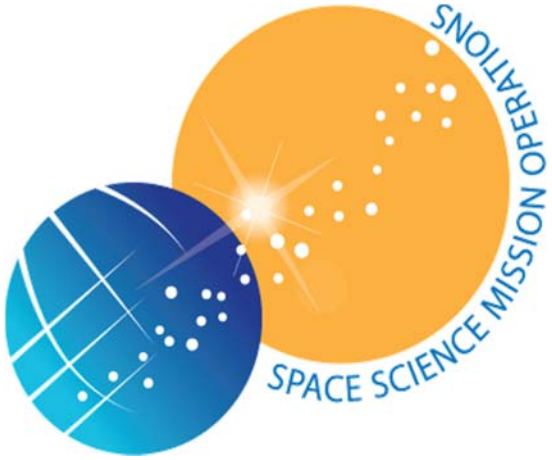
The Virtualized Multi-Mission Operations Center (vMMOC)

and its

Cloud Services



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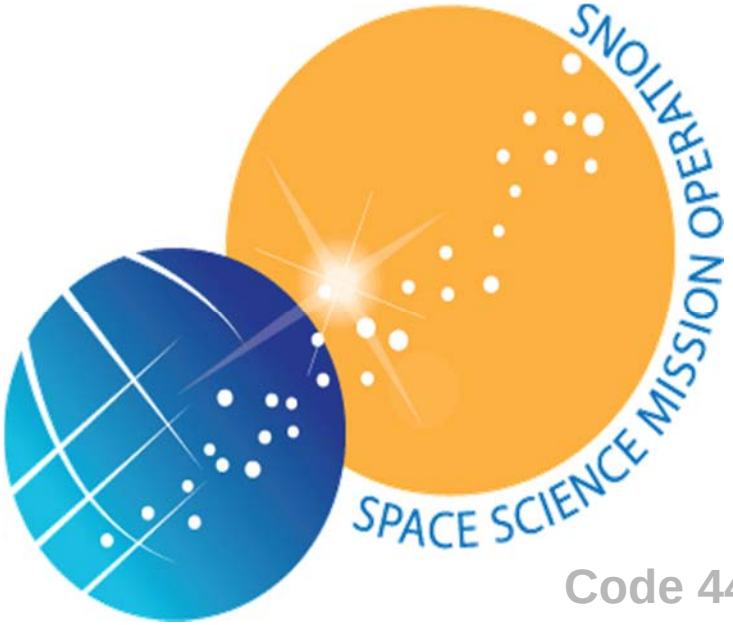
Objective of Presentation

- **What is Space Science Mission Operations (SSMO)?**
- **What is the vMMOC?**
- **Available vMMOC Services**
- **“Looking Beyond the Horizon”**

What is Space Science Mission Operations (SSMO)?



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What is Space Science Mission Operations (SSMO)?

- **SSMO** provides project oversight for 19 NASA *space science* missions for which *GSFC* is responsible

- **SSMO** has a diverse set of missions:
  - heritage/launch date
  - orbit regime
  - spacecraft bus type
  - mission profile
  - communication networks
  - In-house and Out of House Mission Operations Centers (MOCs)

SSMO Spacecraft in Operations

Mission	Launch Year	MOC Location	Science Type	# s/c	Orbit Regime	Catalog #
ACE	1997	GSFC	Heliophysics	1	L1	N/A
AIM	2007	LASP	Heliophysics	1	LEO	31304
ARTEMIS*	2007	UC Berkeley	Heliophysics	2	P1, lunar orbit; P2, Lunar Lagrange Point 1	30581, 30582
Fermi	2008	GSFC	Astrophysics	1	LEO	33053
IBEX	2008	Orbital	Heliophysics	1	HEO (T = 9 days)	33401
IRIS	2013	ARC	Heliophysics	1	LEO	
LRO	2009	GSFC	Planetary (Lunar)	1	Lunar Orbit	N/A
MAVEN	2013	LM - Denver	Planetary	1	Mars Orbit	N/A
MMS	2015	GSFC	Heliophysics	4	HEO	40482, 40483, 40484, 40485
OSIRIS-REx	2016	LM-Denver	Planetary	1	Heliocentric	N/A
Van Allen Probes (RBSP)	2012	APL	Heliophysics	2	HEO	38752, 38753
RHESSI	2002	UC Berkeley	Heliophysics	1	LEO	27370
SDO	2010	GSFC	Heliophysics	1	GEO	36395
SOHO**	1995	GSFC	Heliophysics	1	L1	n/a
STEREO	2006	APL	Heliophysics	2	Heliocentric	n/a
Swift	2004	Penn State	Astrophysics	1	LEO	28485
THEMIS	2007	UC Berkeley	Heliophysics	3	HEO	305880, 30584, 30585
TIMED	2001	APL	Heliophysics	1	LEO	26998
WIND	1994	GSFC	Heliophysics	1	L1	n/a

What is the virtualized Multi-Mission Operations Center (vMMOC)?

