Agile: From Software to Mission System

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MOS & GDS

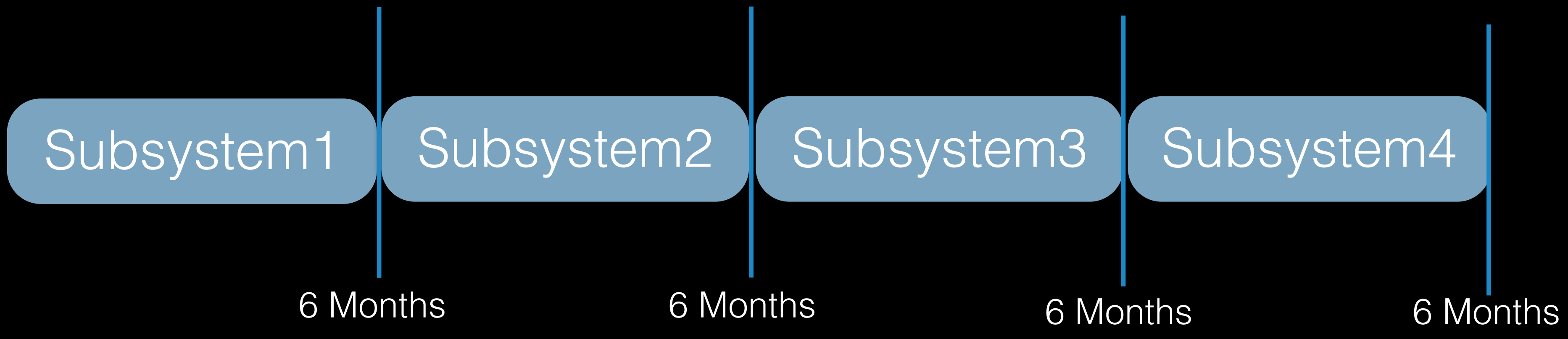
- Mission Operations System (MOS)
  - People, Team(s), Products, Processes
- Ground Data System (GDS)
  - Software, hardware, facilities
- Mission System = MOS + GDS

Waterfall to Agile for Software

- We began the journey to agile design and development with software

In the Beginning (Software)

- Delivery every 6 months
- The 6 month delivery cycle created too much time for customer expectations to diverge from what we were building
    - Customers needed to see the product more frequently
- Progress difficult to measure
- Long and formal design specs
    - Too much time talking, not enough time doing



