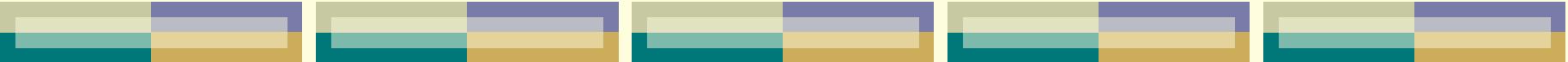




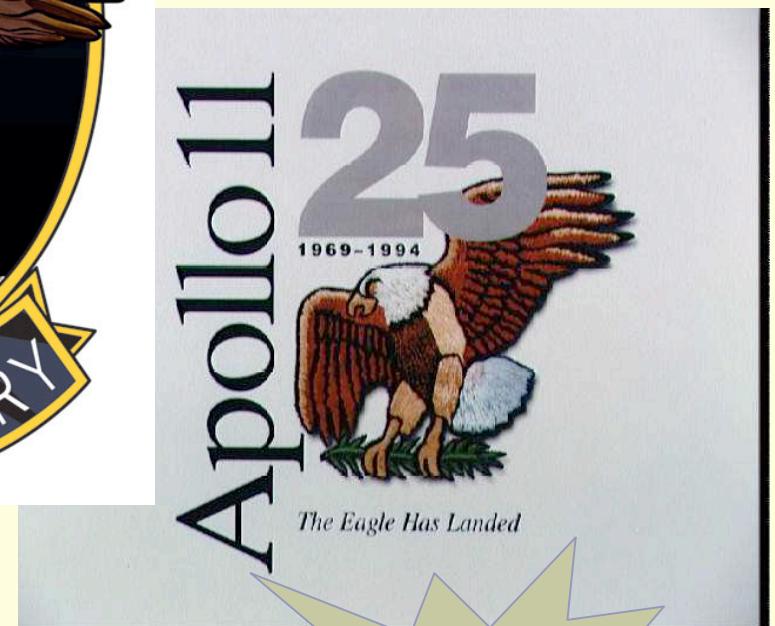
July 20, 1969

The day software bugs nearly
lost us the moon

July 20, 2004



This day, 35 years ago...



(of course, it never happened...)



Flag waving in vacuum



English writing on rocks



- Guidance office (GUIDO) Steve Bales and assistant Jack Garman scrambled to solve the problem.
- Garman recalls a similar incident in simulation only a week or so before.
- Tells Bales "It's executive overflow; if it does not occur again, we're fine."

28 secs

- Bales wants more time to assess
- There is none.
- Flight director Kranz glares at Bales, slamming his fist into the console.
- Bales made his first call: "Go" (loudly and emphatically!) **3 secs**

- Bales makes his second call: "go". Thereby winning the Presidential Medal of Freedom

And, of course, it very nearly didn't

- Computer alarms on descent; threat to landing abort
- Manual takeover at 1300 ft (90 secs of fuel)
- 4 miles downrange, boulder field
- Heart pounding (156 beats per minute) Armstrong landed with only seconds of fuel to spare.

102:38:26 Armstrong: Program Alarm. (6k ft agl)

102:38:30 Armstrong: It's a **1202**.

102:38:32 Aldrin: **1202**.

102:38:42 Armstrong (To Buzz) What is it? Let's incorporate (the landing radar data). (To Houston) Give us a reading on the **1202** Program Alarm.

102:38:53 Duke: Roger. We got you... (With urgency) We're Go on that alarm.

102:39:14 Aldrin: Same alarm.. appears to come up when we have a 16/68 up.

102:42:08 Duke: Roger. Copy.. Eagle, Houston. You're Go for landing. Over

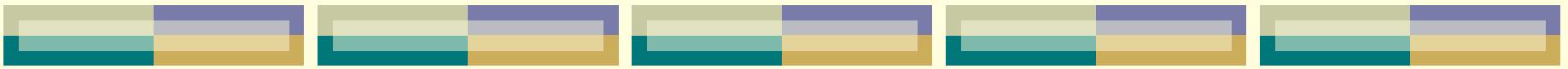
102:42:17 Aldrin: Roger. Understand. Go for landing. ... Program Alarm

102:42:22 Aldrin: **1201** (3k ft)

102:42:24 Armstrong: **1201!**

102:42:25 Duke: Roger. **1201** alarm. (Pause) We're Go. Same type. We're Go.

102:45:58 Armstrong Houston, Tranquility Base here. The Eagle has landed.



Flight director Kranz on Steve Bales:

- (Steve Bales is) one of the original computer nerds.
- I mean, he looks like one.
- He's got these big owlish-type plastic-rimmed glasses you got in there.
- I don't think any of them-they all look like they never needed to shave.
- I mean, they're baby-faced kind of people

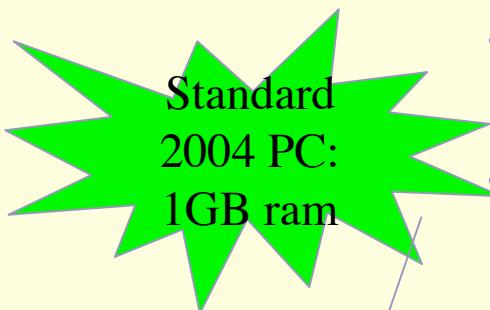


From Gene Kranz: “Failure is Not an Option”



