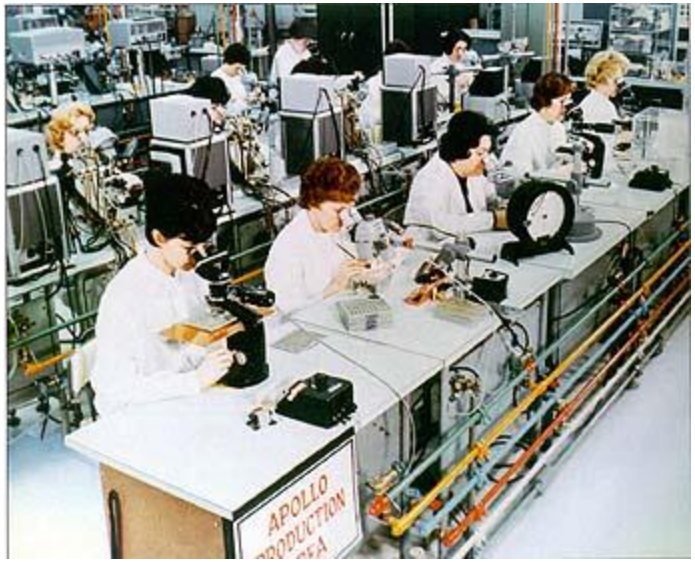
- 36864 words di **ROM** che funzionava come hard disk
- 2048 words di memoria riscrivibile (**RAM**)

Eldon Hall
leader della progettazione del AGC, Apollo Guidance Computer

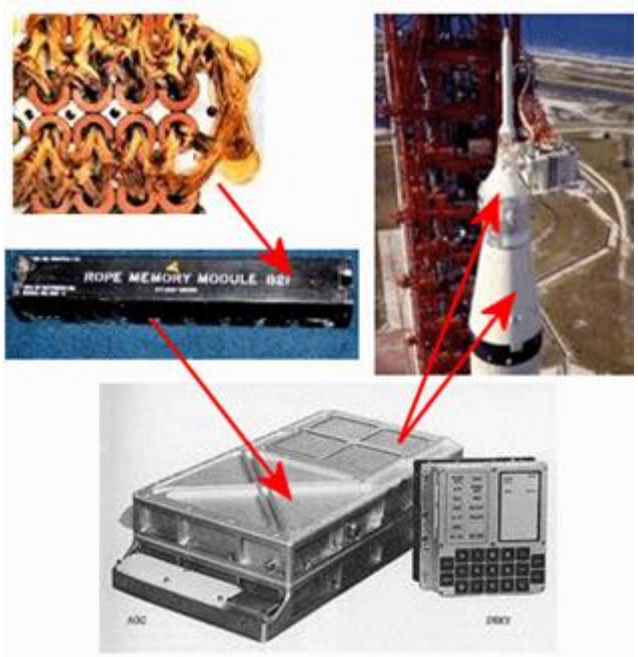
I transistor e i primi circuiti integrati

- Il 60% della produzione mondiale di transistor degli anni ’60 veniva assorbito dal programma Apollo.
- Per verificare l’integrità di un circuito integrato lo si immergeva in Freon liquido sottoraffreddato. Quindi si confrontava il peso originale del circuito prima e dopo l’immersione. Se la differenza era superiore a pochi microgrammi allora il circuito era forato e doveva essere scartato insieme a tutto il lotto cui apparteneva.

Assemblaggio del hardware

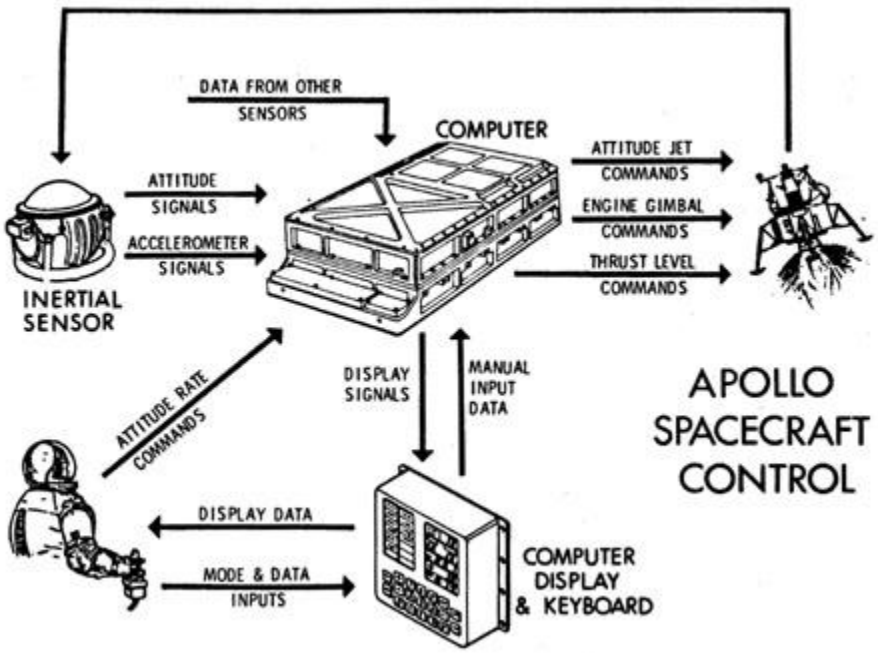


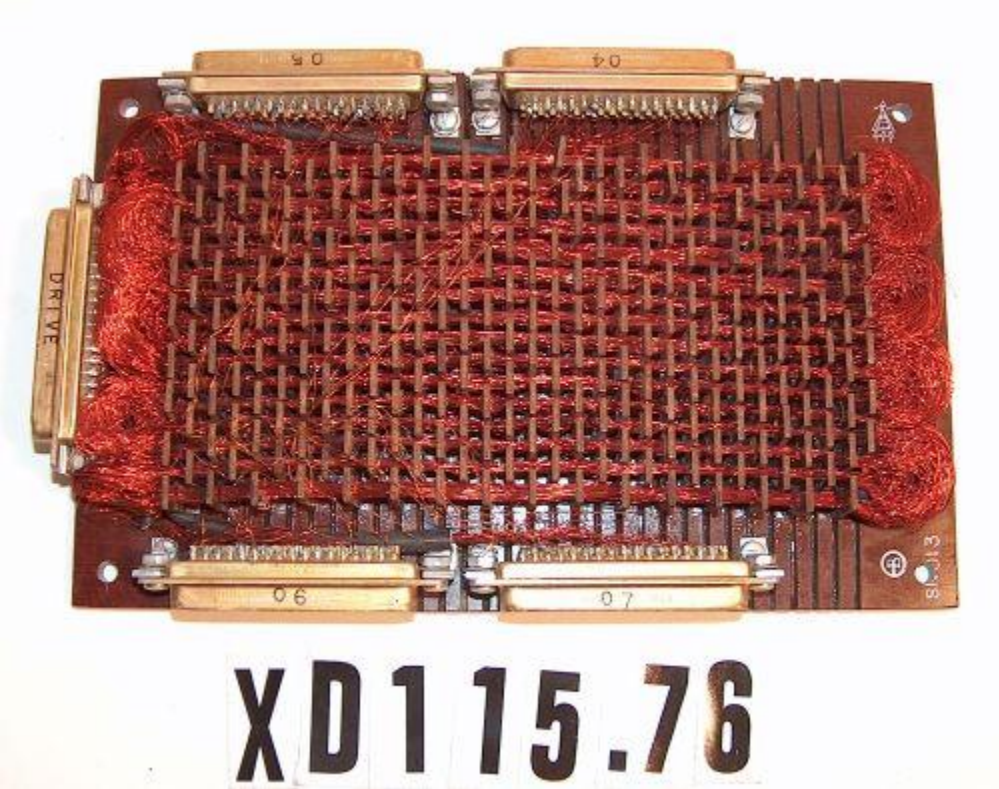
Little Old Ladies

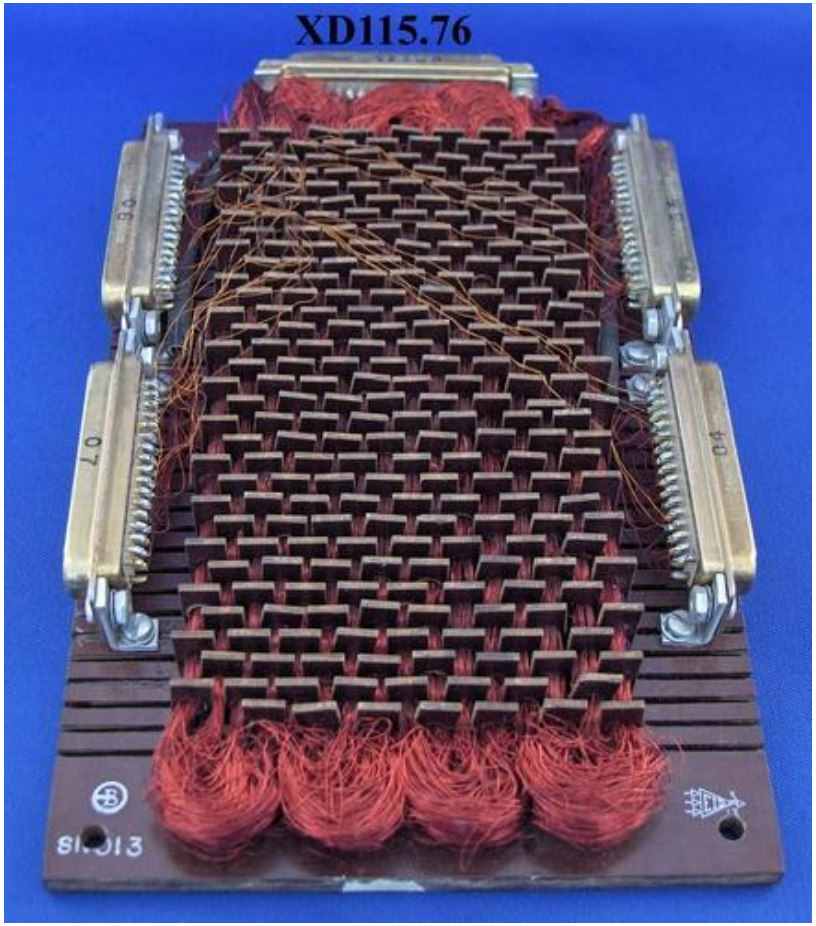


DSKY

Computer di bordo




XD115.76


XD115.76

Each core could have up to 64 wires through it

Apollo software

Real-time system software

- Command module - "Colossus"
- Lunar module - "Luminary"

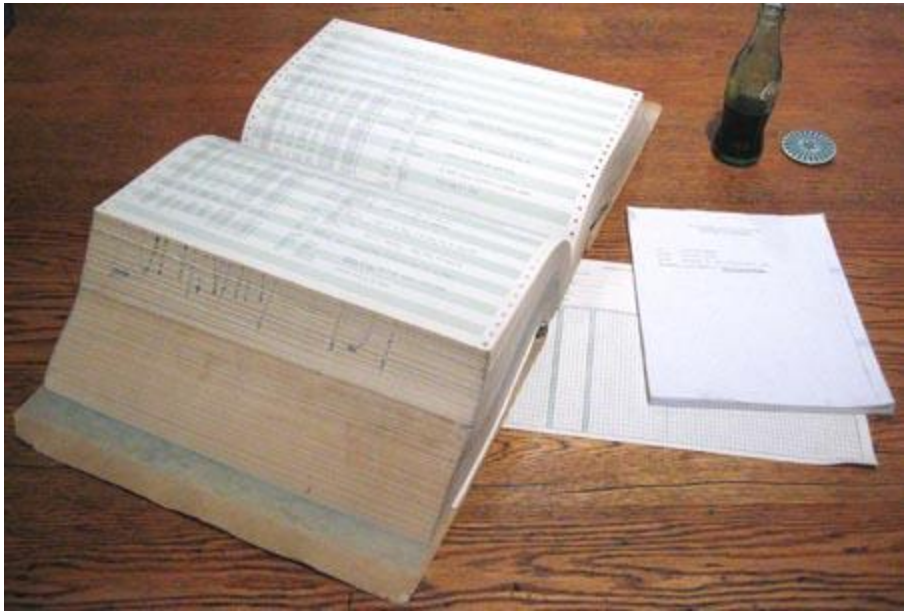
Programs

- EXEC
- WAITLIST
- PINBLL a rudimentary shell

System restart - the ideal recovery from problems

- All programs register a re-start address
- What happens - memory remains intact, but jobs are killed
- Upon restarting - programs reenter at their starting point
- Takes a few seconds

