Jama software®

WHITEPAPER

A Path to Model-Based Systems Engineering (MBSE) with Jama Connect™

Enable Cross-Discipline Collaboration and a Digital Approach to Prioritize Speed of Delivery

Table of Contents

Meeting Market Challenges and Managing Complexities with MBSE

Model-based systems engineering (MBSE) has been a popular topic in the systems engineering community for over a decade, but the level of movement or path towards implementation has not always been clear. Market forces are increasing the demand and urgency for organizations to implement the MBSE discipline across the enterprise.

Across industries including aerospace, transportation, industrial manufacturing, and healthcare, customer demand for new, complex, and interconnected products, systems, and software is ever-increasing — and these systems must now be smarter, safer, and more environmentally friendly — all while remaining affordable.

For teams using a cumbersome, and often disparate document-driven approach, facilitating a common understanding of complex systems across diverse stakeholders can often be problematic. To stay competitive, companies building these complex systems require a solution that reduces time and effort by providing an MBSE approach where the combination of collaboration, modeling, tools, and methods streamlines the end-to-end systems engineering process.

A good MBSE practice will prevent rework due to poorly developed requirements or lack of communication across engineering teams. It will help to eliminate risks by providing an architectural roadmap that makes it easier to visualize and provide validation checks.

Customers will be happy with the system delivered and report fewer complaints because the application of MBSE has enabled the teams to more easily perform requirements analysis and validation to ensure that what is being designed and built is solving the correct problems that the customer has.

To manage increasing complexity, engineers and stakeholders must use tools (like Jama Connect™) and techniques whose data is both human-readable and has the capability to integrate across the ecosystem. The challenge is having the ability to efficiently design and build as well as effectively collaborate across stakeholders with vastly different engineering disciplines (e.g., software, mechanical, materials, electrical, chemical, environmental). Each subsystem needs to interoperate with the others to achieve the expected system function, adhere to safety and/or government regulations, and ultimately meet the customer's requirements.

The Digital Engineering Transformation

In today's age of digital transformation, most product development teams are experiencing an issue of burgeoning software content causing immense effort and complexity to understand, write, design and validate, and produce. Digital engineering (DE) is a broader movement that takes shape in many industry segments such as medical device development, automotive, defense, consumer electronics, and aerospace to reduce the pains of developing new products, systems, and software. But, differences in maturity and methods sometimes make understanding the true state of DE difficult.

DE is an integrated approach that uses authoritative sources of system data and models (instead of documents) as a continuum across disciplines to support lifecycle activities — from concept through disposal. In the simplest of terms, it is the act of creating, capturing, and integrating data using models and innovative technology in an orchestrated manner in order to unlock greater value and provide positive impacts on cost and schedule. It is the system model for which MBSE is useful.

When developing avionics weapons systems, a document-based systems engineering process is inefficient and lacks an authoritative source of truth. Meeting the demands of modern development allows more teams to be connected to the design and engineering process. This allows everyone to have a clear understanding of the big picture and leads to better informed decision making, enhanced communication, increased understanding of and confidence in the system design, and a more efficient engineering process.

MBSE and SysML Defined

NASA describes MBSE as, "applying software-based tools to capture systems engineering evidence — typically called "artifacts" — in a systematic, disciplined way that allows people to manage complexity while communicating effectively across the life cycle of a system." These models provide an efficient way to explore, update, and communicate system aspects to stakeholders, while significantly reducing or eliminating dependence on traditional documents.

- **Model-Based Systems Engineering (MBSE)** is the practice of developing a set of related system models that help define, design, and document a system under development. Moreover, MBSE is the "formalized application of modeling to support system requirements, design analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later lifecycle phases." (INCOSE, 2007)
- **SysML (Systems Modeling Language)** is the now standard model-based language choice for MBSE projects and systems engineering applications. It is a graphical language, defining a set of diagrammatics, modeling elements, a formal syntax, and semantics. SysML supports the specification, analysis, design, verification, and validation of systems that include hardware, software, data, and more.

Although there is often confusion around this, MBSE is not equivalent to SysML.

Understanding the Duality

If MBSE is not equivalent to SysML, then the notion of duality becomes very important. A key insight from the INCOSE IW2019 was the concept of "duality" as applied to requirements and models:

1) Text-based requirements are important and cannot be replaced by diagrams/models.[1]

2) Diagrams/models are also important and cannot be replaced by text-based requirements.[1]

Both are different sides of the same systems engineering coin. Neither is solely sufficient – both are needed![1]

All stakeholders need to be able to define, analyze, and then communicate around the concepts of the system of interest; but because SysML models require a specialist with many months of technical training, to even read and understand a system model can be incredibly challenging.

One solution is to implement a hybrid MBSE tool in conjunction with dedicated SysML tool or even as a standalone system. For example, the data in Jama Connect is organized much in the same fashion as that in a modeling tool and performs many of the same functions but is completely human-readable and requires little to no training to use.

