COMPUTER SCIENCE SOCIETY

TO THE MOON



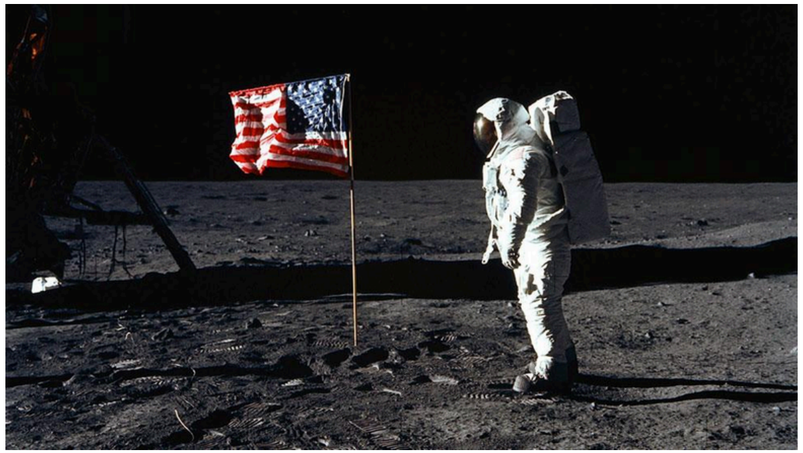
ON 4 KILOBYTES

Presented by Michal, Sergi, Aren

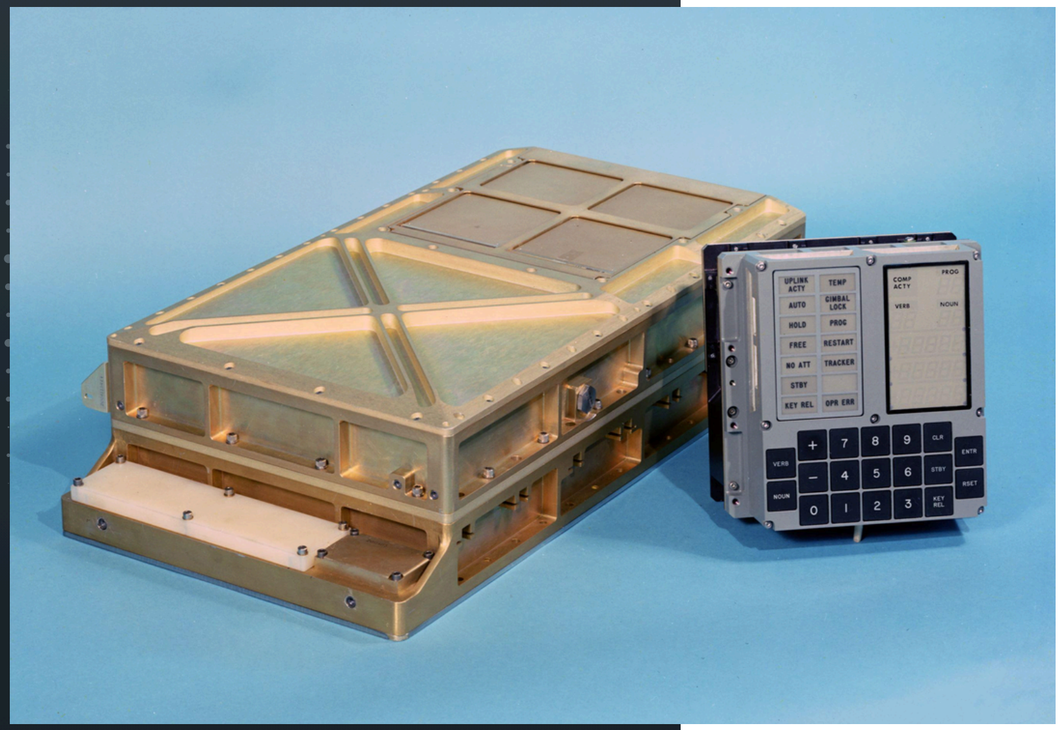
HISTORY & EVOLUTION

THE SIZE OF THE PROBLEM



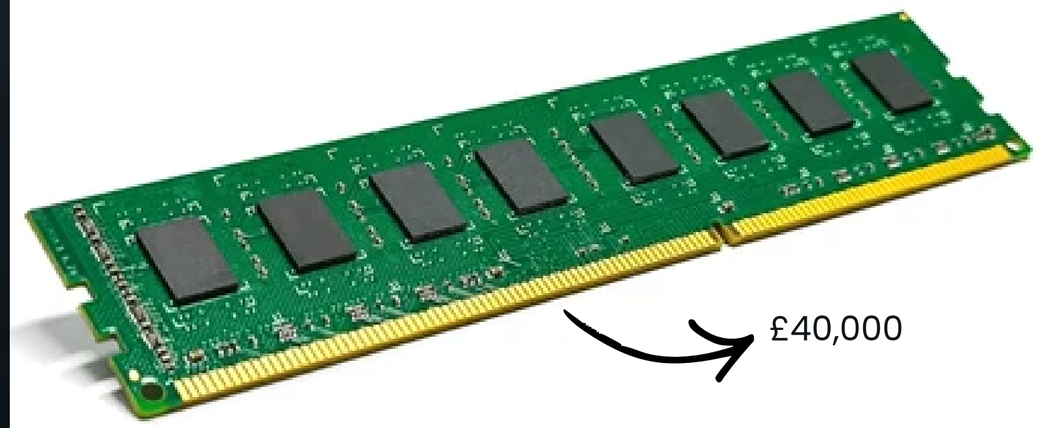


- **The Era:** In the early 1960s, computers were the size of entire rooms. They required massive air conditioning units and thousands of vacuum tubes.
- **The Challenge:** President JFK committed to putting a man on the moon. NASA needed a computer that could navigate a spacecraft across 240,000 miles of dead space.
- **The Catch:** It had to be small enough to fit in a capsule, light enough to launch, and use almost no power.



APOLLO GUIDANCE COMPUTER

- **The Specs:** Processing Speed: ~2.048 MHz (Our phones are thousands of times faster!).
  - RAM: 4 Kilobytes.
  - Weight: 70 lbs (A miracle of miniaturisation for the time).
- **The Secret Weapon:** It was one of the first computers to use Integrated Circuits (Microchips) instead of massive transistors, paving the way for modern electronics.



