A Vision for Future Software

Open Source and Design Thinking at NASA

Jay Trimble
NASA Ames Research Center

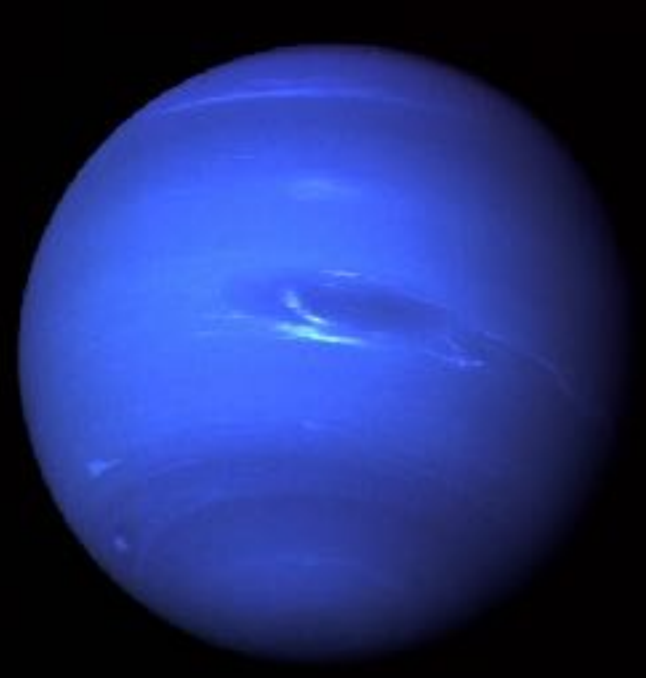
Frontiers 2017

Personal Milestones

1960's

1981

NASA JSC Intern



1989

Science Ops
Voyager Neptune

1994

Lead Ops Director
Space Radar Lab 1

Now

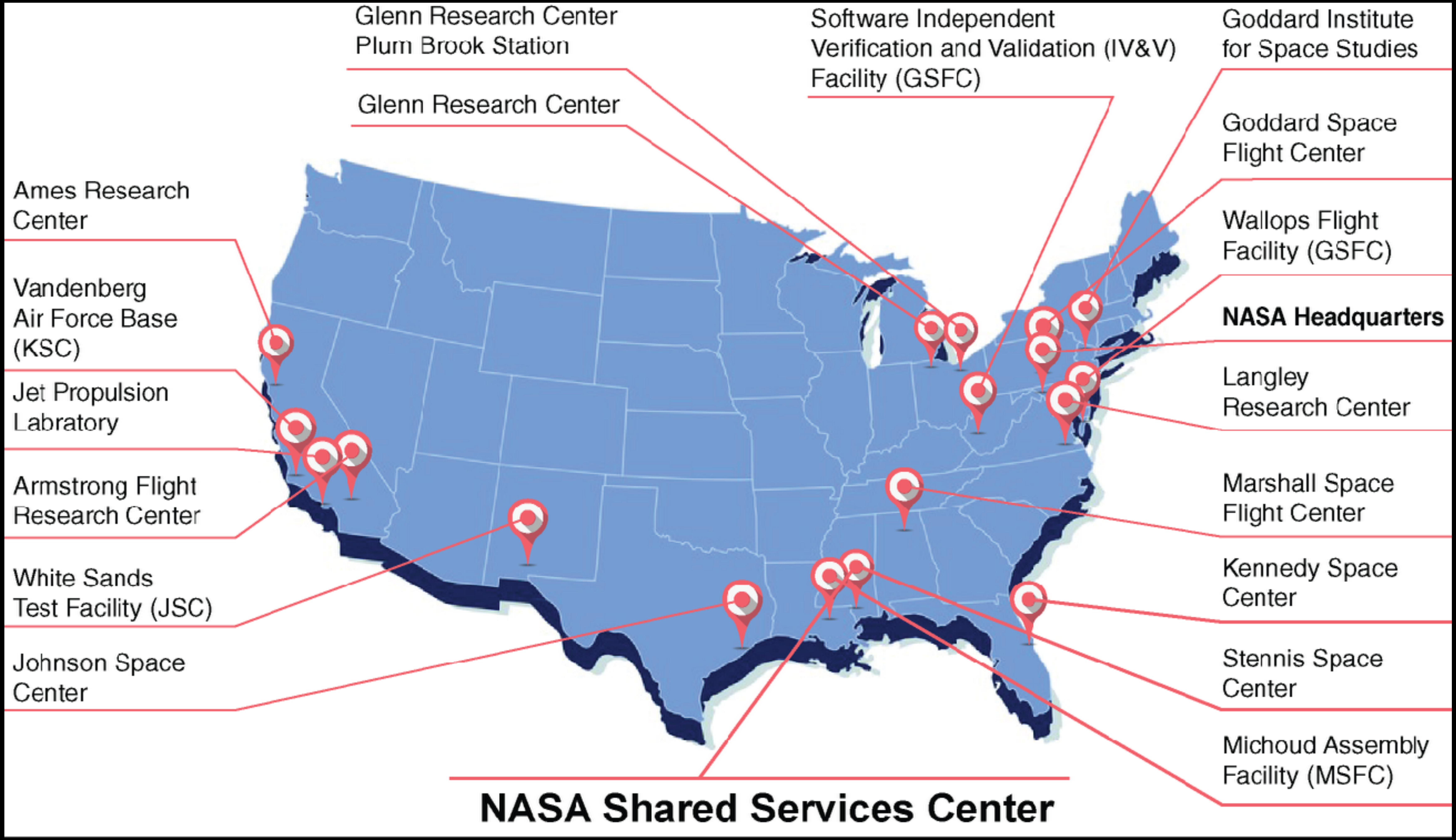
Lunar Rover MOM

NASA Johnson Space Center

NASA Jet Propulsion Laboratory

NASA Ames Research Center

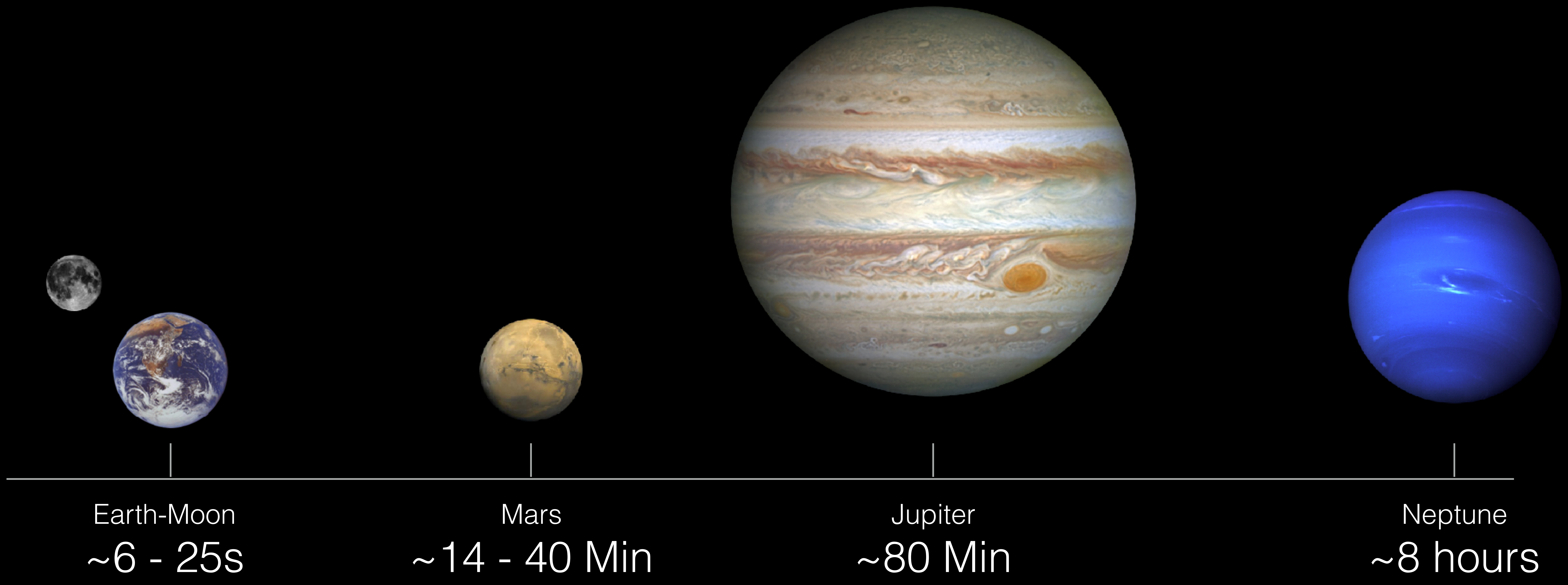
NASA Centers



Mission Control: The Icon

Mission Control for Mars Rovers

The Light Speed Constraint



Mission Control v. Star Trek

- NASA
  - Flight Director
  - Systems
  - Trajectory
  - Payloads/POCC
  - INCO

- Star Trek
  - Captain (Kirk, Janeway, Picard, Cisco,…)
  - Engineering (Mr. Scott)
  - Navigation (Chekov)
  - Science Officer (Spock)
  - Communications (Uhura)

