

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

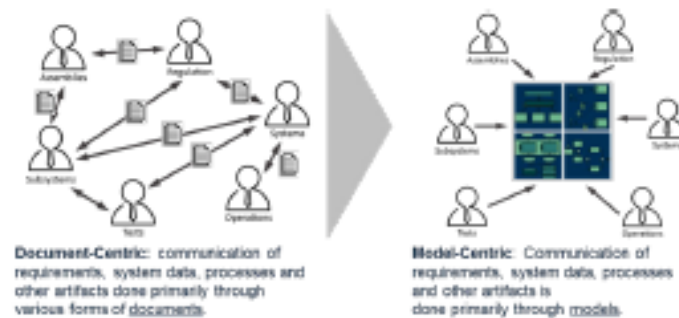
Digital Engineering

Definition

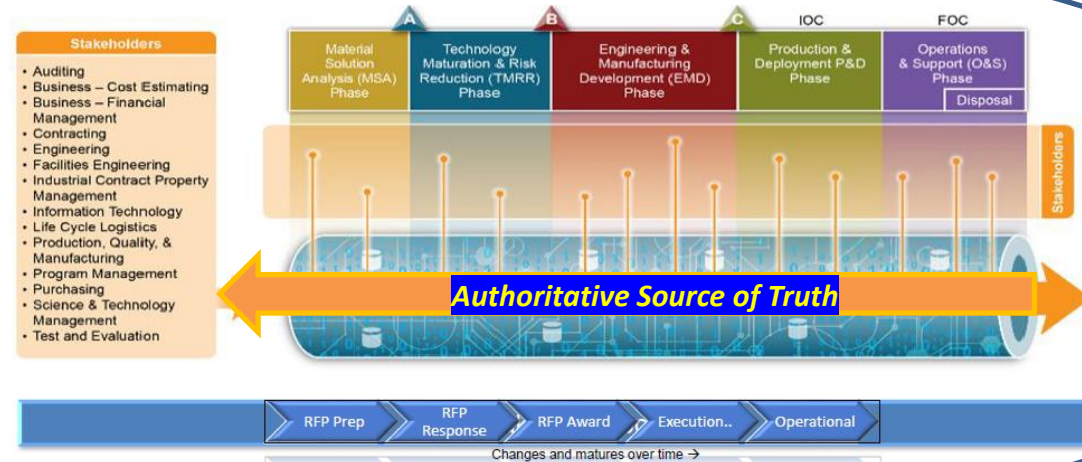
“An integrated digital approach that uses authoritative sources of systems data and models as a continuum across disciplines to support lifecycle activities from concept through disposal”. [1]

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.



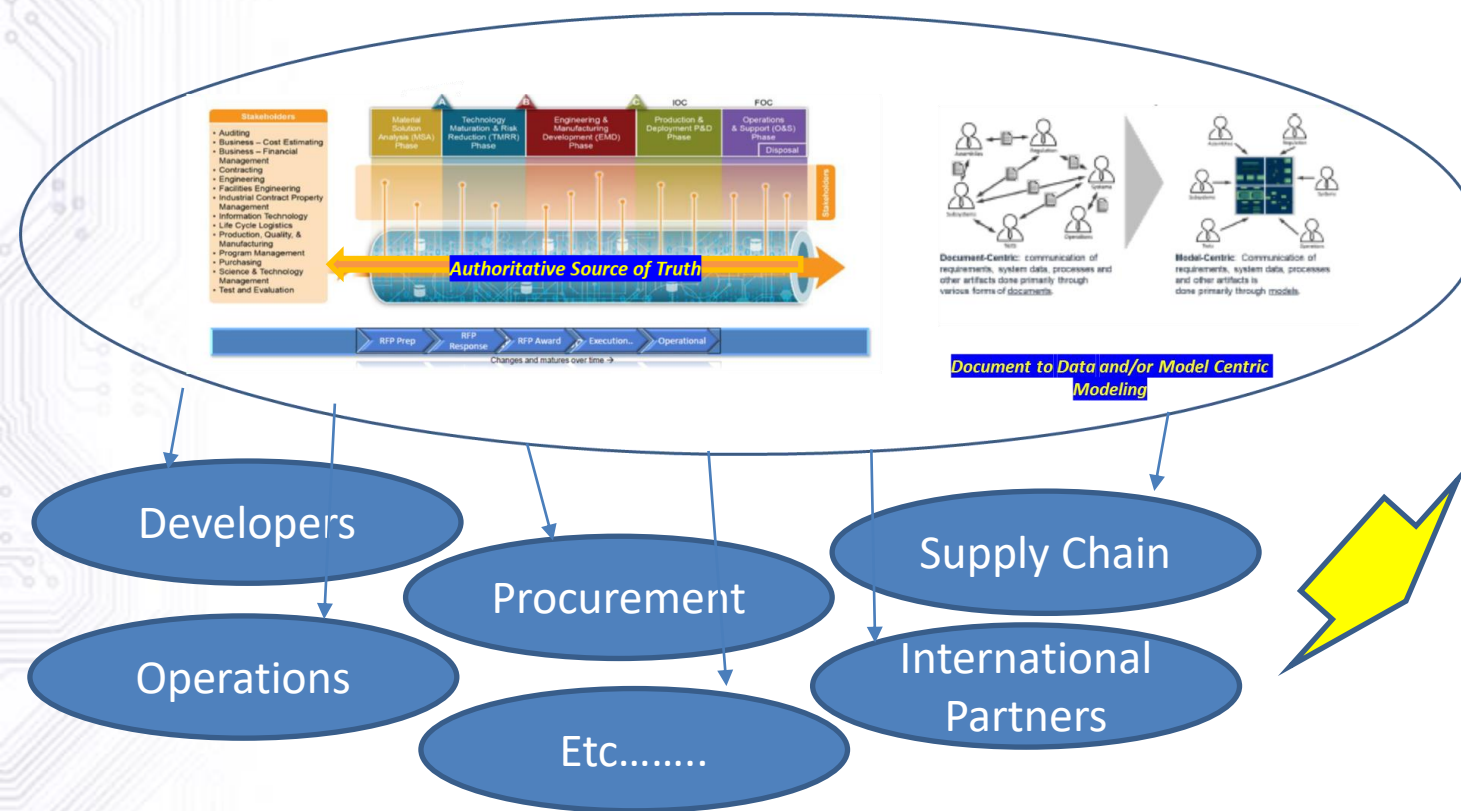
Document to Data and/or Model Centric Modeling