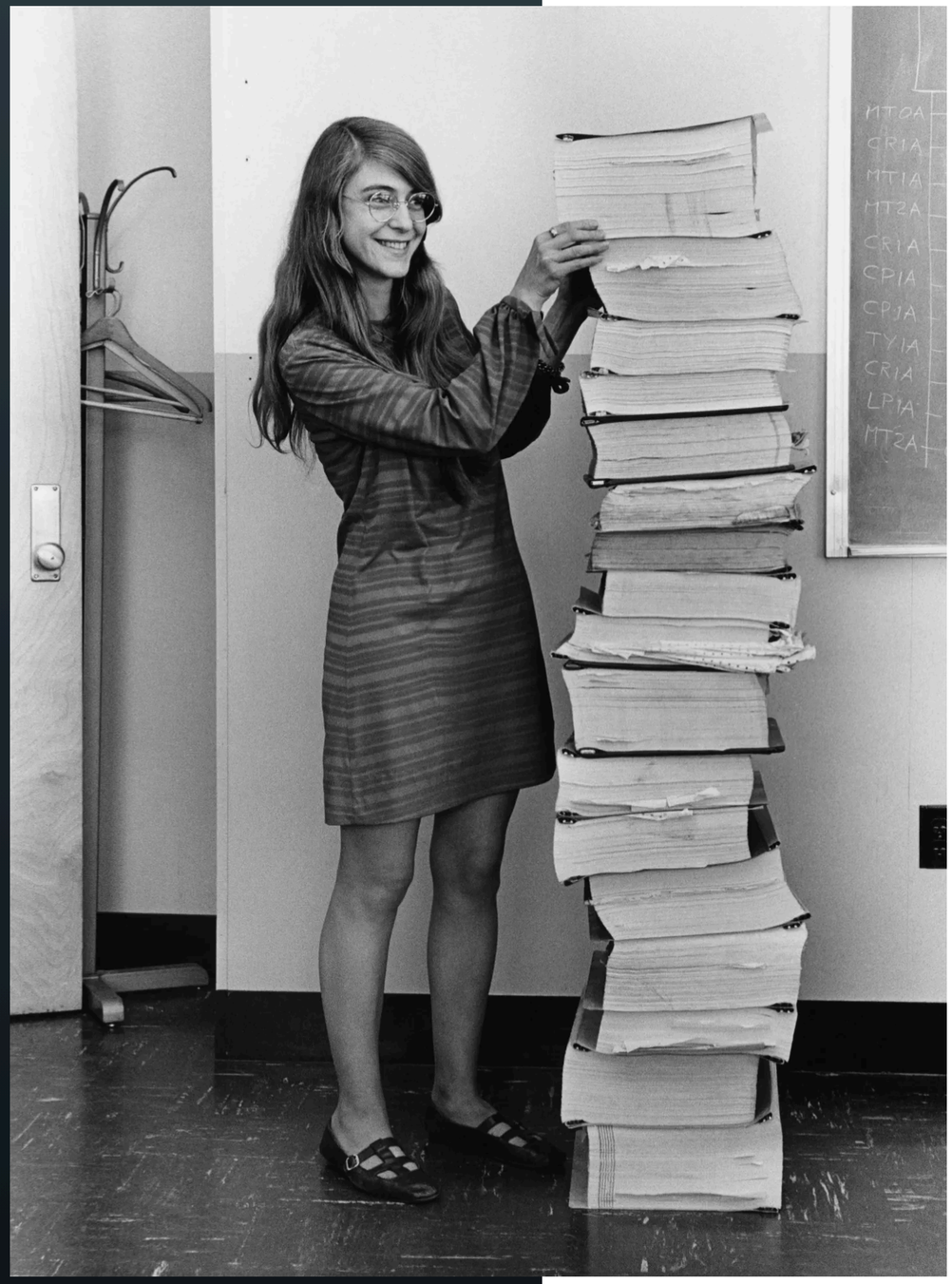
THE PIONEER



MARGARET HAMILTON

- Brilliant mathematician and programmer which became the **director** of the Software Engineering Division at the MIT Instrumentation Laboratory
- Led the **development** of NASA’s guidance computer

- With software engineering being **overlooked**, she alone understood the severity that a bug would have on the survival of the astronauts
- She pushed to maintain the software at the same care as the physical rockets themselves



