Design Reference Missions in an MBSE Integrated Environment

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GLOBAL PRODUCT DATA INTEROPERABILITY
SUMMIT
2022

Biography

Joshua Reicher
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- **15 years at AGI**
  - **acquired by Ansys (Dec 2020)**
- **Background:**
  - **Application Engineer**
    - **Customer and Sales support**
  - **Technical Product Manager**
    - **Product release management**
  - **Developer**
    - **T&E Tool Kit product, initially with F35 test groups**
    - **Space Object Threat Analysis application**
  - **Space Operations Engineer**
    - **Commercial Space Operations Center**
  - **Manager**
    - **Digital Engineering Lab**

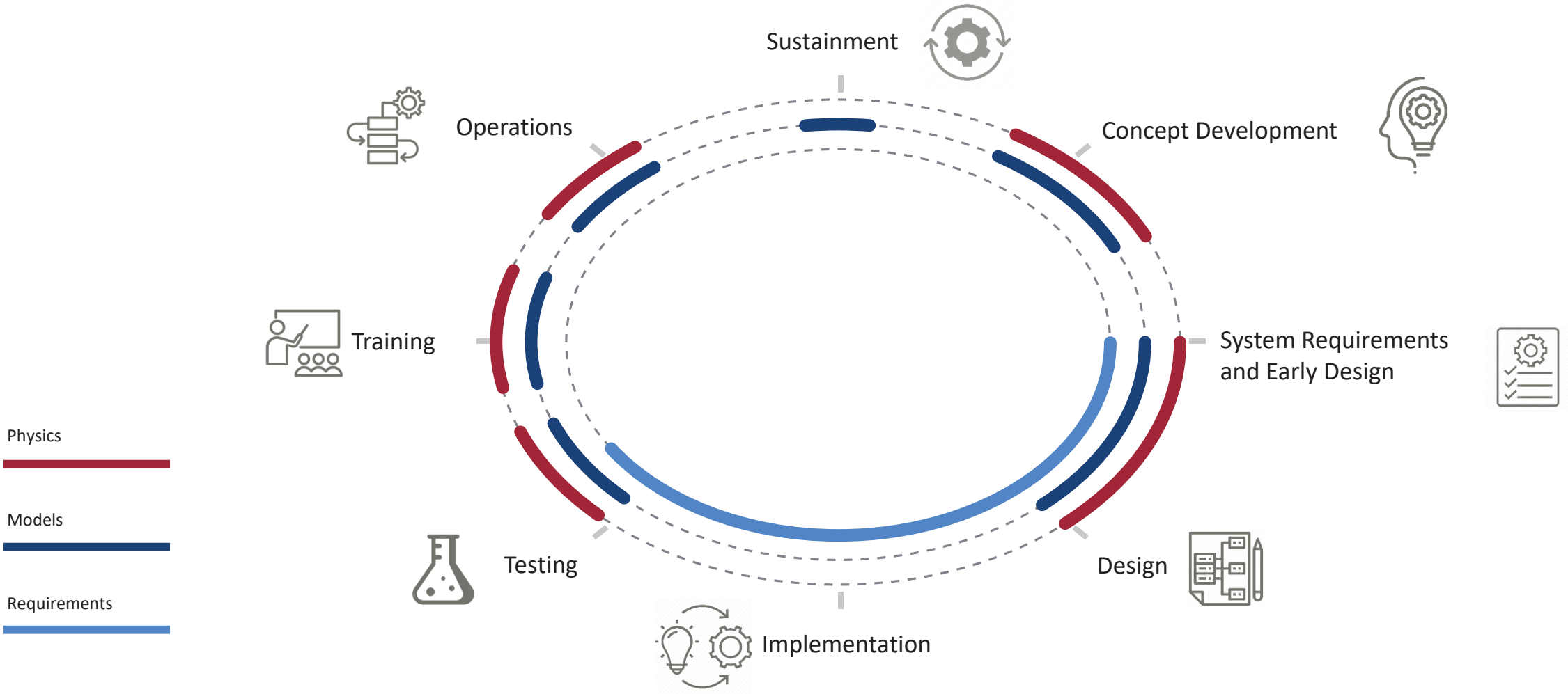
AGI Digital Engineering Lab

Vision

- **The DE Lab is the bridge between users, industry, and product management, reducing noise in the product feedback channels, accelerating integration efforts and improving the efficiency of engineering activities.**

