Model Based Engineering at Northrop Grumman Electronic Systems

April 14, 2015

Guy Babineau

Northrop Grumman Electronic Systems

Chief Engineer for Model Based Engineering

Model Based Engineering – Electronic Systems

MBE is an approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle. (NDIA)

System Architecture Model(s)	HW/SW Architecture Model(s)	Implementation Model(s)
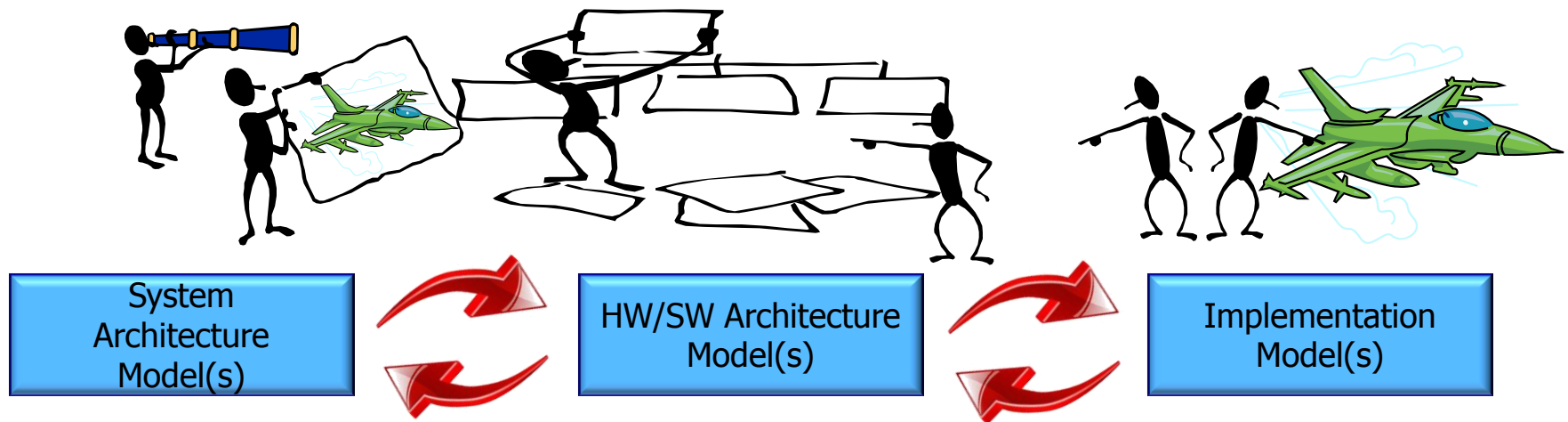
- Proven results at NGES with MBE with demonstrated
  - Reduction in cost
  - Reduction in schedule
  - Improvement in delivered quality
  - Higher customer engagement in the engineering process and satisfaction with the results

MBE is a change to the way engineers may have worked in the past

Systems
- Models are now integral and carried forward for the full life cycle
- Models are used to communicate with internal and external stakeholders
- Multiple models are connected including performance and cost

