Digital Engineering Discussions

Philomena M. Zimmerman
Director, Engineering Tools and Environments
Office of the Under Secretary of Defense
(Research & Engineering)

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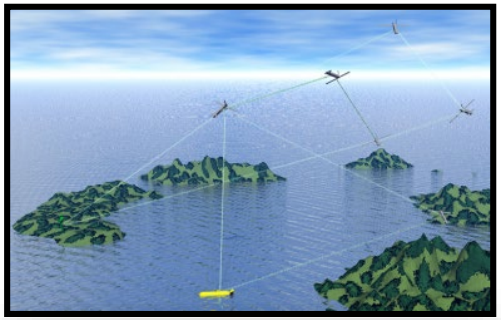
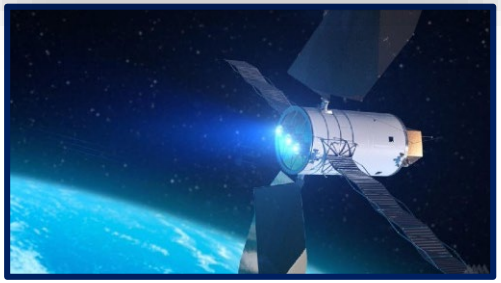
Some Discussion Topics:

- Critical skills and perspectives future officers will need in our R&E enterprise
- Motivation and importance of digital engineering
- How the Digital Engineering Strategy is more than just using digital tools
- How digital engineering fits into the larger systems engineering efforts
- Some context on what DoD is doing to help its organizations with digital engineering implementation approaches

USD(R&E) Mission

- **Ensure Technological Superiority for the U.S. Military**
  - Set the technical direction for the Department of Defense
  - Champion and pursue new capabilities, concepts, and prototyping activities throughout the DoD research and development enterprise
- **Bolster Modernization**
  - Pilot new acquisition pathways and concepts of operation
  - Accelerate capabilities to the warfighter

