Evolving Ground System Engineering Practices
to Meet the Needs of Future Space Missions

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Need & Motivation

• Introduction:
  – Ground System (GS) Engineers apply multi-mission ground system tools and processes to flight projects, customizing them as necessary
  – This work is performed by engineers with 15-20 years of experience
  – Gaps in their expert knowledge can lead to gaps in the design
  – Knowledge capture, retention, & dissemination is essential, yet difficult

• Task need & motivation:
  – Procedures describing ground system engineering practices and related products at JPL were found to lack:
    • granularity: insufficient guidance in descriptions of procedural activities, including expected input & output products and supporting activities
    • traceability: between and among activities and products
    • clarity: in delineation of the roles of, and relationships between, actors’ work; in expected content and presentation of the products
    • consistency: in lexicon, GS architecture description, procedures presentation

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Approach & Benefits

Approach: apply model-based engineering techniques for improved GS procedure & product description

➢ This work is part of a larger, longer-term effort at JPL to revitalize GS engineering processes & products using model-based engineering techniques

Key expected benefits:

– better knowledge capture & dissemination among the current system engineers
– clearer and more efficient communications among GS stakeholders
– identification and reduction of overlapping efforts in GS architecture development and deployment, resulting in cost and schedule savings
Roadmap to Achieve A Vision: Model-Based Approach for Ground System Engineering

This requires creation of the following:

- Discipline-specific taxonomy and ontology; implemented as a SysML profile
- Reusable, model-based libraries for standard representation of viewpoints and products used to describe the various components of a GS
- Standard model organization/structure definition for GS architecture design, development, & deployment for use across multiple classes of projects
- Reference GS architectures, which builds on the above items
  - including adaptation points (and guidance) for project-specific uses of the framework
  - e.g., Earth orbiter, planetary orbiter, planetary lander, etc.

Implementation Step:

- Application of reference, model-based GS architectures to new projects/tasks, with support from the guiding GS procedure & product descriptions

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Layered View of Assets that Procedures Would Point To

Legend:
- Green - project-specific
- Blue - discipline-specific
- Yellow - non-discipline specific

1. Project-Specific Documentation (derived from reference project model)
2. Model-Based Project-Specific Adaptations of Reference Architectures
3. Discipline-Specific Reference Architectures (including adaptation points)
4. Discipline-Specific Component Libraries, Templates, and Tool Customizations
5. Discipline-Specific Profiles (SysML-based, developed in OWL)
6. Discipline-Specific Ontologies + Taxonomies
7. Foundation Ontologies + Taxonomies e.g., system architecture, project, mission descriptions

GS Engineering Procedures + Products Descriptions
Example of Model-Based Implementation of Assets

Legend:
Green - project-specific
Blue - discipline-specific
Yellow - non-discipline specific

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Model-based Engineering for GS Procedure & Product Description Capture

<table>
<thead>
<tr>
<th>Actors</th>
<th>Phase A - Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Data System Engineer</td>
<td>3.1 Work with, as applicable, the Mission Manager, GDS Manager, &amp; Mission Operations System Engineering to:</td>
</tr>
<tr>
<td></td>
<td>a. identify stakeholders (e.g., users &amp; customers), and map to, and analyze their concerns (e.g., needs)</td>
</tr>
</tbody>
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![Diagram]

Identify stakeholders → Stakeholders → Map stakeholders to concerns → Mapping of Stakeholders to Concerns

Identify concerns → Concerns
Concluding Remarks

Currently:

1. Modeling existing procedures & products involved in JPL GS development & deployment

2. Leveraging state-of-the-art practices for model-based engineering
   - representation & relationship capture: SysML, OWL, etc.
   - employing a commercial modeling tool: MagicDraw
   - IEEE Standard 1471 for architecture description taxonomy
   - building upon existing institutional ontologies & taxonomies
   - starting to capture of discipline-specific ontologies & taxonomies

Future:

• Complete & publish updated GS engineering procedures

• Use the updated procedure & product descriptions to:
  - update training & cost models
  - improve consistency and guide expectations for reviews
  - provide guiding representations for expected views in products; i.e., viewpoints library
  - employ models to generate improved GS products—via use of discipline-specific component libraries, templates, & tool customizations

• Coordinate with other synergistic model-based efforts at JPL
  - existing institutional efforts at JPL: Integrated Model Centric Engineering (ontologies); SS-CAE (tools)
  - other program and project efforts: MGSS – Operations Revitalization task, etc.; JEO-EHM

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