

Open Source Lessons Learned with Open MCT

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Open Source CubeSat Workshop 2018



The Vision

- Closed → Open
- Ground systems have traditionally been built on proprietary systems.
 - Duplication of effort - we continually re-create the same thing
- Let's move to a shared model for ground systems and build on each others work
- The internet economy as an analogy - companies may focus on their core differentiators and use existing infrastructure



Immediate Benefits

- Collaboration that works
- Use, adopt, make it your own, contribute
- No ownership issues
- Instant access
- Fork/Pull

A web based mission control framework. <https://nasa.github.io/openmct/>

5,339 commits 247 branches 23 releases 38 contributors

Branch: master New pull request Find file Clone or download

charlesh88 and psarram [Frontend] Adds overflow scrolling to .l-view-section (#2039) ... Latest commit e19ce4a 5 days ago

docs	[Documentation] Add security guide (#1900)	4 months ago
example	Handle string states (#2019)	21 days ago
platform	[Frontend] Adds overflow scrolling to .l-view-section (#2039)	5 days ago
scripts	[Copyright] Update copyright year across platform code references	9 days ago
src	[Copyright] Update copyright year across platform code references	9 days ago
.gitignore	Add functionality to allow users to add hideParameters to the url, wh...	9 months ago
.jscsrc	[Code Style] Add JSHint rules	2 years ago
.jshintrc	Disabled late definition check for functions	4 months ago
.npmignore	[Build] Add npmignore to allow packing	2 years ago
API.md	Summary widget telemetry provider (#1943)	a month ago
CONTRIBUTING.md	[Documentation] Edit for style	a year ago
LICENSES.md	Include 2017 in copyright #1517	a year ago
Procfile	Merging in latest github/master	3 years ago
README.md	prepare -> prepublish	5 months ago
app.js	Revert "[proxyUrl] pass URL parameters to proxied URL"	2 years ago
bower.json	Lock filesaver version (#1956)	2 months ago
build-docs.sh	[Licenses] Update copyright year to 2017	a year ago
circle.yml	Bump Node Version	23 days ago
gulpfile.js	adds v8-compile-cache	5 months ago
index.html	[Autoflow] Rewrite Autoflow Tabular using new APIs (#1816)	6 months ago
jsdoc.json	Squashed commit of the following:	2 years ago
karma.conf.js	[Plugin] Add imported root plugin (#1784)	3 months ago
openmct.js	new-plot import (#1557)	3 months ago
package.json	Enterprise-galactica (#1993)	a month ago
test-main.js	d3 selection filepath changed (#1898)	4 months ago

<https://github.com/nasa/openmct>

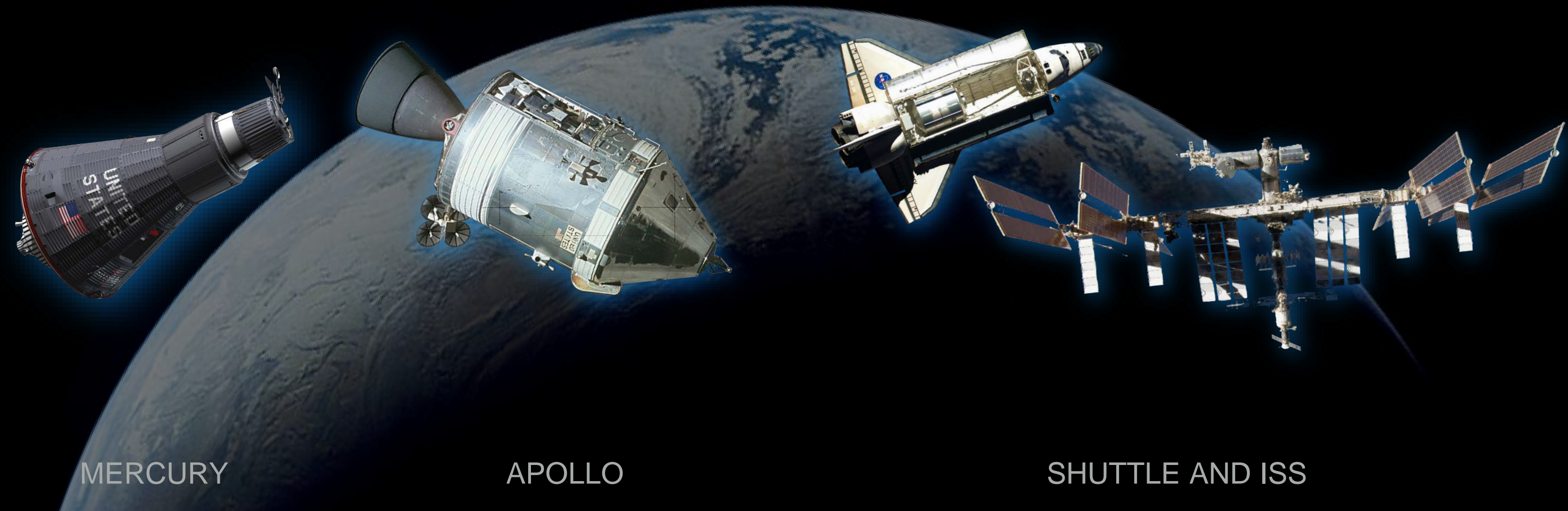


More benefits

- Better software
 - More eyes on your software
 - More users
 - A community that drives you to be better
- Yes, missions do some of this, but the environment is somewhat insular so there are benefits to a broader group of users and contributors



How have we advanced since the 1960's?



1960's



2000 and beyond



Can open source be a vehicle for advancing technology?