Subsystem1 Subsystem2 Subsystem3 Subsystem4

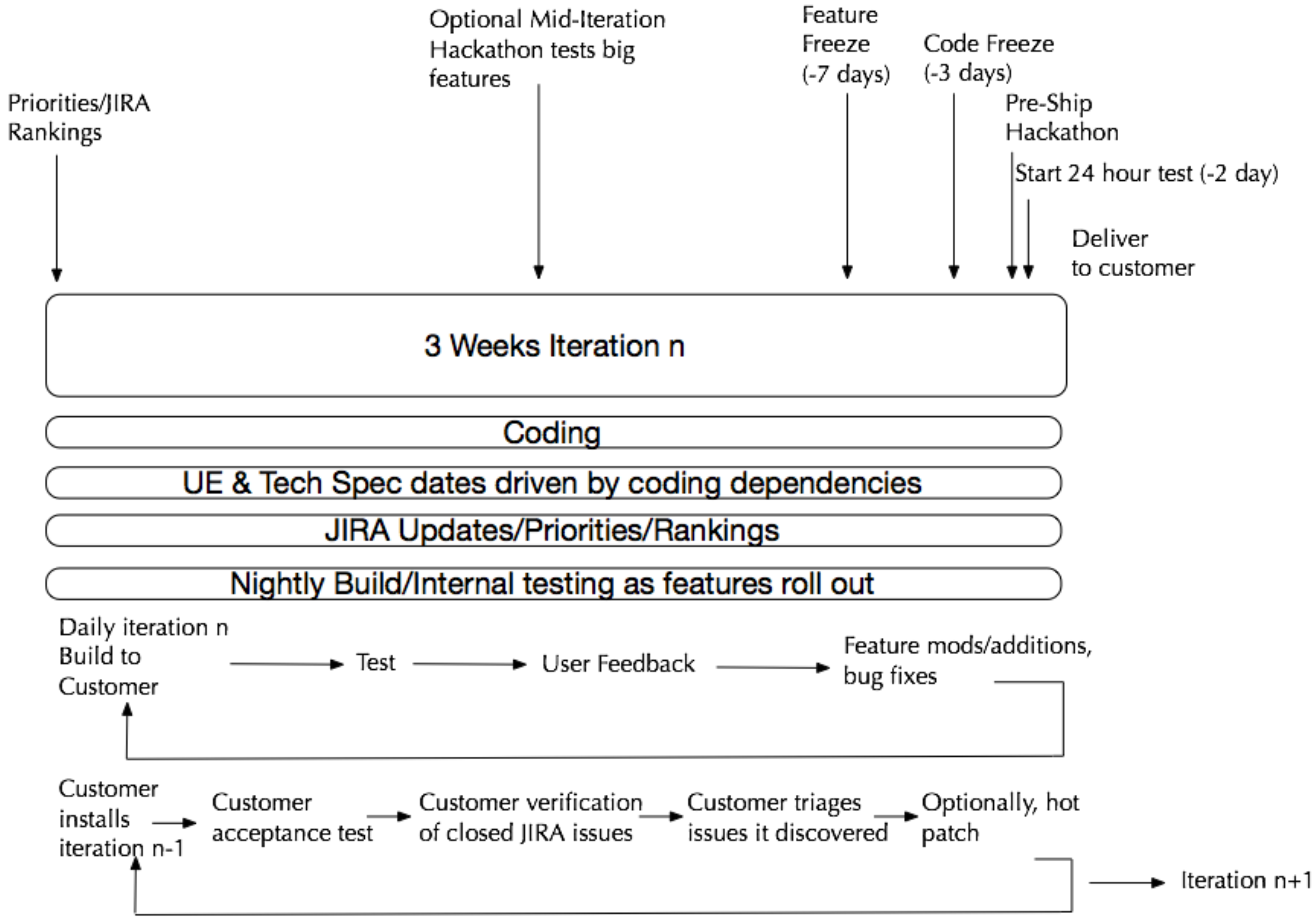
6 Months 6 Months 6 Months 6 Months

Time for Changes

- Fix the problems iteratively, without a broad proclamation of methodology, i.e. “we are going to be agile” or “we are going to be “lean”

Agile Sprint

- Agile Tailored for our team
- Deliver to customer every 3 weeks
- Nightly build
- Release every 3 months
- Emphasis on constant interaction and use



Priorities/JIRA Rankings

Optional Mid-Iteration Hackathon tests big features

Feature Freeze (-7 days)

Code Freeze (-3 days)

Pre-Ship Hackathon

Start 24 hour test (-2 day)

Deliver to customer

3 Weeks Iteration n

Coding

UE & Tech Spec dates driven by coding dependencies

JIRA Updates/Priorities/Rankings

Nightly Build/Internal testing as features roll out

Daily iteration n Build to Customer → Test → User Feedback → Feature mods/additions, bug fixes

Customer installs iteration n-1 → Customer acceptance test → Customer verification of closed JIRA issues → Customer triages issues it discovered → Optionally, hot patch

→ Iteration n+1

Key attributes of our tailored agile process for software

- The measure of progress is working code
- Rank issues, always focus on the highest priorities
- Demonstrations, not presentations
- Customer interaction over extensive requirements meetings (some meetings still required)
- Visible progress - nightly or continuous builds
- Ship on time, features that are not ready go into the next sprint or release
- Verification using both QA and customer use in context

Agile for MOS

- NASA “standard” process definition is waterfall
  - It’s proven, it works
- Why change a proven process?
  - Potential gains in effectiveness, efficiency
  - Team engagement, culture of doing
  - Cost reductions

Tailored Agile

- For MOS
  - Simulation for Design
  - Assessment of capability through demonstration
  - Early and frequent builds and tests
  - Risk reduction through targeted experiments
  - Maturation of tools and processes through frequent use

