

# Applying MBSE Across the Lifecycle

**SPEC Innovations' journey in applying MBSE over 30 years**

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# Model-Based Systems Engineering

- MBSE is not new!
- The concepts behind MBSE can be dated back to the 1960s when computers were being used to capture information about systems and visualize them before building.
- One of the first true MBSE methodologies came from TRW (SREM) in 1969.
- This methodology was the basis for several tools, including Ascent Logic RDD-100 and Vitech Core (now Genesys).
- The term MBSE was defined by INCOSE in 2007 as part of their MBSE Initiative.
- Originally MBSE was a means to deliver documents via modeling.
- MBSE requires a database tool (or tools) to be effective.




See <https://www.incose.org/communities/working-groups-initiatives/mbse-initiative>

**MBSE  $\neq$  SysML**

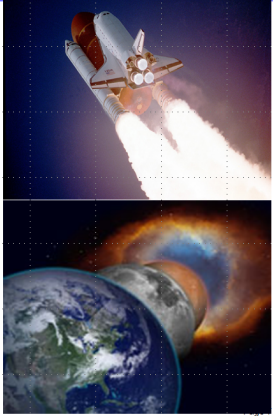
# SPEC Innovations Involvement in MBSE

- SPEC Innovations began in 1993.
- We wrote the first user's manual for Vitech's Core tool.
- We applied this tool and others on major DoD, DOE, and NASA programs, including key architecture studies such as Net-Centric Enterprise Services (NCES) and US Army Future Combat Systems.
- In 2011, we saw a presentation by Dr. Michael Ryschkewitsch, NASA Chief Engineer on the needs for systems engineering tools.
- The requirements for scalability implied the need to apply a new technology – cloud computing.
- But we needed a semantic ontology as the basis for the database schema.



### Vision for MBSE

- Current Engineering environment
  - Document based artifacts
  - Spec, drawings and requirements
  - Domain oriented discipline models
  - Legacy Tools
- Desired future Engineering Environment
  - Model based artifacts
  - Seamless data flow
  - Distributed teams

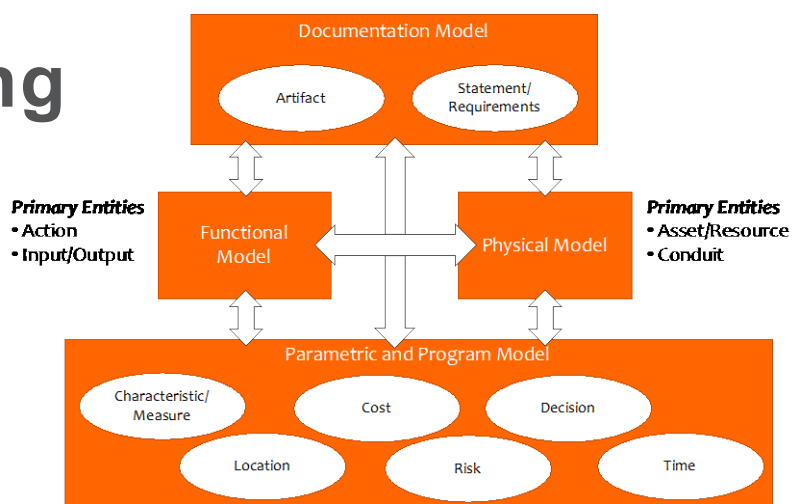


*From a presentation by Dr. Michael Ryschkewitsch, NASA Chief Engineer, at CSER Conference 15 April 2011*

**MBSE needs a common language that is based on systems engineering semantics**

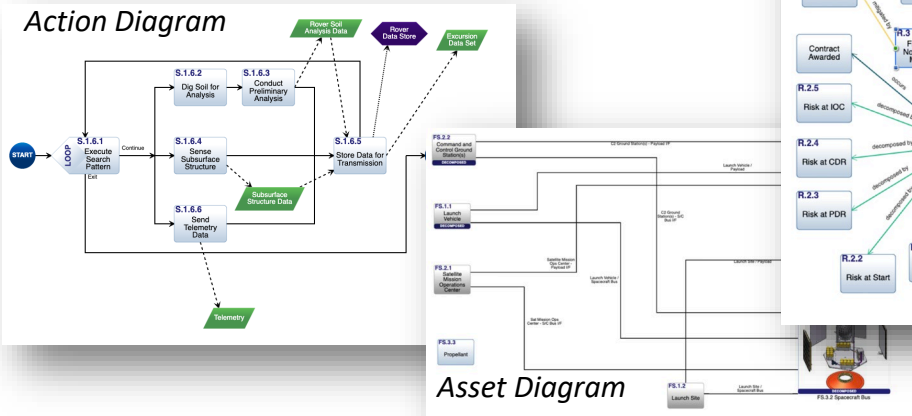
# Lifecycle Modeling Language (LML)

- 10 A simple, easy to use set of classes (nouns).
- 10 Maps to DoDAF, UAF, SysML, BPMN, etc.
- 10 Connected by two-way relationships (verbs).
- 10 Easily extended.

