DIGITAL ENGINEERING
/ SYSTEMS ENGINEERING

Building the Right Systems: Applying MBSE for Optimized Early System Design

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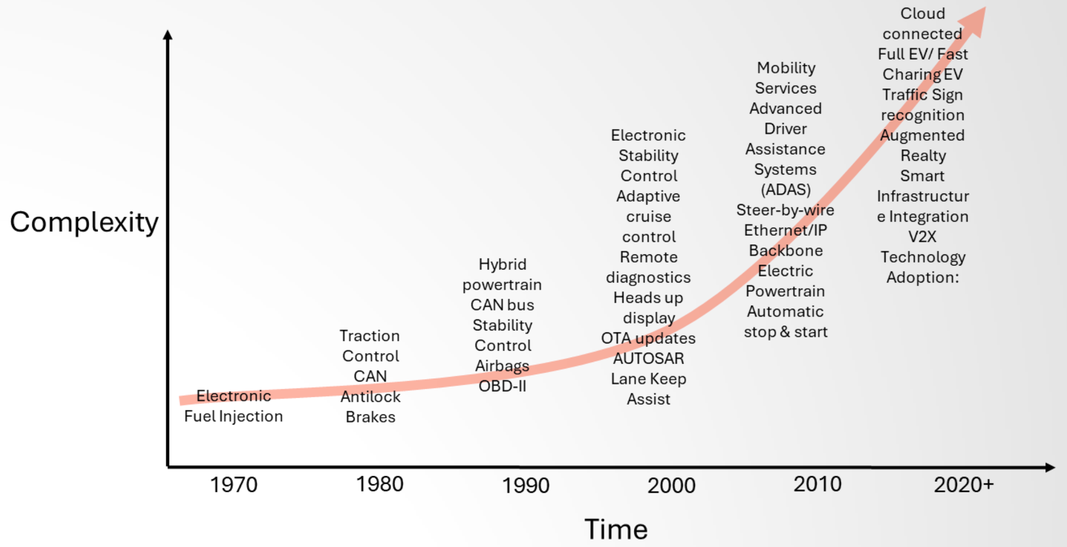
Increased Complexity Requires Good Systems Engineering

- Complexity of all systems are increasing significantly
- The complexity of our military vehicles is outpacing the commercial automotive industry
- Systems Engineering was created to manage the development of complex systems
- MBSE enables more comprehensive and efficient systems engineering

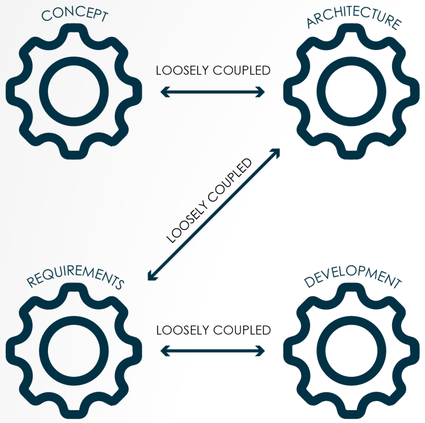


Increased complexity over time in automotive

SE vs MBSE

Traditional Systems Engineering (SE)

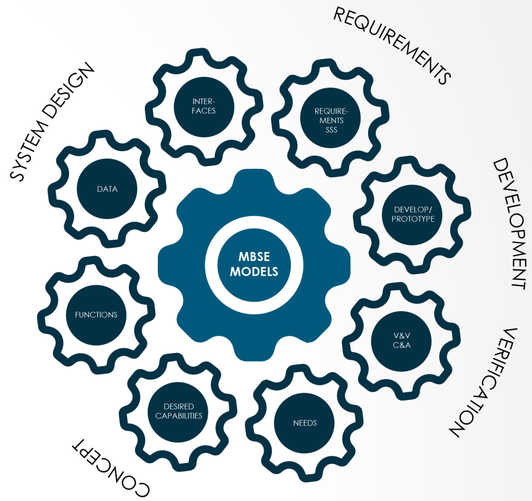
- SE activities are compartmentalized across teams to meet critical milestones
- Focus is on the development and management of documentation to support program milestones
- Relationships between activities is difficult to establish across the documents
- Quality issues can show up during integration, testing, or after delivery



VS.

