The Command Module

INST 154

Apollo at 50

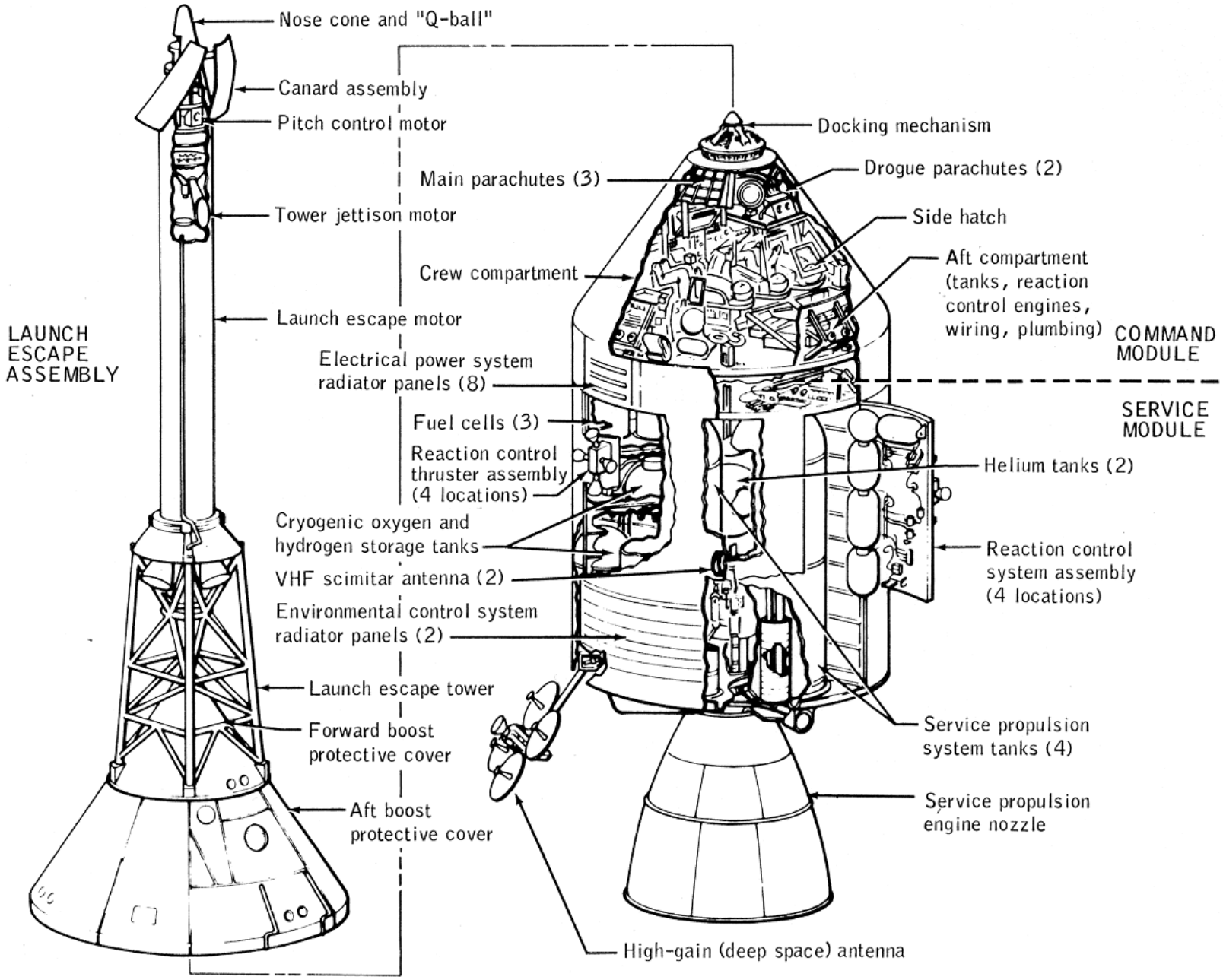
Apollo Guidance Computer

Agenda

- Command and Service Modules
- Contracting
- Discussion Groups
- Apollo Guidance Computer
- Writing your case study

