# 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

# 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

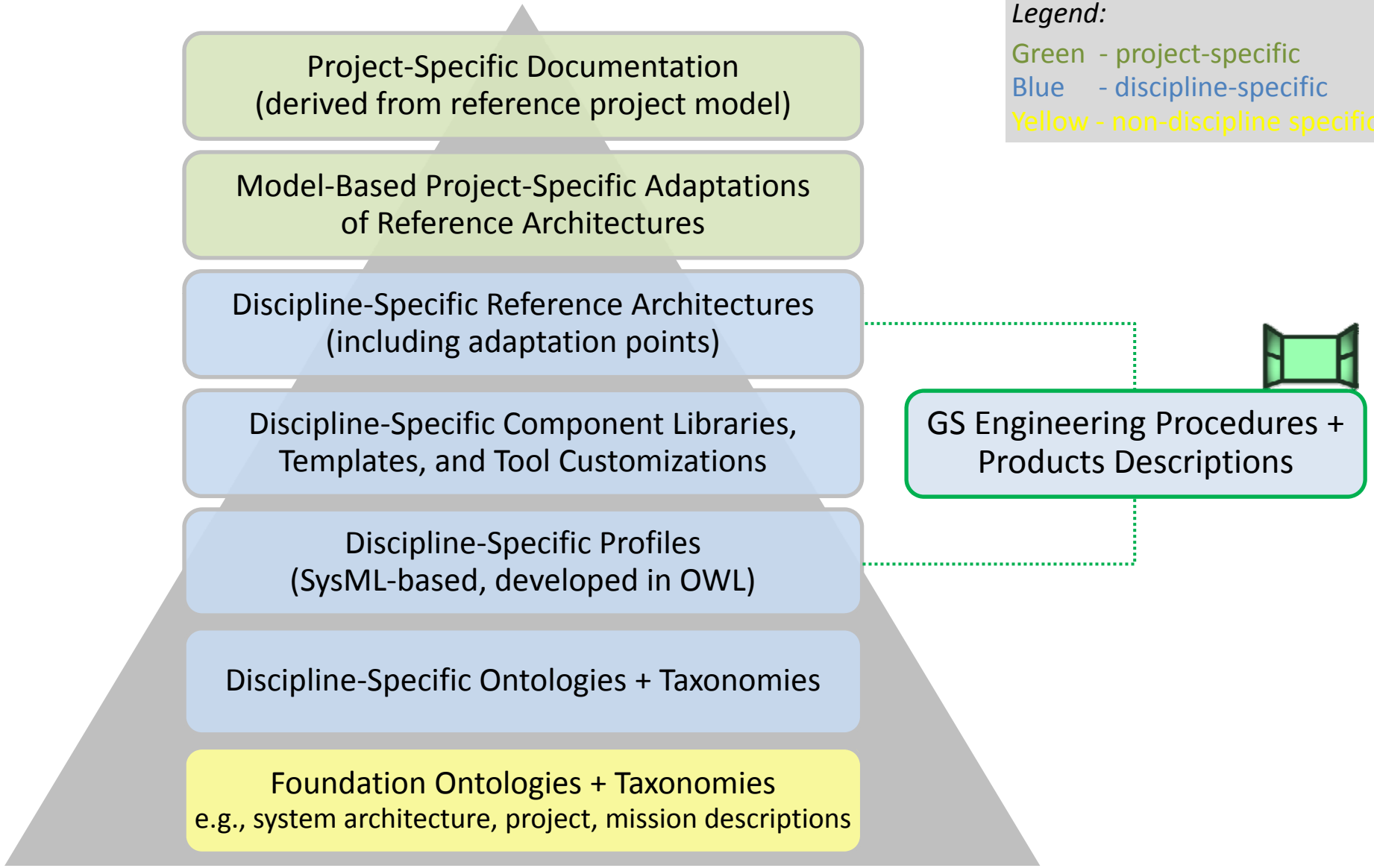
This requires creation of the following:

- 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*

# Layered View of Assets that Procedures Would Point To



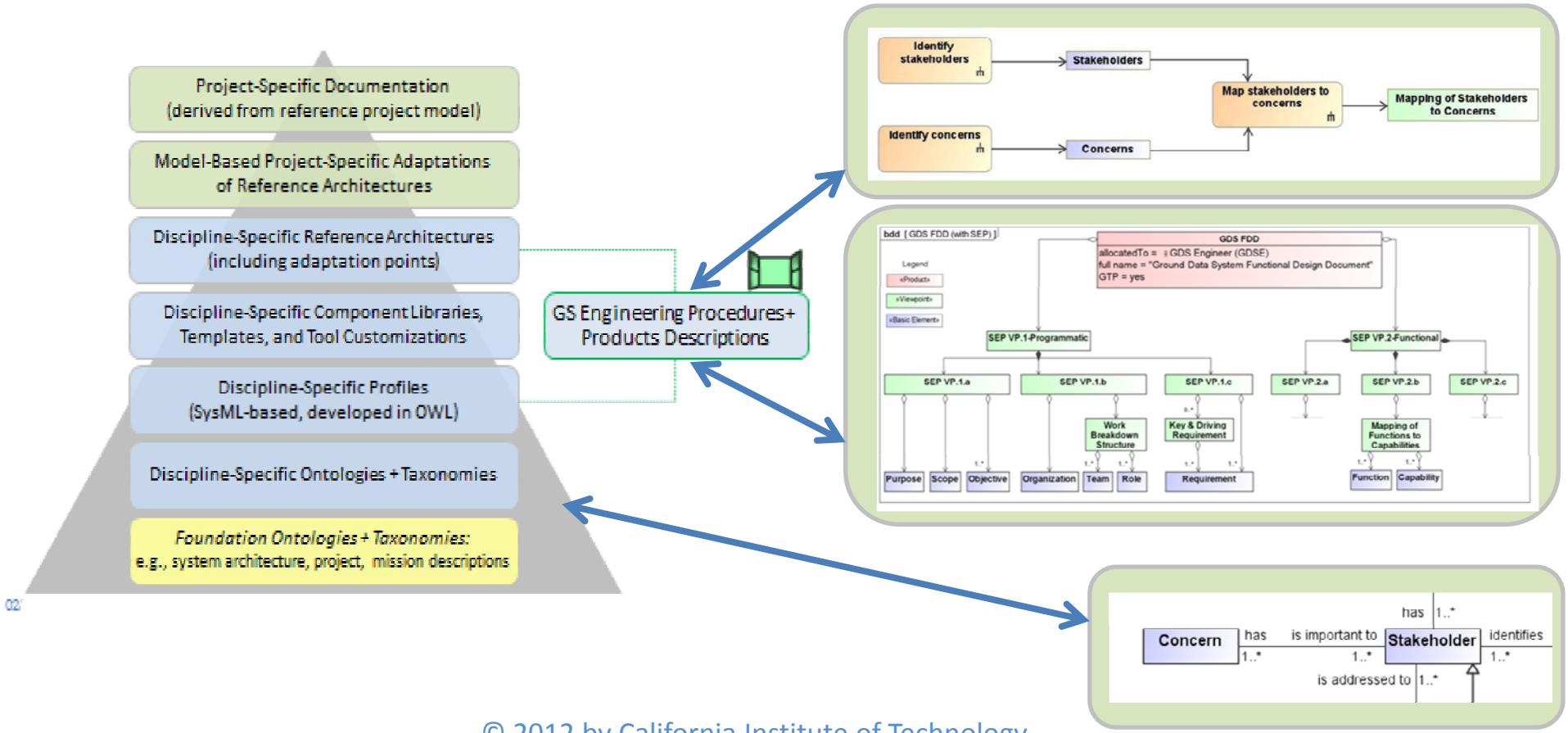
# Example of Model-Based Implementation of Assets

*Legend:*

Green - project-specific

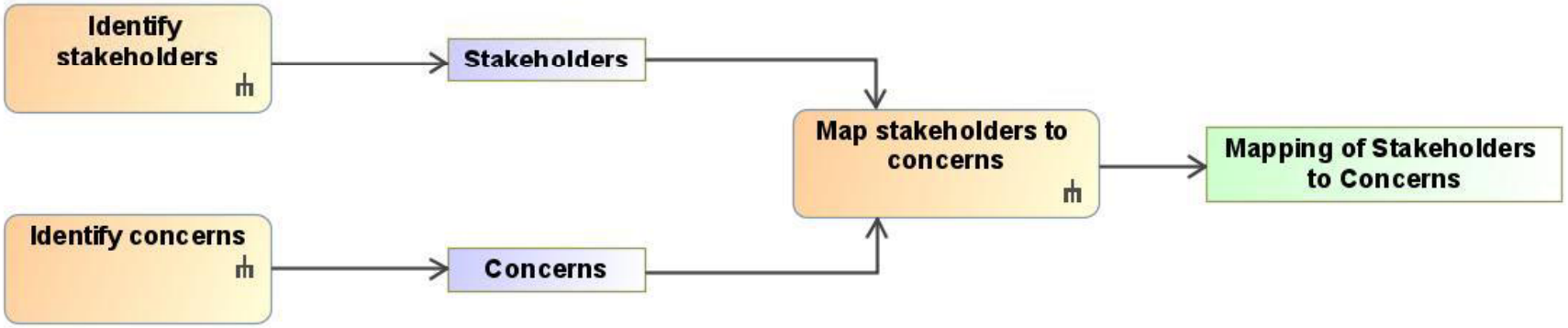
Blue - discipline-specific

Yellow - non-discipline specific



# Model-based Engineering for GS Procedure & Product Description Capture

| Actors | Phase A - Activities |
|---|---|
| Ground Data System Engineer | 3.1 Work with, as applicable, the Mission Manager, GDS Manager, & Mission Operations System Engineering to:<br>a. identify stakeholders (e.g., users & customers), and map to, and analyze their concerns (e.g., needs) |



# 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