Apollo software



Listato del programma “Luminary” per l’allunaggio del LM

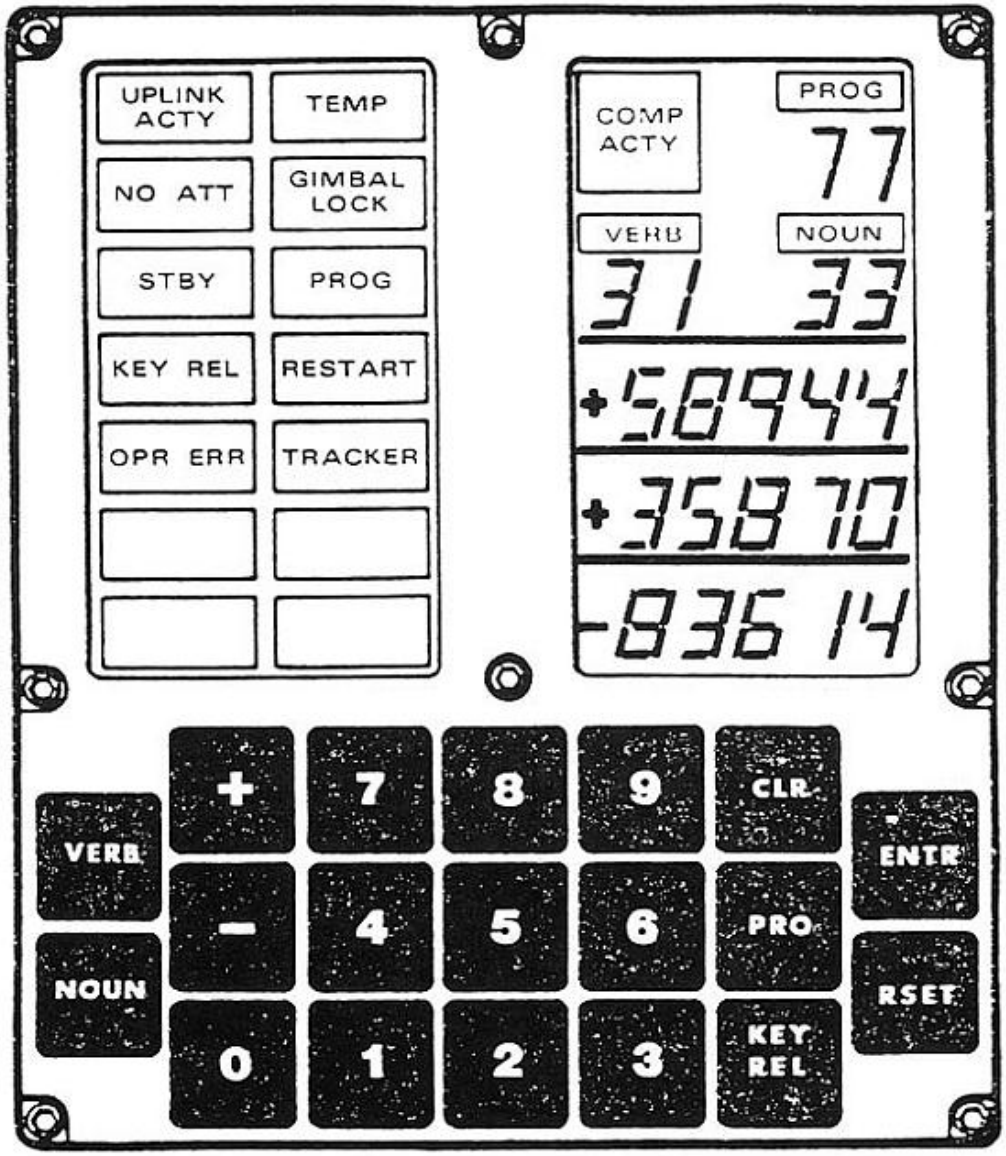
Apollo software

Innovations

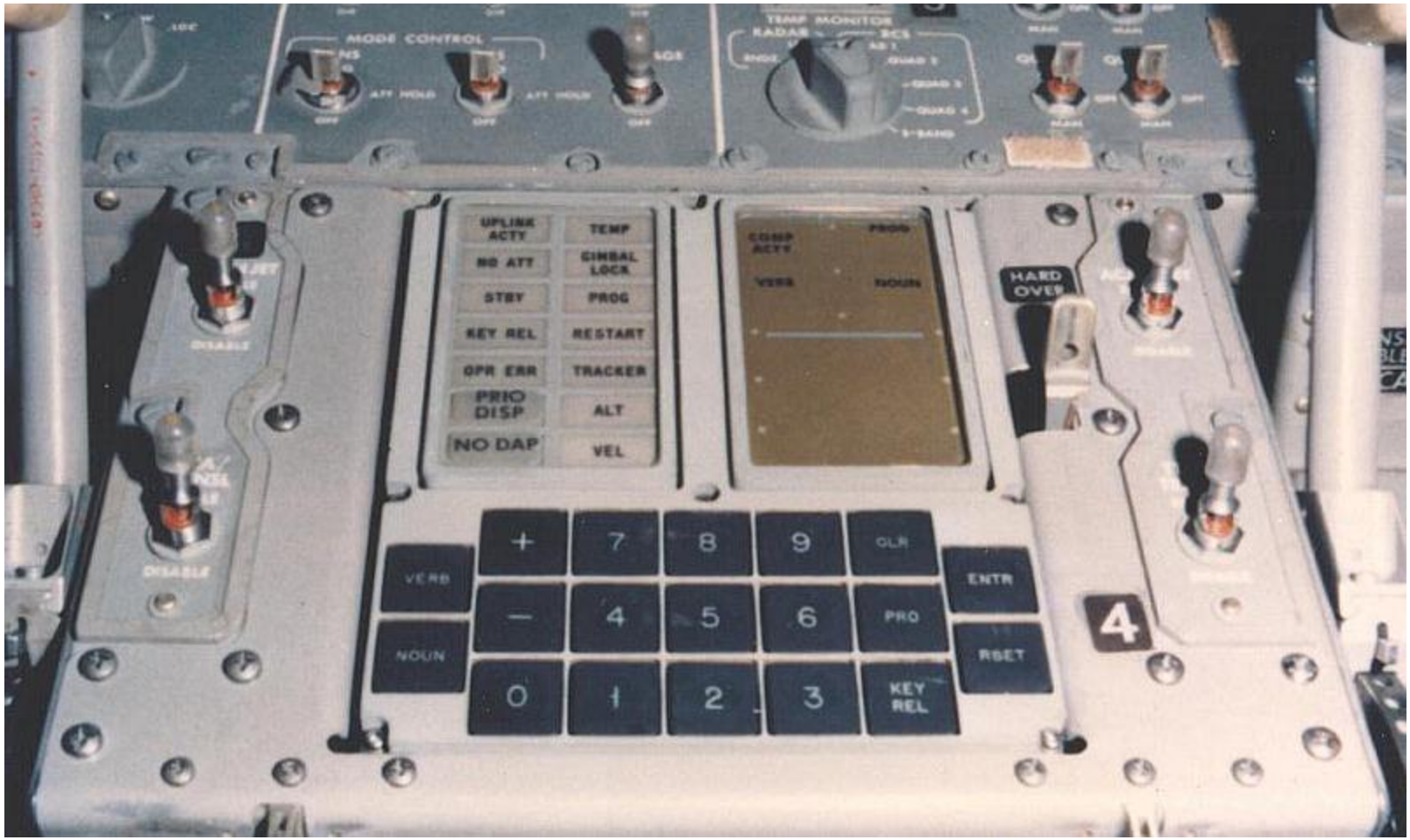
- First computer to use **integrated circuits → Eldon Hall**
- Calculator-style keyboard unit
  - Handheld calculators did not exist yet
- Basis of first "fly by wire" systems

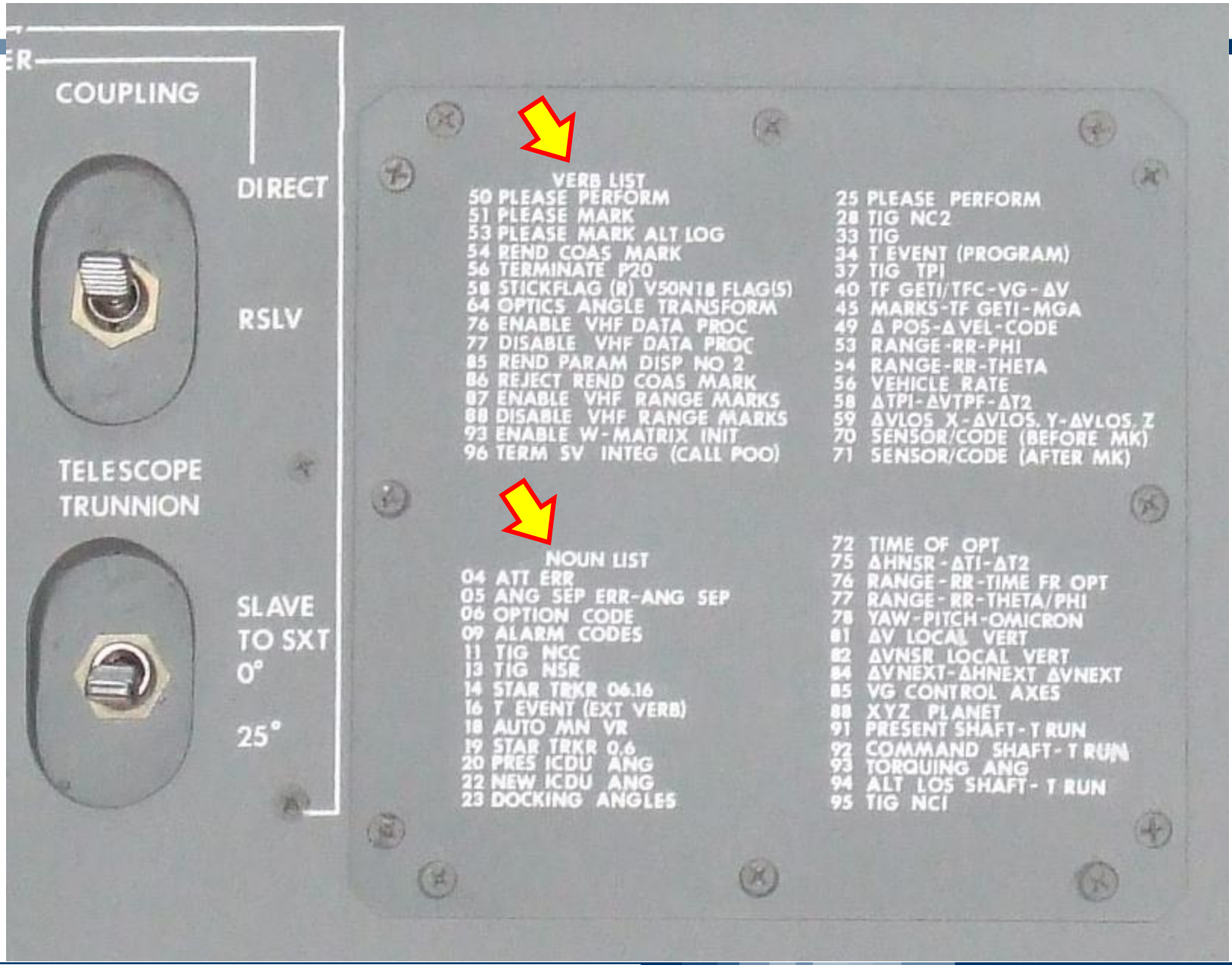
Eldon Hall was the leader of hardware design efforts for the **Apollo Guidance Computer** (**AGC**) at MIT, and **advocated the use of integrated circuits** for this task.

DSKY (display/keyboard)



DSKY


MODE CONTROL
UPLINK ACTY
TEMP
NO ATT
GIMBAL LOCK
STBY
PROG
KEY REL
RESTART
OPR ERR
TRACKER
PRIO DISP
ALT
NO DAP
VEL
COMP ACTY
PROG
VERB
NOUN
HARD OVER
+
7
8
9
CLR
ENTR
VERB
−
4
5
6
PRO
RSET
NOUN
0
1
2
3
KEY REL

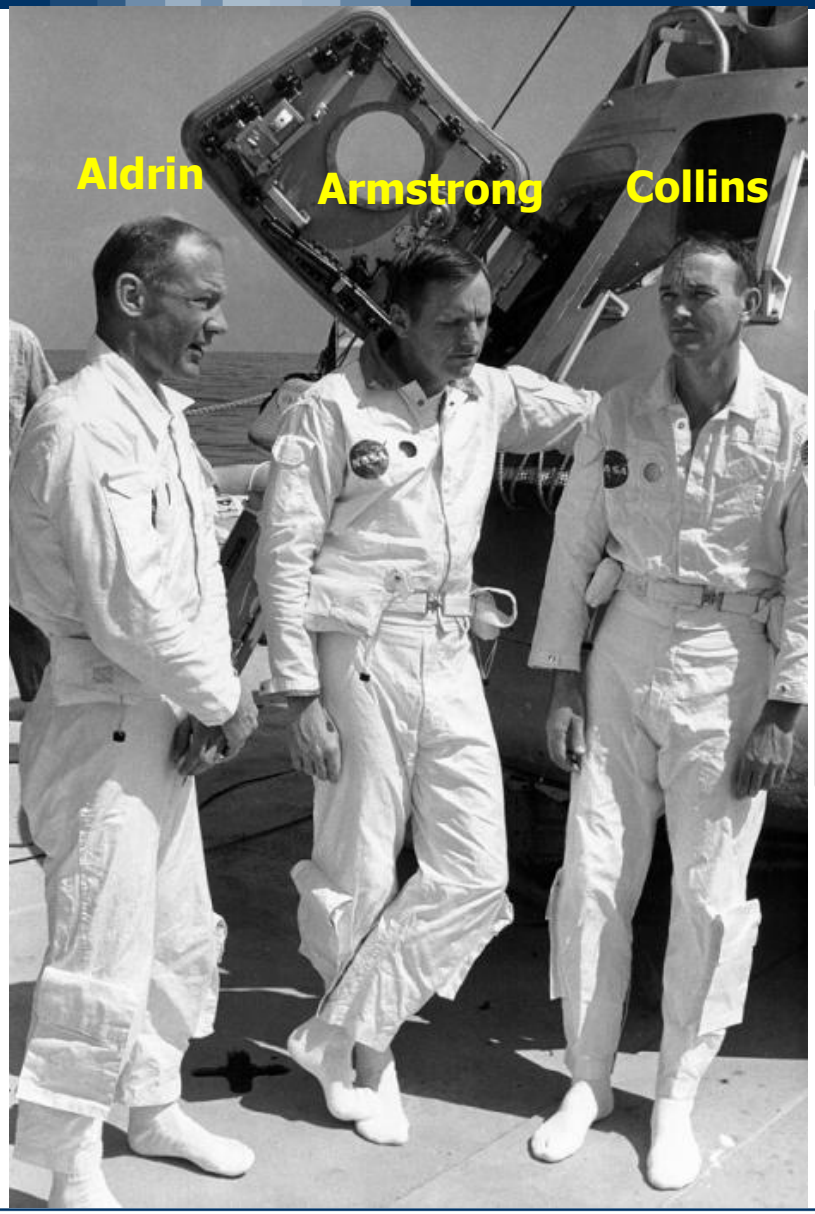

COUPLING
DIRECT
RSLV
TELESCOPE
TRUNNION
SLAVE
TO SXT
0°
25°
VERB LIST
50 PLEASE PERFORM
51 PLEASE MARK
53 PLEASE MARK ALT LOG
54 REND COAS MARK
56 TERMINATE P20
58 STICKFLAG (R) V50N18 FLAG(S)
64 OPTICS ANGLE TRANSFORM
76 ENABLE VHF DATA PROC
77 DISABLE VHF DATA PROC
85 REND PARAM DISP NO 2
86 REJECT REND COAS MARK
87 ENABLE VHF RANGE MARKS
88 DISABLE VHF RANGE MARKS
93 ENABLE W-MATRIX INIT
96 TERM SV INTEG (CALL POO)
25 PLEASE PERFORM
28 TIG NC2
33 TIG
34 T EVENT (PROGRAM)
37 TIG TPI
40 TF GETI/TFC-VG-ΔV
45 MARKS-TF GETI-MGA
49 Δ POS-Δ VEL-CODE
53 RANGE-RR-PHI
54 RANGE-RR-THETA
56 VEHICLE RATE
58 ΔTPI-ΔVTPF-ΔT2
59 ΔVLOS X-ΔVLOS Y-ΔVLOS Z
70 SENSOR/CODE (BEFORE MK)
71 SENSOR/CODE (AFTER MK)
NOUN LIST
04 ATT ERR
05 ANG SEP ERR-ANG SEP
06 OPTION CODE
09 ALARM CODES
11 TIG NCC
13 TIG NSR
14 STAR TRKR 06.16
16 T EVENT (EXT VERB)
18 AUTO MN VR
19 STAR TRKR 0.6
20 PRES ICDU ANG
22 NEW ICDU ANG
23 DOCKING ANGLES
72 TIME OF OPT
75 ΔHNSR-ΔTI-ΔT2
76 RANGE-RR-TIME FR OPT
77 RANGE-RR-THETA/PHI
78 YAW-PITCH-OMICRON
81 ΔV LOCAL VERT
82 ΔVNSR LOCAL VERT
84 ΔVNEXT-ΔHNEXT ΔVNEXT
85 VG CONTROL AXES
88 XYZ PLANET
91 PRESENT SHAFT-T RUN
92 COMMAND SHAFT-T RUN
93 TORQUING ANG
94 ALT LOS SHAFT-T RUN
95 TIG NCI

