# R&M as part of the Digital Engineering (DE) Ecosystem


RAMS Advisory Panel 2023

**PRESENTED BY: Tony DiVenti, NASA R&M Technical Fellow**

# Outline

- What do we mean by a Digital Engineering (DE) and a Digital Engineering (DE) Eco System
  - Definitions
  - Descriptions
- DE / DE Eco System in context of NASA's Digital Transformation Initiative
- DE / DE Eco System + Common R&M Challenges = TRANSFORMATIONAL OPPORTUNITIES
- Highlight some NASA R&M Challenges and Transformational Opportunities

  ( just a few | many more)
- Questions / Discussion

# Digital Engineering

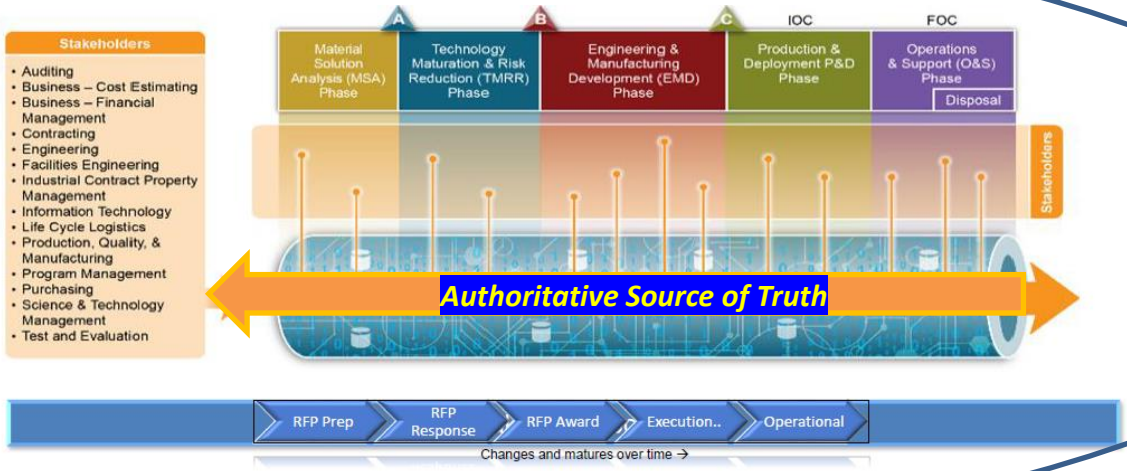
**Definition**

"An integrated digital approach that uses authoritative sources of systems data and models as a continuum across disciplines to support lifecycle activities from concept through disposal". [1]

Leverages model-based engineering (MBE), model-based systems engineering (MBSE), model-based mission assurance (MBMA), MB Anything (MBx), digital thread, digital twin, Semantic Reasoning, etc.

Model-Based Anything - Employ digital models across any/all functional domains to enable our people to address increasing complexity, scope, speed, uncertainty & changes.

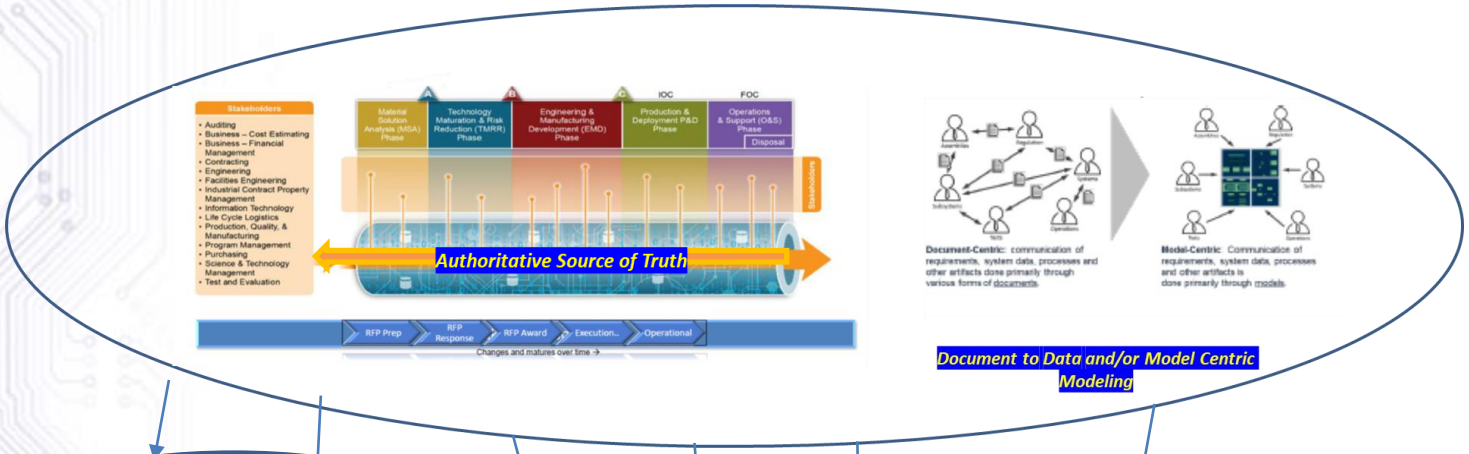

***Document to Data and/or Model Centric Modeling***

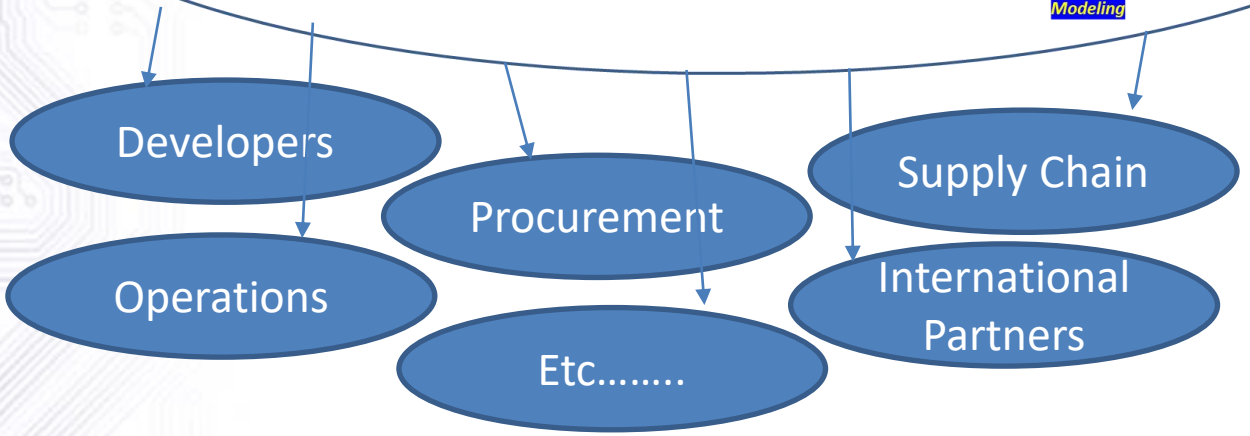



**Purpose**

To better manage the growing complexity of systems and of their development and operations by linking information sources and analysis processes that were otherwise Stove-piped [2]