- **We interact with colleagues, partners and customers to:**
  - **learn about the enterprise level challenges in the industry**
  - **build prototype capabilities and workflows to address those challenges**
  - **and teach others about the lessons learned**

Problems with Legacy Engineering Processes



Digital Mission Engineering Vision

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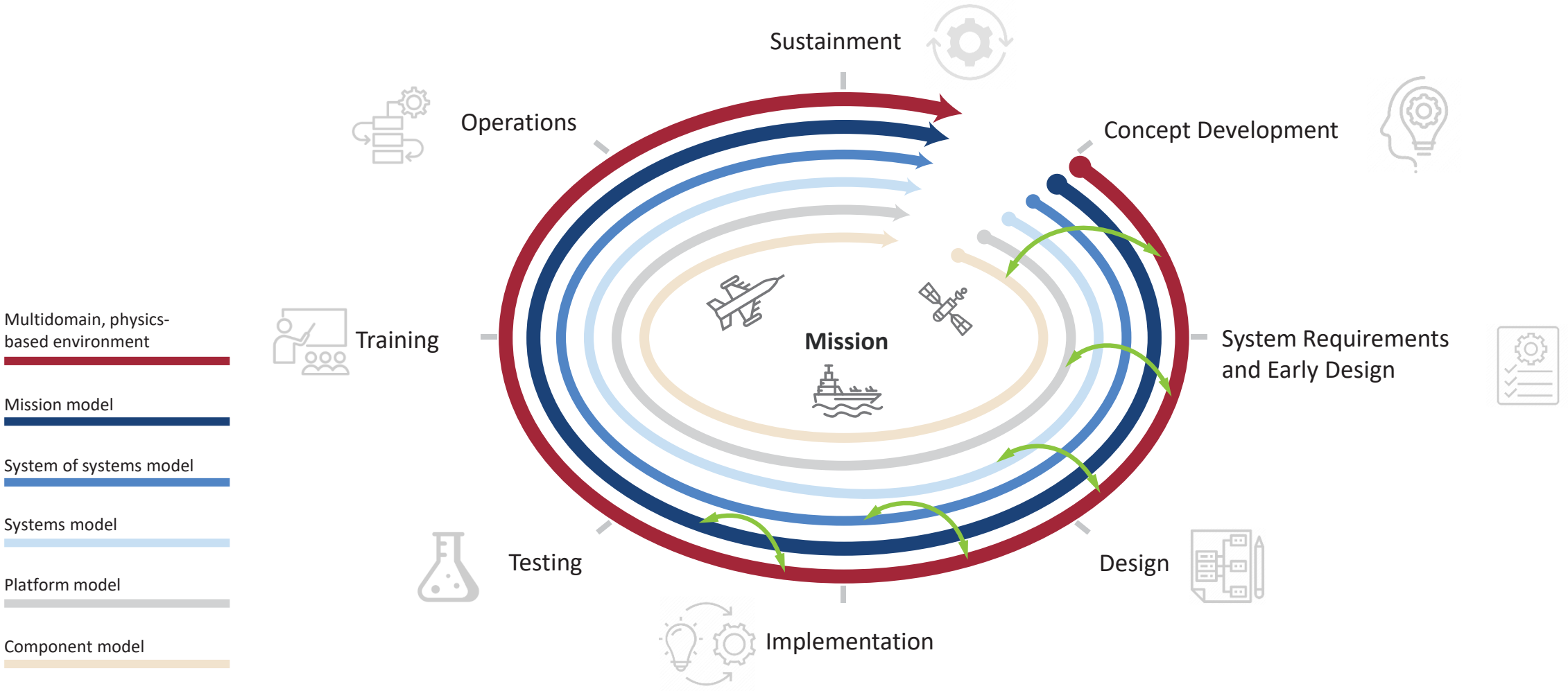
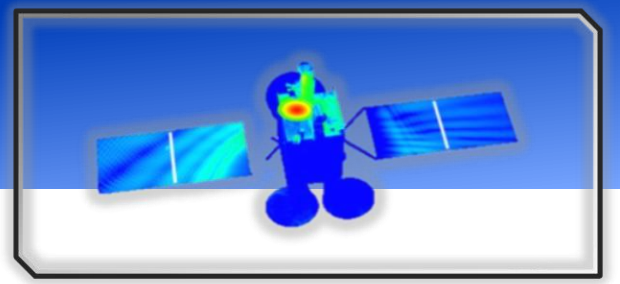
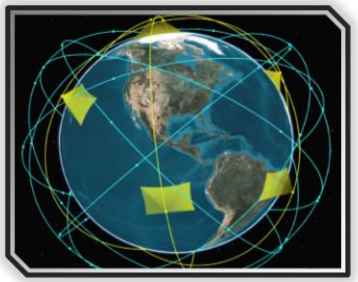