Mission Control Famous Calls

Mission Control Famous Calls

Mission Control Famous Calls

Houston Mid-1980's

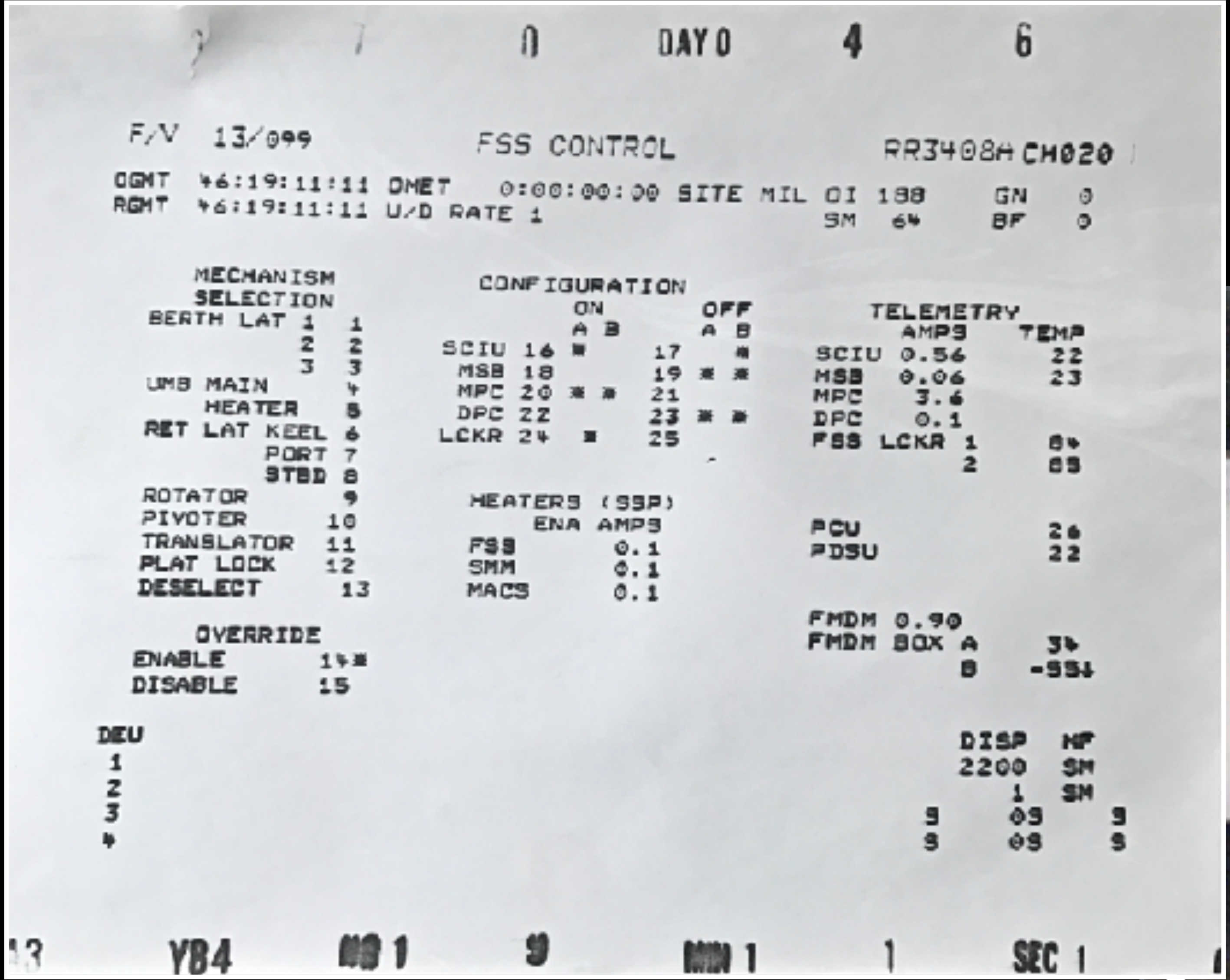
The Mission

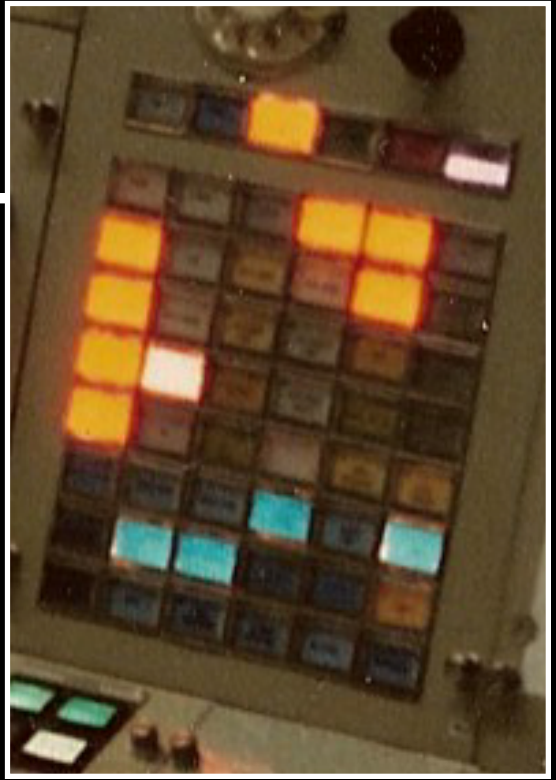
Repair a malfunctioning satellite

In orbit capture and repair has not been done

It's made possible by the Space Shuttle

The First Epiphany





Evolution

Pasadena Early 1990's

The Mission

Earth Observations Using
Synthetic Aperture Radar

Two missions on Space
Shuttle Endeavor

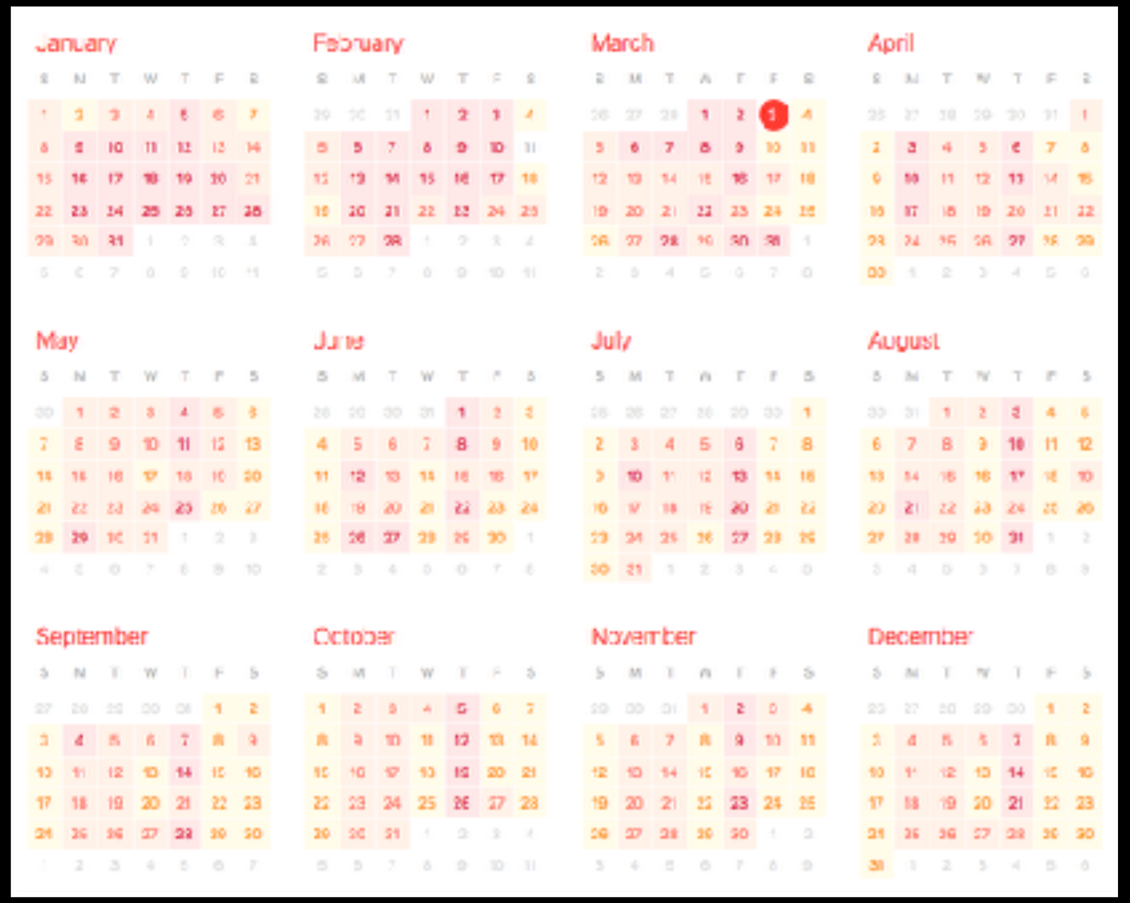
The Second Epiphany

Write software requirements

Customer signs requirements

Expectations and mental models diverge

MOS shall track the orientation of the solar panels with respect to Sun (+/- TBR arcmin)



Expectations Meet Reality

About to get a look → Users see the software → Why this reaction?

There must be a better way

Follow the (as yet undefined for us) road to user centered agile or, take a long vacation

Early 2000's Mars Rover Ops

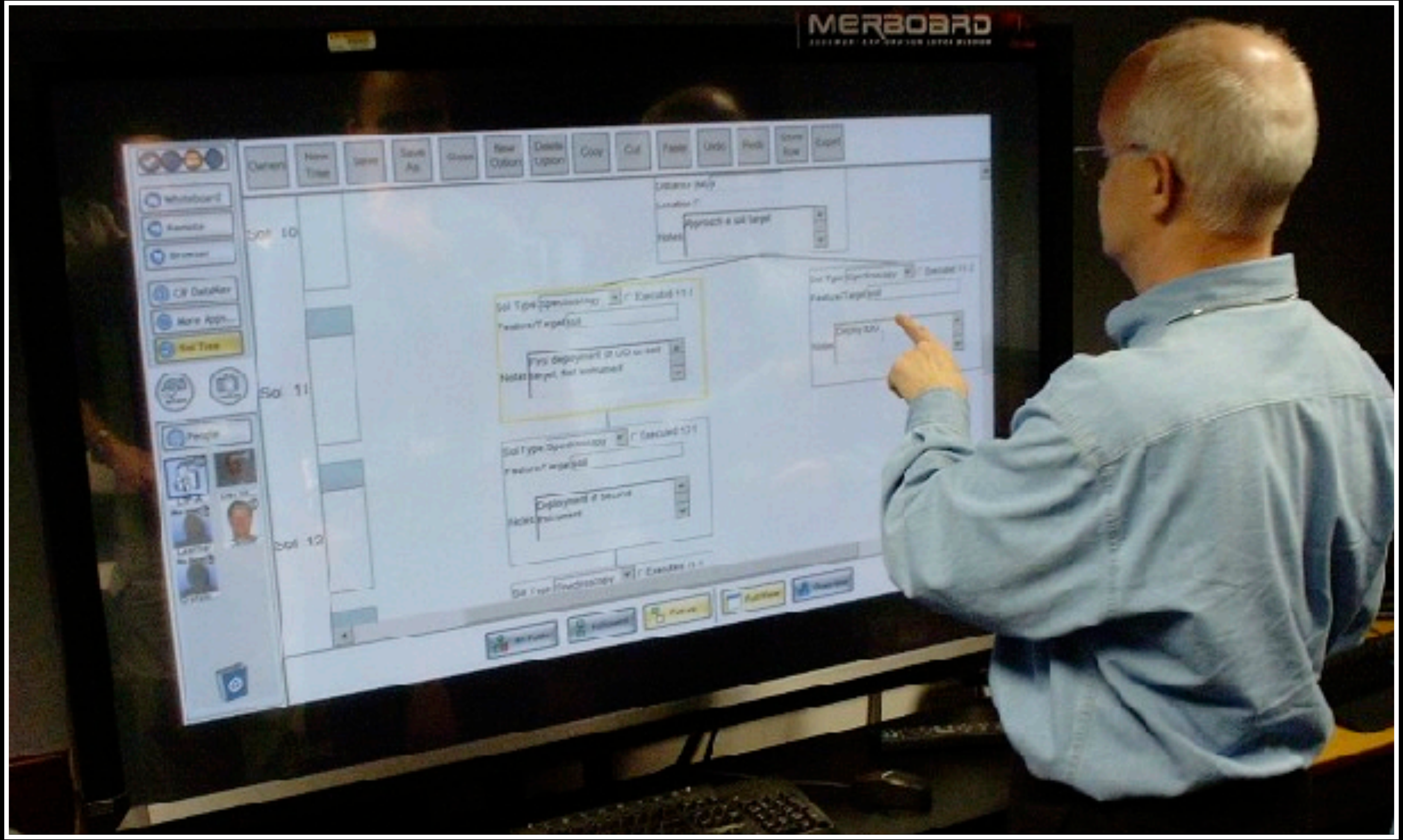
The Mission

Mars Exploration Rovers (JPL)

Human Centered Computing (ARC)

We proposed methods, not specific solutions or tools

We called it Human Centered Computing, inspired by Don Norman, The Invisible Computer