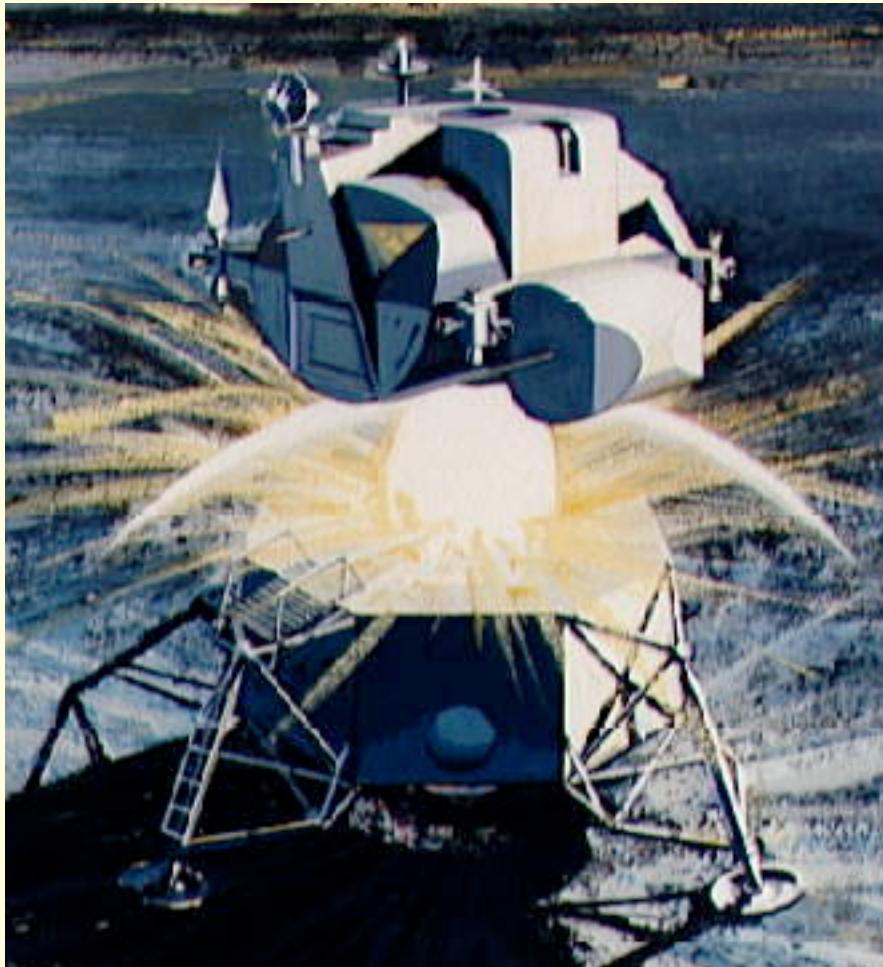
- Final simulation done prior to the launch,
 - Dave Scott and Jim Irwin in the LM simulator.
 - landing simulation was aborted - unnecessarily
 - because of a 1201 program alarm
- Kranz sent Bales off to work up rules for each type of alarm. Later that evening, Bales rings Kranz saying
 - “We should not have aborted (due to that guidance system error)”

Inside the Apollo Computers

- **LEM/CM** computer's had two types of memory:
 - fixed memory
 - programs, constants and landmarks
 - $36,864 \times 15$ bit words = 74KB (!!)
 - erasable memory,
 - variables/ registers used in calculations
 - 2,048 15-bit terms.
 - coincident-current ferrite cores woven into a rope with copper wires and sealed in plastic.
 - Real-time multi-tasking operating system.
 - Always processes the job with the highest priority before other, lower priority jobs
- Standard
2004 PC:
1GB ram
- 
- 
- 



What were the 1202/1201 alarms?



- M.I.T. Instrumentation Laboratory ("the Lab")
 - Built the Apollo Guidance and Navigation System;
- 10 seconds after "the eagle has landed",
 - NASA rang the lab
 - "What were those alarms?"
 - "We're launching in 24 hours and we're not going with alarms."
 - "We must have an operational computer!"

Massive Debugging at M.I.T.



- The bug: “cycle stealing”
- Overload of queue
 - computer not getting to certain computations,
- What was slowing things up?
 - I/O system keeps looking for data.
 - The Rendezvous Radar Switch was in the AUTO position and the computer was doing I/O looking for radar data.
- Error in the crew procedures
 - “Place rendezvous radar switch” to “AUTO” during descent WRONG!
- Why not seen found during simulation?
 - The switch was not connected to a real computer (procedures validation performed on functional simulation)
- Last message before lunar take-off
 - Glenn Lunney,(Flight Controller), calmly told the astronauts...
 - “Please put the Rendezvous Radar Switch in the Manual position”.

Lessons for SQA

- Bad software can kill good hardware (c.f. Ariane V)
- Manuals matter (c.f. Soho)
- Test what you fly (and nothing else)
- Do your criticality analysis right
 - For descent, rendezvous radar was apparently not-critical
 - Rendezvous radar used post ascent, not descent
 - Also, even if it failed on ascent, then just launch to lunar orbit and let CM's systems do the docking.





One footprint is lonely...