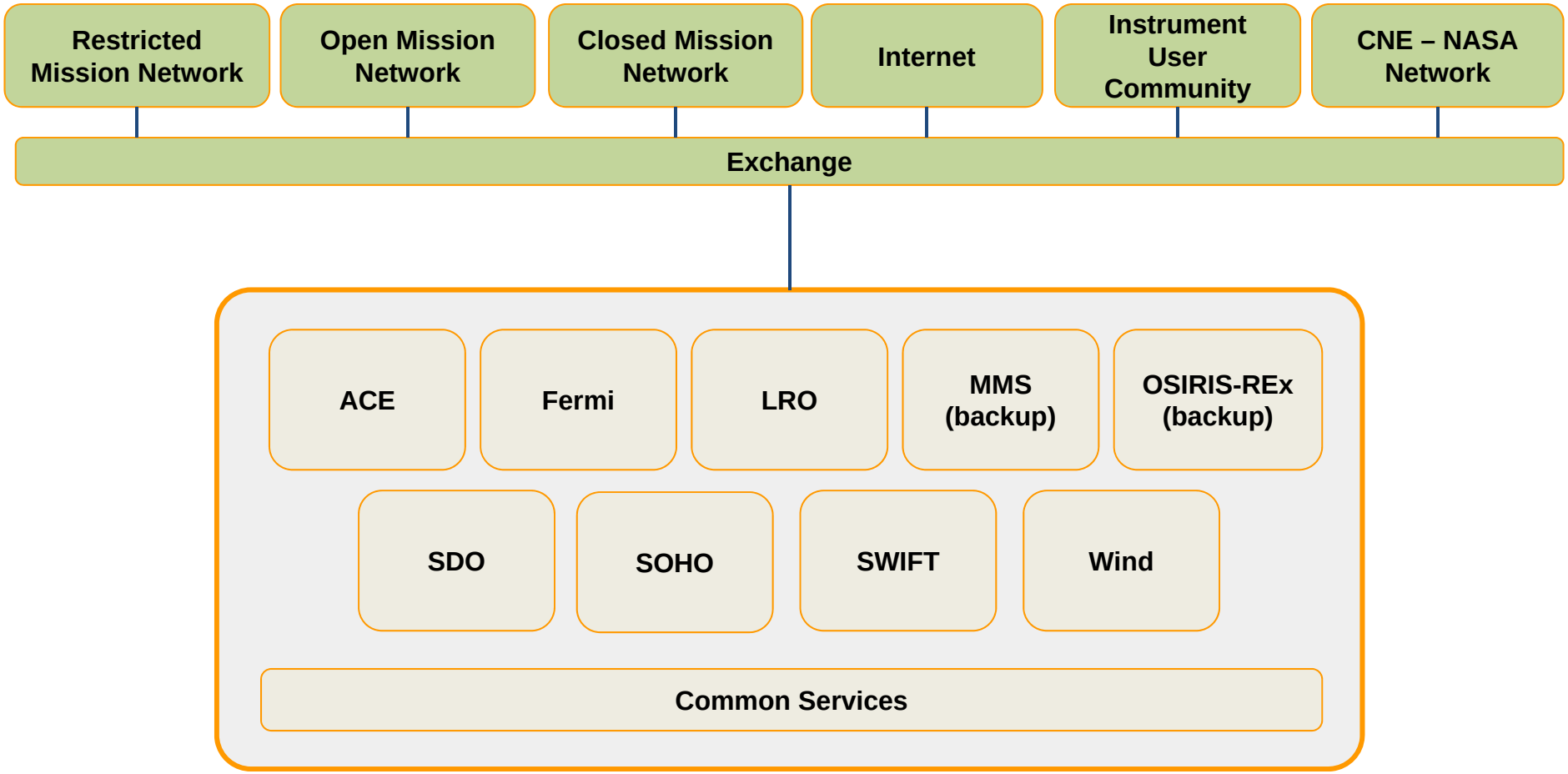
The vMMOC's Objectives are ...

- *Rapid and efficient provisioning and orchestration of spacecraft mission operation environments.*
- *Break the barrier to mission operations and enhance accessibility*

What is the vMMOC?

- **Multiple-missions Operated from one center**
- **Local virtualized infrastructure**
- ***Access* to a secure public cloud computing infrastructure**
- **Situational Awareness Dashboard (a SaaS)**
- **Telemetry as a Service (TaaS)**
  - **Soon to be *Telemetry, and Tracking as a Service* (TTaaS)**
- **Navigation as a Service (NaaS)**

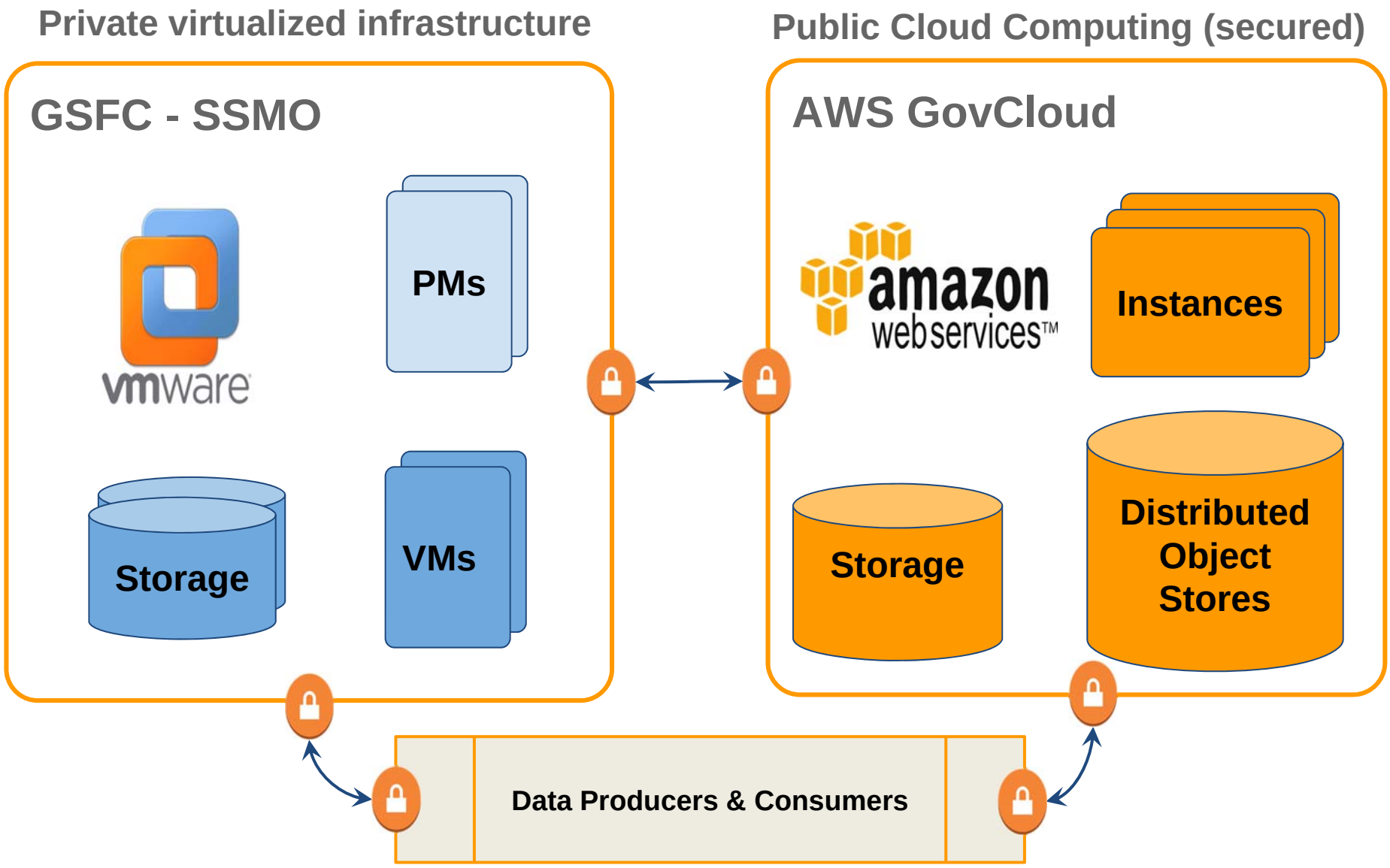
vMMOC's High Level Infrastructure



What is the vMMOC?

- **Shared**:
  - Infrastructure
  - Product formats
  - Networking interfaces
  - Workflows & Procedures
  - Security implementations
  - Hardware and software
  - Core staff
  - Lessons-learned
  - Culture

What is the vMMOC?



Situational Awareness Dashboard

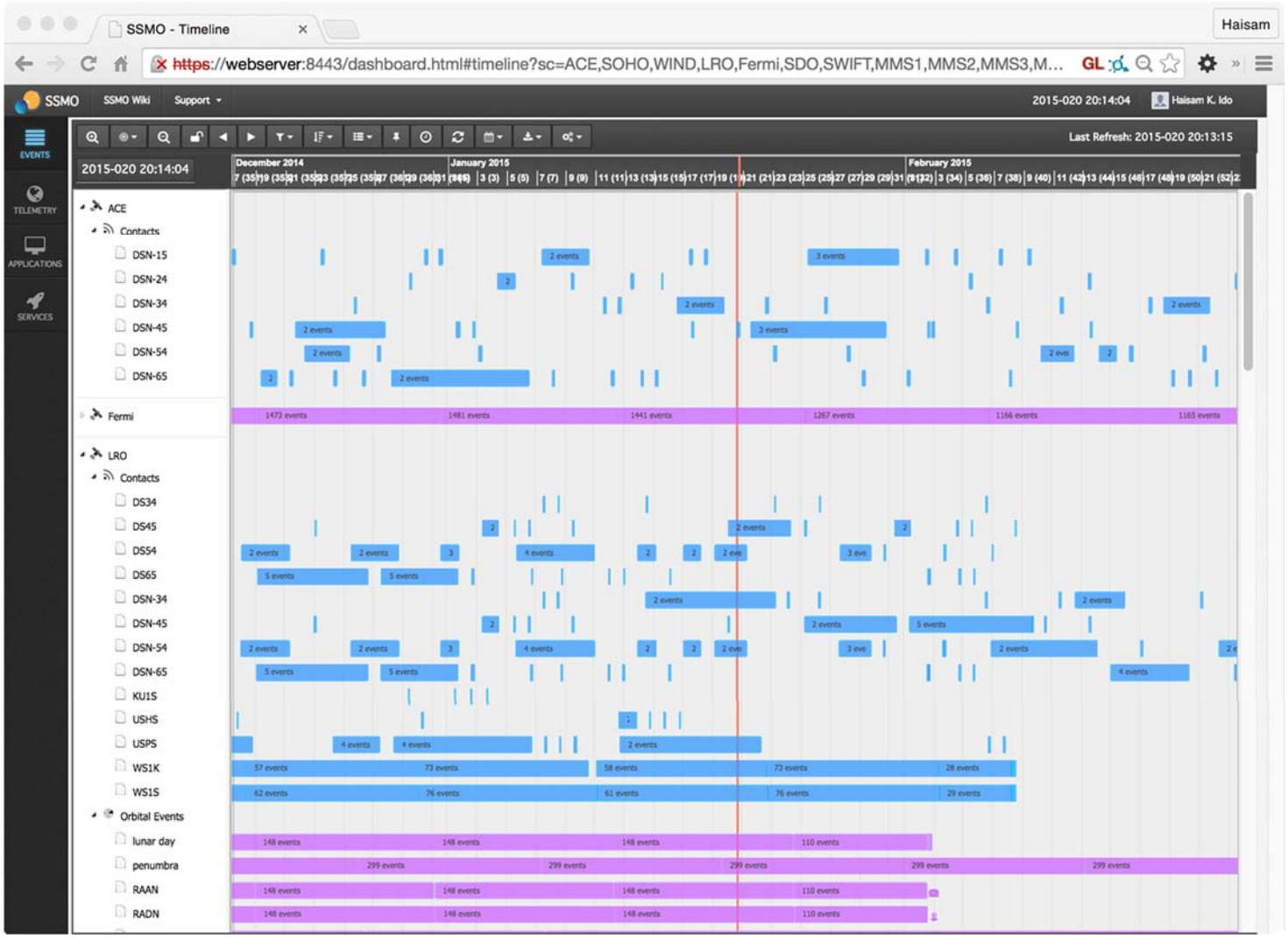
Break the barrier to data access

vMMOC Services - Situational Awareness Dashboard

- **Provide local and remote users an integrated, situational awareness dashboard of major spacecraft and ground events**
  - Secure
  - Tailorable, self-service capability to access all spacecraft timelines
  - Liberate the data
  - Empower each engineer to tailor requests for any SSMO spacecraft
- **A *web service* based on NIST's Software as a Service (SaaS) model**

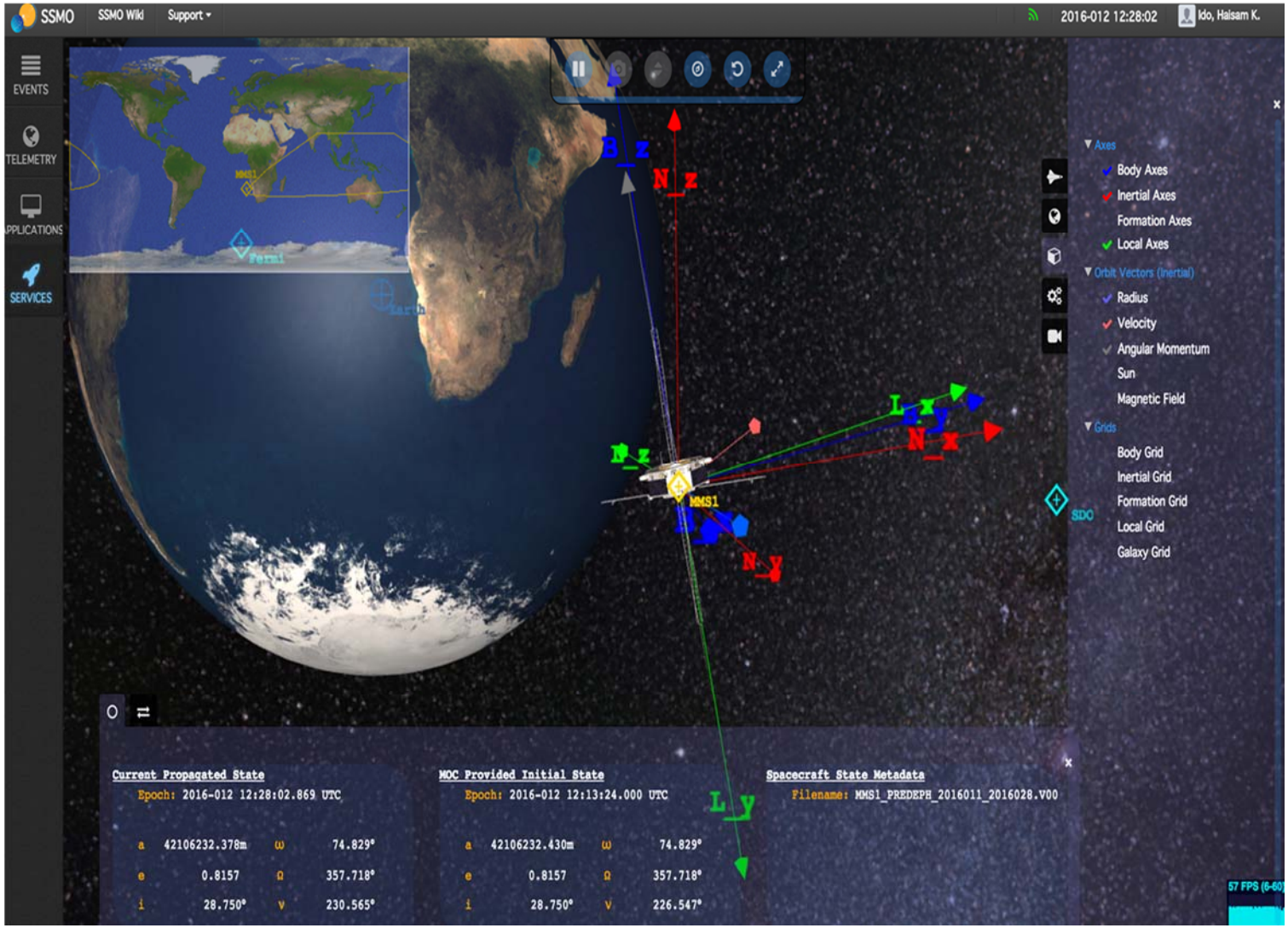
vMMOC Services - Situational Awareness Dashboard

A timeline view of ACE, Fermi and LRO



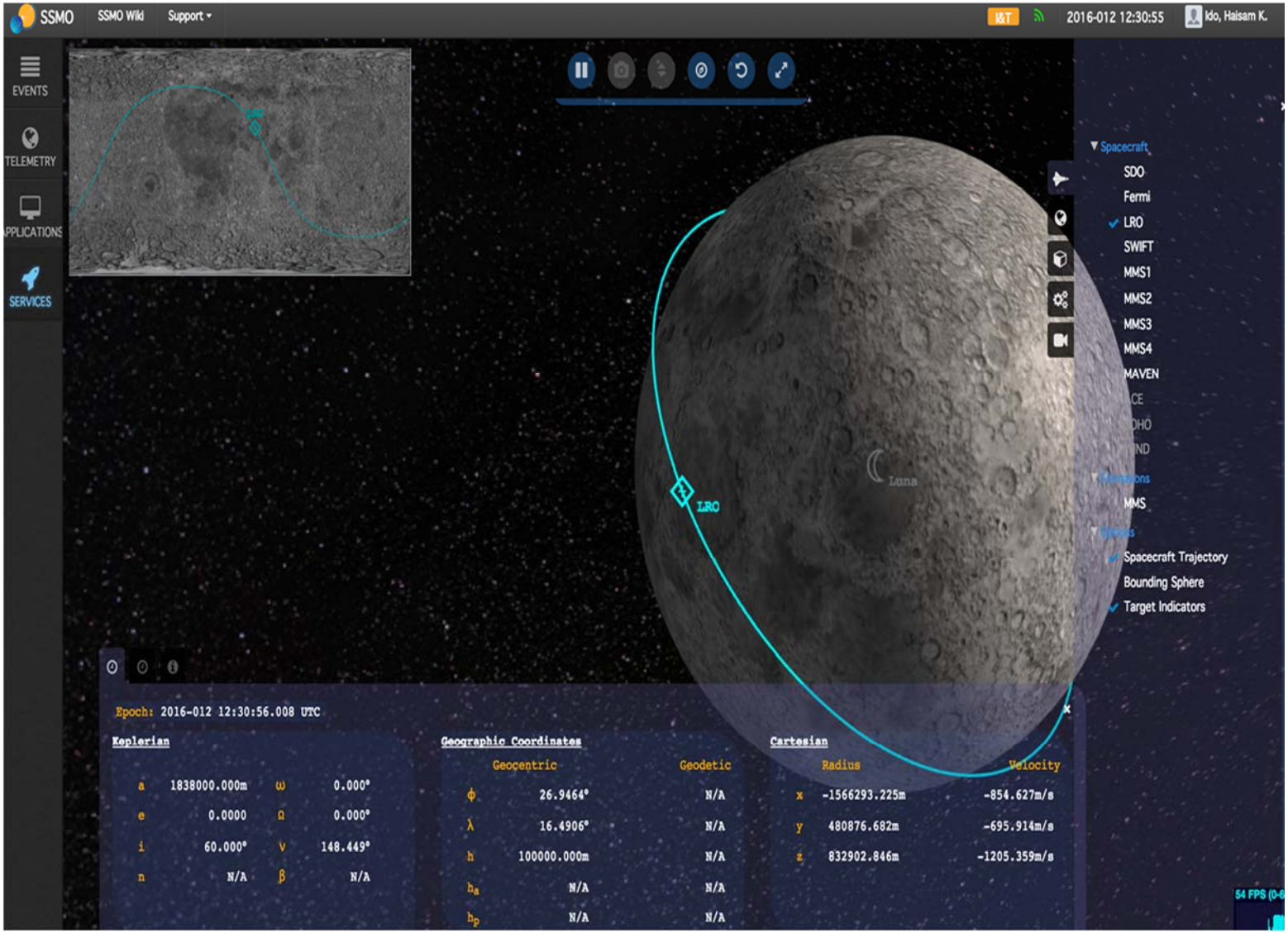
vMMOC Services - Situational Awareness Dashboard

A view of a closeup of MMS1



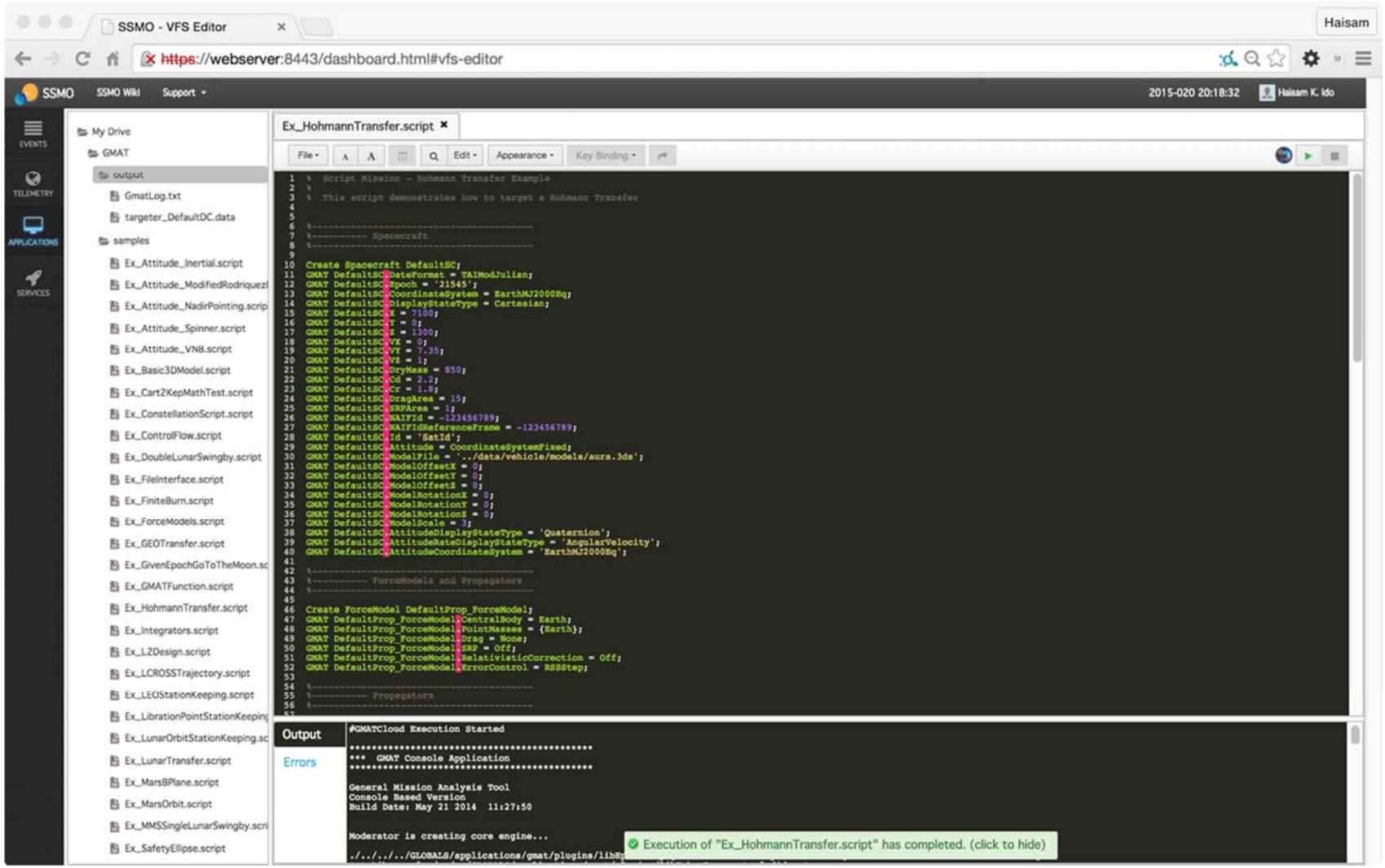
vMMOC Services - Situational Awareness Dashboard

A view of LRO



vMMOC Services - Situational Awareness Dashboard

Execute General Mission Analysis Tool (GMAT) in the cloud



Telemetry as a Service (TaaS)

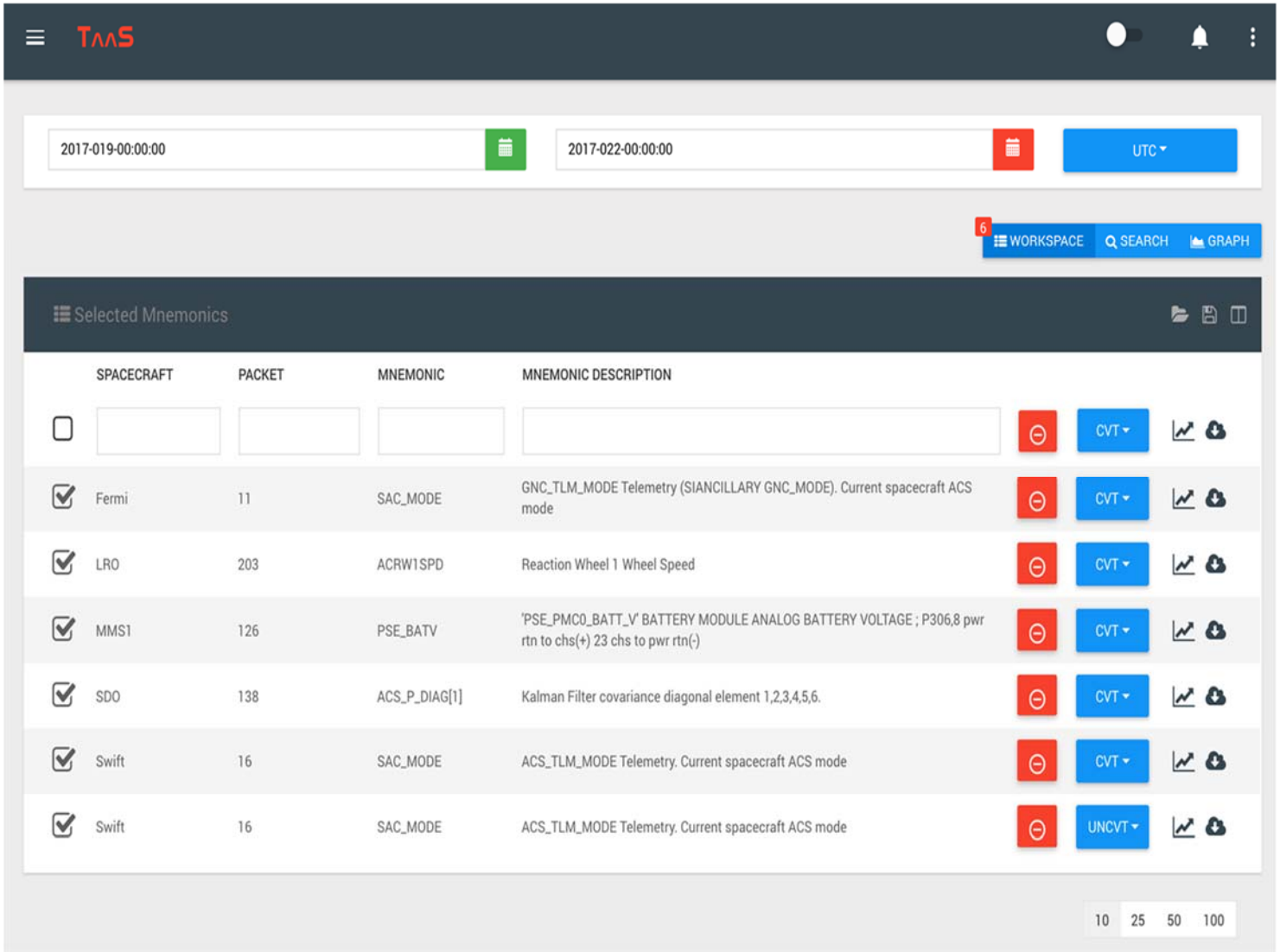
Break the barrier to data access

vMMOC Services - TaaS

- **Provide local & remote users access to *telemetry* & *tracking***
  - Secure
  - Tailorable, self-service capability to access all SSMO spacecraft telemetry & tracking:
  - Liberate the data
  - Empower each engineer to tailor requests for any SSMO spacecraft
  - Each engineer can perform analysis without interfering with operations workflows
- **A *web service* based on NIST's Software as a Service (SaaS) model**

