## Integrated Model Framework for Concept Development

VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

### 2015 User's Conference MBE

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## How can Model Based Engineering (MBE) be implemented on a program?



- Many use MBE successfully today...
  - Solving hard problems
  - Finding new novel solutions
- Unfortunately, most have been stovepiped...
  - Models are typically limited to a discipline, limiting the trade space





## A Cohesive Process Using Integrated Modeling



 The Mission Systems Engineering group at Northrop Grumman decided to take the next step

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- 6-Step process for integrating models
  - "Integrated Model Framework"
  - Phoenix Integration's MBSEPak®
- Will integrated models enable better/quicker system level decisions?



#### **Integrated Model Framework:**

**Descriptive to Analytical and Back** 





## Investigating Radar Performance vs. Cost Over a Variety of Generic Platforms



## Utilizing Disparately Designed Models to Perform Trade Analysis





System level models from different departments inherently share information

## Step 1: Generate a Requirements Diagram



## DOORS or Excel Requirements

- Power Consumption
- Radar System Weight
- Probability of Detection
- Signal to Noise Ratio

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- Requirement Specifications brought into Rhapsody
- Lower and Upper Bounds can be established in Rhapsody
  - Requirement goals are established

### Setting up the System Architecture





## Step 2: Decompose Visio/Initial Block Diagrams to Rhapsody Block Definition Diagrams



- Generate an Architecture based on requirements
- Typically designs are created in Visio
  - Visio does not offer the traceability needed in this process
- Manually decompose Visio diagrams into SysML Block Definition Diagrams







## Step 2: System Architecture Connects to Requirements





## Step 2: Connecting Descriptive and Analytical Models





# Moving Between Descriptive and Analytical House





### Step 3 & 4: Establish Connection Layer





- Phoenix Integration's MBSEPak® will establish physical connections between Descriptive and Analytical Models
- After analysis is performed, ModelCenter® will flow data back to Descriptive Model

#### **Integrated Model Framework:**

#### **Perform Trade Studies**





## Step 5: Perform Trade Studies in ModelCenter

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Visual analysis of the data can be created

 Design of Experiments and Optimization Analysis

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Dashboards are created
 automatically for feedback of requirement verification





## Cost and Performance Scaling of Varying Size Radar Options



- This simple experiment confirms logical expectation:
  - Bigger Radar yields Higher Probability of Detect at a Higher Cost
- Detailed analysis enables discussion of:
  - Can we achieve target performance within specific platform limitations?
  - What performance requirements drive solution cost and size?
  - How much is more performance worth?
- Able to evaluate more experiments along more dimensions using models integrated through ModelCenter® than ever possible manually





### **Investigating Designs:**

Tradeoffs & Model Exercising





## Trade Space Optimization to Investigate Optimal Designs



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Varying 3 design

variables

Copy

Close

- variables by getting as close as possible to the constraints
- ModelCenter® suggests a best design (run 40 out of 86)
- Goal: Minimize Radar Cost
- Constraints are based on requirements

Running the Optimizer provides feedback about the models and flexibility of designs based on requirements

## Higher Fidelity Cost Model Added: SEER-H Integration





#### Mission/Engagement Simulation Validation:

Enhanced Radar Centric Engagement Model





### Integrate ERACE with Engineering Models





#### Analytical Back to Descriptive:

#### Update Architecture with New Attribute Values





## Step 6: Update Descriptive Model with New Design Variable Values

- Design parameters (attributes) have changed due to trade studies performed
  - Rhapsody "Descriptive Model" is updated with new attribute values
  - New parameters show where current architecture fits with performance requirements

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#### Getting Ever Closer to the End-to-End Model

- Linked requirements and architecture (descriptive modeling), with engineering and engagement/mission models (analytical modeling)
- **Generated** vast quantities of trade studies to perform cost vs performance analysis
- Reduced manual communication between teams
- **Paved** the way for validating engineering design decisions with respect to the customer's mission





## THE VALUE OF PERFORMANCE.





Christopher Hoffman is currently in the Professional Development Program as a Systems Engineer for Northrop Grumman Electronic Systems (NGES) in Baltimore, MD where he has worked for the last year. Prior to working at NGES, he worked for an organization designing and building micro and nanosatellites for the Air Force Research Labs in Boston, MA. He received a Bachelor's of Science in Electrical Engineering at Boston University in 2013 and is currently finishing a Master of Science degree in Electrical Engineering at Johns Hopkins University. Since joining NGES he has worked in the Power Conversion Technology group designing and testing power supplies for future radar designs and is now part of the Mission Systems Engineering group tasked with implementing Model Based Engineering practices on internal programs.

#### Abstract



As systems become more complex, turning the many knobs on design choices becomes a complex n-dimensional problem. Not only is this difficult from an analysis point of view but it is further inhibited by the amount of communication needed between different system designers. Because of this, it is easy to optimize a portion of the system at first, say an antenna, but later find that the rest of the system components (power, physical structure, and software design) are now all constrained. Flexibility in both design and cost are now lost and the ability to change designs in the future are timely and expensive. Alleviating the stove piping effect of designing complex individual components for large systems throughout concept development is a must.

An integrated model framework was implemented for an internal customer, generating large amounts of trade studies by connecting architectural models with integrated software, antenna, power, and cost models for a radar design. What came out of this implementation was the ability to cut down on the labor and time required to combine data from independent models from many disciplines. This opened up the possibilities of turning new and more knobs of designs that would not have been considered due to the stove piping of information.

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