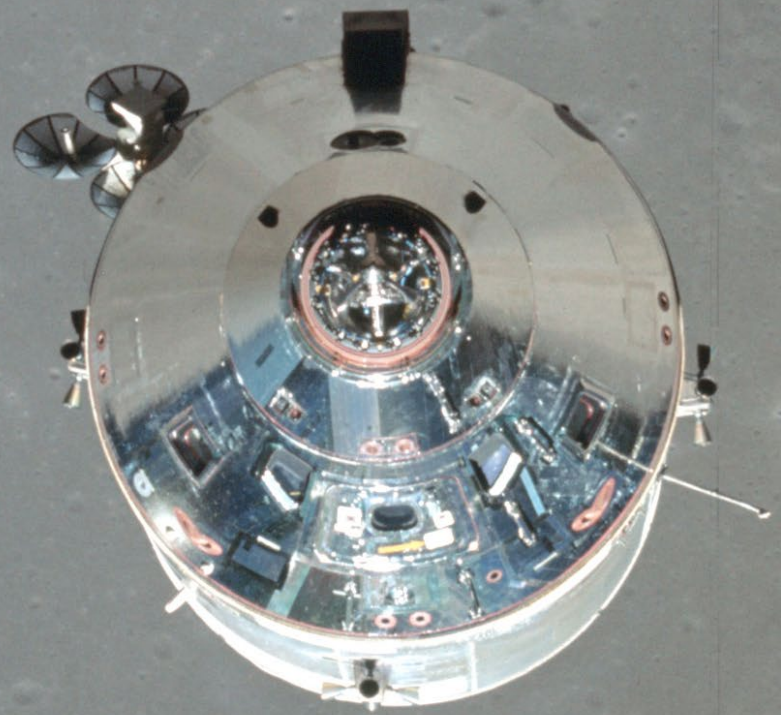
Chronology

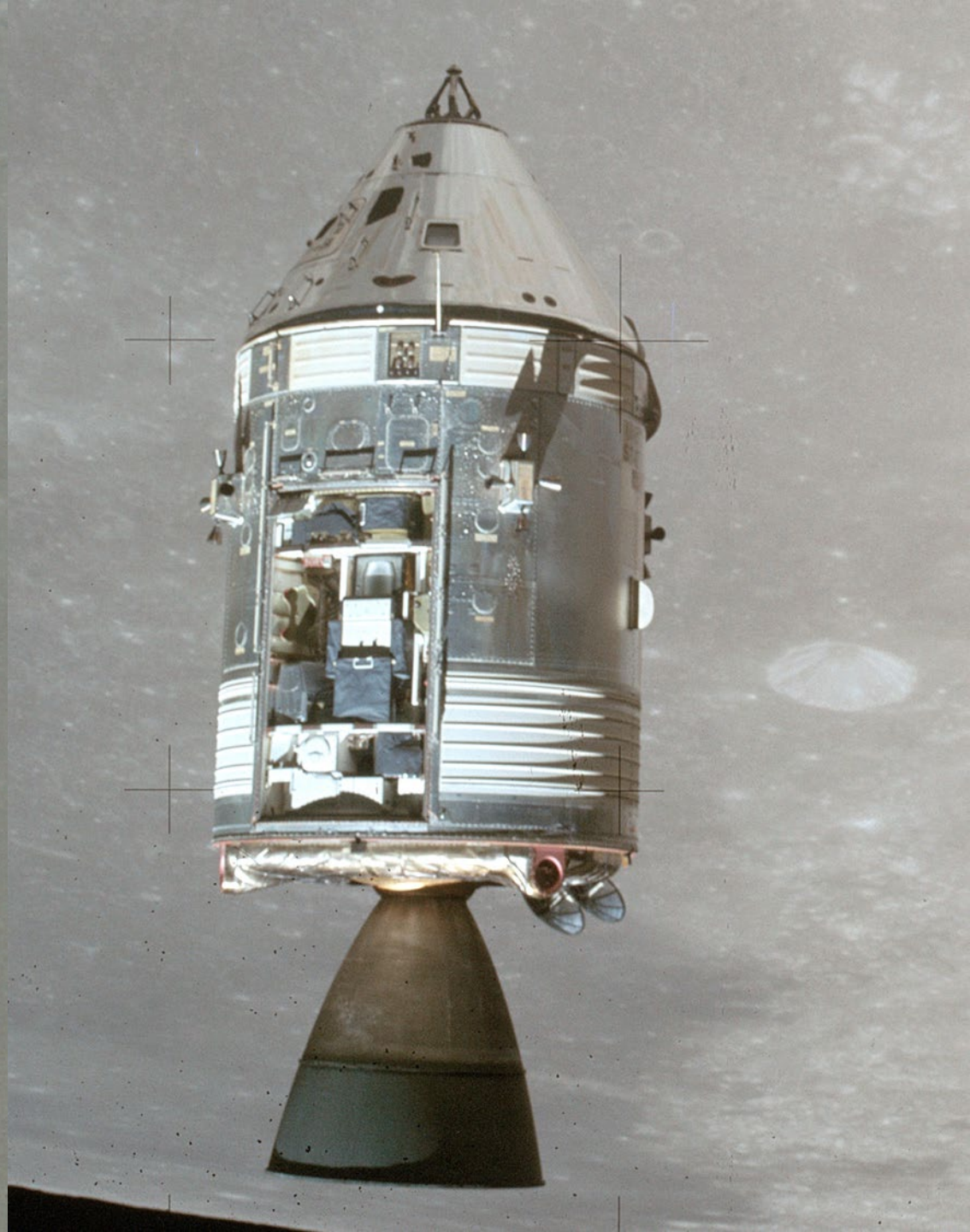
• MIT guidance computer contract award	August 1961
• North American CSM contract award	November 1961
• LOR mode decision	July 1962
• Block II CSM design	January 1964
• First boilerplate launch	March 1964: Saturn 1
• First Block I launch	January 1966: Little Joe 2
• Apollo 1 fire in a Block I CM	January 1967
• First Block II launch	October 1968: Apollo 7