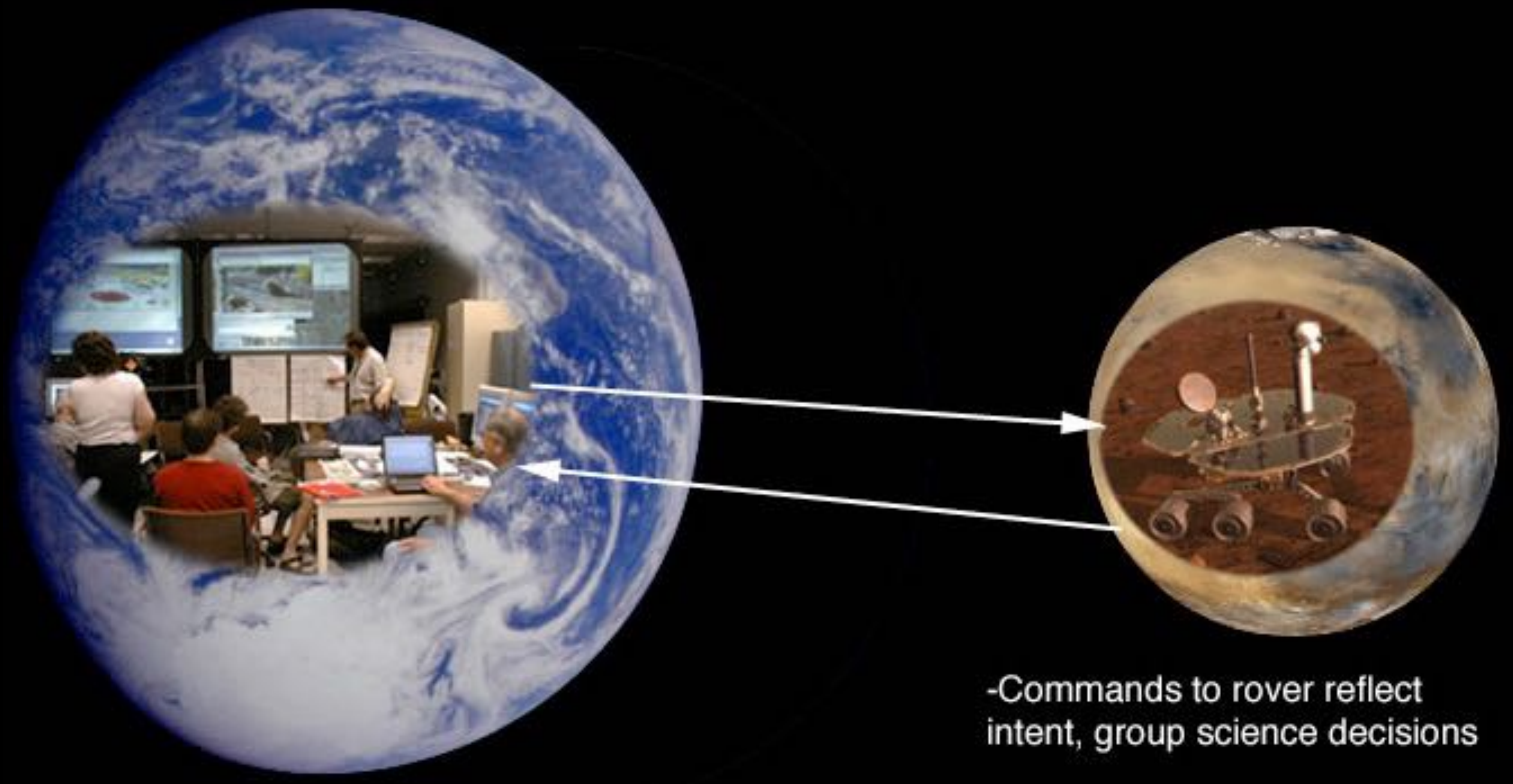


Mars Exploration Rover Scenario

Users on Earth

Rover on Mars

Max round trip light time ~40 min



-Commands to rover reflect intent, group science decisions

-Human Science Team with Computer tools
-Intent, Qualitative Assessment, Judgement,
-Science Priorities, Resource Management

Acceptance

To fund MER HCC, we had to “sell” the ideas to our funders at NASA Ames, to the Mars Exploration Rover Project at JPL and to the users

We focused on outcomes and touched on the methods using analogies

Easier to market an artifact or a result than an idea

Mental model example - Ethnography = User observations - what people say and what they do are often different. How often do you exercise?

Goals - Mission productivity, communications, safety

Note no mention of design thinking, this is 2000

Key Lessons so far

This is a small community and most people know each other

Each mission is it’s own community, somewhat like the cast in a performance

Speak the stakeholders language

Be careful with generalizations like “the invisible computer” or software that adapts to users rather than the other way around

Most of the stakeholders care only about what your product or method does for their mission

Most of users don’t care about design, but they may care about the results

Users who are used to a way of doing things, even an inefficient way, will resist change. Don’t give them change unless it adds significant value.

Don’t go against established conventions, no change for changes sake, use established, mental models

Do not try to take away existing tools. Give them new tools in shadow mode.

Be careful about getting too excited about your cool new technology

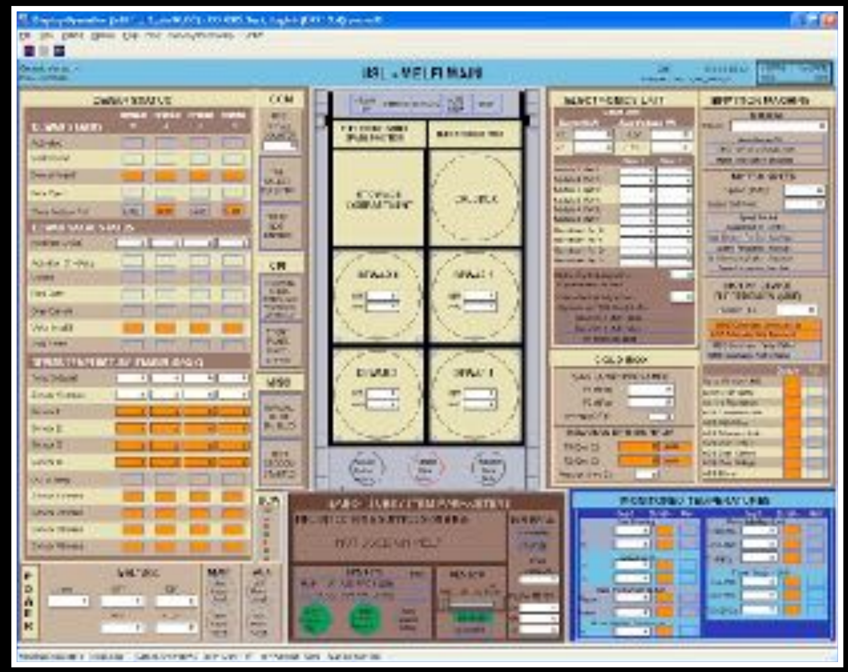
Next

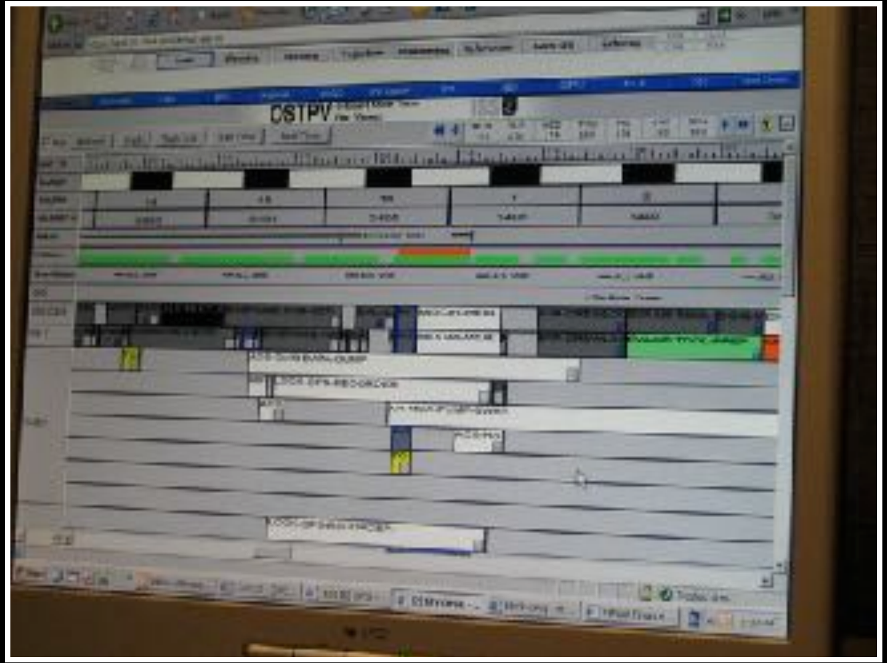
We now believe we need new technology, not just methods and process

So we embark on a new course and instead of proposing methods we propose tools…

We are trying to "fix"

Multiple heterogeneous applications create walls, turning users into integrators





The Selling Points

Decrease Cost

Save on maintenance by retiring existing applications, make the users productive

Empower the users

Compose your own displays without programming, all your stuff in one place

Top Down v. Bottom Up

The top provides the funding

The Bottom provides the advocacy (remember this is a small community)

The problem that we could not see yet

The management funded the project based on the retirement of existing applications

Users are open to new technology but less so when they are told that they are going to lose the current capability on which they depend