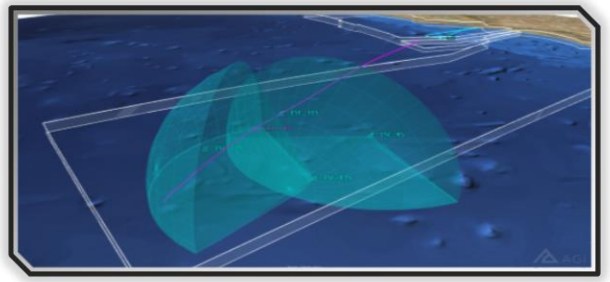
The Design Reference Mission



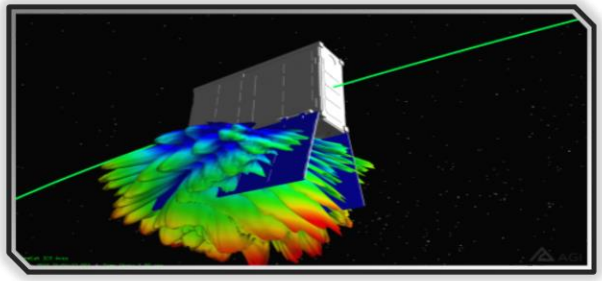
A series of **representative mission profiles** that sufficiently **describe the intended system use** across its nominal and most stressful operating conditions.

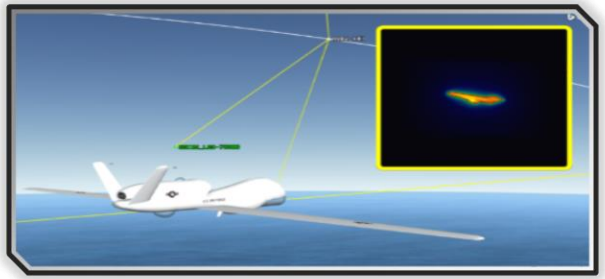
The DRM is the mechanism used to **evaluate system performance** and **guide development efforts**.

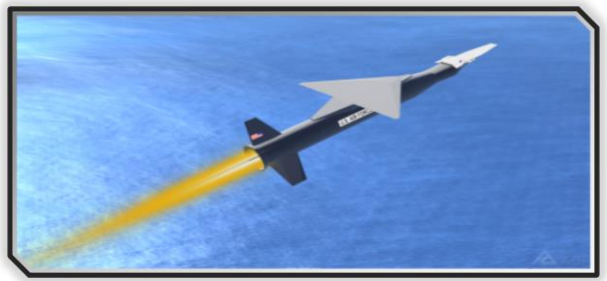


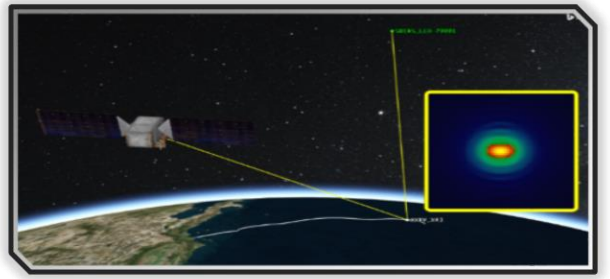


"Use-case scenarios which stress all of the systems' capabilities to a significant extent and which all alternatives will have to be able to accomplish." (NASA-DRM)









