



# Advancing the State of R&M Engineering Practice

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Event  
Do

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# Agenda



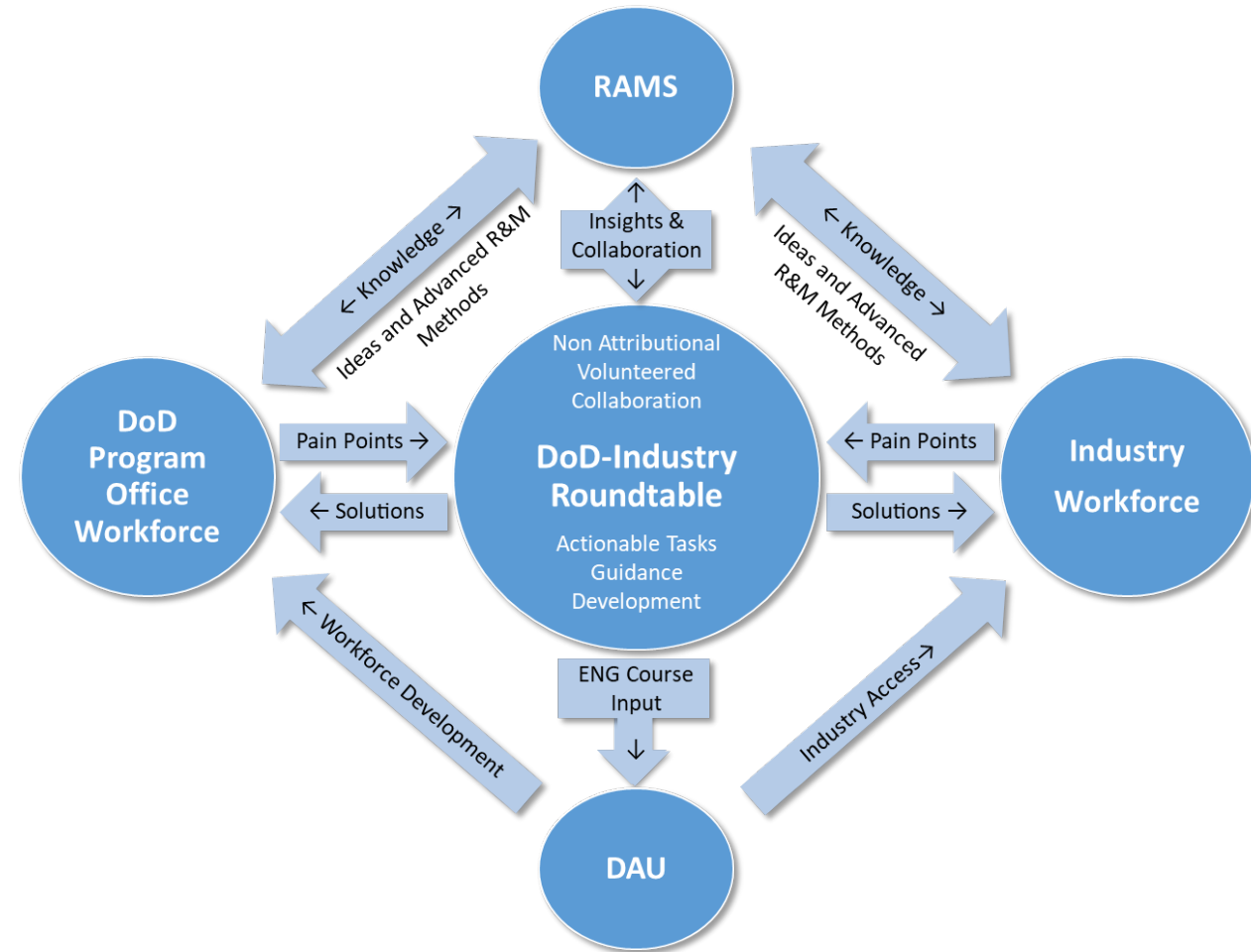
- Reliability and Maintainability (R&M) Engineering Relationships and Interactions
- R&M Engineering Roundtable
- R&M Engineering Pain Points (Topics, Challenges)
  - Model-Based Engineering (MBE) Failure Modes, Effects, and Criticality Analysis (FMECA)
  - Instantiate Digital Engineering into R&M Practices
  - Deliver Reliable Software
  - Reducing Risk with Better R&M Estimates Throughout the Lifecycle
- Summary