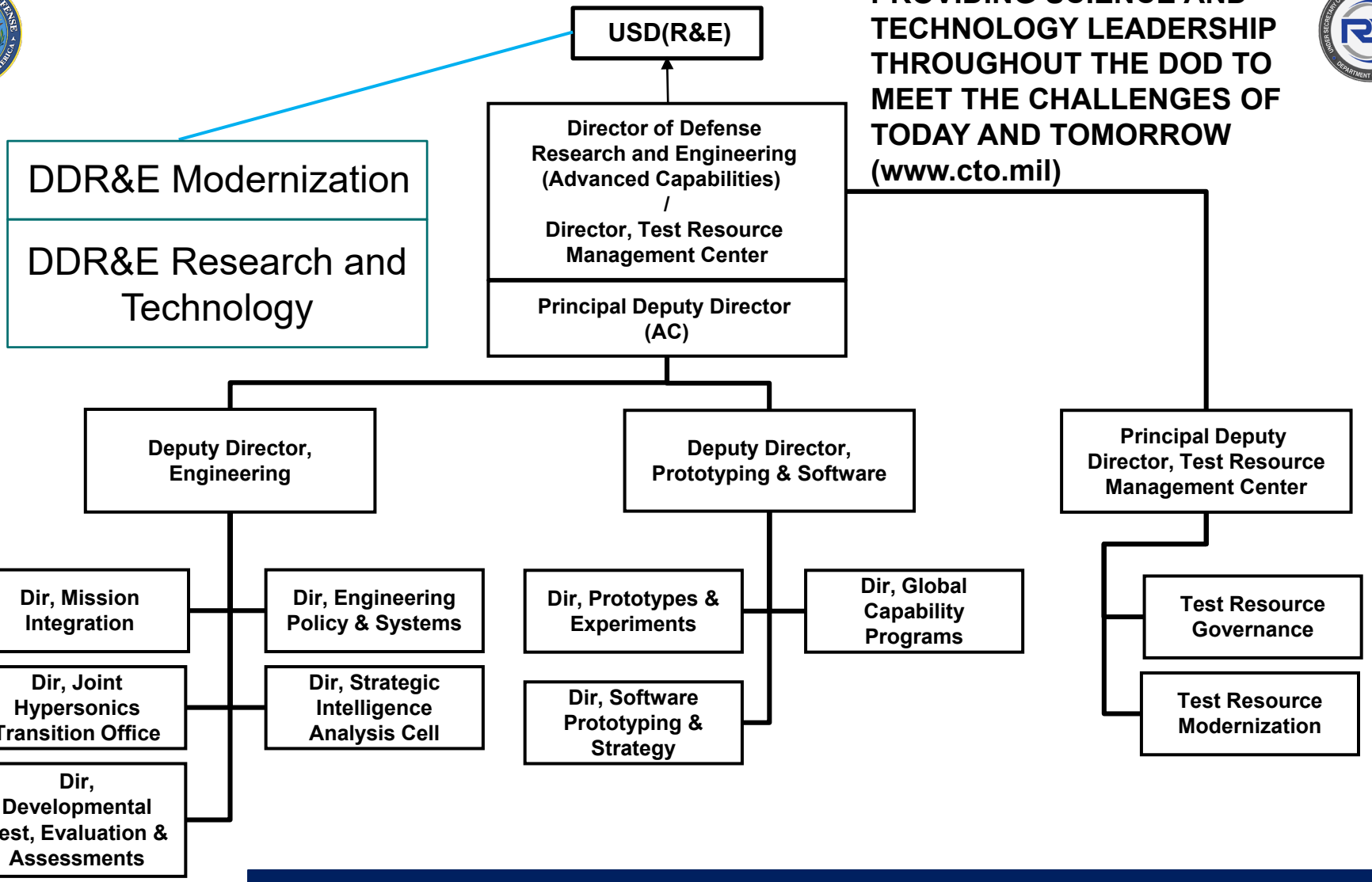




"Our mission is to ensure that we, if necessary, reestablish and then maintain our technical advantage."

– Under Secretary Griffin, April 2018

PROVIDING SCIENCE AND TECHNOLOGY LEADERSHIP THROUGHOUT THE DOD TO MEET THE CHALLENGES OF TODAY AND TOMORROW (www.cto.mil)



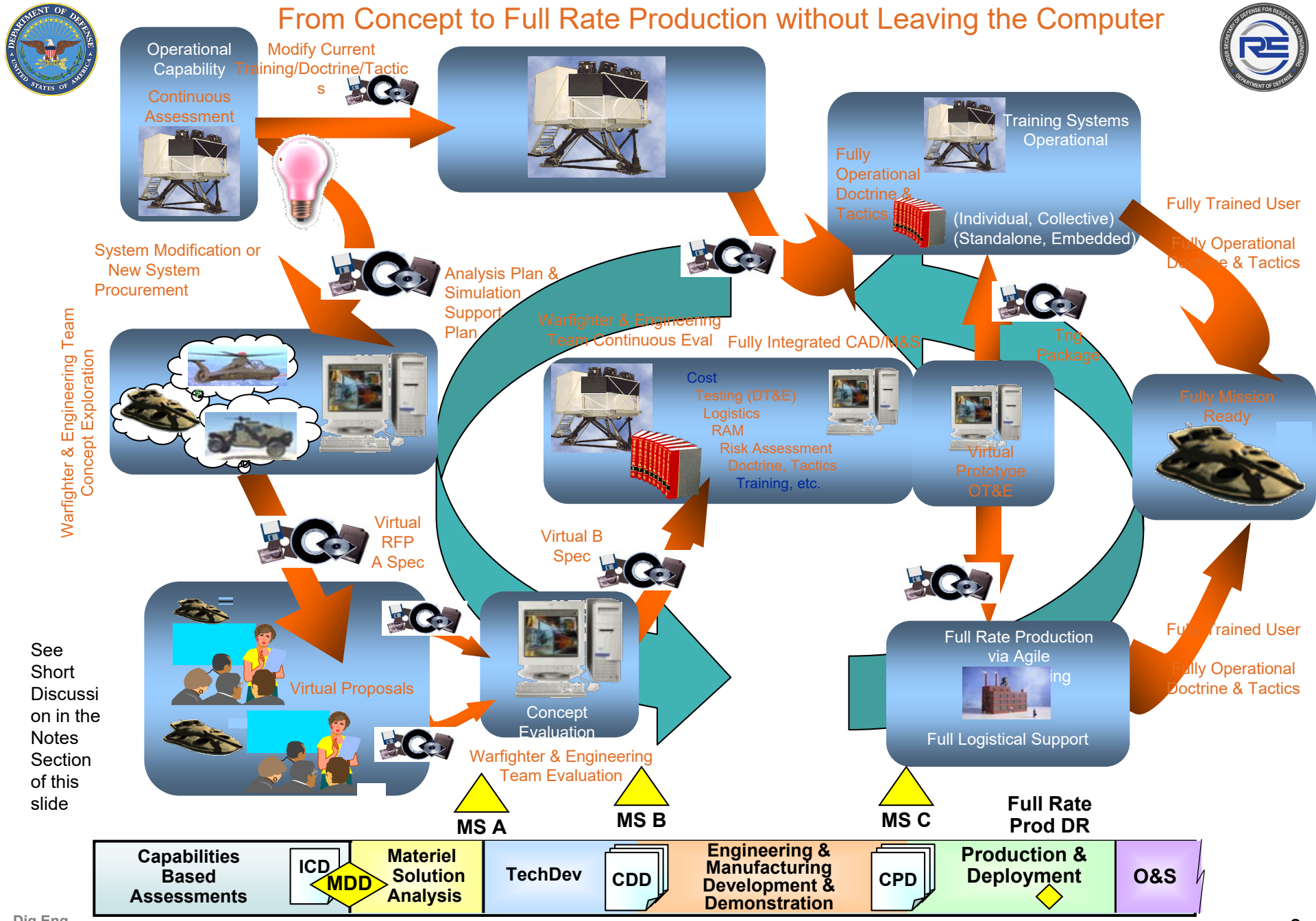
"Advanced Capabilities uses a commercial model for our organization - dividing engineering, prototypes, and test infrastructure to better align with Industry and to ensure products successfully transition from lower TRLs into useful warfighter capabilities." **- Jim Faist, Director of Defense Research and Engineering for Advanced Capabilities**