Esempio di interazione con il computer

Verb 37	!	Change program
Verb 06	!	Display data
Noun 62	!	Speed, height, vertical velocity
Program 12	!	Lunar module engines for ascent & rendezvous
Program 52	!	Setup of the inertial platform

L’equipaggio di Apollo 11

Equipaggio Apollo 11



Position	Astronaut
Commander	Neil Armstrong Second spaceflight
Command Module Pilot	Michael Collins Second spaceflight
Lunar Module Pilot	Edwin E. Aldrin, Jr. Second spaceflight

Equipaggio Apollo 11

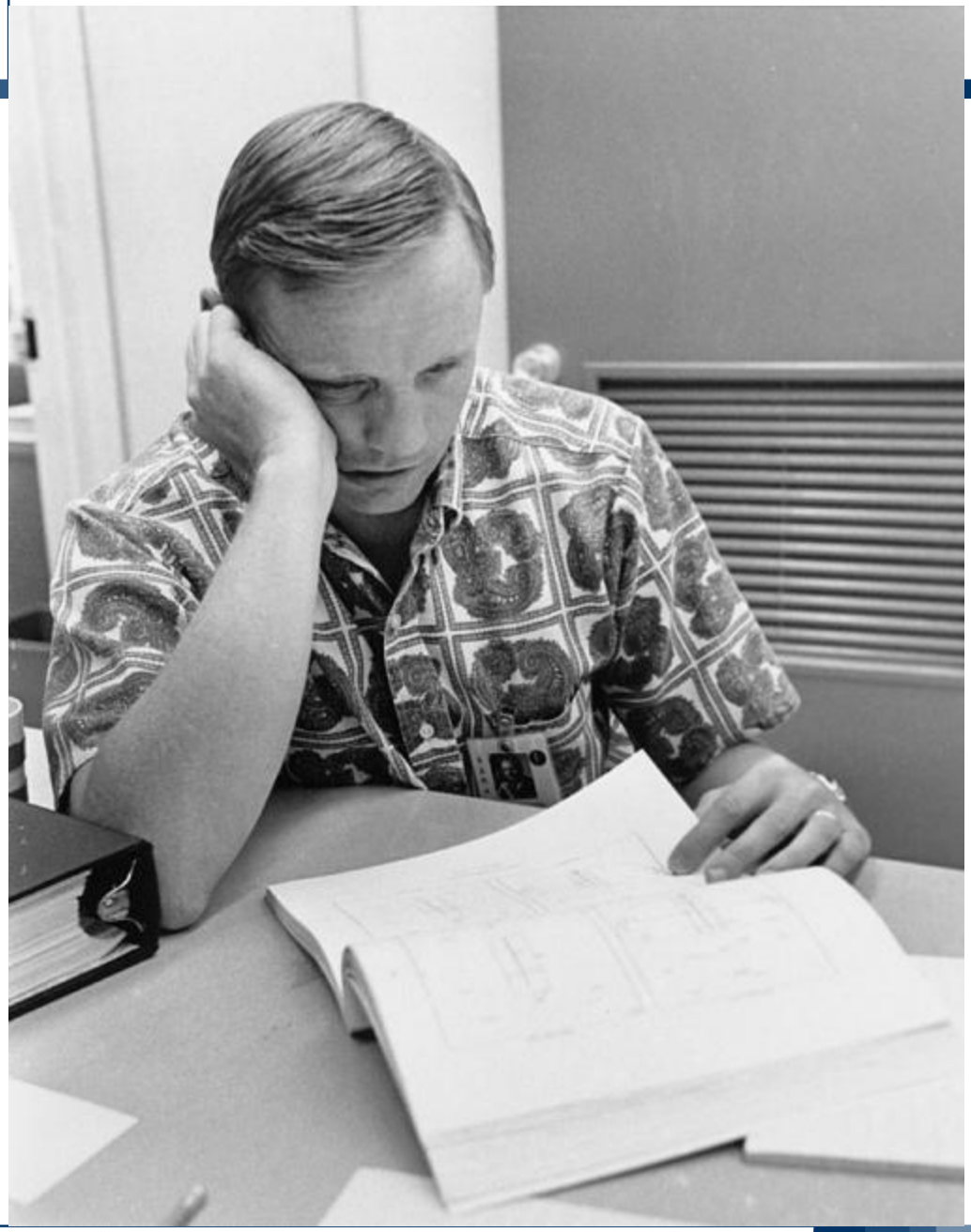
La missione Apollo 11

Apollo 11 – AS-506

- **Partenza (decollo): 16 Luglio 1969 dal John F. Kennedy Space Center**
- **Allunaggio: 20 Luglio 1969 Mare della Tranquillità**

  (esattamente 8 anni, 1 mese e 22 giorni dopo il discorso di John F. Kennedy il 25 Maggio 1961)
- **Arrivo (ammaraggio): 24 Luglio 1969 Oceano Pacifico**

AS-506 including Saturn V, CM-107, SM-107, LM-5



Apollo 11 Commander Neil A. Armstrong reviews flight plans during final preparations for the Apollo 11 mission – **July 14, 1969**

Apollo 11 Lunar Module Pilot Edwin E. Aldrin, Jr., examines photographs of lunar surface during final preparations for the Apollo 11 mission

July 14, 1969

The Apollo 11 crew and Donald K. "Deke" Slayton at the traditional launch day steak and eggs breakfast – **July 16, 1969**

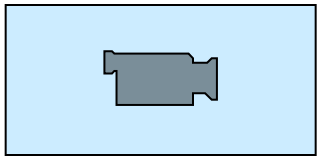
Neil Armstrong during suitup

July 16, 1969

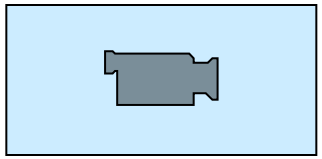
Apollo 11 Commander Neil Armstrong prepares to don his helmet on launch day

(16 July 1969) --- The crew of the Apollo 11 lunar landing mission arrives atop Pad A, Launch Complex 39, Kennedy Space Center, during the Apollo 11 prelaunch countdown

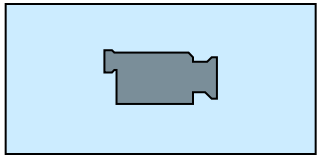
I video



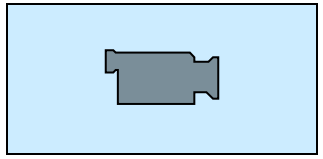
1 – Decollo Apollo 11 e Staging



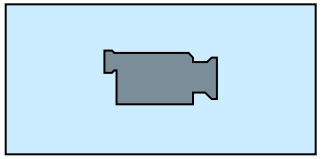
2 – Allunaggio



3 – Primi passi sulla Luna



4 – Rendezvous LM-CSM



5 – Rientro in atmosfera ed ammaraggio

APOLLO 11 COUNTDOWN

The clock for the Apollo 11 countdown will start at T-28 hours, with a six-hour built-in-hold planned at T-9 hours, prior to launch vehicle propellant loading.

The countdown is preceded by a pre-count operation that begins some 5 days before launch. During this period the tasks include mechanical buildup of both the command/service module and LM, fuel cell activation and servicing and loading of the super critical helium aboard the LM descent stage.

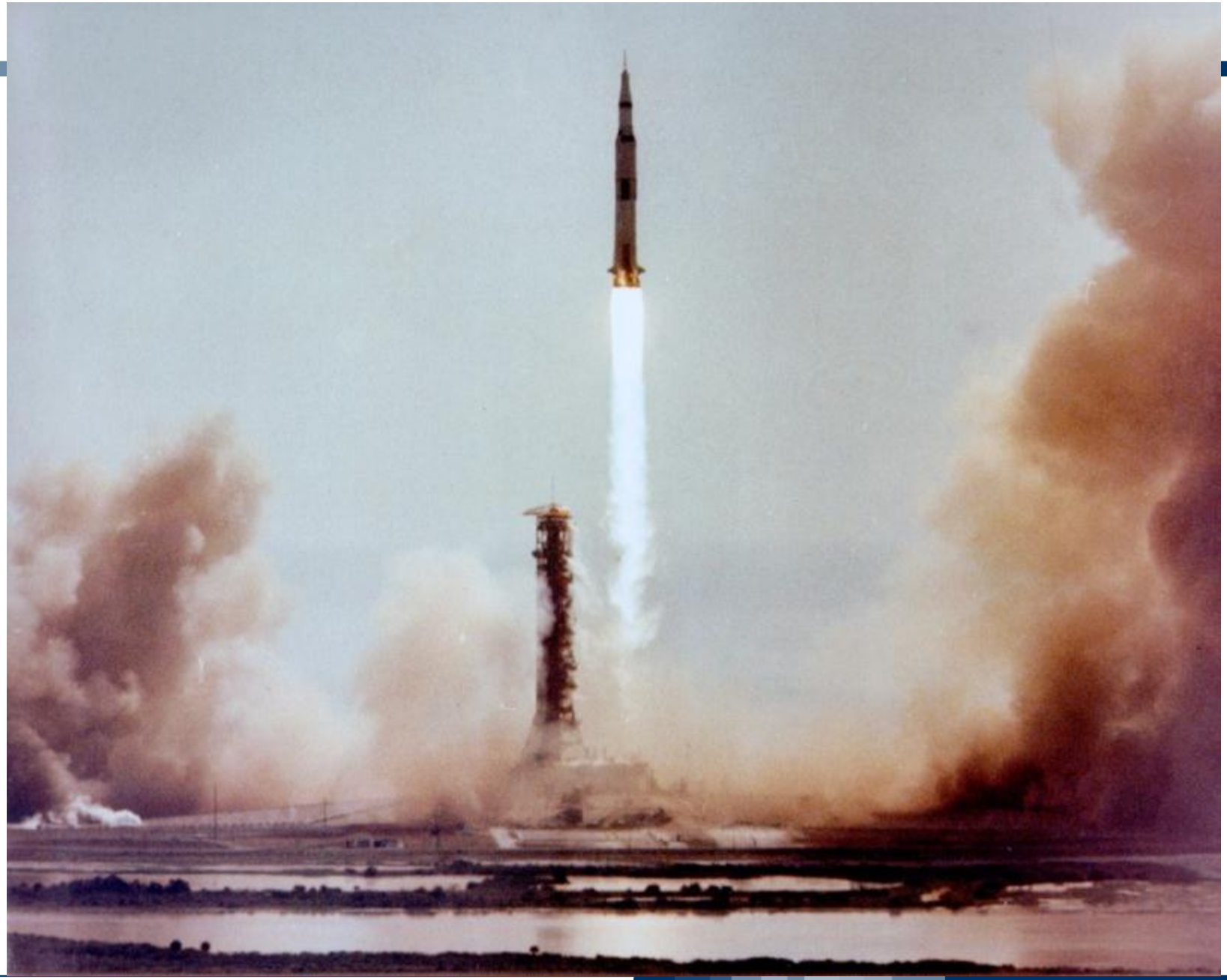
Following are some of the highlights of the final count:

T-28 hrs.	Official countdown starts
T-27 hrs. 30 mins.	Install launch vehicle flight batteries (to 23 hrs. 30 mins.) LM stowage and cabin closeout (to 15 hrs.)
T-21 hrs.	Top off LM super critical helium (to 19 hrs.)
T-16 hrs.	Launch vehicle range safety checks (to 15 hrs.)
T-11 hrs. 30 mins.	Install launch vehicle destruct devices (to 10 hrs. 45 mins.) Command/service module pre-ingress operations
T-10 hrs.	Start mobile service structure move to park site
T-9 hrs.	Start six hour built-in-hold
T-9 hrs. counting	Clear blast area for propellant loading
T-8 hrs. 30 mins.	Astronaut backup crew to spacecraft for prelaunch checks
T-8 hrs. 15 mins.	Launch Vehicle propellant loading, three stages (liquid oxygen in first stage) liquid oxygen and liquid hydrogen in second, third stages. Continues thru T-3 hrs. 38 mins.

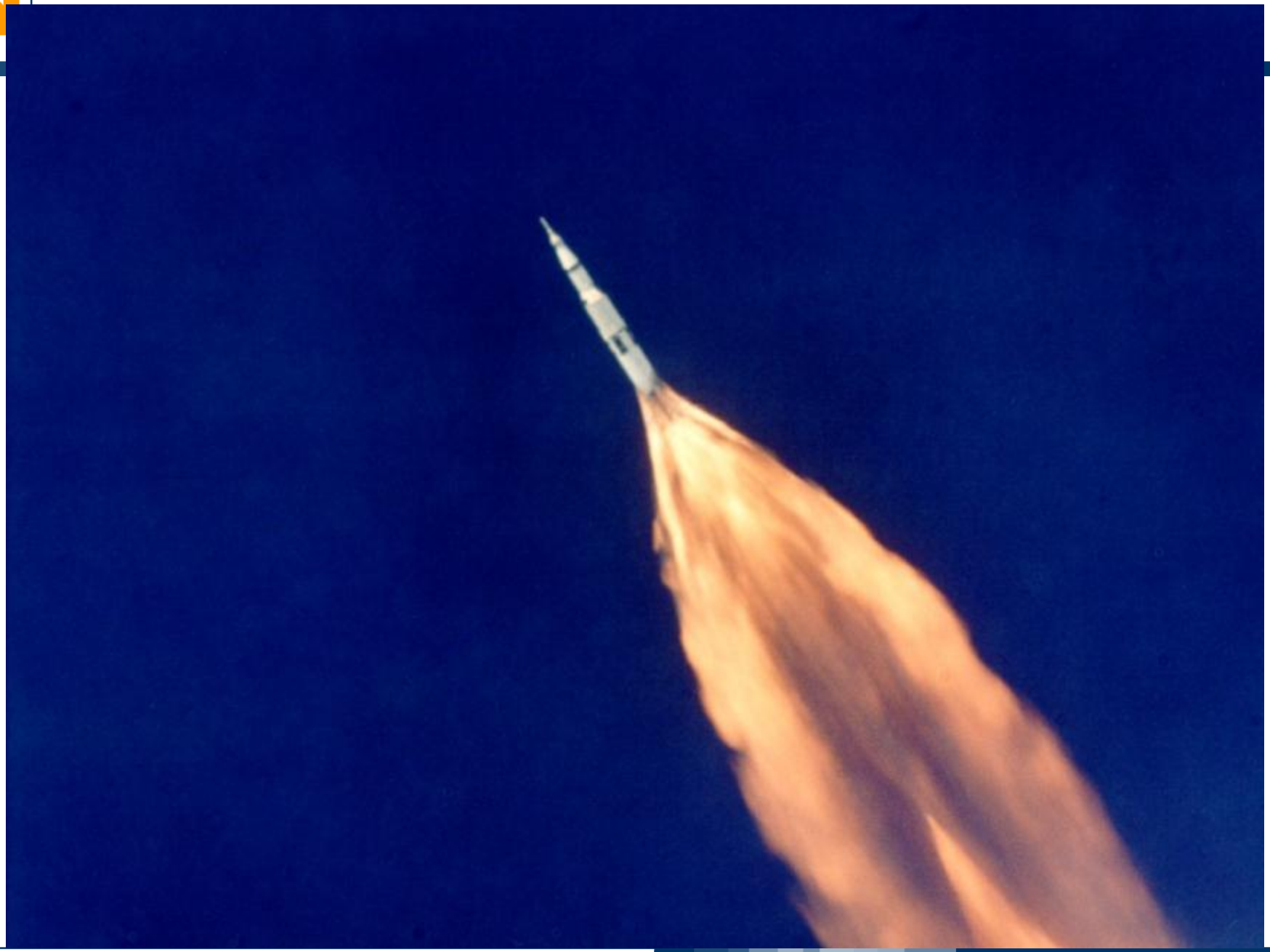
T-5 hrs. 17 mins.	Flight crew alerted
T-5 hrs. 02 mins.	Medical examination
T-4 hrs. 32 mins.	Breakfast
T-3 hrs. 57 mins.	Don space suits
T-3 hrs. 07 mins.	Depart Manned Spacecraft Operations Building for LC-39 via crew transfer van
T-2 hrs. 55 mins.	Arrive at LC-39
T-2 hrs. 40 mins.	Start flight crew ingress
T-1 hr. 55 mins.	Mission Control Center-Houston/spacecraft command checks
T-1 hr. 50 mins.	Abort advisory system checks
T-1 hr. 46 mins.	Space vehicle Emergency Detection System (EDS) test
T-43 mins.	Retrack Apollo access arm to standby position (12 degrees)
T-42 mins.	Arm launch escape system
T-40 mins.	Final launch vehicle range safety checks (to 35 mins.)
T-30 mins.	Launch vehicle power transfer test
	LM switch over to internal power
T-20 mins. to T-10 mins.	Shutdown LM operational instrumentation
T-15 mins.	Spacecraft to internal power
T-6 mins.	Space vehicle final status checks
T-5 mins. 30 sec.	Arm destruct system
T-5 mins.	Apollo access arm fully retracted
T-3 mins. 10 sec.	Initiate firing command (automatic sequencer)
T-50 sec.	Launch vehicle transfer to internal power