APOLLO COMMAND AND SERVICE MODULES AND LAUNCH ESCAPE SYSTEM

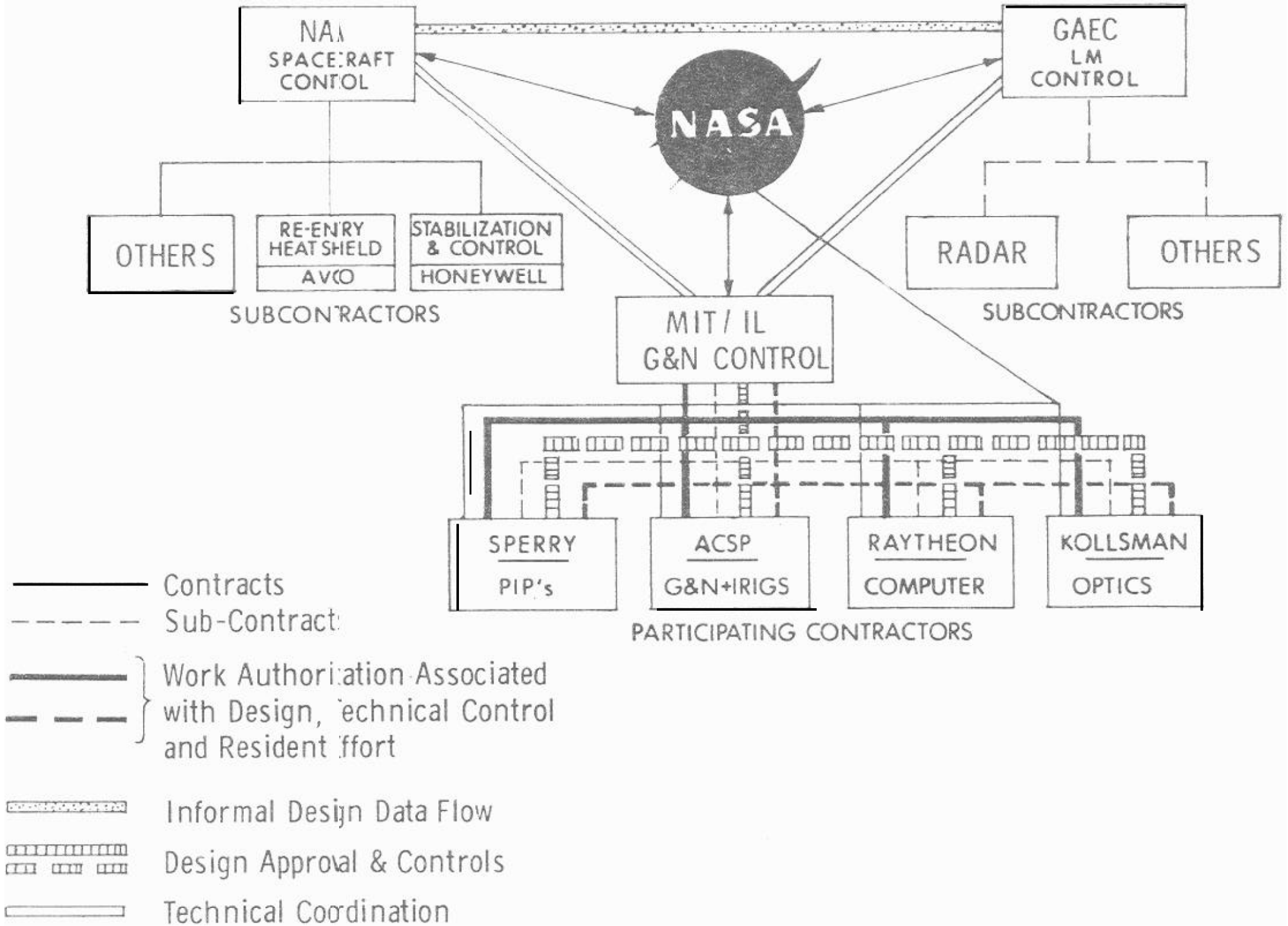
Interior View



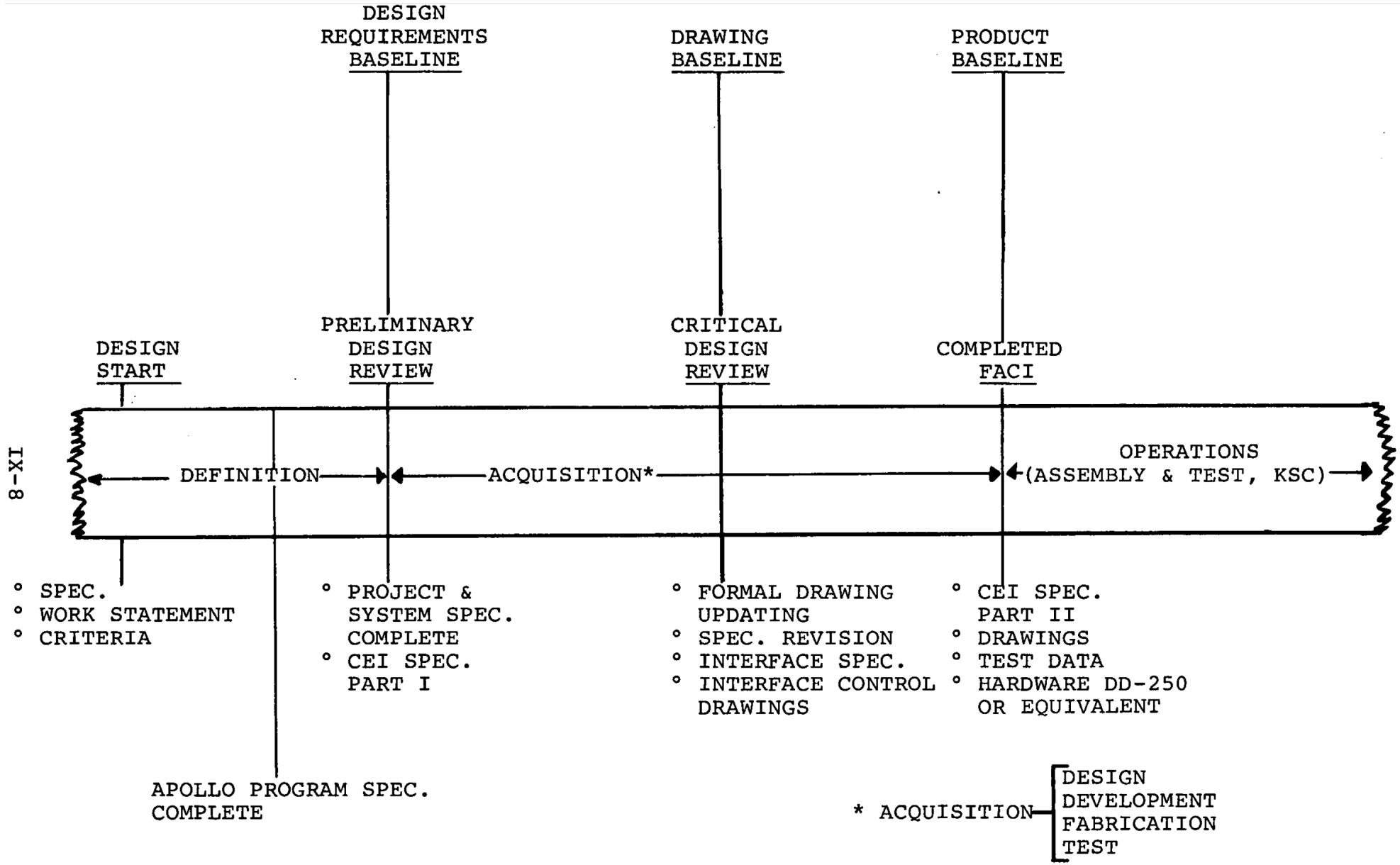


Some Design Questions

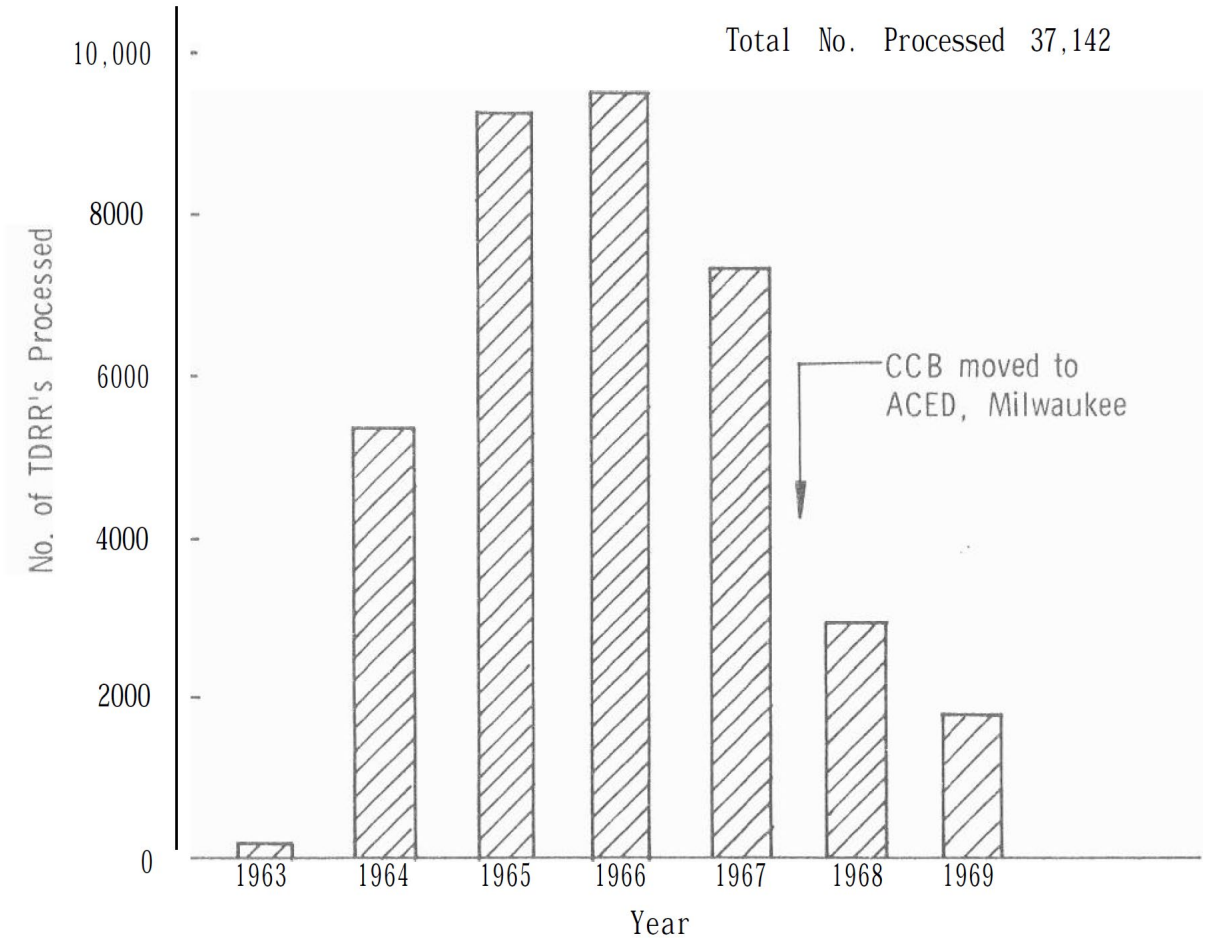
- How many modules?
  - The Soviets had 3, we had 2. Why?
- How to transfer to the Lunar Module?
  - The Soviets used spacewalks, we used a tunnel. Why?
- Whether to return to Earth on land or in the water
  - We tried land; it was hard.
- How to navigate?
  - We spent $100 million for onboard navigation, and then did it from Earth.
- When to wear spacesuits?
  - A bad decision on this killed three cosmonauts.
- Whether to use normal air or pure oxygen?
  - Pure oxygen is simpler and lighter. It killed three astronauts.
- Whether to put a TV camera aboard
  - We had the technology to do this, but had chosen not to in Gemini.