From DoD Summer Study, 2010

Probably the best thing we inside the beltway can do is not think we are smarter than those doing the real work; the objective should be to enable, not do, their work

- Rethink the "M" in "M&S"
- Where virtual simulations can aid user (and developer) understanding of need/requirements, they fall short when it comes to physical system (HW and SW) design
- The techniques/tools tend to be created/used within the needing organization with little (notice I did not say none!) sharing
- A very important point: effective design modeling isn't just about the tools, it isn't even (as some would say) about the tools at all, it's about the modeler and the wide range of techniques available to them – this section is really about enabling the modeler
- Related, the linkage between virtual simulations and high/higher fidelity physics models should also be explored
- Model Based Engineering (MBE): The use of "models" as a way of representing a system that is more expressive than paper but less obtuse than software and less expensive than a hardware prototype

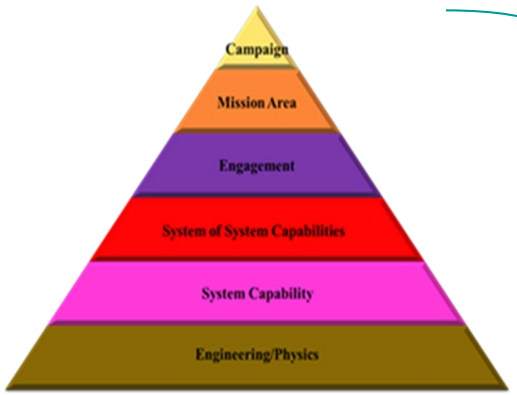
From Concept to Full Rate Production without Leaving the Computer



See Short Discussion in the Notes Section of this slide

M&S

- Modeling and simulation (M&S) is an enabler of warfighting capabilities. It helps to save lives, to save taxpayer dollars, and to improve operational readiness.
- Defense Modeling and Simulation Coordination Office
- Modeling and Simulation Enterprise – Technical Leadership



Model: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process; i.e. "a representation of reality"

All usable in digital engineering; what do you need to do?....

Digital Eng

"The goals (of the Digital Engineering Strategy) promote the **use** of digital representations and components and the **use** of digital artifacts as a technical means of communication across a diverse set of stakeholders."
"Advancements in computing, modeling, data management, and analytical capabilities offer great opportunities for the engineering practice. **Applying** these tools and methods, we are shifting toward a dynamic digital engineering ecosystem."