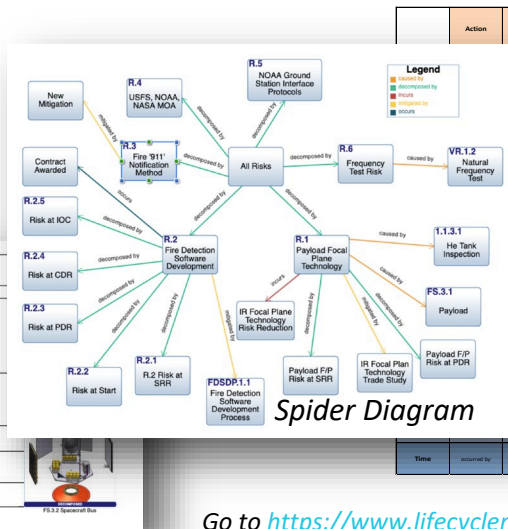


**LML provided a semantic ontology for SysML in 2015!**

### Action Diagram



### Asset Diagram



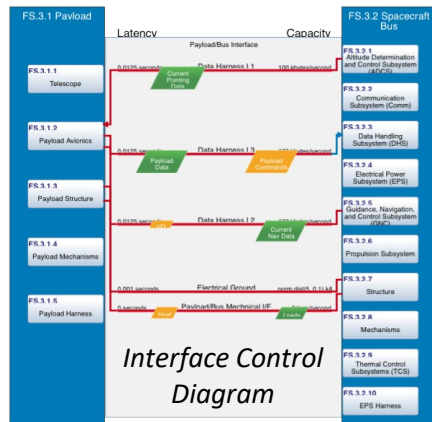
### Spider Diagram

[illegible]

Go to <https://www.lifecyclemodeling.org/> for details.

# LML v2

- 10 Released in April 2025.
- 10 Enhanced ontology for Program Management and V&V
- 10 Added new diagram type: Interface Control Diagram
- 10 Includes new data types, including Equation and Computable for viewing a calculating with LaTeX



Equation

Global ID: L\_ZFF7HG1SBMK0B\_AZFYBMWNKRQSQ

ID: 65038

Class: Equation

Modified: 6/4/2025 by stevendam

Created: 1/3/2024 by stevendam

Attributes:

Number: [ ]

Name: Relativistic Equation

Description: Two forms:  
 $E = mc^2$ , where  $m$  is the relativistic mass  
 $E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$ , where  $m_0$  is the rest mass

Value:  $E = mc^2$

Equation Formatted:  $E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$

Computed Value: 0.00000000000014833668 Joules

Project Dashboard

Wiki Panel

This project is for the distribution of the Lifecycle Modeling Language v2.

Activity Feed

- stevendam updated 1 Title Slide • Metadata was updated a day ago
- stevendam updated New Slide • Metadata was updated a day ago
- stevendam updated New Slide • Metadata was updated a day ago
- stevendam updated 4.1 Action Diagram (Mandatory for Action entities with a day ago

Requirements Document

1 Specification Information

Change Requests

No change requests to display. Change requests automatically display here once your project contains at least one change request.

Comments Feed

- stevendam 4/21/2025 Need to update baseline
- kenwms 7/22/2025 If I/O 2 is a Trigger (ref 3.4.1.2.4.1 LML Spec v2) that enables 1.3 Action in Parallel, what happens when Path 2 is executed and I/O 2 is not generated? I.e., in the event of 1.1, 1.2, and 1.5, 1.6, how does 1.3 complete?
- amirabrari 5/22/2025 The attribute sub-classes is missing definition for "Evidence"

LML v2 now available as a digital standard!