History of the DRM

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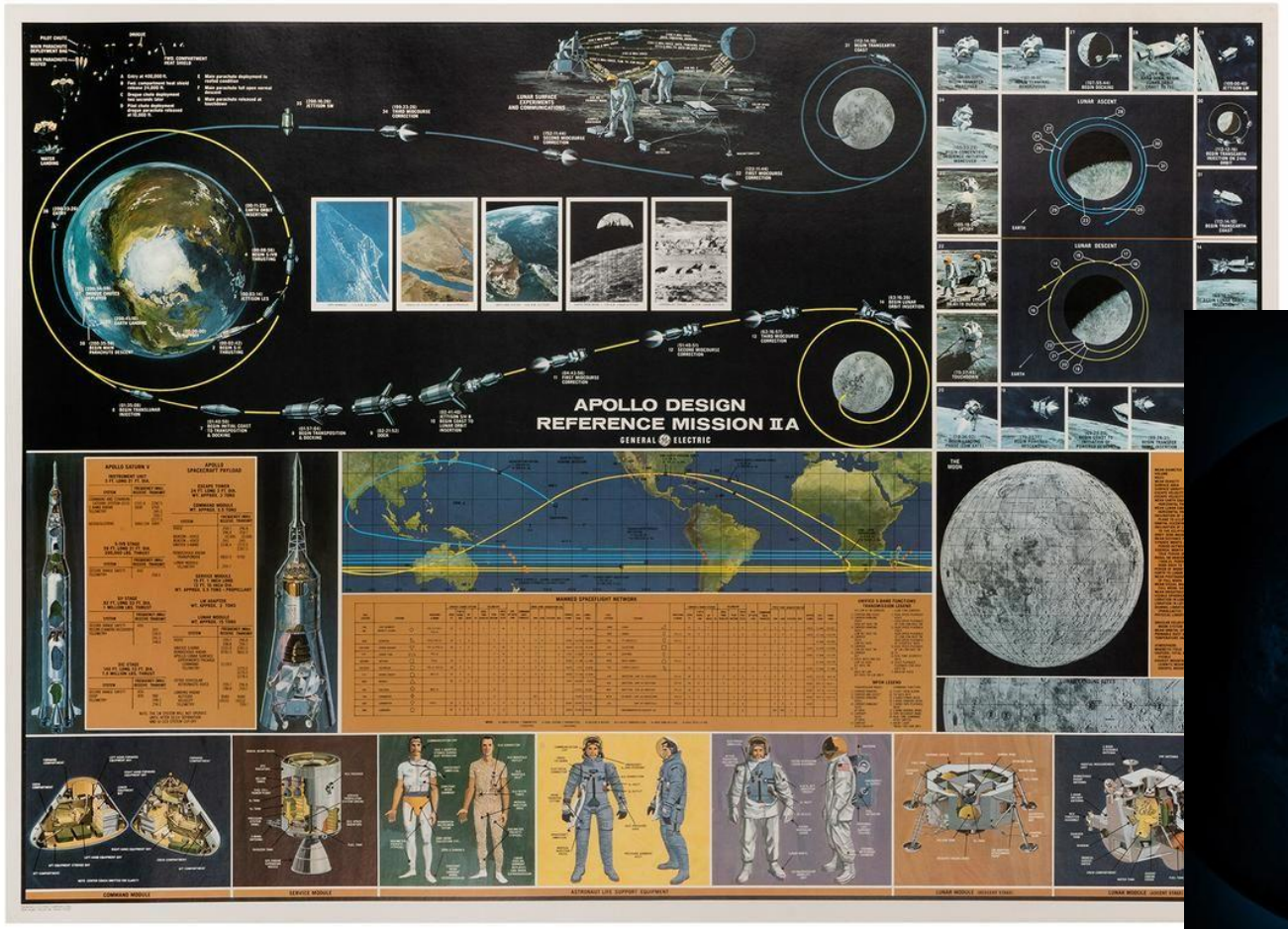
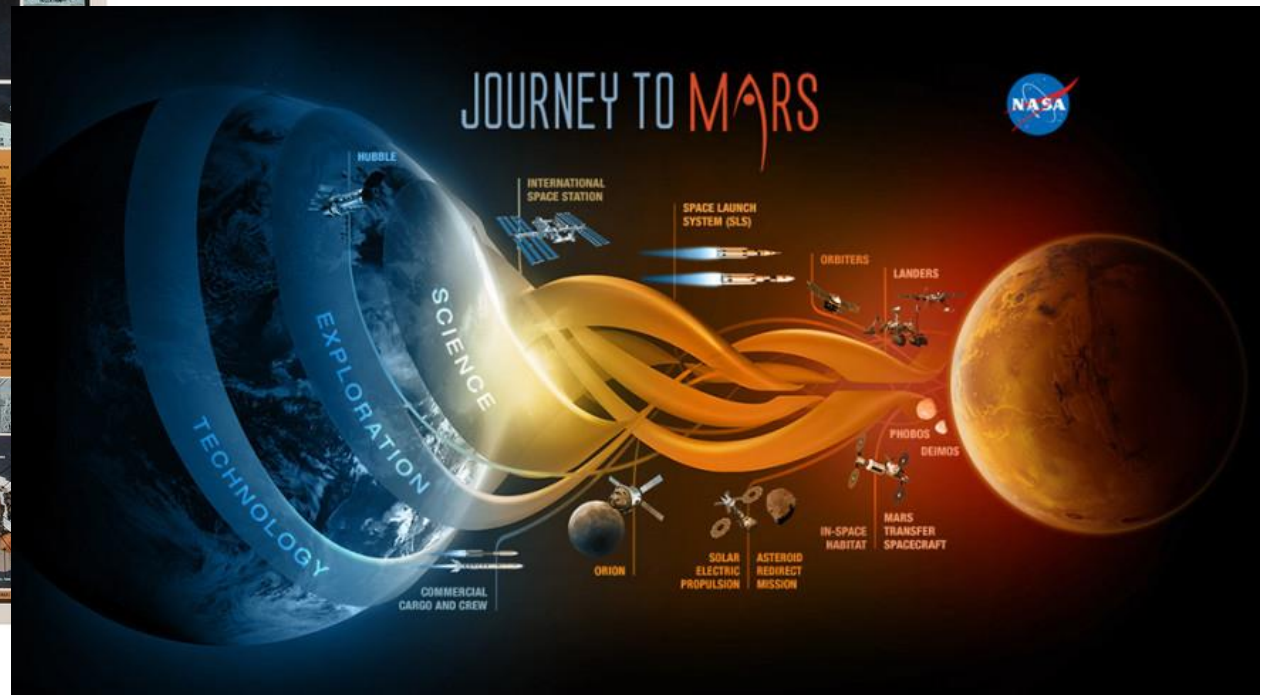