T-8.9 sec.	Ignition sequence start
T-2 sec.	All engines running
T-0	Liftoff

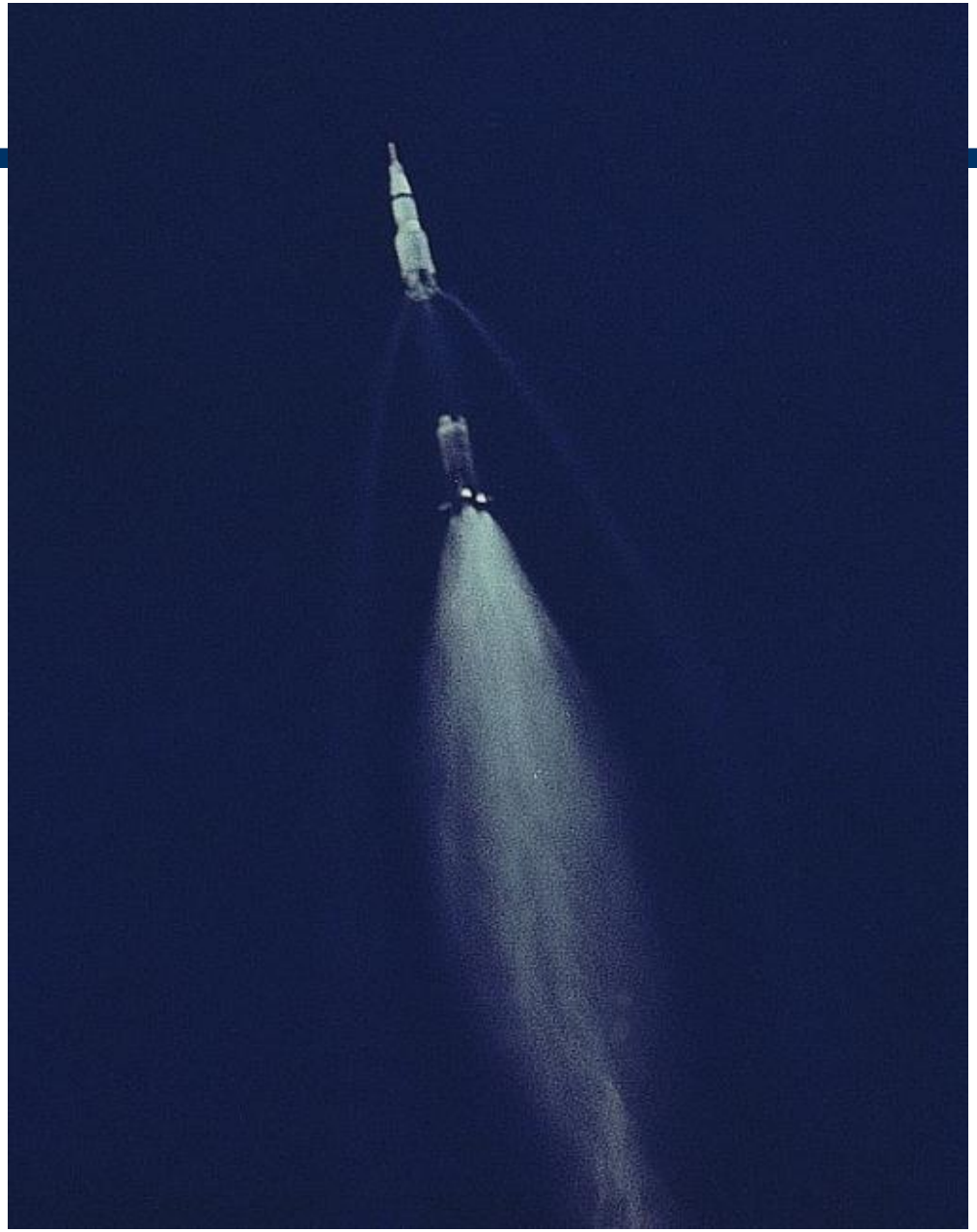
(16 July 1969) --- The huge, 363-feet tall (*i.e.* **110.64 m**) Apollo 11 (Spacecraft 107/Lunar Module 5/Saturn 506) space vehicle is launched from Pad A, Launch Complex 39, Kennedy Space Center (KSC), at 9:32 a.m. (EDT), July 16, 1969.




JOHN F. KENNEDY
SPACE CENTER

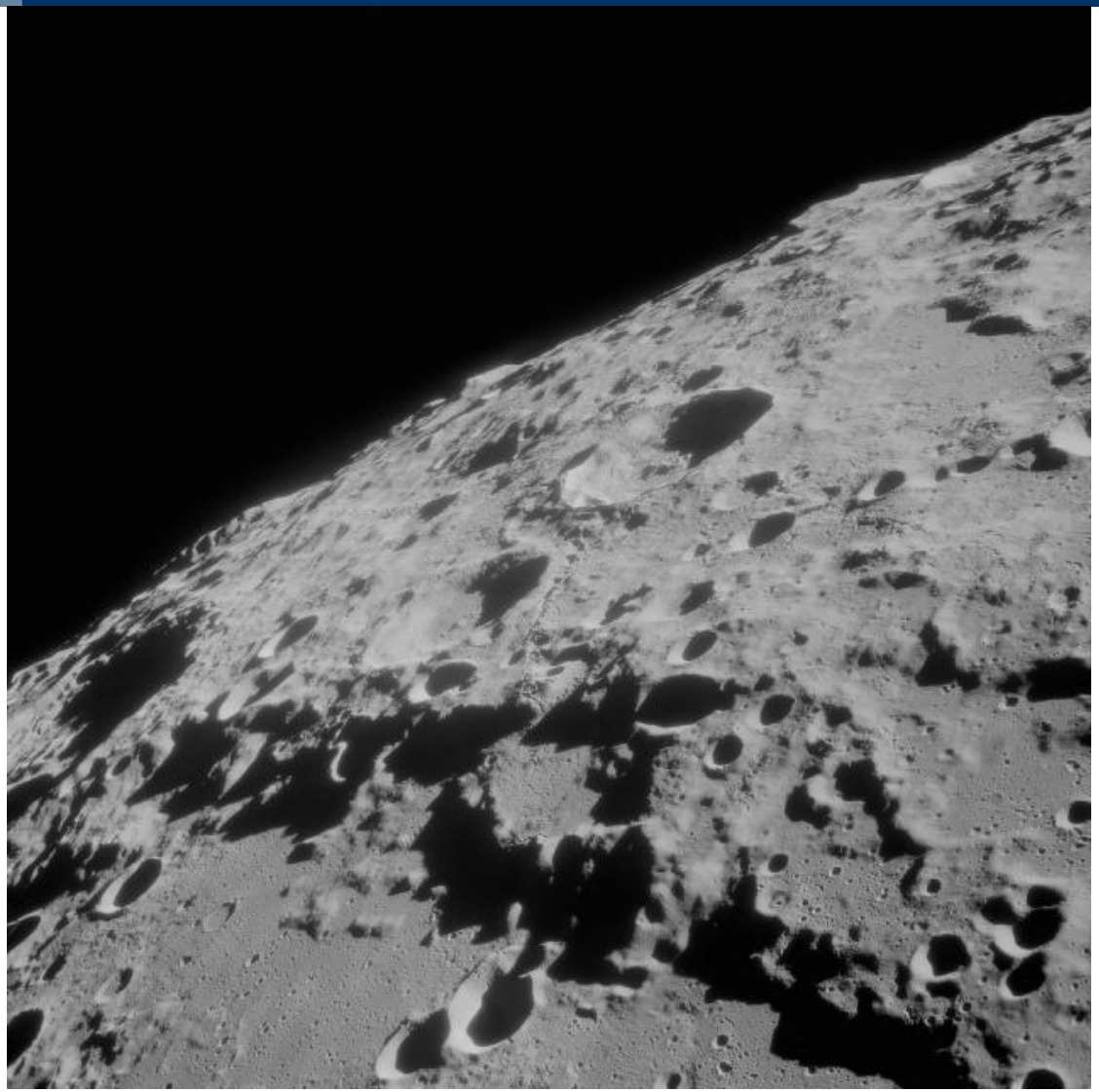


(16 July 1969) --- A 70mm Airborne Lightweight Optical Tracking System (ALOTS) took this picture. ALOTS tracking camera mounted on an Air Force EC-135 aircraft flying at about 12000 m altitude photographed this event in the early moments of the Apollo 11 launch. The 7.6 million-pound thrust Saturn V (S-1C) first stage boosts the space vehicle to an **altitude of 67 km at 94 km downrange in 2 min 40.8 s**. **The S-1C stage separates at 2 min 41.6 s after liftoff**.



As the spent first stage (S-1C) falls away, the mated Apollo spacecraft and Saturn V second (S-II) and third (S-IVB) stages pull ahead under new power from the second stage.

(16 July 1969) --- This view of Earth showing clouds over water was photographed from the Apollo 11 spacecraft following translunar injection.



An Apollo 11 oblique view of the lunar farside in the area of International Astronomical Union crater No. 312, which is about 30 statute miles in diameter

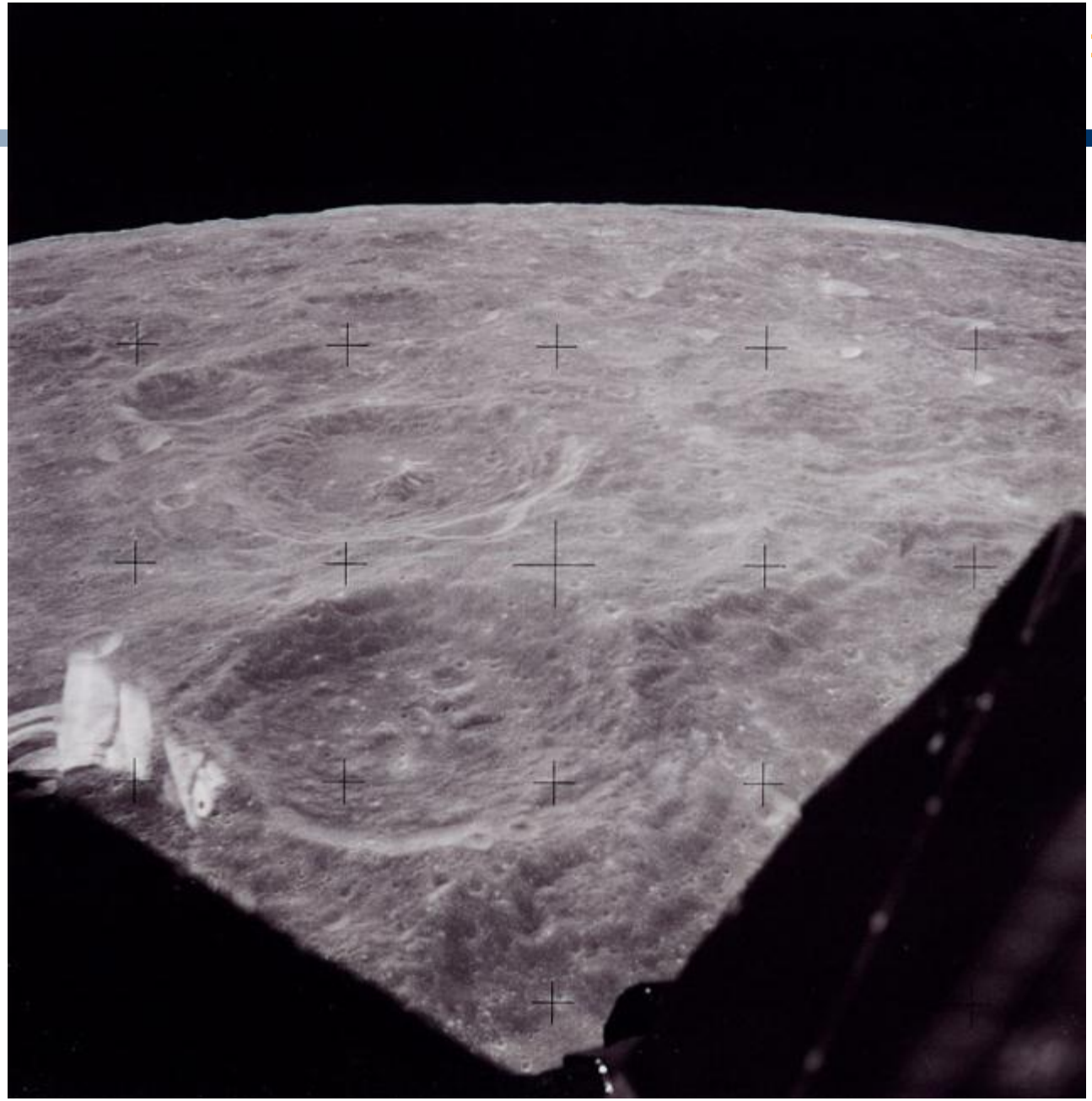
(20 July 1969) --- The approach to Apollo Landing Site 2 in southwestern Sea of Tranquility is seen in this photograph taken from the Apollo 11 Lunar Module (LM) in lunar orbit. When this picture was made, the LM was still docked to the Command and Service Modules (CSM).

