



A New Architecture for Visualization: Open Mission Control Technologies

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ESAW 2017



A New Platform

- Why a new platform?
- Capabilities
 - All of your data in one place - no more application switching
 - View your data the way you want to see it
 - Compose your data without programming
 - Web based, desktop and mobile
 - Data source integration
 - Plug in architecture for customization
 - Open Source



Open Source

- Learn about it
 - <http://nasa.github.io/openmct/>
- Try it
 - <https://openmct-demo.herokuapp.com>
- Get the code
 - <https://github.com/nasa/openmct>



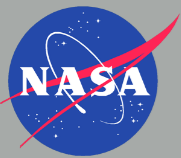
Open Source

- Enables Collaboration
 - Reduces/Eliminates ownership issues
 - Provides immediate access without restriction



Missions

- JPL
 - Mars 2020
 - Mars Science Lab (Beta Test)
 - Earth Science (evaluating)
- Ames Research Center
 - Resource Prospector Lunar Rover



All Your Data in One Place

A layout is a composition of data objects

Search your Data Objects

Browse your Data Objects

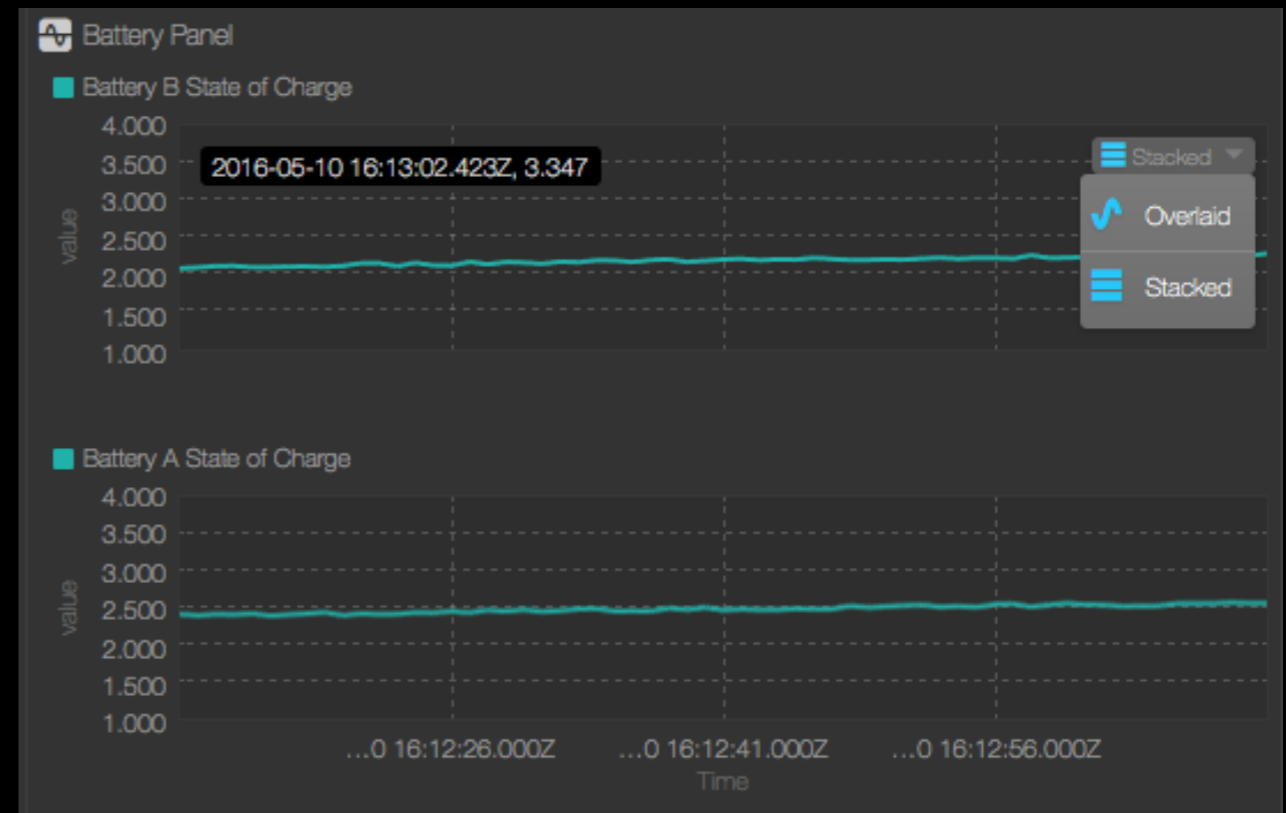
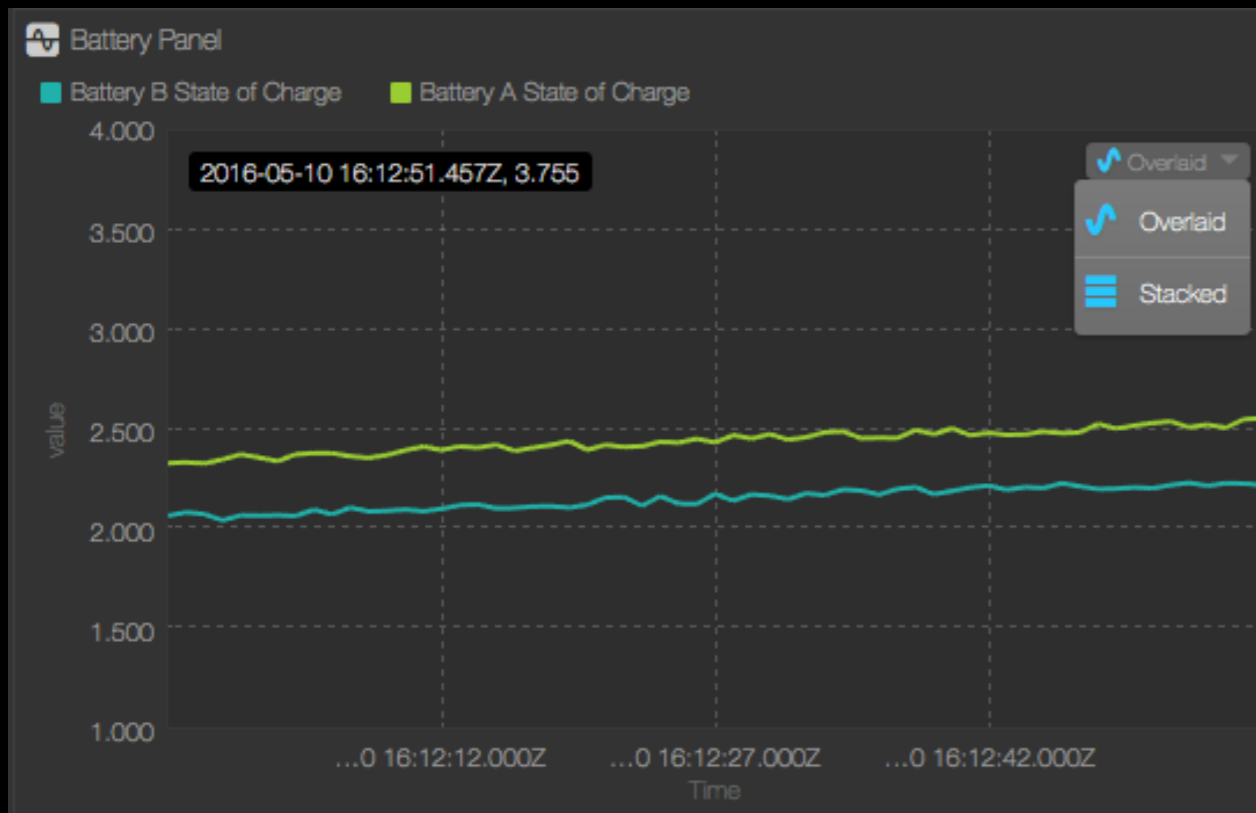
Inspect your Data Objects

The screenshot displays the NASA VISTA web interface. On the left is a navigation tree with categories like SFP, ICE, RBA, and AMMOS Shared. The main area contains several data plots: DMX-1101 - EHA_RT_PROD_CNT (a linear increase), D-1791 - DMD_SAR_READ_MEM_LOC_1 (a step function), DMX-1021 - EHA_REC_NUM_ALWAYS (a fluctuating line), D-1794 - DMD_SAR_READ_MEM_LOC_4 (another step function), and F-0840 - FSW_IDLE_SCRUB_ERR_ADDR_2 (a flat line). On the right, a table titled 'RAD' lists various data objects with columns for ID, Title, Value, and SCET. Below the plots is a timeline with a selected range from 2015-300T06:58:42.617 to 2015-300T15:39:27.246. The bottom right corner features the 'VISTA' logo.

