The **Virtualized Multi-Mission Operations Center (vMMOC)** and its Cloud Services

**Presented by**
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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)?
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

<table>
<thead>
<tr>
<th>Mission</th>
<th>Launch Year</th>
<th>MOC Location</th>
<th>Science Type</th>
<th># s/c</th>
<th>Orbit Regime</th>
<th>Catalog #</th>
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<td>GSFC</td>
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<td>L1</td>
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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

- Restricted Mission Network
- Open Mission Network
- Closed Mission Network
- Internet
- Instrument User Community
- CNE – NASA Network

Exchange

- ACE
- Fermi
- LRO
- MMS (backup)
- OSIRIS-REx (backup)
- SDO
- SOHO
- SWIFT
- Wind

Common Services
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?

Private virtualized infrastructure

GSFC - SSMO

GSFC

PMs

Storage

VMs

Public Cloud Computing (secured)

AWS GovCloud

Instances

Distributed Object Stores

Data Producers & Consumers

Storage

VMware

AWS

PM's

PM's

VM's

Private virtualized infrastructure

Public Cloud Computing (secured)
Situational Awareness Dashboard

Break the barrier to data access
• 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
A timeline view of ACE, Fermi and LRO
A view of a closeup of MMS1
A view of LRO
Execute General Mission Analysis Tool (GMAT) in the cloud
Telemetry as a Service (TaaS)

Break the barrier to data access
• **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

<table>
<thead>
<tr>
<th>SPACECRAFT</th>
<th>PACKET</th>
<th>MNEMONIC</th>
<th>MNEMONIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermi</td>
<td>11</td>
<td>SAC_MODE</td>
<td>GNC_TLM_MODE Telemetry (SIAncillary GNC_MODE). Current spacecraft ACS mode</td>
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<tr>
<td>LRO</td>
<td>203</td>
<td>ACRW1SPD</td>
<td>Reaction Wheel 1 Wheel Speed</td>
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<td>MMSI</td>
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<td>PSE_BATV</td>
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<td>SDO</td>
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<tr>
<td>Swift</td>
<td>16</td>
<td>SAC_MODE</td>
<td>ACS_TLM_MODE Telemetry. Current spacecraft ACS mode</td>
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<tr>
<td>Swift</td>
<td>16</td>
<td>SAC_MODE</td>
<td>ACS_TLM_MODE Telemetry. Current spacecraft ACS mode</td>
</tr>
</tbody>
</table>
A view of a plot of wheel speeds
Navigation as a Service (NaaS)

Break the barrier to data access
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?