7 0 DAY 1 0 1

F/V 13/099 FSS CONTROL RR3408A CH044

QGMT 101:18:12:32 ONET 4:04:14:32 SITE TDR OI 188 GN 62
 RMT 101:18:12:32 U/D RATE 1 SM 64 BF 12

MECHANISM SELECTION		CONFIGURATION		TELEMETRY	
		ON	OFF	AMPS	TEMP
BERTH LAT 1	1	A B	A B	SCIU 0.53	2
	2	SCIU 16 *	17 *	MSB 0.07	0
	3	MSB 18	19 *	MPC 4.7	
UMS MAIN	4	MPC 20 *	21 *	DPC 0.2	
HEATER	5	DPC 22	23 *	FSS LCKR 1	26
RET LAT KEEL	6	LCKR 24 *	25	FSS LCKR 2	13
PORT 7					
STBD 8					
ROTATOR	9	HEATERS (SSP)		PCU	5
PIVOTER	10	ENA AMPS		PDSU	-1
TRANSLATOR	11	FSS *	0.2	FMDM 0.85	
PLAT LOCK	12	SMM	0.1	FMDM BOX A	26
DESELECT	13	MACS	0.1	FMDM BOX B	-554
OVERRIDE				DISP MP	
ENABLE	14*			2011 SM	
DISABLE	15			2011 SM	
DEU				5 20119 ONCS	
1				5 20119 ONCS	
2	RESUME				
3					
4	RESUME				

93 Y84 HQ 1 0 MIN 1 2 SEC 3

1980's Space Shuttle Display

RP OVW LAYOUT 1 Missing: 51344c8a-34f2-46b8-8000-24d2b8a47803/bd6b10ff-c73c-409f-9ddc-a7e9fc294c00?view=layout&tc.timeSystem=utc&tc.startDelta=900000&tc.endDelta=0

3D ROVER MAIN

STATE_OF_CHARGE 76.07421875
 MIN_CELL_VOLTAGE 0.0078126
 MAX_CELL_VOLTAGE 0.01171876
 AVG_CELL_VOLTAGE 0.015625

HAZ CAM L DATA
 2017-04-04 17:35:15.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18739.jpg
 2017-04-04 17:35:16.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18740.jpg
 2017-04-04 17:35:17.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18741.jpg
 2017-04-04 17:35:18.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18742.jpg
 2017-04-04 17:35:19.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18743.jpg
 2017-04-04 17:35:20.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18744.jpg
 2017-04-04 17:35:21.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18745.jpg

HAZ CAM R DATA
 2017-04-04 17:35:14.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18738.jpg
 2017-04-04 17:35:15.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18739.jpg
 2017-04-04 17:35:16.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18740.jpg
 2017-04-04 17:35:17.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18741.jpg
 2017-04-04 17:35:18.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18742.jpg
 2017-04-04 17:35:19.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18743.jpg
 2017-04-04 17:35:20.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18744.jpg
 2017-04-04 17:35:21.480Z https://www.hq.nasa.gov/alsj/a16/AS16-117-18745.jpg

2015-237 17:01:54.287Z

Component	Status	Component	Status
l_fm_3	OK	steer_log4	ON
applicationId	816	susp_log4	ON
length	45	prop_log3	ON
ocads_time_816	15-237-17:02:58.471	steer_log3	ON
ant_ptu	ON	susp_log3	ON
rover_cpu	ON	prop_log2	ON
lm_4	OFF	steer_log2	ON
lm_3	OFF	susp_log2	ON
lm_2	OFF	prop_log1	ON
lm_1	OFF	steer_log1	ON
mast_em	OFF	susp_log1	ON
mast_rcvr	OFF	wireless	ON
CameraMgr	ON	nav_lights	ON
struc_light2	ON	haz_lights	ON
struc_light1	ON	ch8_unused	OFF
prop_log4	ON	ch5_unused	OFF
		prop_motor4	OFF
		steer_motor4	OFF

© 2017/04/04 19:43:10 UTC WARP

Open MCT Display



The platform

- Open Mission Control Technologies - Open MCT
- Info
 - <https://nasa.github.io/openmct/>
 - From info site, click on Try it Now
- Code
 - <https://nasa.github.io/openmct/>

openMCT ABOUT GETTING STARTED CONTRIBUTING DOCUMENTATION TRY IT LIVE

Open MCT is a next-generation mission control framework being developed at NASA's Ames Research Center in Silicon Valley, in collaboration with the Jet Propulsion Laboratory.

Web-based, for desktop and mobile.

[TRY IT NOW](#)
[GET SOURCE](#)

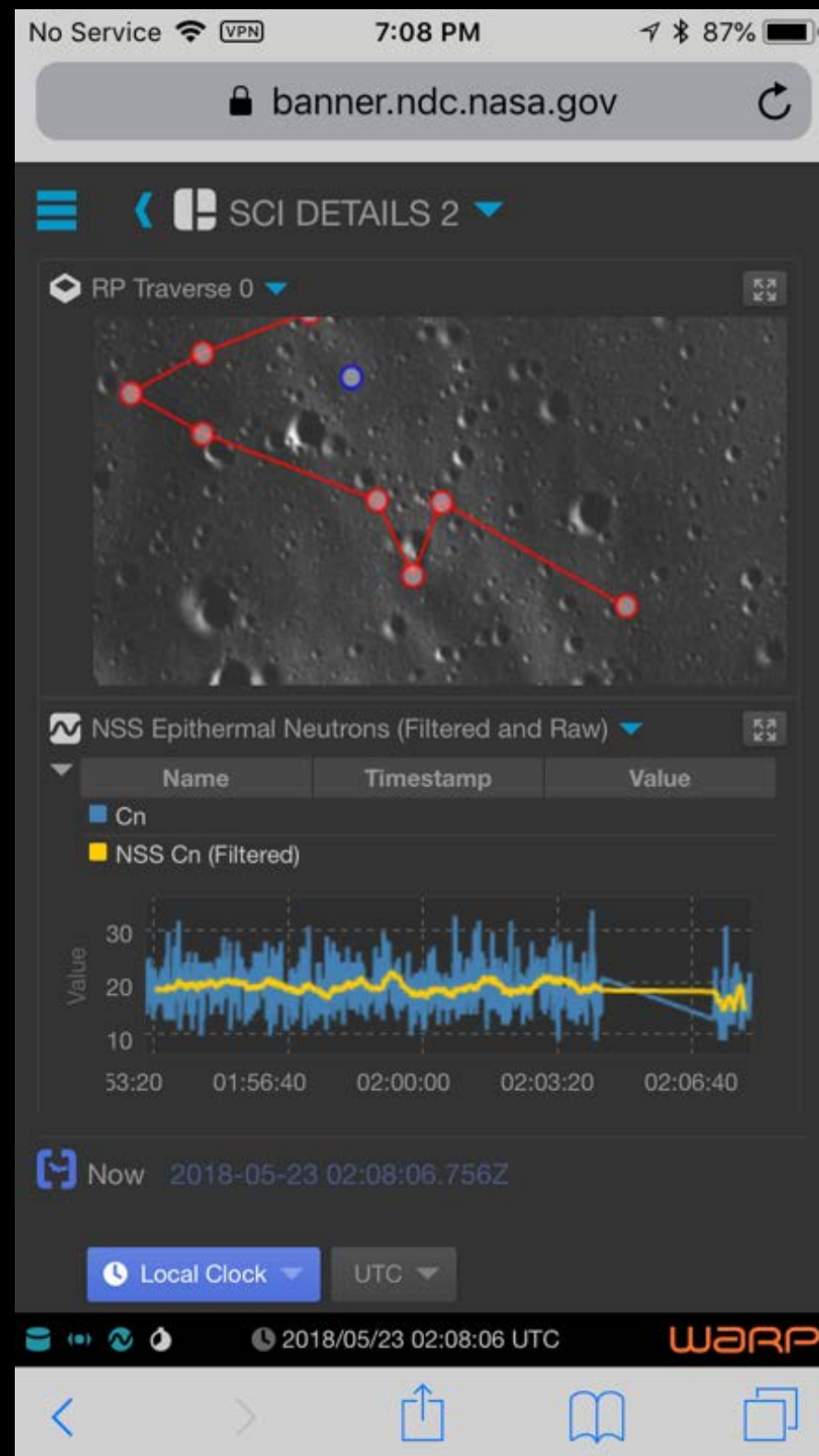
HOW IS NASA USING OPEN MCT?
Software based on Open MCT is being used for mission planning and operations in the lead up to the [Resource Prospector mission](#) at NASA's Ames Research Center, and as a data visualization tool at the Jet Propulsion Laboratory.
[FIND OUT MORE](#)

