The Advantage of Model-Based Systems Engineering and Performing Model-Based Design Reviews

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Presentation Focus

- The Model is an integral part of our systems engineering process and architectural solutions
- Therefore, it is key to review the model with internal stakeholders, subject matter experts and customers
- Model design peer reviews are a valuable way to review the baseline design, assess required life cycle maturity, identify gaps in the system engineering process and seek customer input

Speaker Introduction

- Senior systems engineer with 32 years of experience in aerospace at the Jet Propulsion Laboratory (JPL)
  - Supports space imaging systems in the Astronomy and Astrophysics division
  - Currently, the NEO Surveyor Deputy Project Manager
- Experience spans system engineering, electronics design, optical system design, integration and test, flight software development, product delivery management, and project management

Presentation Agenda

CUSTOMER EXPECTATIONS

CUSTOMER FRAMEWORK

MODELING GUIDELINES

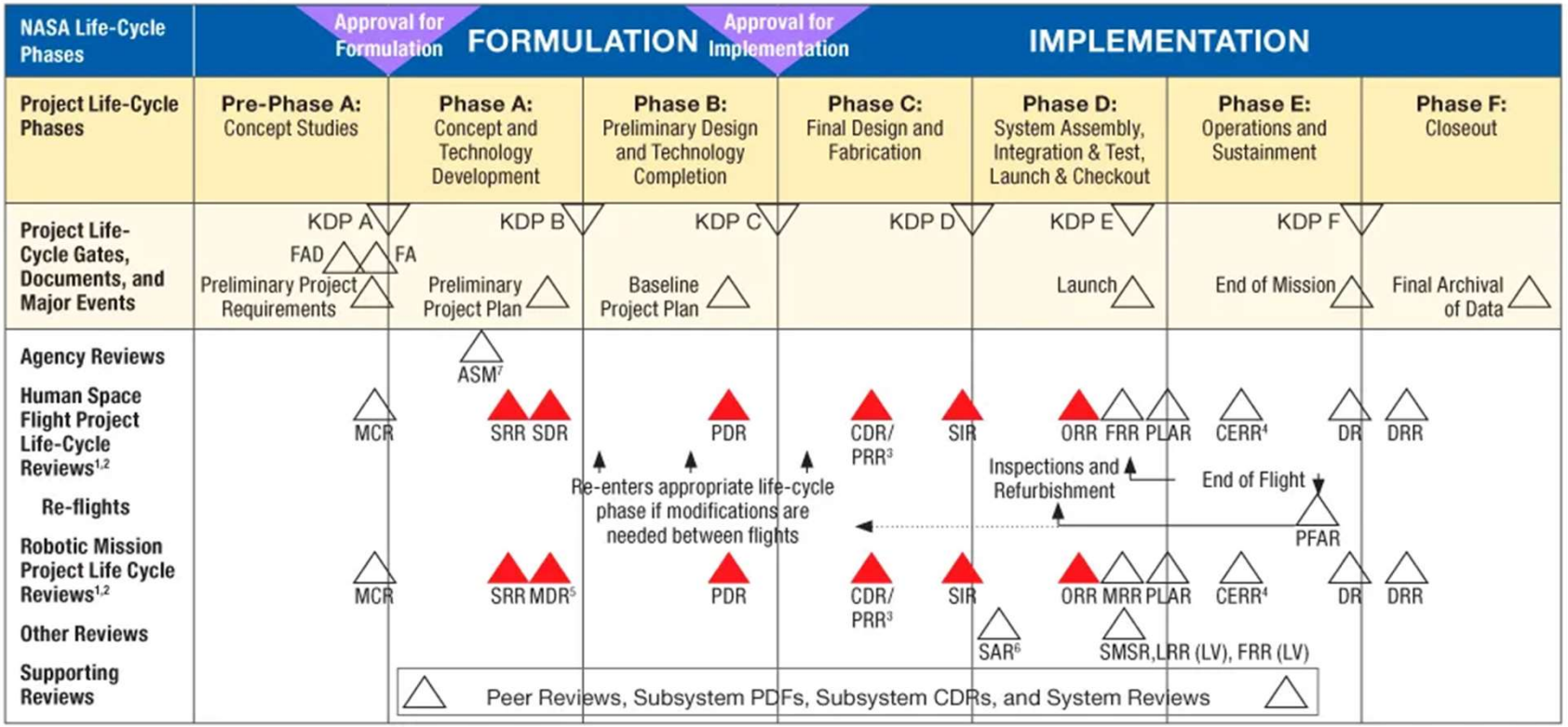
VIEWPOINTS AND VIEWS

PRESENTATION MODE

QUESTIONS

CLOSING COMMENTS

NASA Life Cycle Development



FOOTNOTES

1. Flexibility is allowed as to the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan.
2. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 and Appendix D Table D-3 of this handbook
3. PRR is needed only when there are multiple copies of systems. It does not require an SRB. Timing is notional.
4. CERRs are established at the discretion of program .
5. For robotic missions, the SRR and the MDR may be combined.
6. SAR generally applies to human space flight.
7. Timing of the ASM is determined by the MDAA. It may take place at any time during Phase A.

▲ Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

ACRONYMS

ASM – Acquisition Strategy Meeting
CDR – Critical Design Review
CERR – Critical Events Readiness Review
DR – Decommissioning Review
DRR – Disposal Readiness Review
FA – Formulation Agreement
FAD – Formulation Authorization Document
FRR – Flight Readiness Review
KDP – Key Decision Point
LRR – Launch Readiness Review
LV – Launch Vehicle
MCR – Mission Concept Review
MDR – Mission Definition Review
MRR – Mission Readiness Review
ORR – Operational Readiness Review
PDR – Preliminary Design Review
PFAR – Post-Flight Assessment Review
PLAR – Post-Launch Assessment Review
PRR – Production Readiness Review
SAR – System Acceptance Review
SDR – System Definition Review
SIR – System Integration Review
SMSR – Safety and Mission Success Review
SRB – Standing Review Board
SRR – System Requirements Review