Request access at [info@lifecyclemodeling.org](mailto:info@lifecyclemodeling.org)

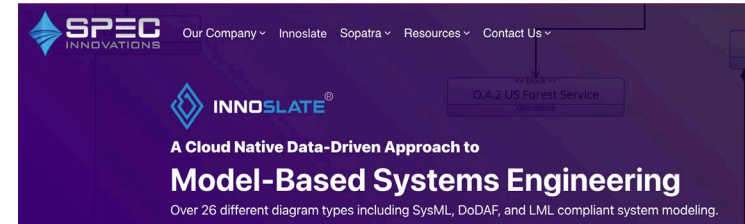
# SPEC Innovations Application of LML

- We prototyped LML using Vitech Core and beta versions of Innoslate.
- Since Innoslate's first release in 2013, we have continued to evolve it into a full lifecycle support tool for integrated systems engineering and program management.
- We have applied the tool to a wide variety of problems from a NNSA/LANL Pu Production Facility strategic study to the design of a High Energy Laser Testbed down to the software message level.
- While working on an MDA project in 2020, we developed a complete digital ecosystem.



Innoslate is made 100% in the United States of America.

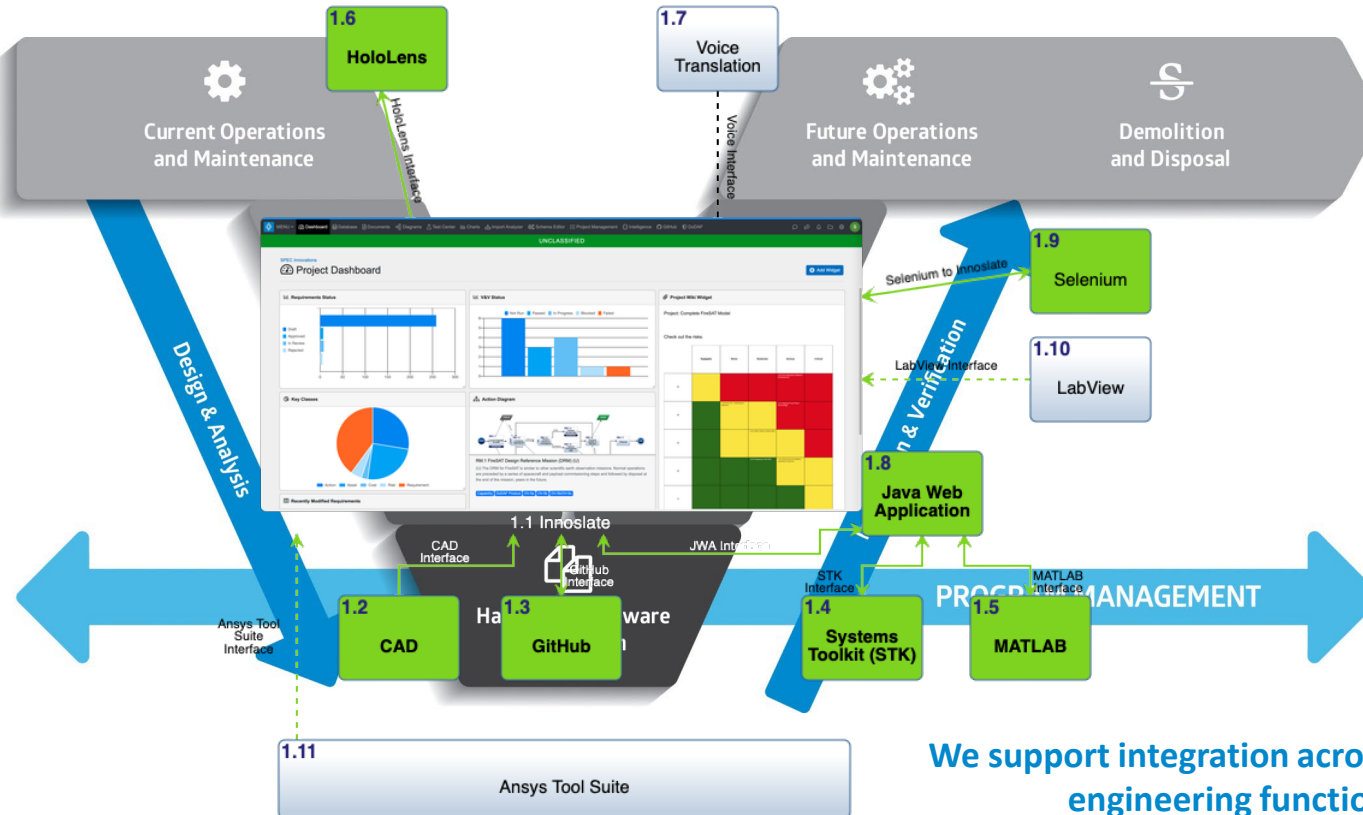
Innoslate was developed solely in the United States of America to give our customers quality and security.