Participatory Design

Designers facilitate design process, users are domain experts

We used The Bridge Method

Built a shared language

Built shared mental modes

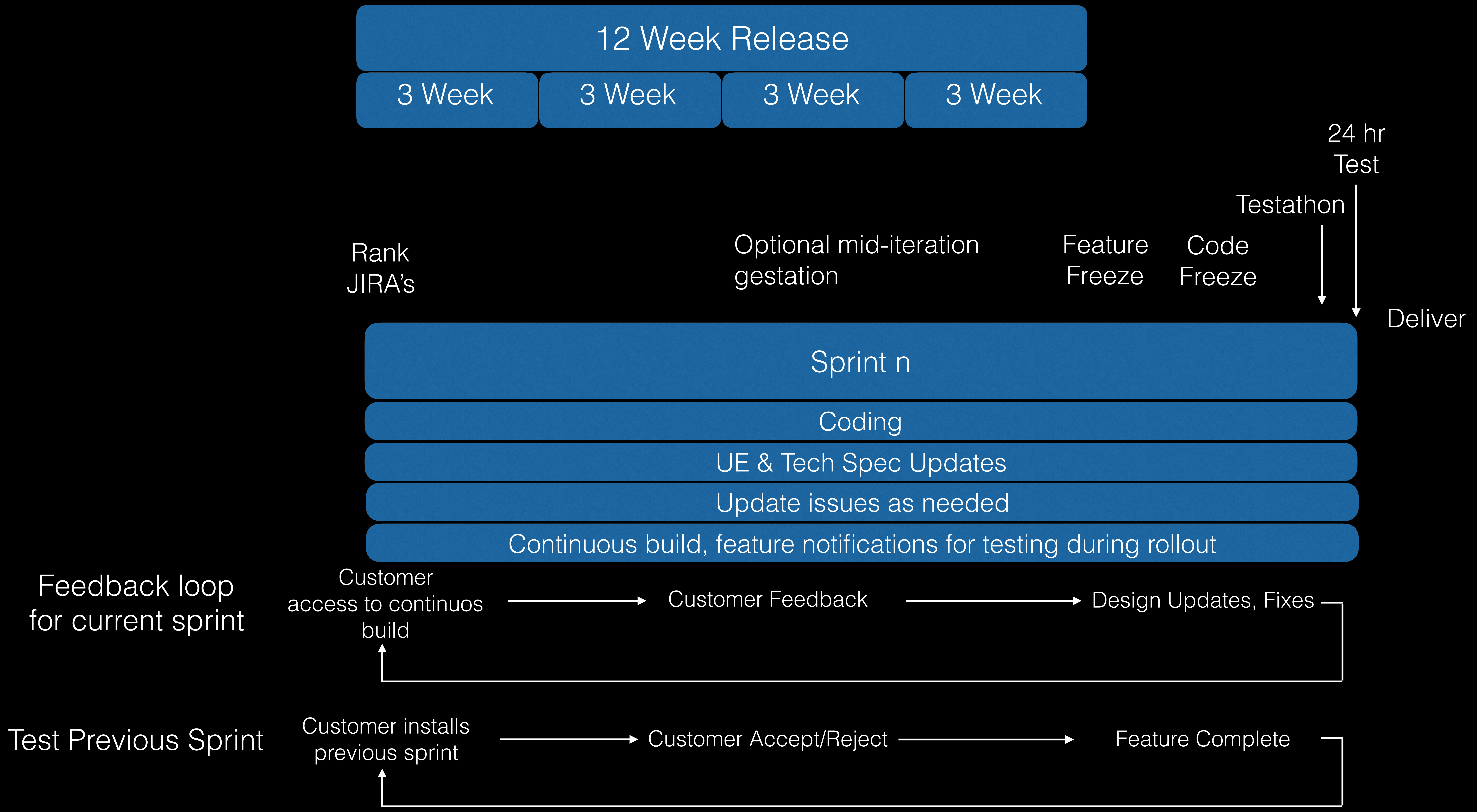
Enabled us to design solutions with users

Created a tight bond between the design team and participatory users

Shared ownership

Created an us v. them between the participatory team and the larger user community

Agile User Centered Design



Did we help the users?

Process steps

What actions does it take to build and test a display?

60% reduction in steps

80% reduction in manual entry

Manual data entry is the primary source of errors / risk

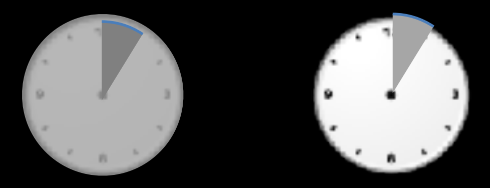
	Legacy	MCT
Steps	20	8
Manual data entries	5	1
External tools used	1	0

Process time

How long does it take to accomplish those steps?

90% reduction in time

	Legacy	MCT
Minutes to complete	65	6



Key Lessons

Design is not enough

End user composition alone is not enough, it must be mixed with the specific job enabling features that users want. The combination is powerful.

The term end user composition is nerdy and does not grab people, the popular lexicon on this shifts… "mashups," "dashboards" and can confuse the message

Unknown cultural differences can have a big impact - our first user test, though we stated it as such, was thought by users to be the final software because this is the only mental model they had

New capabilities take a long time to catch up to "old" capabilities, benefits must outweigh the inconvenience

Don't take away "old" capabilities, let new co-exist with old in shadow mode, for a period of time

Customers will map what you say into their own expectations, creating a mental model that varies across groups and that may be unknown to the design team

Show constant progress, make it visible and accessible

If it's not easy, people won't even try it

Customers want and expect new capabilities, they also want all of their legacy capabilities

Openness increases with time and use

A new mental model, even a better one, at first will be confusing to users

It's all so simple

Succeed

Know who your stakeholders are, focus

Fail

Try to solve too many problems for an undefined stakeholder base

We did better creating generalizations from instances than creating instances from generalizations - start by solving real problems not generalizations

Rebuilding

The desktop version is ultimately cancelled

We rebuild, our funders are now in California

New Stakeholders

Jet Propulsion Lab
Multi-Mission Ground Systems
Multiple missions use the software over time, at many NASA centers

Jet Propulsion Lab
Many Flight Projects
Each one concerned about success of their mission

NASA Ames Research Center
Resource Prospector
Successful Mission

Open Source Community
NASA, Commercial, Other
The success of their project

Stakeholder Language

User Test

Our users mental model in the early 2000's was that software is delivered and that's what you get (remember those inflexible displays). We conducted a user test on early software with unforeseen consequences

Prototype

A designer thinks of a prototype as a question rendered as an artifact, the expectation is that there will be many

A system engineer thinks of a prototype as a risk reduction exercise to buy down risk associated with system requirements, expectation is that there will be few because they tend to be expensive

Demo, Test

Popular mental models, such as dashboards and mashups affect user perception

Say it then sim it

Mental Model Map Example

System Engineering	Design Thinking
Requirements (tendency fewer ideas)	Observations Ideation Synthesis (more ideas)
Prototypes for Risk Reduction, typically few	Prototypes - questions rendered as artifacts, typically many
Review	Try/Use (“Say it then sim it”)
Build	Iterate
Train, Fly	Train, Fly

Open MCT

Open Mission Control Technologies

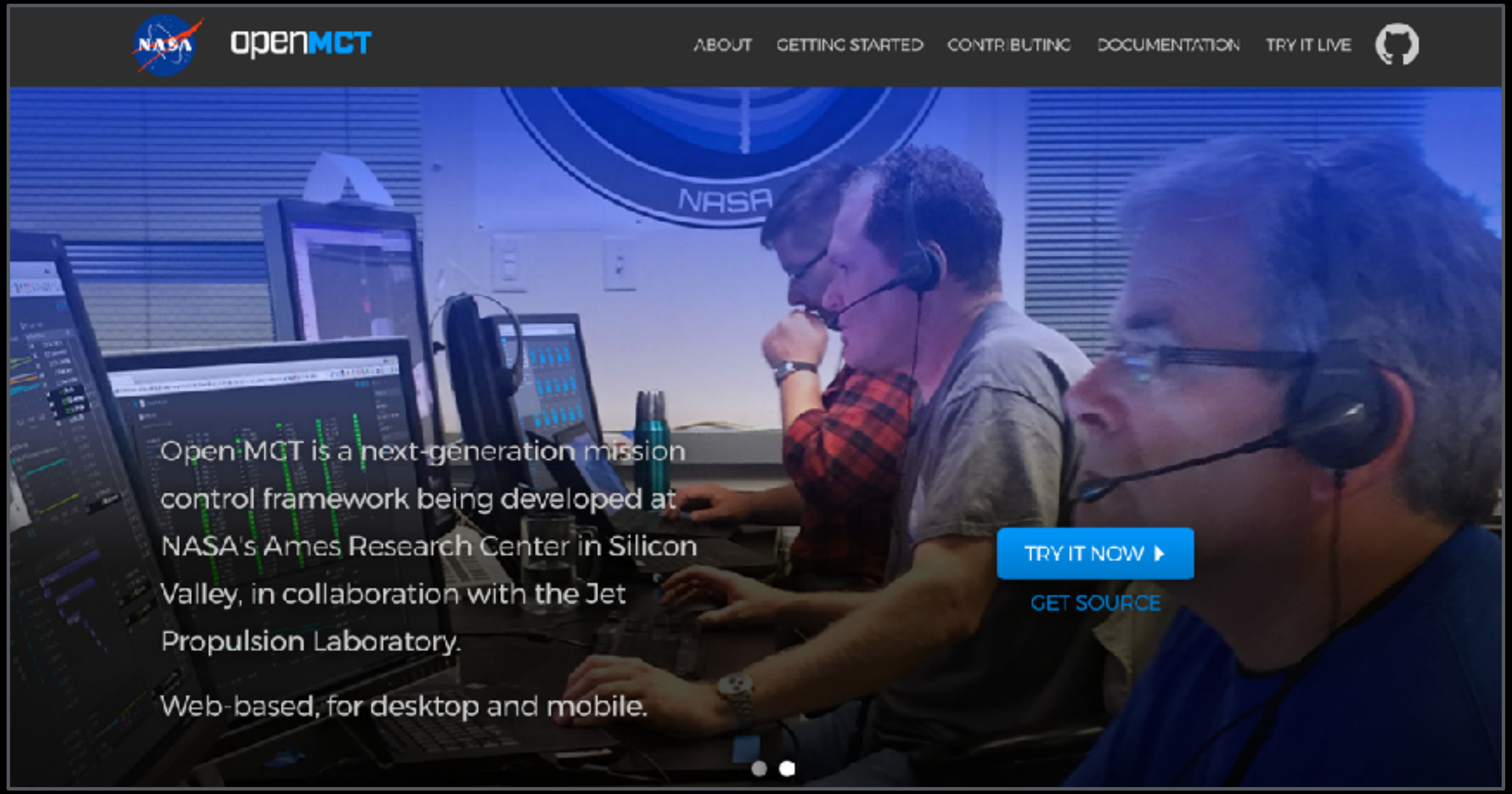
Goals

Provide users with an all your data in one place solution

Empower users to compose their own displays

Create new opportunities for collaboration and community involvement using open source

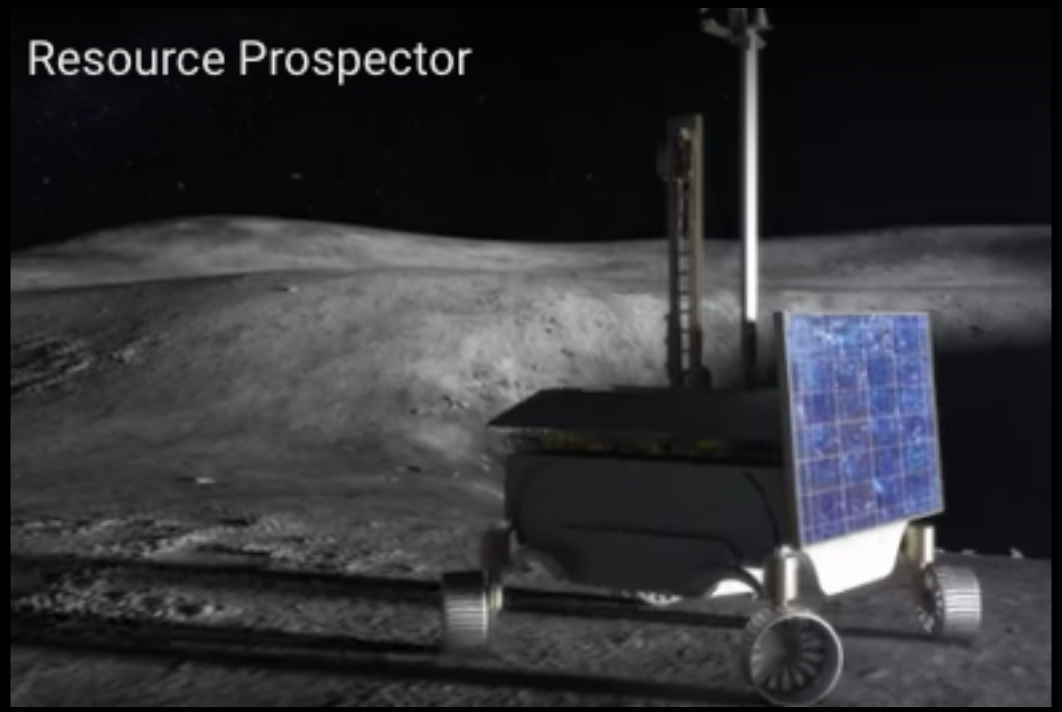
Take what has been a closed and hence mysterious world and open it up