# R&M Engineering Relationships and Interactions



- Annual Reliability and Maintainability Symposium (RAMS)
  - RAMS Advisory Board
  - Paper: Challenges and Lessons Learned from Implementing an MBE FMECA in the DoD
  - DoD 'Reverse' Panel
- R&M Engineering Service Leads
- DoD – Industry R&M Engineering Roundtable





# DoD - Industry R&M Engineering Roundtable



- Hosted annually in conjunction with RAMS with ongoing work activities throughout the year
- Volunteer DoD R&M practitioners and their industry counterparts
- Sharing knowledge, fostering interaction, identifying pain points
- Advancing state-of-the-practice within the R&M community to resolve R&M engineering pain points

## SPONSORS





# R&M Engineering Roundtable Pain Points



## FY19/20

- Develop R&M Mid-Tier Acquisition Contract Language
- Map Standards to the R&M Engineering Body of Knowledge
- Transition the FMECA to an MBE Environment (ongoing)

## FY21/22

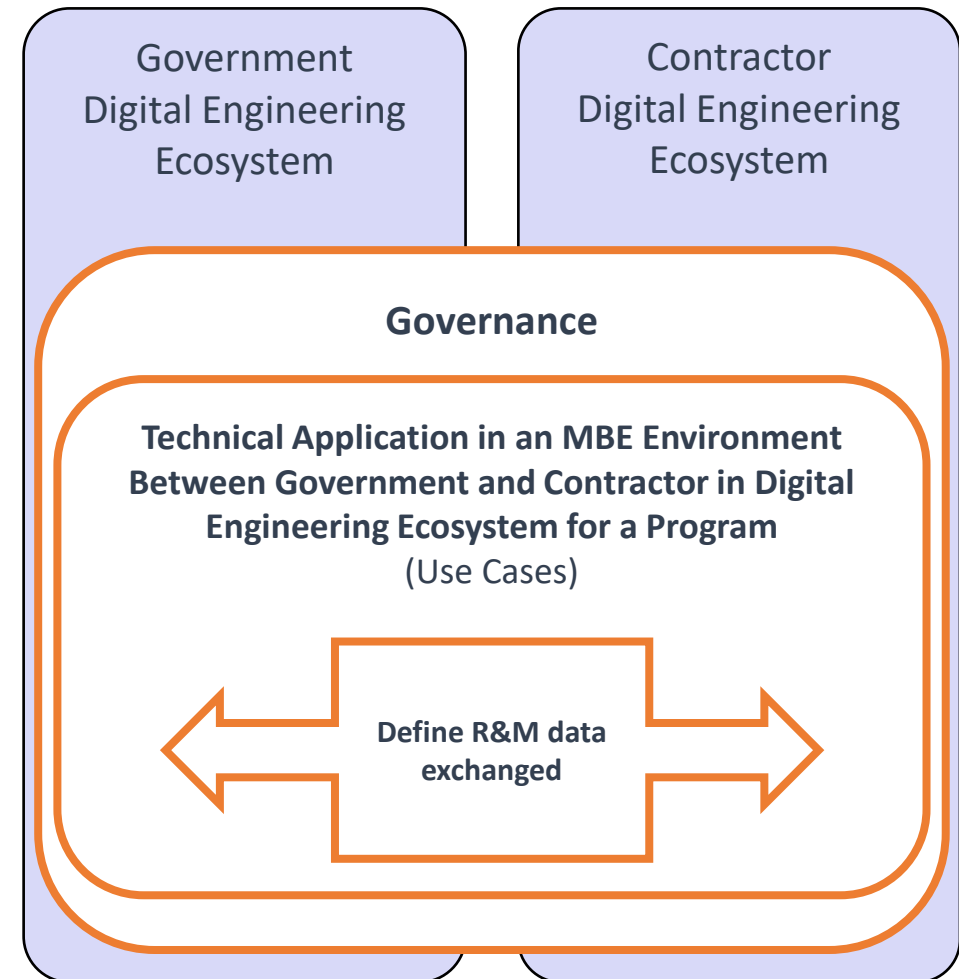
- Instantiate Digital Engineering into R&M Engineering practices
- Deliver Reliable Software
- Reduce Risk with Better R&M Estimates throughout the Lifecycle