ID	Title	Value	SCET
Power			
P-3219	PWR_RDE_SENSED	1	2016-21
State/Health			
R-3005	RAD_OP_STATE	1	2016-21
R-3047	RAD_LUT_INDEX	744	2016-21
R-3024	RAD_DATA_RATE	0	2016-21
D-2199	DMD_UNSENT_RAD_DATA	14448	2016-21
R-0034	RAD_STM_WORD2_WORD3	506672470	2016-21
R-0236	RAD_RFE_PDU_15V_NEG_CURRENT	-0.08712095022201538	2016-21
R-0224	RAD_PDU_RDE_5_I_P	1.7924302816390991	2016-21
R-0249	RAD_DPU_3_3V_DIG_VOLTAGE	3.3047077655792236	2016-21
R-0238	RAD_RBE_PDU_13_5V_CURRENT	0.6470695734024048	2016-21
Universal			
R-0019	RAD_SEQUENCE_AND_MASTER_FLAGS	33024	2016-21
R-0027	RAD_RPM_COUNTER	17511	2016-21
Temps			
R-0175	RAD_HPOL_MIXER_TEMP	13.13481330871582	2016-21
A-0039	ICE_RFE_TEMP_5	23.01238854264858	2016-21
R-0134	RAD_RFE_CTRL_BRD_TEMP	25.499784469604492	2016-21
R-0140	RAD_RFE_1_MID_RANGE_TEMP	20.239271205731335	2016-21
R-0143	RAD_RFE_2_MID_RANGE_TEMP	20.148954848773155	2016-21
R-0146	RAD_RFE_3_MID_RANGE_TEMP	19.950138252678272	2016-21
A-0033	ICE_RBE_RDE_TEMP_1	15.33680941141958	2016-21
A-0043	ICE_RBE_RDE_TEMP_2	14.811549724013275	2016-21
ICE			
ICE/SIM			
A-0117	ICE_STATE		
A-0001	ICE_ERROR_FLAGS		
A-0002	ICE_CMD_ECHO		
RBA			
A-0003	ICE_RBA_BOOM_MOT_PHASE		



View as you want it





Composition - Create

A screenshot of a software interface showing a 'CREATE' menu. The menu is open, displaying a list of options. The background is a light gray, and the menu items are listed in a white box with a blue header. The header contains a plus sign, the word 'CREATE', and a dropdown arrow. The menu items are: Folder, Display Layout, Web Page, Historical Telemetry Table, Real-time Telemetry Table, Overlay Plot, Stacked Plot, Data Set, LAD Table, LAD Table Set, and Data Table.

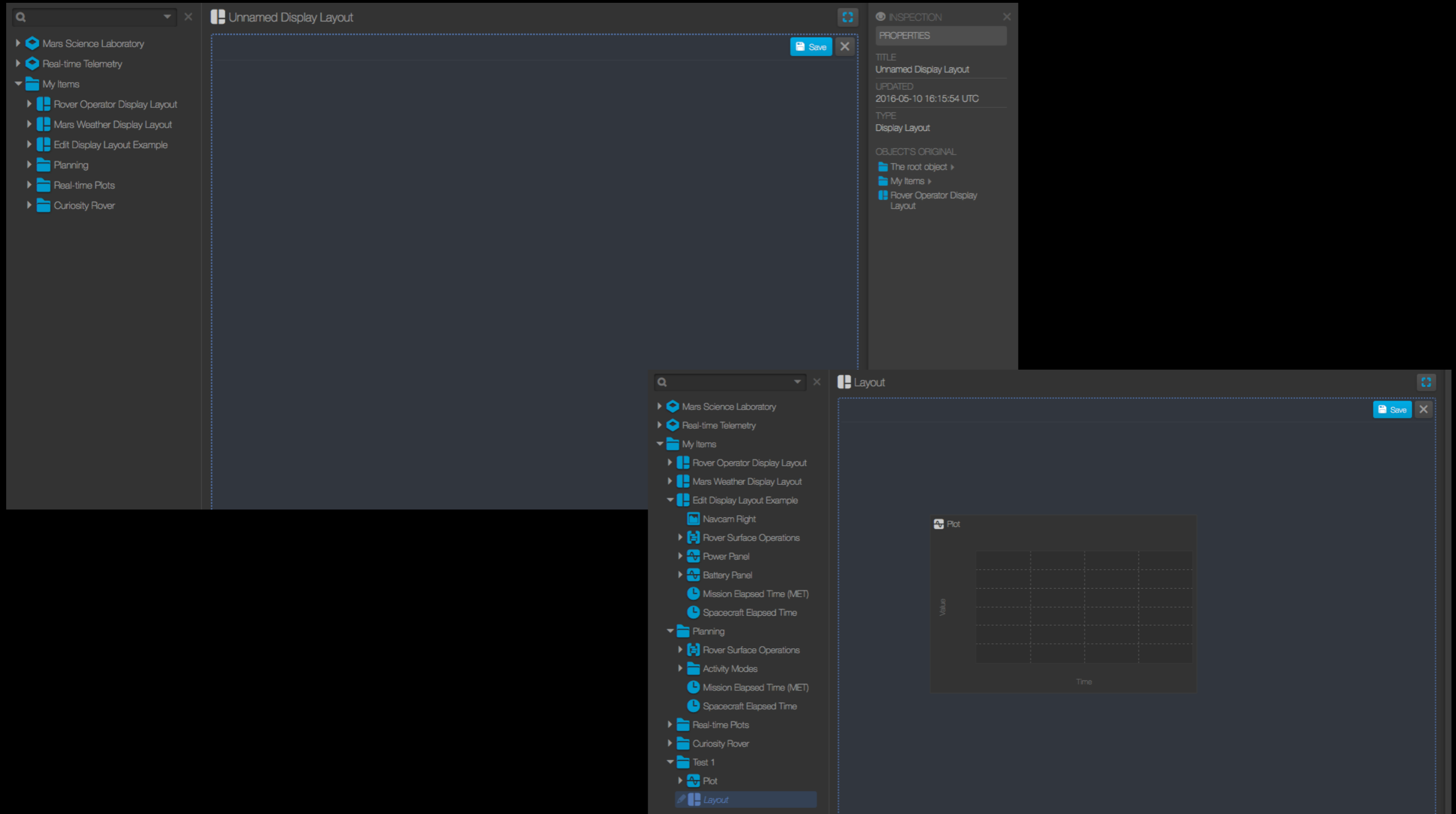
- Folder
- Display Layout
- Web Page
- Historical Telemetry Table
- Real-time Telemetry Table
- Overlay Plot
- Stacked Plot
- Data Set
- LAD Table
- LAD Table Set
- Data Table

A screenshot of a software interface showing a 'Create' menu. The menu is open, displaying a list of options. The background is a dark gray, and the menu items are listed in a white box with a blue header. The header contains a plus sign, the word 'Create', and a dropdown arrow. The menu items are: Web Page, Example Imagery, Event Message Generator, Sine Wave Generator, Clock, Timer, Folder, Display Layout, Telemetry Panel, Timeline, Activity, and Activity Mode.