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

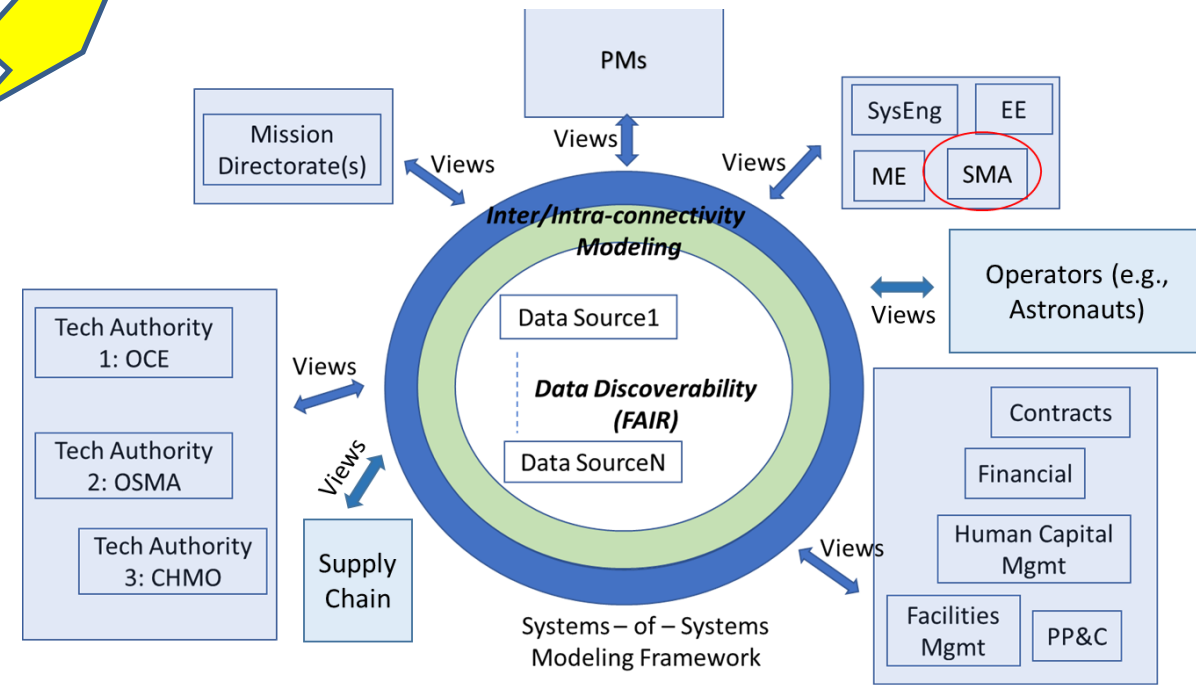


INTEROPERABILITY and INTEGRATION

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
and
**Digital Engineering
Eco System**

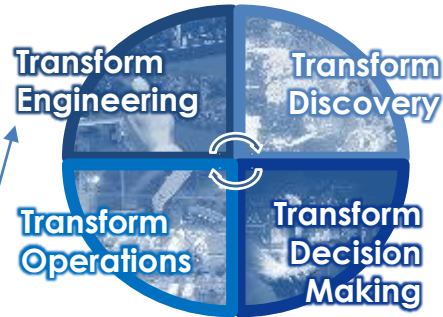


One of the
Keys
to
Digital
and
Business
Transformation

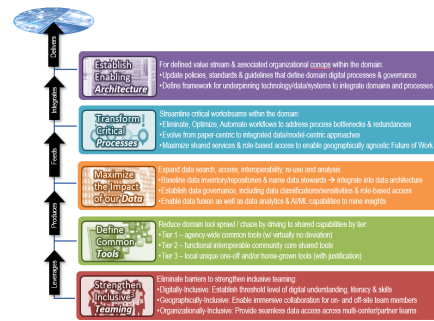
In the context of NASA Transformational Activities



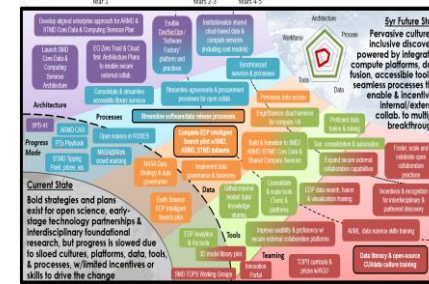
NASA's IT Strategic Plan Goal 3 is to
**"Transform NASA
 with Information
 and Technology"**



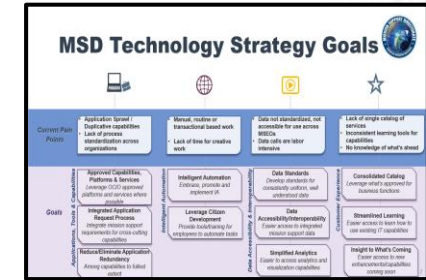
To prioritize and bound Goal 3 investments, DT has worked with NASA has selected four proposed agency **Transformation Targets** to align and focus org actions across NASA



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

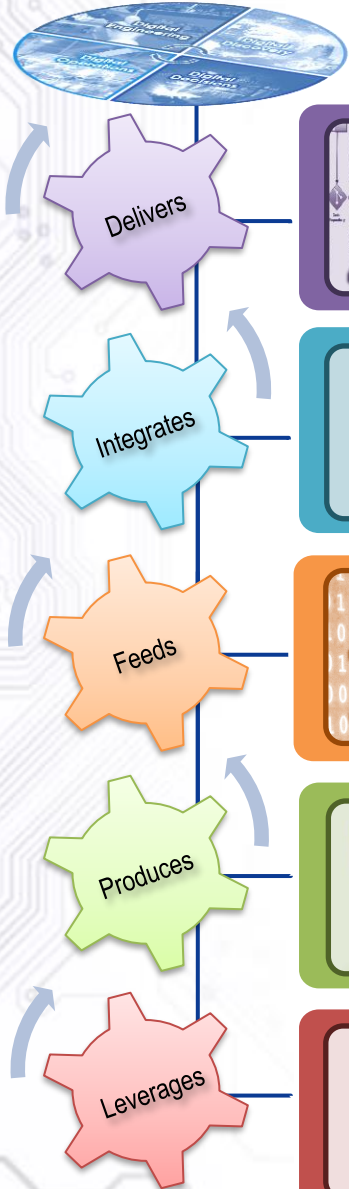


OICs will **create/align org DT / strategic plans** to respond to the approved DT strategy; **DT will integrate org DT plans to identify gaps & opportunities** to drive immediate benefits for each Tx Target.

Digital Engineering (DE) or DE Eco System

5 Digital Levers - Expanded

For any/each Transformation Target...



Establish Interoperable Architectures

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

Transform Critical 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

Maximize the Impact of our Data

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

Adopt Common Tools

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)

Strengthen Inclusive³ Teaming

Eliminate barriers to **strengthen inclusive teaming**:

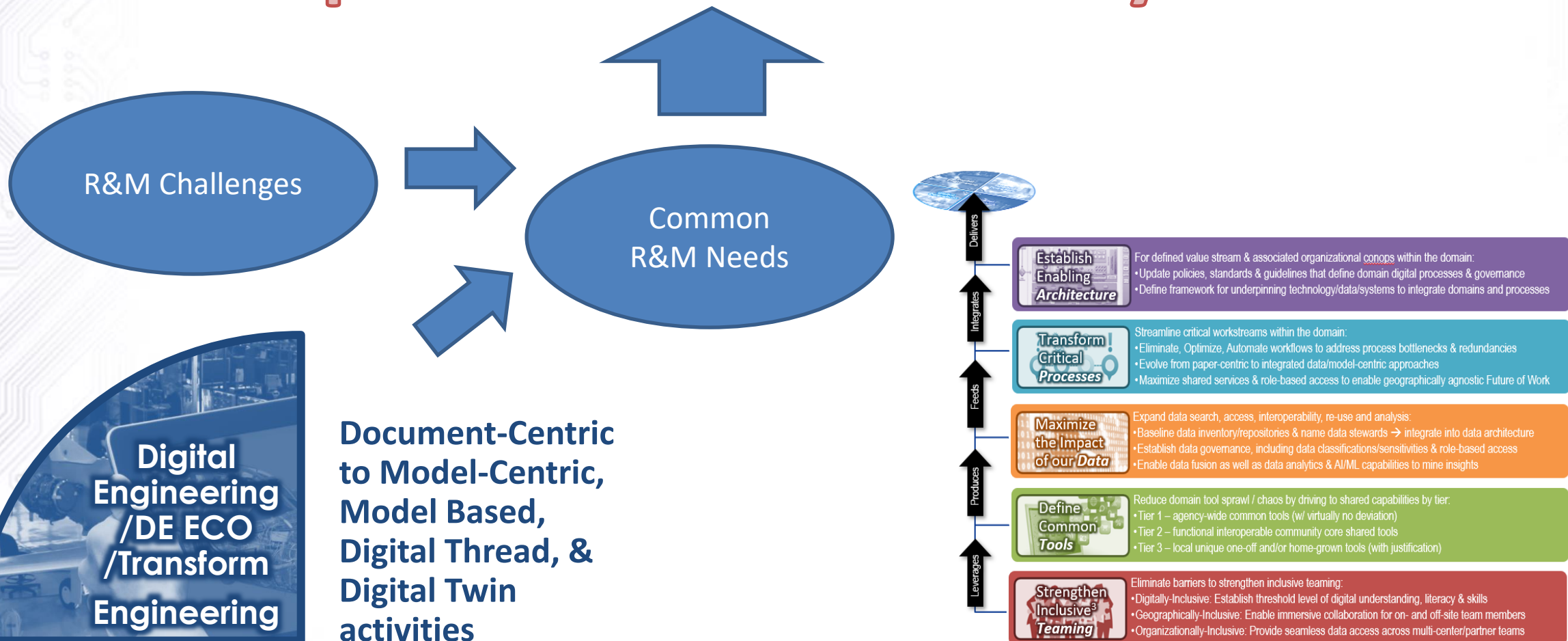
- Digitally-Inclusive: Establish threshold level of **digital understanding, literacy & skills**
- Geographically-Inclusive: Enable **immersive collaboration** for on- and off-site team members
- Organizationally-Inclusive: Provide **seamless data access across multi-center/partner** teams

... 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

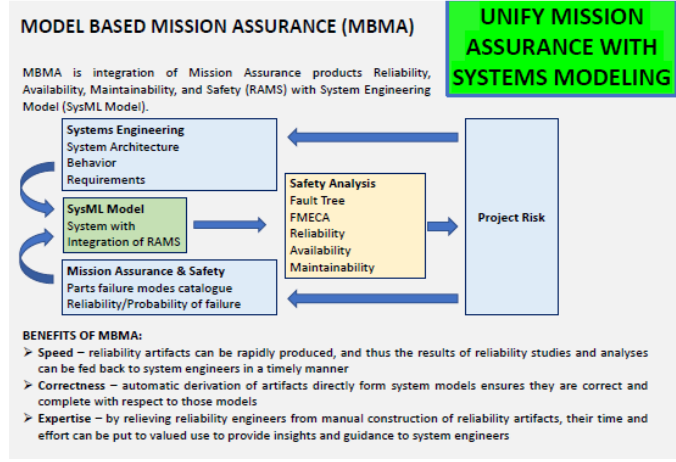
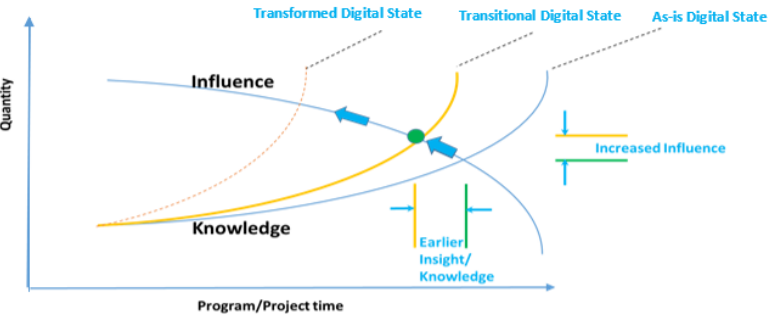


R&M Challenges & Opportunities

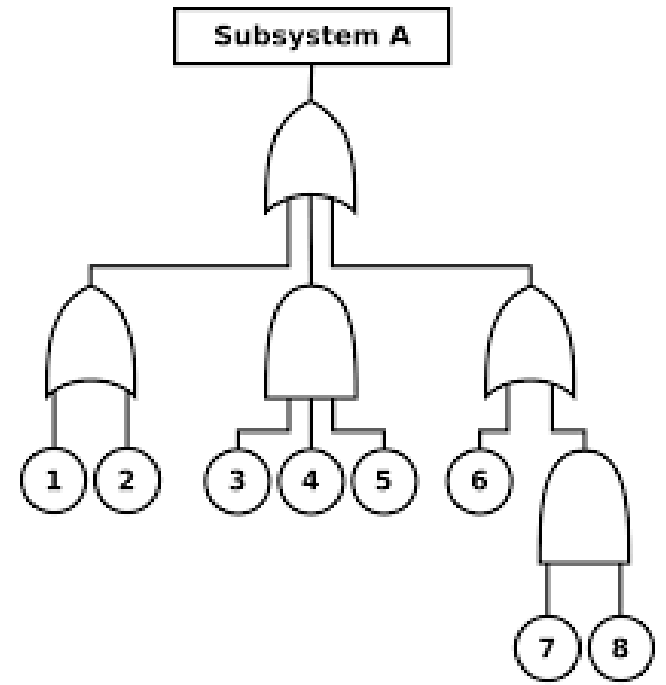
Challenge: Disjointed Reliability Analysis (e.g., FMEA, FTA, RBD) - Not integrated with the Authoritative Systems Reference Model

Analysis coming directly from the Systems Reference Model (SRM)

Model-Based R&M Analysis Product Generation



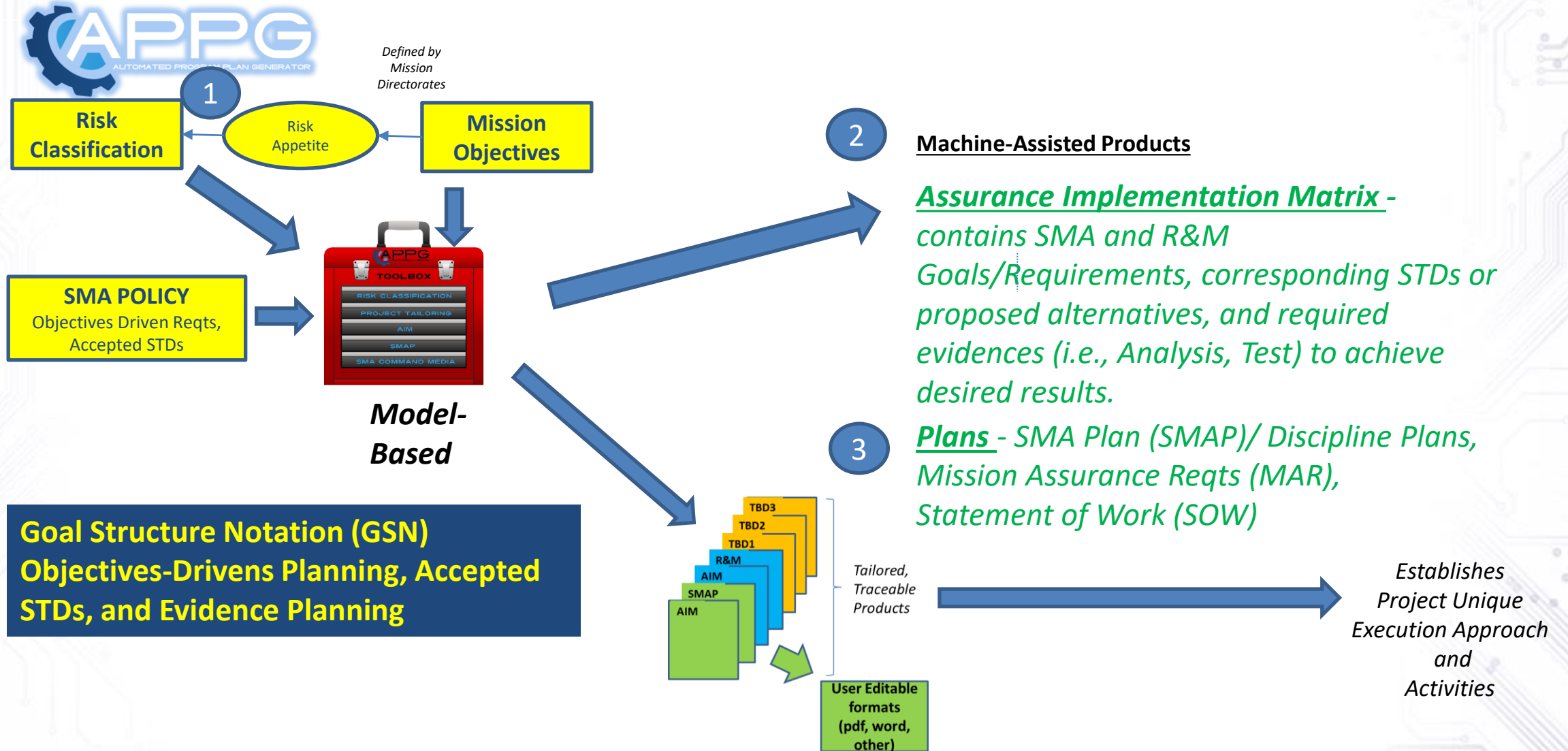
Analysis coming directly from a parallel Goal Function Tree (GFT) Reference Model



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



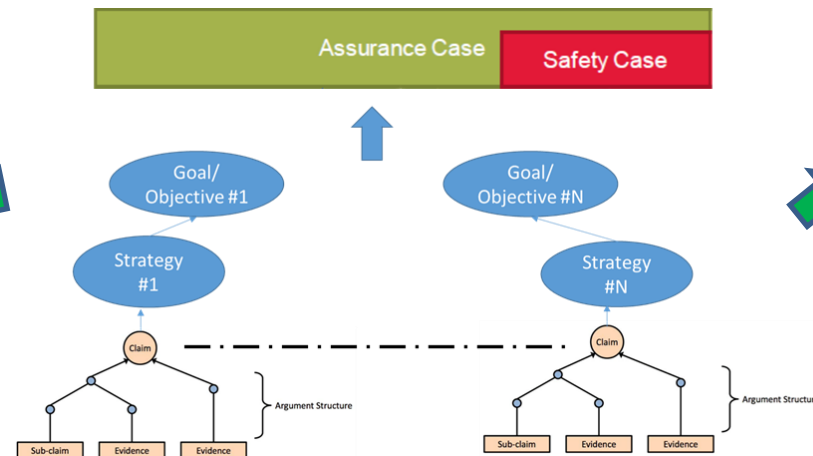
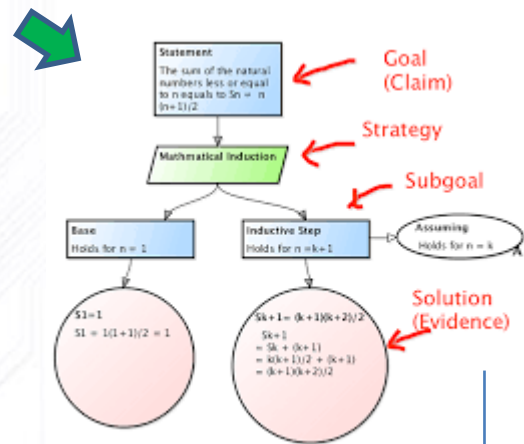
Opportunity: Robust, Machine-Assisted (Model-Based) Planning in a fraction of the time

R&M Challenges & Opportunities

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

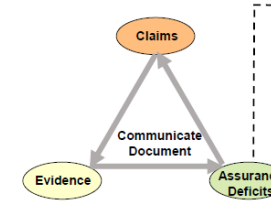


Goal Strategy Planning (with Evidence) = Initial Assurance Case Argument

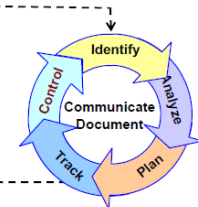


Semantic and Ontological Reasoning

Risk Informed Safety Case Development and Evaluation

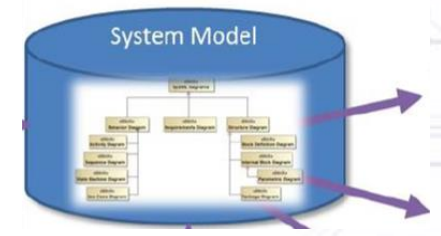


Continuous Risk Management



GAPS

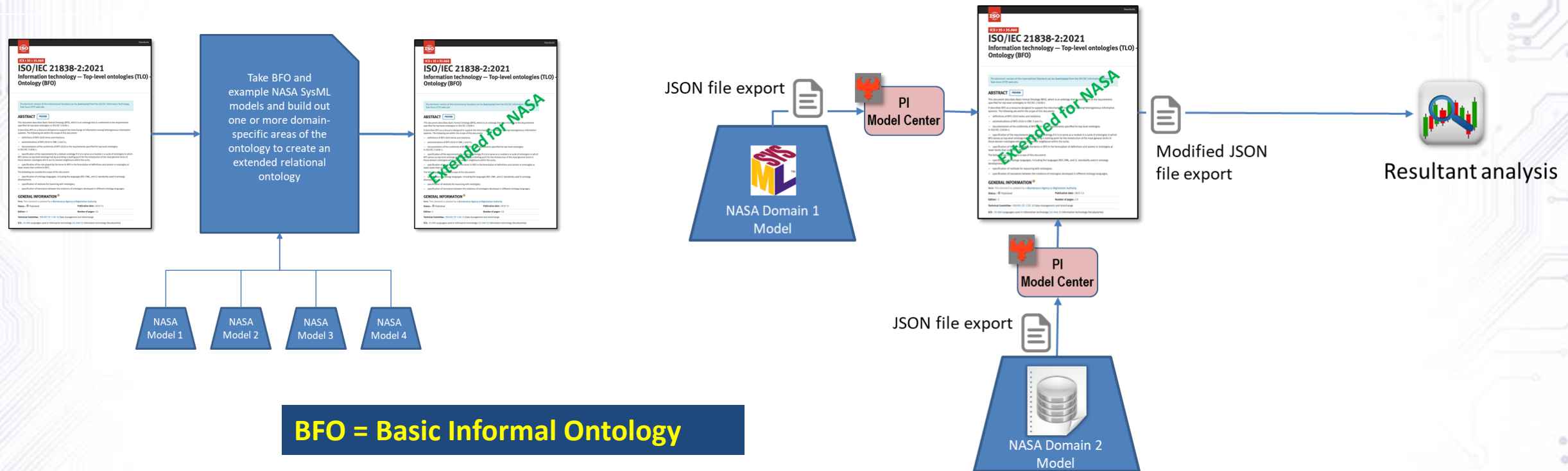
RISKS



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.