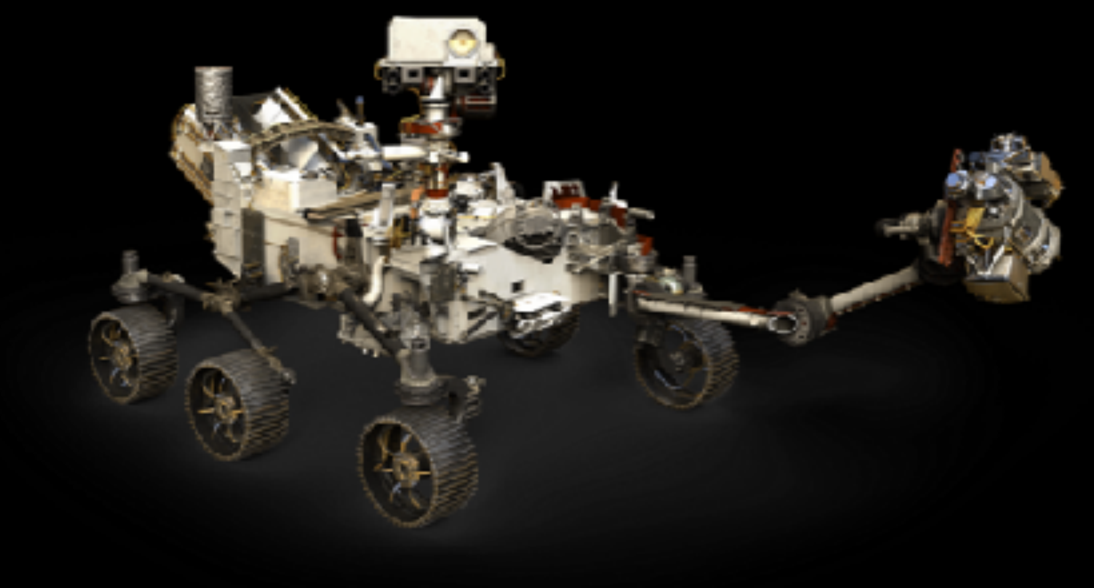
https://nasa.github.io/openmct/

Initial Mission Users

Jason-3



Resource Prospector



Mars 2020
(expected testbed)