See <https://specinnovations.com/innoslate/model-based-systems-engineering-software>

**Innoslate supports MBSE and much more**

# Innoslate-Based Digital Ecosystem



- Innoslate provides a complete MBSE/DE environment.
- A JWA is used to interface between the Innoslate cloud tool and desktop tools.
- We have directly integrated a number of key design engineering technologies to complete the digital thread.

We support integration across all digital engineering functions

# Adding GenAI Has Changed a Lot!

- We applied NLP techniques early in the development of Innoslate.
- We used it for requirements quality checking, traceability assistance and modeling quality heuristics analysis.
- With GenAI, we have been able to generate test cases and risks from requirements, create summaries, translate to other languages, and provide general chatbot prompt access.
- Future agents will enable greater support to the systems engineers, software engineers, and program managers.

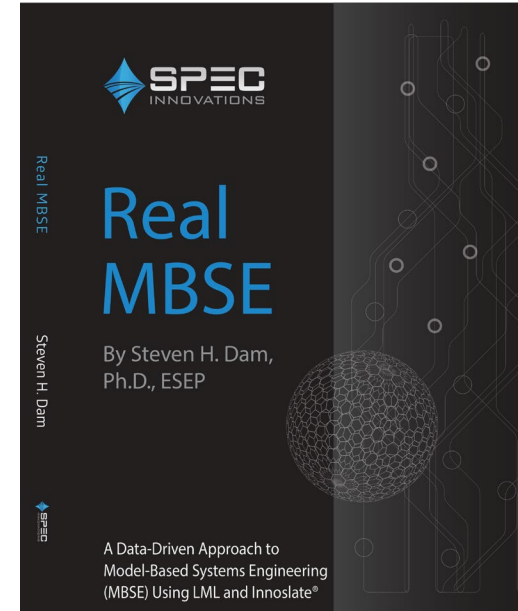
The image displays two screenshots of the Innoslate AI interface. The left screenshot shows the 'Generate Test Case' window, which includes a 'Generate' button and a 'Verify' button. A note at the top states: 'Note: The generated output may contain inaccuracies. Please review and revise it to ensure it meets your requirements. After creating the test case, you will be able to find it in the database.' The window also shows a 'Number' field with 'TC.MR.2', a 'Name' field with 'Coverage Area Validation', and a 'Description' field with a list of steps: '1. Access the FireSAT system interface.', '2. Initiate a coverage check feature.', '3. Input geographical coordinates for various locations across the contiguous United States, Alaska, and Hawaii.', '4. Execute the coverage check for each location.', and '5. Record the system's response regarding coverage status for each input.' The 'Expected Result' field contains 'The FireSAT system should confirm coverage for all input locations, including Alaska and Hawaii.' The 'Verification Method' field contains 'Test'. The 'words' and 'chars' counts are 42 and 367, respectively. The right screenshot shows the 'Generate Risks' window, which includes a 'Setup' button, a 'Generate' button, and a 'Verify' button. A note at the top states: 'Note: The generated output may contain inaccuracies. Please review and revise it to ensure it meets your requirements. After creating the risks, you will be able to find them in the database.' The window also shows a 'Number' field with 'R1.MR.2', a 'Name' field with 'Regulatory Compliance for Coverage', and a 'Description' field with a paragraph: 'This risk pertains to the potential challenges and complexities associated with ensuring that the FireSAT system adheres to all relevant federal, state, and local regulations across the United States, including Alaska and Hawaii. Non-compliance could lead to legal penalties, project delays, and increased costs. To mitigate this risk, it is essential to conduct thorough regulatory research and engage legal experts to ensure compliance. Regular audits and updates to compliance strategies should be implemented as regulations evolve.' The 'Consequence Description' field contains 'Failure to comply with regulatory requirements could result in significant legal penalties and project delays, impacting the overall timeline and budget of the project.' The 'Consequence' field contains '80'. The 'words' and 'chars' counts are 76 and 535, respectively. Both windows have a 'Cancel' button at the bottom.

**Innoslate implements AI to support better systems engineering**



# Real MBSE Requires Well Defined Processes

- Program management and systems engineering use defined processes to enable teams to work efficiently together.
- These processes include:
  - Project planning, tracking, and control
  - Risk, quality, and configuration management
  - Requirements and functional analysis
  - Solution synthesis and trade studies
- Our Real MBSE book contains proven processes for performing program management and systems engineering tasks, thus enabling effective and efficient MBSE.
- The third edition will be released Fall 2025.