HOW CAN YOU USE OPEN MCT?
Open MCT can be adapted for planning and operations of any system that produces telemetry. While Open MCT is developed to support space missions, its core concepts are not unique to that domain. It can display streaming and historical data, imagery, timelines, procedures, and other data visualizations, all in one place.
[LEARN MORE](#)

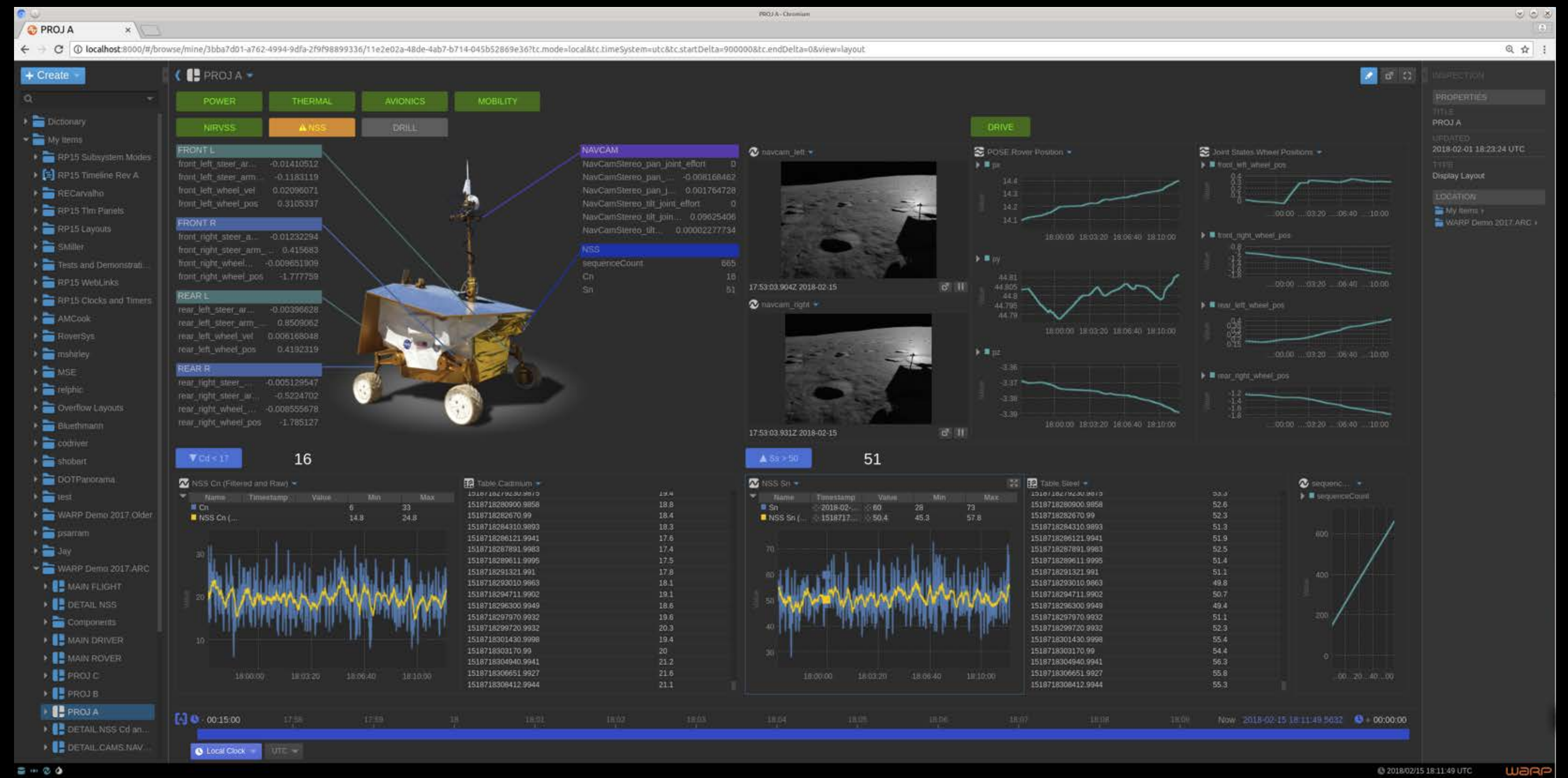
HOW TO CONTRIBUTE
We are looking for enthusiastic people who want to help contribute to NASA's exploration of the solar system. Are you a student, professional software developer, or just a space enthusiast? We'd love to hear your ideas for new features or ways of visualizing data. If you're a coder you can help us develop new features or capabilities, and fix bugs.
[GET MORE INFO](#)



The Platform



Mobile

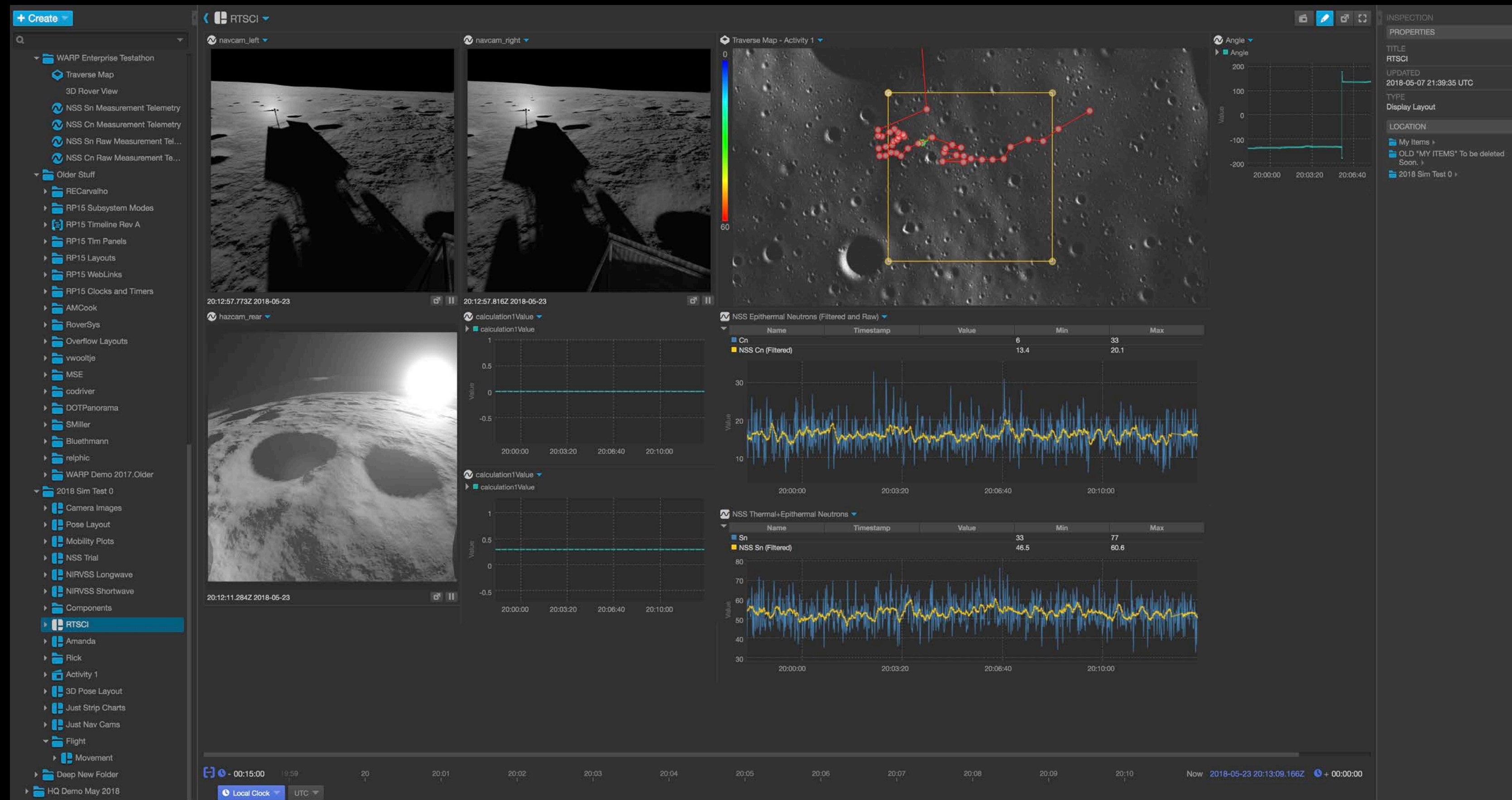


Desktop

<https://github.com/nasa/openmct>



All Your Data in One Place



All your data here

Data Visualizations, cross domain

Inspector



Mix Data Across Domains

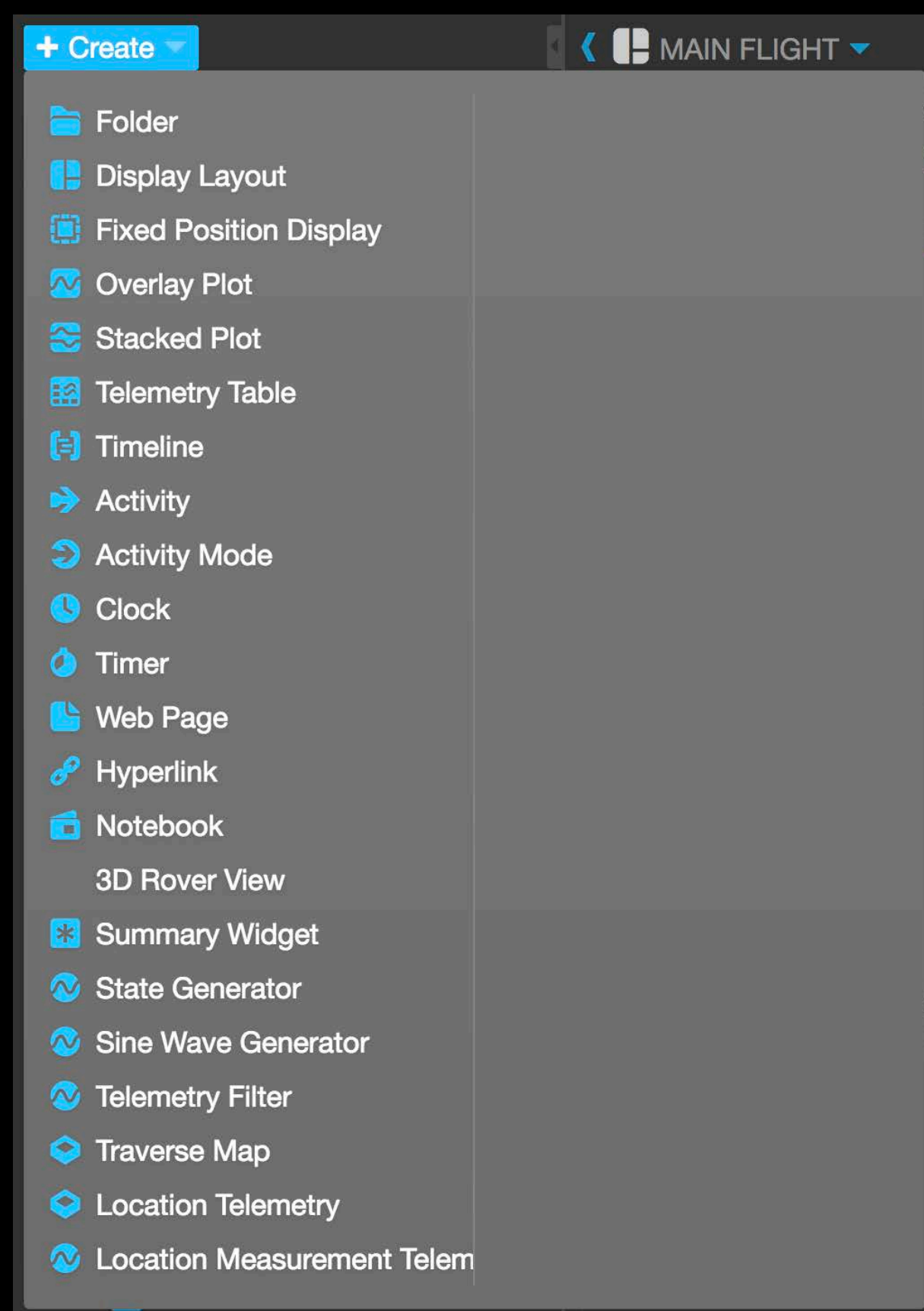
The screenshot displays a complex mission control interface with several key components:

- Clocks and Timers:** A top bar showing time in UTC (20:00:28), MET (+114D 23:10:28), SET (+112D 02:14:28), and SS7 Timer (+840:09:05). It also includes a 'Time in Current A...' field and a set of domain-specific buttons: MOBILITY, THERMAL, DRILL, AVIONICS, NIRVSS, NSS, WAVE, and POWER.
- Images:** A grid of camera feeds including 'Unkown point hazcam_fron...', 'hazcam_rear', 'navcam_left', and 'navcam_right', each with a timestamp and playback controls.
- 3D Rover View:** A central 3D visualization of the rover on a terrain map, with a 'DRIVE' button and a 'Rover Mobility Visual' data table. The table lists parameters for REAR R, REAR L, FRONT R, and FRONT L wheels, such as 'rear_right_steer_arm_vel' (0.005370588) and 'front_left_wheel_vel' (-0.007616996).
- Telemetry:** A large panel on the right side of the interface, labeled 'Telemetry', which likely contains the detailed data from the mobility visual and other system metrics.
- Procedures:** A bottom-right window titled 'SS7 Procedures' showing a task list for 'Science Station 7' with steps like 'Arrive at Science Station', 'Drive AIM', 'Set Drilling Location', 'Drive to Drill Location', and 'Prep for Drilling'. It also includes a 'Resource Graph Legend' and a 'Power (watts)' graph.
- Timelines:** A bottom-left window showing a detailed timeline for 'Science Station 7' with a horizontal axis and various task bars.

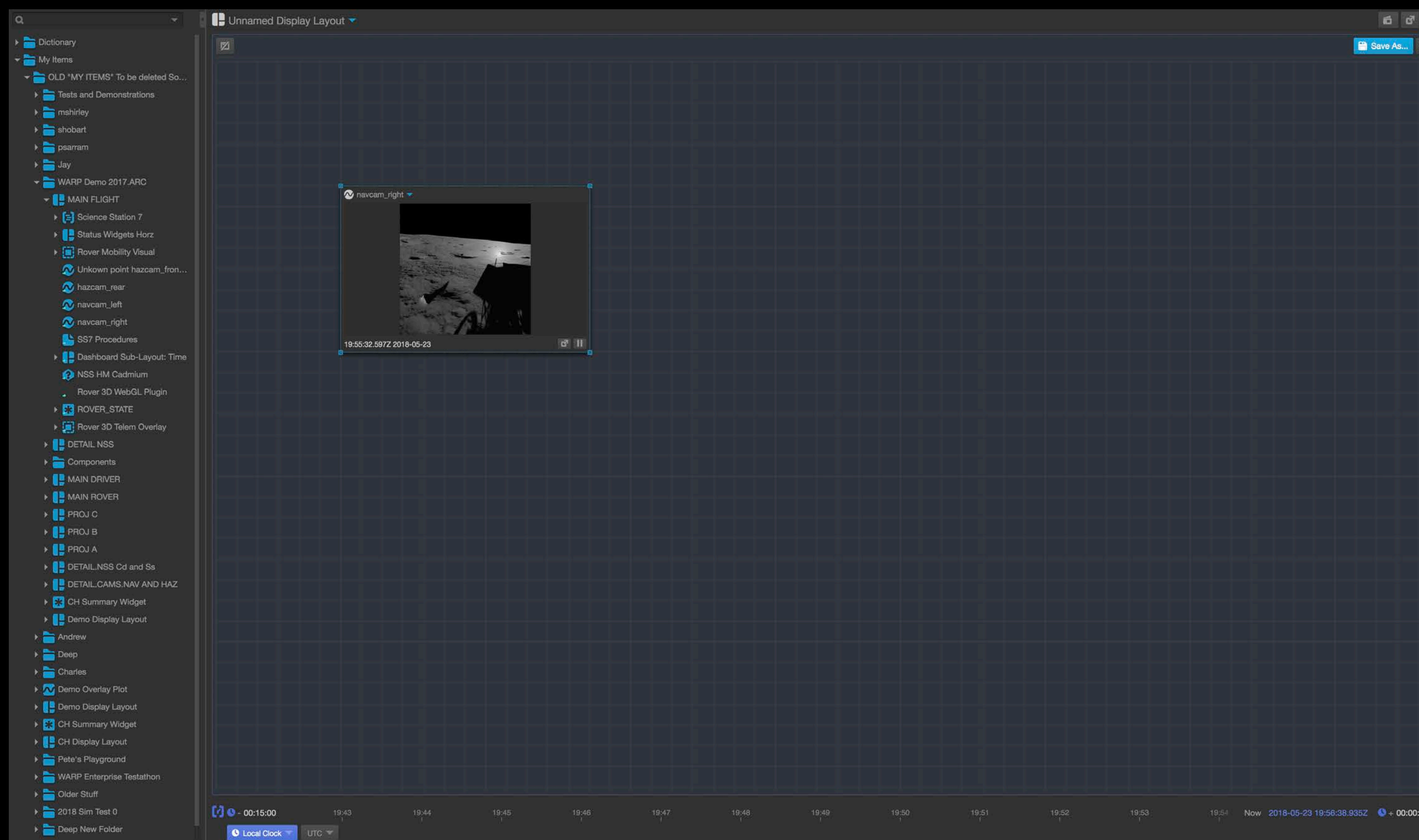
Add capabilities with plugins



Make Your Own Displays



Create



Build a display layout

<https://github.com/nasa/openmct>



Who has Open MCT in NASA



More...

<https://github.com/nasa/openmct>



Open MCT in ESA

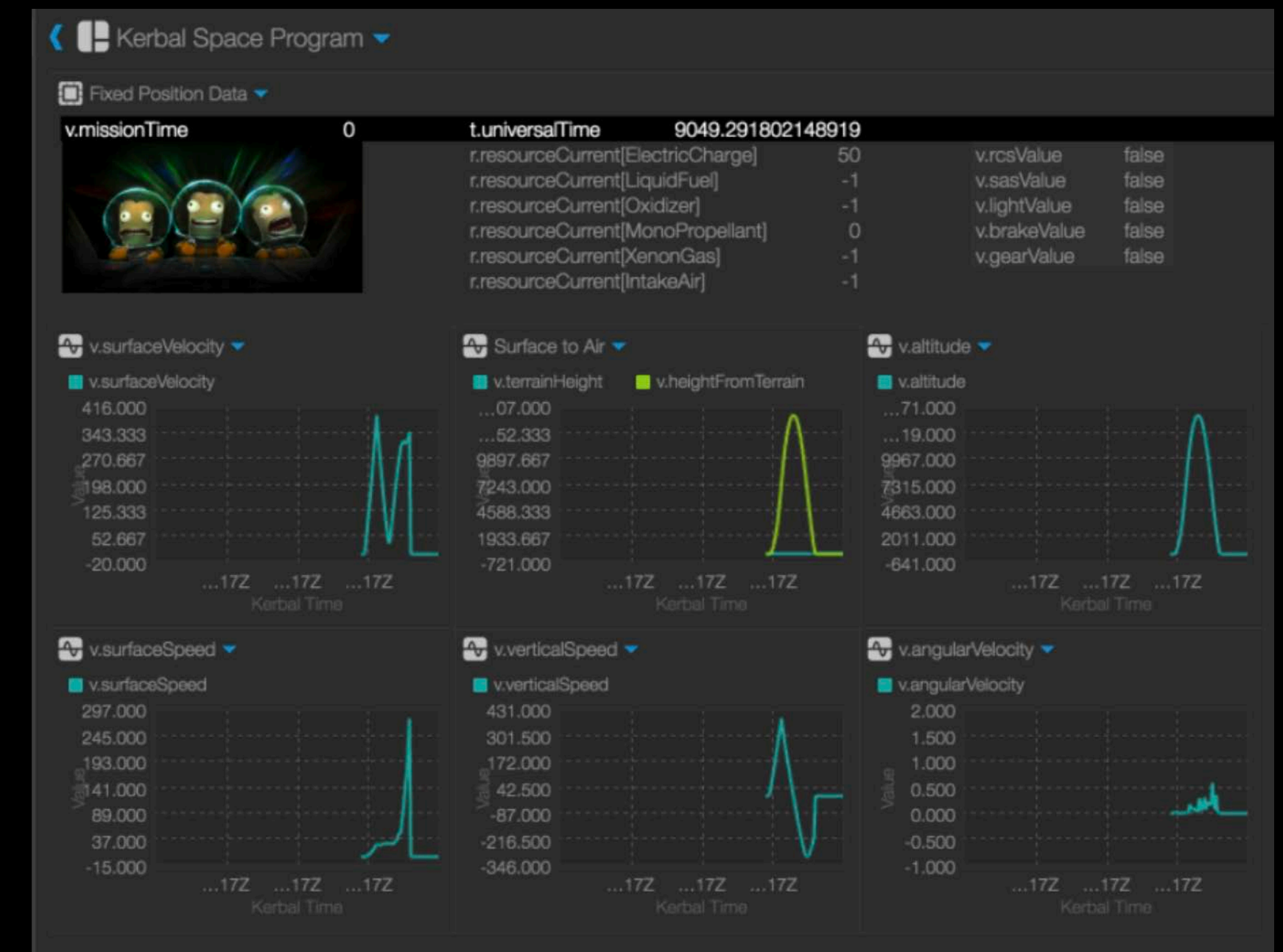
- ?



Samples from the community outside NASA

C-base backspace Berlin

Kerbal Space Program



<https://bergie.iki.fi/blog/nasa-openmct-iot-dashboard/>

<https://github.com/nasa/openmct>



Contributors

- 50+ registered contributors, who have submitted:
 - New features
 - Improvements to Documentation
 - Suggestions



Example Contribution 1

- User of Open MCT found an issue that caused new builds to fail
- They had submitted a PR to fix it before we had even started looking into it

The screenshot shows a GitHub pull request titled "d3 selection filepath changed #1898". It is marked as "Merged" and shows that "akhenry" merged 2 commits into the "nasa:master" branch from the "thesamprice:d3selectionFix" branch on February 5. The interface includes tabs for "Conversation" (7), "Commits" (2), "Checks" (0), and "Files changed" (2). A comment from "thesamprice" dated January 30 states: "d3 changed the location of this file, npm install fails when trying new builds." Below the comment, a commit message is visible: "d3 selection changed from build to dist." with a commit hash "f087a24".

The screenshot shows a comment from "akhenry" dated January 31. The comment reads: "@thesamprice Thanks for pushing this fix! Hard-coding the paths of node dependencies into our Require configuration is brittle. That's our bad. We need a better strategy here. I'd like to do a little testing before we merge this because I have seen inconsistencies which possibly relate to node version, npm caching, and various other things. This might be what we're seeing with the CircleCI build. Stand by! And thanks again!"



Example Contribution 2

- Contributor updated all of our copyright statements
- Important tasks, but other priorities meant we hadn't done it yet