# Digital Engineering Eco-System



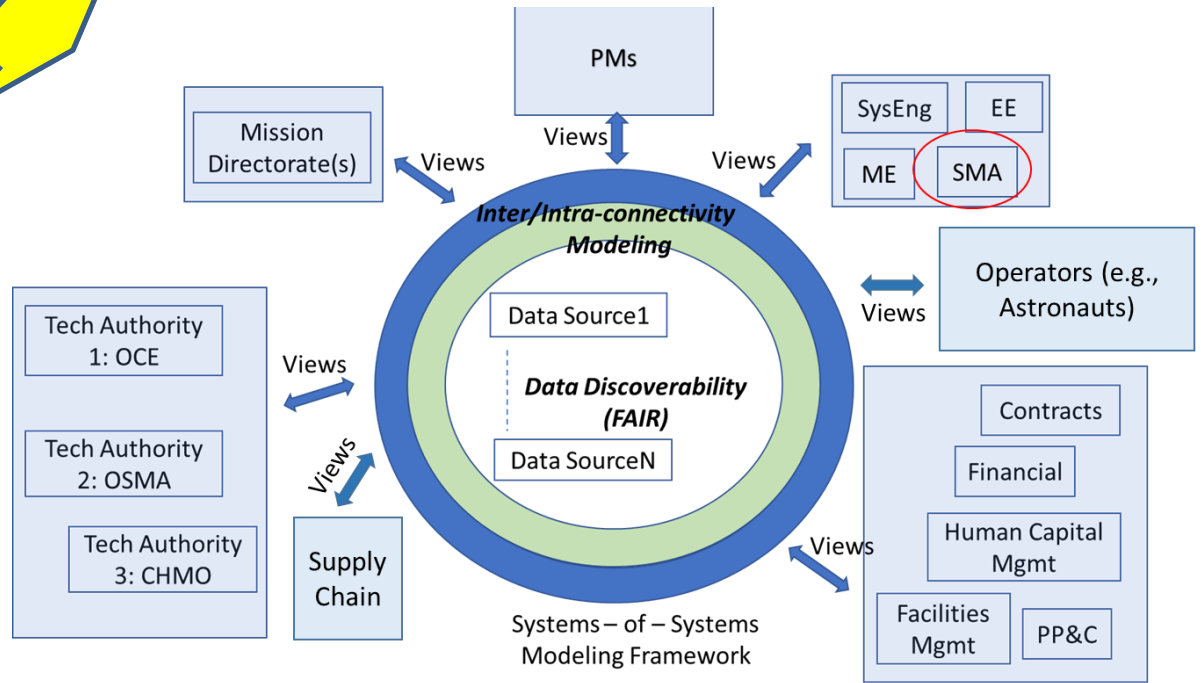




**INTEROPERABILITY and INTEGRATION**

## Definition

A ***digital engineering ecosystem*** includes Enterprise interconnected digital environments, stakeholder-networks, and semantic and ontological reasoning that allows the exchange of digital artifacts from an authoritative source of truth to serve the stakeholder communities' interests [1].

## Everyone has a Seat at the TABLE



# Digital Engineering in the context of NASA Tx Activities

***Digital Engineering***
**and**
**Digital Engineering**
**Eco System**

One of the
**Keys**
to
Digital
*and*
Business
**Transformation**

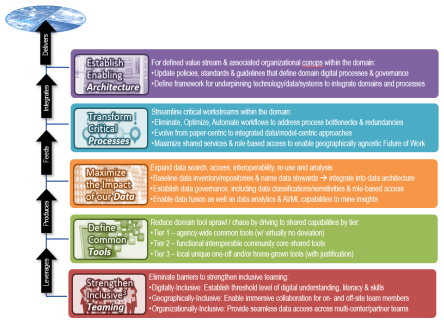
# In the context of NASA Transformational Activities

We are here

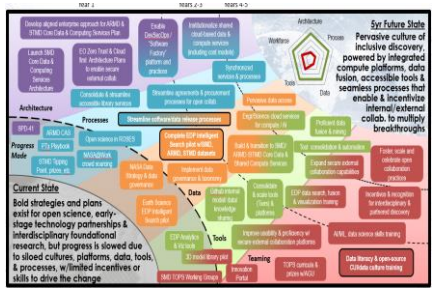
NASA IT Strategic Plan Goal 3 → Transformation Targets → Digital Levers → Community DT Roadmaps → Org Plans


NASA's IT Strategic Plan Goal 3 is to "**Transform NASA with Information and Technology**"

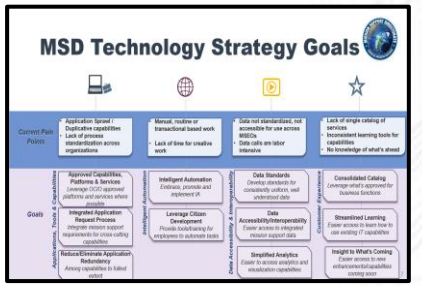

To prioritize and bound Goal 3 investments, DT has worked with NASA has selected four proposed agency **Transformation Targets** to align and focus org actions across NASA




To facilitate org planning & elevate common needs, DT has defined five **Digital Levers** as a systematic methodology to harness information & technology to enable future capabilities



DT will facilitate each Tx Target community to develop living **Tx Target DT Roadmaps,** using the Digital Levers to drive transformation outcomes and guide / inform individual org planning

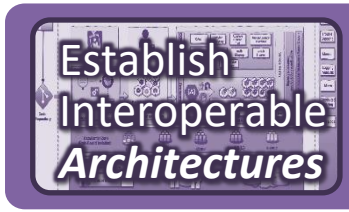



OICs will **create/align org DT / strategic plans** to respond to the approved DT strategy; **DT will integrate org DT plans to identify gaps & opportunities** to drive immediate benefits for each Tx Target.

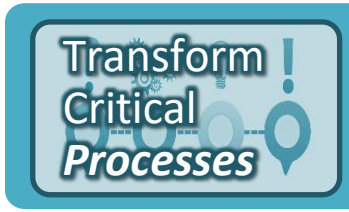
# Digital Engineering (DE) or DE Eco System

# 5 Digital Levers - Expanded

## For any/each Transformation Target…


***Define value streams & associated organizational conops** within the domain:*
- Update **policies, standards & guidelines** that define domain digital processes & governance
- Define framework for **interoperable platforms/systems** to integrate domains and processes

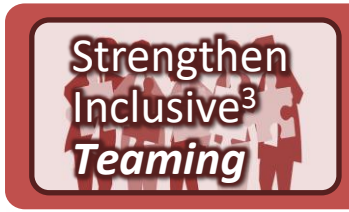

***Streamline critical workstreams** within the domain:*
- **Eliminate, Optimize, Automate workflows** to address process bottlenecks & redundancies
- Evolve from paper-centric to **integrated data/model-centric approaches**
- Maximize **shared services & role-based access** to enable geographically agnostic Future of Work



*Expand **data search, access, interoperability, re-use and analysis**:*
- Baseline **data inventory/repositories** & name **data stewards** → integrate into **data architecture**
- Establish **data governance**, including data classifications/sensitivities & role-based access
- Enable **data fusion** as well as **data analytics & AI/ML** capabilities to mine insights



***Reduce domain tool sprawl / chaos** by driving to shared capabilities by tier:*
- Tier 1 – **agency-wide common tools** (w/ deviation by exception)
- Tier 2 – functional interoperable **community core shared tools**
- Tier 3 – **local unique one-off** and/or home-grown tools (with justification)