Integration and Test
- Models are used for early retirement of risks in integration
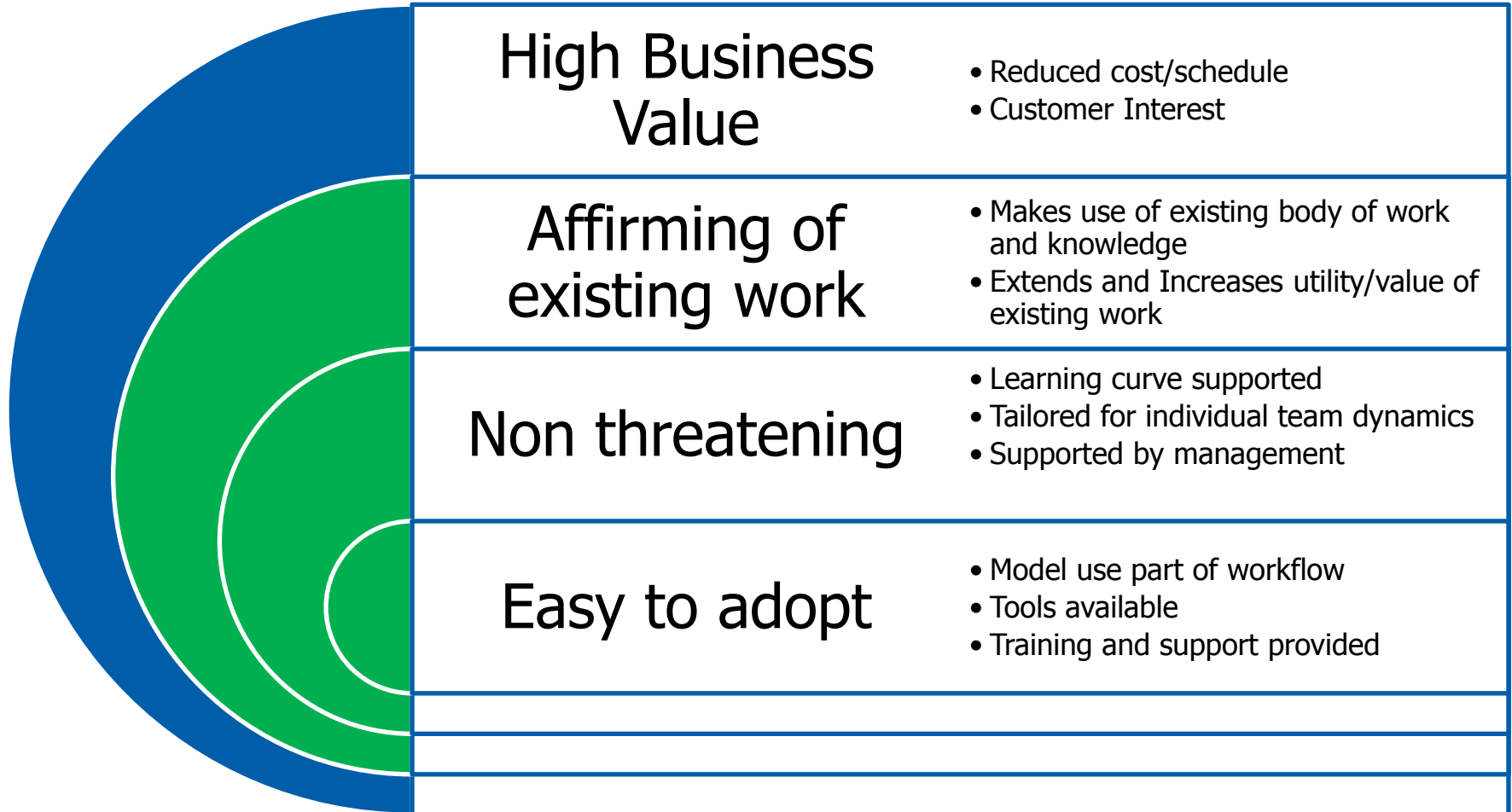- Models are used to predict performance and reduce the need for physical testing and resources

Software
- Models derive from the systems models
- Models are used to generate the code (structure and logic)
- Changes are made via the model, not the code

Hardware
- Models digitally connect to implementation e.g. to manufacturing
- Changes are made via the model, not in downstream derivatives
- Hardware disciplines are digitally interrelated and derived from systems models

Common Elements of Successfully Sustained Transformations

High Business Value
- Reduced cost/schedule
- Customer Interest

Affirming of existing work
- Makes use of existing body of work and knowledge
- Extends and Increases utility/value of existing work

Non threatening
- Learning curve supported
- Tailored for individual team dynamics
- Supported by management

Easy to adopt
- Model use part of workflow
- Tools available
- Training and support provided