- For Software
  - The measure of progress is working code
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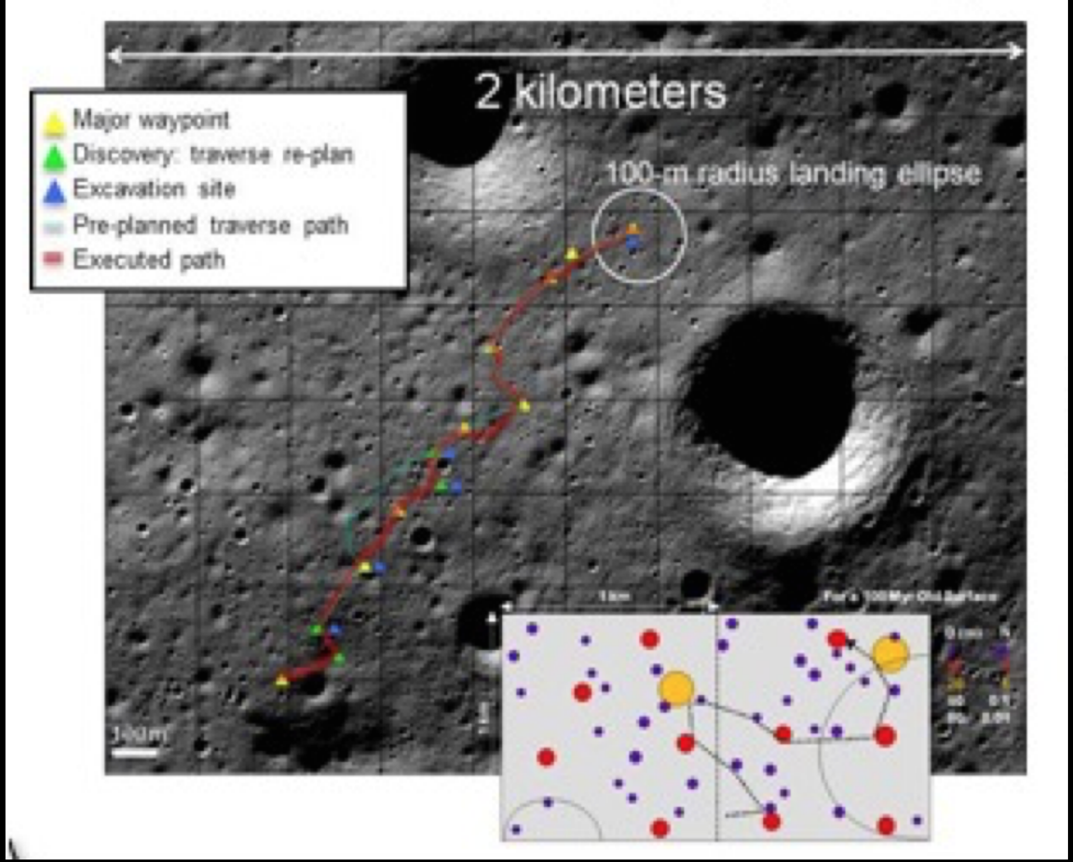
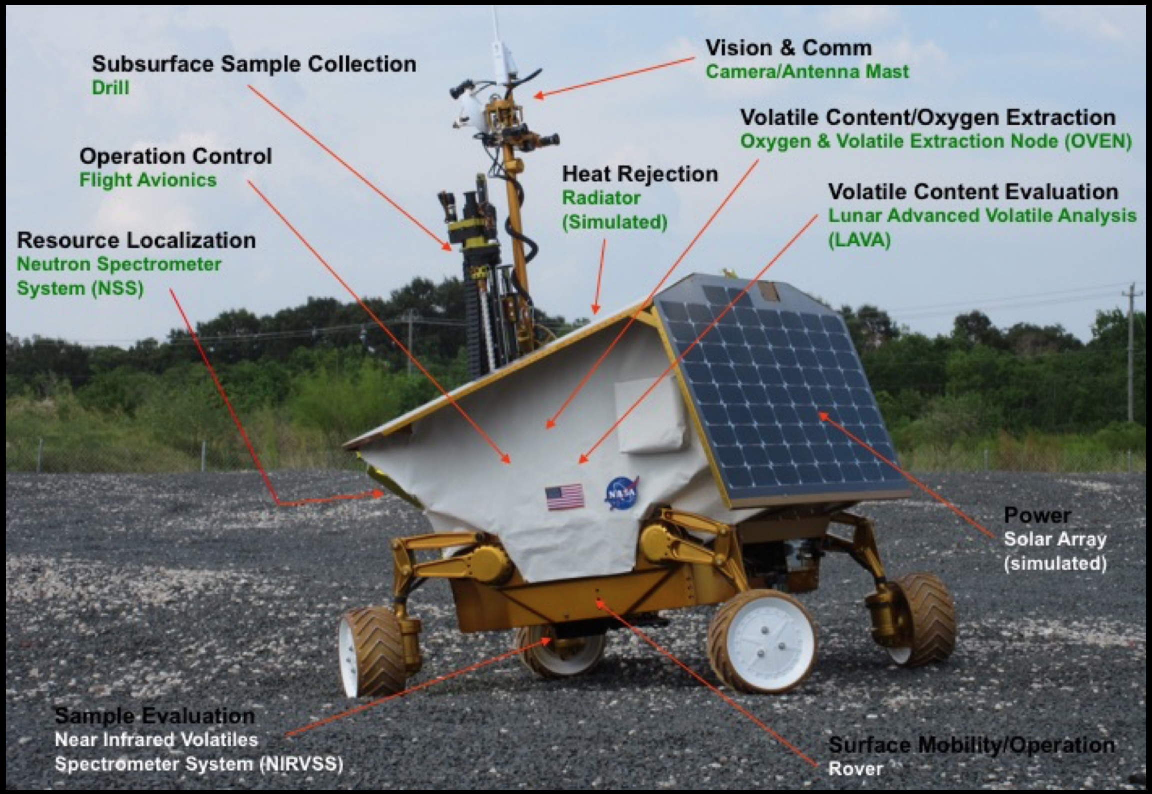
Agile Applied: Resource Prospector MOS