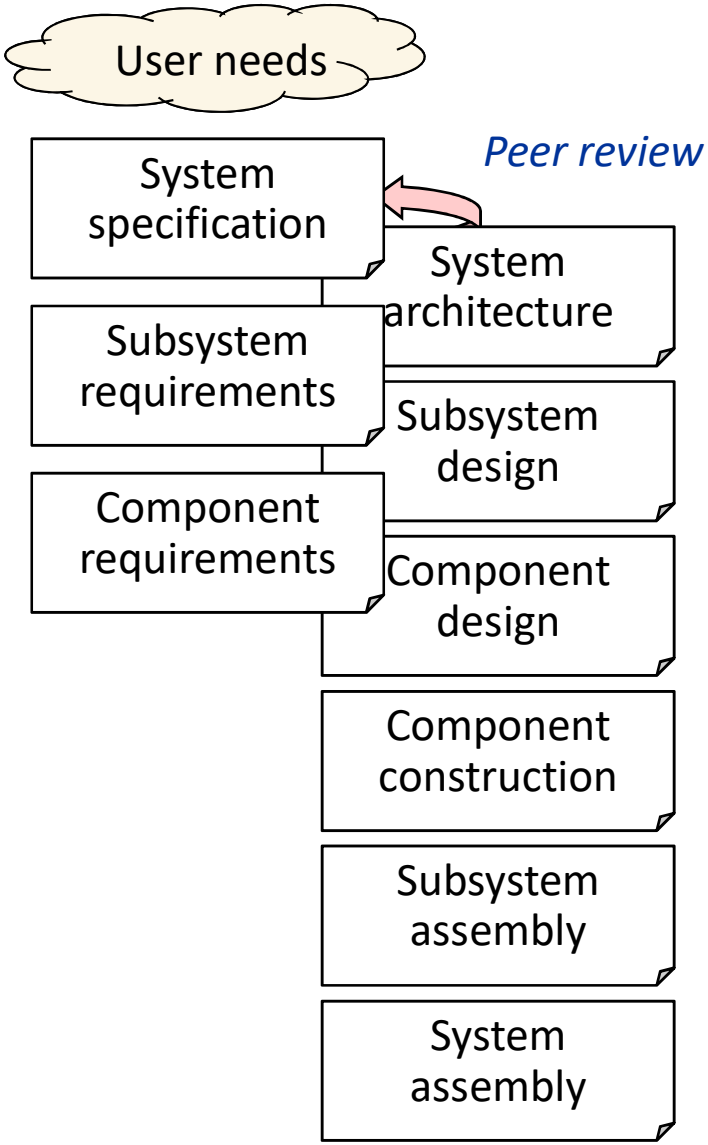
FIGURE 3.0-1 NASA Space Flight Project Life Cycle from NPR 7120.5E

Institutional Guidelines to Peer Reviews

- Review objectives
- Review scope
- Detailed topics
- Technical content to be covered
- Selection of subject matter experts
- How to handle actions
- Customer involvement

Peer Reviews

- Review of a work product by an author's peers (practitioners capable of producing the product)
- Types vary by:
  - Amount of structure (processes for identifying peers, preparation, review, recording potential errors, meeting, addressing potential errors)
  - Preparation, meeting conduct
  - Size of review team



Expectation Example

Customer required MBSE to be used on the contract

- Established SDRLS and DRDs for model guidelines and requirements\
- Demonstrated the importance of the MBSE investment by applying resources at the top level to develop a structured model
- Provided guidance as to what was expected in the model content at the System Requirements Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR)

SRR Model expectations:

- Requirements structure
- Traceability/flow down
- Requirements completeness assessment
- Requirements TBXs and burndown, conceptual thoughts on V&V, customer Level 1 requirements assessment, and customer Concept of Operations assessment

