*Presented to:*

**University of Alabama Huntsville**

# MBSE Applications

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

**Nov 3, 2016**

*Presented by:*

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**U.S. Army Aviation and Missile Research, Development, and Engineering Center**

Presented to:

**University of Alabama in Huntsville**

TriVector SERVICES INC.

▸Experience ▸Performance ▸Value

# MBSE Applications

**November 3, 2016**


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*A Huntsville Area Small Business*


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# Agenda

- **Introduction**
- MBSE Application
- Summary and Path Forward

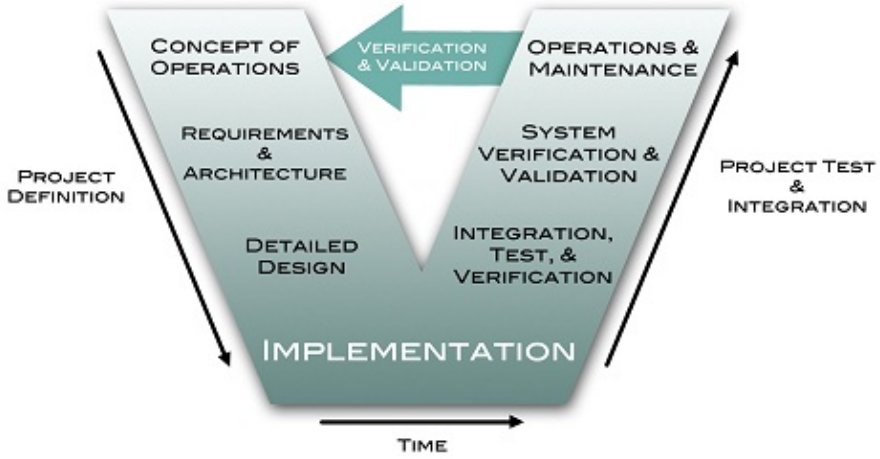
# Introduction
## System Engineering Challenges

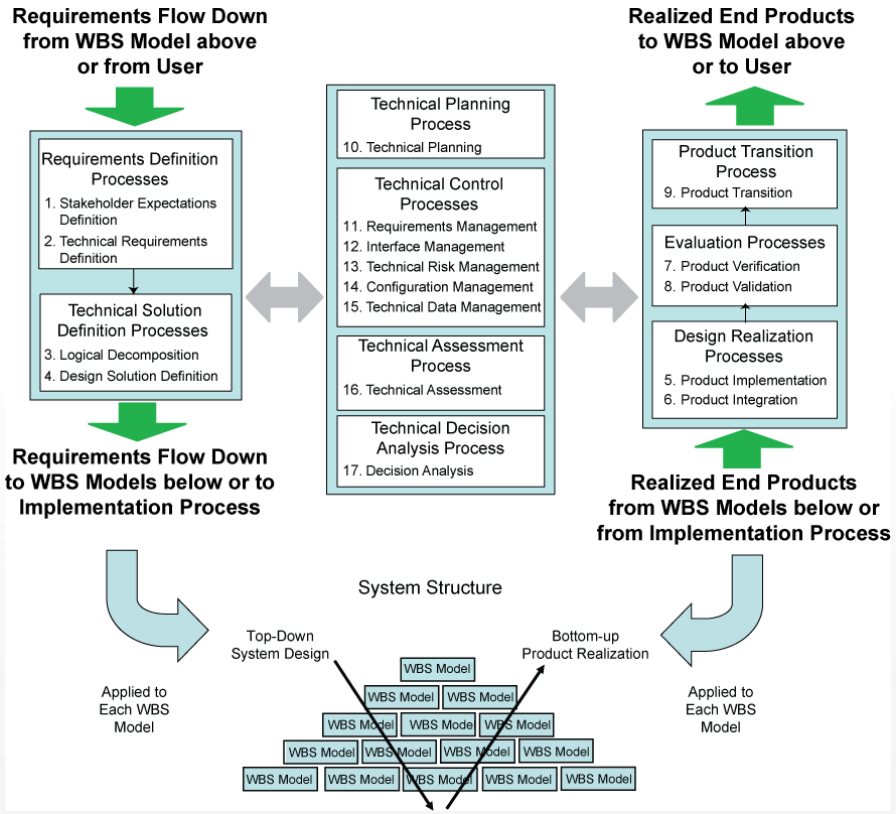
- **When speaking of overcoming past engineering failures, Dr. Mike Griffin (*How do we Fix Systems Engineering*) stated, "We need to rise above process, to examine the technical, cultural, and political mix that is 'system engineering', and to examine the education and training we are providing to those who would practice this discipline."**
- **Challenges of engineering complex systems - Dr. Michael Watson (*Engineering Elegant Systems: Theory of Systems Engineering*)**
  - "While at its core system engineering is concerned with the interfaces between and among separable system elements, it should be realized that the more important understanding concerns the dynamic behavior of the interactions between these elements.."
  - Gentry Lee who stated, "it's about the partials, not the values". Properly understood, system engineering is concerned with context over structure, with interactions over elements, with the whole over the sum of the parts.

***Tools available to System Engineers greatly enhance the ability to develop elegant (robust, efficient, effective) complex systems***

# Introduction
## Classical Systems Engineering

- **Classical Systems Engineering (SE) has tended toward *process* focus as opposed to *physics* focus**

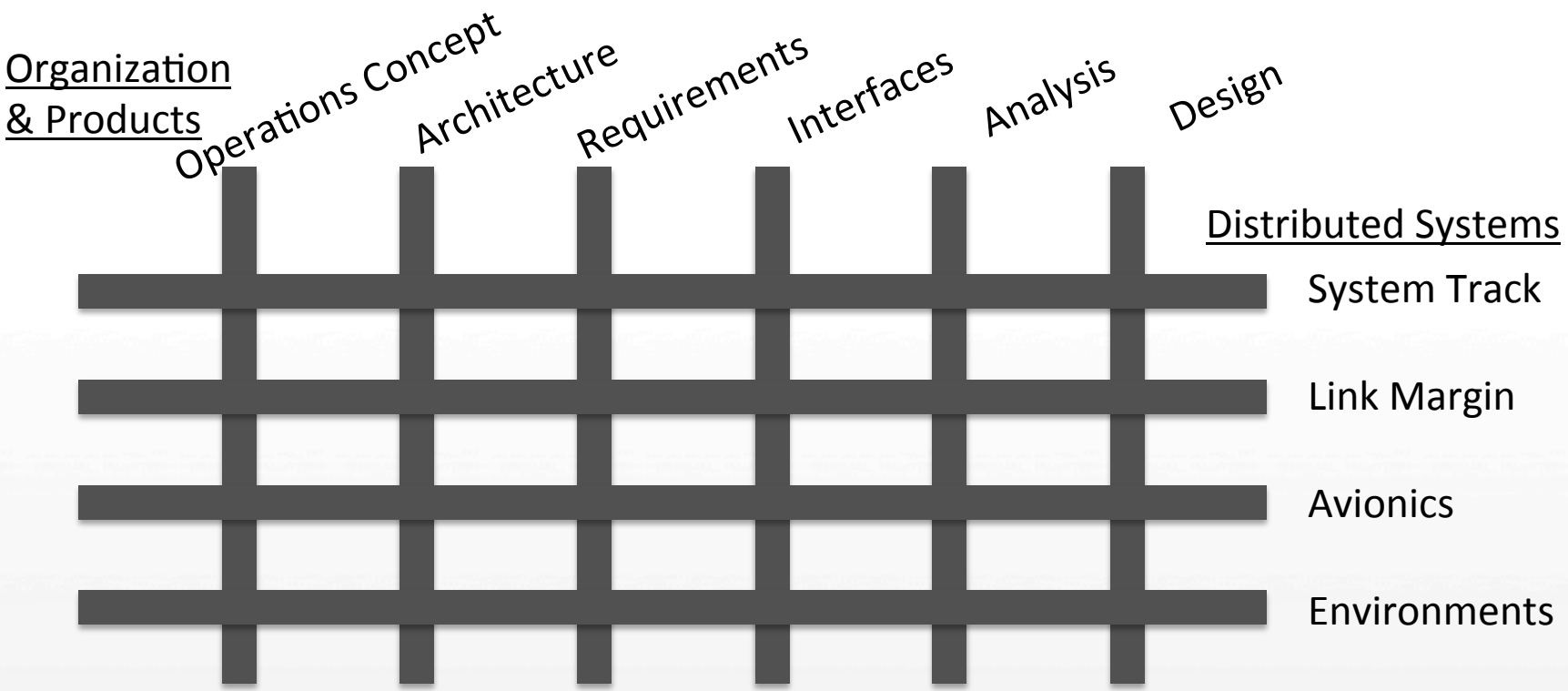



***Process is necessary but you cannot totally rely upon the process to produce the desired outcome, must be physics/engineering focused***

# Introduction
## Classical Systems Engineering

- **Classical Systems Engineering (SE) has tended toward *process* focus as opposed to *physics* focus**




***Avoid 'stove-pipes' and focus on vertical and horizontal engineering: tools (i.e. MBSE), organization/people, products, culture,…***

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# AMRDEC CoMBAT

***AMRDEC CoMBAT is the Center of Model-Based Acquisition & Technology Project***

***Focused on performing good systems engineering utilizing MBSE***

**AMRDEC Director's Corner Article**
**January 13, 2015**
***The Ultimate Coolness of Model Based Systems Engineering (MBSE)***

AMRDEC Director's Corner Article
January 13, 2015
*The Ultimate Coolness of Model Based Systems Engineering (MBSE)*

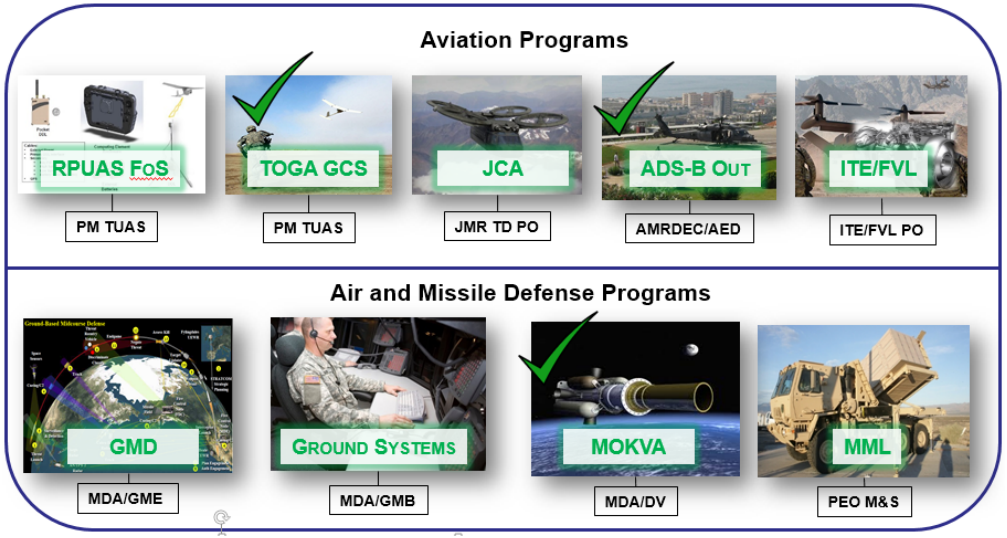
*Bottom-line upfront: MBSE is an emergent, increasingly accepted application of modeling as a more affordable and ease of analysis approach to systems engineering. This article is designed to introduce the basic concept of MBSE and convey that AMRDEC intends to define its corresponding policy, procedure, and competency standup plan moving forward.*

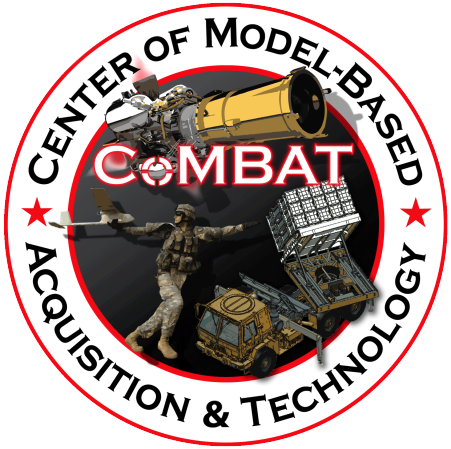
Earlier this week, I was given a multi-directorate overview brief of MBSE and what AMRDEC is doing to implement it on actual aviation and missile systems programs. MBSE is a formalized methodology that depicts a system in model format to support requirements relationships, functional analysis, design synthesis and verification and validation activities for any program whether it be in early concept phase all the way out to sustainment upgrade capability support. The advantages of using a model in the systems engineering process cannot be overstated. As our systems become more complex, interoperable and thus architected to operate in increasing system of system operating formats, use of modeling can ease the ability to analyze and truly understand performance behaviors and identification of development risk. These models also act to form the foundation for service oriented architectures to better enable open-systems operating constructs; characteristics essential for more adaptable, scalable and more affordable weapon systems that can be more easily upgraded over a longer service life.

The importance of MBSE quickly emerges when one compares and contrasts it to traditional approaches. In a traditional approach, the systems engineering process produces reams of paper documentation that appropriately outline requirements flow-down, functional analysis, design specifications, and verification & validation approaches but in stove-piped, expensive and time consuming format that is prone to errors and/or incorrect assumptions. It becomes difficult when one wants to view system relationships between these domains. Add on top the complexity of a system interoperating with another in network centric format and / or in a system of system (e.g., missile launched from host platform but controlled via datalink from an independent sensor source) and it becomes exponentially difficult to do appropriate analysis whether it be functional determinations or sensitivity analysis of design feature iterations (e.g., reliability impacts, power margin allocation, etc.)

MBSE is the "ultimate cool way" to look at our products in a refreshing approach that better holistically captures "the system" in operation; a rain/vigorated approach that I hope garners the excitement and attention especially for our young, future leader workforce. If and when it makes sense from a timing and opportunity for insertion standpoint, use of MBSE needs to be increasingly adopted so that AMRDEC can provide the best, robust, systems-capture analysis and architecture of our aviation and weapon products for our Customers. This is about creating of our skill sets in this area and working to communicate the affordability and efficiency benefits of MBSE to various program office leadership personnel. I recognize standup of this as a core technical competency will take time. A team of dedicated personnel working across multiple directorates will develop a MBSE implementation roadmap that will include how we can define and create a MBSE "tool box" for adoption onto any effort. The team will also define how we should define our MBSE policy as well as consistent processes and procedures for implementation. Recognize that sometimes MBSE usage makes sense and sometimes otherwise due to the time it takes to implement a model and the degree of systems complexity at-hand. We need to be smart on helping our Customers determine the business case for MBSE on a case by case basis.