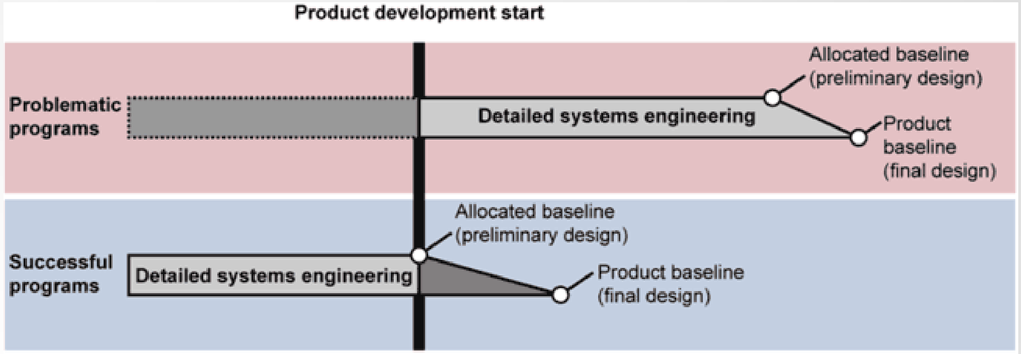
Model-Based Systems Engineering (MBSE)

- SE activities are integrated through the formalized application of modeling
- Focus is on designing a solution to meet user needs
- Relationships between requirements, analysis, design and test are established through the models
- Iterative validation of products across stakeholders at each phase in the system's lifecycle



Optimization in early design with MBSE

1. MBSE should serve as the “blueprint” in early design, and be used to facilitate the communication between stakeholders, reducing risk in later phases of integration, test, & delivery
2. The model should support decision analysis / trade offs, early validation of requirements, and be used to optimize design
3. Graphically modeling behavior with structure allows engineers to identify issues and evaluate designs early in the lifecycle

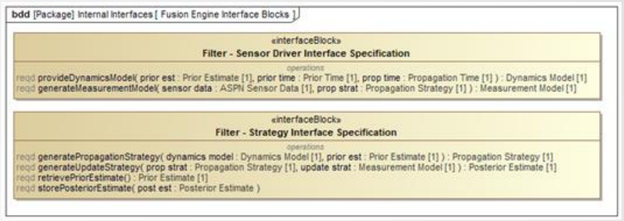


Source: GAO analysis of Department of Defense guidance and selected program data. | GAO-17-77

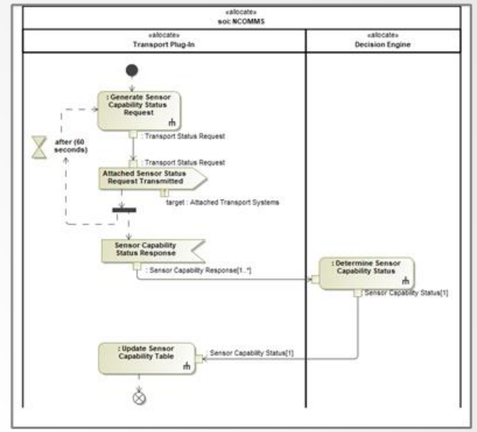
“if detailed systems engineering is done early, a program can resolve such risks through trade-offs and additional investments before a program starts.” – GAO-17-77

MOSA & MBSE in Early Design

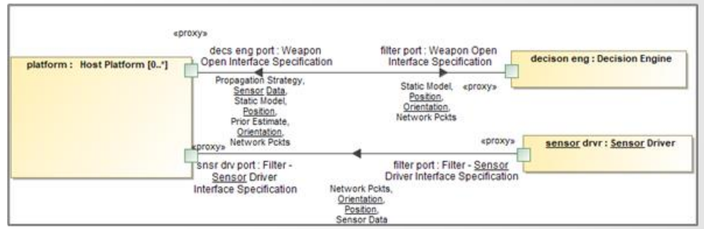
- An MBSE approach emphasizes separation between logical vs physical elements, enabling the customer to identify what the system needs to do, without specifying a physical solution
- Proprietary details of the vendor system do not need to be disclosed to the modeling team to support the system design
- Iterative aggregation and partitioning of activities to design modules that are loosely coupled and highly cohesive
  - Aggregation groups together elements that are strongly related.
  - Partitioning bounds the related elements into discrete modules of functionality.
  - At the boundary of these modules the key interfaces emerge.
- Open interface standards / messages are used to specify interface constraints