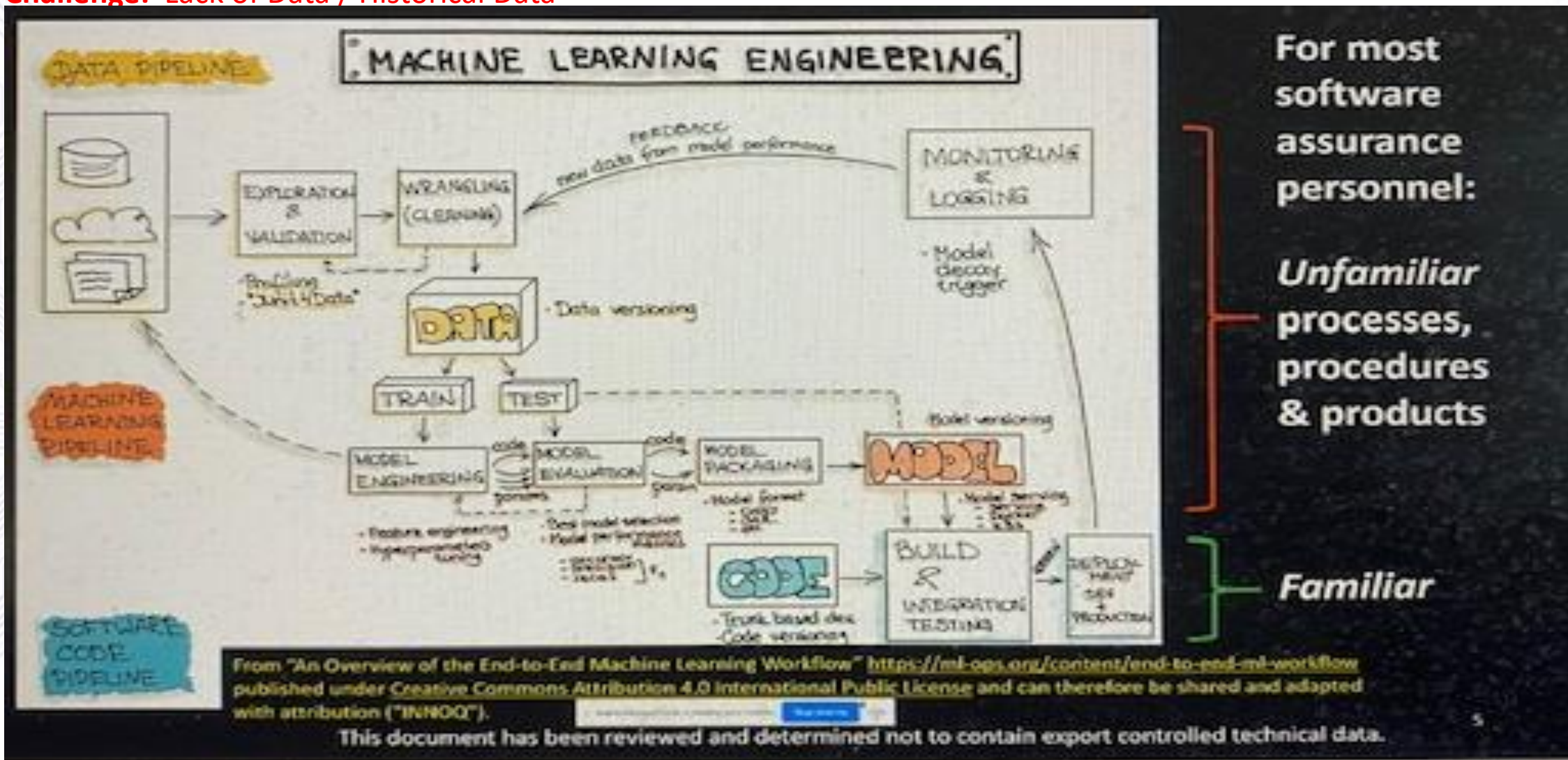


Opportunity:

- 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

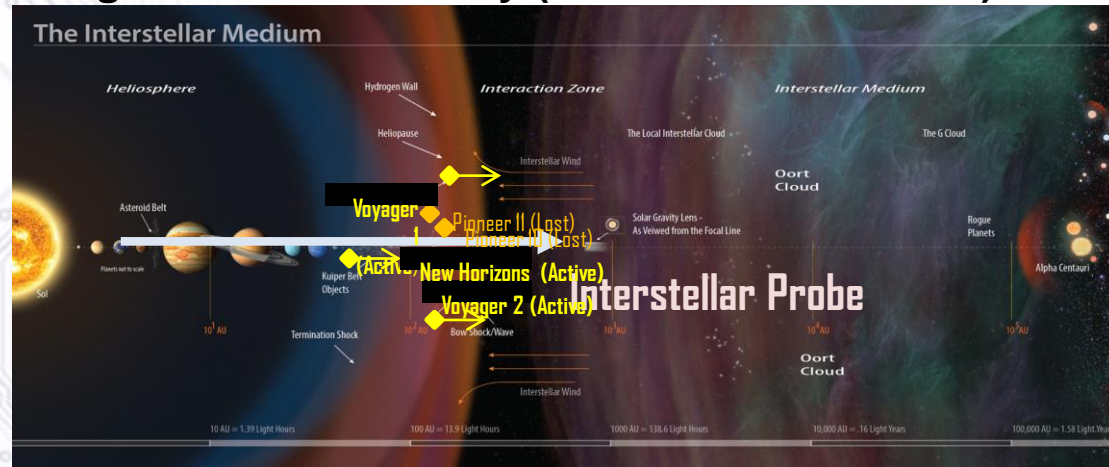
Challenge: Lack of Data / Historical Data



Opportunity: Greater utilization of Machine Learning Workflows

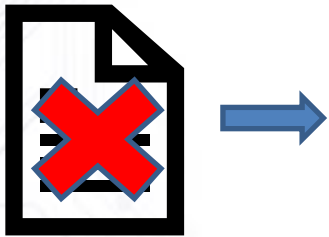
R&M Challenges & Opportunities

Long Duration Reliability (Inter-Stellar Missions)



Challenge

Handbook Data



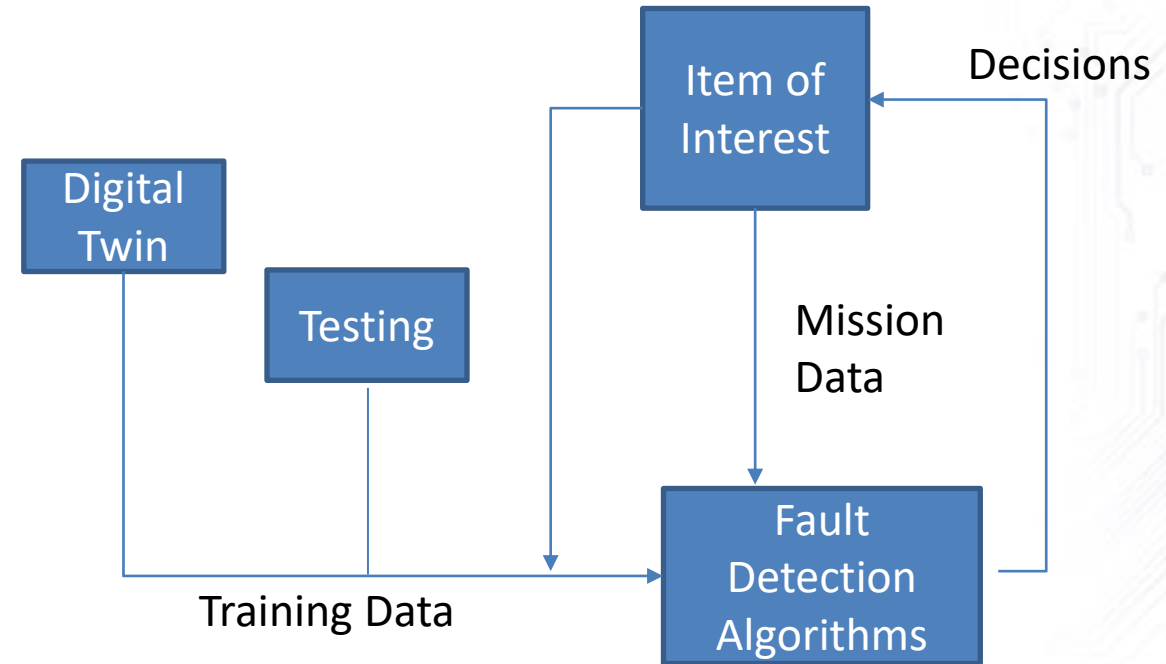
Probabilistic Physics of Failure Modeling

AI-based methods

Testing

System Health and Prognostics

Opportunity

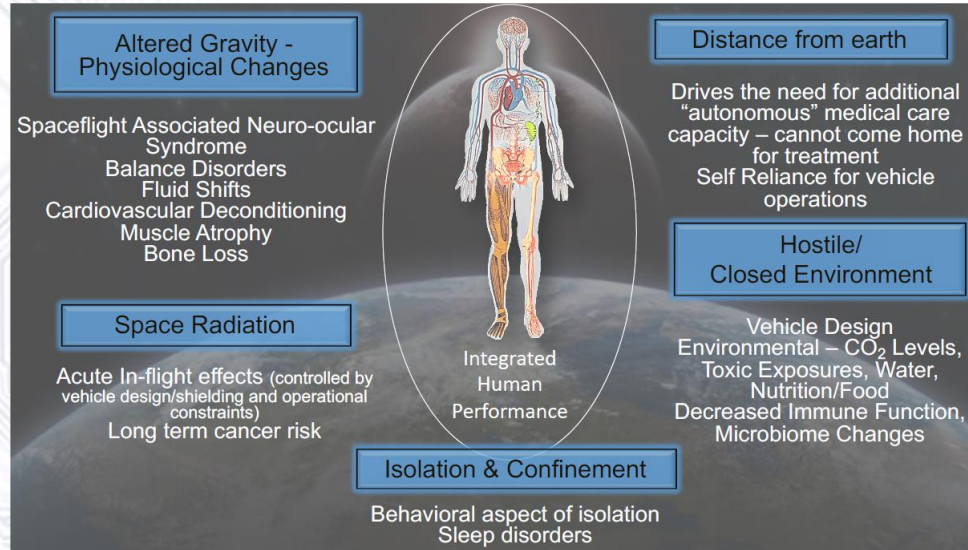


System Health Management and Prognostics

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

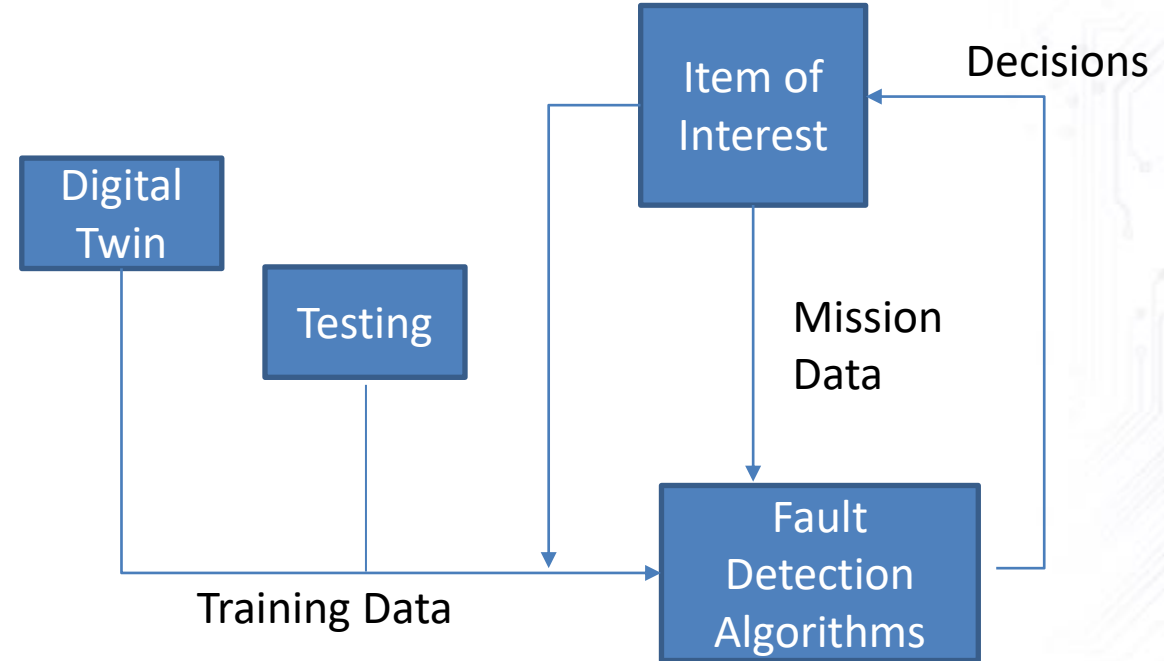
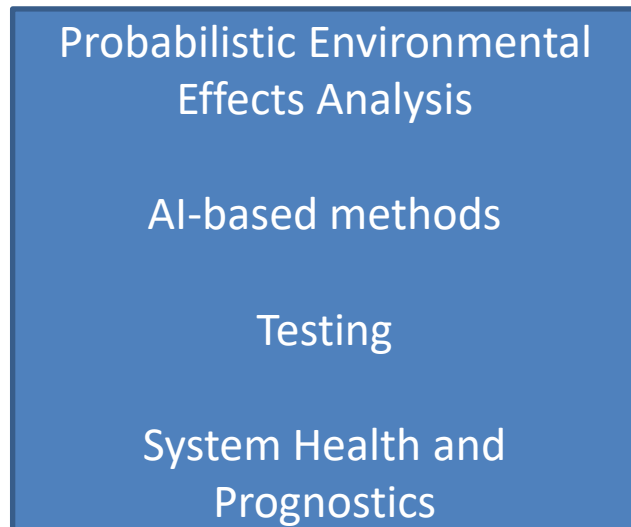
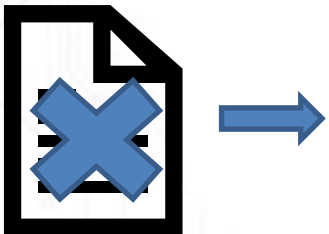
R&M Challenges & Opportunities

Human Missions Beyond LEO (Moon, Mars, Beyond)



Challenge

Traditional Data Curves



System Health Management and Prognostics

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

Opportunity

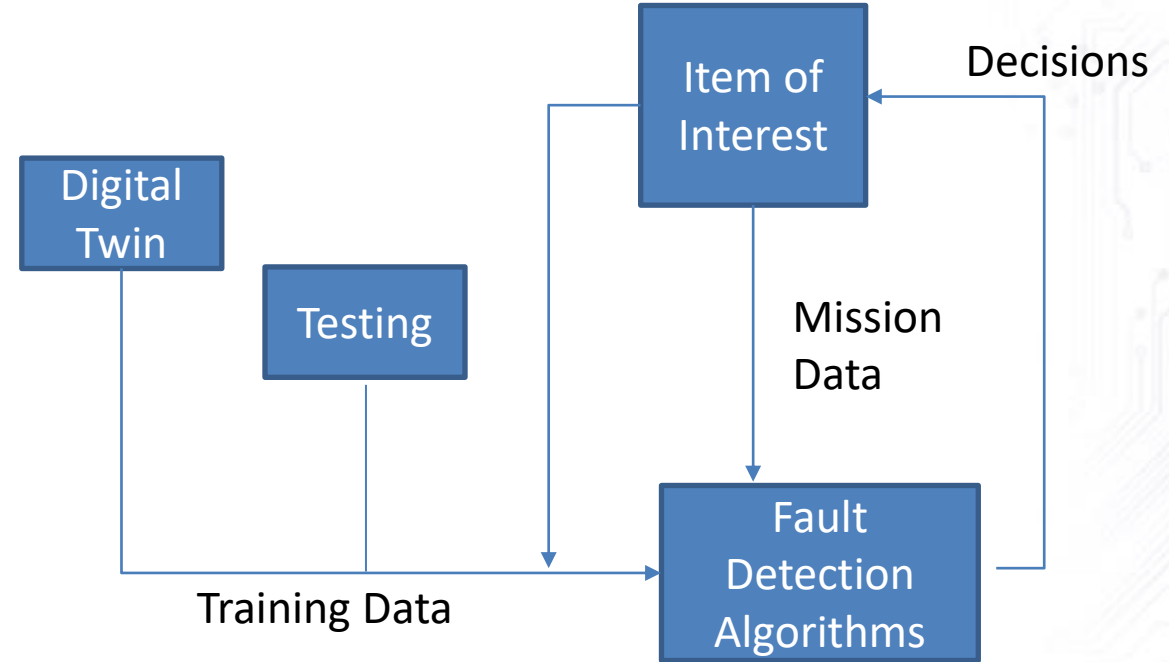
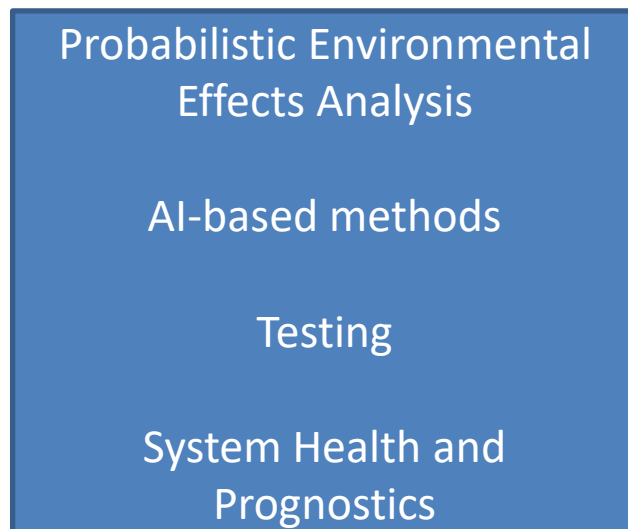
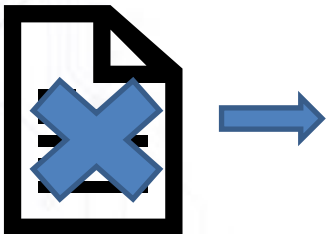
R&M Challenges & Opportunities

Unmanned Air Vehicles (UAVs)



Challenge

Traditional Data Curves



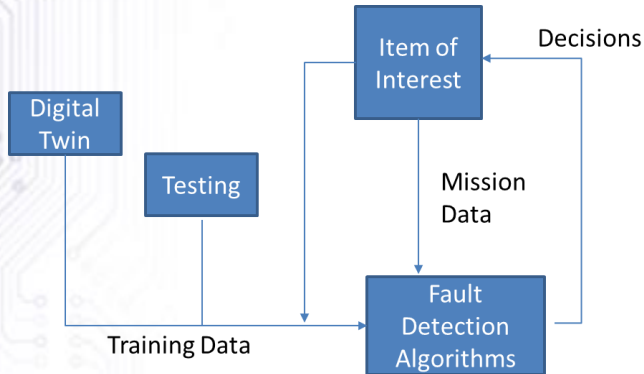
System Health Management and Prognostics & Autonomous Operations

- Operational Modifications
- Reconfigurations
- Maintenance / Conditioning

Opportunity

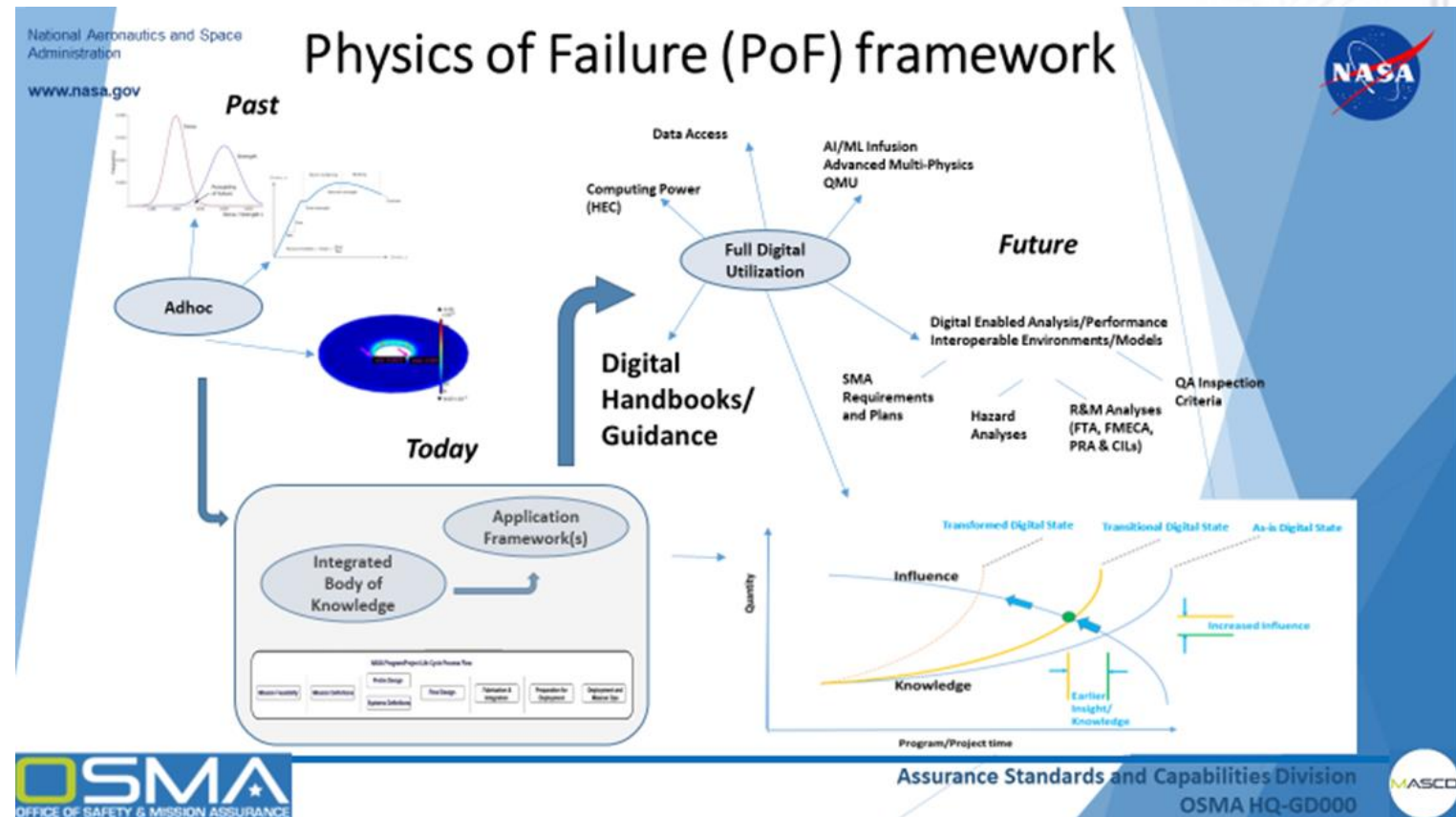
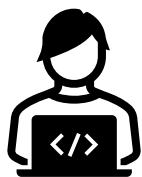
R&M Challenges & Opportunities

