Boots on the Moon and Beyond ... A Practical Look at What We Need
Disclaimer ...

I am just a computer, software, systems engineer … and cannot presume to suggest I know everything that is needed

But can we spend the next 20 – 30 minutes critically thinking about how we continue providing valuable solutions to NASA as we endeavor to reach for greater heights
Easy First Step in This Discussion …

2015 NASA Technology Roadmaps

Roadmaps summarize technologies that NASA could develop

Guidance for investment in technology research and development across NASA

Mission Directorate and Office Programs implement the Technology Portfolio
First Step in Discussion … Yields

Developing the skills and capabilities of next generation workforce

The engineer in me says if my organization focused on this framework then it will be easy to be seen as a valuable asset to the Agency

Developing technologies, science solutions

Students / Faculty

Technology / Knowledge
So I will Start Implementing This Logic

Technology Roadmaps
Identify my organization’s competencies, what we have, what we want to develop, etc..

Maybe

• Power generation, energy storage
• Autonomous Rendezvous and Docking
• Engineered Materials and Structures
• Etc …

Refinement

Investment Portfolio
I know the areas NASA is going to be spending money

NASA Programs
I will establish working relations so that my students, faculty, solutions continue to be visible (in addition to my Space Grant Consortium)

• Mission solutions being advanced for missions
• Sciences advancing knowledge as well as mission capabilities
• Next generation workforce

Value
But Wait …

… Something else to Stress!

... 03:00:00

... Something else to Stress!
Consider Apollo Moon Landing

• Shortly after noon on July 20, 1969
  • About 70 miles above lunar surface
  • Armstrong and Aldrin detach lunar lander from command module … where Collins watched
• Apollo Guidance Computer
  • Most sophisticated 70 pound device humanity had yet conceived
  • Aldrin, using numeric keypad, would punch in 2-digit commands he had memorized
  • Guidance computer would respond on 3 small panels with 5-digit codes that he knew how to interpret

• First Stage of Descent
  • Computer put lander in an elliptical orbit, Aldrin punched in new program which dropped the lander from an orbit to a contact course with lunar surface
  • Around 46,000 feet, to account for moon’s irregularities in its gravity, acquire new measurements from landing radar
    • Aldrin punched in new codes to compare lander’s calculated position with reading from landing radar
    • Guidance computer crashed!
Guidance officer (GUIDO) Steve Bales and assistant Jack Garman scramble to solve the problem. Garman recalls a similar incident in simulation only a week before. Tells Bales “It’s executive overflow; if it does not occur again, we’re fine.”

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!)

Bales makes his second call: “go”.
Thereby winning the Presidential Medal of Freedom

• Computer alarms on descent → threat to abort landing OR worse
• Less than ~100 feet “abort” impossible and would trigger
  • Hard crash landing – crew dies
  • Not so hard landing – crew survives … BUT
    • Stranded on Lunar surface → Mission Control bids farewell and cuts communication → Collins would translate for Earth rendezvous

102:38:26 Armstrong: Program Alarm. (6k ft agl)
102:38:30 Armstrong: It’s a 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.
102:42:22 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.

Less than ~100 feet an “abort” command was not possible

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

- Overload of queue on the computer ("cycle stealing")
  - Computer not getting to certain computations
  - 1202 meant computer has managed to save nav data before resetting
  - Resulting in “GO” scenario from Houston

- 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 (NOT LANDING RADAR the Rendezvous Radar)

- 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

- Last message before lunar take-off
  - Glenn Lunney, (Flight Controller), calmly told the astronauts…
  - “Please put the Rendezvous Radar Switch in the Manual position"
Good Story … But Here is the Point I want to Stress

• Astronauts train tirelessly … we build our systems as robust and reliable as we possibly can→ all possible errors can’t be tested
  • For Apollo it required a “GO” command or “Abort” command from Houston

• Focus directions towards …
  • Technology that can adapt, think for itself, repair itself … relative to the technology roadmap
  • Develop next generation of systems engineers
  • How can we gain assurance these technologies can accomplish the mission
    • Next cubesat or ThinSat mission … fly an artificial intelligence payload