2019 Mid-Atlantic Space Grant Consortia Meeting

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

Marcus Fisher
NASA GSFC Code 180

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

ission Directorate / Office	Program
	Advanced Exploration Systems
	Human Research Program
uman Exploration nd Operations ission Directorate	International Space Station
	Orion Spacecraft
	Space Biological and Physical Research Program
	Space Communications and Navigation Program
	Space Launch System Program
	Advanced Component Technology
	Advanced Information Systems Technology
	Astrophysics Research and Analysis Program (A
	Heliophysics - Technology and Instrument Devel
	Homesteader (Europa Technology)
	In-Space Validation of Earth Science Technologi
	Instrument Incubator
cience Mission irectorate	Mars Technology
	Maturation of Instruments for Solar System Explo
	Nancy Grace Roman Technology Fellowships
	Planetary Instrument Concepts for the Advancem
	Planetary Science and Technology Through Ana
	Radioisotope Power Systems Technologies
	Strategic Astrophysics Technology
	Studies / Advanced Technology Initiatives
	Centennial Challenges Program
	Center Innovation Fund Program
	Flight Opportunities Program
pace Technology ission Directorate	Game Changing Development Program
	NASA Innovative Advanced Concepts Program
	Small Business Innovation Research / Small Bus
	Small Spacecraft Technology Program
	Space Technology Research Grants Program
	Technology Demonstration Missions Program
	Advanced Air Vehicles Program
eronautics Research ission Directorate	Airspace Operations and Safety Program
	Integrated Aviation Systems Program
	Transformative Aeronautics Concepts Program
ffice of Safety and ission Assurance	Nondestructive Evaluation Program
ffice of the Chief nformation Officer	IT Innovation Challenge Series

Mission Directorate and Office Programs implement the Technology Portfolio

First Step in Discussion … Yields

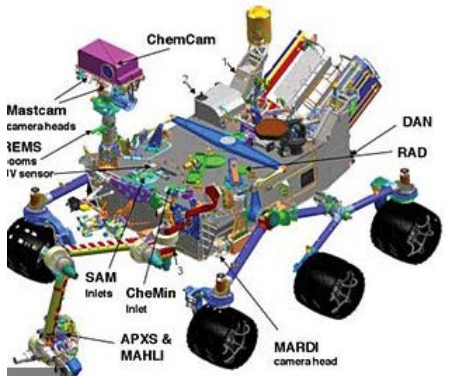
Developing the skills and capabilities of next generation workforce

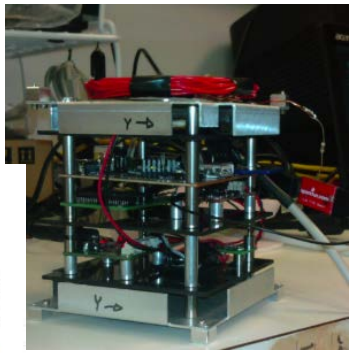
Students / Faculty

Developing technologies, science solutions

Technology / Knowledge

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





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)

Value

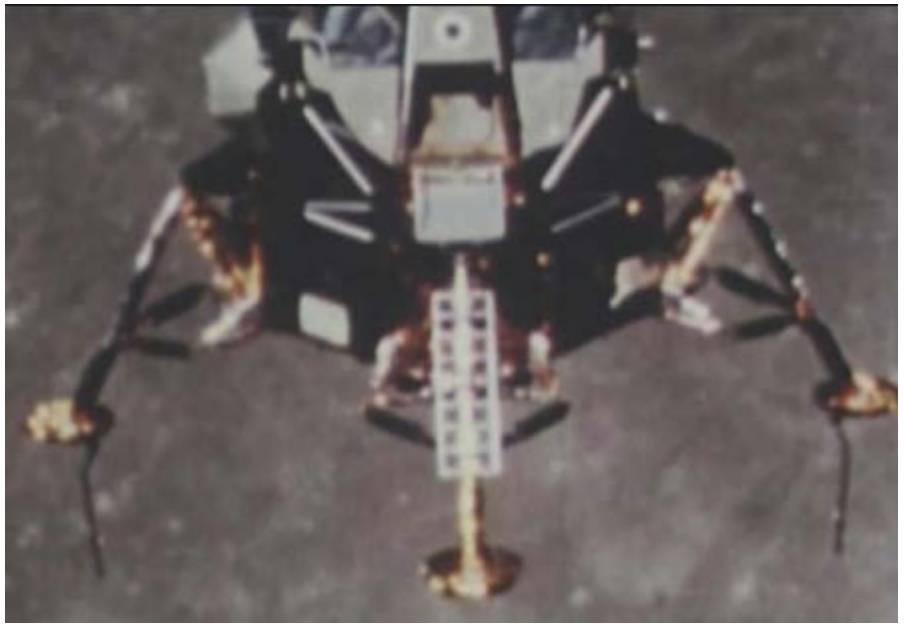
- Mission solutions being advanced for missions
- Sciences advancing knowledge as well as mission capabilities
- Next generation workforce

But Wait …

… 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."

- 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*.

102:38:32 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.

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!)

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)

Less than ~100 feet an "abort" command was not possible

Bales makes his second call: "go".

Thereby winning the Presidential Medal of Freedom

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.

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
  - **<u>For Apollo it required a "GO" command or "Abort" command from Houston</u>**

- 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