- Web Page
- Example Imagery
- Event Message Generator
- Sine Wave Generator
- Clock
- Timer
- Folder
- Display Layout
- Telemetry Panel
- Timeline
- Activity
- Activity Mode

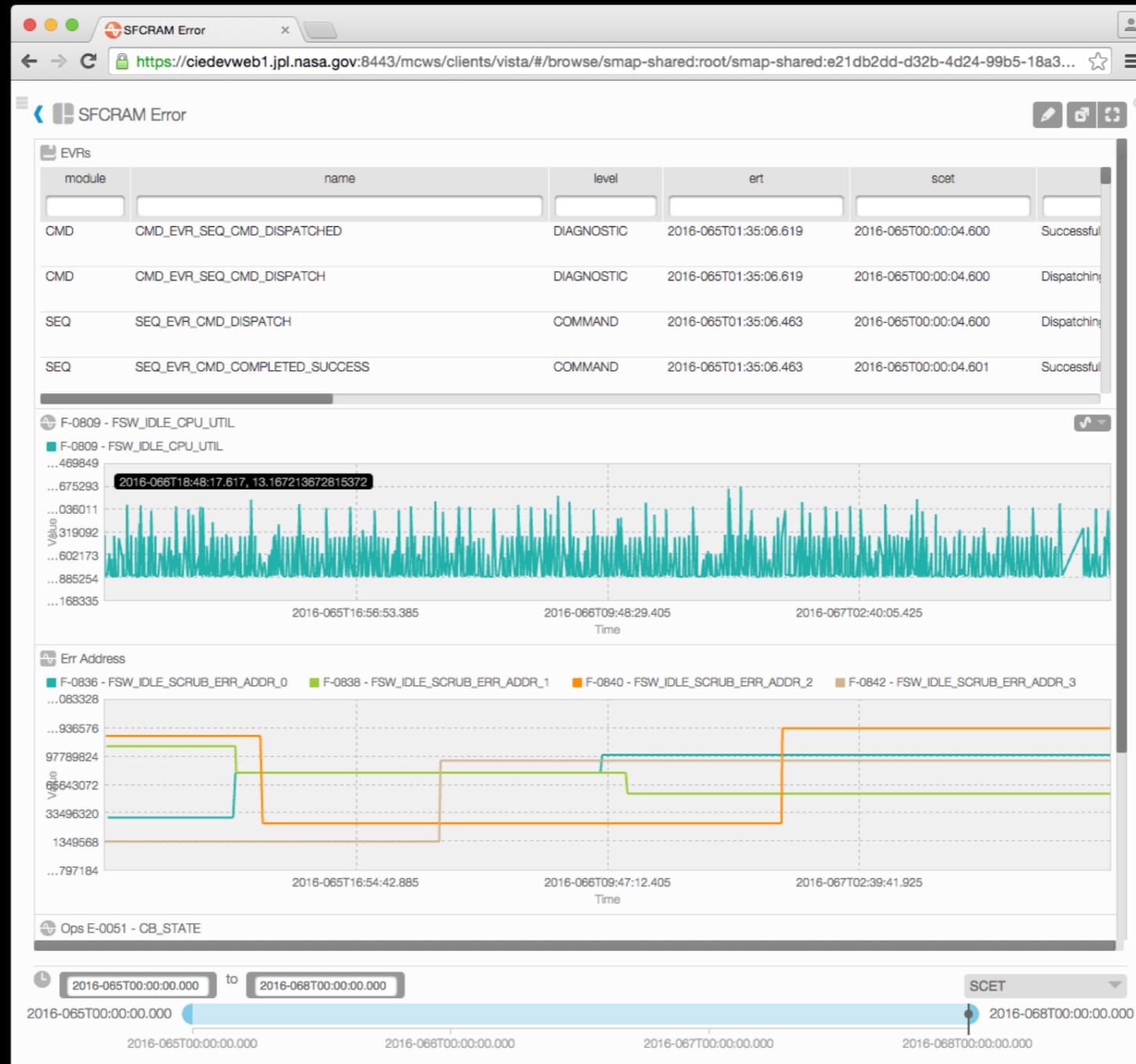


Compose in Layouts



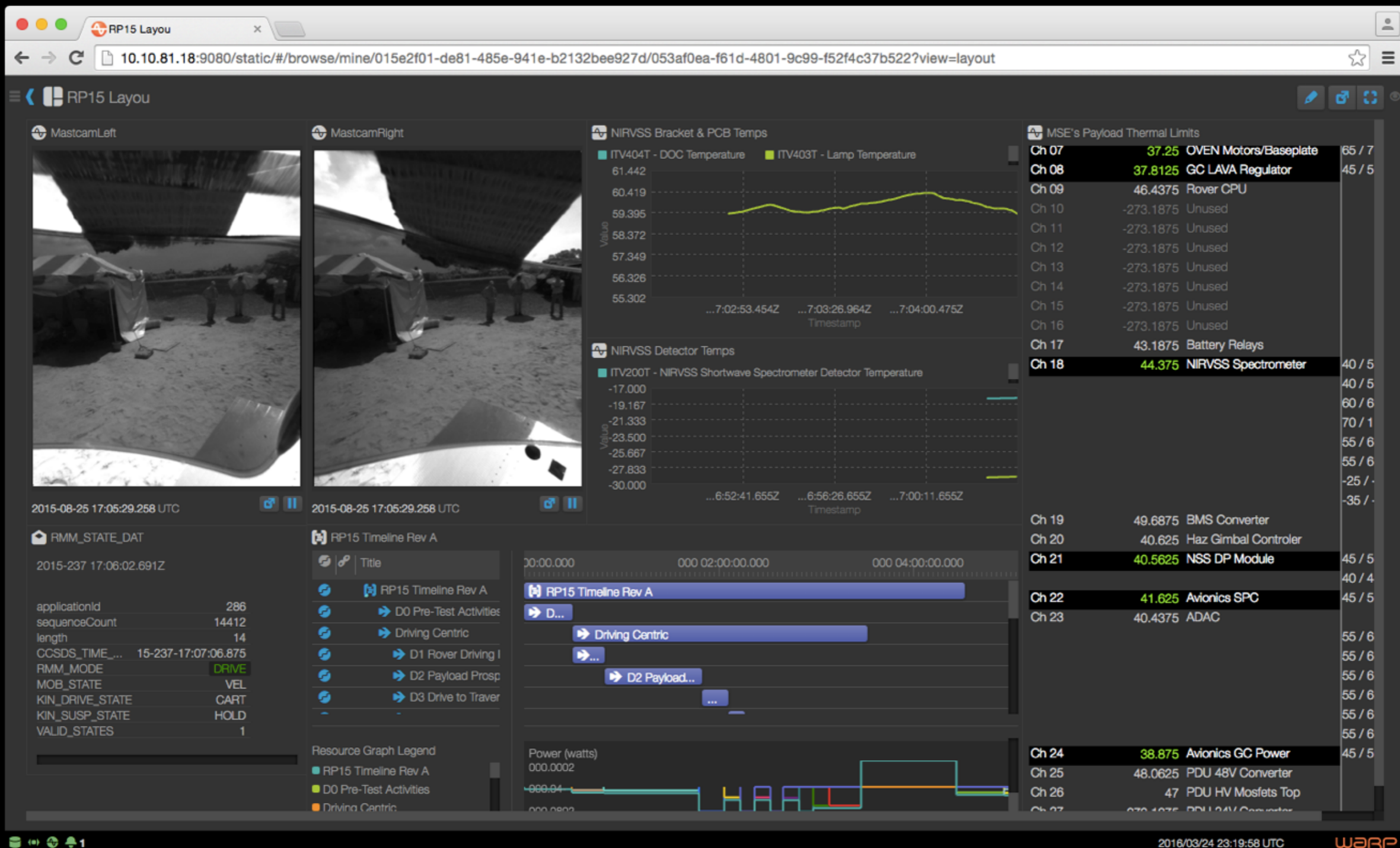


Mars Science Lab Composition (JPL)





Resource Prospector Composition (ARC)





On the Desktop



Browser window showing a 'Power Layout' page. The address bar contains the URL: <https://10.10.81.18:10080/static/index.html#/browse/mine/67a5522d-139e-40b6-812b-04e00a702b32/3a3169b2-be00-462e-9217-bc49b3d92d10?vie...>. The browser tabs include 'Apps', 'Bookmarks', 'WebTADS', 'WebEx', 'SpaceOps Abstract', 'OpenMCTWeb', 'VISTA', 'WARP SNRF', 'RP Ops Wiki', and 'UI WARP v1.5.2.2'. The browser interface also shows a search bar and navigation icons.