# MBE FMECA



- MBE FMECA divided into three sub-working groups at the August 2019 DoD-Industry Roundtable
  - Define the R&M Data Exchanged (Elements)
  - Governance - Defense Standardization Program Office (DSPO)
  - Technical Application in a Digital Engineering (DE) Ecosystem







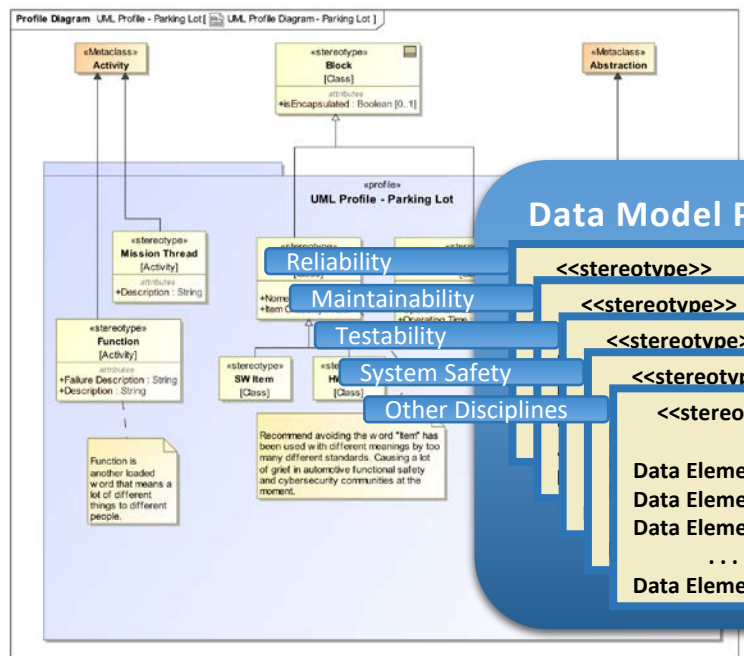
# Technical Application in a DE Ecosystem

- Data Elements
- R&M Data Sources
- Activities and Use Cases
- Analysis Methods
- Reporting
- Government Access

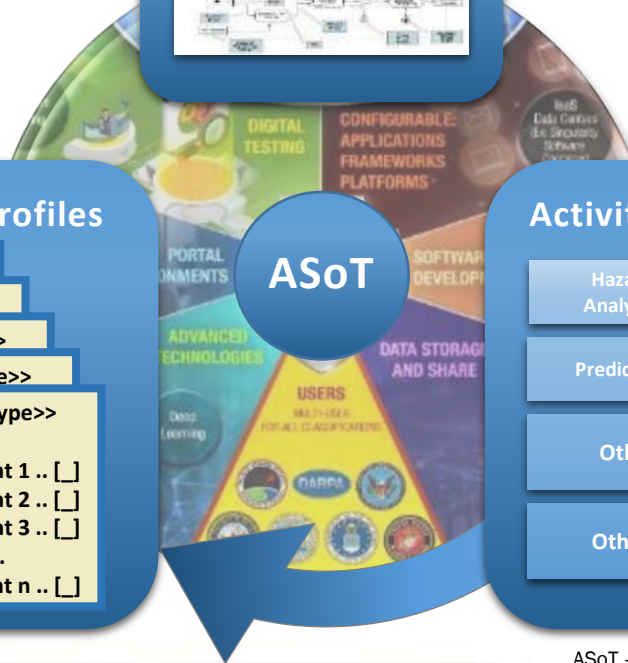
System Design (Requirements)