- The Mission
  - Lunar Rover
  - Search for volatiles at a polar region
  - Launch 2021?
  - For now, using agile methods on
    - New design
    - Where it increases effectiveness


2 kilometers
▲ Major waypoint
▲ Discovery: traverse re-plan
▲ Excavation site
Pre-planned traverse path
Executed path
100-m radius landing ellipse
1km
100m



Resource Prospector Ops

- Lunar surface operations, round trip light time + comm latency = 6 - 30 seconds
- Short duration surface mission 5 - 7 days
- Fully distributed operations, including core teams, everyone operates from home institution
- Lighting, power constraints
- Operation in shadowed regions, no light for a billion years, rover is solar powered
- Continuous comm requirement
- Class D Mission

Agile Applied on RP

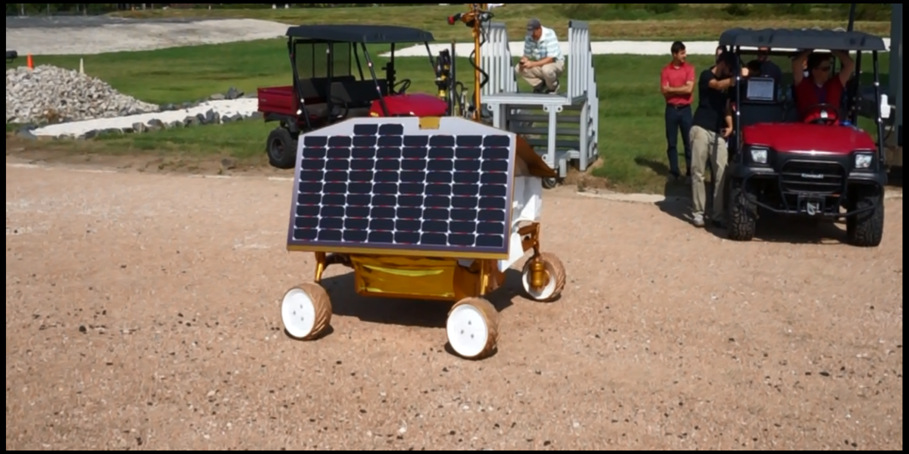
- 2015 Distributed Operations Test (DOT)
- Traditional design approach
    - Write a document (s)
    - Present, discuss, review
    - Train the team and test the design in simulations, late in the mission development flow
- Agile approach
    - Write a simple document
    - Conduct a series of simulations, for design, not training (though the team was trained in processes and procedures), early in the flow
    - Test and iteratively improve the concept of operations by trying it

