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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<tbody>
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<td>GSFC</td>
<td>Heliophysics</td>
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<td>L1</td>
<td>n/a</td>
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</table>
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

- Storage
- VMs
- PMs

Public Cloud Computing (secured)

AWS GovCloud

- Storage
- Distributed Object Stores
- Instances

Data Producers & Consumers
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
A view of a closeup of MMS1
vMMOC Services - Situational Awareness Dashboard

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

![Image of the portal](image)

<table>
<thead>
<tr>
<th>SPACECRAFT</th>
<th>PACKET</th>
<th>MNEMONIC</th>
<th>MNEMONIC DESCRIPTION</th>
</tr>
</thead>
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<tr>
<td><strong>Fermi</strong></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><strong>LRO</strong></td>
<td>203</td>
<td>ACRW1SPD</td>
<td>Reaction Wheel 1 Wheel Speed</td>
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<td><strong>MMSI</strong></td>
<td>126</td>
<td>PSE_BATV</td>
<td>'PSE_PMCO_BATT_Y' BATTERY MODULE ANALOG BATTERY VOLTAGE ; P306,8 pwr rtn to chs(<em>) 23 chs to pwr rtn(</em>)</td>
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<td><strong>SDO</strong></td>
<td>138</td>
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<td><strong>Swift</strong></td>
<td>16</td>
<td>SAC_MODE</td>
<td>ACS_TLM_MODE Telemetry. Current spacecraft ACS mode</td>
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<tr>
<td><strong>Swift</strong></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?