1. The Role of Requirements in an MBSE World, Lou Wheatcraft, Wheatland Consulting LLC

Digital Engineering & MBSE Benefits, Obstacles, and Success Factors

A 2020 study by Systems Engineering Research Center, (SERC), Benchmarking the Benefits and Current Maturity of Model-Based Systems Engineering Across the Enterprise, expresses the benefits, obstacles, and enablers of success with DE/MBSE adoption. We're highlighting some of the key findings here.

According to the study, the top stated benefits of DE/MBSE are as follows:

Reason for Integrating MBSE	Value from Consistent Model Management	Benefit from Collaboration
Reduce cost	Increased capacity for reuse	Better communication / information sharing
Reduce time	Improved consistency	Improved system understanding
Better accessibility of info	Improved system understanding	Better accessibility of info
Increased efficiency	Reduce time	Improved consistency
Improved consistency	Better communication / information sharing	Reduce errors
Increased traceability	Better accessibility of info	Reduce time
Improved system understanding	Reduce cost	Increased capacity for reuse

Category	List of Success Factors		
Leadership	Leadership support/ commitment	Leadership understanding of MBSE	
Communication	Awareness of MBSE benefits/value	Communicating success stories/ practices	Need for change
Resources	Cost to use MBSE tools	General resources for MBSE tools	
Workforce	General MBSE awareness and knowledge	People willing to use MBSE tools	Teamwork
	MBSE learning curve	People in SE roles	Training
	Workforce knowledge/skills		
Change Processes	Champions	Competing priorities	Legacy/current processes
	Change management process design	Integration to support MBSE implementation	Vision and strategy for MBSE
	Community of practice	Demonstrating benefits/results	
MBSE Processes	MBSE methods/processes	MBSE tools	Security of data and IP
	MBSE terminology/ ontology/libraries	Projects/programs to apply MBSE	
Organizational Environment	Alignment with business strategy	Organizational culture	Success metrics
	Organizational characteristics	Rewards/recognition	Supportive infrastructure
External Environment	Alignment with customer requirements	Customer/stakeholder buy-in/ engagement	
	External regulations	Use in SE community	

According to the same SERC study mentioned above, the most frequently reported obstacles to MBSE adoption were:

- Organizational culture
- Workforce knowledge/skills
- Leadership support/commitment
- Awareness of MBSE benefits and value
- MBSE tools
- Change management process design

Perhaps interestingly, the most frequently reported enablers were similar and included:

- Leadership support/commitment
- Workforce knowledge/skills
- People willing to use MBSE tools
- Champions
- People in systems engineering roles
- Training
- Demonstrating benefits and results

Gauging Your MBSE Organizational & Tool Maturity

MBSE methods and processes, tools, training, resources, and leadership support and commitment were the most frequently reported changes necessary to improve MBSE implementation.

Is your organization ready for MBSE?

INCOSE's Capability Matrix was developed to help organizations that have already made the decision to implement DE/MBSE capabilities assess and grow these capabilities in a comprehensive and coherent manner. Keep in mind systems engineering is a discipline. It's like how Agile is not a tool but rather a discipline. It is a way of thinking — an approach that an entire organization takes. INCOSE's maturity stages represent an assessment of the degree to which an entire organization has adopted MBSE as a discipline.

INCOSE'S Model-Based Capabilities Matrix Structure

Increasing Stages of Capability generally defined as:
Stage 0: No MBSE capability or MBSE applied ad hoc to gain experience
Stage 1: Modeling efforts are used to address specific objectives and questions
Stage 2: Modeling standards are applied; ontology, languages, tools
Stage 3: Program/project wide capabilities; model integrated with other functional disciplines, digital threads defined and digital twin
Stage 4: Enterprise wide capabilities: contributing to the enterprise, programs/projects use enterprise defined ontologies libraries, standards

Jama Software's MBSE Tools Maturity Matrix

Jama Software provides and easy to use MBSE approach for the masses.

There is a misnomer that in order to do MBSE that you have to then apply SysML. This itself, becomes a barrier for organizations to adopt the discipline of MBSE. Jama Software is well positioned to be the bridge that enables teams to begin their discipline of MBSE.

The Jama Software MBSE maturity model represents the degree to which organizations have implemented MBSE-specific tools. Our maturity model can be applied at the individual program level.

MBSE Maturity Levels
Stage 0: Only Documents, No MBSE
Stage 1: Requirements Managment Tool
Stage 2: RM + Diagram Tool
Stage 3: RM + Diagram + SE Structure (JAMA Hybrid MBSE Solution)
Stage 4: RM + Graphical Modeling Tool (SysML)

This matrix is exclusively designed to help understand the use of tools in an organization's MBSE journey and help you gain clarity around gaps and opportunities on the journey towards MBSE. Understanding where your organization is will create a roadmap for success, enabling you to meet your MBSE objectives.