Interface Definitions



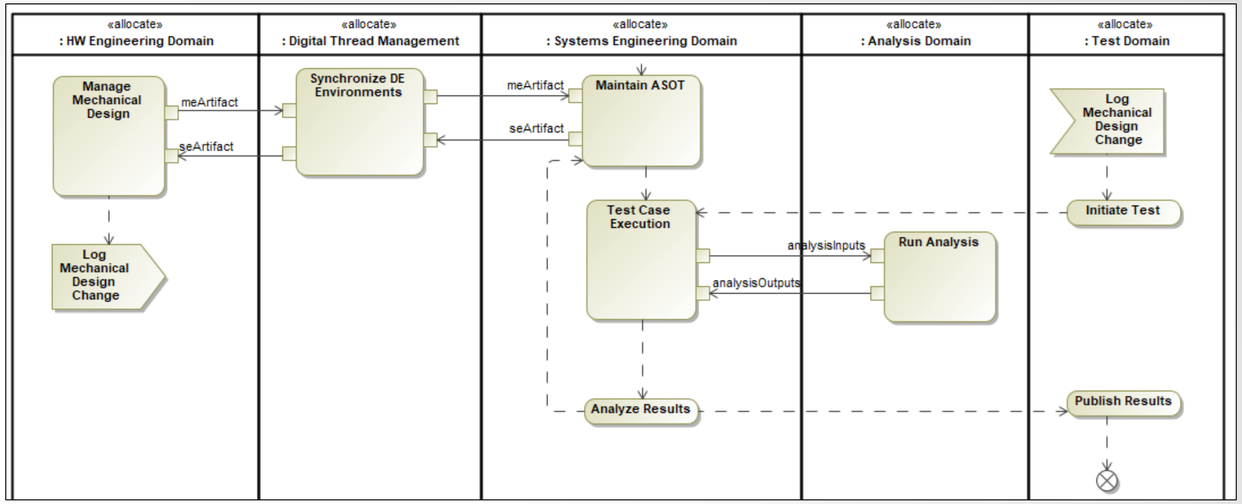
System Partitioning



Data Flows Between Modules

Early & Iterative Validation

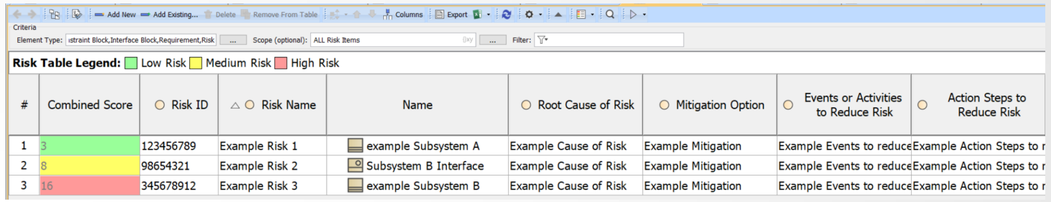
- Data from the systems model can be connected to other engineering tools (e.g. mechanical, software) Incorporate test and simulation early in design process
- Iterative simulation workflows can be used to test to validate early design changes
- Reuse test executions through lifecycle
    - Automate the Generation of Test artifacts
    - Execute tests using CI/CD methods
    - Replace components with physical models when available



Example model-based test across engineering domains

Track Risks & Impacts Early

- Integrating Risk Management with the systems model provides better visibility into risks and impact of risks
- Reduce time spent on required and typically underemphasized activities such as risk management early in the program lifecycle



Add New | Add Existing... | Delete | Remove From Table | Columns | Export

Criteria

Element Type: ...straint Block,Interface Block,Requirement,Risk | Scope (optional): ALL Risk Items | Filter:

Risk Table Legend: Low Risk | Medium Risk | High Risk

#	Combined Score	Risk ID	Risk Name	Name	Root Cause of Risk	Mitigation Option	Events or Activities to Reduce Risk	Action Steps to Reduce Risk
1	3	123456789	Example Risk 1	example Subsystem A	Example Cause of Risk	Example Mitigation	Example Events to reduce	Example Action Steps to r
2	8	98654321	Example Risk 2	Subsystem B Interface	Example Cause of Risk	Example Mitigation	Example Events to reduce	Example Action Steps to r
3	16	345678912	Example Risk 3	example Subsystem B	Example Cause of Risk	Example Mitigation	Example Events to reduce	Example Action Steps to r

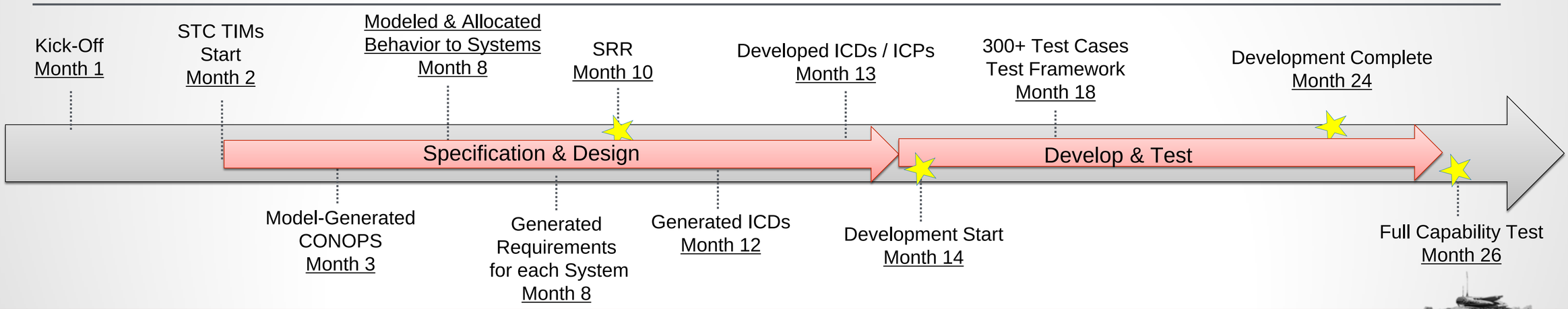
Risks, Issues, and Opportunities tracked & managed in system model IAW Department of Defense Risk, Issue, and Opportunity Management Guide for Defense Acquisition Program

5x5 Risk Matrix **generated from model** for reporting

Example STC Risk Management Plugin

MBSE Army - Case Study

- MBSE applied from onset of initial program start
- Need to field a new capability across 10+ existing systems to support PGMs in NAVWAR environments
- Result of our effort:
  - Integrated stakeholders & engineering efforts through weekly TIMs
  - Establish an authoritative source of truth for the effort
  - Generated 10+ Development Packages (SSS, Models, ICDs) for Each POR
  - MBSE produced a measurable reduction in development costs & test times



Takeaway from Case Study

- **Confidence in Early System Design**
  - Build the right thing the right way; MBSE facilitates the communication of the system design across stakeholders reducing rework later in the lifecycle.
- **Rapid Impact Analysis of Evolving System Design**
  - The model data and relationships allow us to identify an impact to the overall system as changes to the system components or requirements occur.
- **Model-based Documentation Saves Time**
  - Traditional systems engineering documents are generated directly from the model, bridging the gap between document-centric engineering and model-based, allowing engineers to focus on specification and design.
- **Model-Based Testing Improves Design**
  - Through integrated simulation capability, we're able to verify requirements directly in the model and optimize the design before development.

Best practices & Recommendations

1. Too often, tool users are misrepresented as systems engineers and the focus becomes capturing physical design, which reducing the impact of MBSE -- hire good systems engineers with expertise in applying the tools

2. Incorporate stakeholder feedback early in the process; use the system model to facilitate discussions of the system's specification & design

3. Don't underemphasize the logical architecture – define how the system will function and what its composition looks like (without getting into physical implementation details) which will enable trades and support a good design

4. Ignore the naysayers, MBSE applied correctly is a game changer for complex systems development

Questions?