Download for free at  
<https://specinnovations.com/download-real-mbse-ebook>

**Innoslate supports MBSE and  
much more**

# What's the ROI for MBSE?

- A study was led by Jim Duffy on a George Mason University (GMU) graduate capstone project.
- It focused on ways to identify how to evaluate tools to show return on investment (ROI) for MBSE.
- “Stand Alone tools provide benefit towards only a portion of the overall system engineering workload. The Integrated tools however all provide a significant increase in value over the benchmark tools.”

**MBSE can have a high ROI with the right tools**

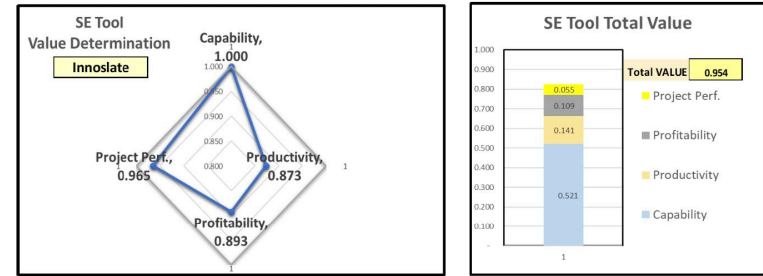


Figure 17. Value Determination of A SE Software Tool (Innoslate)

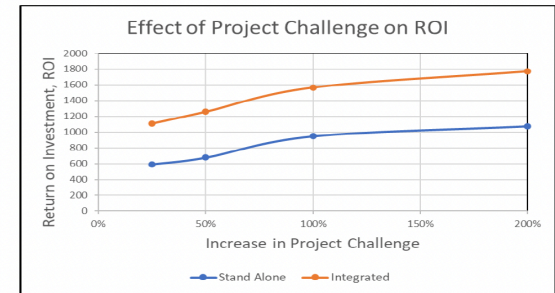


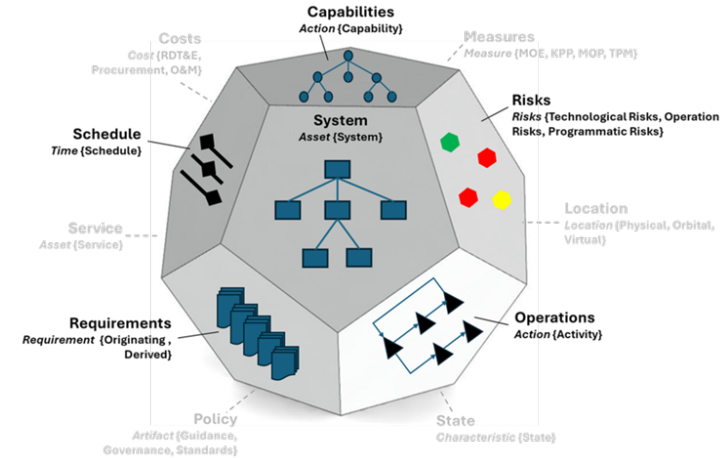
Figure 18. Effect of Project Challenge on SE Software Tool ROI

See July 2021 paper

<https://incose.onlinelibrary.wiley.com/doi/abs/10.1002/j.2334-5837.2021.00870.x>

# The Future of MBSE is Data-Driven!

- Unfortunately, many people have equated MBSE to SysML.
- Since SysML is only a subset of the information needed for complete systems engineering and has no substantive impact on program management, we need to think in new terms.
- The Lifecycle Modeling Organization has proposed the term Data-Driven Engineering (DDE) to move us forward.
- Semantic languages, such as LML, enable better integration with Generative AI capabilities.



*See Dr. Warren Vaneman's article in the August 2025 issue of the Project Performance International's SysEN Systems Engineering Newsletter*

**Transforming MBSE into DDE**

# Summary

- MBSE can enhance how we do systems engineering across the entire lifecycle, but not if we limit it to simple modeling frameworks like SysML. We need LML!
- For adoption of MBSE principles by all stakeholders, we need to recognize that they need clear, easy to understand language and tools.
- Focusing on the “essential elements of information” needed to describe the system fully, including the items decision makers care about most (cost, schedule, performance, and risk) will enable greater adoption of MBSE.

**We systems engineers need to learn how to speak our stakeholders' languages, not force them to speak ours!**