Customers may require a specific Architectural Framework to guide model scope

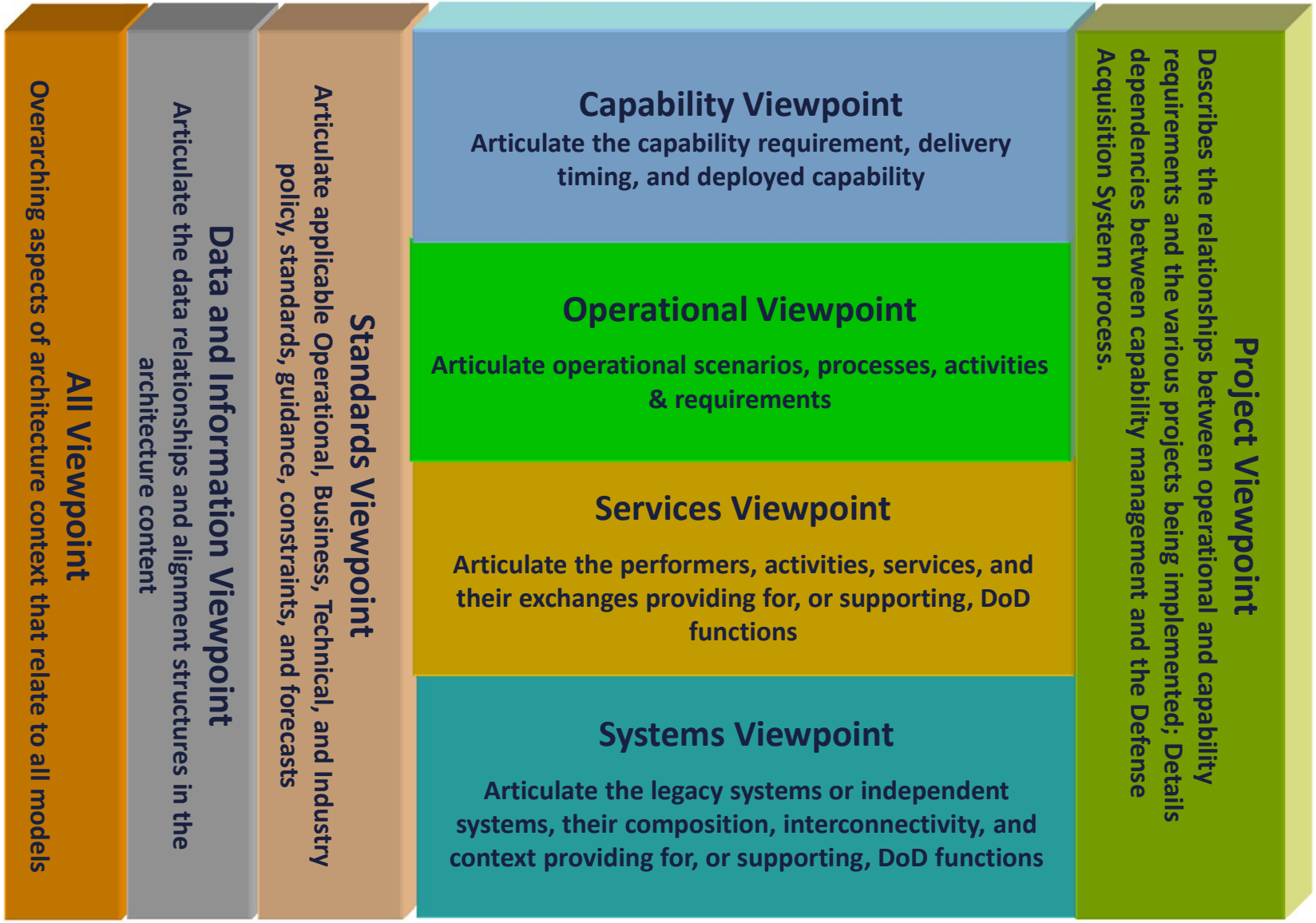
- **DODAF** - The Department of Defense Architecture Framework (DoDAF) is an architecture framework for the United States Department of Defense (DoD) that provides visualization infrastructure for specific stakeholders concerns through viewpoints organized by various views. (DODAF Viewpoints and Models)
- **MOSA** - A Modular Open Systems Approach (MOSA) is an integrated business and technical strategy to achieve competitive and affordable acquisition and sustainment over the system life cycle. In the development of Department of Defense (DoD) systems, MOSA is an acquisition and design strategy, consisting of technical architectures, that adopts open standards and supports a modular, loosely coupled, and highly cohesive system structure.
- **WOSA** - Weapon Open System Architecture is now a standard for a modular open systems approach to acquiring weapons systems. WOSA is different from acquisition processes of the past. The standard requires that a partnering relationship exist between the vendor and the government. (New technical standard refines open solution > WIN THE FUTURE > News)
- **NAF** - The aim of the NATO Architecture Framework Version 4 (NAFv4) is to provide a standard for developing and describing architectures for both military and business use. (NATO All View Viewpoint - UAF 1.2 Plugin 2021x Refresh2 - No Magic Documentation)

DoDAF Viewpoints and Models

- DoDAF is designed to meet the specific programmatic and operational requirements of the DoD
- DoDAF defines a way of representing an architecture that enables stakeholders to focus on areas of interests in the system in a common, well recognized way
- Provides the means of abstracting information from the complexity and presenting it in a way that maintains consistency
- Used to present this information in a way that is understandable to the many stakeholder communities involved
- Divides the problem into manageable pieces

DODAF Viewpoints and Models (defense.gov)

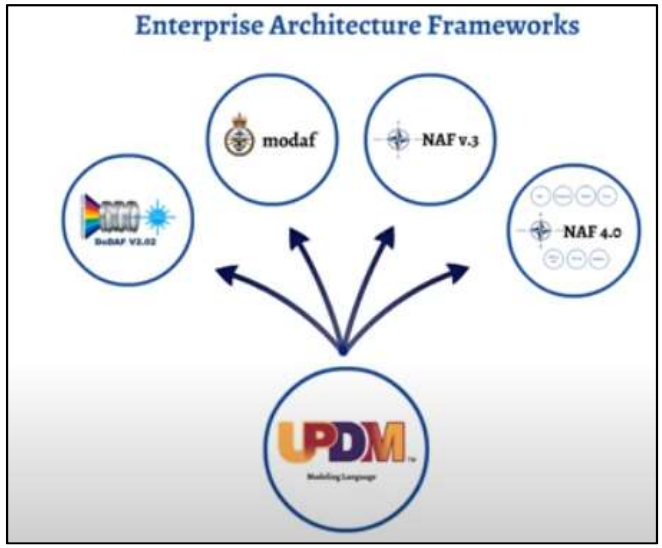
DoDAF v2.02 Architectural Viewpoints



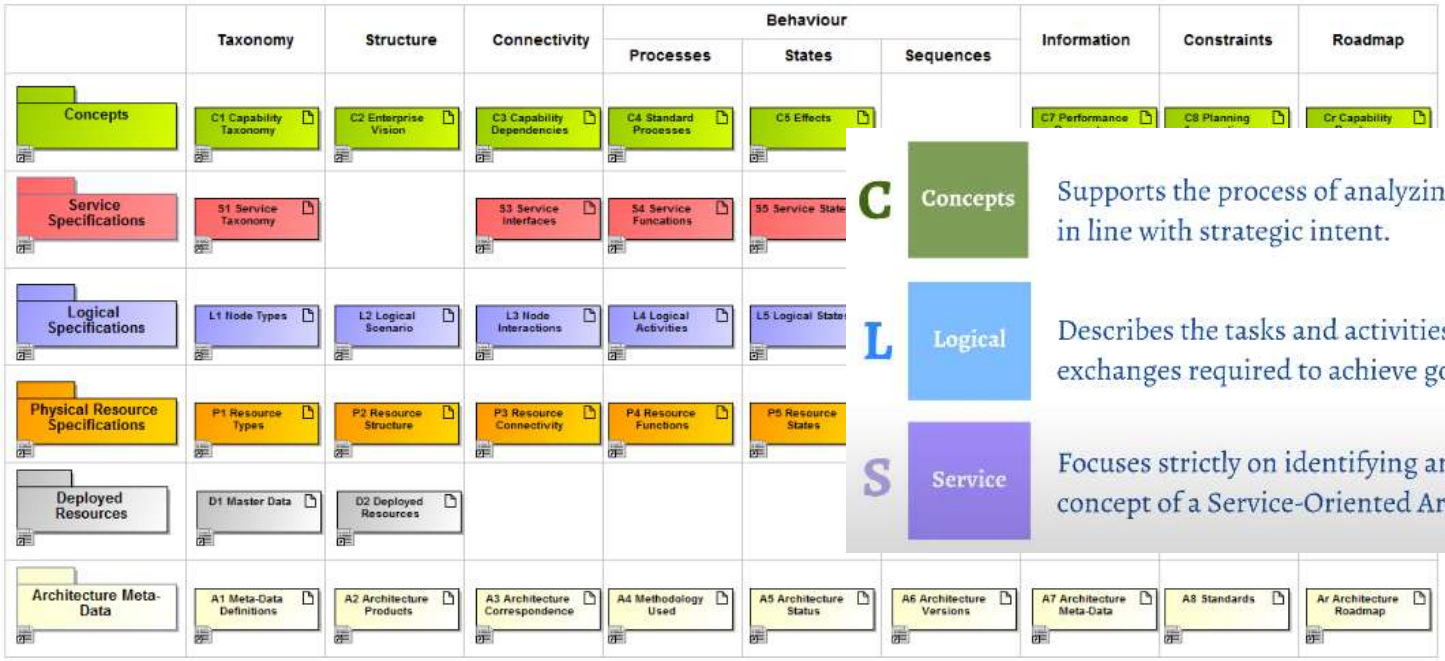
DODAF Viewpoints and Models (defense.gov)