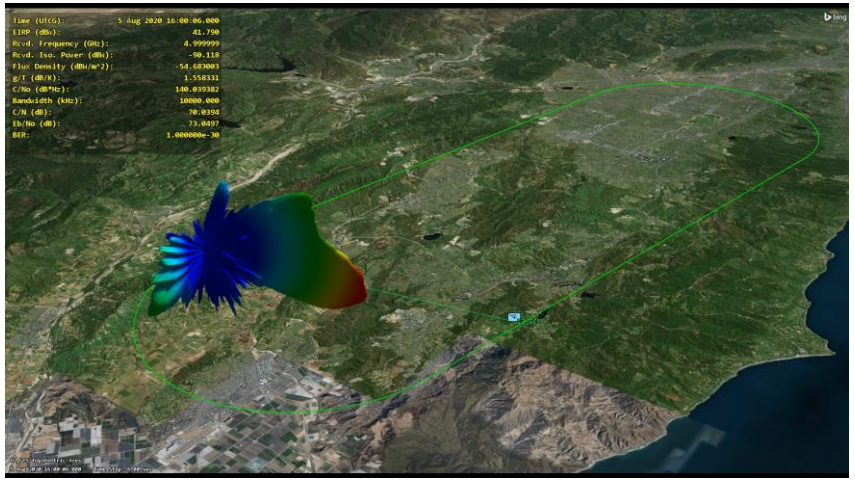


HOW TO IMPLEMENT THE DRM

As told through some of the lessons I've learned the hard way…

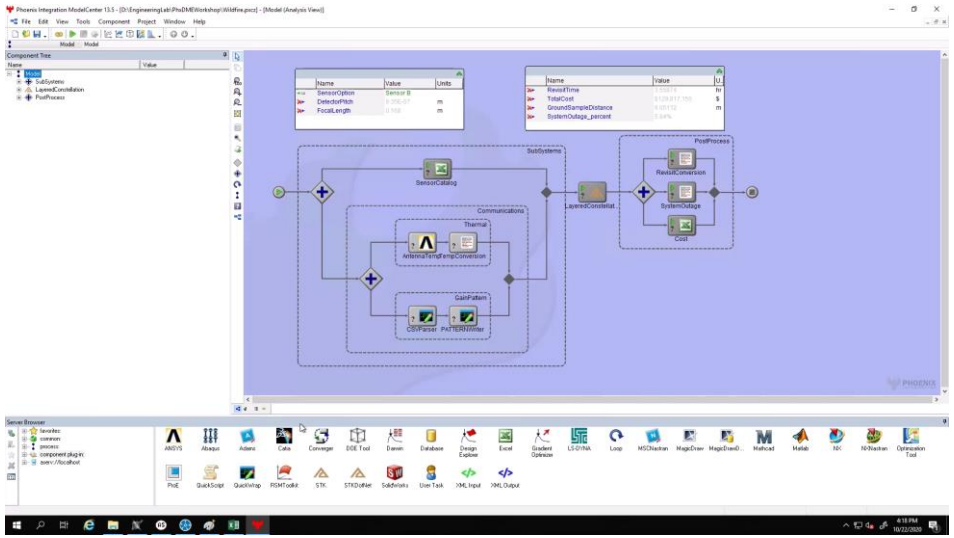
Lesson 1: A good mission simulation is worth at least 3 test flights

- **Create mission vignettes for all use cases and requirements described in your SysML**
  - **Interactions between dynamic platforms and payloads are difficult to infer from static diagrams**
  - **Mission simulations will be simple at first and gain fidelity throughout the lifecycle**
  - **Using a common framework for mission simulations enforces consistency in models**



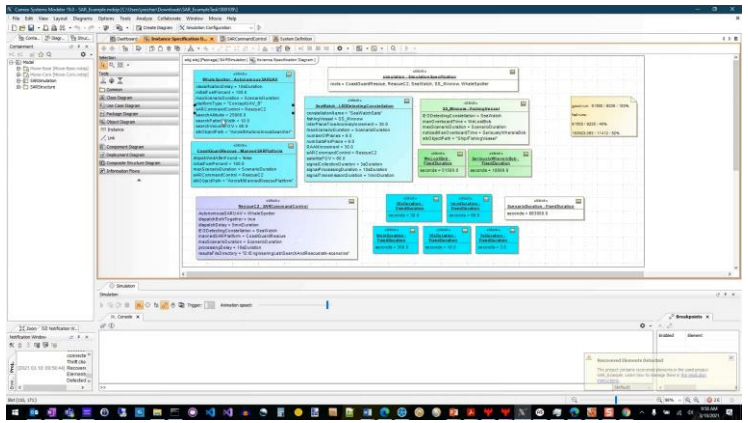
Lesson 2: Automate yourself out of a job and then begin working

- **Leverage Process Integration and Data Optimization tools where possible**
  - **Building point-to-point integrations doesn't scale well across an organization**
  - **A common framework for tool wrappers allows for quick construction of workflows**



Lesson 3: Losing sync with the ASoT causes unnecessary panic

- **Maintain a link between the simulations and the descriptive model**
  - **The inputs to component and mission simulations should be directly linked to properties in the SysML**
  - **System behaviors modeled in state machine diagrams must be executed directly**
  - **The DRM, once linked to the descriptive models, removes the SME requirements to exercise mission simulations and gain insight into requirements**

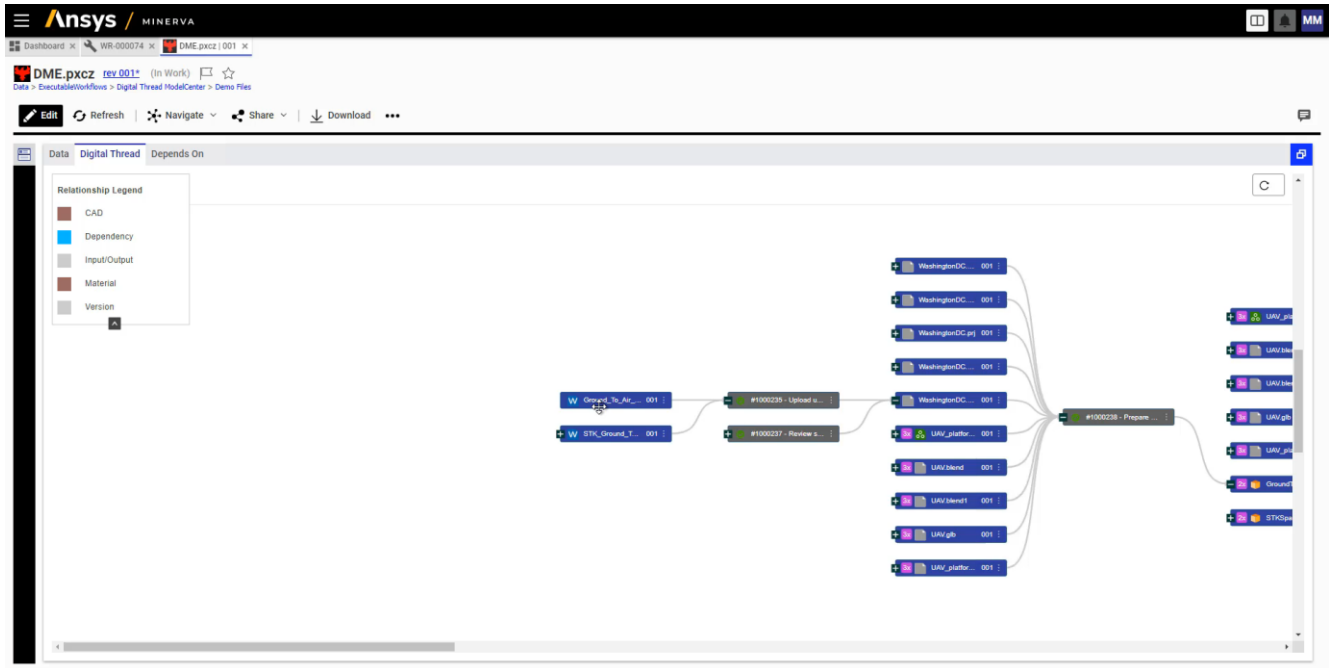


Lesson 4: Getting an email notification that you broke the build gives you time to fix it before your teammates notice

- **An automated test suite will identify issues before they become a problem**
  - **A well defined DRM provides your system with full test coverage**
  - **Linking those DRM vignettes to the descriptive model and requirements provides traceability between engineering changes and mission impacts**
  - **Design validation (or automated tests) can be configured to run when changes are checked in and/or at regular intervals**

Lesson 5: Traceability lets me know who deleted my project… but version control allows me to keep working.