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

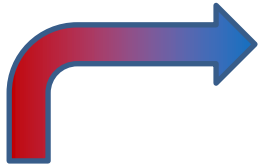


Sources

- [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 Enterprise 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



Risk Assessment

5

4

3

2

1

1

2

3

4

5

High

Med

Low

Decreasing (Improving)

Increasing (Worsening)

Unchanged

New Since Last Period

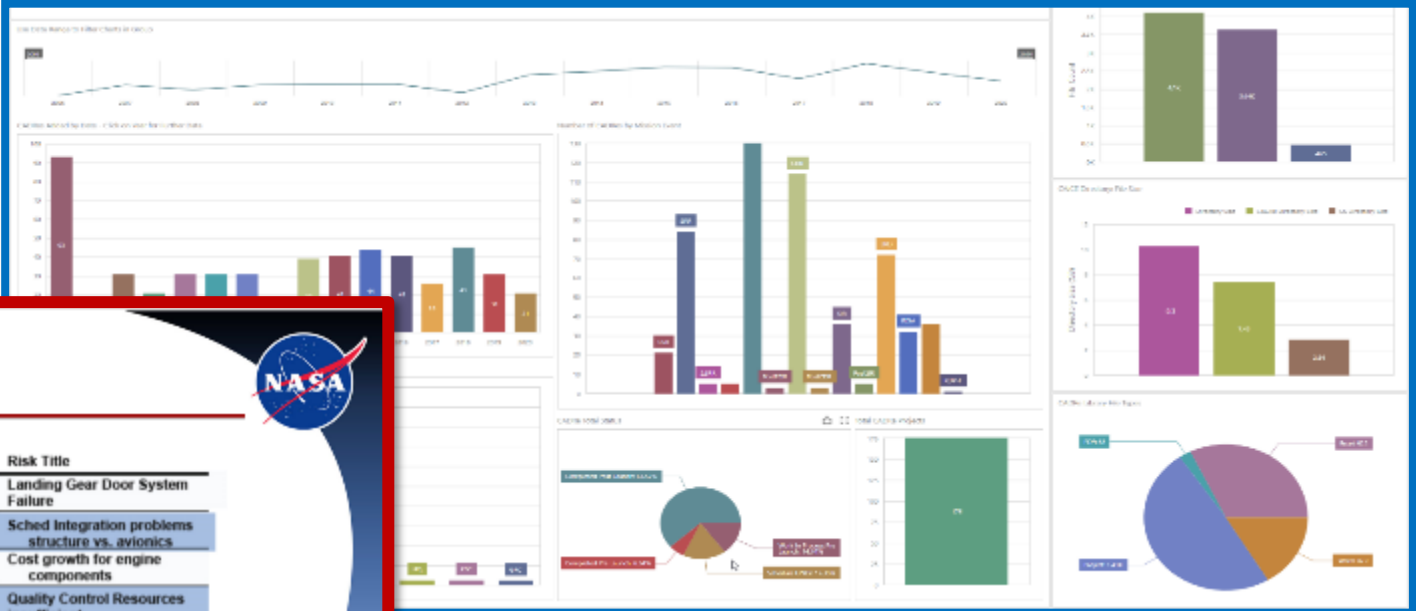
M - Mitigate

W - Watch

A - Accept

R - Research

Rank & Trend	Risk ID	Approach	Risk Title
1	DFRC-34	R	Landing Gear Door System Failure
2	DFRC-12	M	Sched Integration problems structure vs. avionics
3	DFRC-07	W	Cost growth for engine components
4	DFRC-24	A	Quality Control Resources insufficient
5	DFRC-01	W	Avionics software behind schedule
6	DFRC-11	R	Payload Capacity & Volume Trade-offs design issues
7	DFRC-04	R	Limited Flight Envelope, due to technical issues
8	DFRC-02	R	More flight testing may be required for Soft V&V



1	Easy Filters (hide using minus sign above)		Suggested Availability per Mission Type (CLICK HERE FOR TYPE DEFINITIONS)						198		Total # of Best Practices		YES		Related Documents		
2			R - Recommended NR - Not Recommended T - Favor										NO		1. Design Verification Development Set https://www.nasa.gov/briefs/01newsw/21newsw17223		
3													LAL ORFD		Similarity score: 0.348811052460395		
4															2. KAO (Kaiser Airborne Observatory) Gravity Well Dist... https://www.nasa.gov/briefs/01newsw/21newsw17225		
5															Similarity score: 0.266671563076613		
6	Filter by Category		Filter by Type		A	B	C	D	E	F	Item Number	LaRC-Specific Engineering Best Practices		US		ACCEP	
7	AIT - Assembly Integration & Test		Heading								01.00	Assembly Integration and Test (AIT)					
8																3. Limitations of extended use of simplified modeling set https://www.nasa.gov/briefs/01newsw/21newsw17222	
9																Copy documents to clipboard	
10	AIT - General		Heading								01.01	AIT - General				Document Abstracts	
11	AIT - General		Heading 2								01.01.01	Verification Methods Hierarchy				1. TWO METHODS FOR DESIGN VERIFICATION	
12	AIT - General		Best Practice								01.01.01-a	Verification Methods Hierarchy - Testing should be the primary method for design verification. However, selection of verification methods should be based on technical, cost, and schedule risk analysis. Other methods of verification to be considered should include inspection, analysis or demonstrations. Results of verification by analysis using models or simulations should be independently reviewed and should include a validation of the simulation or model to ensure the appropriateness of its use.				3. No Abstract for this document	
13					R	R	R	R	R	T						4. No Abstract for this document	
14	AIT - General		Rationale								01.01.01-b	Rationale - Testing is considered by far the most robust method of verification. However, other methods may be applicable as stated above.				5. Penetration and cavities can have a significant impact on both the structural and thermal loads of a spacecraft. The value model for (EM) of future spacecraft should be as clean as possible, and all penetrations and cavities should be minimized or minimized. Definition of induced design environments for the Space Shuttle Vehicle presented a significant	
15	AIT - General		Implementation								01.01.01-c	Implementation - Challenges, Test Issues should be described, as well as					

Smart Reviews

AI-powered PM Digital Assistants