Design Iterations

System Model(s)



Data Model Profiles



Activities & Analyses

Hazard Analyses	FMECA
Prediction	RBD
Other R&M Activities	
Other Design Activities	

ASoT – Authoritative Source of Truth  
ConOp - Concept of Operations



# FMECA DI-SESS-81495B [Active]



- Objective – Transition current FMECA process to an MBE process

## DATA ITEM DESCRIPTION

**Title:** FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS

**Number:** DI-SESS-81495B

**Approval Date:** 20190516

**AMSC Number:** N10028

**Limitation:** N/A

**DTIC Applicable:** Yes

**GIDEP Applicable:** Yes

<http://www.dtic.mil/dtic/submit>

<http://www.gidep.org/data/submit.htm>

**Preparing Activity:** AS

**Project Number:** SESS-2019-016

**Applicable Forms:** N/A

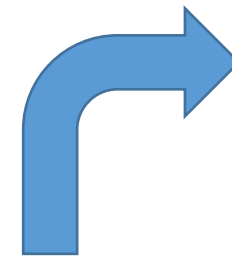
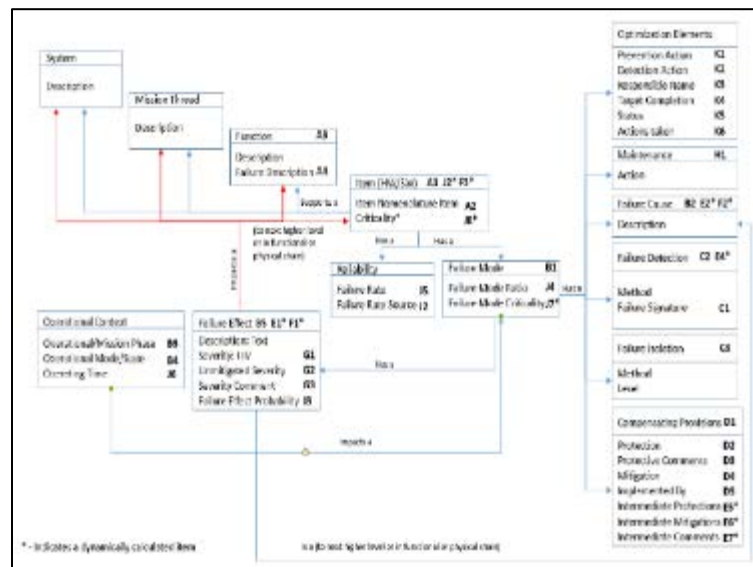
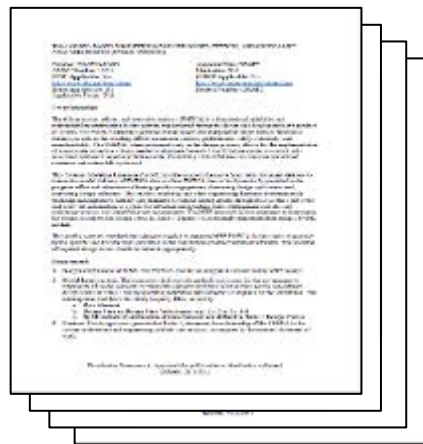
2. Content. These data shall explicitly show and document the relationship of the FMECA to the systems architecture and engineering artifacts and analysis, as required by the contract statement of work, and shall include:

- a. Identification of how the FMECA aligns to the digital systems engineering environment.