COINING SOFTWARE ENGINEERING

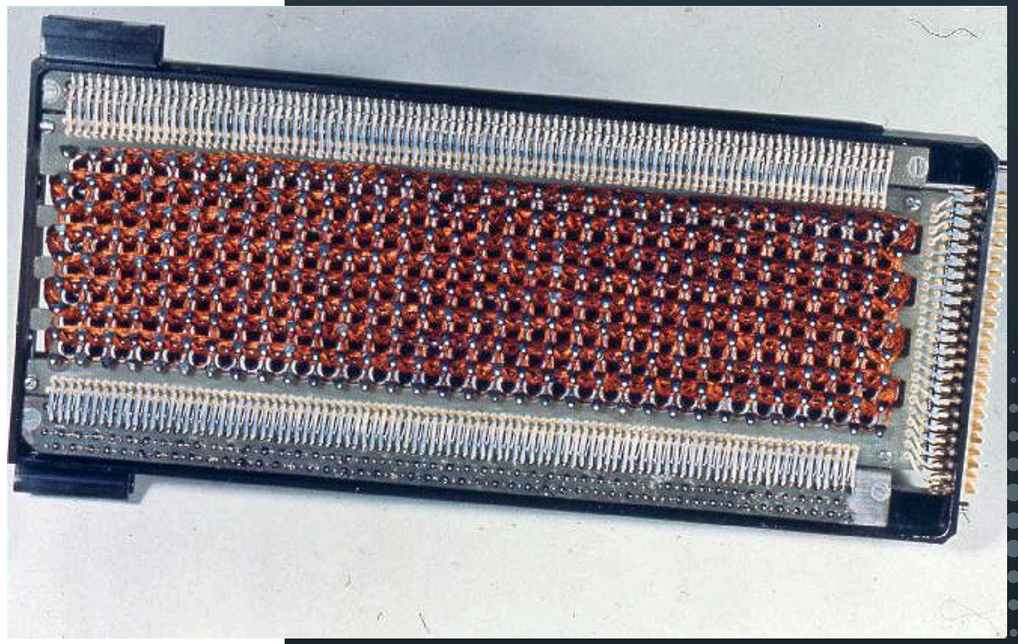
The Definition: Hamilton literally invented the term "Software Engineering" to give her team's work legitimacy.

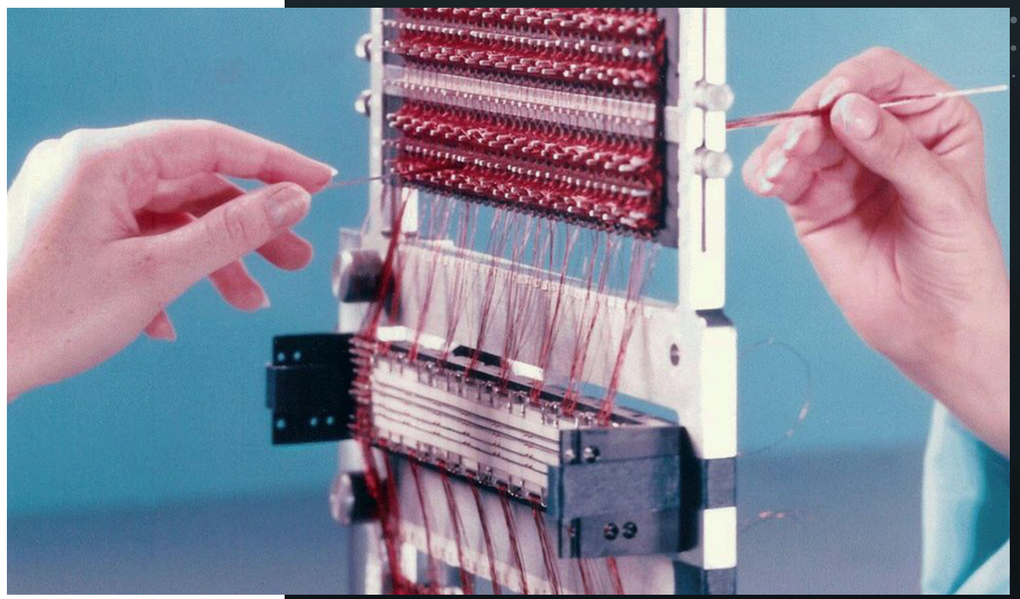
The Philosophy: She introduced concepts we use every day: asynchronous software, priority scheduling, and extreme error recovery.

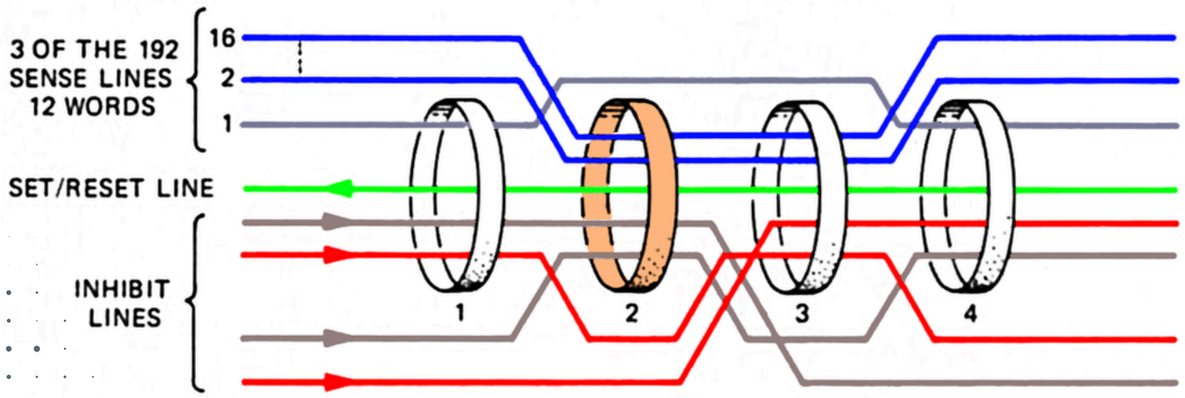
CORE ROPE MEMORY

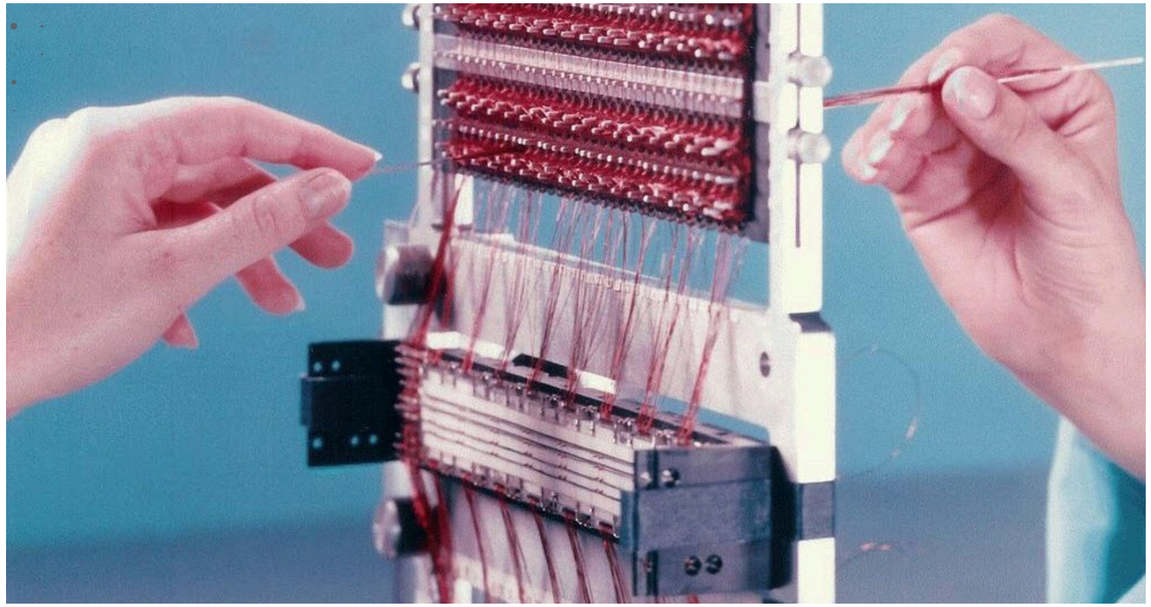
The Danger: Space is full of radiation. Standard magnetic memory could be easily wiped by cosmic rays, causing the ship to forget how to fly.

The Solution: They made the memory indestructible by physically building it out of copper wires and magnetic rings.









LOL MEMORY

How it Worked: If a wire was threaded through the magnetic ring, it was a 1. If it went around the outside of the ring, it was a 0.