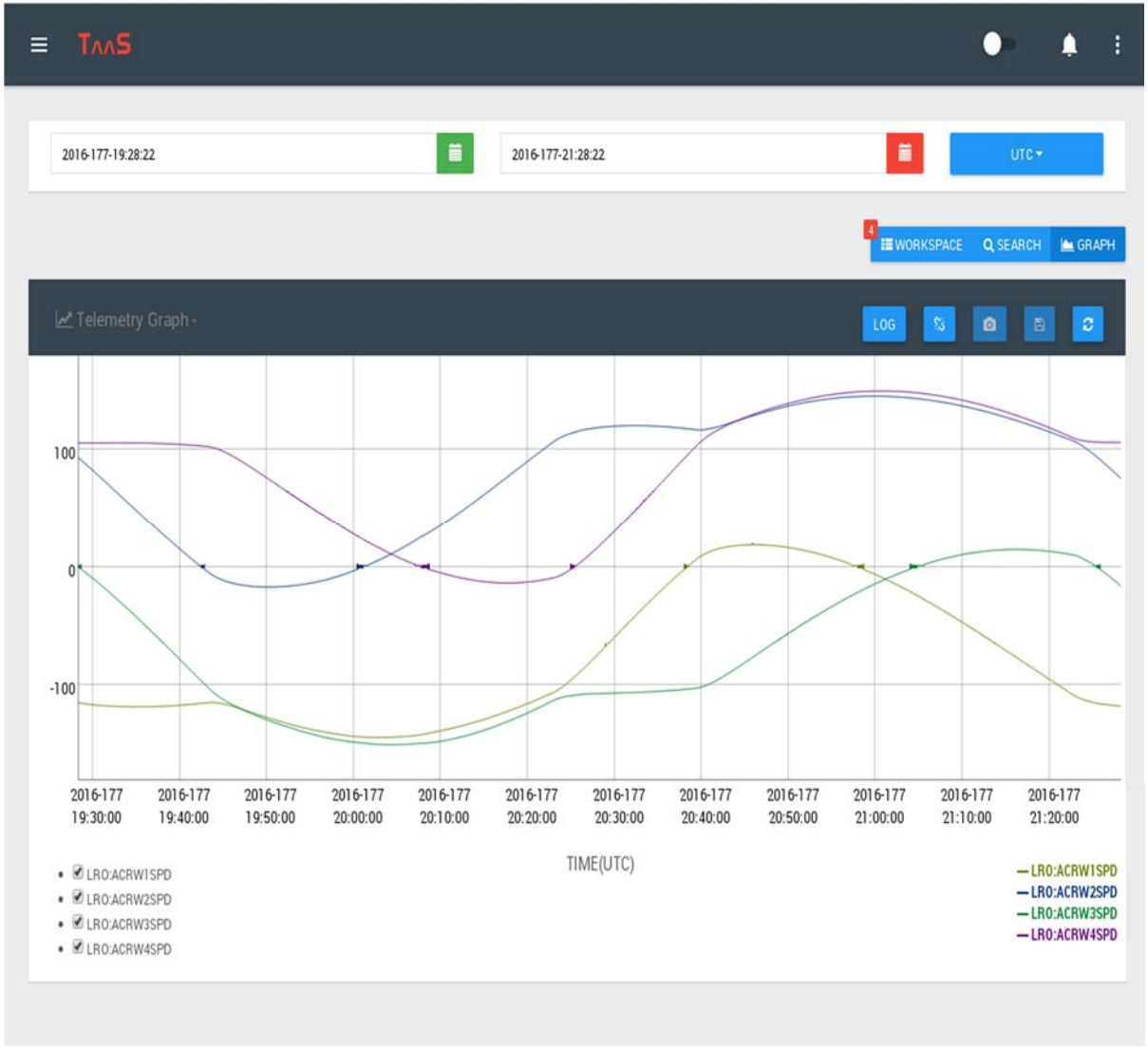
vMMOC Services - TaaS - Web Portal

A view of the portal



vMMOC Services - TaaS - Web Portal

A view of a plot of wheel speeds



Navigation as a Service (NaaS)

Break the barrier to data access

vMMOC Services - NaaS - Its functions

Navigate the Spacecraft in Support of Mission Operations

Navigation Services

- Maneuver planning
- Maneuver execution
- Maneuver reconstruction
- Orbit estimation & control
- Attitude estimation & control

Scheduling & Planning in Support of Navigation

- Maneuvers
- Network Availability
- Antenna Availability
- AOS/LOS
- Shadows
- Interference
- Tracking

"Looking Beyond the Horizon"

How would one simulate hundreds of spacecraft?

- **With the coming age of OneWeb, and other massive spacecraft operations proposals, how does one:**
  - Design, Model and Simulate Ground and Space Segments ?
  - **Leverage Cloud Computing & Create Service Models, such as:**
    - Spacecraft as a Service (SCaaS)
    - Flight Software as a Service (FSWaaS)
    - Ground Segment as a Service (GSaaS)
    - Auto Provision, Orchestrate & Terminate services at will

Thank you.

Any Questions?