*Eliminate barriers to **strengthen inclusive teaming**:*
- Digitally-Inclusive: Establish threshold level of **digital understanding, literacy & skills**
- Geographically-Inclusive: Enable **immersive collaboration for on- and off-site** team members
- Organizationally-Inclusive: Provide **seamless data access across multi-center/partner** teams

**…** we can accelerate transformation progress by systematically facilitating & coordinating organizational transformation action plans to **harness Digital Levers**

***Digital Levers aligned with extremal benchmarking of digital North Stars***

# How to do we leverage DE / DT for R&M?

# R&M Transformational Opportunities as part of the DE Eco System

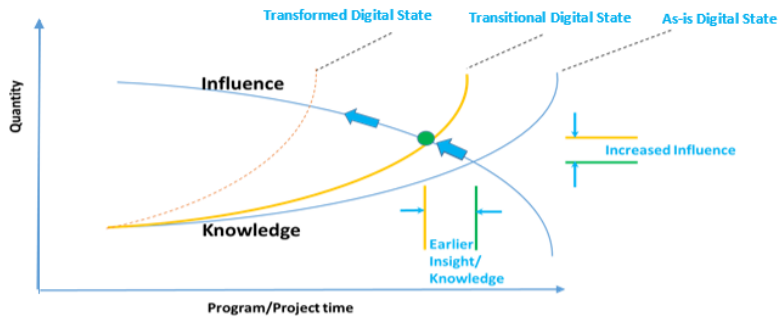
R&M Challenges

Common R&M Needs

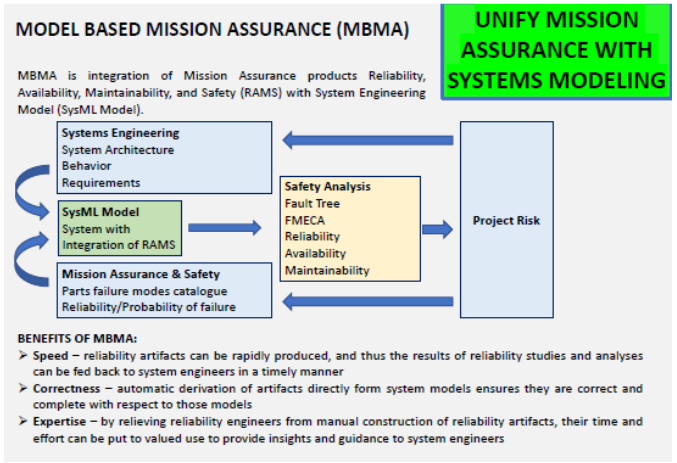

**Document-Centric to Model-Centric, Model Based, Digital Thread, & Digital Twin activities**

# R&M Challenges & Opportunities

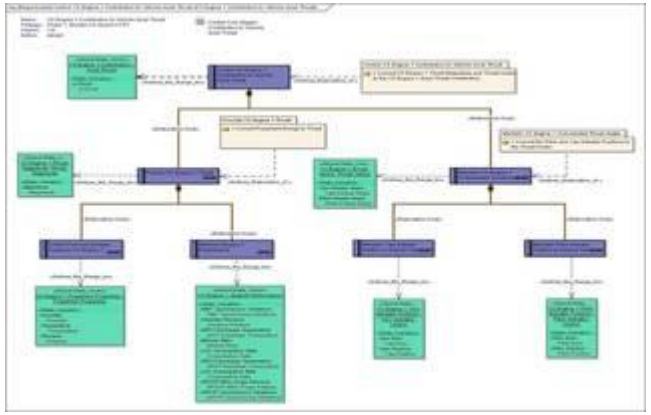
**Challenge:** Disjointed Reliability Analysis (e.g., FMEA, FTA, RBD) - Not integrated with the Authoritative Systems Reference Model



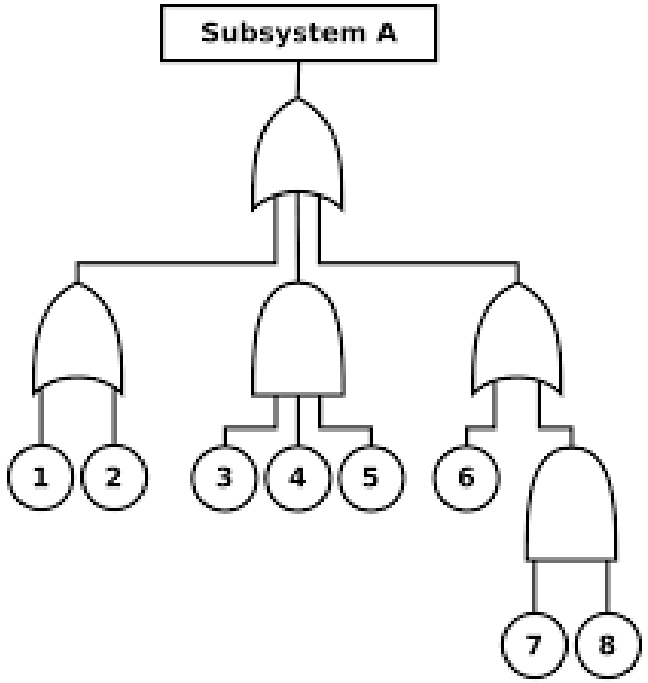

Analysis coming directly from the Systems Reference Model (SRM)




Analysis coming directly from a parallel Goal Function Tree (GFT) Reference Model



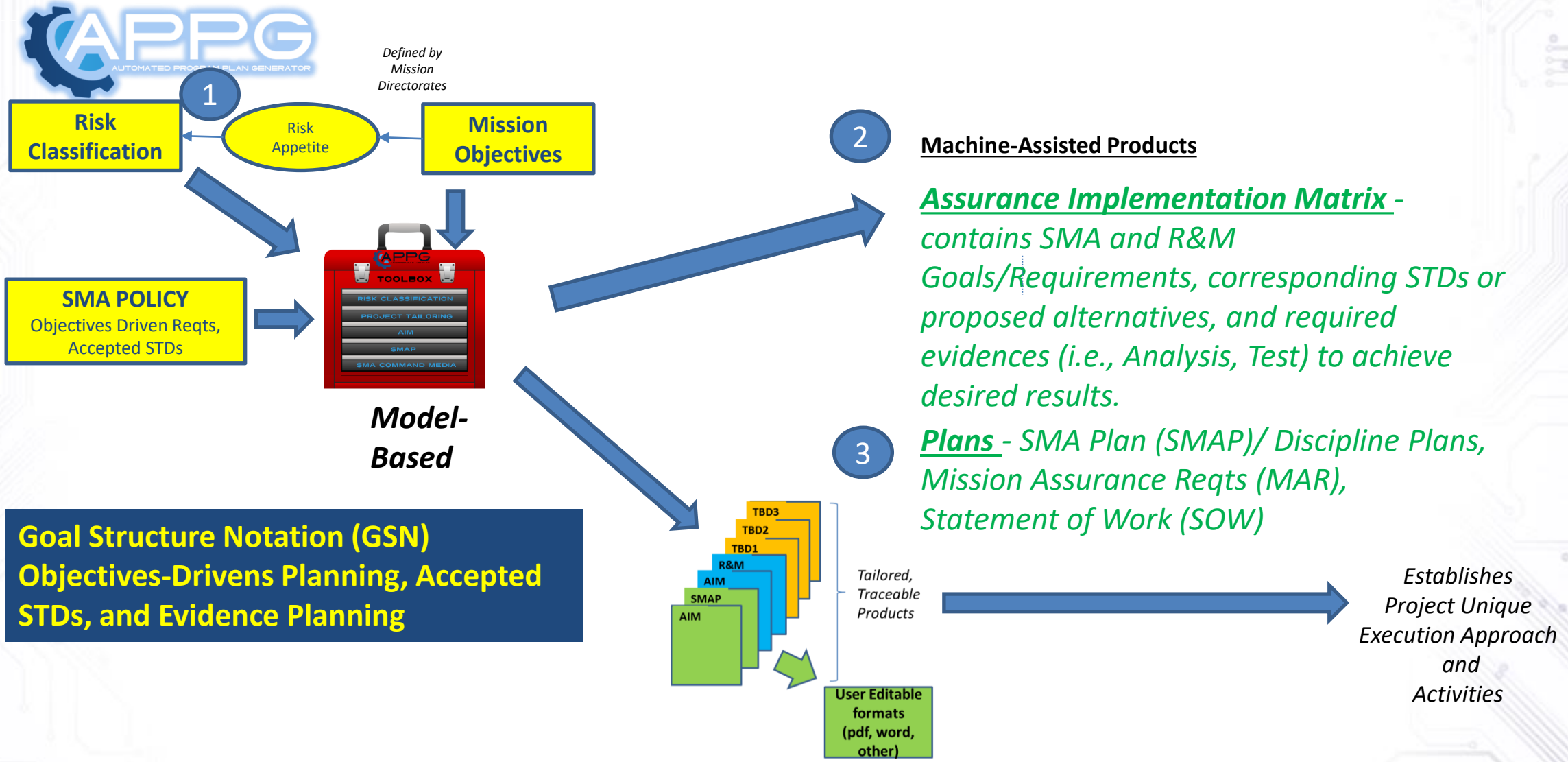
Model-Based R&M Analysis Product Generation




**Opportunity:** Two-Way**, Real-Time Synced,** Model-Based generation of Analysis Products (e.g., FMEA, FTA, RBDs)

# R&M Challenges & Opportunities

**Challenge:** Document-Centric Planning Takes too Long, subject to human errors

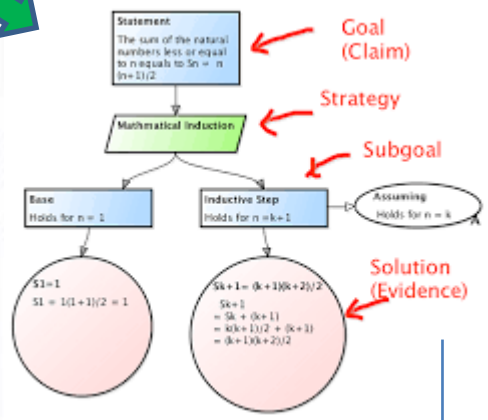


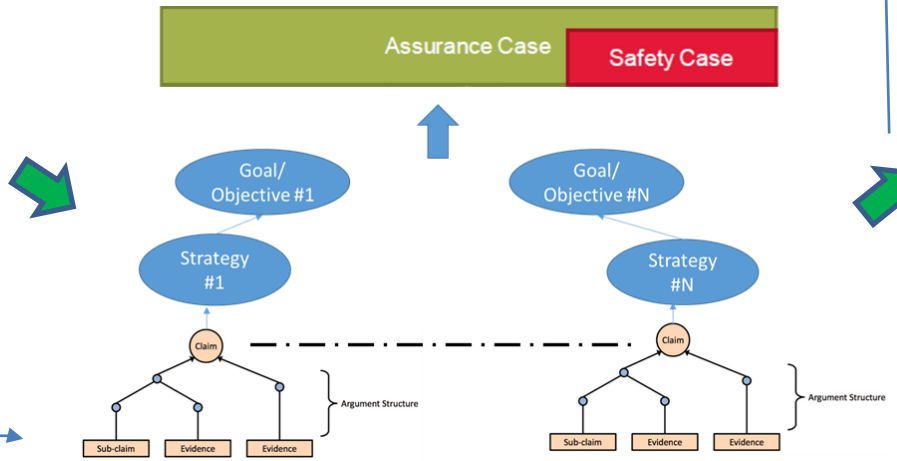

**Opportunity:** Robust, Machine-Assisted (Model-Based) Planning in a fraction of the time

# R&M Challenges & Opportunities

**Challenge:** Lack of Insight / Oversight into Project (including Commercial) R&M and related actives

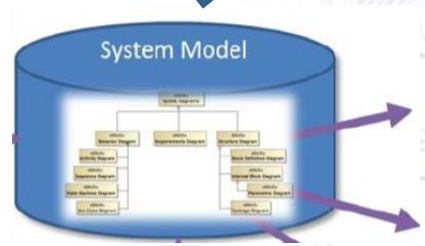

Goal Strategy Planning (with Evidence) = Initial Assurance Case Argument

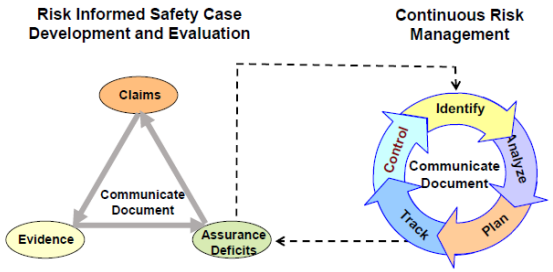



Semantic and Ontological Reasoning

RISKS



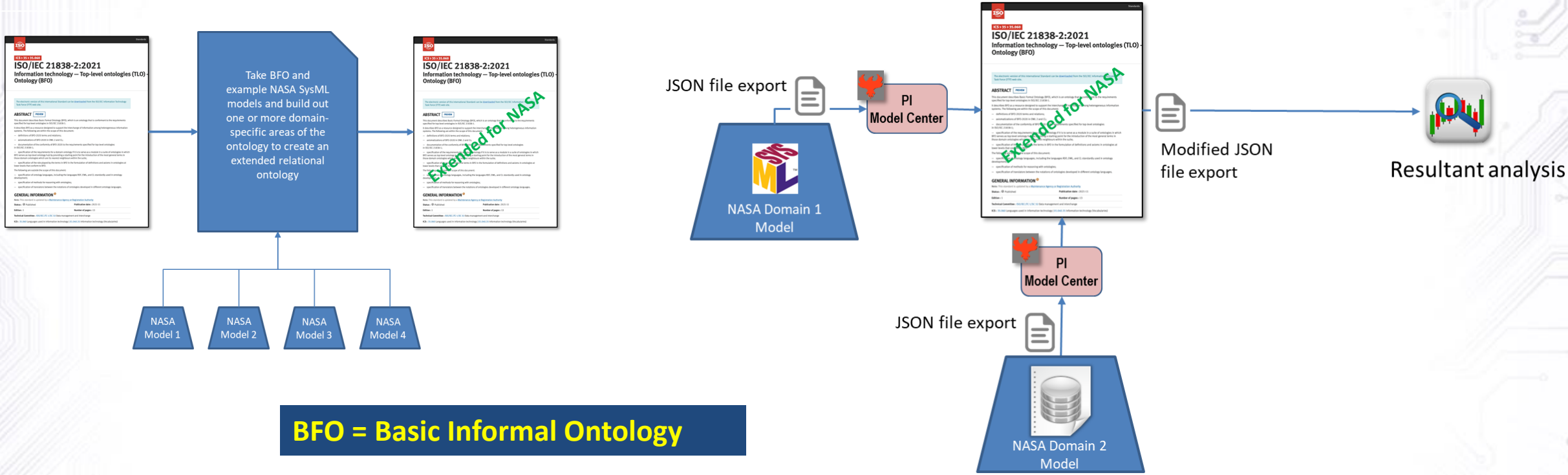




GAPS

**Opportunity:** Model-Based, Digital Thread development, tying Evidences to Higher Level Requirements and Objectives

# R&M Challenges & Opportunities

**Challenge:** Lack of Cross-Project (Cross-Domain) insight and knowledge utilization.



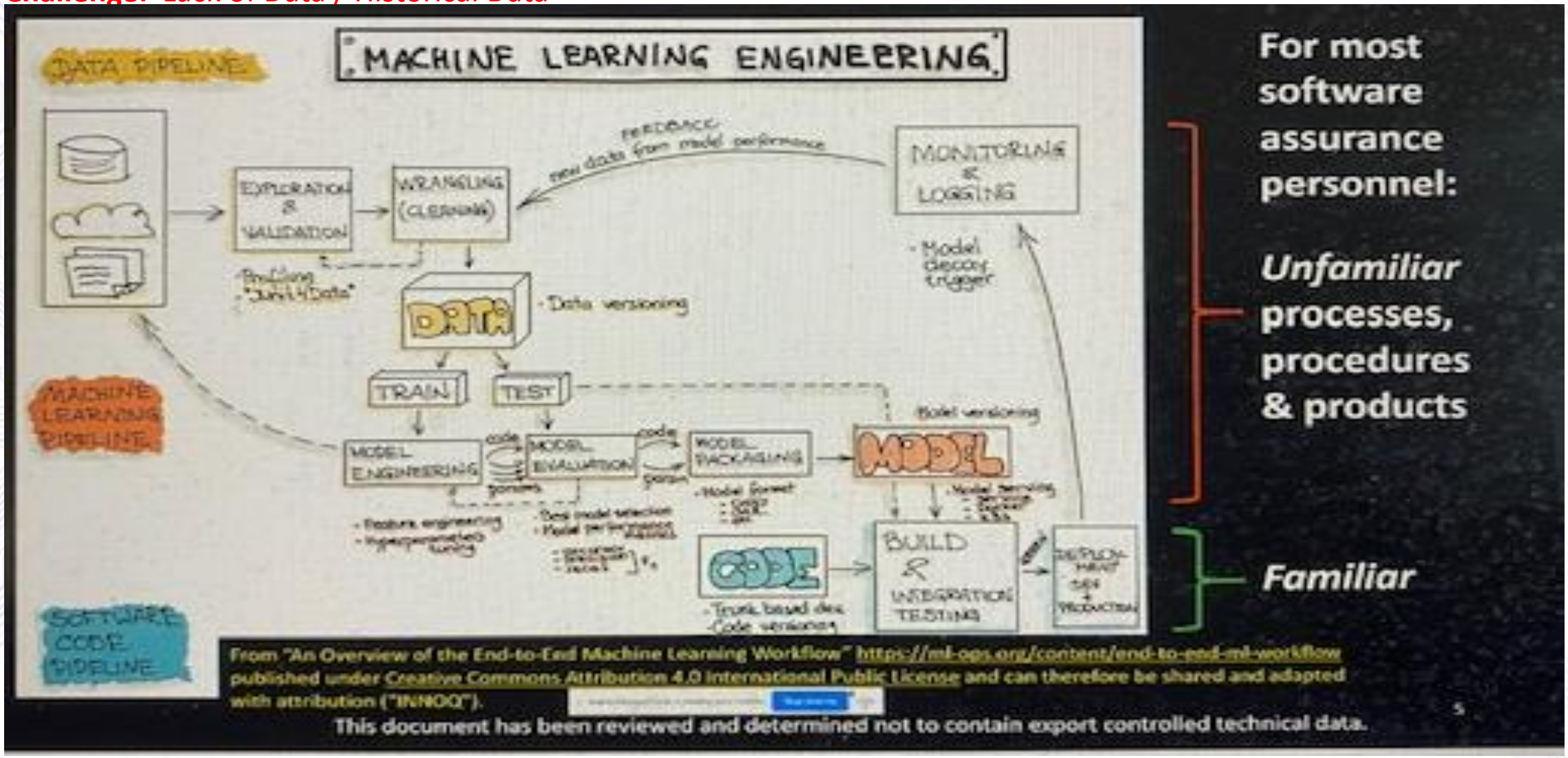

**BFO = Basic Informal Ontology**

**Opportunity:**

- Model-Based, Systems-of-Systems, Digital Twin and Digital Thread development providing a common Rosetta Stone between different domains (e.g., projects) as part of an integrated systems-of-systems toolchain and framework.
- Use NASA Extended Ontology to perform queries to answer specific questions.

# R&M Challenges & Opportunities

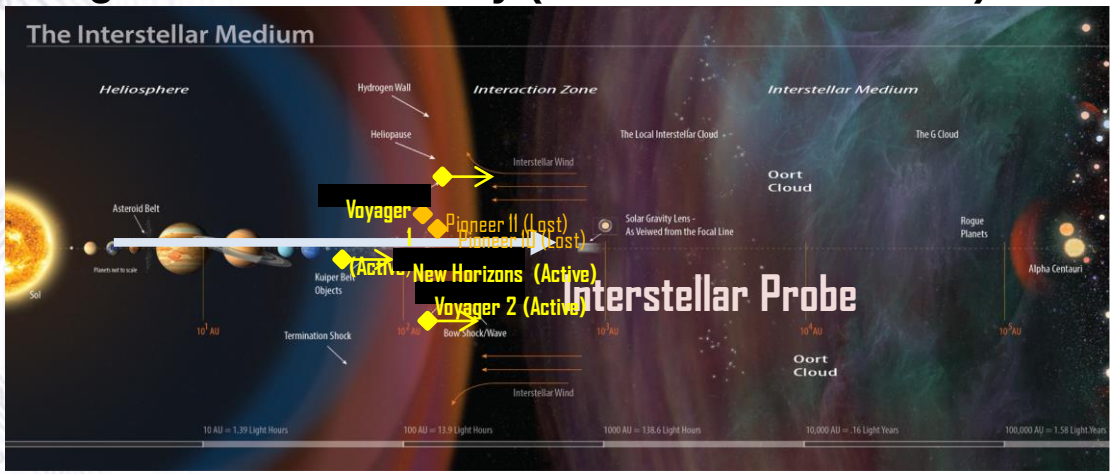
**Challenge:** Lack of Data / Historical Data




**Opportunity:** Greater utilization of Machine Learning Workflows

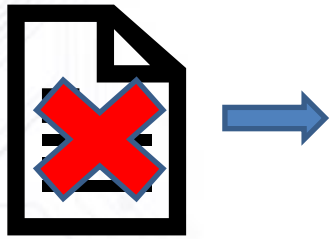
# R&M Challenges & Opportunities

## Long Duration Reliability (Inter-Stellar Missions)




***Challenge***

**Handbook Data**



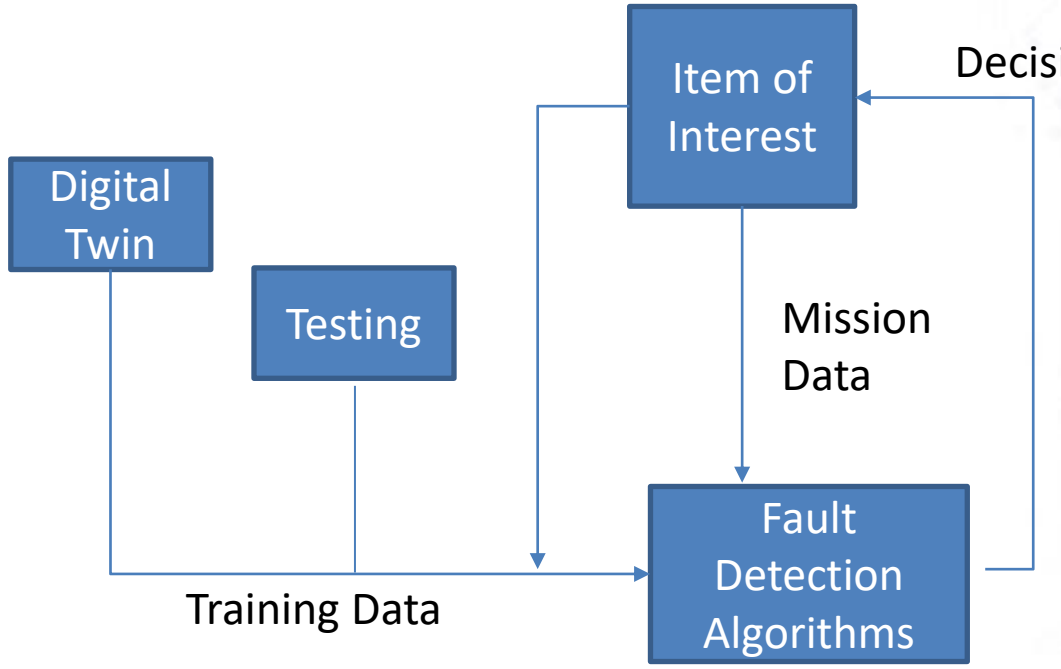
Probabilistic Physics of Failure Modeling

AI-based methods

Testing

System Health and Prognostics

***Opportunity***

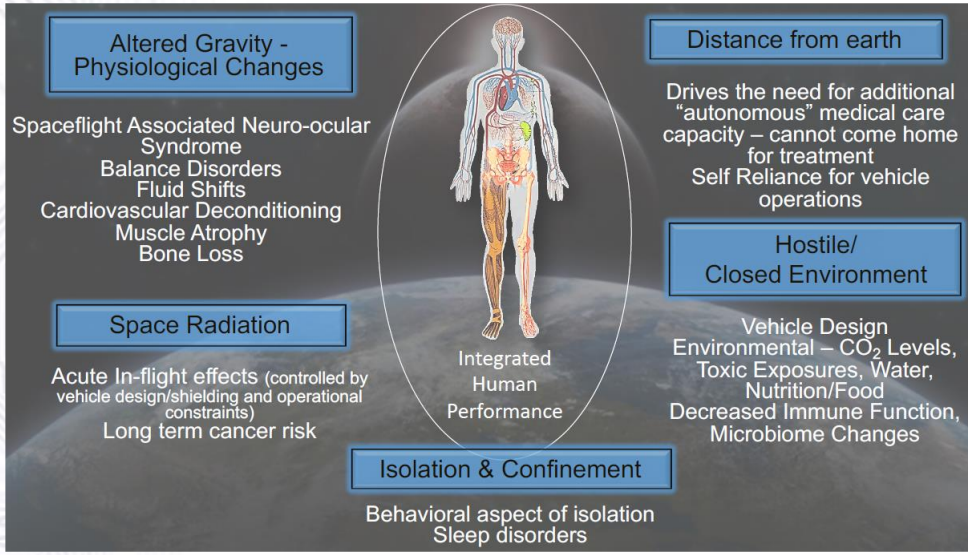


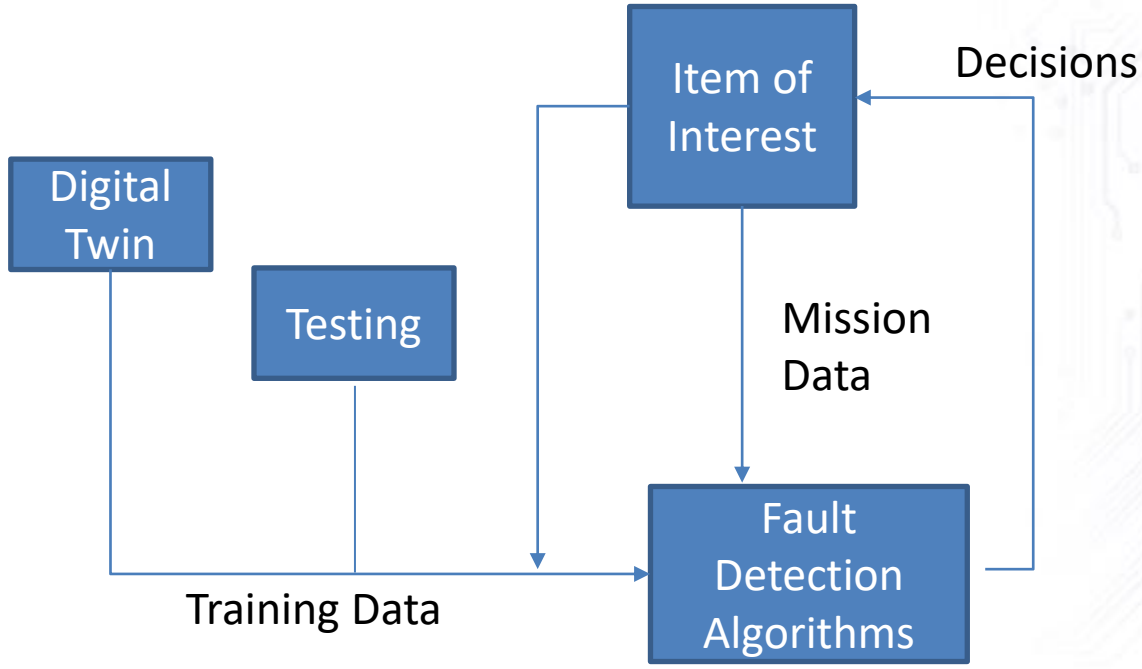

**System Health Management and Prognostics**

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

# R&M Challenges & Opportunities

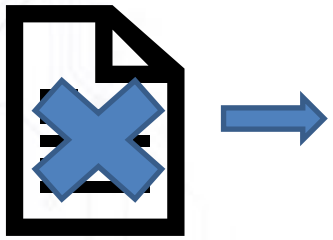
**Human Missions Beyond LEO (Moon, Mars, Beyond)**




***Challenge***

**Traditional Data Curves**



Probabilistic Environmental Effects Analysis

AI-based methods

Testing

System Health and Prognostics

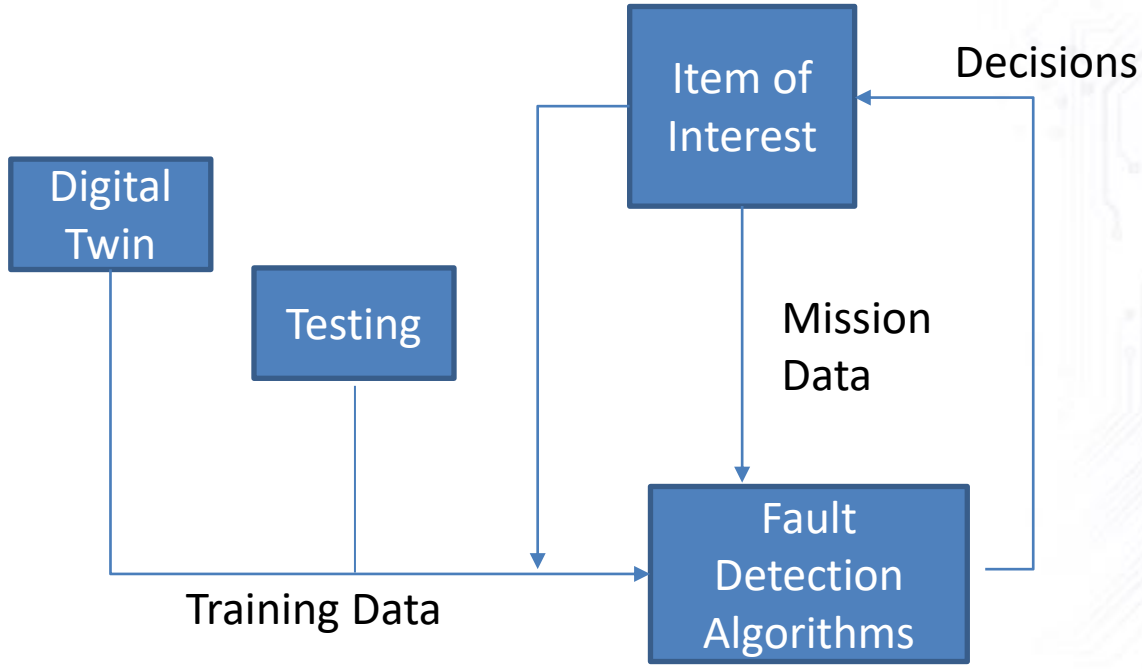
**System Health Management and Prognostics**

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

***Opportunity***

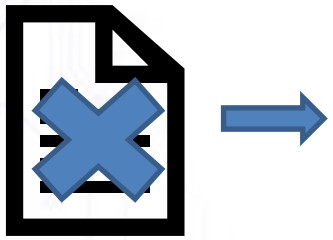
# R&M Challenges & Opportunities

**Unmanned Air Vehicles (UAVs)**


***Challenge***

**Traditional Data Curves**



Probabilistic Environmental Effects Analysis

AI-based methods

Testing

System Health and Prognostics

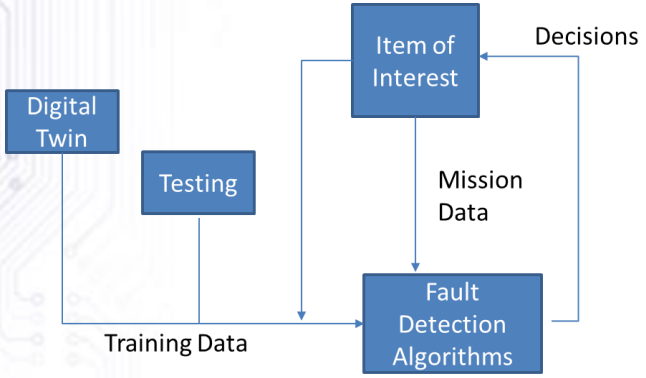
**System Health Management and Prognostics & Autonomous Operations**

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

***Opportunity***

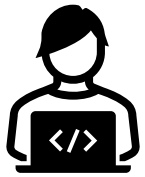
# R&M Challenges & Opportunities

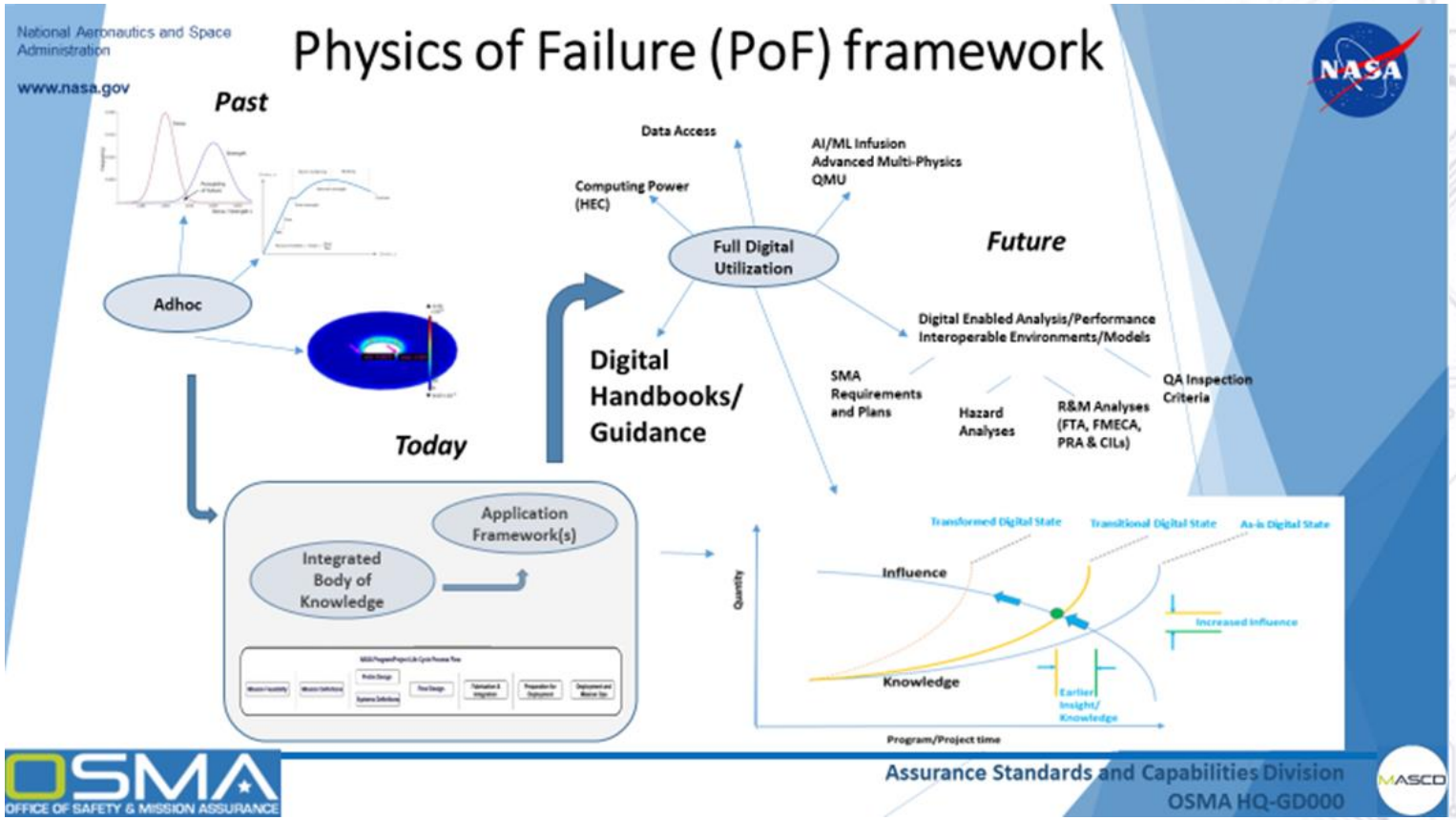
**Challenge:** Digital Acumen **/** Wider utilization of AI/ML




***Opportunity:*** *Increase Digital Acumen and Utilization through Application Frameworks*

**Application Frameworks**






- **Utilization of AI/ML**
- **Continually Analyze / Re-Analyze Operational Data**
- **Routinely assess Ground and Flight Resiliency**
- **Continually update our R&M Body of Knowledge**
- **Infuse Knowledge back into standard Design and Analysis products**

# Questions / Discussion

# Sources

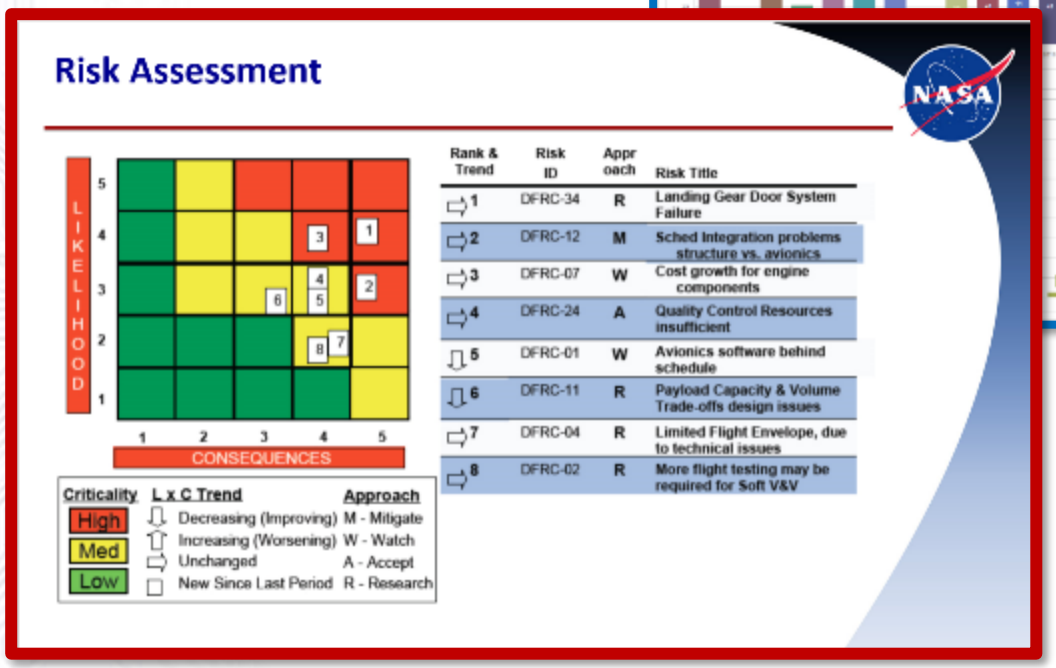
[1] U.S. Department of Defense (DoD) Digital Engineering (DE) Strategy, https://man.fas.org/eprint/digeng-2018.pdf

[2] Noguchi, R.A., Wheaton, M. J., & Martin, J. N. (2020, July). Digital Engineering Strategy to Enable Enterpise Systems Engineering. In INCOSE International Symposium (Vol. 30, No. 1, pp. 1727-1741).

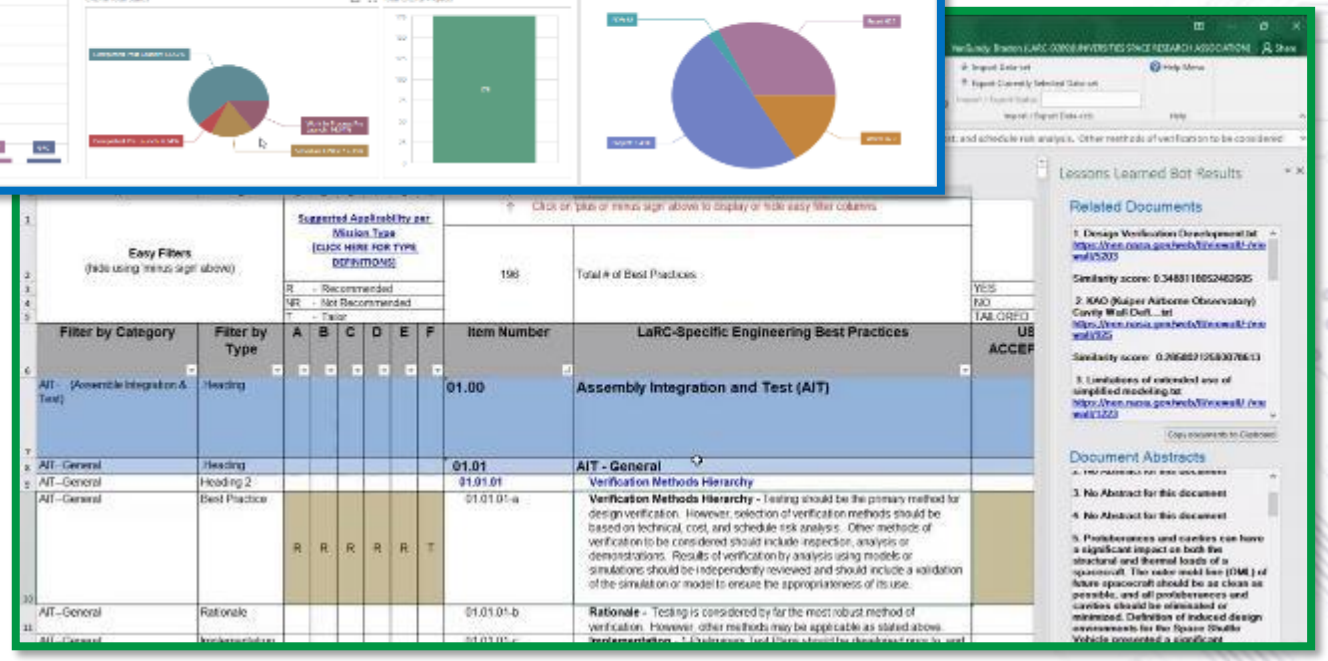
[3] Office of the Deputy Assistant Secretary of Defense (Systems Engineering), "Digital Engineering Ecosystem," DAU Glossary, 2017. [Online]. Available: https://www.dau.mil/glossary/Pages/3625.aspx.

# Transform our Reviews

*2D Charts*




*Live, drill-down Dashboards w/analytics*




**Smart Reviews**

*AI-powered PM Digital Assistants*