NAA
SPACECRAFT
CONTROL
GAEC
LM
CONTROL
NASA
OTHERS
RE-ENTRY
HEAT SHIELD
AVCO
STABILIZATION
& CONTROL
HONEYWELL
SUBCONTRACTORS
RADAR
OTHERS
SUBCONTRACTORS
MIT / IL
G&N CONTROL
SPERRY
PIP's
ACSP
G&N+IRIGS
RAYTHEON
COMPUTER
KOLLSMAN
OPTICS
PARTICIPATING CONTRACTORS
Contracts
Sub-Contracts
Work Authorization Associated
with Design, Technical Control
and Resident Effort
Informal Design Data Flow
Design Approval & Controls
Technical Coordination

Configuration Management



Configuration Control Board



(1) ☐ SV ☐ AGE ☐ FAC ☐ TRAINING ☐ GIE ☐ DS RPIE

NASA ORG. _____

CONFIGURATION CONTROL BOARD DIRECTIVE

PAGE 1 OF _____

(2) CCBD NUMBER

DATE: DAY MO. YR.

(3) CONTRACTOR:

(19) ECP TITLE

SUPERSEDES ISSUE OF DAY MO. YR.

(4) ECP NO.

(4A) DATE:

(5) SUPERSEDES ECP NO.

(5A) DATE:

(20) NOMENCLATURE, CONTRACT END ITEM

(6) END ITEM NO.

(21) EFFECTIVITIES

(22) PROCUREMENT ACTION REQUIRED

(7) END ITEM PART NO.

FIRST	LAST	TYPE	FIRST	LAST	TYPE

(8) TCTR NO. & TYPE

A. END ITEM MOD.

B. SPARES MOD.

C. TECHNICAL DATA

PART NO CHANGE: ☐ YES ☐ NO

(10) SPARES AFFECTED ☐ YES ☐ NO

(11) INTERFACE REQUIREMENTS

TYPE LEGEND

P - PRODUCTION

S - RETROFIT

(12) DESIGN DEFICIENCY ☐ YES ☐ NO

(13) ECP NOTED IN BLOCK (4) IS
☐ APPROVED AS WRITTEN
☐ DISAPPROVED
☐ APPROVED WITH CHANGES. AS NOTED BELOW

(14) SPECIFICATION NO.

REMARKS:

(15) SPECIFICATIONS AFFECTED:
PROGRAM SPEC NO. ☐ YES ☐ NO
(16) PROJECT SPEC. NO. ☐ YES ☐ NO
(17) SYSTEM SPEC NO. ☐ YES ☐ NO
(18) CEI SPEC NO. ☐ YES ☐ NO

(23)	CONCUR	NON CONCUR
TECHNICAL		
RELIABILITY		
TEST		
MANUFACT.		
QUAL. CONTROL		
CONTRACTS		
COSTS		
SCHEDULE		
OPERATIONS		
LOGISTICS		

PROG. MANAGER CCB-MSC	CONCUR	NON CONCUR	PROGRAM MANAGER MSC-IMCC	CONCUR	NON CONCUR
PROGRAM MANAGER CCB-MSFC			OTHER		
PROGRAM MANAGER CCB-KSC			OTHER		

CHAIRMAN PROGRAM MANAGER CCB

CHAIRMAN APOLLO PROGRAM DIRECTOR CCB

NASA FORM 1238 (AUG 65)