Examples of Successfully Sustained Transformations

- Digitally connecting models for system optimization

- Models used for communication with the customer

- Models are used for software code generation

- Hardware design models extend to production

- When models are supported by customer demand

| High Business Value |
| Affirming of existing work |
| Non threatening |
| Easy to adopt |
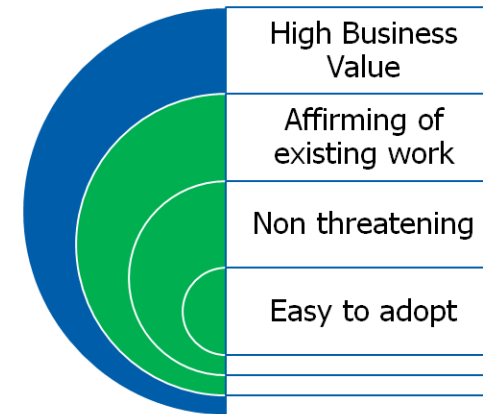
Digitally Connecting Models for System Optimization – Value Proposition

- Typical Challenge for radar design
  - Customer need for certain performance
  - Customer constraints for example in cost, weight, space, available power

- Non-connected solution
  - Individual performance models
    - Weight, Power, Performance, Reliability, …
  - Separate Descriptive Models
    - Architecture, Redundancy
  - System optimization for all constraints difficult, time consuming and error prone
  - Typically takes multiple days to determine performance of a single solution

- Digitally connected solution
  - Automates connections between related models and eliminates transcription error
  - Performance of a single solution can be performed in seconds, minutes (depending on complexity of individual models)
  - Automates the identification of optimal solutions (based on value functions)

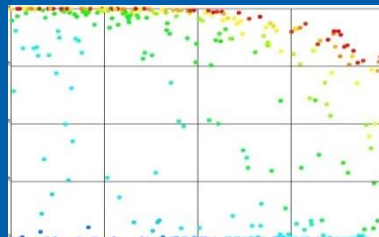# Investigating Radar Performance vs. Cost Over a Variety of Generic Platforms

NORTHROP GRUMMAN

Helicopter
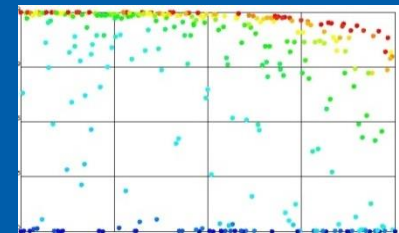- Altitude
- Weight
- Speed
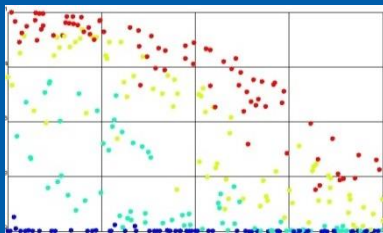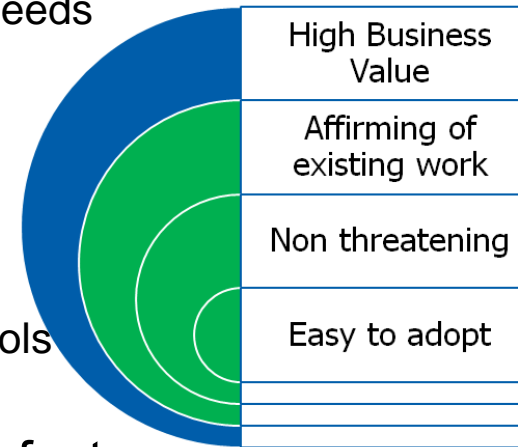
Large Aircraft
- Altitude
- Weight
- Speed

Fighter Jet
- Altitude
- Weight
- Speed

Why Digitally Connecting Models Works Culturally

- Affirms and honors the prior work of the team
  - Performance models developed and proven over a career can be used in new ways
  - With visualization and combining with other models, demonstrates depth of knowledge and ability
  - Shows direct link of engineering analysis work to customer needs

- Is non threatening
  - Doesn't replace existing models
  - Discipline engineers stay within their toolset
    - Connection of models can be performed with multiple tools

- Makes a difficult and error prone process "Easy" and fast.