NAF 4.0 viewpoints and views

- NATO Architectural Framework
- An Enterprise Architectural Framework for business, systems and project modeling
- It is valuable for complex interface between system of systems
- It is a benefit for government and commercial companies



Unified Profile



aspects

NAF 4.0 viewpoints and views - UPDM 2 Plugin 19.0 LTR - No Magic Documentation

The Model's Purpose is Defined

- The purpose of the model must be clearly stated and understood by the design team for use of the model over the project lifecycle
- Used by different engineering disciplines involved in the design
- Example: The stakeholders and their intended use can be defined as stakeholder viewpoints

Examples:

- Specify and design a new or modified system
- Represent a system concept
- Specify and validate system requirements
- Synthesize system designs
- Specify component requirements
- Maintain requirements traceability
- Evaluate the system
- Conduct system design trade-offs
- Analyze system performance requirements or other quality attributes
- Verify that the system design satisfies its requirements
- Assess the impact of requirements and design changes
- Estimate the system cost
- Train users on how to operate or maintain a system
- Support system maintenance and/or diagnostics

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Model Scope

- The scope of the model should be sufficient to meet the intended use of the model as described above
- This scope should be balanced with the available schedule, budget, skill levels, and other resources
- Determine the right size of tool for the job
- This helps to determine realistic expectations and the required level of resources for the modeling effort

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Model Scope Dimensions

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Model breadth

- Determine which parts of the system need to be modeled
- Determine what are the new aspects of the architecture that would gain the most from the model
- Determine what are the updated user of system requirements that need to be developed and implemented

Model depth

- Determine the level of hierarchy to define system functionality
- Determine where in the life cycle the model will be used
- Determine the level of detail that is required to meet the intent of the model
- Determine what diagrams or viewpoints are required to meet the intent of the model - ***how low do you go!!!***

Model fidelity

- The fidelity of the model must match the level of detail required
- Determine as and example if a simple activity diagram is sufficient or if the team will require call behaviors and control flow

Talk to the team about it and define this in the style guide

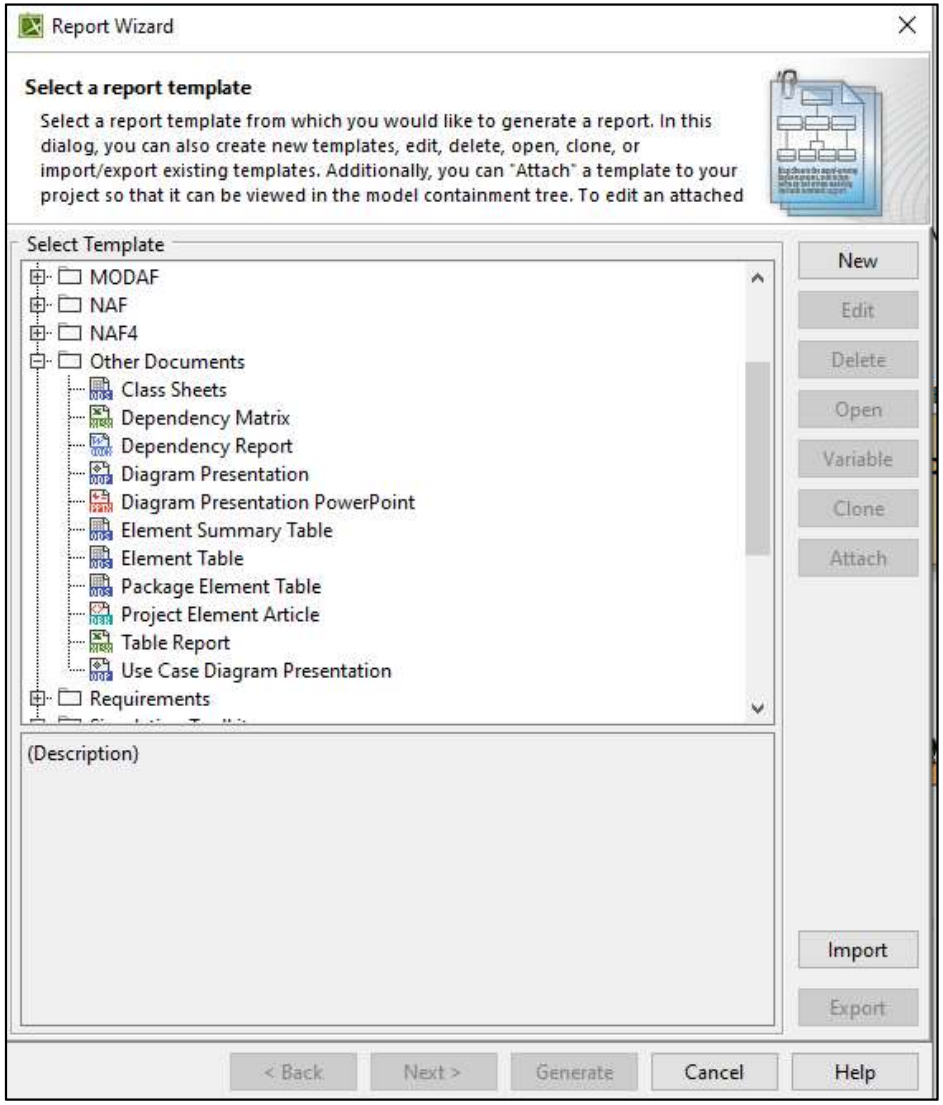
Model Consistency

- Rules are built into the language to ensure model consistency
- Additional constraints can be imposed by the MBSE method used
- Type checking can help determine whether interfaces are compatible or whether units are consistent among different properties
- Constraints can be expressed in the object constraint language (OCL)
- Constraints assists in maintaining consistency across the model, but it does not prevent design inconsistencies – two modelers can give the same element different names
- Inconsistencies are found in design reviews and model reports

A well-defined style guide is absolutely required to ensure model consistency

A Self-Documenting Model

- Documentation throughout the model, annotation, notes and comments are helpful to the team
- Capture the rationale for design decisions, listing issues or problem areas for resolution
- Generate documentation that is automatically generated from the model
- Document in the style guide what level of consistent documentation is required



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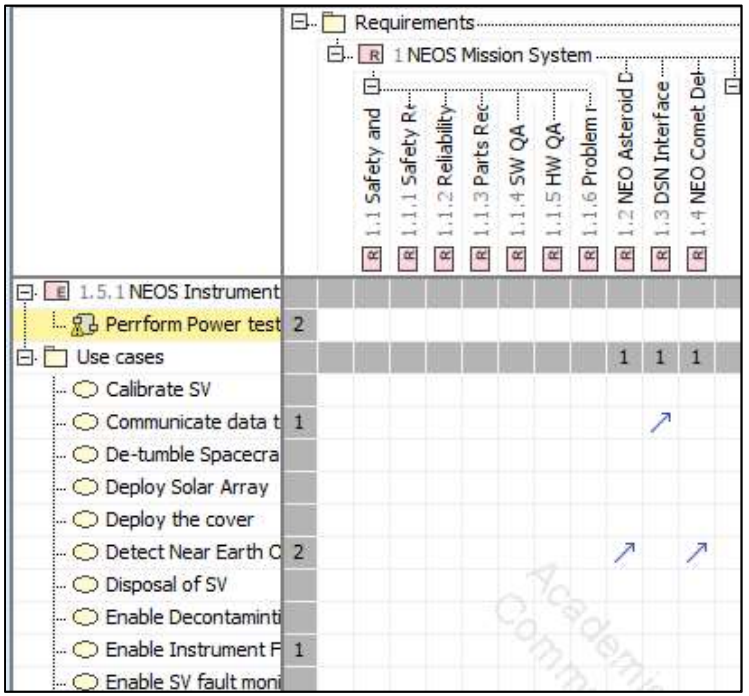
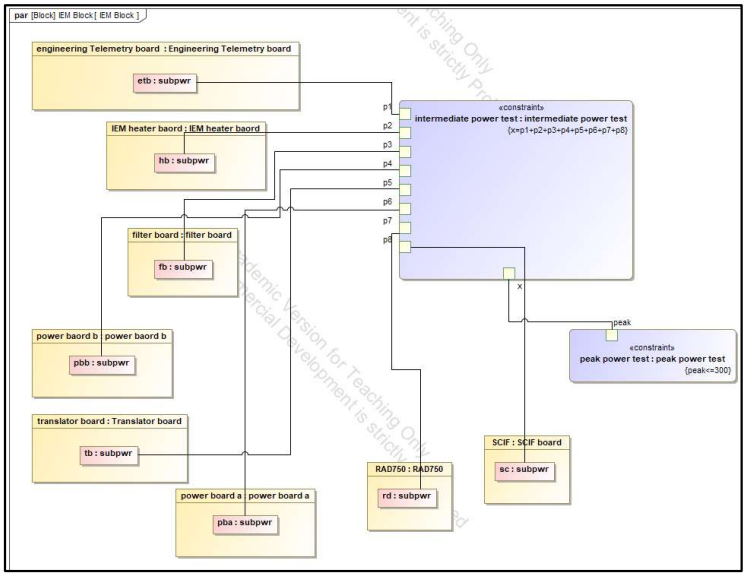
Model Based Metrics

- Metrics can be defined to assess model quality
- Assessing requirements satisfaction, requirements verification, and technical performance metrics as done traditionally provide good model assessment
- Other relationships can be used in this manner, as discussed prior with dependency matrices, to establish model completeness and team progress
- Parametric modeling and trending over time help to determine the design maturity and fidelity





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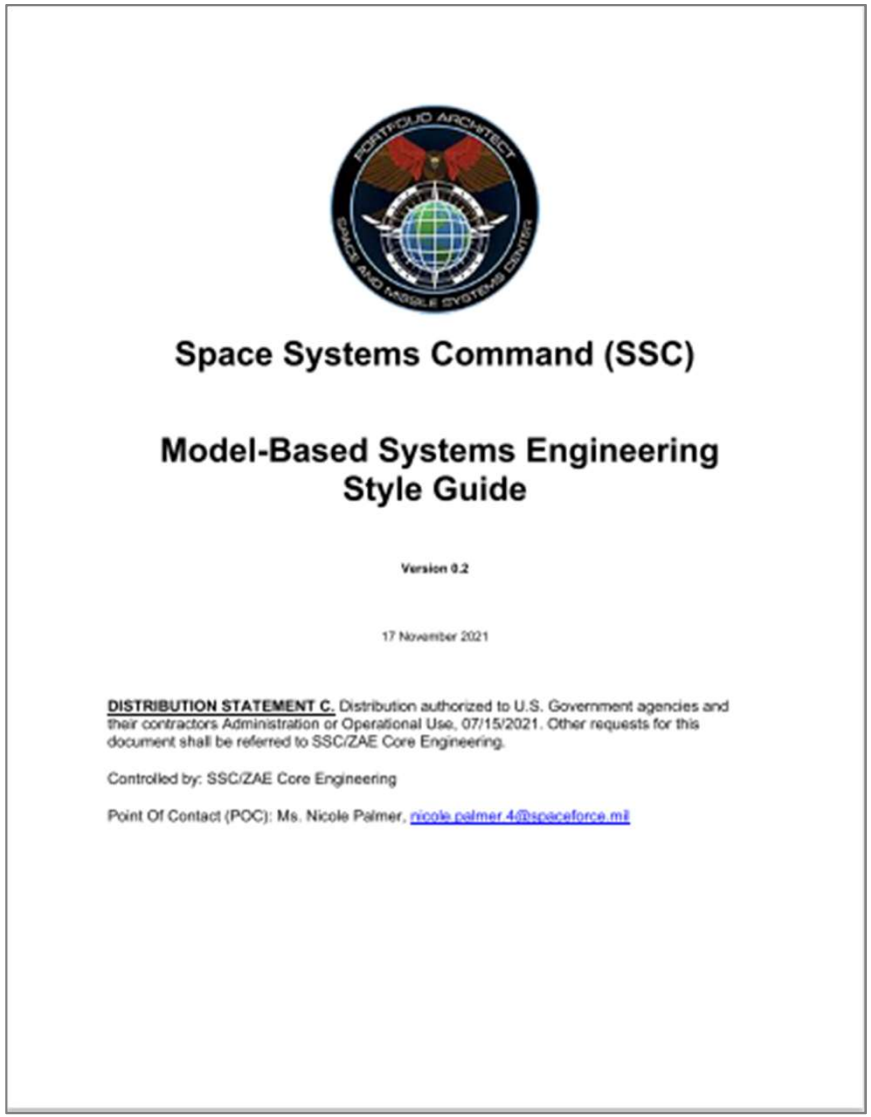
Style Guide Process

- A style guide helps to get most of the work done in the same fashion so the models the team builds are similar
- As the team gets to parts in our modeling effort that the Style Guide doesn't adequately cover, then we can decide on a style and add it to the Style Guide
- One person on the team can be appointed as the final reviewer for all models (for style adherence, not technical correctness)



Space Systems Command (SSC)

Model-Based Systems Engineering Style Guide

Version 0.2

17 November 2021

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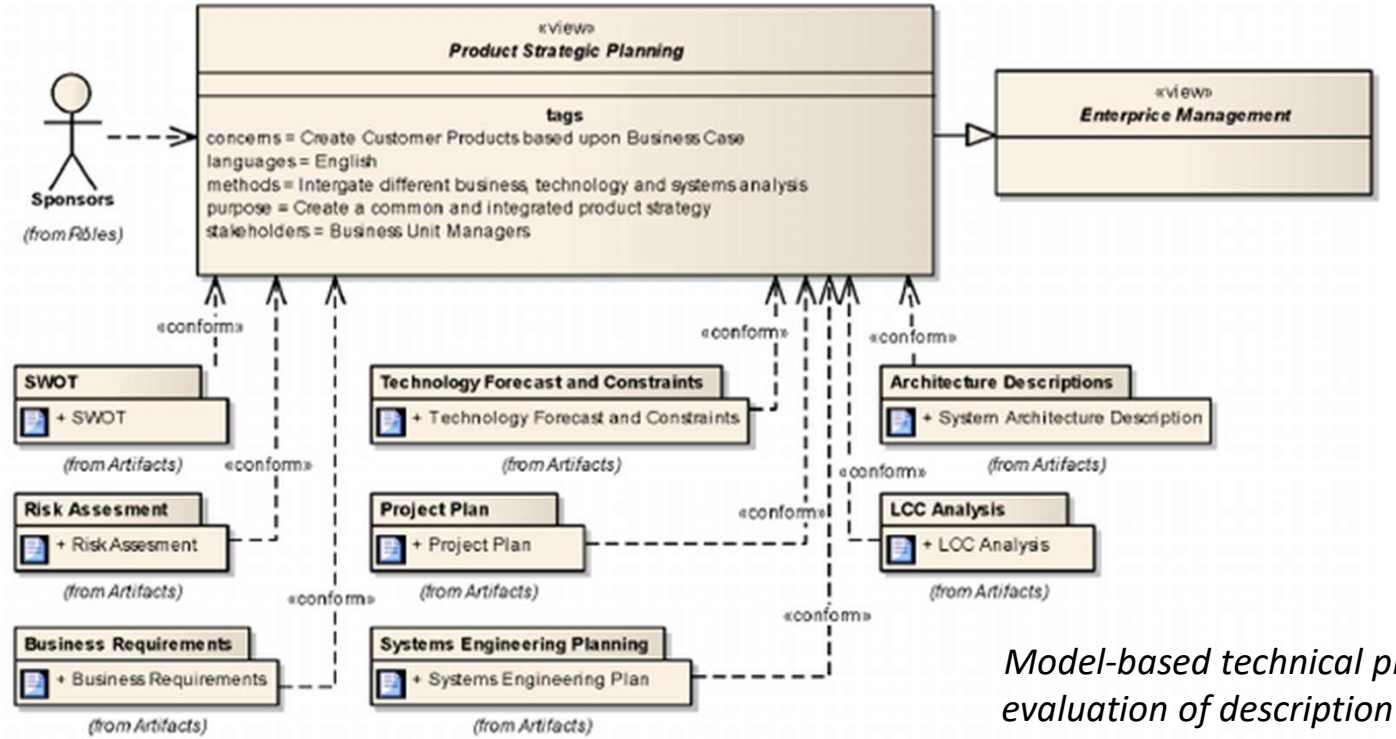
General Criteria for Effective MBSE Models

- ✓A scope which matches the scope of the project… the entire SOI?
- ✓Representative of a complete perspective from all relevant viewpoints
- ✓Compliance with a previously established standardized modeling language….SysML
- ✓Include relevant information for the system of interest (SOI) and its desired use-case(s).
- ✓Contain a description of the system functional and structural architecture
- ✓Fully complete given its scope
- ✓Integrated with any necessary auxiliary or support models

Effective system models capture key system information regarding requirements, system functionality/behavior, structure, properties, and interfaces between system components and the external subsystem

Particular Viewpoints

- A model will typically be viewed by different stakeholders who commonly have quite different roles with respect to the part of the system being modeled
- To ensure the model is useful to a particular stakeholder, views can be created representing what is seen when looking at the model from a particular viewpoint



Model-based technical planning: An evaluation of description techniques

View and Viewpoint - Considerations

One can create multiple viewpoints for the various stakeholders on your project

Creating views and viewpoints is a capability that allows the team to capture all the details of the system design in a single model repository

Creating views and viewpoints enables stakeholders to navigate through a portion of the model to see their focused work products

Views and Viewpoint Simple Example

Peer Review Type:

Requirements

Fault protection

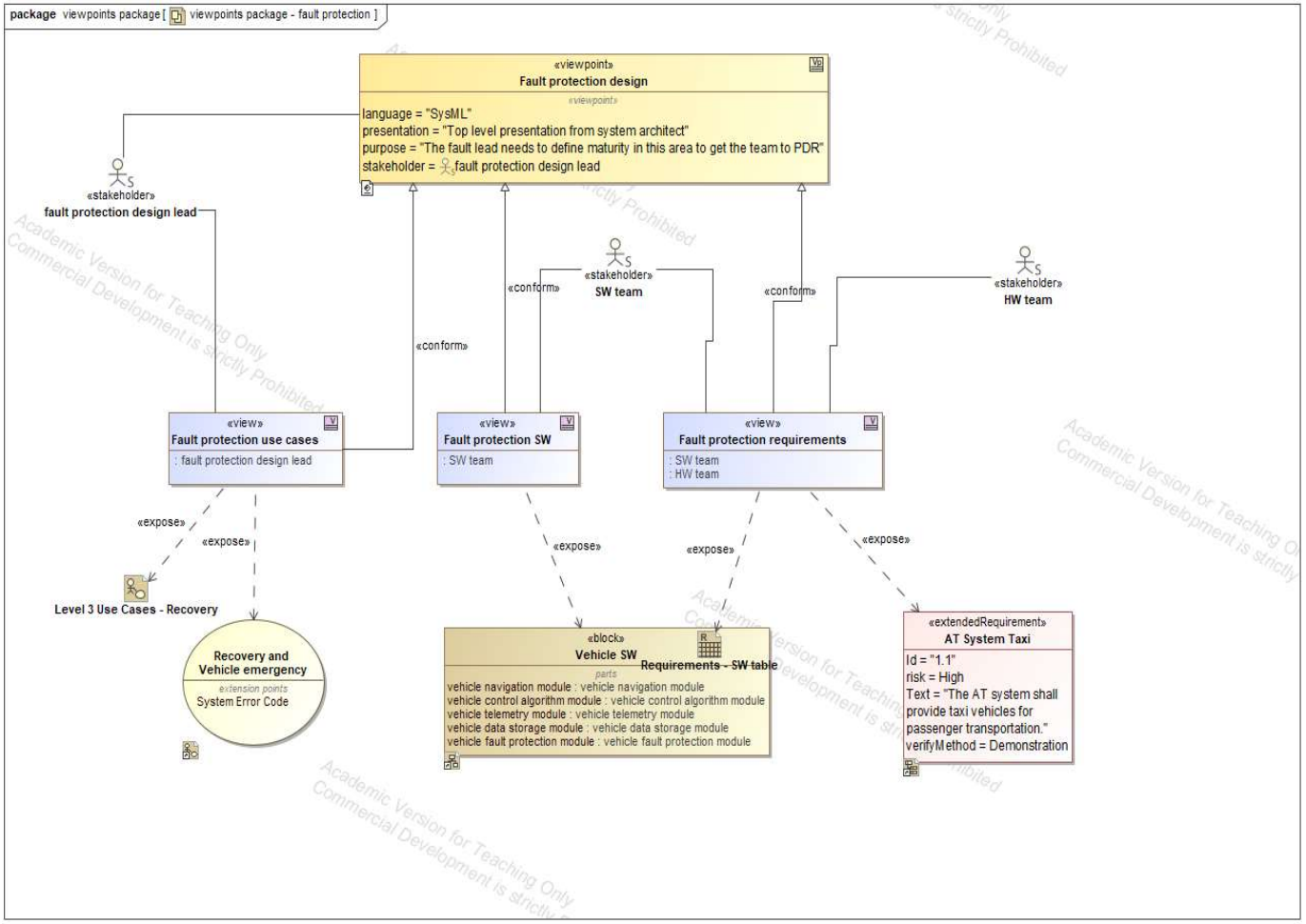
Mission States

Interfaces

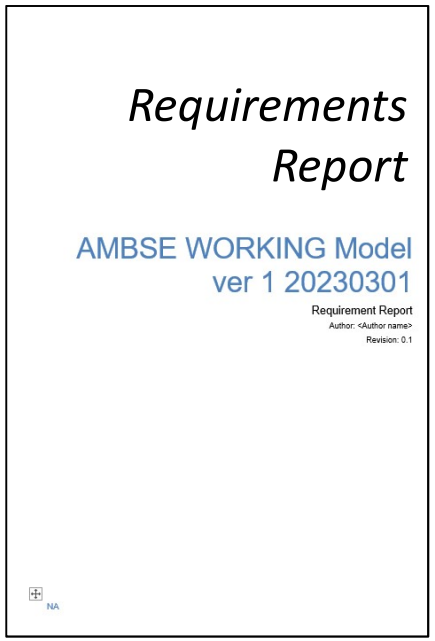
HW/SW design

Concept of operations

Operational Scenarios