(OVER)

Figure 1

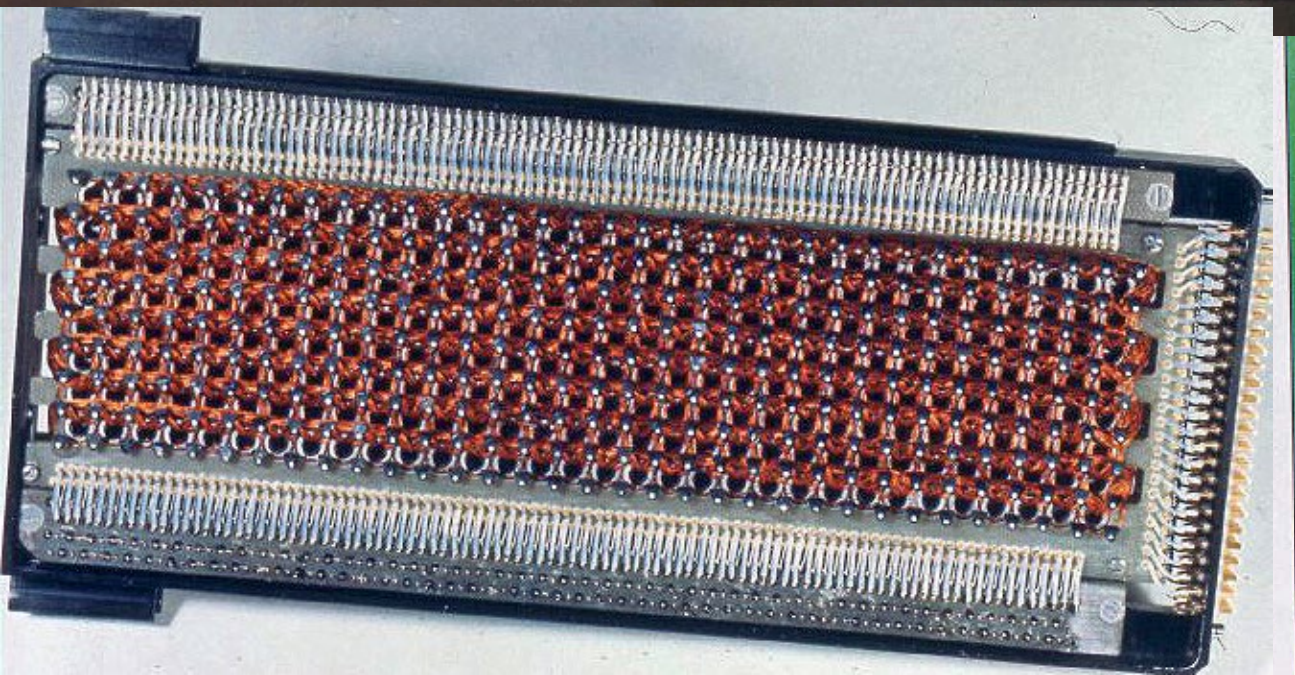
Discussion Groups

- Moon Machines Video (“Command Module”)
  - An overview, including interviews with some of its builders
- Gray Chapter 12
  - The view from the North American (the CSM prime contractor)
- Mindell Chapter 5 (“Braincase on the Tip of a Firecracker: Apollo Guidance”)
  - The view from MIT (the Guidance and Navigation prime contractor)

Apollo Guidance Computer

- Clock speed: ~500 µsec
- ROM: ~70kB
- RAM: ~4kB
- Word length: 16 bits (15+parity)
- Weight: 70 lbs
- Power: 55 watts
- Language: Assembler
- Peripherals: DSKY, IMU, landing radar, engines, …


INTERFACE MODULE A27-29
INTERFACE MODULE A27-29
INTERFACE MODULE A27-29
INTERFACE MODULE A25-26
INTERFACE MODULE A25-26
LOGIC MODULE A28
LOGIC MODULE A28
LOGIC MODULE A28
LOGIC MODULE A28
LOGIC MODULE A28




UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
NO ATT
TRACKER
STBY
KEY REL
OPR ERR
COMP ACTY
PROG
13
VERB
NOUN
33
13
+35870
+40611
+03614
VERB
NOUN
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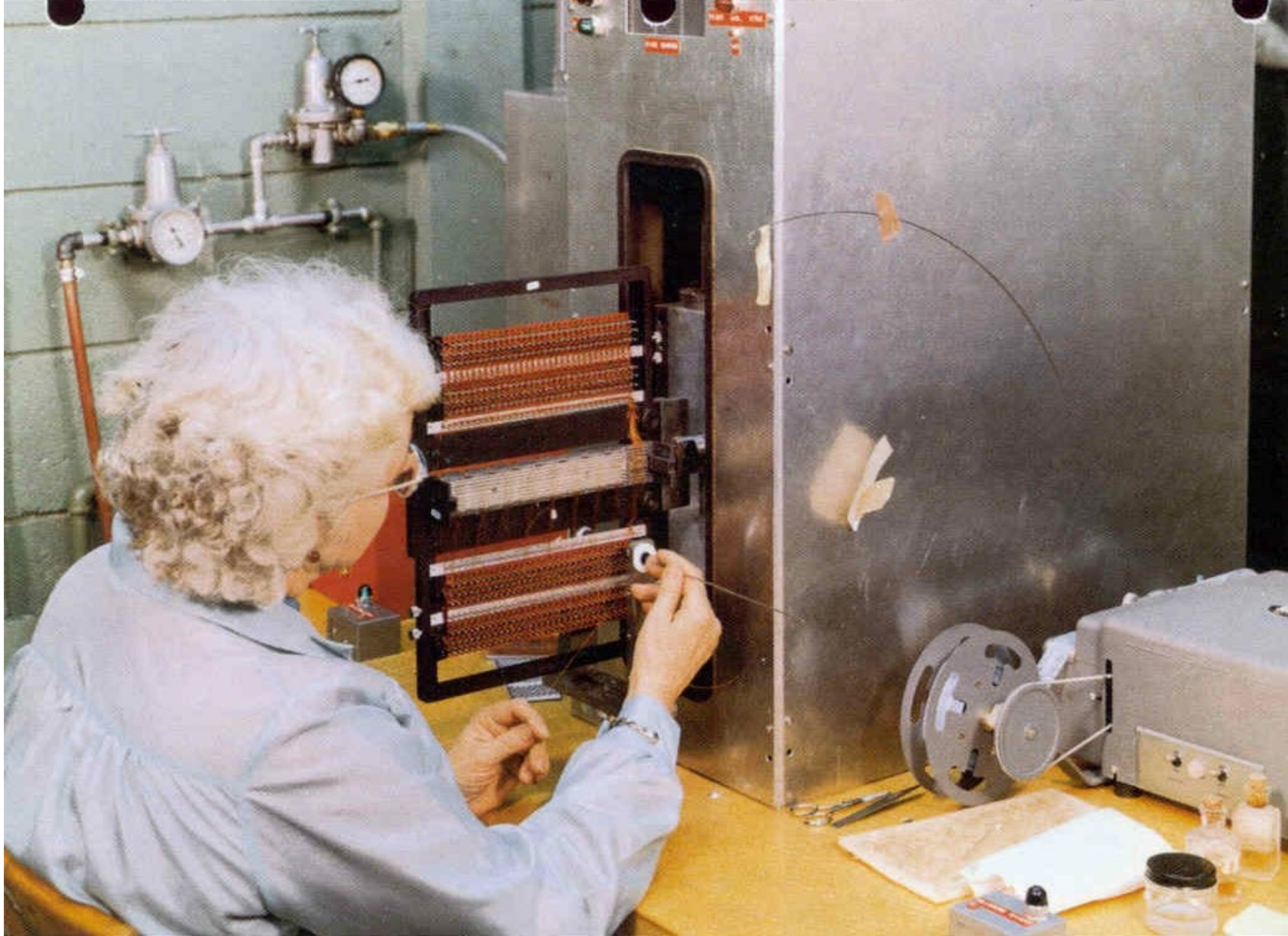
3
CLR
ENTER
STBY
RSET
KEY REL

Programming Core Rope Memory



Case Study

- Read broadly about your assigned person
  - The one linked reading is just a starting point
  - Consult at least five sources
  - May take time to get some library materials!

- Organize your writing in four parts
  - Pre-Apollo career
  - Apollo career
  - Post-Apollo career
  - One vignette

- References
  - **Any quoted content must be in quotes**
  - Sources for all content that is not original must be cited