Distributed Operations Test

- Simulation for Design
- Assessment of capability through demonstration
- Maturation of tools and processes through use
- Early and frequent builds and tests

California

Florida



Texas

DOT

- Test/ Validate
  - Distributed decision making
  - Distributed command and data flow
  - Integrated situational awareness tools/integration into flight and ground system processes
  - Integrated ground/flight system test procedures
  - Team composition and roles
  - Waypoint driving

- What we did
- Multiple simulations culminating in the Distributed Operations Test (DOT)
  - Three day DOT
- Iterative refinement to procedures and processes
- Mission operations teams using prototype tools
- Distributed teams
  - Mission Team, science, rover drivers in California, rover hardware, rover systems in Texas, payload in Florida, drill in Southern California

What was Agile about DOT?

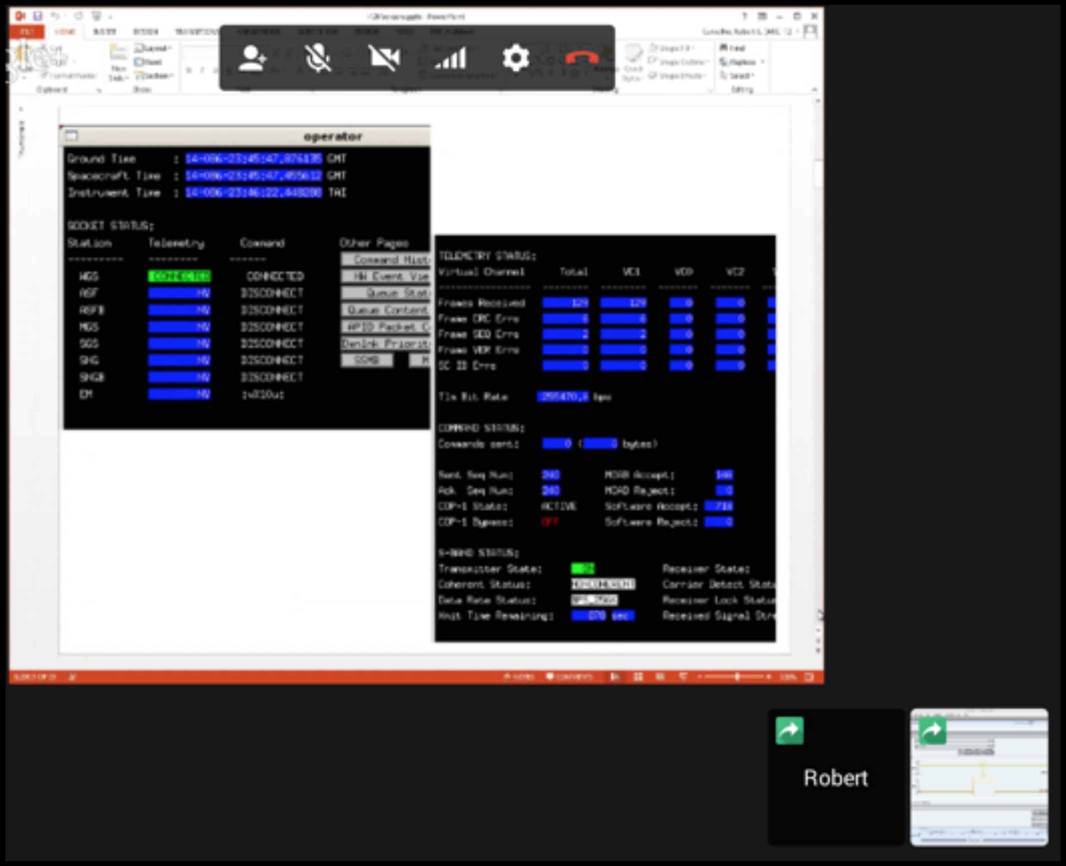
- ✓Simulation for Design
- ✓Assessment of capability through demonstration
- ✓Early and frequent builds and tests
- ✓Risk reduction through targeted experiments
- ✓Maturation of tools and processes through frequent use

- How we used the information
  - GDS architecture improvements for robustness and reliability
  - Updates to team composition and roles
  - Updated requirements
  - Update software designs

Agile Example: Procedures

- “Say it then sim it”
- We wrote procedures, conducted a brief review then tried them
- Develop procedures by trying them out
- User paper simulations to fill in what’s not there yet

Procedures Sim/Walk Through



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operator
Ground Time      : 14-086-23:45:47.876138 GMT
Spacecraft Time  : 14-086-23:45:47.455612 GMT
Instrument Time  : 14-086-23:46:22.448288 TAI

SOCKET STATUS:
Station    Telemetry    Command       Other Pages
WGS        CONNECTED    CONNECTED
ASF               NV    DISCONNECT
ASFB              NV    DISCONNECT
MGS               NV    DISCONNECT
SGS               NV    DISCONNECT
SNG               NV    DISCONNECT
SNGB              NV    DISCONNECT
EM                NV    :v010u:

TELEMETRY STATUS:
Virtual Channel    Total    VC1    VC0    VC2
Frames Received      129    129      0      0
Frame CRC Errs
Frame SEQ Errs         2      2      0      0
Frame VER Errs         0      0      0      0
SC ID Errs             0      0      0      0

Tlm Bit Rate  255470.8 bps

COMMAND STATUS:
Commands sent:   0 (   0 bytes)

Sent Seq Num:  240      MCAR Accept:
Ack  Seq Num:  240      MCAD Reject:      0
COP-1 State:   ACTIVE   Software Accept:
COP-1 Bypass:  OFF      Software Reject:  0