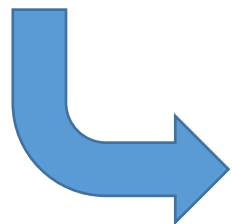
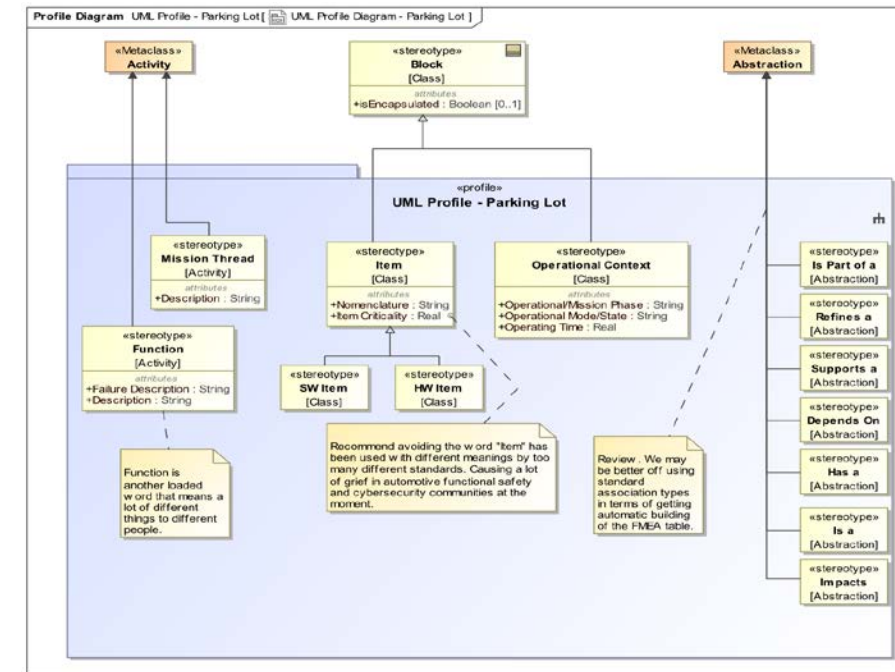


# Transition to an MBE FMECA Profile

From Human Readable



To Machine Readable (SysML)



To Representation



# Standard Data Elements and Views - Profile



- Establish Contract Language
  - Data Item Description (DID) Process
  - Data Elements
  - Design Views
- Develop Draft MBE FMECA DID
- Pilot on DSPO ASSIST Database
  - Human Readable PDF
  - Machine Readable XML

A2 – **Item Identification Nomenclature:** The name or nomenclature of the item or system function being analyzed for failure mode and effects.

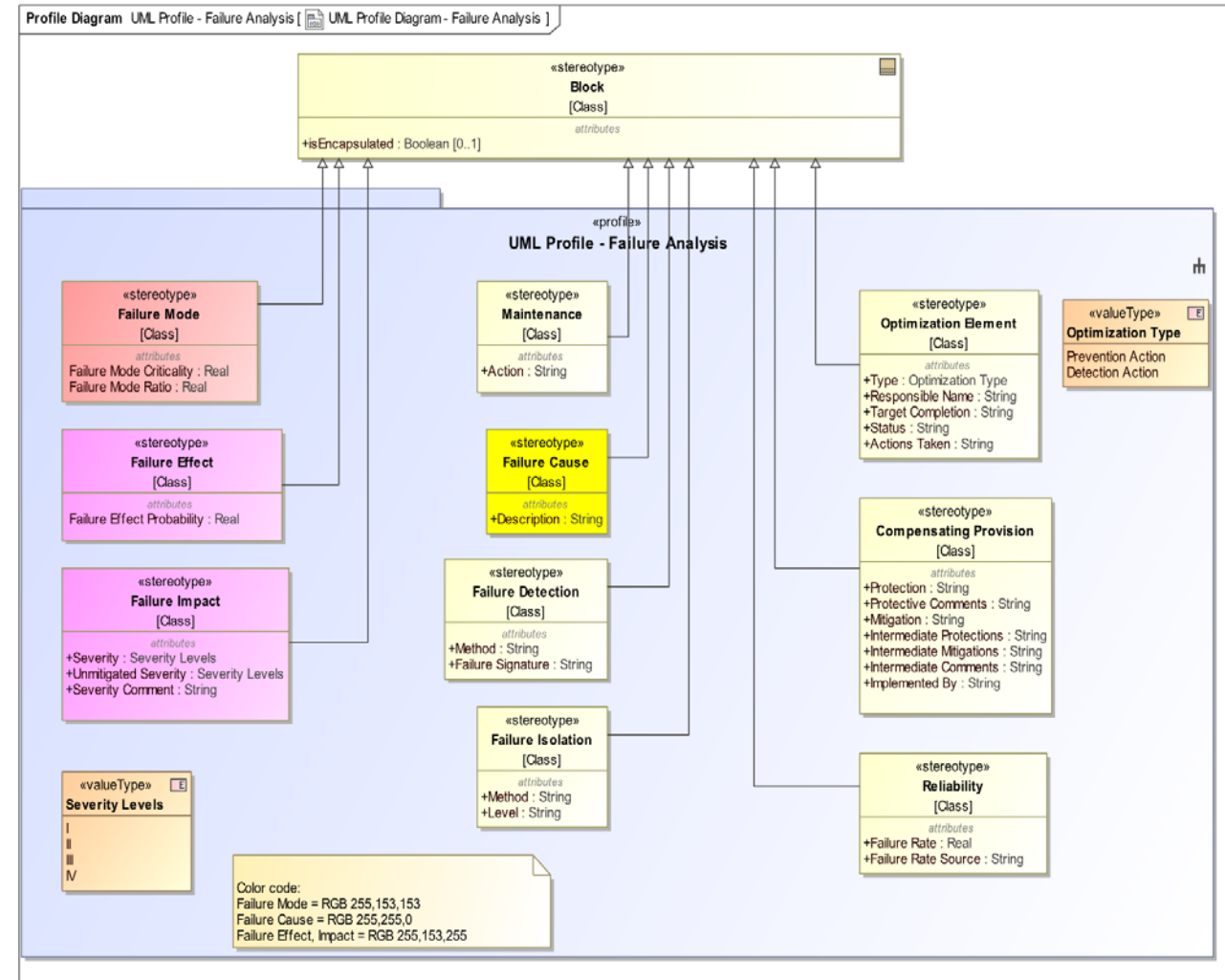
A3 – **Function:** A concise statement of the performance required by the function of the item including any performance standards.

A4 – **Function Failure Description:** Ways an item can either partially (with upper and/or lower

**Table 1 – Design Views<sup>1</sup>**

No.	Category	IEWS
1.	Failure modes and effects summary (FMES)	a) <b>Item:</b> Name or identification of the item
		b) <b>Item Description:</b> Description of the item (taken from the SysML block documentation field)
		c) <b>Failure Mode:</b> Failure mode of the item
		d) <b>Failure Mode Description:</b> More detailed description of the failure mode
		e) <b>Local Failure Effects:</b> Performance effects that identify the impact of a failure mode on the operation and function of an item
		f) <b>System Failure Effects:</b> Performance effects that identify the impact of a failure mode on the operation and function of the system
		g) <b>Local Failure Mode Occurrences:</b> Number of times this failure mode appears as a local (i.e., left most) failure mode. Reveals the number of system failures caused by a particular failure mode. Supports weak link analysis. Not to be confused with probability of occurrence
		h) <b>Intermediate Effects Occurrences:</b> Number of times this failure mode is a cause for an effect (i.e., failure effects after the first failure mode). Reveals the number of system failures caused by a single failure mode. Supports weak link analysis. Not to be confused with probability of occurrence
		i) <b>Unique Failure Modes and Effects Occurrences:</b> Number of unique propagations in which this failure mode appears
		j) <b>Total Failure Modes and Effects Occurrences:</b> Sum of local

- Load the profile into SysML
- Populate blocks with data
  - Failure modes
  - Failure causes
  - Failure rates
- “Push a button” and generate the desired views
- Challenges
  - Trade-off: SysML model vs External R&M tools, data, and models
  - Scalability
  - Model overload with other disciplines
  - External access, Data Rights (IP)





# Policy Directs R&M Digital Representations



- DoDI 5000.88 – Engineering of Defense Systems
- “...integral part of the overall engineering process and the digital representation of the system”
- “...strategy consisting of...digital artifacts”

## b. Reliability and Maintainability (R&M).

(1) For all defense acquisition programs, the LSE, working for the PM, will integrate R&M engineering as an integral part of the overall engineering process and the digital representation of the system being developed.

(a) The LSE will plan and execute a comprehensive R&M program using an appropriate strategy consisting of engineering activities, products, and digital artifacts, including:

1. R&M allocations, block diagrams, and predictions.
2. Failure definitions and scoring criteria.
3. Failure mode, effects, and criticality analysis,
4. Maintainability and built-in test demonstrations.
5. Reliability testing at the system and subsystem level.
6. A failure reporting, analysis, and corrective action system maintained through design, development, test, production, and sustainment.





# Instantiate DE into R&M Engineering Practices



- Number 1 (out of 14) Pain Points Identified by the R&M Engineering Community in FY21
- Informed by the MBE FMECA efforts and advancing the flow of failure mode and effects analysis (FMEA) data
  - Design FMEA
  - Process FMEA
  - Supportability FMEA (Logistics Product Data)
- Expanding to all R&M Engineering Activities
- Including the flow from Model-Based Systems Engineering to Model-Based Product Support



# DE into R&M Engineering Goals



- Educate and train R&M engineers on the application of MBE
- Move from current static document delivery to interactive model delivery of R&M data
- Leverage interfaces to authoritative 3D engineering models (sources of truth) for components and systems
- Allow efficient and continuous engagement of R&M engineers with designers to increase design influence
- Decrease design cycle times
- Ensure R&M models to support weapon systems during Operations and Support phase (MBSE to MBPS)





# DE into R&M Engineering Path Forward



- R&M MBE Use Cases (How SysML models are used in R&M engineering analyses)
- Pilot opportunities in MBE (Based on the Use Cases)
- Guidance
  - Lessons learned
  - Best practices
  - Model and data exchange between R&M engineering and other engineering models
  - Exchange between government program office and prime contractor manufacturers
  - Updated DAU R&M Engineering 08XX courses as necessary
- Initial guidance at the DoD – Industry R&M Roundtable co-located during RAMS, January 2022



# Deliver Reliable Software



- Number 2 Pain Point within the R&M Engineering Community
- Opinions on software reliability vary – Why Reliable Software
  - “There is no such thing as software reliability”
  - “You can observe it but it is difficult to predict”
  - “You can track defects with software quality and maturity”
  - “It is either zero or one”
  - “Why not use IEEE-1633-2016”
  - “You can do a software FMEA but not a FMECA because the ‘CA’ requires quantitative prediction of software reliability”



# Deliver Reliable Software – Path Forward



- Develop guidance and contract language
  - Use of DevSecOps
  - Metrics (allocate? measure, test, observe)
  - Requirements (restore time, frequency of restarts, availability)
  - Failure definition and scoring criteria
  - Failure mode identification, risk assessment, severity
  - Data collection methods
  - Roles (who is responsible software, reliability, quality, safety, others?)
- Initial guidance at the DoD – Industry R&M Roundtable co-located during RAMS, January 2022



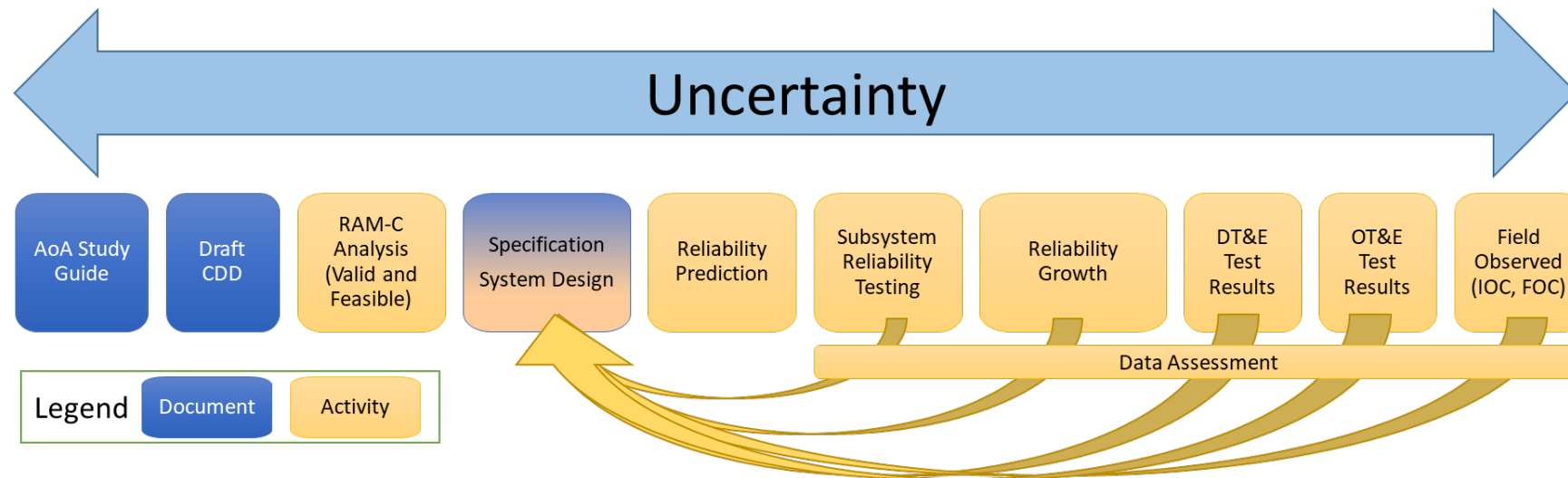
# Reduce Risk with Better R&M Estimates



- Number 3 Pain Point within the R&M Engineering Community
- Why? R&M estimates inform many products throughout the lifecycle
  - Allocations and predictions
  - Criticality Analysis
  - Spares Analysis....to name a few
- Not just “better” estimates, help with understanding
  - Incorrect usage
  - Purpose of estimates change throughout the lifecycle
  - Source of data change
  - Fidelity, accuracy, and cleanliness of data
  - Feedback from test and operational usage to inform better up front estimates

# Better R&M Estimates Path Forward

- Understand all estimates have uncertainty
- Understand what R&M value to use for each activity
- Use modern data analytic techniques
- Initial guidance at the DoD – Industry R&M Roundtable co-located during RAMS, January 2022





# Summary



- Anyone want to join our R&M Engineering Roundtable?
  - Government (DoD, NASA) ?
  - Industry DoD Manufacturers ?
- Transitioning to a MBE FMECA is leading the R&M community to a DE ecosystem
- Instantiating DE into R&M is helping to flow engineering design to manufacturing and product support
- Delivering reliable software with DevSecOps methods is minimizing the occurrence of software failures that would occur in operations
- Reducing the risk with better R&M estimates ultimately increases the readiness of our systems for the warfighter
- Collaborating on the combined pain points helps deliver Reliable, Maintainable, and Supportable Advanced Capabilities to the Warfighter





# Contact

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