Tradespace
Exploration of MBSE and MBE Integrated Workflows

Tony Davenport
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Systems Engineering Transformation

SET Framework
4 Elements

- Elimination of paper CDRL artifacts and large-scale design reviews
- Continuous insight/oversight via digital collaborative environment and interaction with the Single Source of Truth

CDD

Right-size CDD – very few KPPs, all tied to mission effectiveness

Instantiation System Spec in a model

Single Source of Truth

Mechanical Design Models
Electrical Design Models
Software Design Models
Testing Methods & Models

Integrated Test Vehicle #1

Move rapidly to mfg. Substantiation and insight via modeling environment

Element 4

Integration Events

Design & Manufacture Release

Element 3

Element 2

Analysis Tools

MDAO*/SET-BASED DESIGN

* Multi-Disciplinary Analysis & Optimization

NAVAIR Public Release 2017-370. Distribution Statement A – “Approved for public release; distribution is unlimited”
MBSE Integration Example

Components, Sub-System & System Analytical Models - Integrated and Linked to the Mission

Multi Disciplinary Models Leveraged & Connected

Integrated Cost-Performance Model

Requirements

Driven

Visualization & Optimization

Cost-Optimal Solutions

Mission Effectiveness & Performance

AFSIM (Advanced Framework for Simulation Integration and Modeling)

Design Of Experiments

Link To Radar

Radar Payload

Constraints

Approved For Public Release #18-0280; Unlimited Distribution
Integrated Model Framework Example

Descriptive to Analytical and Back
Phoenix Integration Brings A Team with 20+ Years Of MBE & MBSE Experience To Customers
ModelCenter is an Integration Conductor for both MBE and MBSE
ModelCenter’s 3 Major Components

- **ModelCenter Integrate**
  - Automate
  - Integrate
  - To Create a Workflow

- **ModelCenter Explore**
  - Iterate The Workflow
  - Design Studies
  - Optimizations
  - Risk/Reliability

- **ModelCenter MBSE Pak**
ModelCenter Integrate
Integrate Any Simulation via an easy to use GUI

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A ModelCenter User Can…

- Integrate just about any software solution – COTS or Home Grown software,
- Integrate and update CAD and SysML solutions as part of a workflow,
- Perform DoE, Probabilistic, Optimization, and Sensitivity Studies on the workflow,
- Allows nesting of existing workflows,

...So your organization can create a more robust, high fidelity analysis and design.
Utilize MaaS to *Share the Execution* of Models but *NOT the IP* (Intellectual Property) Across *Your Organization & Supply Chain*

IP is kept *LOCAL*, as only Key Parameters and Results are passed.
MaaS Maturity Through Time (X) & Supply Chain Connectivity (Y)
How Does MBE/MBSE Integration Work?

- Integrated Workflows are created through the ModelCenter graphical environment.
- Models and Workflows can be integrated from any location world-wide.
- Inputs and Outputs of a Software Solution are easily stitched together.
- Workflows can then be “ Played” with new inputs through the click of a button.
Create and Automate Workflows

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Video Demonstration of ModelCenter
Contact Phoenix Integration for more details.
- **ModelCenter Integrate**
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- **ModelCenter MBSE Pak**
MDAO In Decision Making

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Sensitivity Analysis

Trade Space Visualization

Optimization

Probabilistic Analysis
Reducing the Variables via Design Sensitivity Analysis

Increase design maturity
The principle

Reduction of Variables via Sensitivity Analysis

Explore boundaries
determine driving parameters
find area of global optimum
Pareto front
check robustness w.r.t. variance in input

Determine design variables + experiments
approximation of behaviour to enhance performance
find optimum

DOE → RSM → global MOO → local MOO → robustness analysis

analysis model
RSM model
area of optimum + analysis model

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Evaluate Program-Specific Tradeoffs and View Structure of Data Using Visualization Tools

Pareto Front: Max EIRP vs. Cost

3-D Data Manifold of KPP Output Space: Max EIRP vs. Cost vs. Prime Power

Define Component & SWaP Constraints

Color Shading Design Cases Based on Best (Blue) to Worst (Red); Able to Gray Out Design Cases That Do Not Meet Specified SWaP Constraints
ModelCenter Risk/Reliability Analysis Benefits

Statistical Validation of Propellant Load

- Propellant load validated from CRS Performance Integrated Monte Carlo analysis
- Analysis calculated total mission $+3\sigma$ propellant, fuel, and oxidizer consumption
  - Total mission $+3\sigma$ propellant results in 7-9% reduction vs. sum of budget $+3\sigma$ line items
- Propellant load is validated with Monte Carlo simulation

"results in 7-9% reduction [in propellant mass]"
• ModelCenter Integrate
  • Automate
  • Integrate
  • To Create a Workflow

• ModelCenter Explore
  • Iterate The Workflow
  • Design Studies
  • Optimizations
  • Risk/Reliability

• ModelCenter MBSE Pak
MBSE – Moving System Engineering from Document to Authoritative Source of Truth

MBSE in a Nutshell

Traditional Systems Engineering  Model Based Systems Engineering

http://sysengonline.mit.edu/
MBSE - SysML

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The Four Pillars of SysML

- Behavior
- Requirements
- Structure
- Parametrics

Phoenix Integration
ModelCenter®
Today: Connect SysML with Engineering Analysis

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System Model (SysML)

- Analysis requests
- Analysis specifications

Requirements
Architecture
Behavior
Traceability

Systems Engineering Model

Bridge the Gap - MBSEPAk

Bidirectional Integration via ModelCenter

- Performance estimates
- Trade study results

ModelCenter

Mechanical
Electrical
Simulation
Cost
Manufacturing

Analysis Optimization Visualization

Domain Engineering Models
Design Exploration with MBSE integration
SysML Model to ModelCenter

• Automatic requirement verification via domain expert simulation results.

• Access ModelCenter Explore (MDAO) capabilities without leaving the SysML tool.
Design Exploration with MBSE integration
SysML to ModelCenter

Video Demonstration of ModelCenter
Contact Phoenix Integration for more details.
Responding to a Change Request with MBSE integration: ModelCenter to SysML Model

• Share performance requirements from SysML models with domain experts through SysML integration.

• Automatically generate workflows from SysML models to rapidly respond to requirements changes.
Responding to a Change Request with MBSE integration

ModelCenter with SysML model

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Video Demonstration of ModelCenter
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Generate Workflow from SysML…

Import Current Design Values From SysML Into Domain Expert Models…

Push back to SysML with Single Click…

And Review/Verify Requirements Stored in SysML Model
Domain Experts are using the same Analysis As the Systems Engineer…

And Storing the Results in the Authoritative Source of Truth…

With the Same Values…

With the same context as other Domain Experts and Systems Engineers!
The Domain Experts & Systems Engineers are fully participating as a team, both utilizing the same Models and Data.

Fielding Technology Faster!

And Storing the Results in the Single Source of Truth…

With the same context as other Domain Experts and Systems Engineers!
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Integrated Workflows

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• Modeling Framework Requirements
  • HPC enabled
  • Single Source of Truth
  • Integration of Multi-domain/physics models
• Method for Model Integrity
• Systems Engineering (SE) activities... in the context of a Digital Thread.

Why Did You Choose ModelCenter?

"During our earlier analysis with NAVAIR, when we went out and visited industry, government, and academia... We interacted with over 30 organizations, 21 onsite visits... they all used ModelCenter."

Dr. Mark Blackburn, Ph.D. – Stevens Institute Systems Engineering Research Center (SERC)

Applications for Three Research Use Cases in Model Centric Engineering using ModelCenter and MBSE Pak

STEVENS INSTITUTE OF TECHNOLOGY
https://www.phoenix-int.com/applications-three-research-use-cases-model-centric-engineering-using-modelcenter-mbse-analyzer/