High Business Value

Affirming of existing work

Non threatening

Easy to adopt

# Models Are Used for Customer Communication

- **Design Reviews**
  - Design reviews with customers/stakeholders are important validation events
    - Helps ensure design is meeting customer/stakeholder objectives
  - However, this has led to the proliferation of multi-day reviews with hundreds of slides at multiple levels of a complex system
  - Often, these presentations use "pictures" of the design rather than the model itself
    - The pictures are easy to print and put on slides
    - If the pictures become the embodiment of the design, the design becomes disconnected from the model
 - We have had more success when the design reviews work within the design model themselves instead of pictures

- **Customer involvement**
  - We have had success even with customers who did not have prior experience with modeling languages
  - Challenges remain in standards and ability to deliver models

High Business Value

Affirming of existing work

Non threatening

Easy to adopt
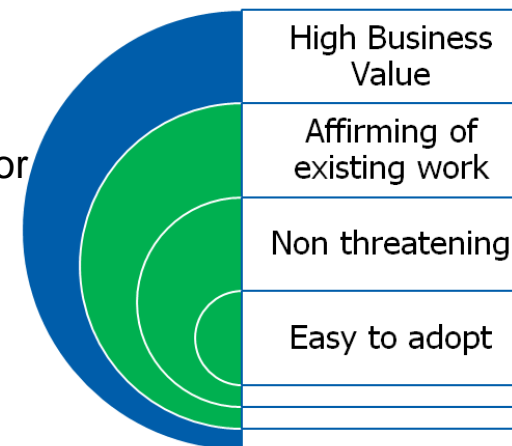
Using Models for Code Generation Enhances Sustainability

- Generation of code structure
  - Componentization
  - Class structure
  - Interface definition
  - Deployment

- Generation of business logic
  - Algorithms
  - Control flow
  - User Interfaces

- In both cases, projects which have been successful in continuing this technique make changes at the model level, not intermediate levels (no code patches)

- At NGES we have projects using both techniques with a range of code generation from the models with results ranging from 15% to 90% of code generated and maintained exclusively from model (vs by hand or tables).
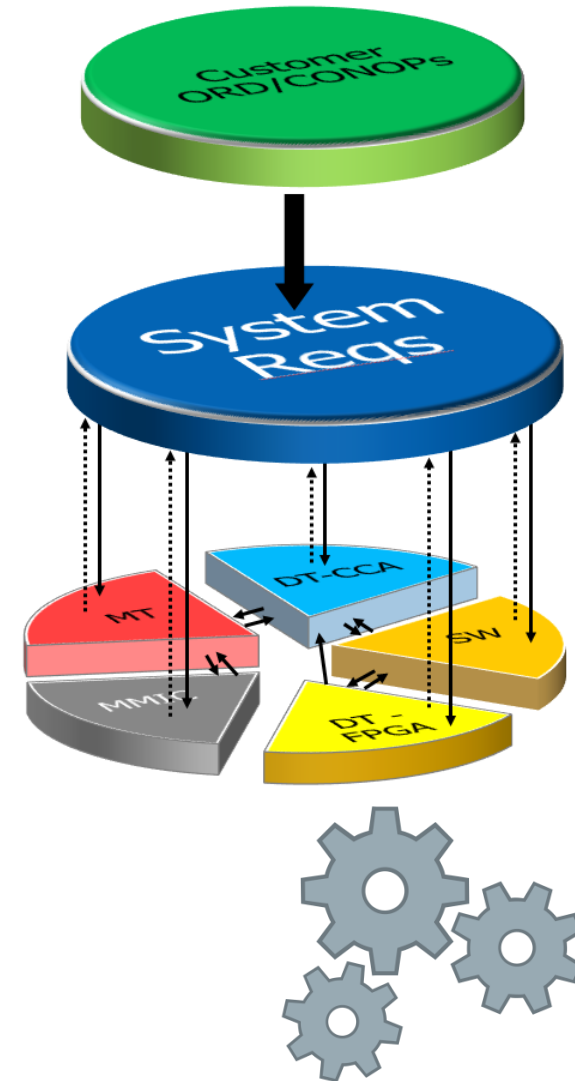
MBE and Hardware Engineering