Display Layout Power Layout

2015-233 17:16:50.796Z

applicationId	816	ch6_unused	OFF	Cameras	ON	f_susp_log1	OK
sequenceCount	9776	ch5_unused	OFF	ch39_unused	OFF	f_wireless	OK
length	45	imu	ON	ch38_unused	OFF	f_nav_lights	OK
cosds_time_816	15-233-17:17:54.980	ch3_unused	OFF	Drill	OFF	f_haz_lights	OK
ant_ptu	ON	imu_por_rel	ON	NSS	ON	f_ch6_unused	OK
rover_cpu	ON	ch1_unused	OFF	payload_ADAC	ON	f_ch5_unused	OK
llm_4	OFF	ch64_unused	OFF	hazcam_ptu	ON	f_imu	OK
llm_3	OFF	ch63_unused	OFF	navcam_ptu	ON	f_ch3_unused	OK
llm_2	OFF	ch62_unused	OFF	f_ant_ptu	OK	f_imu_por_rel	OK
llm_1	OFF	ch61_unused	OFF	f_rover_cpu	OK	f_ch1_unused	OK
mast_erm	OFF	ch60_unused	OFF	f_llm_4	OK	f_ch64_unused	OK
estop_rcvr	ON	ch59_unused	OFF	f_llm_3	OK	f_ch63_unused	OK
CameraMgr	ON	ch58_unused	OFF	f_llm_2	OK	f_ch62_unused	OK
struc_light2	ON	ch57_unused	OFF	f_llm_1	OK	f_ch61_unused	OK
struc_light1	ON	ch56_unused	OFF	f_mast_erm	OK	f_ch60_unused	OK
prop_log4	ON	ch55_unused	OFF	f_estop_rcvr	OK	f_ch59_unused	OK
steer_log4	ON	prop_motor4	ON	f_CameraMgr	OK	f_ch58_unused	OK
susp_log4	ON	steer_motor4	ON	f_struc_light2	OK	f_ch57_unused	OK
prop_log3	ON	susp_motor4	ON	f_struc_light1	OK	f_ch56_unused	OK
steer_log3	ON	prop_motor3	ON	f_prop_log4	OK	f_ch55_unused	OK
susp_log3	ON	steer_motor3	ON	f_steer_log4	OK	f_prop_motor4	OK
prop_log2	ON	susp_motor3	ON	f_susp_log4	OK	f_steer_motor4	OK
steer_log2	ON	ch48_unused	OFF	f_prop_log3	OK	f_susp_motor4	OK
susp_log2	ON	prop_motor2	ON	f_steer_log3	OK	f_prop_motor3	OK
prop_log1	ON	steer_motor2	ON	f_susp_log3	OK	f_steer_motor3	OK
steer_log1	ON	susp_motor2	ON	f_prop_log2	OK	f_susp_motor3	OK
susp_log1	ON	prop_motor1	ON	f_steer_log2	OK	f_ch48_unused	OK
wireless	ON	steer_motor1	ON	f_susp_log2	OK	f_prop_motor2	OK
nav_lights	ON	susp_motor1	ON	f_prop_log1	OK	f_steer_motor2	OK
haz_lights	ON	ch41_unused	OFF	f_steer_log1	OK	f_susp_motor2	OK

BMS VOLTAGE Batt SOC

@JPL

@ARC



Mobile

9:41 AM 10.10.81.184 100%

Display Layout Gimbals

- NAVCMPT_STATUS_DAT

applicationId	395
sequenceCount	7929
length	33
ccsds_time_395	15-233-16:01:30.080
azimuth	-0.5323254
tilt_pos	0
pan_pos	0
tilt_vel	0
pan_vel	0
tilt_enable	1
pan_enable	1
pan_home	1
tilt_home	1
active	0
at_target	0
- NAVCAMIO_DAT

applicationId	330
sequenceCount	15550
length	29
ccsds_time_330	15-233-16:01:29.906
pan_pos	0
tilt_pos	0
pan_vel	0
tilt_vel	0
pan_enable	1
tilt_enable	1
pan_home	1
tilt_home	1
- HAZCAMPT_STATUS_DAT

applicationId	
sequenceCount	
length	
ccsds_time_390	15-233-16:01:29.906
azimuth	-0.5323254
tilt_pos	0
pan_pos	0
tilt_vel	0
pan_vel	0
tilt_enable	1
pan_enable	1
pan_home	1
tilt_home	1
active	0
at_target	0

MastcamLeft MastcamRight

2015-08-21 15:59:50.810 UTC 2015-08-21 15:59:50.810 UTC

2015/08/21 16:00:15 UTC CONNECTED CONNECTED STREAMING

iPad

10:05 AM 66%

https://192.168.1.107:10080/static/index.html#/browse/mir

Display Layout Battery

- Rover Mode

rmm_mode	SAFE
mob_state	STOP
kin_drive_state	OFF
kin_susp_state	OFF
Estop	0.000
Pitch	0.039 rad
Roll	-0.023 rad
Ride Ht	0.346 m
Tim Filter	to_highrate.tbl(*)
Data Rate	BAU... 900000.000
- Battery SOC

STATE_OF_CHARGE	1593.000
MIN_CELL_VOLTAGE	2.000
MAX_CELL_VOLTAGE	3.000
AVG_CELL_VOLTAGE	4.000
- BMSIO_DATA_DAT

applicationId	
sequenceCount	
length	
timeStamp	
CONTROL_EN	
ARM_FIRE_DEBUG	
MANUAL_BALANCING_EN	
ARM_FIRE_BALANCING	
- BMSIO_DETAIL_DAT

applicationId	961	CELL_VOLT_S3_C2	998	CELL_TEMP_S1_C05	364
sequenceCount	1880	CELL_VOLT_S3_C3	998	CELL_TEMP_S1_C06	359
length	229	CELL_VOLT_S3_C4	998	CELL_TEMP_S1_C07	359

2015/08/21 15:05:14 UTC CONNECTED CONNECTED STREAMING

WARP

Phone



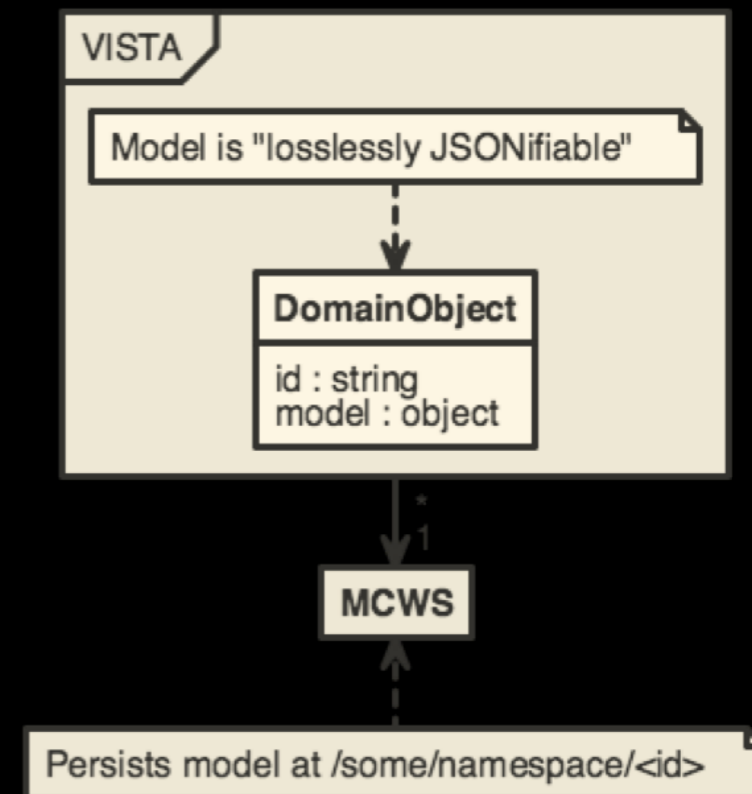
Architecture

- JavaScript
- HTML and CSS
- Domain Objects
 - Identifier, Model, Dynamic Behavior
- Views



Persistence

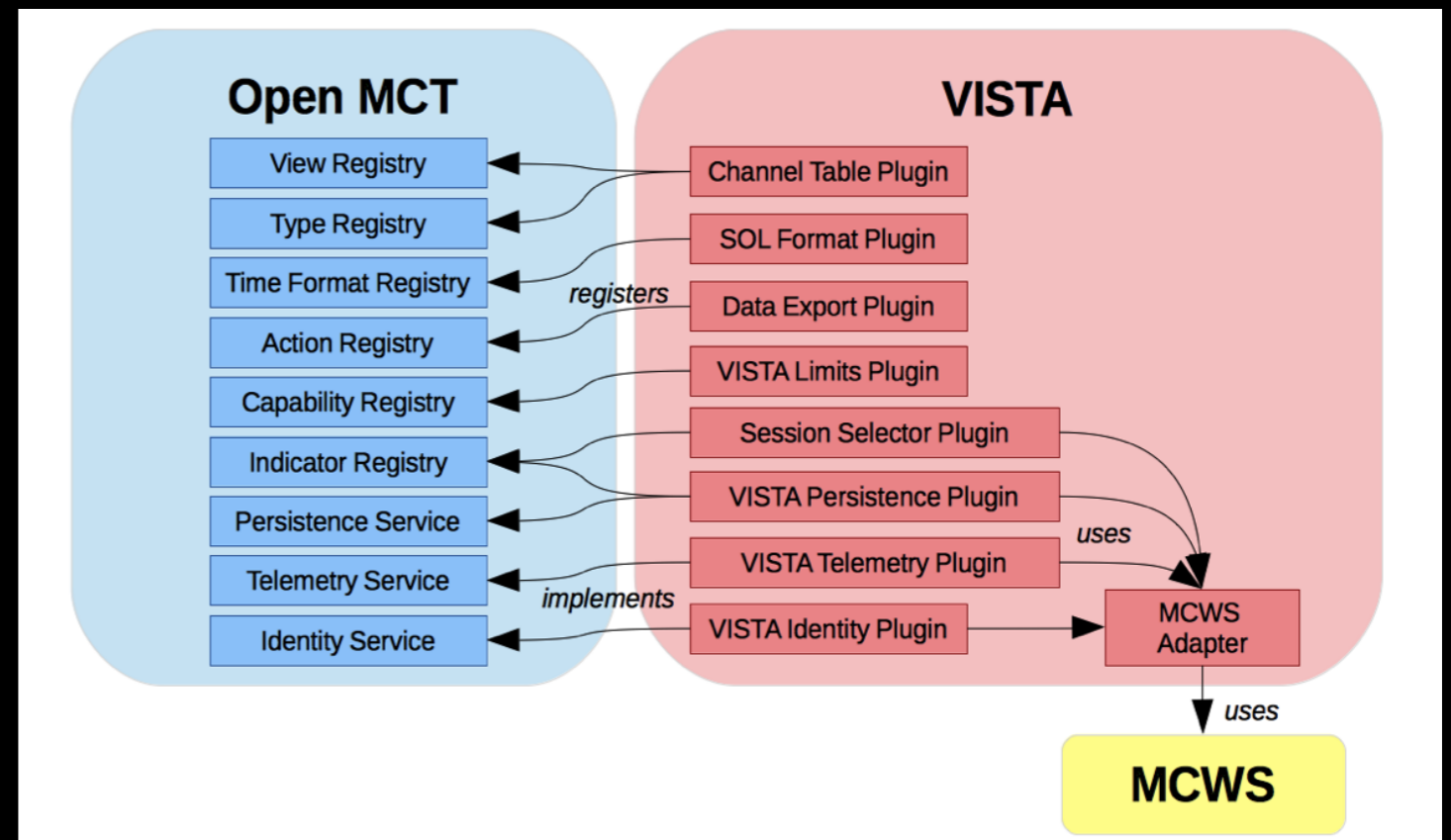
- User created objects stored as JSON documents on mission control web services (MCWS) at JPL





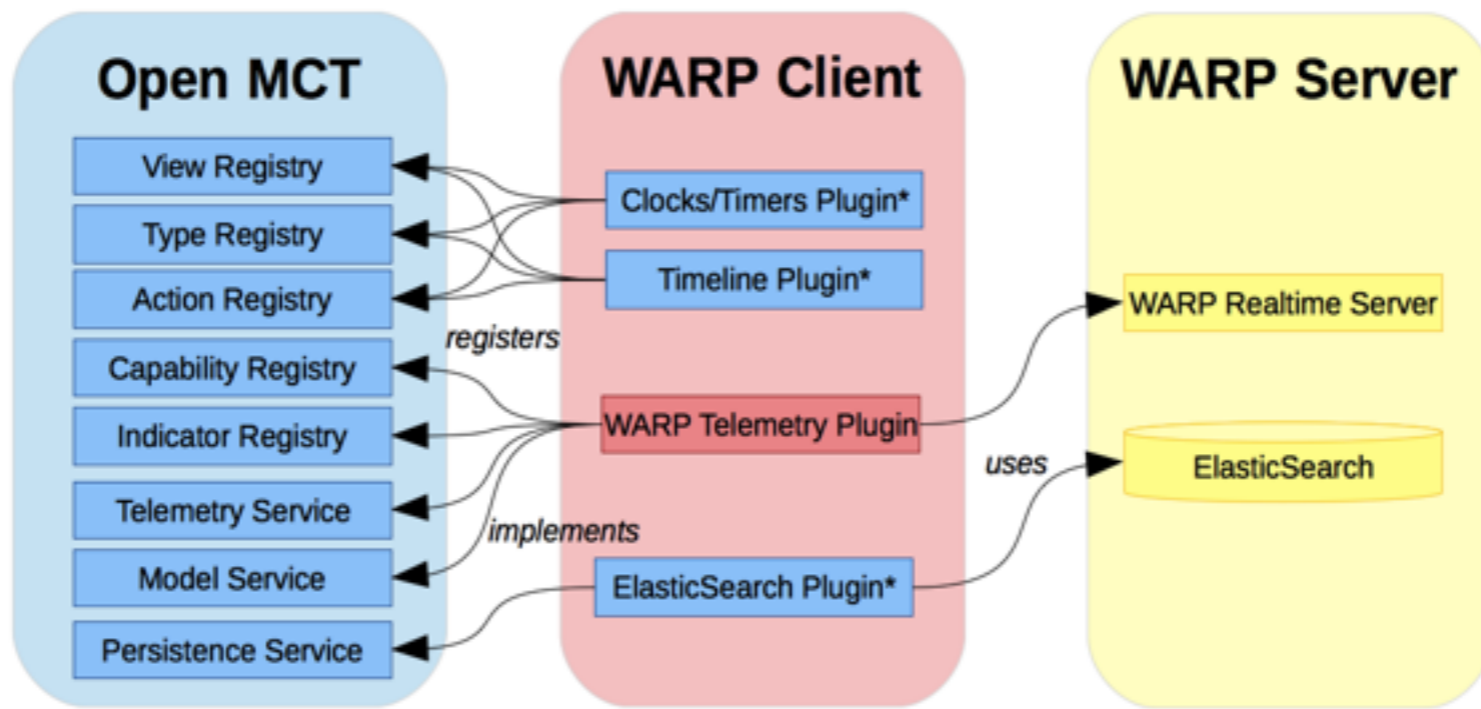
Mission Adapters JPL

- Open MCT integrates with mission data sources via adapter plug ins
- Adapters handle requests for real-time subscriptions and/or historical queries
- Views initiate requests for the data they will display, Open MCT Mediates
- Plug in mechanism avoided coupling to specific server side data





Mission Adapters ARC

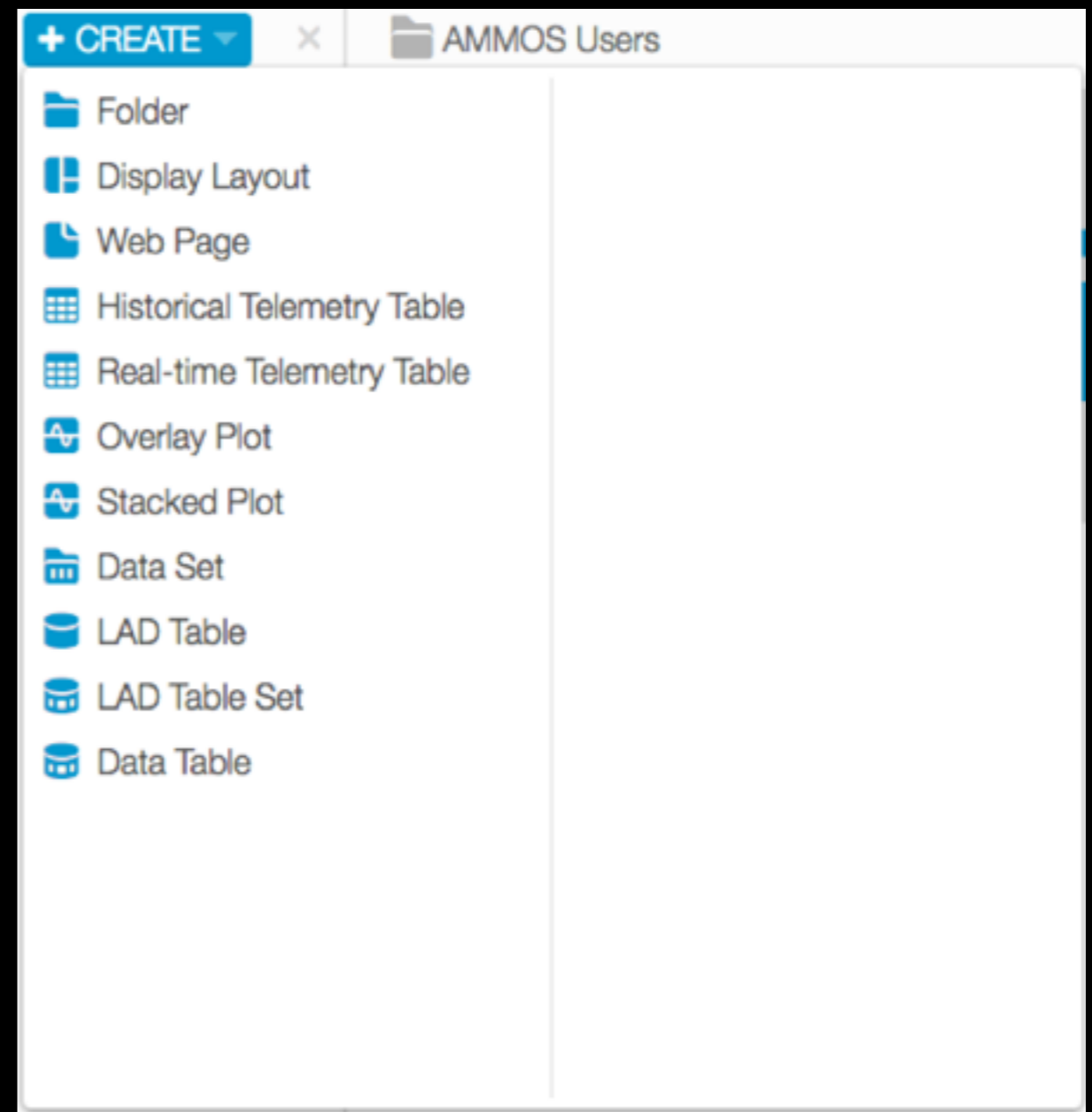


* Optional plugins included with Open MCT, used by WARP.



VISTA Objects

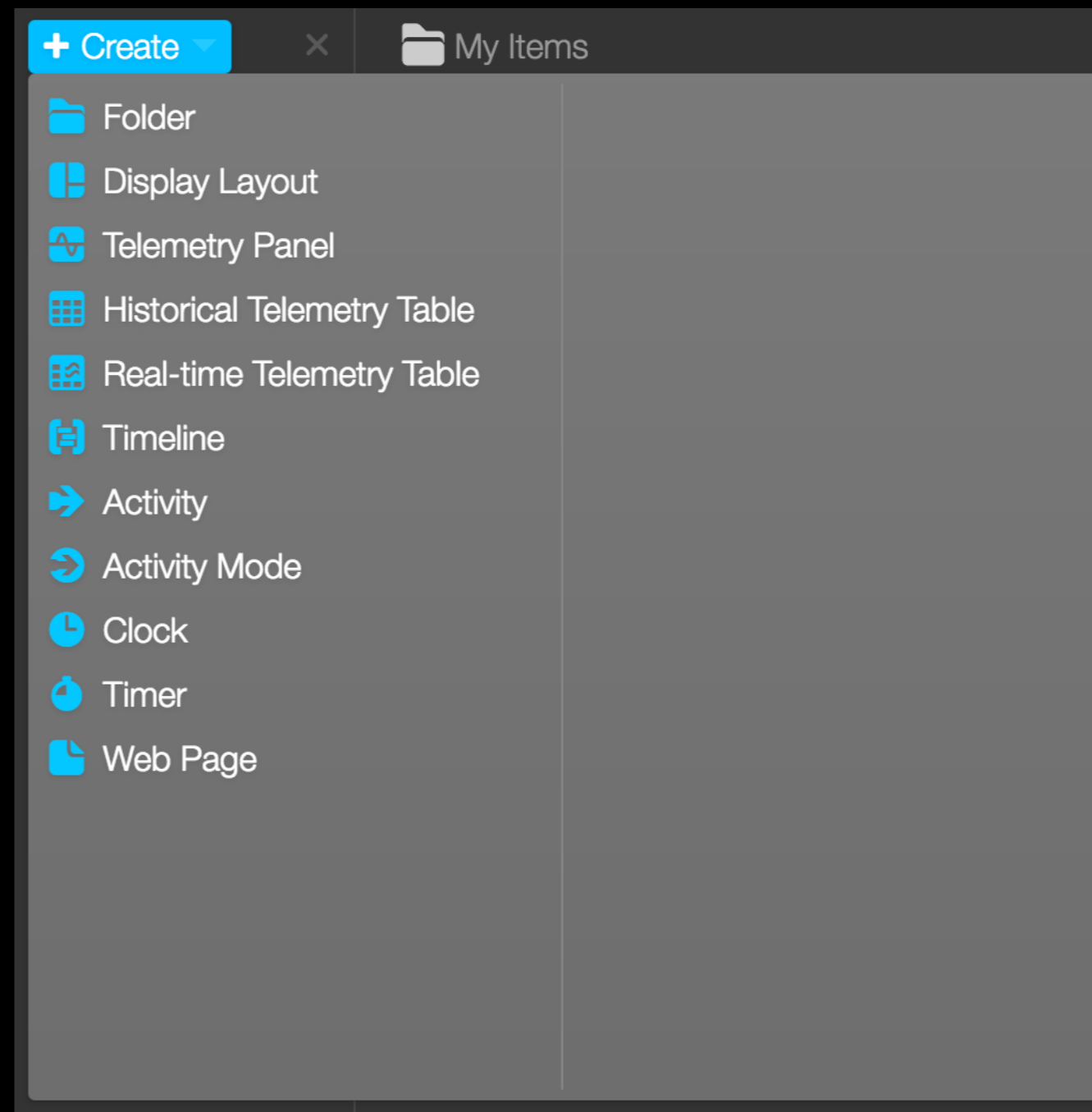
- VISTA is Open MCT customized by plugins
- Customized for the JPL Mission Domain
- More objects on the way





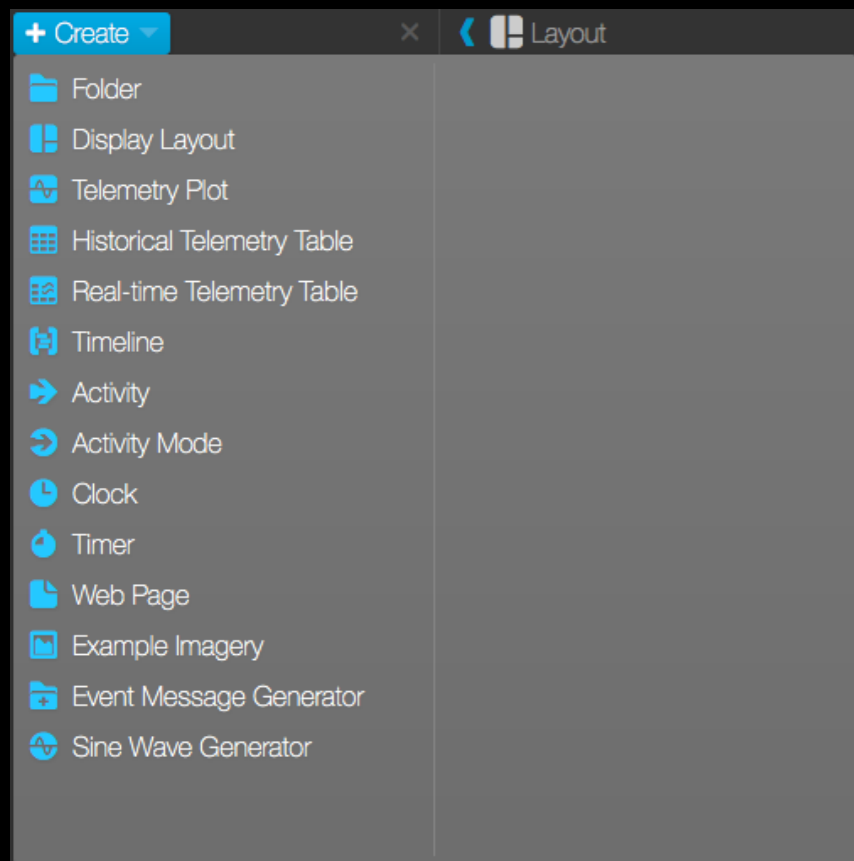
WARP Objects

- WARP is Open MCT, customized by plug ins
- Deployed at ARC

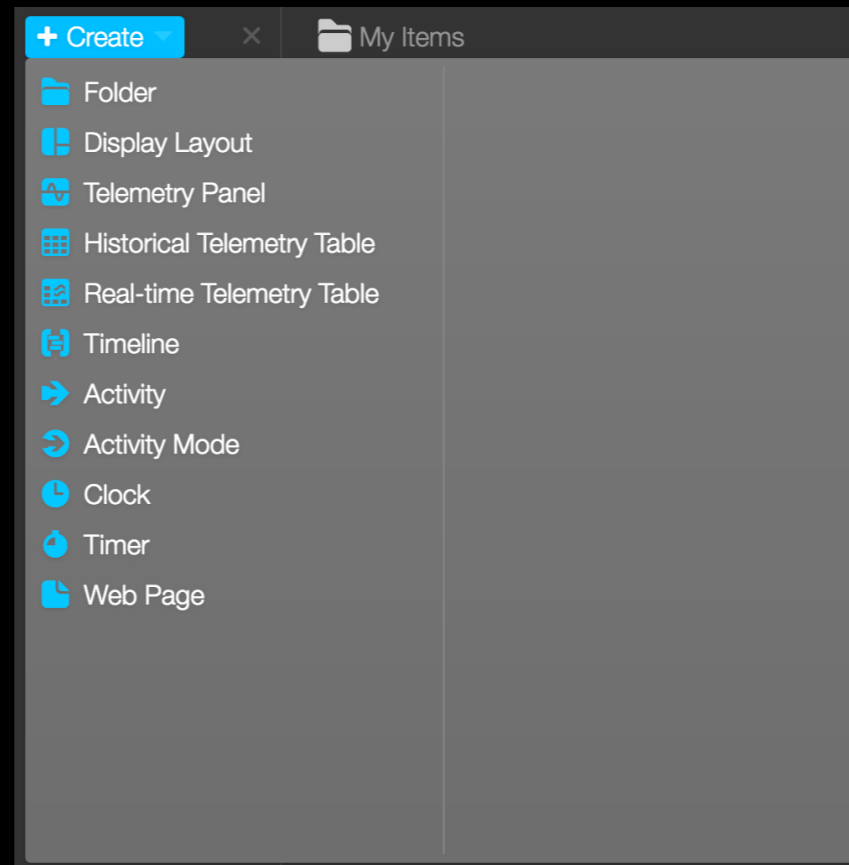




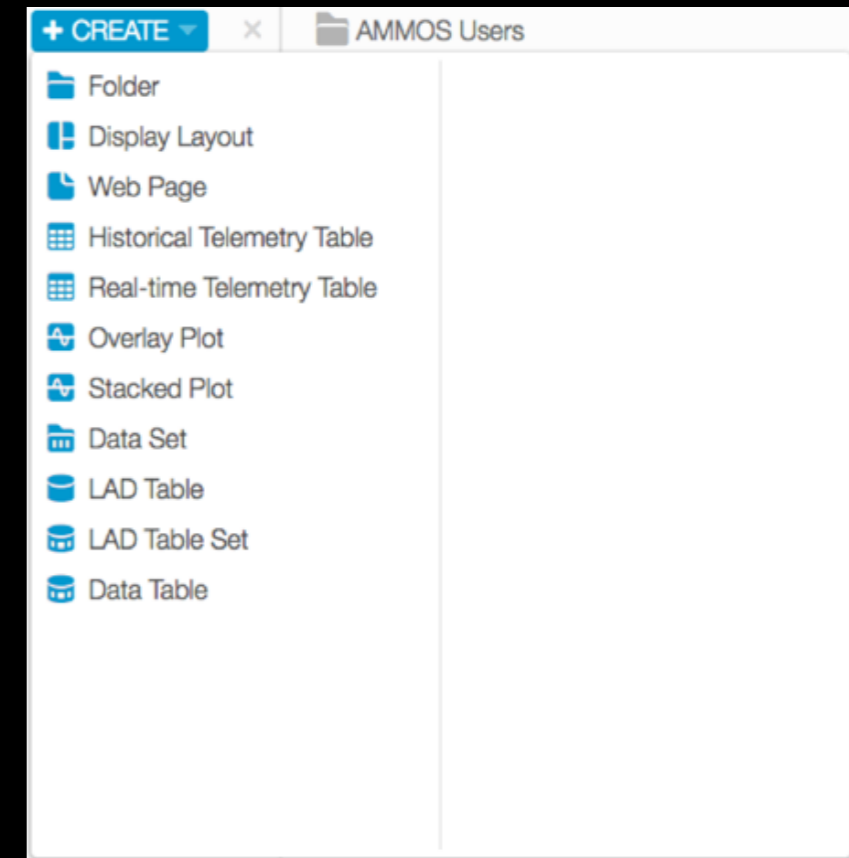
Compare



Open



WARP



VISTA



WARP Objects

+ Create

- Web Page
- Example Imagery
- Event Message Generator
- Sine Wave Generator
- Clock
- Timer
- Folder
- Display Layout
- Telemetry Panel
- Timeline
- Activity
- Activity Mode

My Items

2015-08-25 16:57:44.457 UTC

RMM_STATE_DAT

2015-237 16:58:13.591Z

applicationId	266
sequenceCount	9262
length	14
CCSDS_TIME...	15-237-16:59:17.775
RMM_MODE	DRIVE
MOB_STATE	WAYPT
KIN_DRIVE_STATE	CART
KIN_SUSP_STATE	HOLD
VALID_STATES	1

RP15 Layout

10.10.81.18:9080/static/#/browse/?view=layout

The interface displays two camera feeds of the rover's wheels. To the right, there are two graphs: 'ITV404T - DOC Temperature' and 'ITV403T - Lamp Temperature', both showing values between 42 and 58. Below these is a 'NIRVSS Detector Temps' graph. On the far right, a 'Rover Sensor Temperatures' table lists 23 channels with their current values and limits.

Channel	Value	Limit
Ch 01	50.0625	28V Converter Top
Ch 02	-273.1875	28V Converter Bottom
Ch 03	49.375	28V Converter Middle
Ch 04	44.9375	Cam Man Converter
Ch 05	40	System Current Sense
Ch 06	40.875	Drill Avionics
Ch 07	37	OVEN Motors/Baseplate
Ch 08	37.1875	GC LAVA Regulator
Ch 09	45.625	Rover CPU
Ch 10	-273.1875	Unused
Ch 11	-273.1875	Unused
Ch 12	-273.1875	Unused
Ch 13	-273.1875	Unused
Ch 14	-273.125	Unused
Ch 15	-273.1875	Unused
Ch 16	-273.1875	Unused
Ch 17	42.75	Battery Relays
Ch 18	44.125	NIRVSS Spectrometer
Ch 19	49.375	BMS Converter
Ch 20	40.0625	Haz Gimbal Controller
Ch 21	39.8125	NSS DP Module
Ch 22	41.0625	Avionics SPC
Ch 23	40	ADAC

RP15 Timeline Rev A

- D0 Pre-Test Activities
 - Driving Centric
 - D1 Rover Driving Prep
 - D2 Payload Prospecting Prep
 - D3 Drive to Traverse Large
- D4 T...

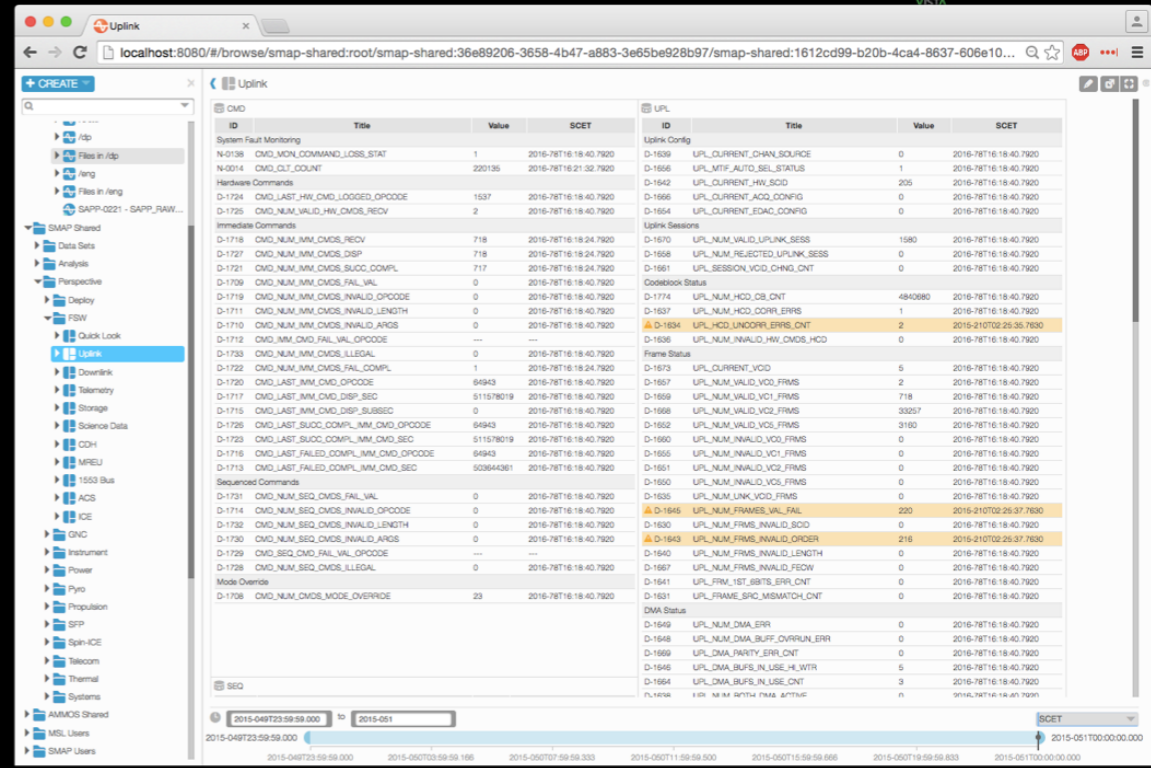
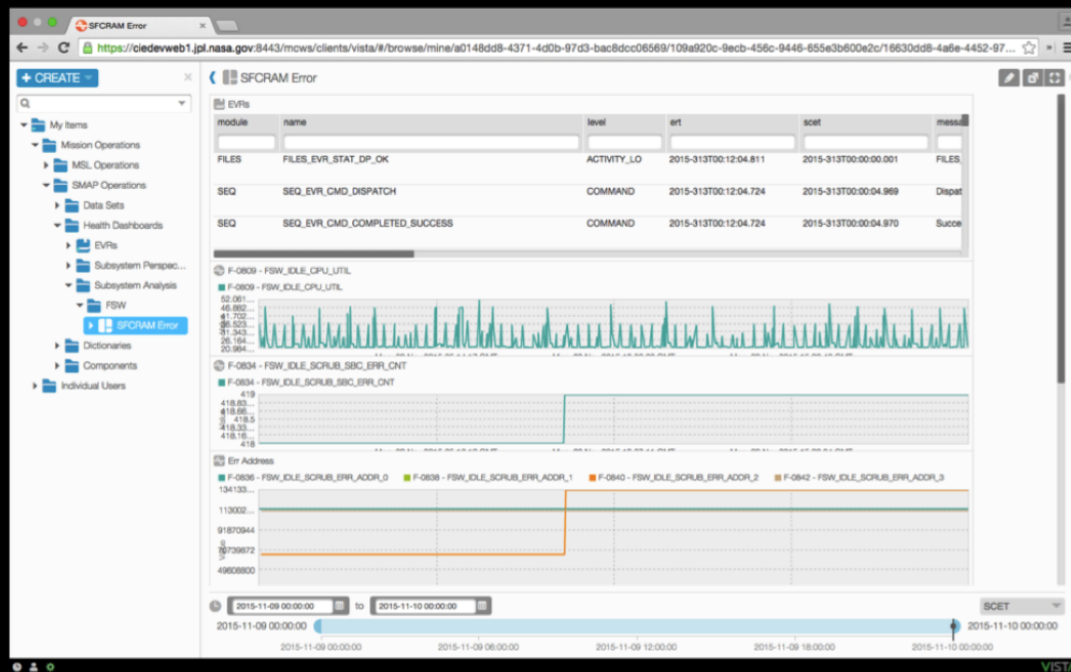
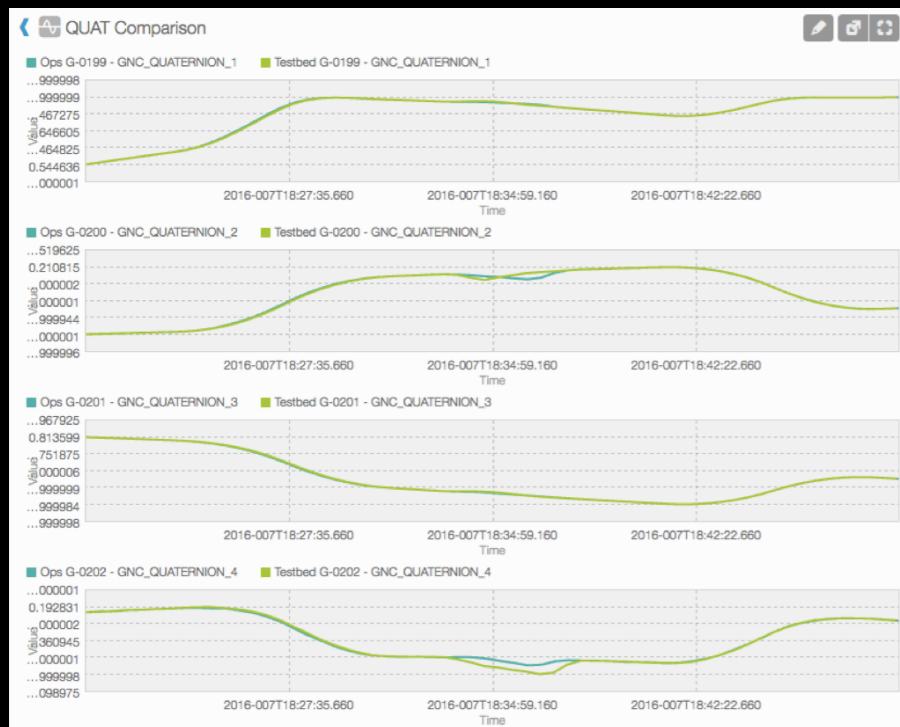
Resource Graph Legend

Power (watts)





VISTA at JPL





Mobile WARP for Rover Ops

Mobile WARP interface screenshot showing a web browser with the URL `https://192.168.1.107:10080/static/index.html#/browse/mir`. The interface displays a sidebar with a file tree under "My Items" and a main panel titled "Display Layout Battery".

Display Layout Battery

Rover Mode		Battery SOC		BMSIO_DATA_DAT	
rmm_mode	SAFE	STATE_OF_CHARGE	1593.000	No updates	
mob_state	STOP	MIN_CELL_VOLTAGE	2.000	applicationId	
kin_drive_state	OFF	MAX_CELL_VOLTAGE	3.000	sequenceCount	
kin_susp_state	OFF	AVG_CELL_VOLTAGE	4.000		
Estop 0.000					
Pitch	0.039 rad				
Roll	-0.023 rad				
Ride Ht	0.346 m				
Tim Filter	to_highrate.tbl(*)				
Data Rate	BAU... 900000.000				
BMSIO_DETAIL_DAT					
2015-233 15:05:14.797Z					
applicationId	961	CELL_VOLT_S3_C2			
sequenceCount	1880	CELL_VOLT_S3_C3			
length	229	CELL_VOLT_S3_C4			

2015/08/21 15:05:14 UTC CONNECTED CONNECTED STREAMING