Adoption Practices for Achieving MBSE Maturity

Further insight from the SERC study — from analysis of both obstacles and enablers and mapped to the Baldrige Criteria for Performance Excellence — was used to define a preliminary set of adoption practices for achieving maturity in MBSE:

1. Leaders communicate a clear reason and need for MBSE adoption
2. Leaders understand MBSE
3. Leaders support and are committed to MBSE
4. People understand the benefits of MBSE
5. MBSE is aligned with the overall business strategy
6. MBSE is used for the right projects/programs
7. MBSE adoption is aligned with what customers need/require
8. Customers and stakeholders buy-in to MBSE
9. Data management processes support MBSE
10. The IT infrastructure supports MBSE use
11. Clear metrics are defined to track results and progress of MBSE
12. Systems engineers have the skills needed to support MBSE use
13. Training is provided to develop needed skills
14. People are rewarded/recognized for using MBSE
15. The organizational culture is aligned with MBSE use

Bridging the Language Gap Between Digital Engineering/MBSE and Humans

A systems engineer's primary job is to work with the end users who will be using the system. They have operational requirements and needs that must be satisfied so that they can use the system to solve specific challenges. The systems engineer (SE) becomes the translator from the electrical engineers to the mechanical engineers to the computer scientists to the operator of the system to the maintainer of the system to the buyer of the system. Each of these teams speaks a different language. The vision is to leverage MBSE and use models to analyze and manage those requirements to ensure they are met at the end of the product development.

The idea of using models (e.g., electrical, CAD, system models, software models) was a means to provide communication in a simple, graphical form, yet only a tiny percentage of programs have demonstrated MBSE's utility to achieve this vision. Smart systems engineers today recognize that models need to be expressed in more human-consumable formats to the broader stakeholder community so that communication gap can be bridged and collaboration across engineers can take place.

> *"A modeling method is something like a road map; it's a documented set of design tasks that a modeling team performs to create a system model. More precisely, it's a documented set of design tasks that ensures that everyone on the team is building the system model consistently and working toward a common end point. Without such guidance, there will be wide variance in the breadth, depth, and fidelity that each member of the team builds into the system model."*
>
> **Delligatti, SysML Distilled**

The Benefits of Using Jama Connect for MBSE

In order to be successful with DE/MBSE, organizations need a modern requirements, validation and verification, and risk management platform like Jama Connect that acts as an authoritative source of system data. A single source of truth where teams can build mission and safety-critical systems using an integrated digital approach and human-readable, hybrid-MBSE model that includes frameworks and templates aligned to industry standards.

By using a tool like Jama Connect, instead of disparate documents or legacy requirements tools, the primary means for communication moves away from static and disconnected documents and shifts the paradigm to models and living data serving as the basis for connecting traditionally siloed elements — providing an integrated information exchange throughout the lifecycle.

Jama Connect for MBSE

Expected Benefits:

- Reduces time and effort
- Positive impacts on costs and schedule

Key Capabilities:

- Connects system relationships
- Control system configurations
- Communicate an overall system picture accessible to all
- Makes it easier to integrate disparate material
- Ensures everyone is working on the same, up-to-date material at all times
- Eliminates problems with version control

Three Pillars of an Effective MBSE Framework

1. **A Modern Requirements Management Tool:** Jama Connect
2. **A Shared Language:** That expresses item types and relationship types
3. **A Defined Methodology:** An MBSE process and solution

The Jama Connect platform is purpose-built to facilitate data sharing across various stakeholder disciplines and location boundaries. The right MBSE framework combines the right requirements management platform, a defined and comprehensible language, and the right methodology to help engineering teams manage complexities, reduce the risk of errors, support innovation, increase product quality, and achieve their MBSE objectives.

Jama Connect's architecture and MBSE methodology eases its integration within the digital engineering tool ecosystem. Jama Connect has a built-in RESTful API and supports the industry standards OSLC and ReqIF formats for exchanging data. These important capabilities mean that when organizations go to integrate their digital engineering tools, numerous readily available 3rd party integration platforms are available; and in many cases already have templates to connect the endpoints in place.

Jama Connect can be used in conjunction with dedicated SysML tools or as a standalone system. In fact, the data in Jama Connect is organized much in the same fashion as that in a modeling tool and performs many of the same functions. This is what makes it very attractive to organizations that do not have enough staff trained to use dedicated SysML graphical modeling tools.

Whether Jama Connect is used in conjunction with MBSE SysML models or used as a standalone digital engineering platform, the system provides:

- Visualization of the shared system model and the status of its artifacts in the development lifecycle
- Faster requirements development
- Validation of requirements developed in the model
- Mechanisms for broader audience communication and participation — tool specialists are not needed
- Baselining of requirements
- Requirements attribute management
- Requirements decomposition and tracing
- Specialized document generation and data reporting

Jama Software provides the leading platform for requirements, risk, and test management. With Jama Connect, engineering teams realize improved cycle times, increased quality, improved time to compliance and faster time-to-market. Jama Software has a growing customer base of more than 600 organizations, across 30 countries, serving the following industries: aerospace and defense, medical device development, automotive, semiconductor, software development, financial services and insurance, and industrial manufacturing. To learn more, please visit us at: jamasoftware.com