- **Simulation, Process and Data Management provides insight into the heritage of the solution.**
  - **Especially valuable when requirements change or people transistion through roles**



DEMONSTRATION

Managing the Digital Thread

Architectural Models

SysML Authoring Tools

4 pillars of SysML

- **Structure**
- **Parametrics**
- **Requirements**
- **Behavior**

Model Structure and Execute Parametrics

Run trade studies on the impact SysML-defined physical characteristics have on mission performance

Perform trade studies on system behaviors

Execute Behaviors

Simulate the impact SysML-defined *behaviors* have on mission performance

Analytical Models

Simulation Tools

STRUCTURES

TETK

MATLAB

FLUIDS

ELECTRONICS

STK

Excel

Human-in-the-loop simulations
Custom simulations
Other tools

Example: Search and Rescue Mission

Fisherman falls overboard

Fishing vessel discovers the fisherman is missing and sends distress signal

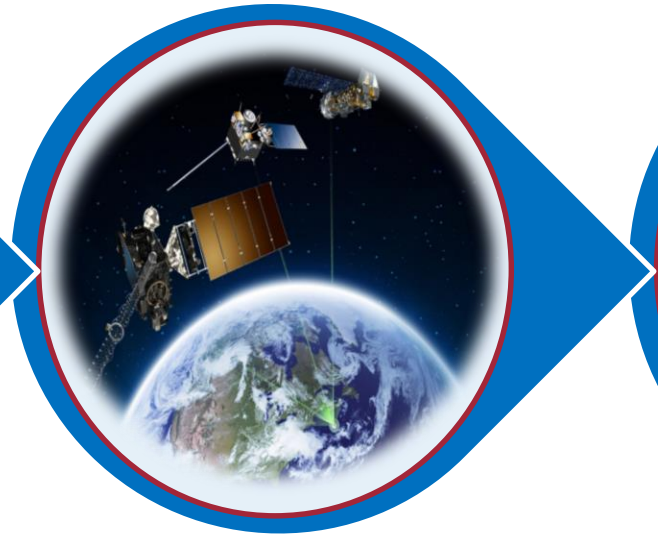
Satellite crosses overhead and receives distress signal, relays it to local Coast guard station

Coast Guard station sends out autonomous search UAV and manned rescue helicopter

UAV establishes search pattern over region around estimated overboard location

UAV finds lost fisherman

Rescue helicopter retrieves fisherman and transfers him back to Coast Guard station



Hard limit for temperature exposure in the wate

Evaluate CONOPS in Behavior Simulations

Engineering Phases

- **Challenges**
  - **Inconsistencies in the mission and environment models between teams and time spent rebuilding tools and models**
  - **Incomplete virtual design validation suite**
  - **Disconnect between the descriptive model and the simulations**
  - **Component level engineers are often not mission experts and have little to no capability of evaluating their component in the larger mission context**

- **DRM Solutions**
  - **Using a common framework for mission simulations enforces consistency in models**
  - **Every component in the SysML is connected to the DRM, providing full system coverage**
  - **The DRM, when linked to descriptive models, removes the SME requirements to exercise mission simulations**

Testing and Operations Phases

- **Challenges**
  - **Identifying test points capable of validating individual requirements**
  - **Ability to rapidly review test results and verify requirements in time for the next test event**
  - **Increasing complexity of mission systems – multi-domain, ..**
  - **Inefficient Tests (low test-point density) and high re-test rates**
  - **Communicating test results**
  - **Changing CONOPS to meet new requirements stresses operational workflows**

- **DRM Solutions**
  - **Mission vignettes in the DRM are already linked to requirements making selection of test points much easier**
  - **The DRM captures interactions between all assets in all domains**
  - **The DRM is a natural communication conduit, showing how tests relate to requirements and engineering models**
  - **The DRM is built on executable system models, making construction of new mission profiles significantly easier**

Questions?