- Today's tools allow us to fully specify electrical, mechanical and other designs fully in a model

- We can verify performance of the design in the model

- We can take the verified model directly into production/procurement
  - Programmable Logic, Additive Manufacturing, CNC, Etc

- Where this has been successful is when changes are incorporated at the model level, not at intermediate levels

HW Architecture Model(s)		Implementation Model(s)
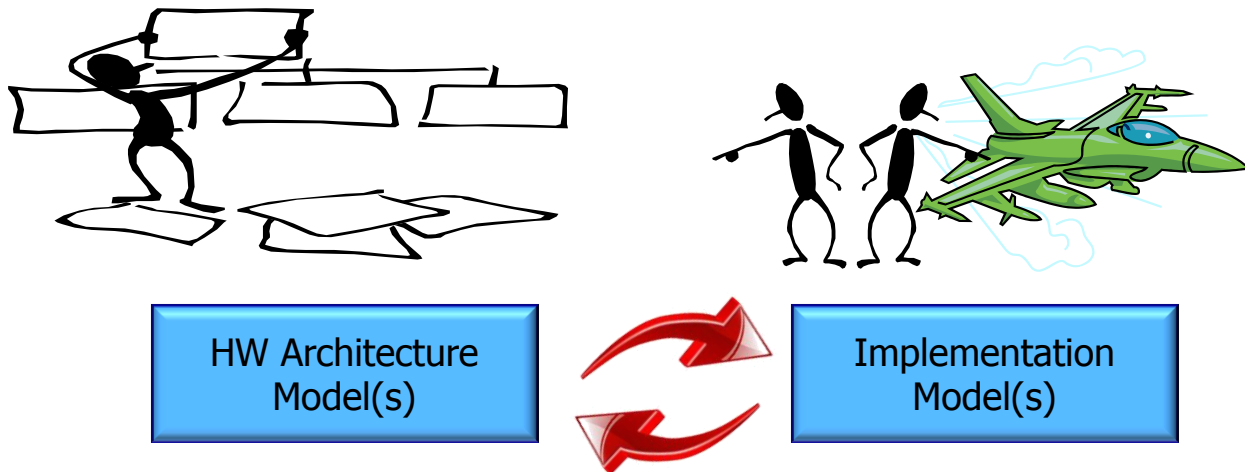
Customer Demand for MBE drives Adoption

Cost Reduction

- Reduction/Elimination of "flight" testing
- Risk Mitigation through early testing
- Automation of intermediate processes

Open Business Model

- Better defined interfaces increase competition for components
- Verification with models at the early phase mitigates integration risk

Communication

- Ability to co-develop the design with the model
- Ability to understand design
- Ability to up-sell activities to higher level organizations

Enterprise Demand

- Beginning to see common requests for MBE
- Not yet standardized
- Driven by belief in positive outcomes

Customer Demand Drivers

Providing a Vision – Communication Approach

NORTHROP GRUMMAN

Listen and Learn

- Remember that MBE is not the end goal, business success is
- What challenges does the team have?
- Recognize the good work they are already doing in MBE and seek to learn!

Provide a Compelling Need

- Explaining why we need to change is necessary for building ownership
- Provide straight talk!

Provide a Vision and Successful Examples

- Vision must be broad but speak to individual teams
- Successful examples – Local examples best

Follow Through

- Communicate messages multiple times in multiple ways
- Find champions to communicate in team's own language
- Address issues quickly e.g. resources or training

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN