

Lecture 12
by Richard H. Battin

“Some Funny Things Happened on the Way to the Moon”

1957: Sputnik launched; you could see it pass overhead with the naked eye, and everyone realized it was an important event.

[photo of Doc Draper’s lab in his building circa 1957, which was inside a shoe polish factory in Cambridge, MA]

MIT began planning an unmanned fly-by mission to Mars, to photograph the surface. Involved an extra orbit around the Sun as part of the return trip – but this would take 3 years, and engineers were uncertain about creating an automated system that could manage a trip of this length by itself.

- Battin feels it was the most famous spacecraft that never flew
- Project began under the USAF and was taken over by NASA once it was formed.
- Major problem: system would not be able to receive uplinks or in-flight changes; would have to be totally self-sustained for 3 years.

Then came 1961 and Alan Shepard’s flight and safe return, which sparked Kennedy to decide on a manned mission to the Moon.

- Battin calls 1961 “the Year of the Challenge” [to get the moon].
- MIT was awarded the 1st Apollo contract in this year

Why was MIT awarded the prime contract for Apollo?

- they had impressed NASA with their Mars computer ideas, so NASA believed they might be able to design the necessary systems for Apollo; MIT did not (could not) compete with industry, since industry supported MIT
- MIT Mars probe did not fly but the on-board computer did evolve into the Apollo guidance computer

Why was MIT chosen for guidance and control?

- Doc Draper knew the head of NASA (Jim Webb) – see slide for their conversation (this is the story that Draper told, anyway)
- Bob Chilton memo demonstrates awareness that the MIT Instrumentation Lab had demonstrated an interest in “self-contained navigation,” and that their report on the subject were “alike in principle to that desired for Apollo.”
 - o This memo was confidential, along with everything else back in those days.

Battin got an original carbon copy of this memo; his thought was “we’re sending men to the moon, but we don’t even have a good method of copying things...” (i.e. no Xerox machines yet)

1962: decided to try to go to Venus, instead (fly-by). Would take less than 2 years, and would go out as far as Mars’ orbit, so you could actually fly by it, too, if you timed it

right for both planets' orbits. Right timing only occurred once every 6 years, though, so it wasn't practical.

1961 was the first year Battin taught "Astronautical Guidance" at MIT; three of the Apollo moon-walkers took this class – Buzz Aldrin, Dave Scott, and Ed Mitchell.

NASA Management triad: Webb (admin), Hugh Dryden (deputy admin) and Bob Seamans (assoc. admin, promoted to deputy after Dryden died in 1965)

Draper volunteered to be an astronaut, despite his age (60).

Apollo Guidance System

When asked how big the computer would be, the lab really didn't have a solid idea, but estimated a cubic foot. Later they wanted more room, but other aspects of the project had been planned around that estimate, so they were stuck! But they managed: the computer ended up at 0.97 cubic feet.

Core rope memory [illustration on slide]

Mars probe:

ROM: 8 kb

RAM: 0.5 kb

Speed: 24 microseconds

Apollo guidance and control – upgraded from the Mars computer a bit...

ROM: 74 kb

RAM: 4 kb

Speed: 12 microseconds

Cores were designed by the Inst. Lab, built by Raytheon (by the textile workers).

How many computers?

- one in the CM and the LM
- no in-flight repair
- no built-in redundancy
- no ground uplink
- many possible single-point failures
- BUT... quality control could not calculate MTBF (mean time between failures)
 - o The AGC never failed in any flight

Software:

- the Mariner 1 went off-course to Venus due to a software error: one missing minus sign. George Mueller framed and hung a minus sign over his desk to remind people how important perfection in the code was.

Mueller allowed companies to bid on fitting enough software into half the memory/space MIT proposed, and though a lot of companies would have wanted to take the job, at least one realized, and stated, that it was probably impossible to do any better. So, Inst. Lab kept the job.

Ground-based navigation: allowed NASA to get information from the spacecraft and make their own calculations and checks.

The Mars project plan involved being able to make measurements and corrections on-board; ground navigation would actually have been impossible, due to the margin of error about where Mars actually was.