The Process: The code wasn't downloaded; it was woven. NASA hired expert textile workers from local factories to physically weave the binary code by hand.

The Nickname: Engineers affectionately called it "Little Old Lady" (LOL) Memory. Once it was woven, it could never be changed or corrupted.

APOLLO SYSTEM DESIGN

THE DISPLAY AND KEYBOARD

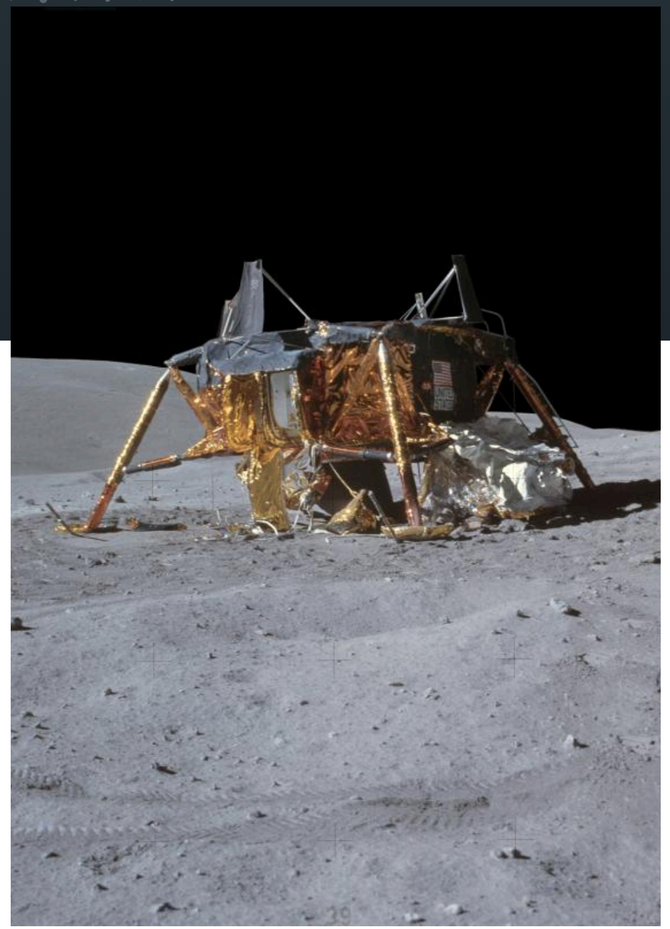
The Problem: Astronauts were pilots, not computer scientists. They needed a way to talk to the computer while wearing thick space gloves.

The Interface: A calculator-like keypad with a two-digit display. Verbs and Nouns: It operated on a simple syntax. You typed a "Verb" (an action, like Display) and a "Noun" (a target, like Velocity).

Example: Pressing "Verb 16, Noun 36" told the ship to display the current time.



THE DESCENT



The Scenario: Neil Armstrong and Buzz Aldrin are **30,000 feet** above the moon. The radar locks on to the surface.

The Error: Suddenly, the DSKY flashes a **1202 Program Alarm.**

The Panic: Mission Control has seconds to decide: do they abort the mission and fly home, or risk crashing into the moon?

1202 ALARM

- **The Glitch:** A hardware switch was in the **wrong position**, causing the radar to flood the AGC with **useless data**.
- **The Overload:** The computer’s tiny 4KB of **RAM** was completely **overwhelmed**. It was being asked to do 115% of its maximum workload.
- **The Reality:** On any normal computer of that era, the system would have frozen, crashed, and the astronauts would have died.

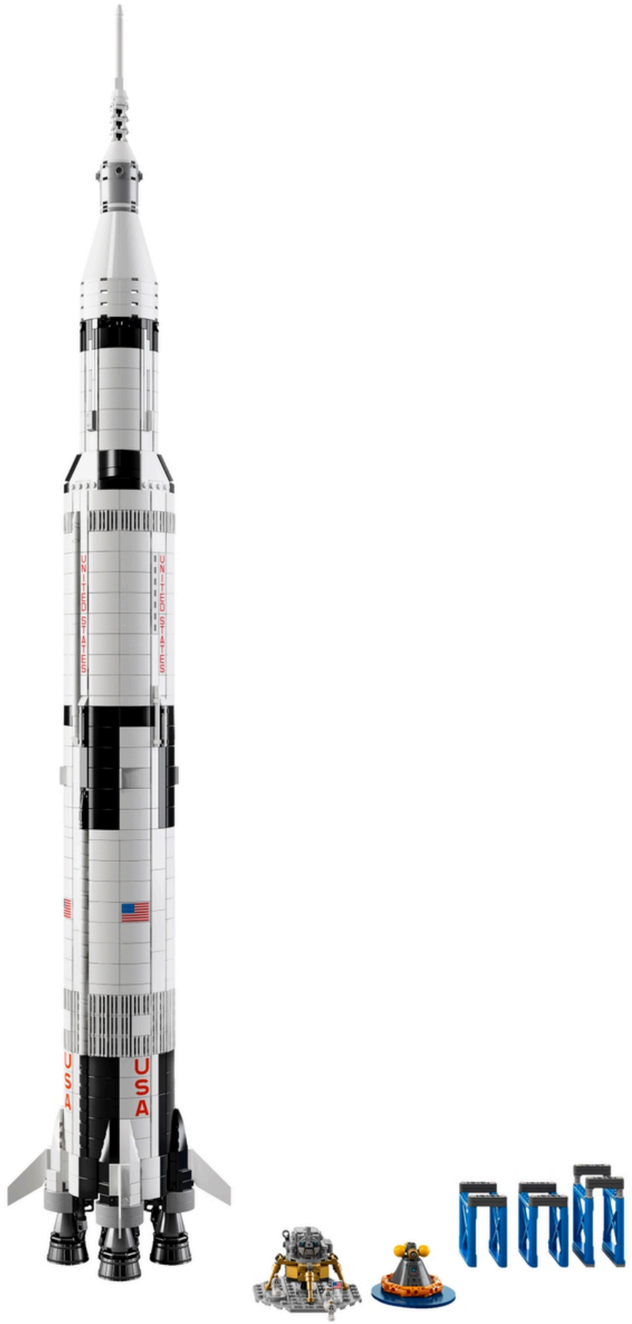


PRIORITY SCHEDULING

Hamilton's Genius: Margaret Hamilton’s team had programmed an "Asynchronous Executive."

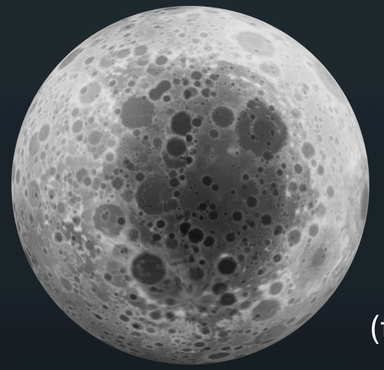
How it acted: When the computer realized it was overloaded, it didn't crash. It looked at all its tasks, **dropped everything** that wasn't **strictly necessary** (like updating the display), and put 100% of its power into keeping the thrusters firing.

The Result: The 1202 alarm was the computer saying, "I'm overloaded, so I'm **ignoring** the radar and focusing on landing." They landed safely.



APOLLO'S LEGACY

The Impact: The techniques invented for the **AGC**, **fly-by-wire, priority scheduling**, and rigorous software testing, are now the foundation of modern aviation, medical devices, and self-driving cars.



(to scale)

Next Week: We will be diving into the dark side of the web - Cybersecurity, Cryptography, and the multi-billion dollar silent war.

THE MOON ON 4 KILOBYTES

THANK YOU



Looking back, we were the luckiest people in the world. There was no choice but to be pioneers; no time to be beginners. - Margaret E. H. Hamilton

Presented by Aren, Michal, Sergi