**CoMBAT Supported Programs**




*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*

# Model-Based Systems Engineering (MBSE)

Text-Based

Evolving our Approach to Acquisition

Model-Based

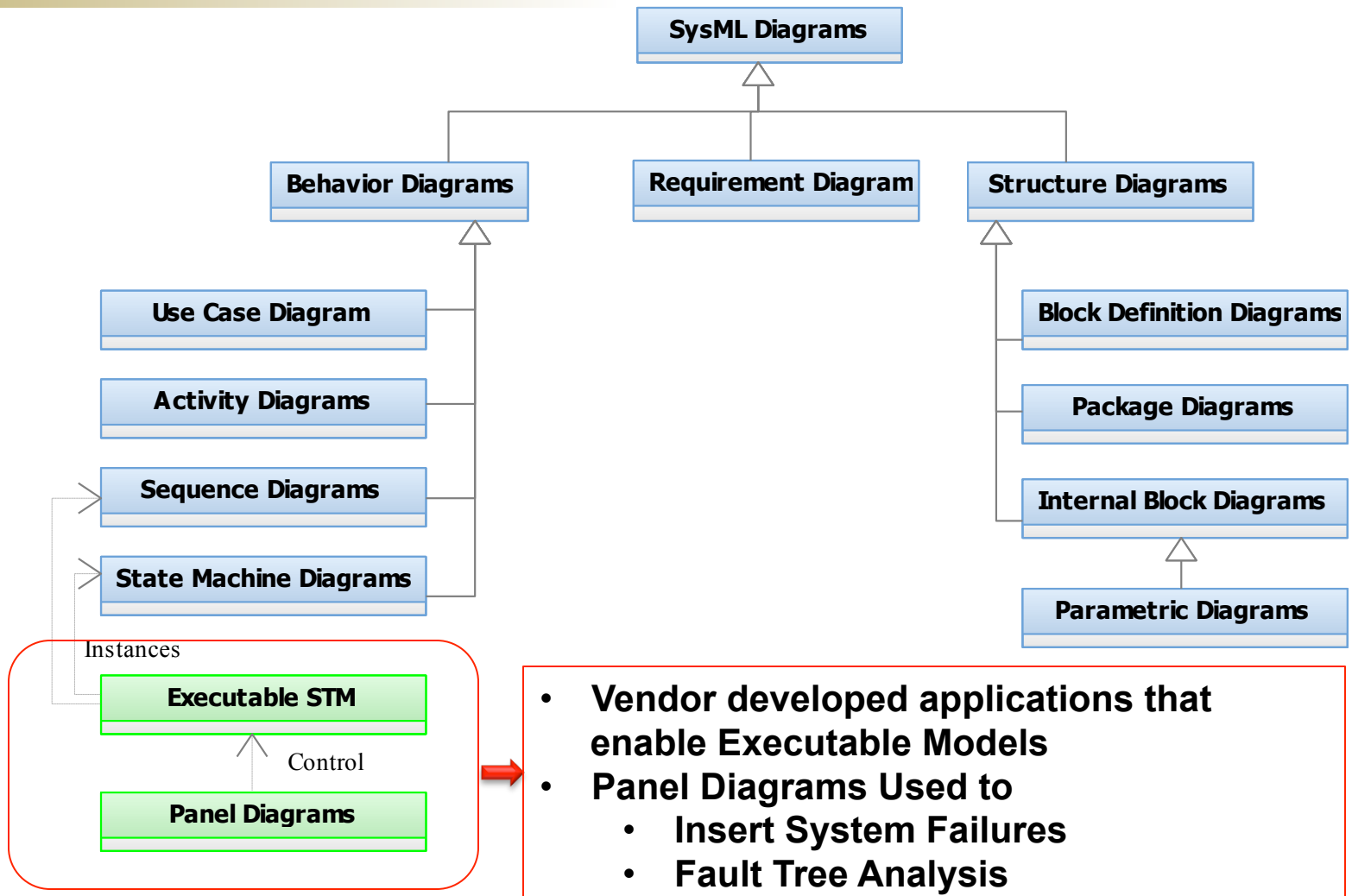
The MBSE Puzzle


***MBSE is a Systems Engineering paradigm that puts emphasis on applying visual modeling principles***

# Systems Modeling Language -SysML-

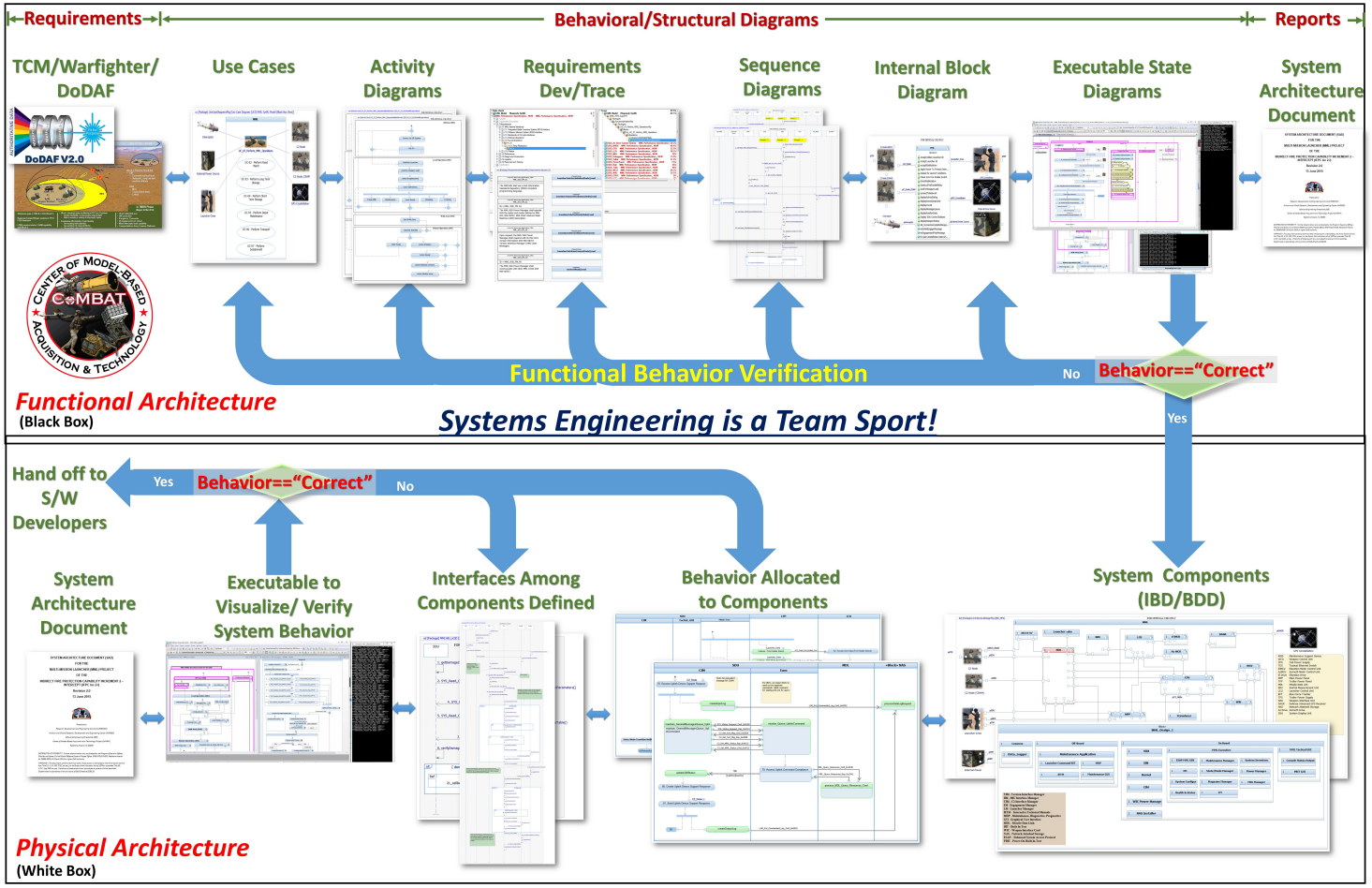
- 2006 - Officially adopted by the Object Management Group (OMG)
- 2007 – SysML 1.0
- 2008 – SysML 1.1
- 2010 – SysML 1.2
- 2012 – SysML 1.3
- 2015 – SysML 1.4
- SysML 2.0 is currently being developed by the OMG

# Systems Modeling Language -SysML-




- Vendor developed applications that enable Executable Models
- Panel Diagrams Used to
  - Insert System Failures
  - Fault Tree Analysis
  - Alternate Flows
  - Event Visualization

