MBSE in the Department of Defense

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Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE))

Presentation for Goddard Space Flight Center Engineering Seminar

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DASD, Systems Engineering

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Stephen Welby
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Major Program Support
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Supporting USD(AT&L) Decisions with Independent Engineering Expertise

- Engineering Assessment / Mentoring of Major Defense Programs
- Program Support Assessments
- Overarching Integrated Product Team and Defense Acquisition Board Support
- Systems Engineering Plans
- Systemic Root Cause Analysis
- Development Planning/Early SE
- Program Protection

Engineering Enterprise
Robert Gold

Leading Systems Engineering Practice in DoD and Industry

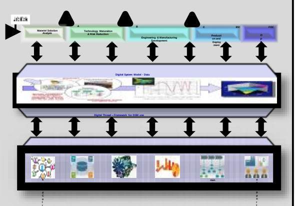
- Systems Engineering Policy and Guidance
- Technical Workforce Development
- Specialty Engineering (System Safety, Reliability and Maintainability, Quality, Manufacturing, Producibility, Human Systems Integration)
- Security, Anti-Tamper, Counterfeit Prevention
- Standardization
- Engineering Tools and Environments

Providing technical support and systems engineering leadership and oversight to USD(AT&L) in support of planned and ongoing acquisition programs

Engineering Tools and Environments

Digital Engineering Design

- Digital System Model/Digital Thread
- Education
- Policy & Guidance
- Data Rights

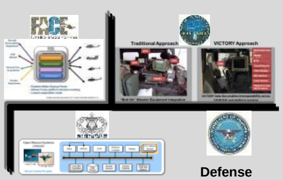


Engineered Resilient Systems

- Trade Space Analysis
- SERC
- CREATE/HPCMO

Modular Open Systems Architecture

- BBP 3.0
- Technical Standards
- Curriculum Development



Outreach: INCOSE/JPL, NDIA, MBE Summit, AMSWG

Engineering processes, tools and techniques incorporating the latest digital practices for making informed decisions throughout the acquisition lifecycle.

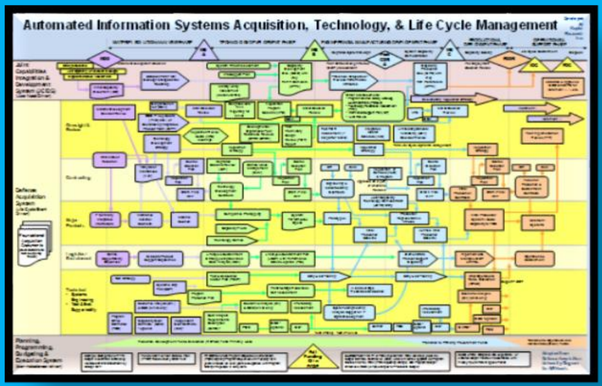
Change the Focus for Modeling and Simulation Use in Acquisition

(1) WSARA

(2) DoDI 5000.02

(3) DAG Chapter 4

(4) Fundamentals



<u>Modeling and Simulation as SE enabler</u>: shift in focus: Establishes modeling and simulation needs from acquisition use, data consumed, and results produced

1 Weapon Systems Acquisition Reform Act of 2009

- The Act of Congress passed in 2009 that was created to reform the way the Pentagon contracts and purchases major weapons systems. (http://www.ndia.org/Advocacy/PolicyPublications Resources/Documents/WSARA-Public-Law-111-23.pdf)

2 DoDI 5000.02, Operation of the Defense Acquisition System

- Requires the integration of Mod/Sim activities into program planning and engineering efforts (http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf)

3 Defense Acquisition Guidebook (DAG) Ch 4 – System Engineering

- Defines the Mod/Sim capabilities, benefits, roles, responsibilities, and activities (https://acc.dau.mil/dag4)

4 MS&A Fundamentals

- Defines a set of high-level truths for Mod/Sim <u>usage</u> in Systems Engineering support to acquisition (http://www.acq.osd.mil/se/docs/SE-MSA-Fundamentals.pdf)

The MS&A Fundamentals Product

MDA
USA
USN
USAF
USMC

DEPARTMENT OF DEFENSE
ACQUISITION MODELING AND SIMULATION WORKING GROUP

Systems Engineering Modeling, Simulation, and Analysis Fundamentals

1. The responsibility for planning and coordinating program modeling and simulation efforts belongs to the Program Manager and may be delegated to the Program Systems Engineer and other program staff as appropriate.
2. Modeling and simulation efforts are included in the systems engineering effort as part of program/project risk management and cost and schedule planning. Modeling and simulation efforts include identifying metrics that relate the use of modeling and simulation to cost savings and risk reduction.
3. Systems engineers use models to define, understand, communicate, assess, interpret, and accept the project scope; to produce technical documentation and other artifacts; and to maintain "ground truth" about the system(s).
4. Programs should identify and maintain a system model, representing all necessary viewpoints on the design and capturing all relevant system interactions.
   a. Unless impractical, the program should develop the system model using standard model representations, methods, and underlying data structures.
   b. The system model is a product of both system and design engineering efforts. The program should construct the model by integrating data consumed and produced by the modeling and simulation activities across and related to the program. The program should confirm the model baseline at appropriate technical milestones.
   c. The program should construct depictions of system concepts developed in support of technical reviews using the system model as source data.
   d. The system model should include, but should not be limited to, parametric descriptions, definitions of behaviors, internal and external interfaces, cost inputs, and traces from operational capabilities to requirements and design constructs.
   e. The system model should be a part of, and should evolve with, the program development baseline. The system model should be integrated throughout the program life cycle and across domains within a program's various phases.
   f. The system model can provide source data for the program to use to construct instantiated models to support system trades; optimizations; design evaluations; system, subsystem, component, and subcomponent integration; cost estimations; etc.
   g. The program should update the system model throughout the program life cycle. Capturing these updates in the system model will provide continuity among the program modeling and simulation users and activities. Unless impractical, during the development and construction of models and simulations, the program should ensure the models will be applicable to other program areas such as training and testing.
5. The development of models, construction of simulations, and use of these assets to perform program definition and development activities (to include pre-MDD, and pre-milestone A) requires collaboration among all project stakeholders.
6. Proper use of modeling and simulation throughout the acquisition life cycle is critical for program success. The program should provide sufficient training to support the appropriate use of modeling and simulation. The program should identify metrics and track the metrics to support the linkage between the training and increased support to the program.
7. Modeling and simulation provides critical capabilities to effectively deal with issues including but not limited to interoperability, joint operations, and systems of systems across the entire acquisition life cycle.
8. Models employed in acquisition activities should be credible, and the program should use the models while acknowledging a level of risk appropriate to the application (see DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)).

Version 3.0, March 2014. For Additional Information: http://www.acq.osd.mil/se/initiatives/init_ms.html
Distribution Statement A: Approved for public release.

http://www.acq.osd.mil/se/docs/SE-MSA-Fundamentals.pdf

- **Key Areas Emphasized:**
  - **Program Systems Engineer (SE) is responsible for Mod/Sim planning and coordination**
  - **Modeling and Simulation is included in key schedule and programmatic plans**
  - **SE uses models to define, understand, and communicate technical artifacts**
  - **Models are continually updated throughout program life-cycle**
  - **Project success is dependent on appropriate Mod/Sim training of team**
  - **Models used on the program need to be accepted and credible**

DoDI 5000.02, January 7, 2015

ENCLOSURE 3, SECTION 9: MODELING AND SIMULATION

Department of Defense
INSTRUCTION

NUMBER 5000.02
January 7, 2015

USD(AT&L)

SUBJECT: Operation of the Defense Acquisition System

References: See References

1. PURPOSE. This instruction:

a. In accordance with the authority in DoD Directive 5000.01 (Reference (a)), reissues the interim DoD Instruction 5000.02 (Reference (b)) to update established policy for the management of all acquisition programs in accordance with Reference (a), the guidelines of Office of Management and Budget Circular A-11 (Reference (c)), and References (d) through (ce).

b. Authorizes Milestone Decision Authorities (MDAs) to tailor the regulatory requirements and acquisition procedures in this instruction to more efficiently achieve program objectives, consistent with statutory requirements and Reference (a).

2. APPLICABILITY. This instruction applies to OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the DoD (referred to collectively in this instruction as the "DoD Components").

3. POLICY. The overarching management principles and mandatory policies that govern the Defense Acquisition System are described in Reference (a). This instruction provides the detailed procedures that guide the operation of the system.

4. RESPONSIBILITIES

a. Defense Acquisition Executive (DAE). The DAE is the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). The DAE will act as the MDA for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) programs. In accordance with Table 1 in Enclosure 1 of this instruction, the DAE may

"The Program Manager will integrate modeling and simulation activities into program planning and engineering efforts. These activities will support consistent analyses and decisions throughout the program's life cycle. Models, data, and artifacts will be integrated, managed, and controlled to ensure that the products maintain consistency with the system and external program dependencies, provide a comprehensive view of the program, and increase efficiency and confidence throughout the program's life cycle."

Systems Engineering Opportunity
The Builder is Always Defined by the Tools

"I believe we are on the threshold of seeing … integrated design tool suites for complex electromechanical systems. I believe we will begin to see simulation become a more integrated part of the design process rather than something that is engaged separately. I believe we will see the ability to affordably explore much more complex design spaces, with the opportunity to better understand how the implication of design changes downstream ripples back across an entire product design."

Remarks at 23rd Annual INCOSE International Symposium, June 25, 2013, Philadelphia, PA

Model-based systems engineering plays a key role in making this vision possible

Mr. Stephen P. Welby
DASD, Systems Engineering

How Does Modeling Support SE?

Critical items in DoD Systems Engineering

- **Flexible designs that adapt and are resilient to unknown missions and threats**
- **Cost and affordability as quantifiable attributes of the trade space**
- **Systems of Systems, and Enterprise, contexts responding to multiple stakeholders**
- **Responsive, balancing agility with rigorous analysis and data**
- **Safeguarding critical information while designing for interoperability**
- **Applied across significantly diverse domains**

Balancing these axioms is challenging to SE. It drives the need for, and use of engineering models to:

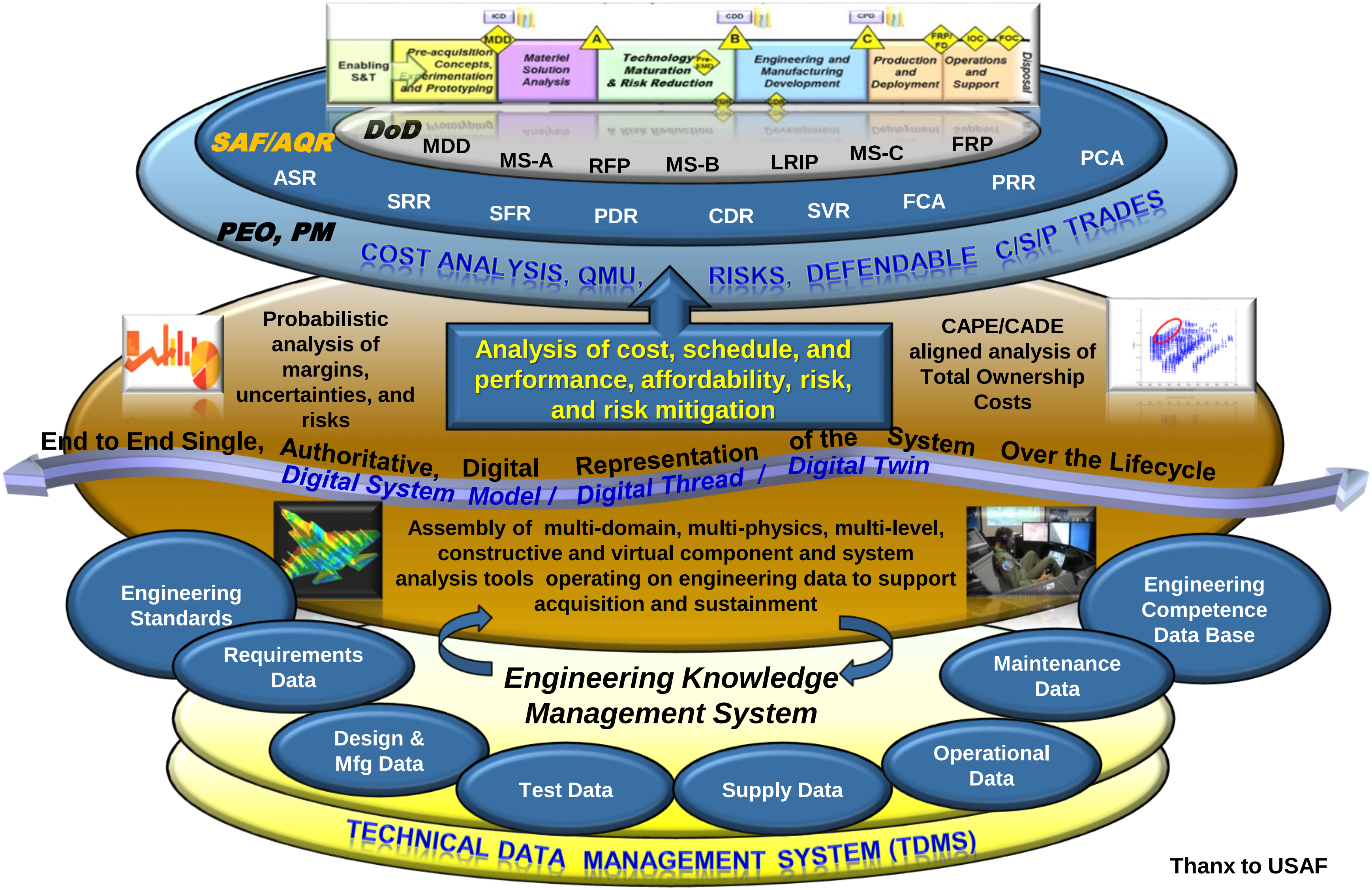
- **Maintain consistency about the system**
- **Integrate technical and non-technical drivers**
- **Understand the various perspectives on the system under development**

What If…

- The performance capability and total ownership cost of a weapon system could be quantitatively estimated at every stage of the acquisition lifecycle?
- Program risks could be identified and quantitatively estimated up front?
- The expected impact of specific program activities/decisions on program risks, performance capability, and total ownership cost could be quantitatively estimated up front?
- Program risk, performance capability, and total ownership cost estimates could be updated as program activities are completed?

Digital System Modeling enables rapid development and acquisition of capable, reliable, and affordable weapon systems.

Modeling Support to Acquisition



Thanx to USAF

The DSM/DT Concept

The DSM/DT can be used to address SE challenges

Digital System Model

		Using traditional methods:
Do the requirements trace to test cases?	*Automated traceability*	Manual mapping from requirements tool to test cases.
How are risks identified and analyzed?	*Provides the technical data to quantitatively identify and analyze risks.*	Qualitative identification and analysis using SME judgment.
If a requirement changes, what is potentially impacted?	*Provides historical system knowledge to enable multi-dimensional trades*	Requirements tool trace gives only a clue; info is in needed from SE SMEs.
What does the design look like?	*Maintains authoritative technical parameters*	No authoritative source for technical data (e.g., size, weight, power) parameters. Is it 479Kg or 491Kg?
How are documents generated and maintained?	*Auto-generated from the DSM/DT*	Often a manual process to generate and make changes to documents.

Traditional methods lead to inconsistencies, re-creation of data, miscommunication, errors, redundant processes, and extensive re-work

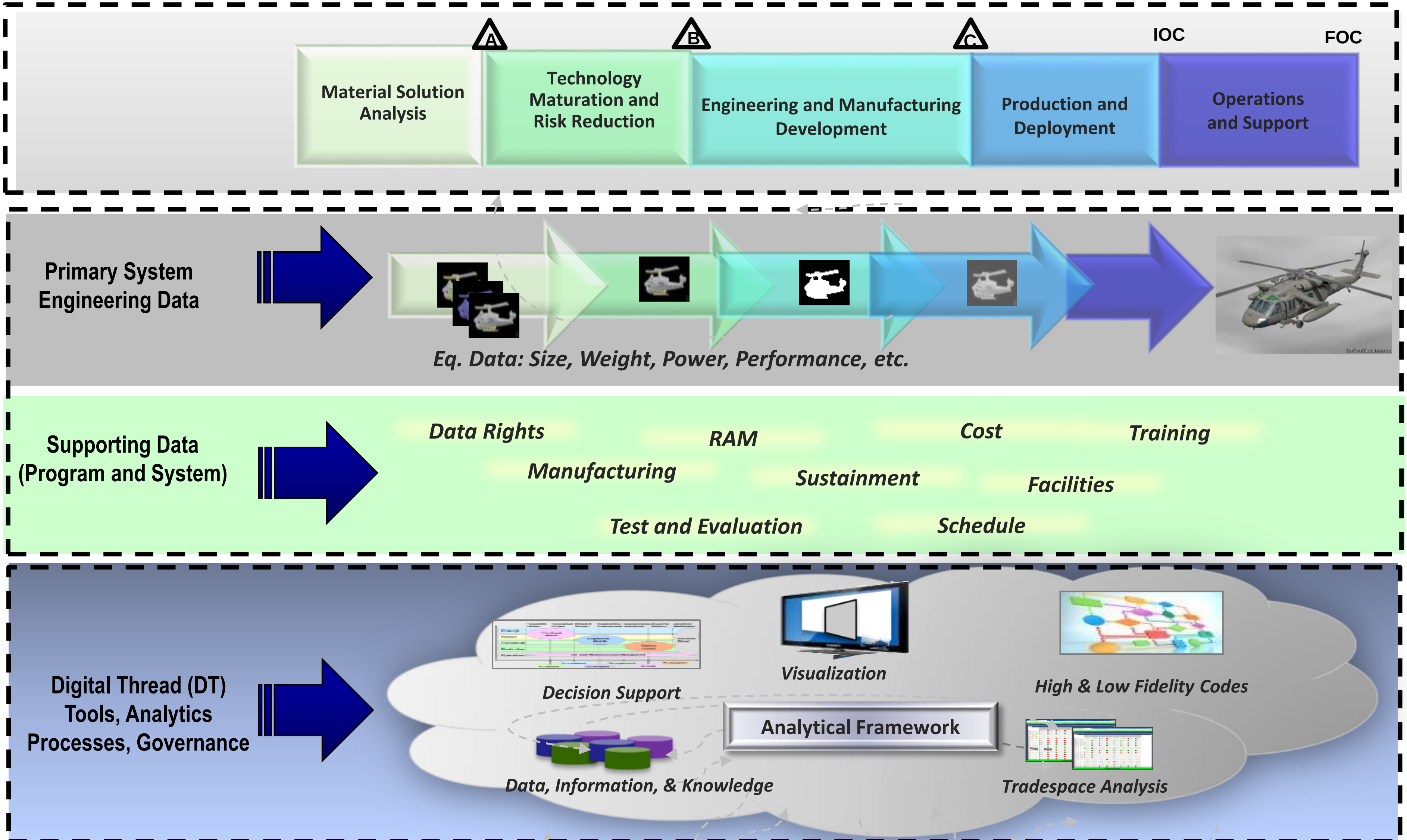
Definitions

- **<u>Digital System Model</u> – A digital representation of a defense system, generated by all stakeholders, that integrates the authoritative data, information, algorithms, and systems engineering processes which define all aspects of the system for the specific activities throughout the system lifecycle. (M&S Glossary proposed)**

- **<u>Digital Thread</u> – An extensible, configurable and component enterprise-level analytical framework that seamlessly expedites the controlled interplay of software, authoritative data, information, and knowledge in the enterprise data-information-knowledge systems, based on the Digital System Model template, to inform decision makers throughout a system's life cycle by providing the capability to access, integrate and transform disparate data into actionable information. (M&S Glossary proposed)**

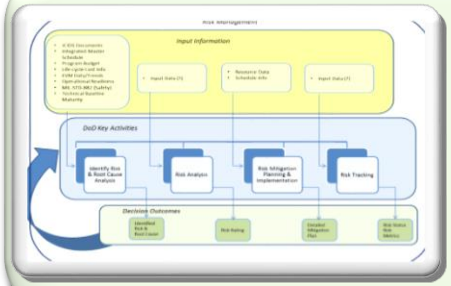
- **<u>Technical Data</u> – means recorded information, regardless of the form or method of the recording, of a scientific or technical nature (including computer software documentations). The term does not include computer software or data incidental to contract administration, such as financial and/or management information. <u>(DFARS 252.227-7103(a)(15))</u>**

Digital System Model/Digital Thread Framework for Communication



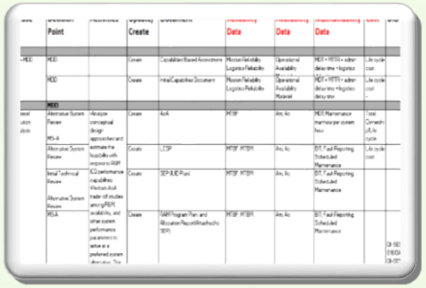
Overview: Approach for Developing the DSM Taxonomy

(1) Identify



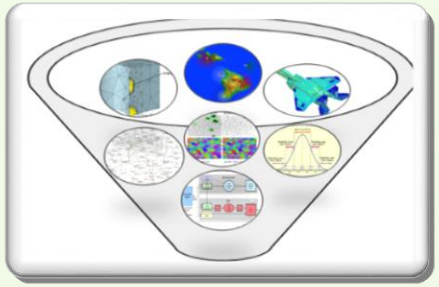
- Develop a framework to:
  - identify the processes, artifacts, and key decision points across the lifecycle

(2) Define



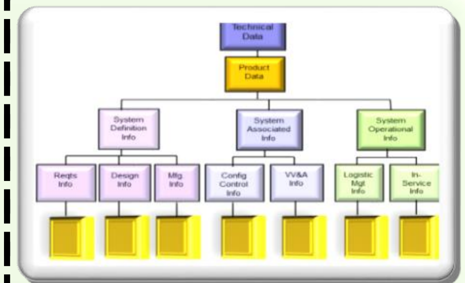
- Use the framework to :
  - Define the data and analytics to support key decisions

(3) Inventory



- Inventory existing data, models, and algorithms to support key decisions

(4) Develop



- Develop data taxonomy to support key decision points across the lifecycle

Developed generic approach to develop taxonomy for DSM weapon system data and supporting data

Taxonomy Progress

Digital System Model

Pre-MDD to Pre-MS-A

Geometric emphasis – easily maps to Mil-STD 881

- Mil-STD 881 WBS is hardware-centric
- Pre-MS-A (CP&A/Concept Dev) Data maps to elements of the 881 WBS

Acquisition Phases

MS-A to MS-C

Functional development – cross-cutting many Hardware elements – NOT easily mapped to 881

- Data elements are Cross-cutting – System-wide:
    - Damage Tolerance
    - Corrosion Control
    - Durability
    - etc
- Need to figure out the appropriate data elements in these Acq Phases

Post MS-C to disposal

As built – easily maps to Mil-STD 881

- Mil-STD 881 WBS is hardware-centric
- As built/ production data maps to elements of the 881 WBS

Digital Engineering and Design: Current Collaborators

Digital System Model/Digital Thread

Army

Common product data and processes shared and employed by program, engineering and product support functions (i.e., FVL)

Air Force (SAF-AQ) *

Develop the technical data taxonomy (i.e., JSTARS Recap)

Navy

Technical exchange regarding MBSE, Digital Thread/Digital System Model (i.e., CVN-78)

CAPE- AFCAA

Define the cost driving technical data parameters

NASA *

Evolution, and introduction of model-centric concepts to revise the conduct of engineering functions.

Working Groups

Digital Thread Working Group

Digital Engineering Design (TBD)

Promote innovation through collaboration

Industry *

National Defense Industrial Association

INCOSE

MORS

Study to identify the essential elements of the system model

* Briefings at SE Conference

Proof of Concept

Potential Case Examples:

- Air Force Airframe Structural Integrity Program
- Air Force C-X Airlift Aircraft Program
- Air Force Joint Surveillance Target Attack Radar System Recapitalization (*JSTARS Recap*)
- Army Future Vertical Lift Program
- Enterprise Product Lifecycle Management Integrated Decision Environment (ePLM IDE)
- Navy Ford (CVN-78) Class Aircraft Carrier Program
- NASA Sounding Rocket Program

Focus Areas: Preliminary targeted areas (aligned with ETE areas) to advance model-centric engineering within the Department of Defense

Some Challenges

- **Use of digital engineering artifacts is occurring in DoD in ‘pockets’ – need to leverage and share the practices**
  - Establish a digital engineering ‘demand’ signal from leadership / workforce
- **Getting the complete picture of digital engineering for DoD**
  - What are the digital artifacts? How are they leveraged completely?
- **Identification of acquisition system insertion points for digital artifacts**
  - Advance the use of model-centric approach within the DoD
- **Taking advantage of technology, without overselling**
  - Ensuring that advances are properly described, and applied
- **Properly trained workforce**
  - Understanding digital artifacts, and properly using them
- **Understand the advantages and disadvantages**
  - E.g. Cost savings, vs. Cost avoidance, program protection, etc.
- **Understanding and selecting proper tool support**
  - Government must be able to make objective selection

Summary

- **Leveraging industry and professional organizations in the shift to digital engineering**
- **Policy / guidance changes sufficient for shift to digital engineering**
- **Digital System Model / Digital Thread (DSM/DT) can identify the data necessary for continuity of the system from concept development through disposal**
- **Many unknowns still exist in use of the digital engineering artifacts**
  - How do we contract for the parts of the Digital System Model?
  - What do we need to educate the acquisition workforce in?
  - How do we effectively make the transition without disrupting the current acquisition programs

Information

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