S-BAND STATUS:
Transmitter State:                Receiver State:
Coherent Status:                  Carrier Detect State
Data Rate Status:                 Receiver Lock Status
Wait Time Remaining:  070 sec     Received Signal Str
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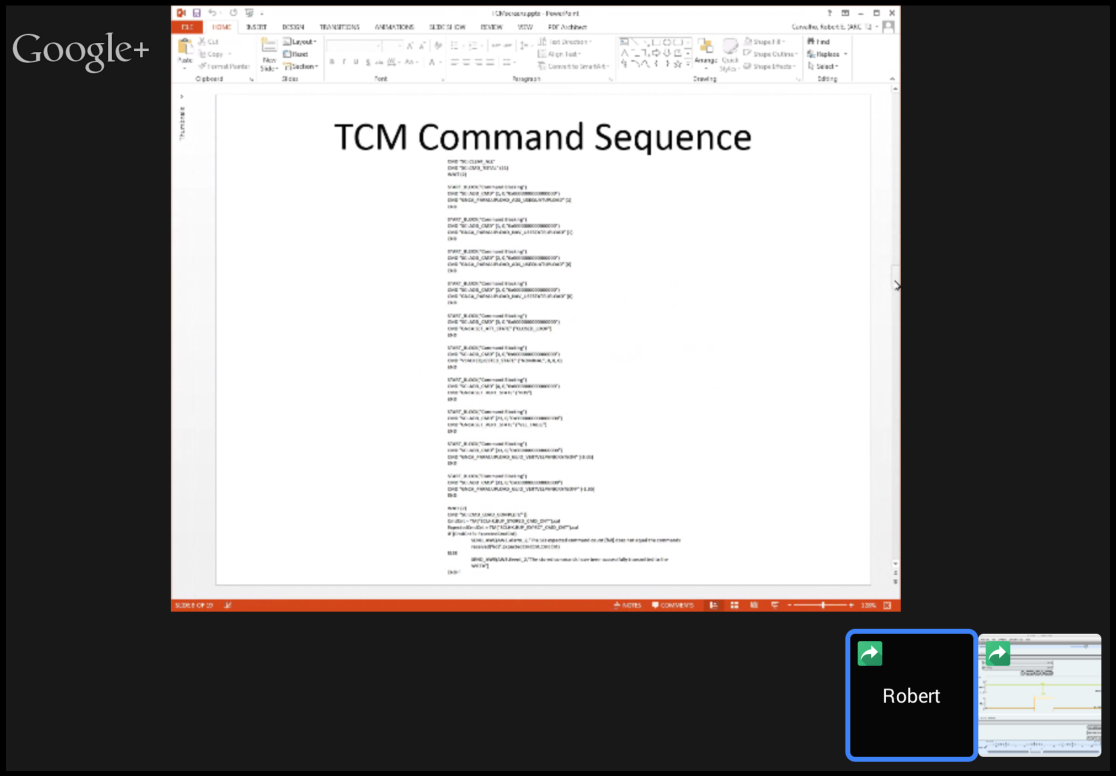
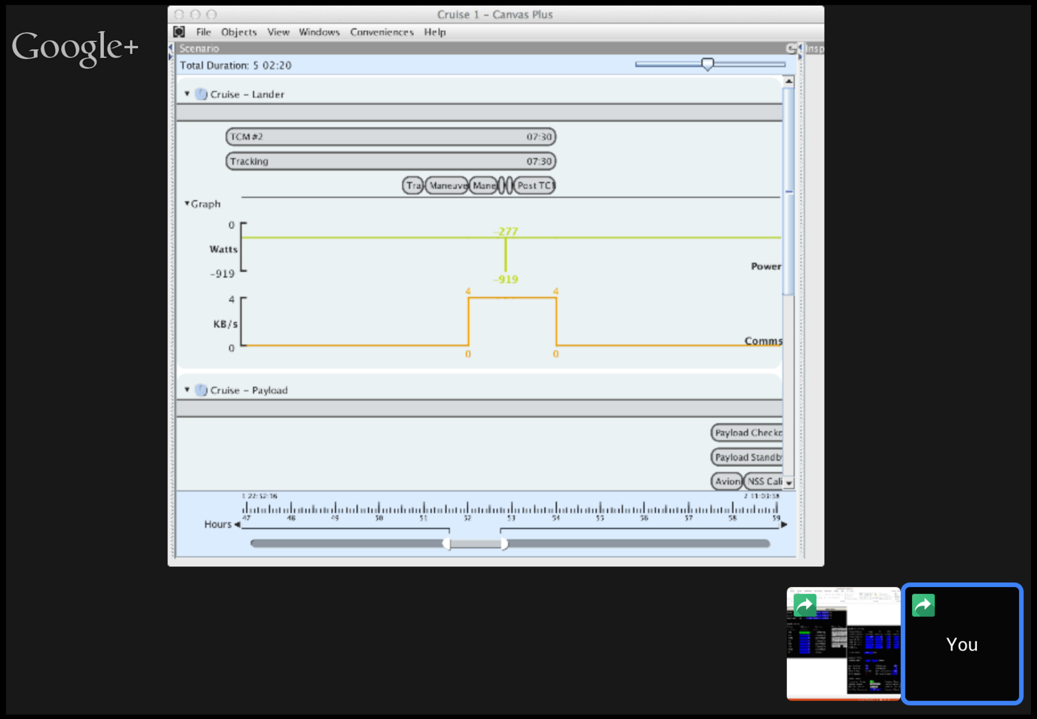
- Procedure Sim
- Google Hangouts to connect NASA centers
- Mix of paper and prototype software



TCM Command Sequence



Cruise 1 – Canvas Plus

Total Duration: 5 02:20

An Agile MOS requires an Agile GDS

- DevOps
  - Medium to high fidelity simulations require parts of the GDS
  - Updating GDS across multiple locations
  - Prototype system for near-continuous integration, testing and deployment
    - Kickstart, Ansible, Docker
  - Rapid deployments, containers

Challenges

- Are low fidelity simulations beneficial?
- High fidelity simulations may be complex and labor intensive to set up
  - Focus on flight forward work, don’t put extensive effort into simulation work that is not flight forward
- Difficult to sim frequently

Conclusions

- Ideal - fly early and often
- If we can’t fly as often as we want
  - Focus on doing
  - Say it, then sim it
- After an issue is articulated in a meeting, instead of ongoing meetings, say it, then sim it

Conclusion

- Team culture can be shifted from a culture of meetings and documents to a culture of doing