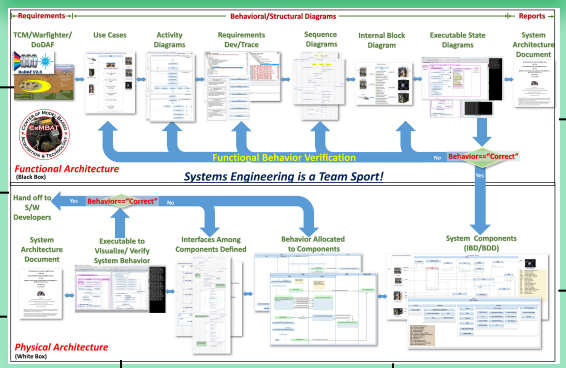
# SED's CoMBAT MBSE Process




***Highly Iterative Process where behavior and structure diagrams are tightly Integrated***

# Key CoMBAT MBSE Tools

Tool Integration and Customization




magicdraw

Training
Leadership
Presentations

Camtasia Studio

ENTERPRISE ARCHITECT

SERENA DIMENSIONS

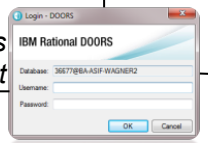
UPDM

DoDAF V2.0

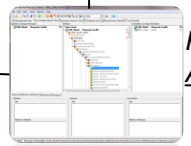
Rational Rhapsody

TortoiseSVN

Requirements Management




DOORS



Gateway

Requirements Analysis

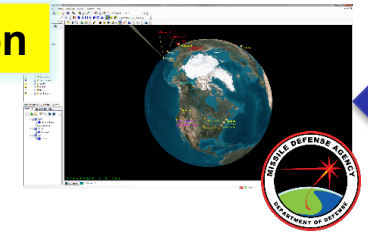
CENTER OF MODEL-BASED ACQUISITION & TECHNOLOGY
CoMBAT

RDECOM AMRDEC
SED
Software Engineering Directorate

# GMD Support

**Visualization**

STK



Integration to Analyze Raid Behaviors

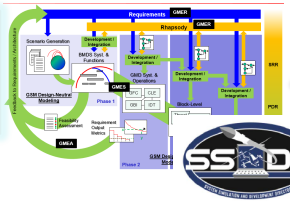
**Performance Analysis**

Simulations

Integration to Analyze Behavior & Performance

**Requirements Optimization**

Specification Model



Analyze System Level Requirements to Optimize Performance

*Reliability & Probability Analysis*

**SysML Model**

Rational Rhapsody


***Integrating Functional Models with Performance Models to Conduct more Complete System Analysis***

STK – System Tool Kit
GMD – Ground-Based Midcourse Defense

MDA – Missile Defense Agency
SysML – Systems Modeling Language

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# Summary and Path Forward
## MBSE Benefits

- Communication
  - Enhances consistency of documentation
  - Enables highly interactive reviews
  - Used as a tool to solicit feedback from stakeholders
- Integration
  - Establishes team integration through developing the model and requirements (Systems, Software, Requirements, Test) with a Battle Rhythm
  - Reduces stove piping with a single source of truth
- Requirements Analysis
  - Specification/requirements development, requirements validation (with emphasis on functional requirements)
  - Assists in requirements leveling and gap analysis
  - Requirement orphans and widows quickly identified

**The Ability to "Visualize" the System and Integrated Component Architecture proves valuable in Revealing Undesired and/or Unexpected Behavior**

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# Summary and Path Forward
## Recommendation

- **Government Acquisition Process Challenges**
  - Contract deliverable items in standard formats (non-models)
  - (Typically) procurements require a government developed specification
- **Program Engineering Focus Areas for MBSE**
  - Reliability Engineering (probabilities)
  - Failure Modes Analysis and Off Nominal Scenarios
  - Investigate development of a Government Standard for consistent translation between SysML tools
    - Enhance better collaboration
    - Less vendor dependency
- **MBSE Training**
  - Academic Degree program that integrates Systems Engineering with other Engineering disciplines (Aerospace, Mechanical, Software, Chemical, Civil…)
  - Job training to expose engineers to tools necessary to solve complex integration problems

***System Engineers: "Examine the education and training we are providing to those who would practice this discipline"***

## AMRDEC Web Site
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## Facebook
www.facebook.com/rdecom.amrdec

## YouTube
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## *Through our Experience, Performance and Value,*

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## *Critical Customer Challenges*

and *Deliver Superior Technical Solutions*