LM separation from CSM

(20 July 1969) --- The Apollo 11 Lunar Module (LM), in a lunar landing configuration, is photographed in lunar orbit from the Command and Service Modules (CSM).

Flight controllers Charles Duke (Capcom), Jim Lovell (backup CDR) and Fred Haise (backup LMP) during lunar module descent

Cliff Charlesworth – Flight director



View from LM during approach to landing site

04 06 38 29 CDR 1202; 1202.

04 06 38 40 CDR What is it?

04 06 38 42 LMP That's in core ...

04 06 38 46 CDR Give us a reading on the 1202 program alarm.

04 06 42 15 LMP Roger; understand. Go for landing, 3000 feet.
Program alarm - 1201.

04 06 42 22 CDR 1201. Okay. 2050.

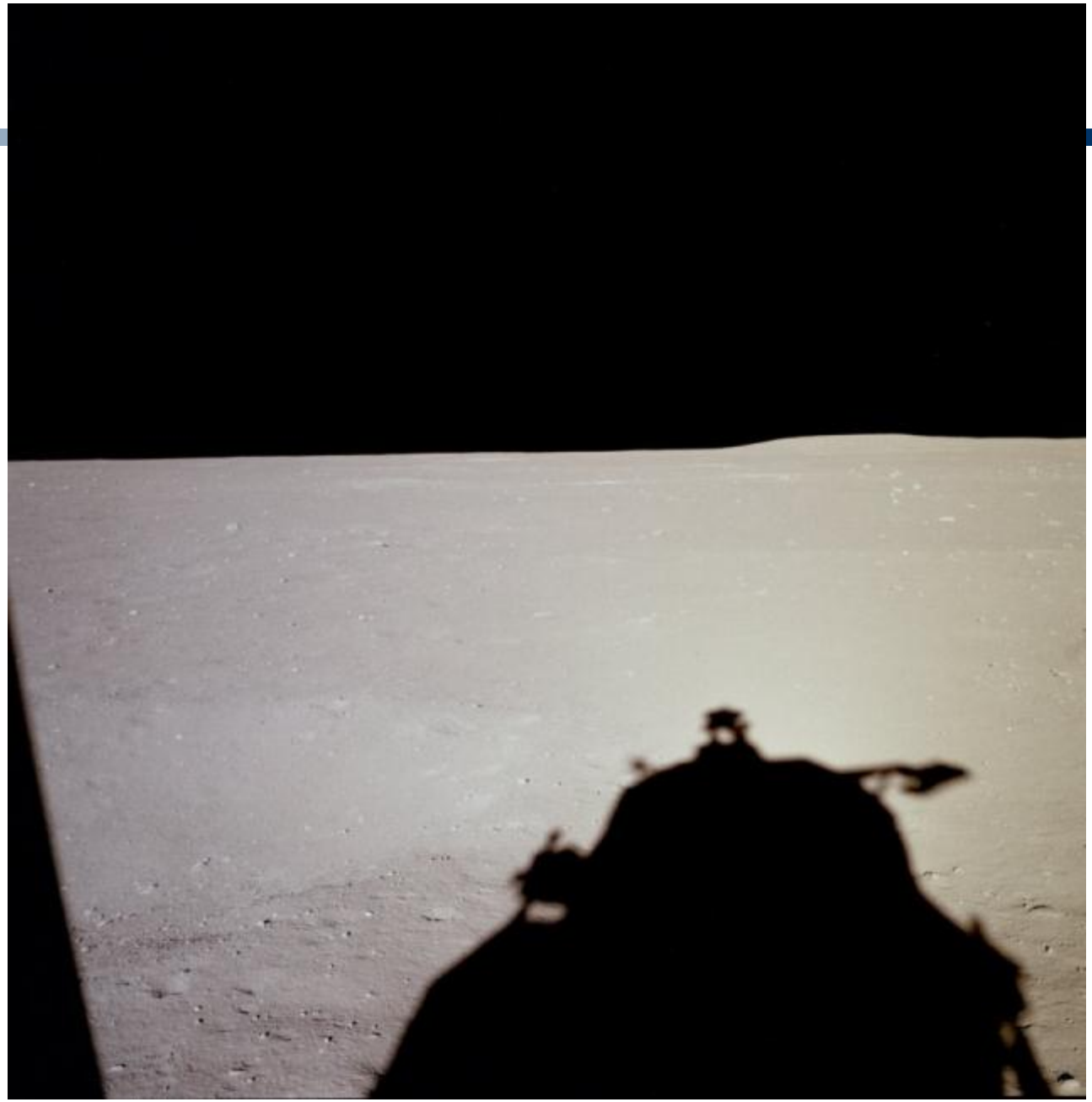
Passaggio dalla esecuzione distribuita dei singoli task a quella basata su priorità di esecuzione

Hal(combe) **Laning** inventor of the interruptible executive design for the Apollo computer, which allowed it to prioritize jobs during the flight

04 06 45 58 CDR

Houston - Tranquility Base here. THE EAGLE HAS LANDED.

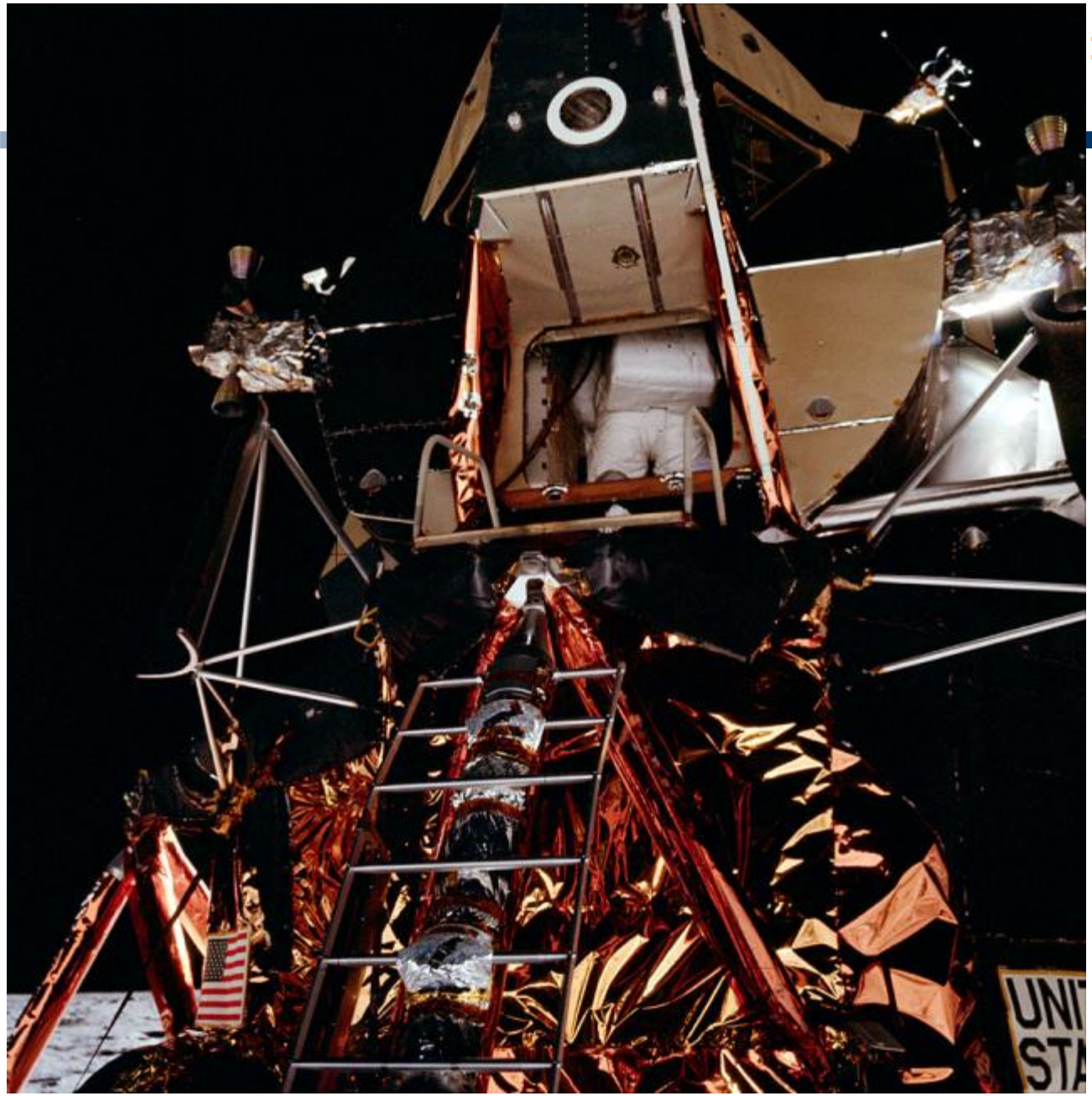
20-Jul-1969



View from LM window just after landing

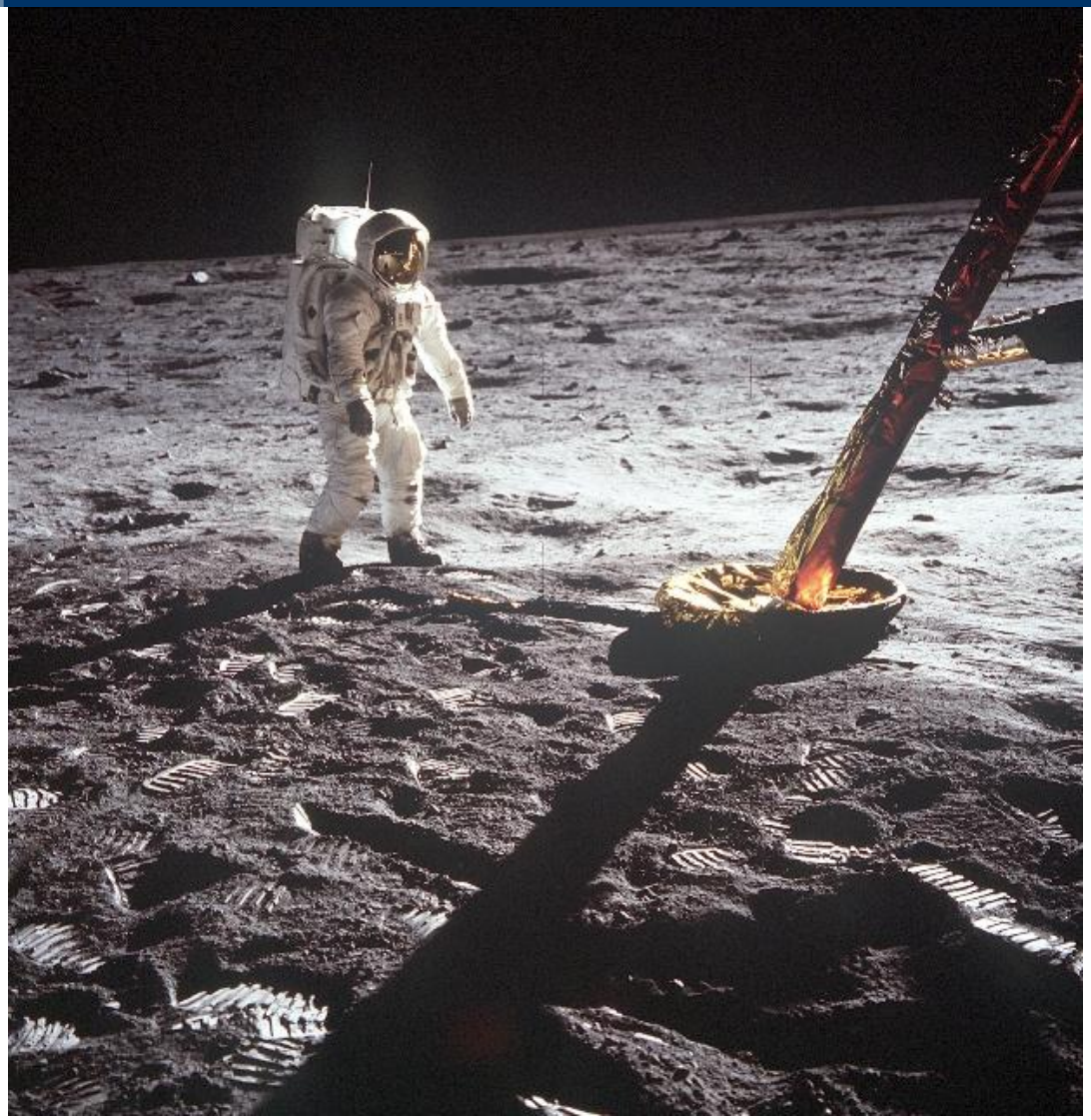
(20 July 1969) --- A close-up view of an astronaut's bootprint in the lunar soil

(20 July 1969) --- A close-up view of an astronaut's boot and bootprint in the lunar soil

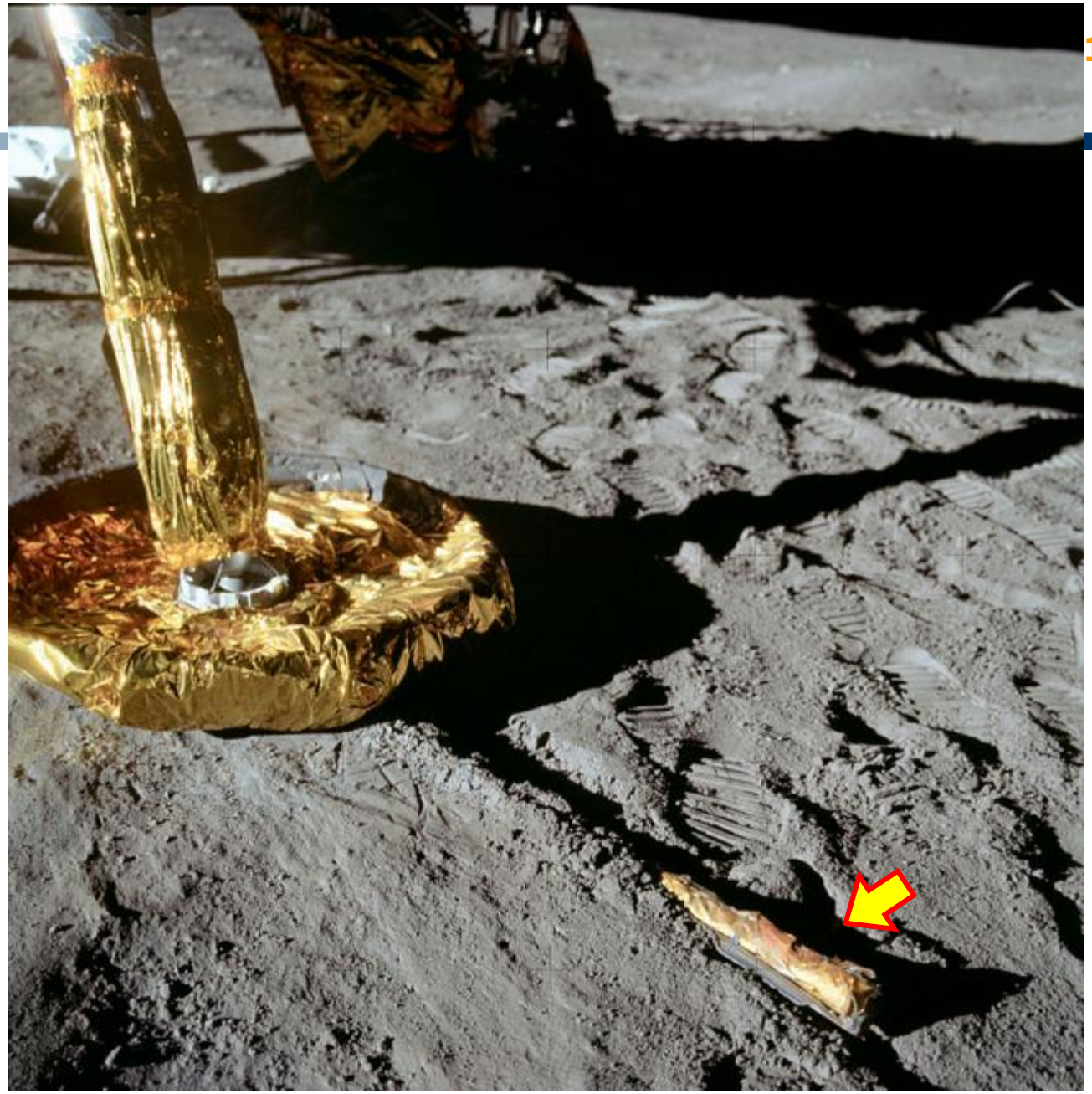


Aldrin backing out through LM hatch

Astronaut Edwin E. Aldrin Jr., lunar module pilot, descends the steps of the Lunar Module (LM) ladder as he prepares to walk on the moon

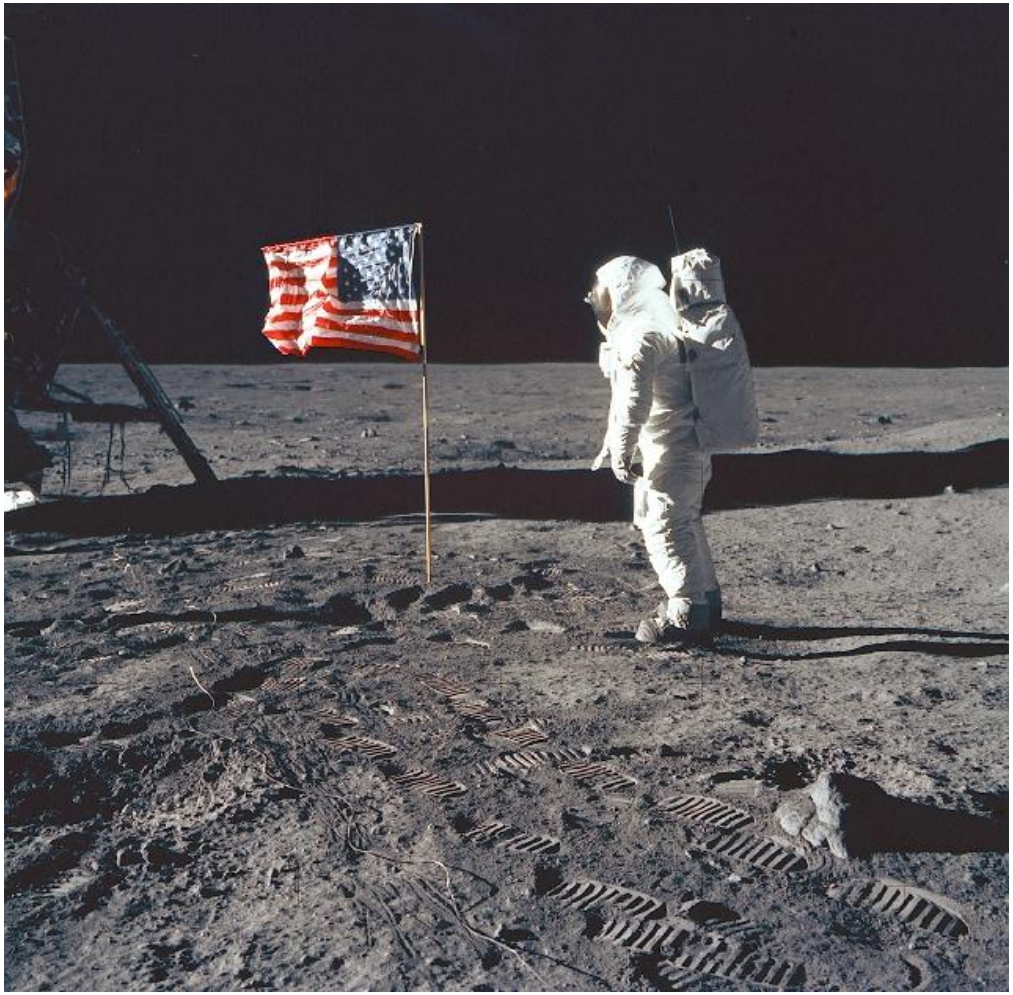


Astronaut Edwin E. Aldrin Jr., lunar module pilot, walks on the surface of the moon near a leg of the Lunar Module during the Apollo 11 extravehicular activity (EVA). Astronaut Neil A. Armstrong, Apollo 11 commander, took this photograph with a 70mm lunar surface camera.



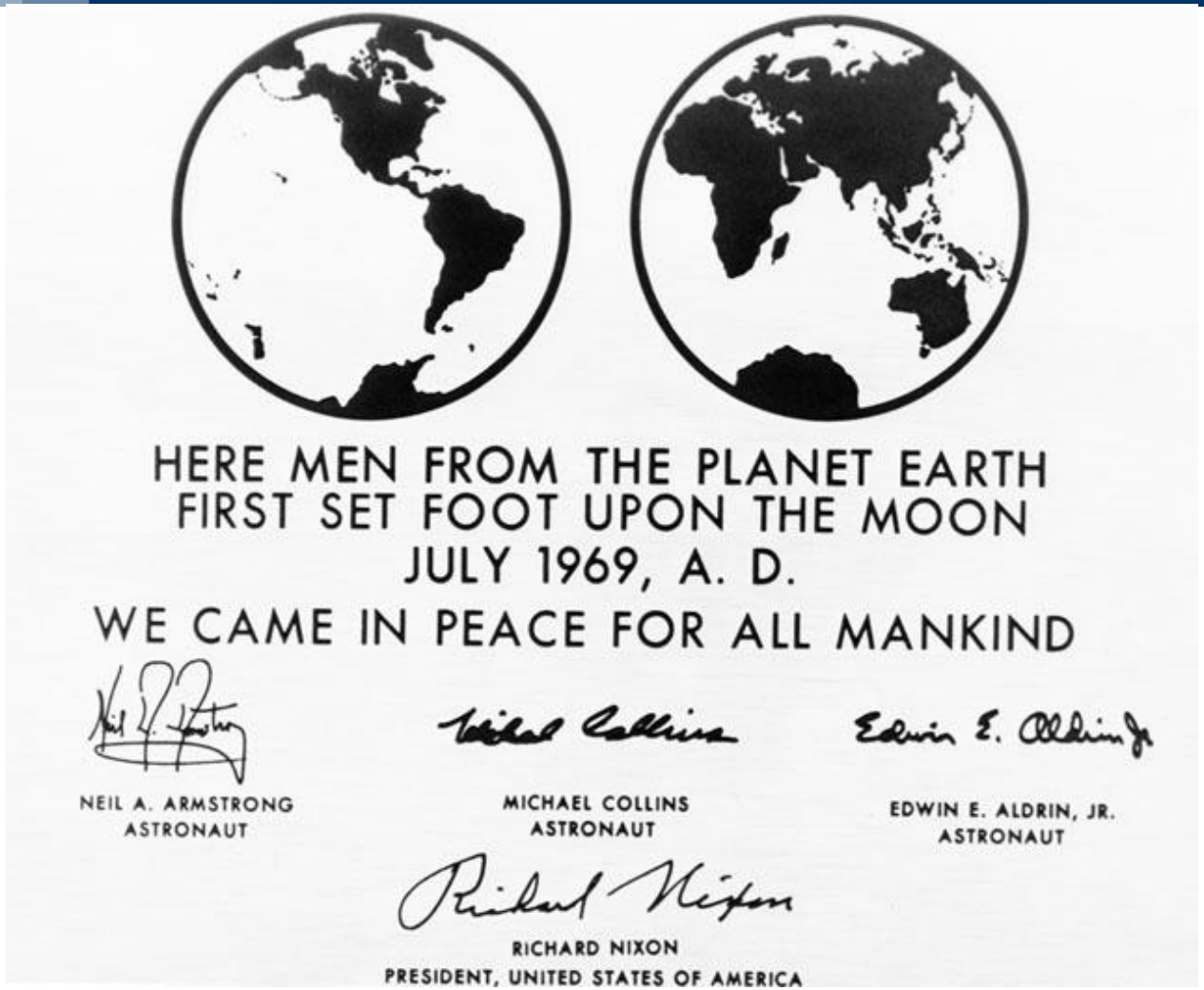
LM footpad and contact probe. Kapton and Mylar-foil from DuPont (16 layers), -150° +130 °C)

Aldrin poses for portrait

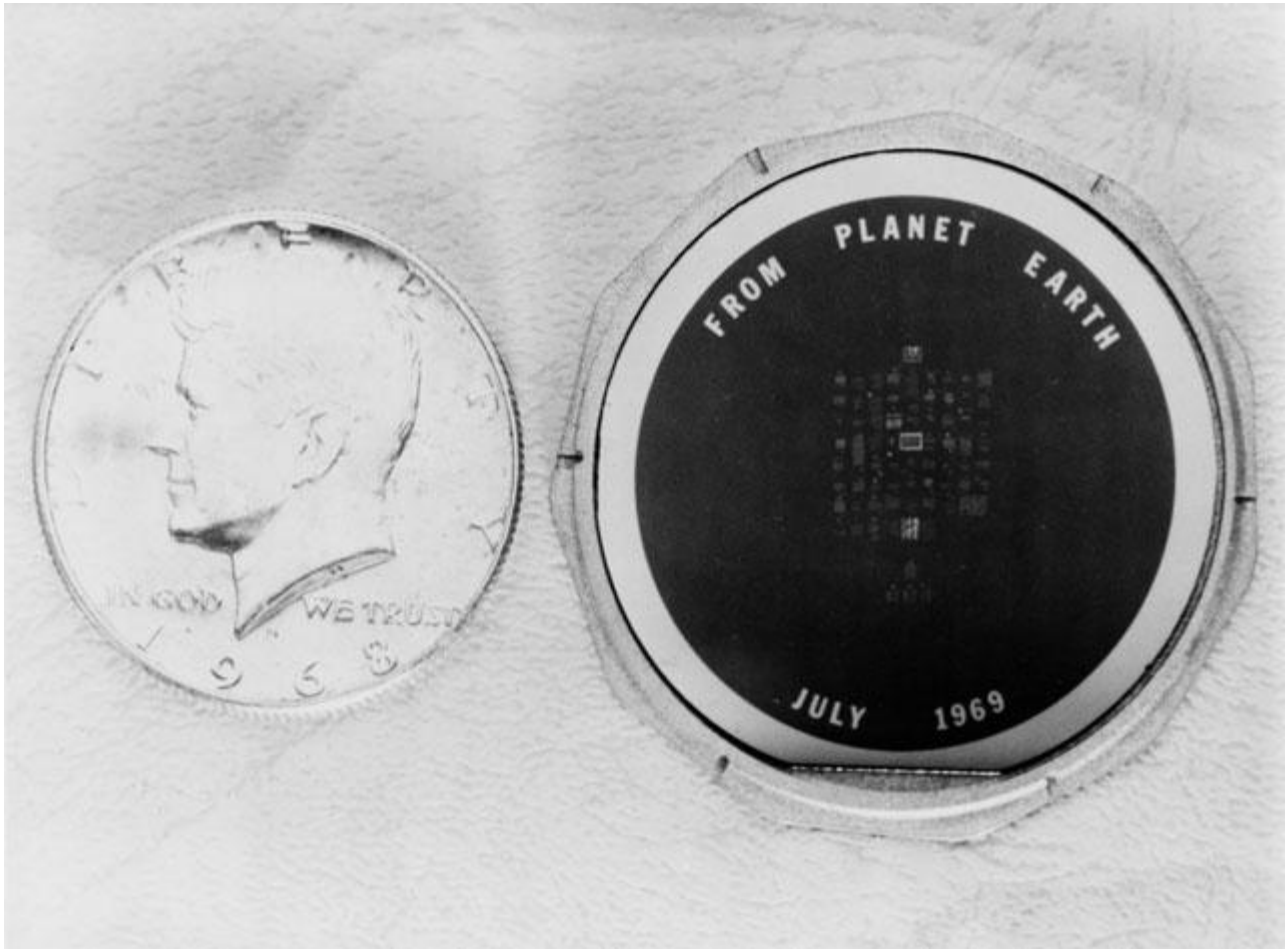


(20 July 1969) --- Astronaut Edwin E. Aldrin Jr., lunar module pilot of the first lunar landing mission, poses for a photograph beside the deployed United States flag during an Apollo 11 extravehicular activity (EVA) on the lunar surface. The Lunar Module (LM) is on the left, and the footprints of the astronauts are clearly visible in the soil of the moon. Astronaut Neil A. Armstrong, commander, took this picture with a 70mm Hasselblad lunar surface camera. While astronauts Armstrong and Aldrin descended in the LM, the "Eagle", to explore the Sea of Tranquility region of the moon, astronaut Michael Collins, command module pilot, remained with the Command and Service Modules (CSM) "Columbia" in lunar orbit.

(20 July 1969) --- Close-up view of the plaque which the Apollo 11 astronauts left on the moon in commemoration of the historic lunar landing mission. The plaque was attached to the ladder on the landing gear strut on the descent stage of the Apollo 11 Lunar Module (LM). The plaque was covered with a thin sheet of stainless steel during flight.