https://nasa.github.io/openmct/

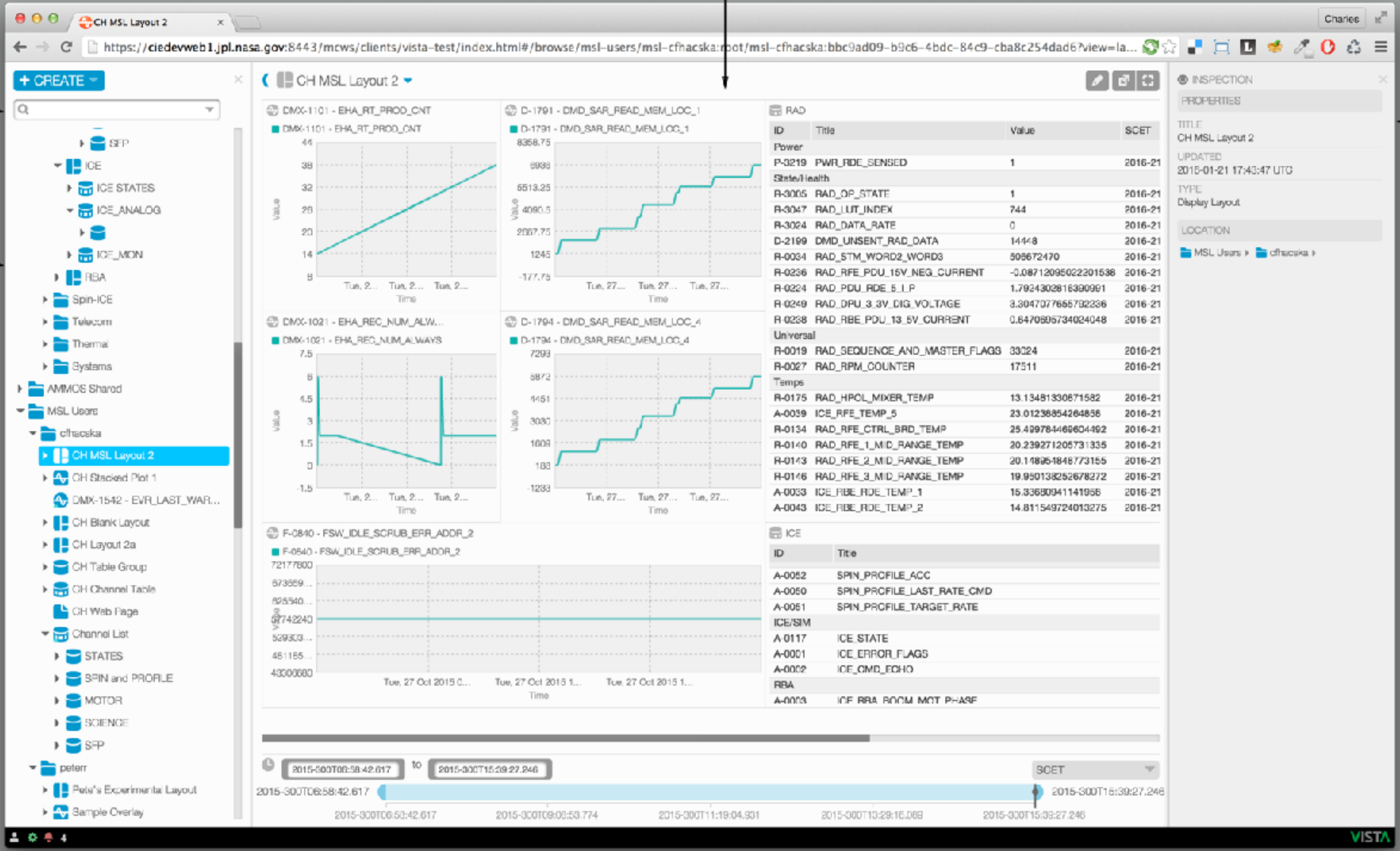
All Your Data in One Place

A layout is a composition of data objects

Search your Data Objects

Browse your Data Objects

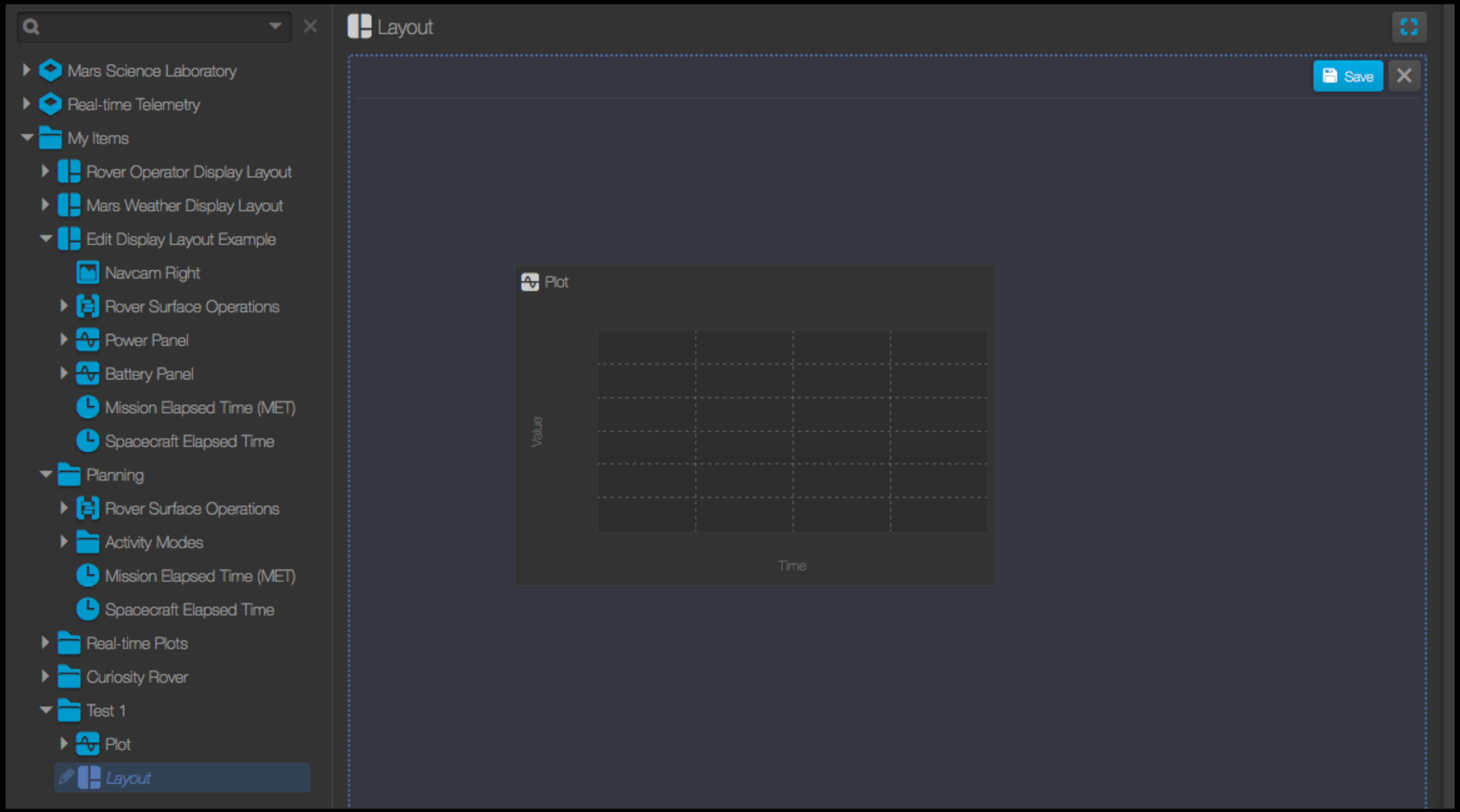
Inspect your Data Objects



https://nasa.github.io/openmct/

Create & Compose

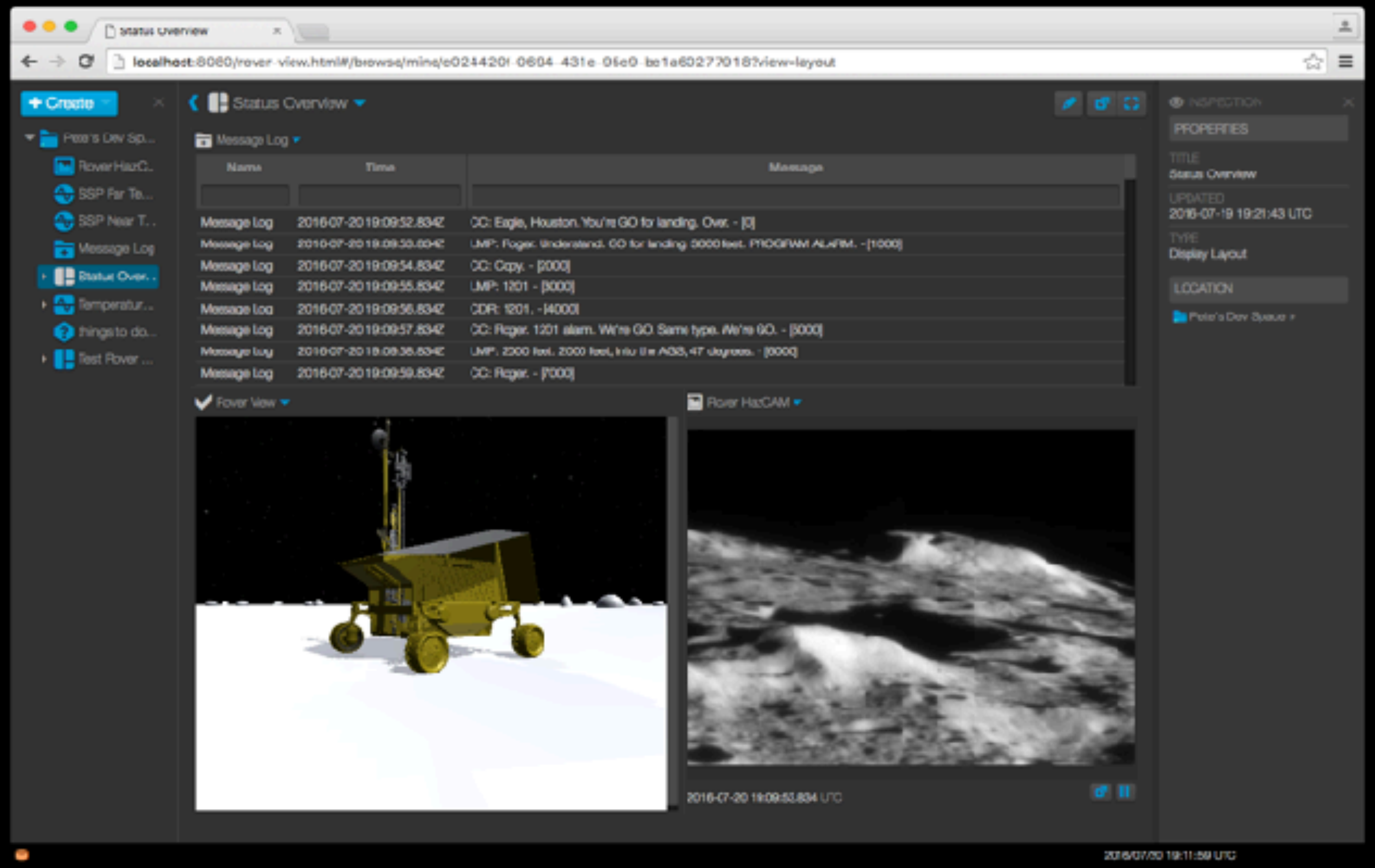
Example of user object types

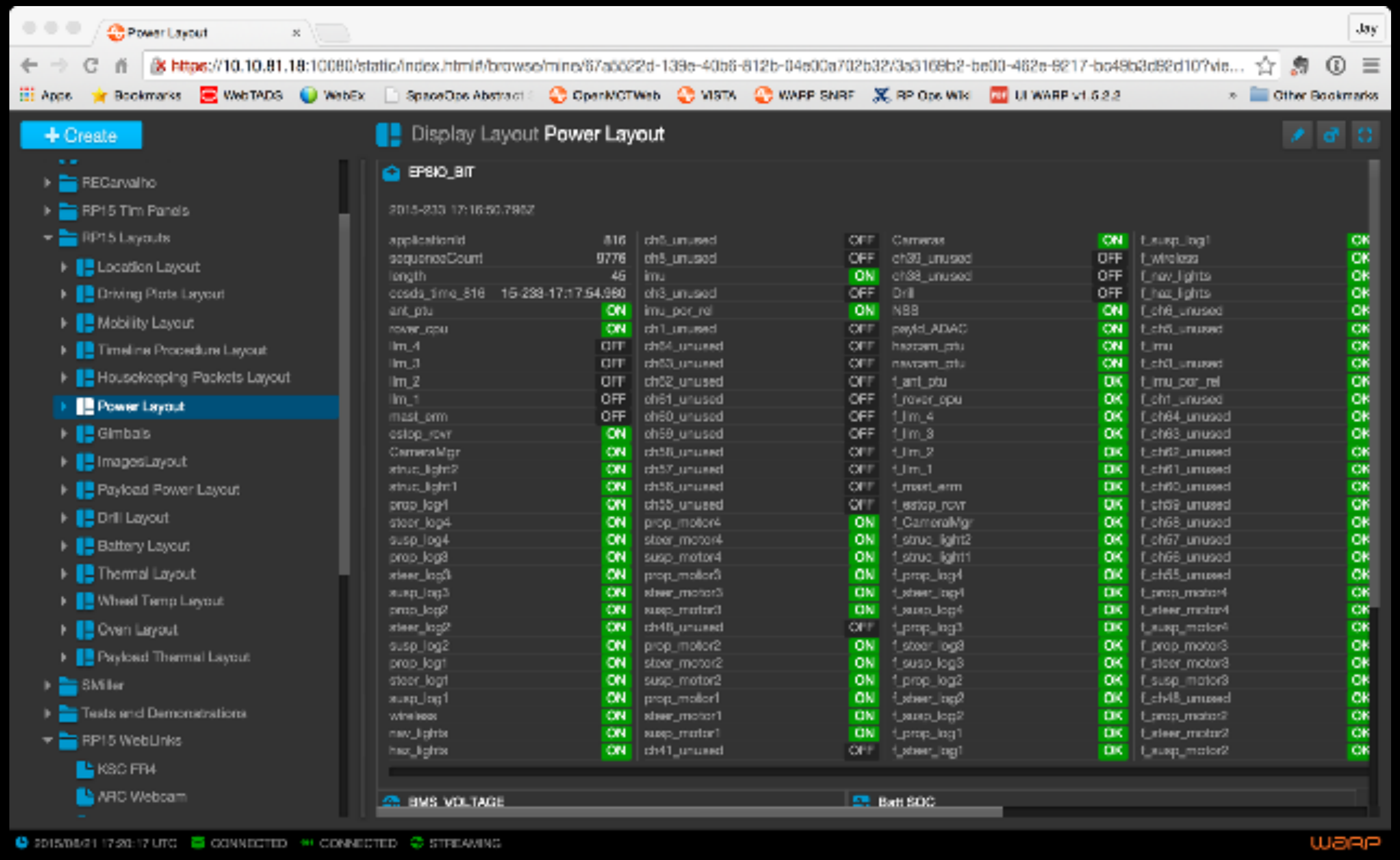


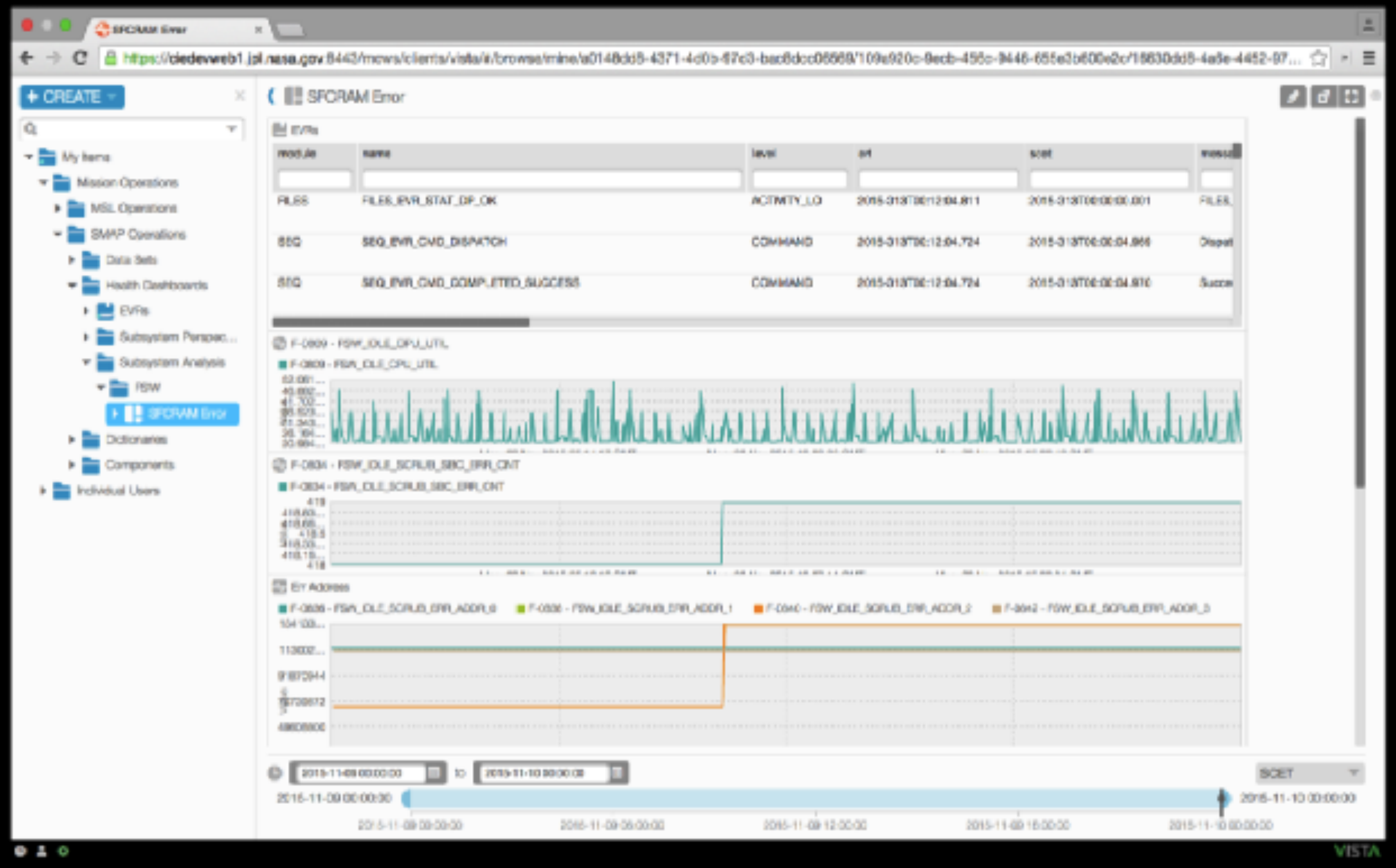
Layout is the users canvas

