Empowering Defense Engineering: The Intersection of AI and R&M Practices

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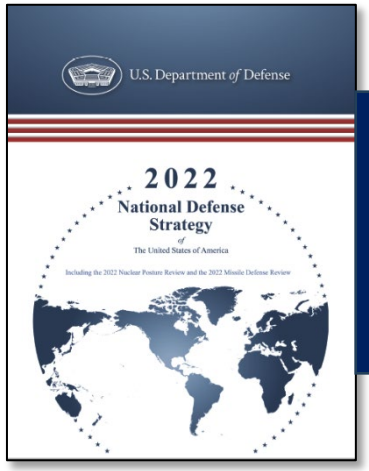
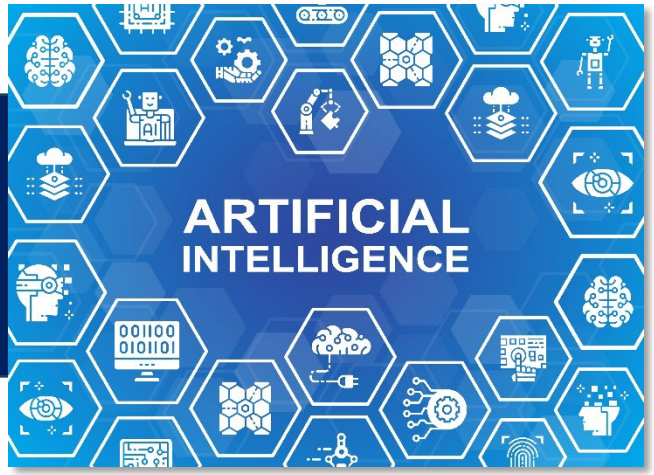
National Defense Strategy

"The Defense Department's vision for artificial intelligence is guided by the National Defense Strategy, which describes an increasingly complex security environment with technological challenges from adversaries in every domain."

From: https://www.defense.gov/Spotlights/Artificial-Intelligence/



"Because Joint Force operations increasingly rely on data-driven technologies and integration of diverse data sources, the Department will implement institutional reforms that integrate our data, software, and artificial intelligence efforts that speed their delivery to the warfighter"



AI in Statute and Policy

Statue

10 USC Subtitle A, PART V, Subpart E, CHAPTER 303, SUBCHAPTER I: Front Matter

- "(1) In general.-The Secretary of Defense shall establish a set of activities within the Department of Defense to coordinate the efforts of the Department to acquire, develop, mature, and transition **artificial intelligence** technologies into operational use.
- "(2) Emphasis.-The set of activities established under paragraph (1) shall include-
- "(A) acquisition and development of mature **artificial intelligence** technologies in support of defense missions;
- "(B) applying **artificial intelligence** and machine learning solutions to operational problems by directly delivering **artificial intelligence** capabilities to the Armed Forces and other organizations and elements of the Department of Defense;
- "(C) accelerating the development, testing, and fielding of new **artificial intelligence** and **artificial intelligence-enabling capabilities**; and "(D) coordinating and deconflicting activities involving **artificial intelligence** and **artificial intelligence-enabled** capabilities within the Department.

https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title10-chapter303-subchapter1-front&num=0&edition=prelim

Policy

DoDD 5000.01 "The Defense Acquisition System" (DAS) establishes the overarching policy that governs the DAS, and includes the requirement for AI:

- 1.2.s. Employ **Artificial Intelligence**, Machine Learning, Deep Learning, and Other Related Capabilities throughout Execution of the Acquisition Process. To ensure a culture of performance that yields a decisive and sustained U.S. military advantage, the acquisition system will leverage capabilities including **artificial intelligence**, machine learning, and deep learning to maximize efficiency and streamline the acquisition of goods and services.

https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/500001p.pdf

DoD Is a Data-Centric Organization

David L. Norquist, Deputy Secretary of Defense 2020

- "Unleashing data to advance the National Defense Strategy"
- Guiding Principle #5: Enterprise-Wide Data Access and Availability "DoD data must be made available for use by all authorized individuals and non-person entities through appropriate mechanism."
- "Data underpins digital modernization and is increasingly the fuel of every DoD process, algorithm, and weapon system."

"We have a very large AI challenge ahead of us but in order to do this, we have to get the data right"

Craig Martell, Pentagon CDAO, 2022 Intelligence & National Security Summit (C4ISRNET September 15)

Objectives of Applying AI to R&M

AI may provide the opportunity to achieve the following results:

- AI-powered predictive maintenance could improve accuracy in forecasting equipment failures, allowing for timely repairs and reducing downtime.
- AI could analyze vast datasets in real-time, enabling data-driven decision making.
- AI could continuously monitor equipment conditions, providing early warnings of potential failures.
- AI could optimize resource allocation by identifying critical maintenance tasks and streamline maintenance processes.
- AI could minimize unplanned downtime by addressing issues before they escalate.
- The AI model can use augmented or supplementary data containing human experience or knowledge-centric decision-making about a problem to develop its predictions and/or classifications.

Applying AI to R&M is about increasing readiness, reducing downtime, and enhancing overall affordable system operational effectiveness.

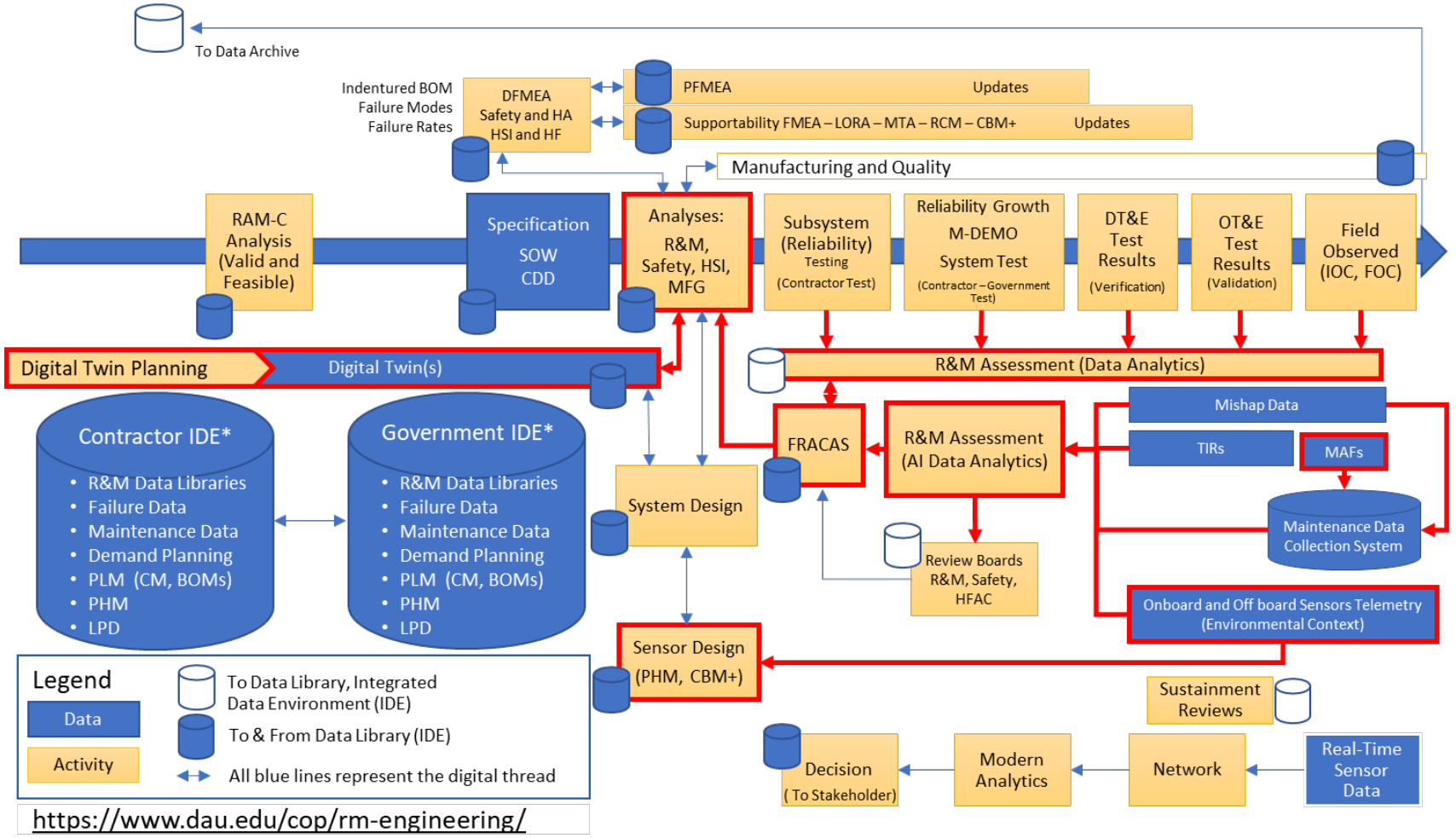
R&M Applications of AI

The AI system will be rich with data from sensors and other sources that can be used to support R&M applications. It is important to understand how that data can be used and what algorithms will be needed to enable the new R&M AI applications. Below are some examples of R&M applications in AI:

- **FMECA** records can be analyzed through AI algorithms to identify potential failure modes and to recommend repair or replace maintenance actions on failed components to operators in the field.
- **Condition-Based Maintenance Plus (CBM+)** systems using embedded sensors such as accelerometers or temperature sensors can be analyzed by AI algorithms designed to identify the need for maintenance on failed or potentially failing components.
- AI algorithms can review **FRACAS** records to monitor and analyze failure trends and identify the need for specific organizational level spares to improve operational availability
- Digital images of failed components or maintenance discrepancies can be analyzed by AI systems to assist in identifying **root cause** of failure and the recommended **corrective actions**

The engineering community will apply AI in various ways to improve systems readiness

Data Flow in Its Relationship to R&M Activities



***Contractually agreed to content, views, access, and delivery of data.**

Data Sources for AI-Enabled Systems

The quality of an R&M model is driven by the data used to build them. When additional, disparate data is available, the better (more accurate, reliable) the output will be. With today's computing power, AI systems can analyze vast amounts and types of data more quickly than an R&M engineer can, thereby improving the quality of R&M models.

In addition to primary data sources in a Technical Data Package secondary sources can be used:

- To fill data gaps
- To corroborate multiple data sources
- To add operational or other context to analysis
- To refine R&M predictions/output
- To enhanced training of AI models using additional data sources

Secondary Data Sources include:

- Tactical Sensors
- Environmental/Meteorological Data
- Imagery Data (Corroborates the Presence of an In-Service Failure)
- Online Customer Feedback Reports for COTS Equipment
- User Experience (Operator's Observation or Maintenance Report)
- Data from other DoD Services
- Synthetic Data

Secondary Data Sources can be used to benefit the quality of R&M AI Models

Data Considerations for AI

Data Considerations

- VAULTIS?
- File Formats?
- Data Rights?
- Interface Requirements?
- Security classification?
- Location?

VAULTIS

- **Visible:** Data is available for authorized users when and where it is needed.
- **Accessible:** Data must be made accessible through documented standard Application Programming Interfaces (APIs).
- **Understandable:** The data must be stored in a comprehensive data format such that other applications can understand the data being stored and where it is located.
- **Linked:** The Data must be linked with all users requiring the data
- **Trustworthy:** All users must have confidence in the data
- **Interoperable:** The data must be made available through standards that allow it to be readily used.
- **Secure:** The data is protected from unauthorized use and manipulation

Access to data with VAULTIS characteristics is critical to AI system performance

R&M Engineering Workforce Development

- OUSD Specialty Engineering (SpE) provides technical content to DAU
- DAU responsible for course production, deployment and maintenance.
- **ENG1400, Artificial Intelligence (AI) in Reliability and Maintainability (R&M) Engineering – FY24Q4 (Content developed)**
- ENG0850, R&M Engineering Management - 29 Sep 2021, 13 Hours
- ENG0860, Planning for R&M Engineering - 12 Mar 2020, 7 Hours
- ENG0870, Designing for R&M Engineering - 10 Sept 2020, 6 Hours
- ENG0880, Procurement for R&M Engineering - 7 Jan 2021, 7 Hours
- ENG0890, Technical & Program Reviews for R&M Eng - 26 May 2021, 7 Hours
- ENG0900, R&M Engineering interface with Product Support – 09 Nov 2023, 5 hours

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