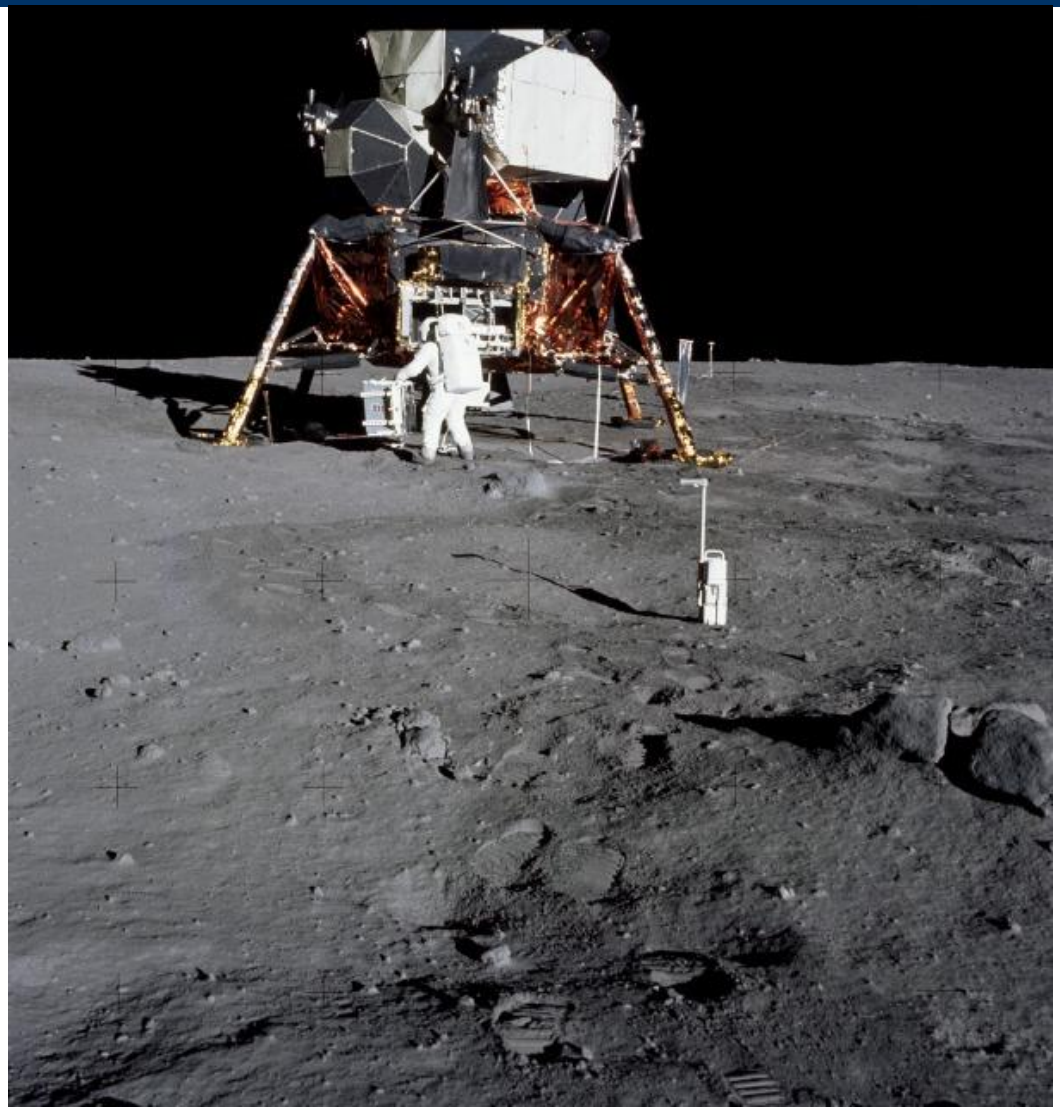
This is a replica of the plaque which the Apollo 11 astronauts will leave behind on the moon in commemoration of the historic event. The plaque is made of stainless steel, measuring nine by seven and five-eighths inches, and one-sixteenth inch thick. The plaque will be attached to the ladder on the landing gear strut on the descent stage of the Apollo 11 Lunar Module (LM). Covering the plaque during the flight will be a thin sheet of stainless steel which will be removed on the lunar surface.



Close-up view of the one and one-half inch silicon disk which will be left on the moon by the Apollo 11 astronauts. The disk bears messages of goodwill from heads of state of many nations. The process used to make this wafer is the same as that used to manufacture integrated circuits for electronic equipment. It involves making tiny photographic images and depositing metal on the images. The Kennedy half-dollar illustrates the relative size of the memorial disk.

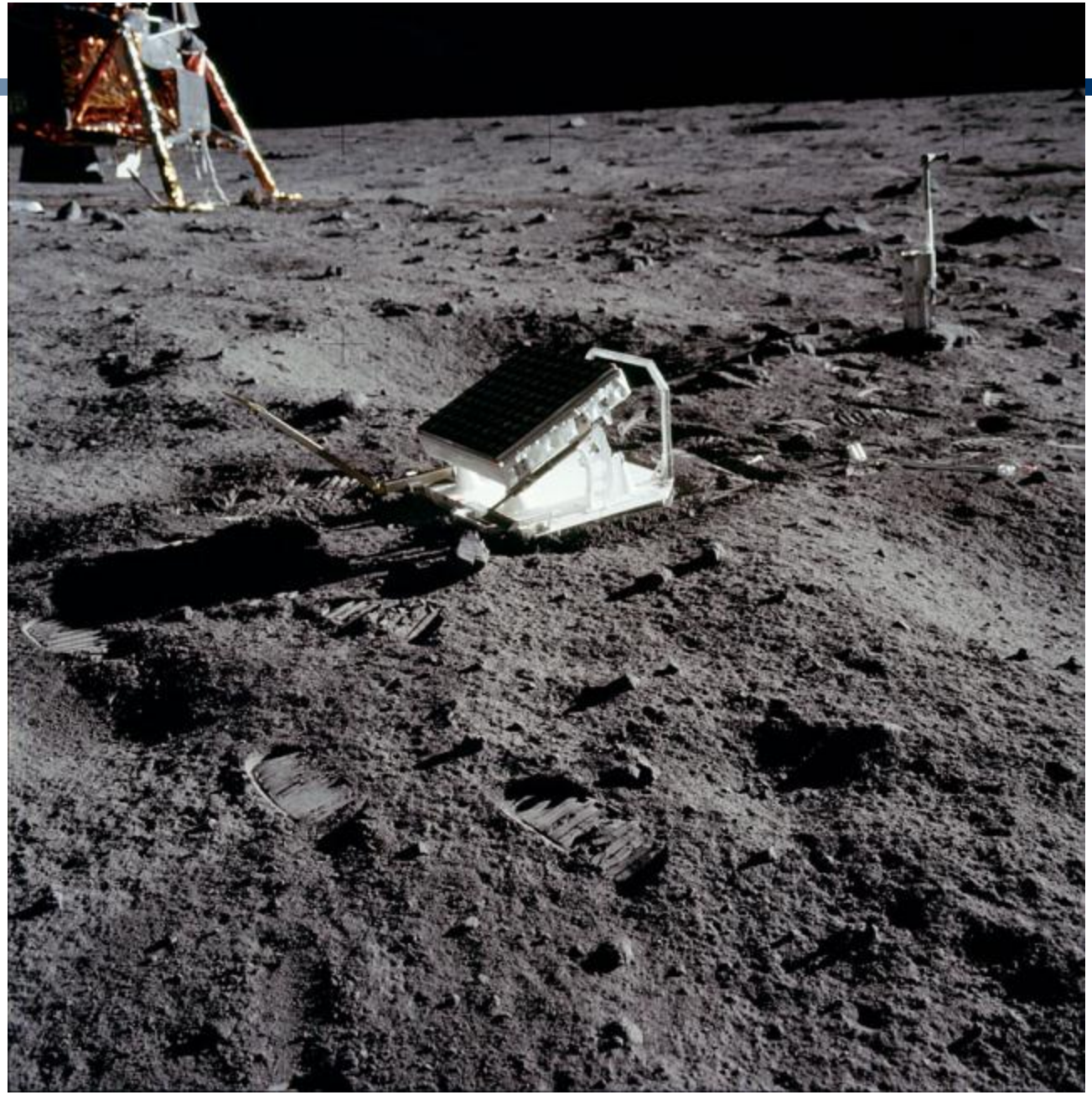
This picture is of the gold replica of an olive branch, the traditional symbol of peace, which was left on the moon's surface by Apollo 11 crewmembers. Astronaut Neil A. Armstrong, commander, was in charge of placing the small replica (less than half a foot in length) on the moon. The gesture represents a fresh wish for peace for all mankind.

Aldrin unpacks experiments from LM



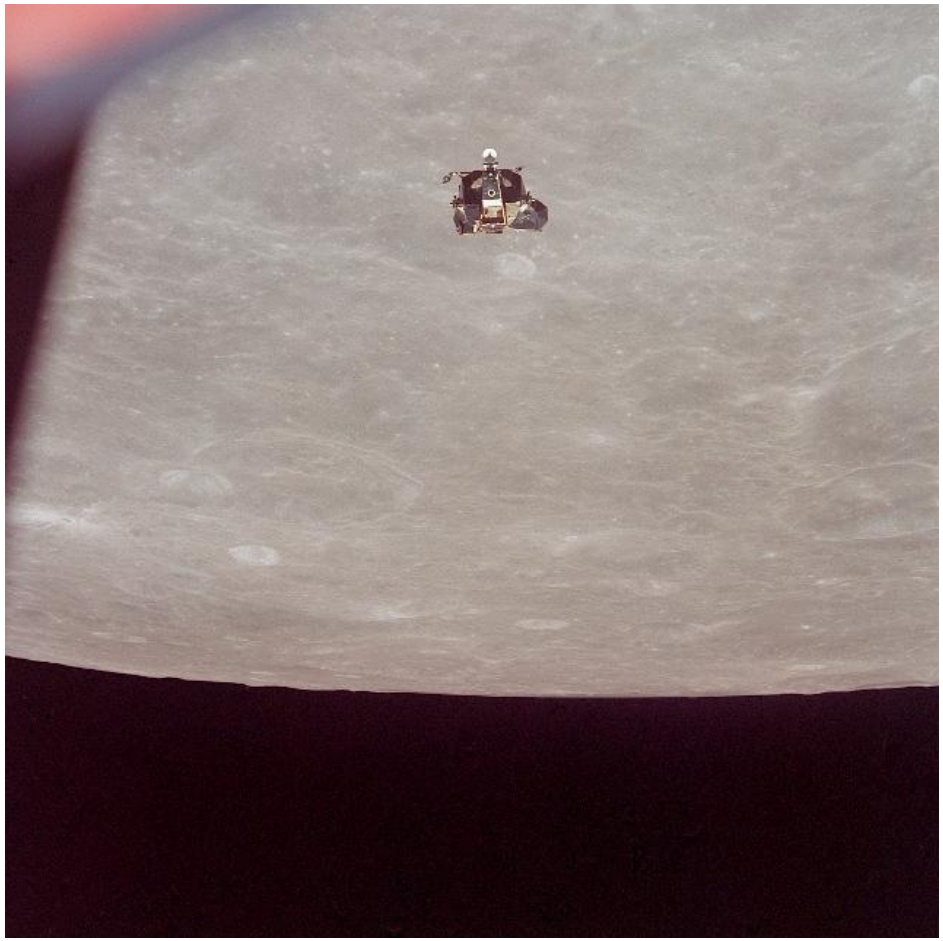
(20 July 1969) --- Astronaut Edwin E. Aldrin Jr., lunar module pilot, prepares to deploy the Early Apollo Scientific Experiments Package (EASEP) on the surface of the moon during the Apollo 11 extravehicular activity.

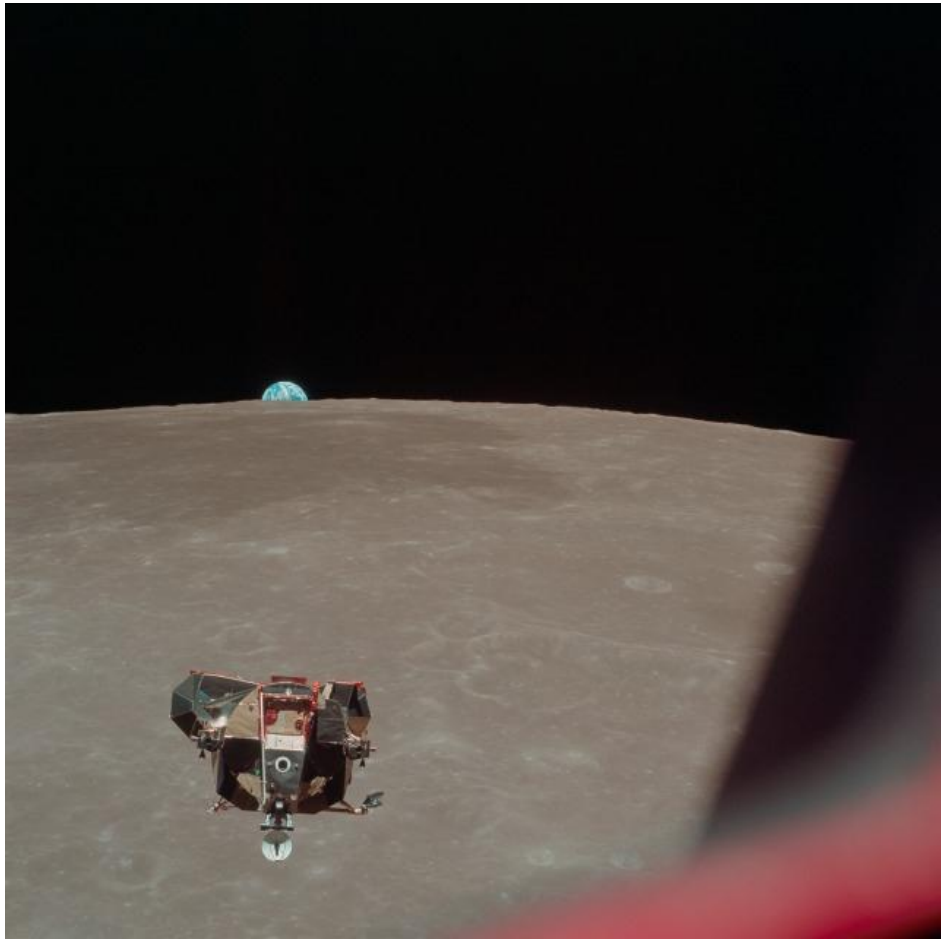
(20 July 1969) --- Astronaut Edwin E. Aldrin Jr., lunar module pilot, is photographed during the Apollo 11 extravehicular activity (EVA) on the moon. He has just deployed the Early Apollo Scientific Experiments Package (EASEP). This is a good view of the deployed equipment. In the foreground is the Passive Seismic Experiment Package (PSEP); beyond it is the Laser Ranging Retro-Reflector (LR-3); in the center background is the United States flag; in the left background is the black and white lunar surface television camera; in the far right background is the Lunar Module (LM).