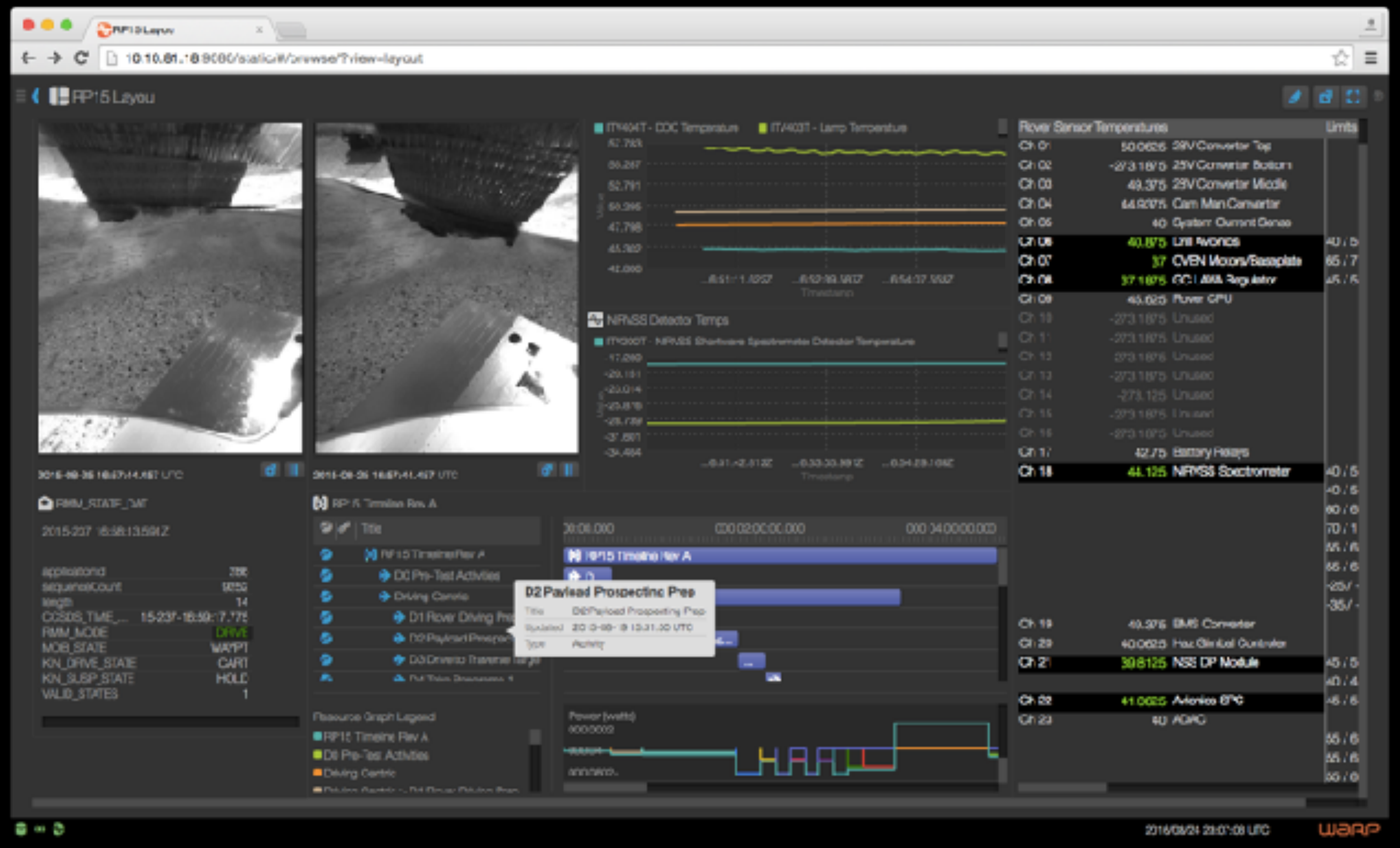
https://nasa.github.io/openmct/

User-Built Compositions

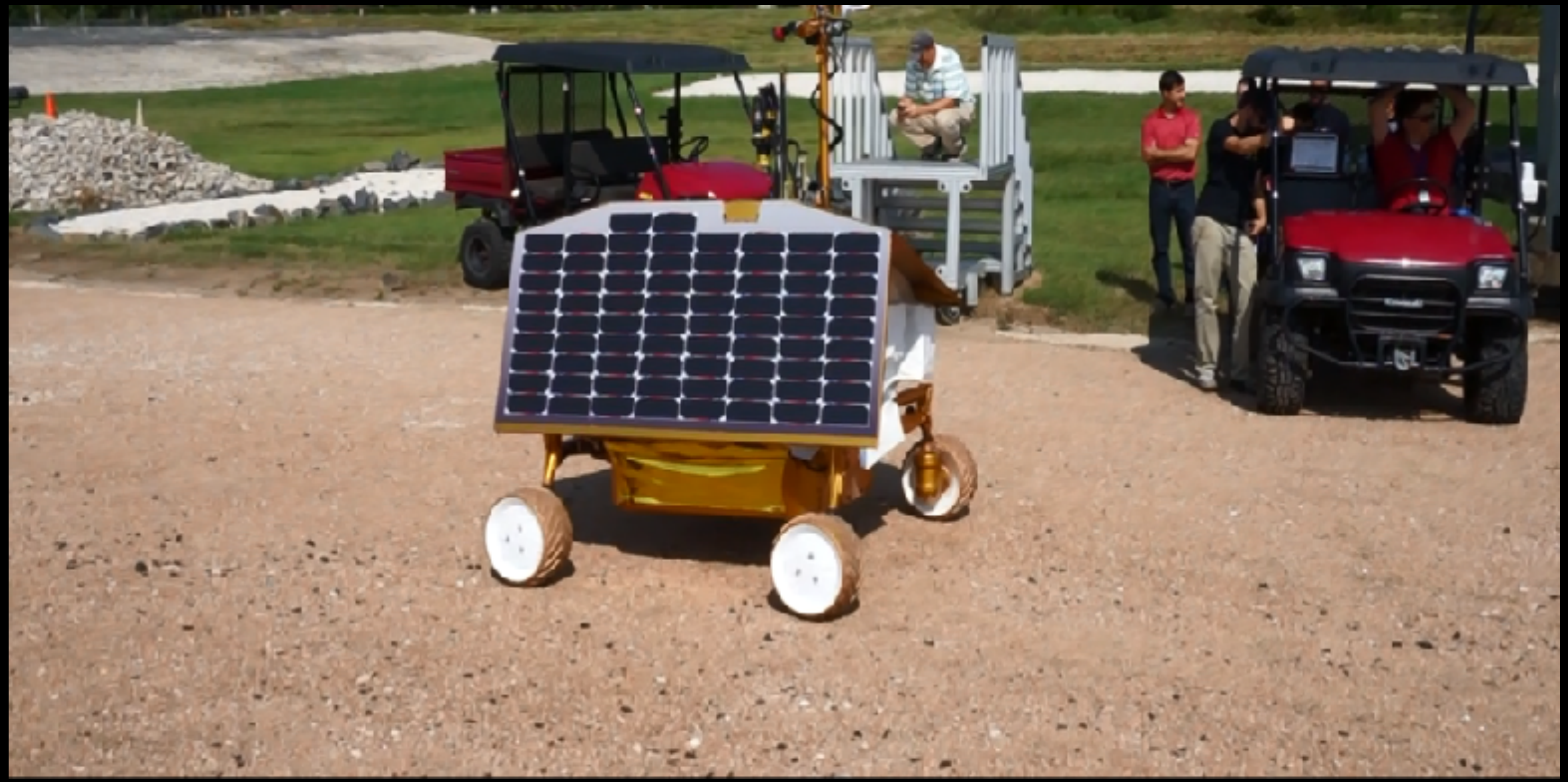


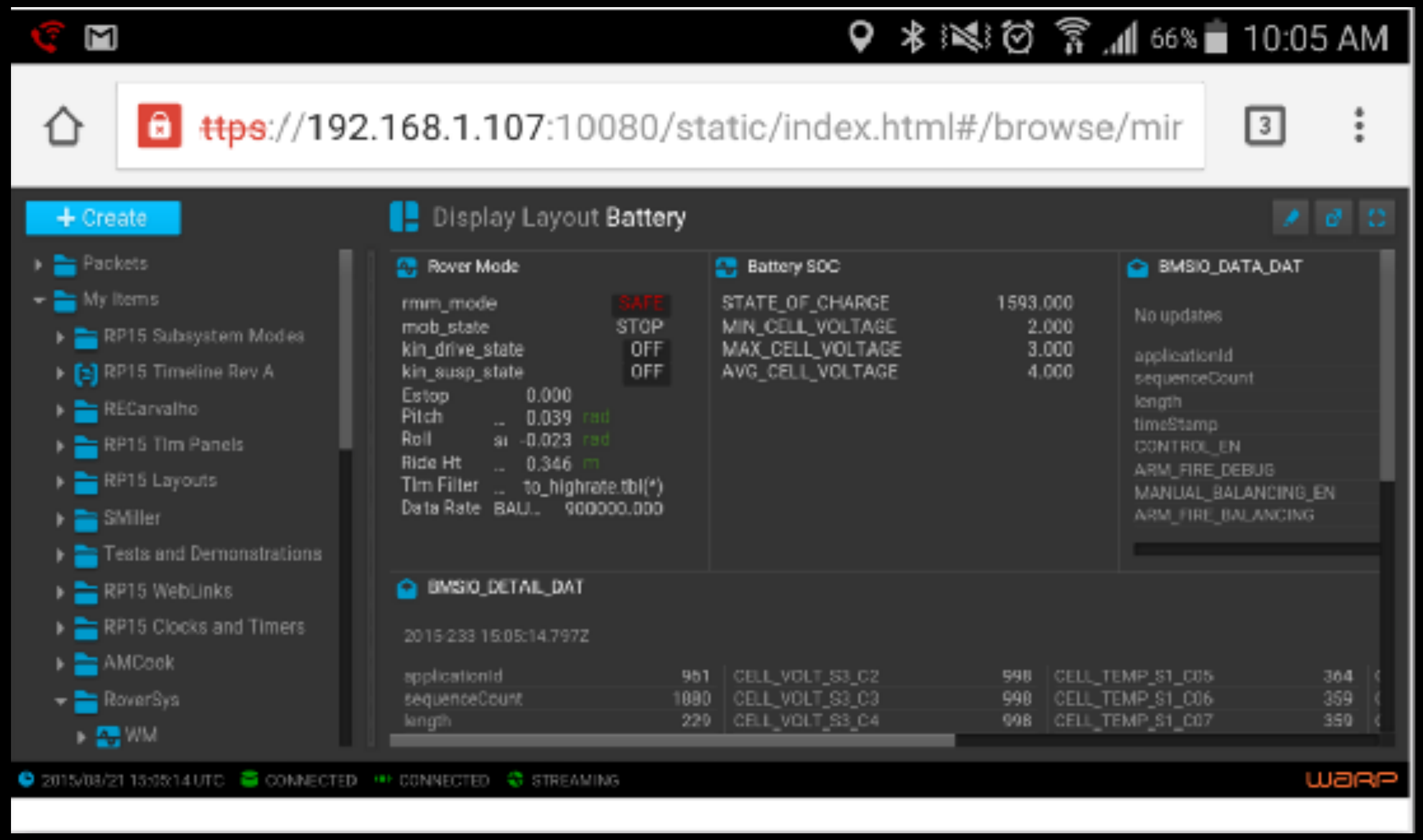




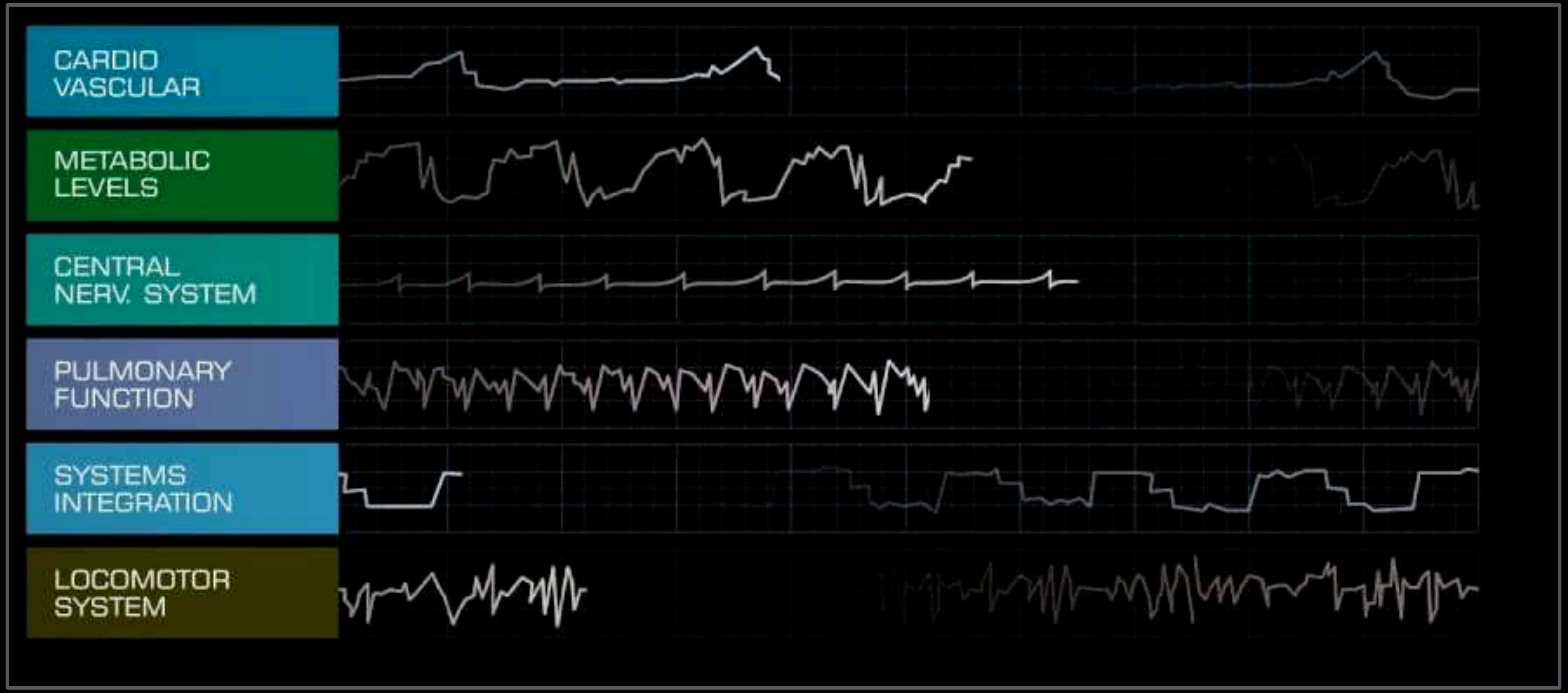


User Testing

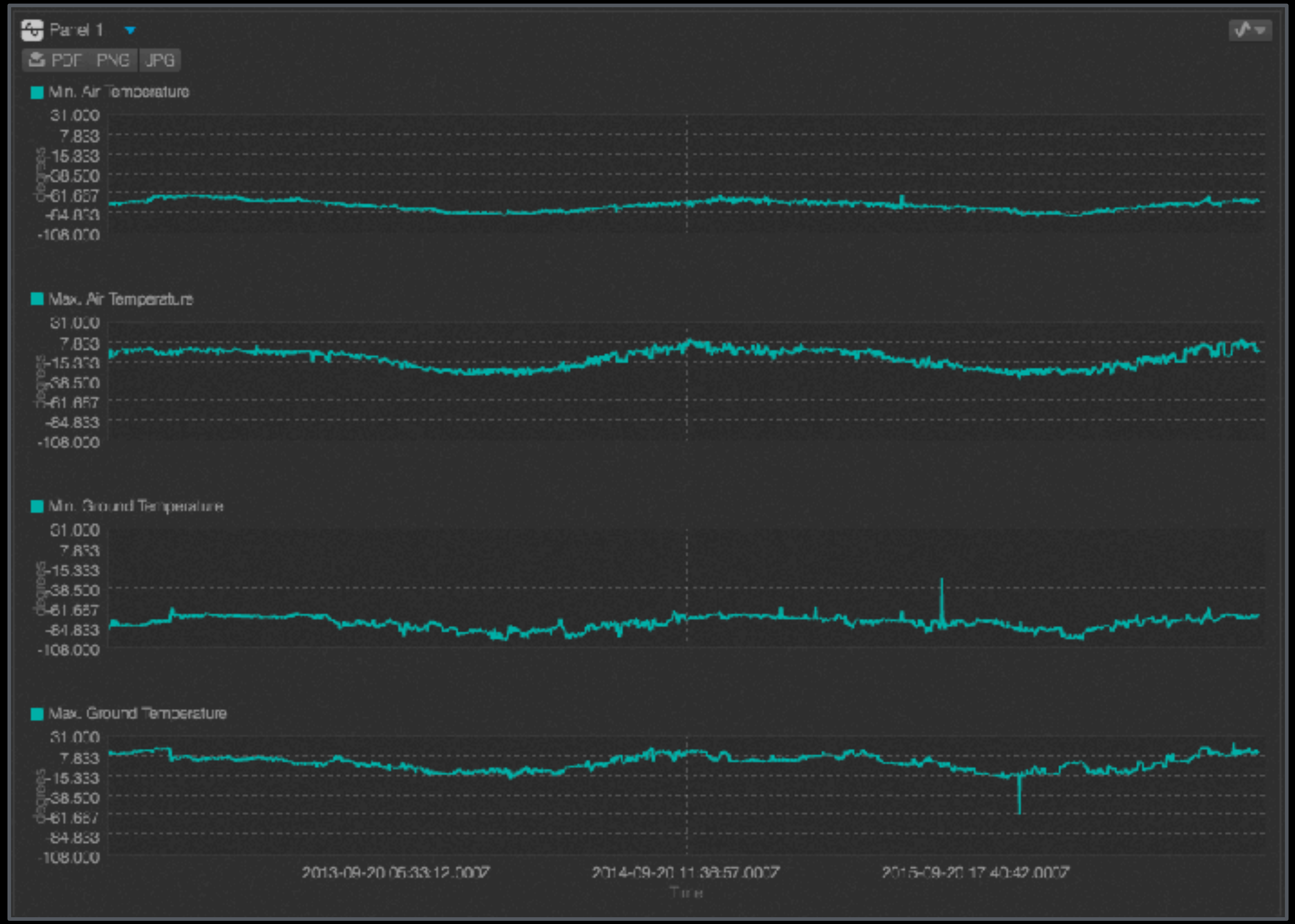




For Fun

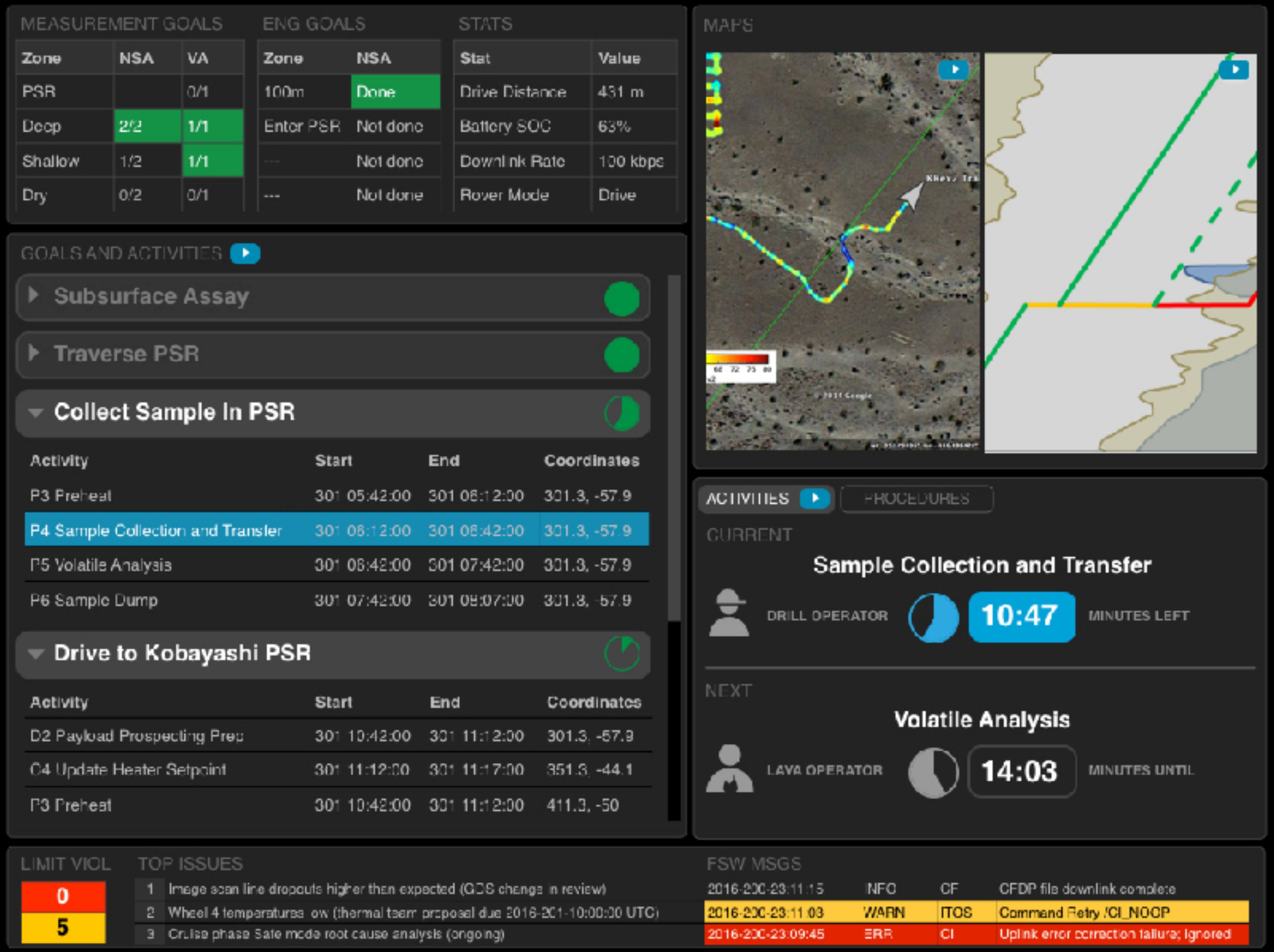


2001: A Space Odyssey



Open MCT

Sprint



GV Style Design Sprint

The Community

https://nasa.github.io/openmct/

60 Visitors per week then..

User Reddit Post

20k visitors in two days

Outside contributors

Collaborations inside and outside of NASA that were not possible or practical before open source

The Role of Failure

“Failure is not an option” - Gene Kranz

Referring to human space flight operations

Design Thinking

…is now an accepted part of our organization, though it is only practiced by a small number of teams.

My team is moving design thinking from software, where we first established it, to the design and development of the mission system for a lunar prospecting rover.

“Say it then sim it”