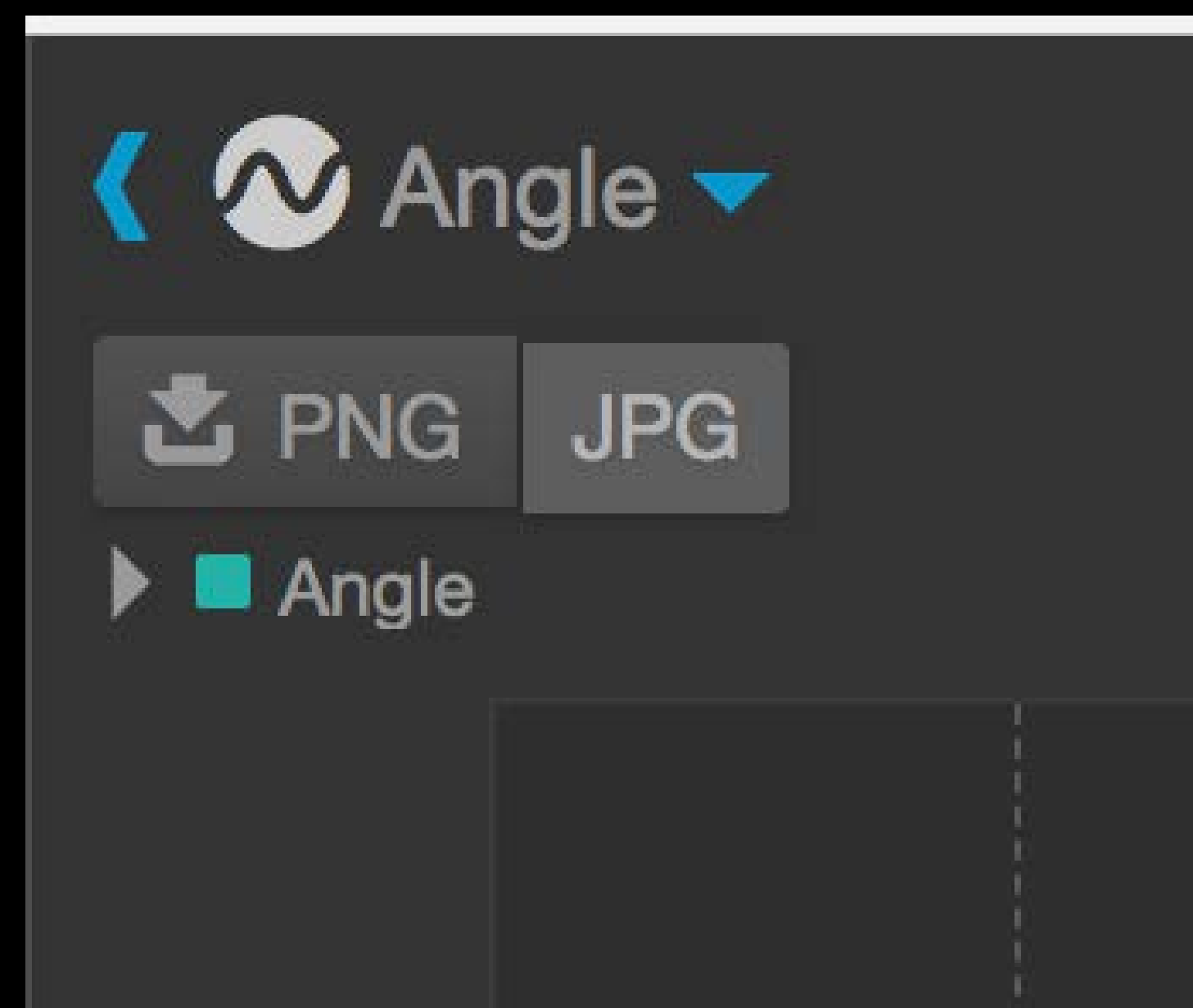
The screenshot shows a GitHub pull request titled "Update copyright year across platform code references" with issue number #2035. The pull request is merged, showing "psarram merged 1 commit into nasa:master from PunkChameleon:copyright-year" 9 days ago. The interface includes a "Merged" badge, statistics for conversation (3), commits (1), checks (0), and files changed (824), along with a diff indicator (+825 -825). A comment from PunkChameleon, posted 10 days ago, states: "Quick update addressing #2034. All regression tests pass." Below the comment is an "Author Checklist" with four items: "Changes address original issue? Y", "Unit tests included and/or updated with changes? Y", "Command line build passes? Y", and "Changes have been smoke-tested? Y". The pull request commit is "Update copyright year across platform code references" (da81319), reviewed by psarram 9 days ago. A "View changes" button is visible. A final comment from psarram says: "@PunkChameleon LGTM! Please add the contributor checklist and I'll approve and merge." The right sidebar shows metadata for Reviewers (psarram), Assignees, Labels, Projects, Milestone, and Notifications.

<https://github.com/nasa/openmct>



Example Contribution 3

- Export plot as image
- Based on user requests
- Implemented by open source contributor





Statistics

- 2015
 - Unknown
- 2018
 - Over 140,000 visitors

GitHub - Favorites	4925
GitHub - Forks	512
GitHub - Watches	224
GitHub - Average Daily Visitors	~80
Website - Page Views	1,214,368
Website - Unique Visitors	148,380
Website - Average Daily Visitors	~100
Signed Contributor License Agreements	51
Code Contributions	34



Contribution Process

- Sign Contributor License Agreement
- Make changes
- Submit Pull Request (PR)
- Circle CI runs unit tests, enforces code standards through tooling
- Code review by core team member
- Feedback or Merge



Developing Software in the Open

- As well as our software being open source, our process is as well
- Software process documentation available from GitHub repository
- GitHub Projects used as “Kanban” board for each sprint
- All open source bugs and new features tracked as GitHub issues
- Intra-team code reviews via PRs



Building a Community 1

Active Web Presence

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

Active Repository

<https://github.com/nasa/openmct>

<https://github.com/nasa/openmct>



Building a Community 2

- Provide a codebase that is clean, and fun to develop for
- Provide clear and comprehensive developer documentation
- Provide a simple and powerful Application Programming Interface (API)
- Tutorials for extending Open MCT with a focus on common use-cases.
- “Help-wanted” issues that cater to a range of abilities

The screenshot shows the GitHub repository page for `nasa/openmct`. The repository has 219 watchers, 5,026 stars, and 517 forks. The current view is for issues, with 284 issues in total. A search filter is applied: `is:open label:"help wanted"`. The list of issues includes:

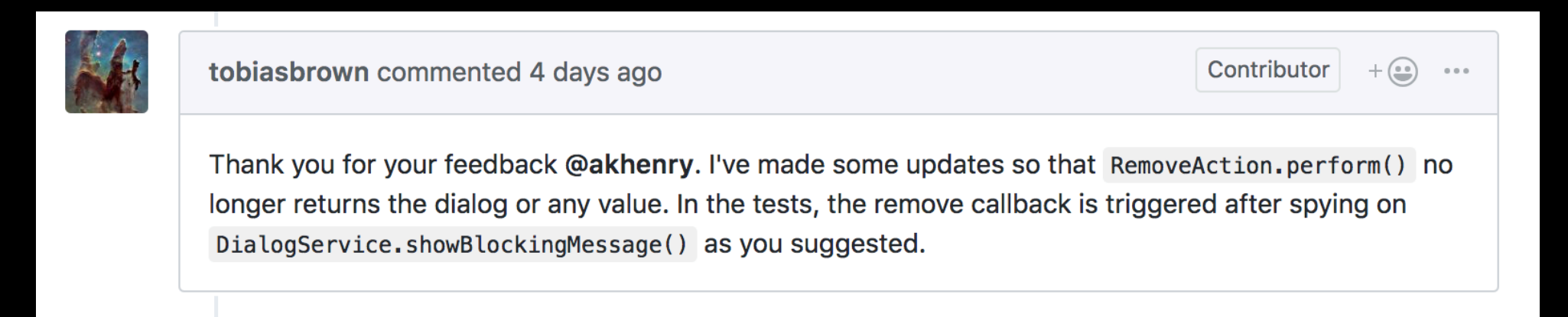
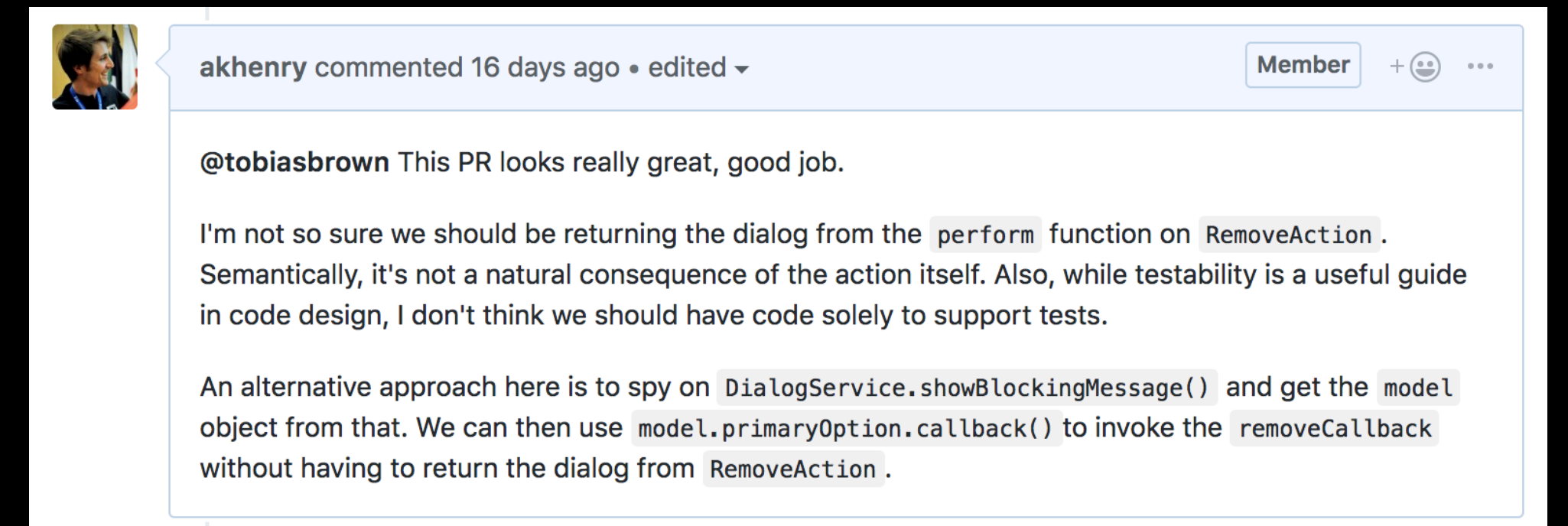
- [Imagery] Duplicate image showing in history** (help wanted) - #2012, opened 22 days ago by dtailor90, 1 comment.
- [Tables] Add clear filter button to Table View column filters** (help wanted) - #1989, opened on Apr 11 by charlesh88, 2 comments.
- [Build] Unknown/unknown appear in About dialog** (help wanted) - #1924, opened on Feb 22 by vicfx.
- [Tree] Drop down arrow remains even though object has no children** (bug, help wanted) - #1826, opened on Dec 5, 2017 by dtailor90, 15 comments.
- support bignum for number types not representable with float64** (help wanted) - #1788, opened on Oct 25, 2017 by larkin, 3 comments.
- disable spellcheck on date fields** (help wanted) - #1682, opened on Aug 18, 2017 by larkin, 1 comment.
- Add telemetry plugin for DSN station telemetry and status** (enhancement, help wanted) - #1656, opened on Jul 25, 2017 by larkin, 8 comments.
- Remove action is available for non-editable objects** (bug, help wanted) - #1542, opened on Apr 26, 2017 by akhenry, 4 comments.
- [search] Provide a way to disable ElasticSearch from affecting Search** (help wanted) - #1399, opened on Jan 12, 2017 by charlesh88, 1 comment by Stross.
- [Fixed Position, Layouts] Better default sizing for new objects in Fixed Position views** - #1399, opened on Jan 12, 2017 by charlesh88, 5 comments.

<https://github.com/nasa/openmct>



Supporting a Community

- Be responsive to comments and questions from the community
- Friendly, supportive environment with constructive developer feedback
- Dedicate the time to support the community





Try it

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[TRY IT NOW](#)

[GET SOURCE](#)

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[GET MORE INFO](#)

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

CREATE

- Demo Objects
 - Mars Weather Display Lay...
 - Planning
 - Rover Operator Layout**
 - Example Rover
 - Mars Science Laboratory
 - My Items

UTC 2018/05/25 16:28:47 Mission Elapsed Time 431D 23:32:22

Rover Navcam 1

Battery Voltage

Value

Timestamp

16:28:40.000Z 2018-05-25

Rover Surface Operations

Title	Start	End
Rover Surface Operations	000 00:00:00	000 02:00:00
Post-landing shakedown	000 00:00:00	000 02:00:00
Lander Egress	000 02:00:00	000 03:00:00
Driving	000 03:00:00	000 03:35:22
Drilling	000 03:35:22	000 03:35:22

Resource Graph Legend

Battery Current

Value

Timestamp

Welcome to Open MCT
This brief tour will introduce you to the main elements and concepts of the application. To cancel at any time, click the 'x' in the top right of this box, or click 'Next' to continue.

[Next](#)

On Line Demo



Lessons Learned

- Supporting Open Source requires time
- Our code contributions have been of high quality on the whole
- Once a project is open-source and online you do not control the profile of the project. Someone submitted us to Reddit and we hit 20,000 visitors a day
- Substantial code contributions are made by a small number of contributors, who tend to make multiple contributions
- Help contributors to help you - documentation, tutorials
- Still a lot of work to do to improve our API, but we're making progress



Status & What's Next

- Open source is a proven means to enhance collaboration and adoption of mission operations software
- It is possible to build an “outside” community of contributors who add value to the software through contributions and feedback
- Future goals
 - Build an active community of mission contributors building on each other's work
 - Use open source as a vehicle for advancing technology