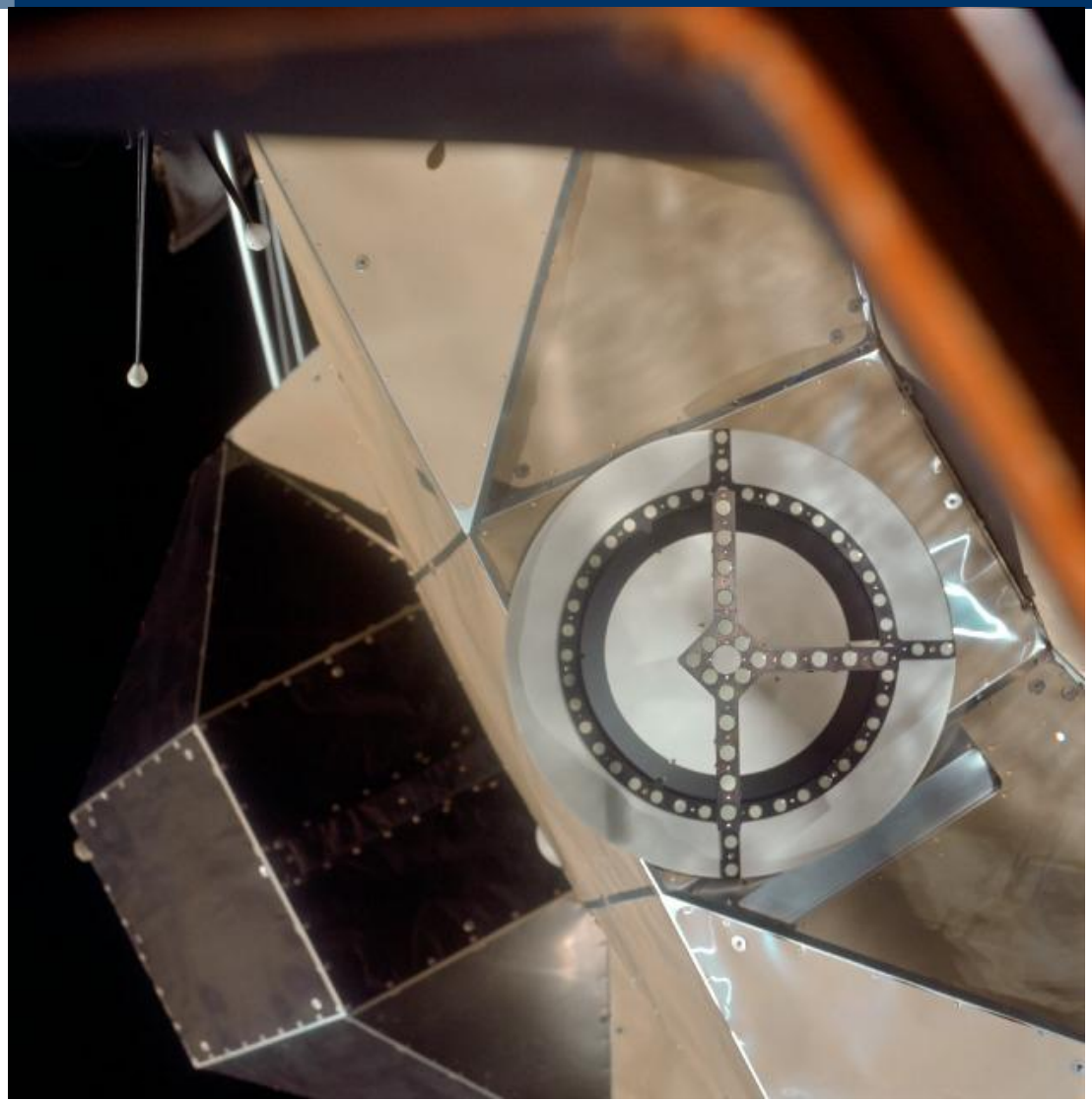
Laser reflector

This view from the Apollo 11 spacecraft shows Earth rising above the moon's horizon.





(21 July 1969) --- The Apollo 11 Lunar Module (LM) ascent stage, with astronauts Neil A. Armstrong and Edwin E. Aldrin Jr. aboard, is photographed from the Command and Service Modules (CSM) in lunar orbit



(21 July 1969) --- A close-up view of the docking target on the Apollo 11 Lunar Module (LM) photographed from the Command Module during the LM/CSM docking in lunar orbit.

Moon as viewed from Apollo 11 CM Columbia after TransEarth Injection

To the 400,000

"We would like to give special thanks to all those Americans who built the spacecraft; who did the construction design, the tests, and put their hearts and all their abilities into those craft. To those people tonight, we give special thank you, and to all the other people that are listening and watching tonight. God bless you. Good night from Apollo 11"

Neil Armstrong

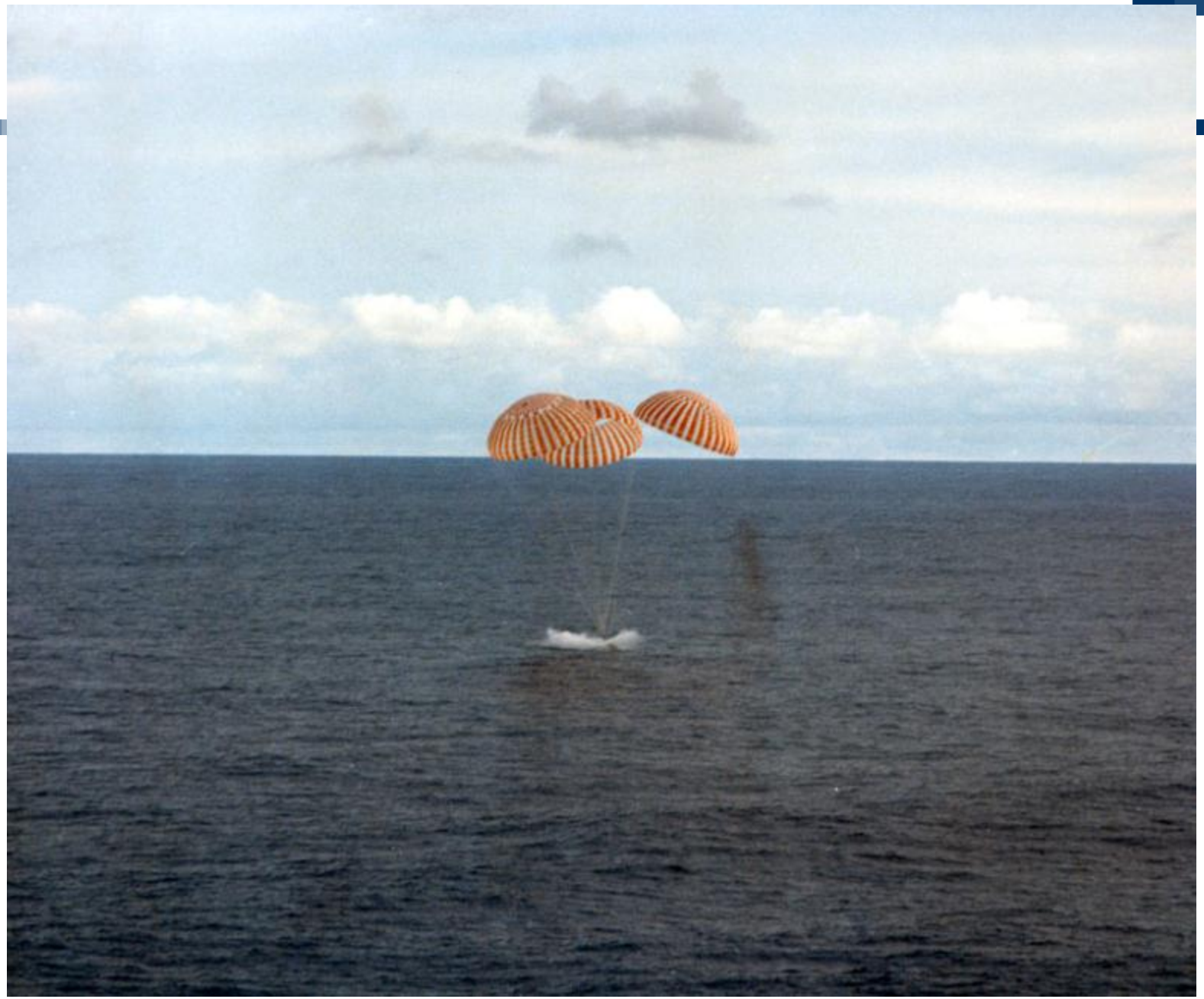
23 July 1969

On the way home from Moon

Crescent Earth photographed during return trip

Apollo 13 near splashdown

Apollo 12 splashdown



Apollo 13 splashdown

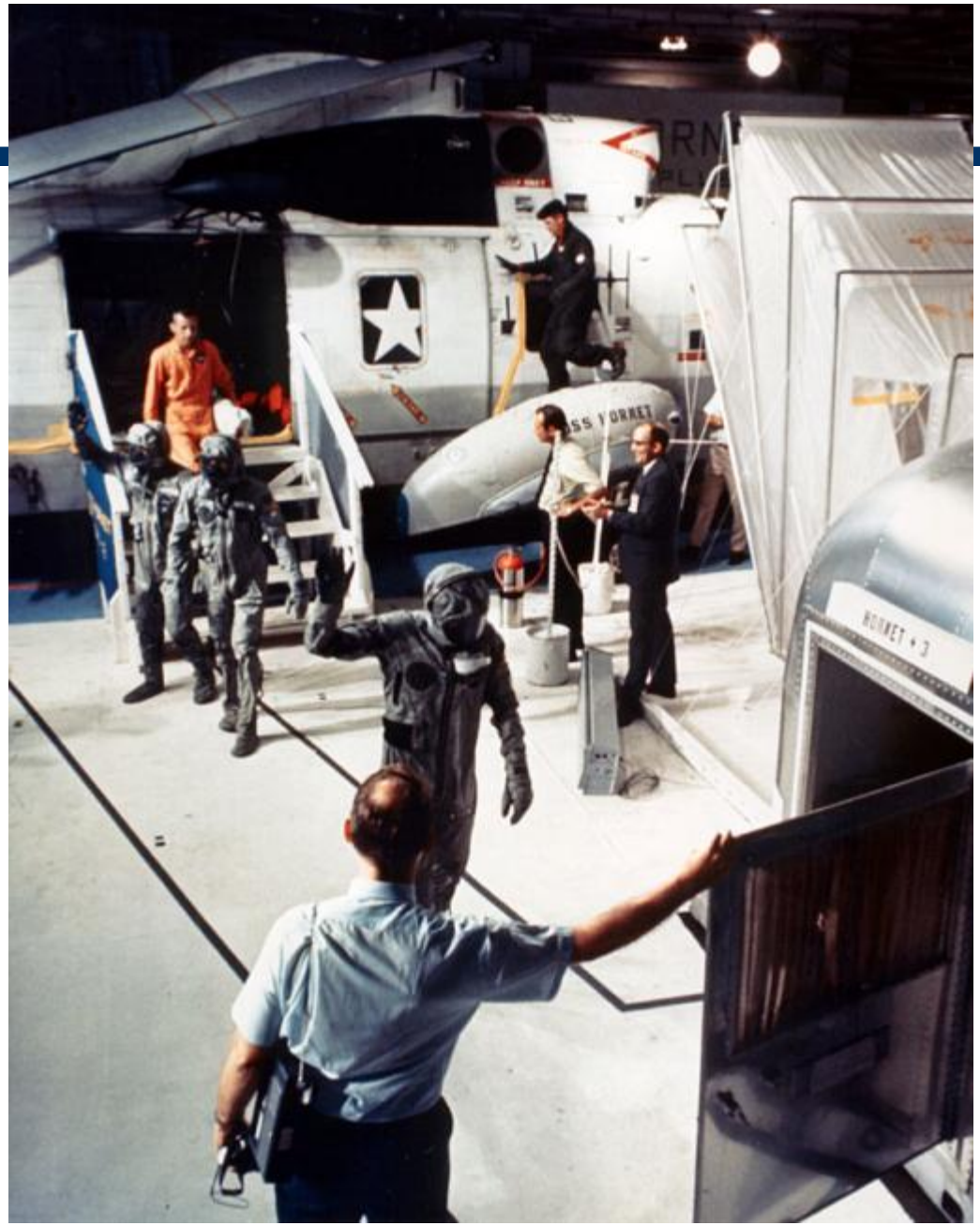
(24 July 1969) --- The three Apollo 11 crew men await pickup by a helicopter from the USS Hornet, prime recovery ship for the historic Apollo 11 lunar landing mission. The fourth man in the life raft is a United States Navy underwater demolition team swimmer. All four men are wearing biological isolation garments. Apollo 11, with astronauts Neil A. Armstrong, commander; Michael Collins, command module pilot; and Edwin E. Aldrin Jr., lunar module pilot, onboard, splashed down at 11:49 a.m. (CDT), July 24, 1969, about 812 nautical miles southwest of Hawaii and only 12 nautical miles from the USS Hornet.

Apollo 11 crew in isolation suits after splashdown

(24 July 1969) --- The Apollo 11 Command Module (CM) is photographed as it is hoisted aboard the USS Hornet, prime recovery vessel for the historic Apollo 11 lunar landing mission. The splashdown took place at 11:49 a.m. (CDT), July 24, 1969, about 812 nautical miles southwest of Hawaii, only 12 nautical miles from the USS Hornet.

(24 July 1969) --- Overall view of the Mission Operations Control Room (MOCR) in the Mission Control Center (MCC), Building 30, Manned Spacecraft Center (MSC), showing the flight controllers celebrating the successful conclusion of the Apollo 11 lunar landing mission.

Mission Control celebrates Apollo 11 mission



The Apollo 11 crewmen, wearing biological isolation garments, arrive aboard the U.S.S. Hornet during recovery operations in the central Pacific.

(27 July 1969) --- **The Apollo 11 crewmen, still under a 21-day quarantine, are greeted by their wives**. They arrived at Ellington Air Force Base very early Sunday after a flight aboard a U.S. Air Force C-141 transport from Hawaii. Looking through the window of a Mobile Quarantine Facility (MQF) are (left to right) astronauts Neil A. Armstrong, Edwin E. Aldrin Jr., and Michael Collins. The wives are (left to right) Mrs. Pat Collins, Mrs. Jan Armstrong, and Mrs. Joan Aldrin. The crew of the historic Apollo 11 lunar landing mission remained in the MQF until they arrived to the Crew Reception Area of the Lunar Receiving Laboratory at the Manned Spacecraft Center (MSC). **The astronauts will be released from quarantine on Aug. 11, 1969**.

President Nixon greets the Apollo 11 astronauts aboard the U.S.S. Hornet

(14 Aug. 1969) --- The Apollo 11 spacecraft Command Module (CM) is loaded aboard a Super Guppy Aircraft at Ellington Air Force Base for shipment to the North American Rockwell Corporation at Downey, California. The CM was just released from its postflight quarantine at the Manned Spacecraft Center (MSC).

(25 July 1969) --- The first Apollo 11 sample return container, containing lunar surface material, is photographed just after it arrives at the Lunar Receiving Laboratory (LRL), Building 37, Manned Spacecraft Center (MSC). The box arrived by air at Ellington Air Force Base just before noon on Friday, July 25, 1969, from the Pacific recovery area. It was taken immediately to the Manned Spacecraft Center. The lunar samples were collected by astronauts Neil A. Armstrong and Edwin E. Aldrin Jr. during their lunar surface extravehicular activity (EVA).

(13 Aug. 1969) --- New York City welcomes Apollo 11 crewmen in a showering of ticker tape down Broadway and Park Avenue in a parade termed as the largest in the city's history. Pictured in the lead car, from the right, are astronauts Neil A. Armstrong, commander; Michael Collins, command module pilot; and Edwin E. Aldrin Jr., lunar module pilot.

Apollo 11 – AS-506

Riferimenti e link

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