Model Documentation



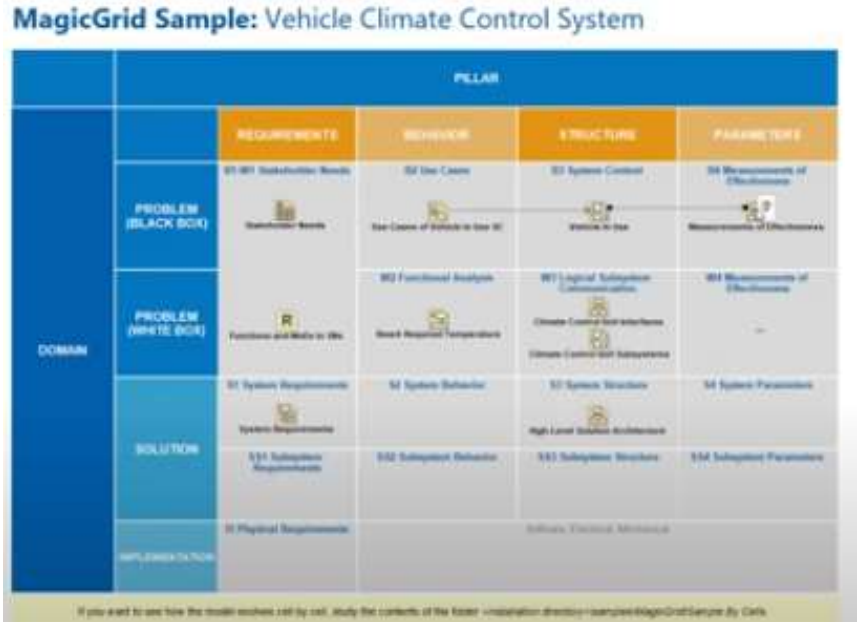
- Each relevant model element should be documented, e.g. package, block, port, interface, connector, data, and property
- For each diagram describe what it shows or what is its viewpoint
- The system engineers should ask: What is the diagram conveying and who is it for?
- Document the system being modeled:
  - Regular notes/comments: for documenting the content of the system you model, to enhance understanding of the system;
  - Problem: for marking a potential problem in the system development
  - Rationale: for justifying any decision during the development, e.g. derive of a requirement or decision on design alternatives

Cookbook for MBSE with SysML

Magic System of Systems Presentation Mode

Presentation Mode - MagicDraw 2021x - No Magic Documentation

- Create diagram views and a series of diagrams to present to stakeholders for specific peer review focus
- Allows engineers to focus the content for purpose and flow
- Legend items can be selected to bring attention to specific aspects of diagram



Questions

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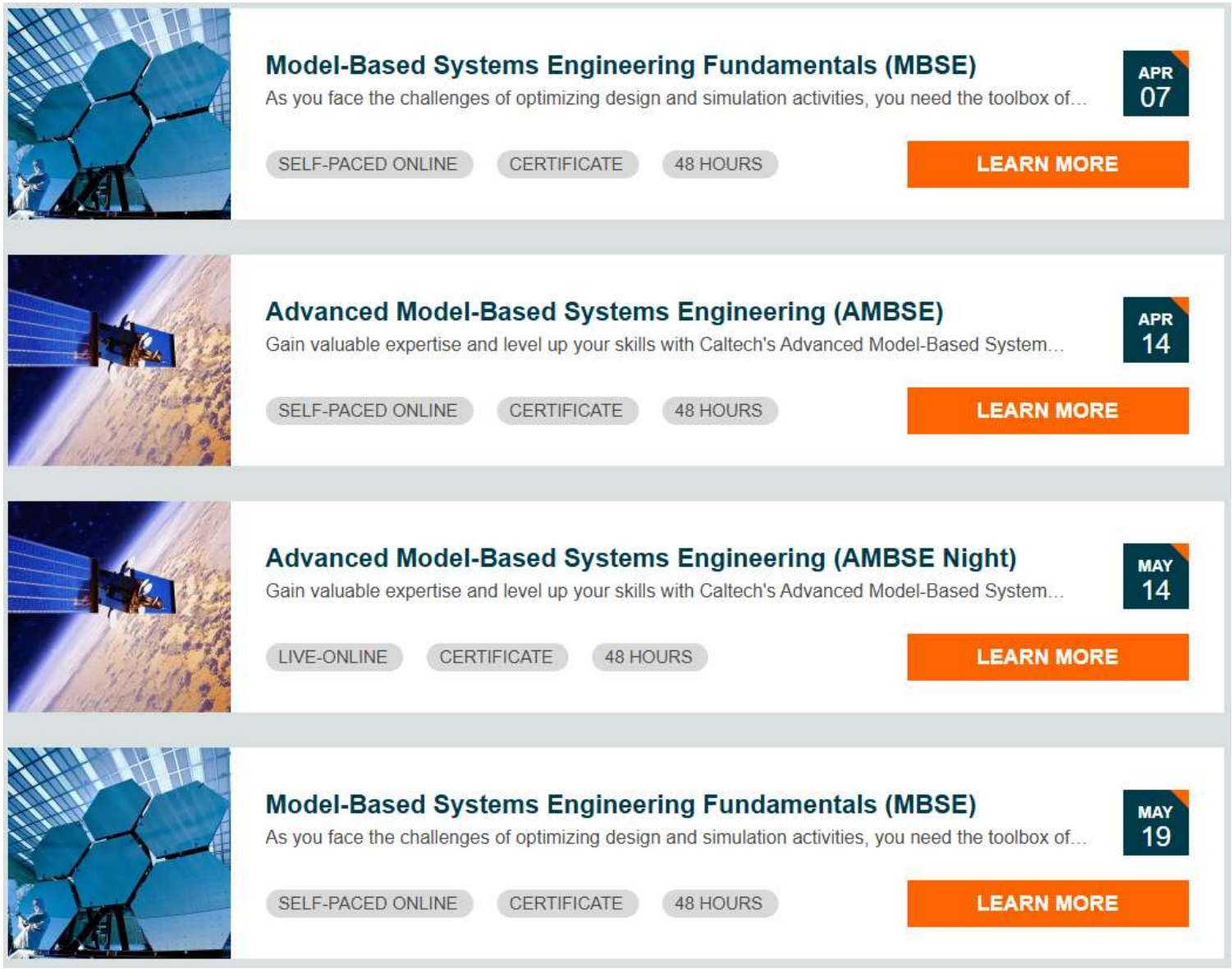
Caltech MBSE and AMBSE Courses



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