Digital Engineering

An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support life cycle activities from concept through disposal

1. Formalize the **development, integration and use of models** to inform enterprise and program decision making
2. Provide an enduring **authoritative source of truth**
3. Incorporate **technological innovation** to link digital models of the actual system with the physical system in the real world
4. Establish supporting **infrastructure and environments** to perform activities, collaborate, and communicate across stakeholders
5. Transform a **culture and workforce** that adopts and supports Digital Engineering across the lifecycle

Digital Engineering (DE)

- **Definition: Automation applied to rigorous definition of system elements**
  - Characterizes properties/relationships precisely
  - Models behavior using mathematics and physics
  - Curates with fierce discipline to maintain a *single*, *digital* definition of a system
- **DE yields measurable benefits. Examples:**
  - Sikorsky reports results on four helicopter projects:
    - 30% reduction in hardware engineering (CAD) design times
    - 50% reduction in error norms
    - Clean-sheet design: concept to 1st flight in 57 months vs. ~100 month baseline
    - Landing gear installation performed in 4 hours vice planned 2 days
  - Ford plans to reduce the schedule for new vehicle design by one year, convert vehicle testing from 80% physical/20% virtual to 20%/80%, and to make recalls based not on fleets, but on individual vehicles
  - GE models each individual commercial jet engine with its unique health history

Multiple case studies cite measurable benefits from implementing DE

Some ARMY examples:

"The Army Modernization Enterprise (AME) will evolve towards routine use of digital environments, tools, skillsets and artifacts to create, manipulate, analyze, integrate and share a product's data throughout its lifecycle, in order to allow the workforce to more effectively and efficiently perform their jobs and deliver products to the Warfighter at the speed of relevance. Policy for the Implementation of Digital Engineering throughout the Assistant Secretary of the Army (Acquisition, Logistics and Technology) Enterprise"

"The Army is turning to "**digital-twin" technology** to resolve challenges and boost efficiencies for its enduring fleet of Black Hawk helicopters. "The intent of the **UH-60L program** is to demonstrate the application of this technology in fleet sustainment operations to increase timelines and operational readiness, reduce the cost of documentation, and increase sustainment affordability"

Raider X is a concept for a fast, agile, survivable compound coaxial helicopter that will equip future aviators to address evolving peer and near-peer threats in the most difficult environments. Raider X is "fully utilizing our **digital thread** and **virtual prototyping tools** to maximize the capabilities Raider X provides to our soldiers while optimizing the platform's affordability and sustainability over the lifecycle."

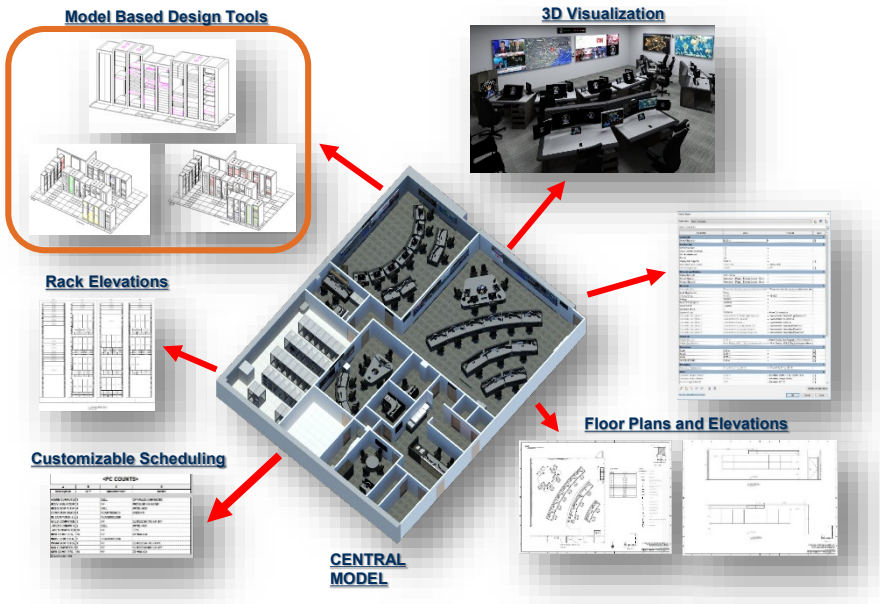
Future Vertical Lift (FVL) Architecture Framework (FAF) represents a baseline of digital content aligning **MBSE processes, concepts, tools and guidance** across the FVL Family of Systems. FAF is a MOSA and MBSE enabler to address system architecture development and implementation, and the Government's vision for an authoritative single source of truth.

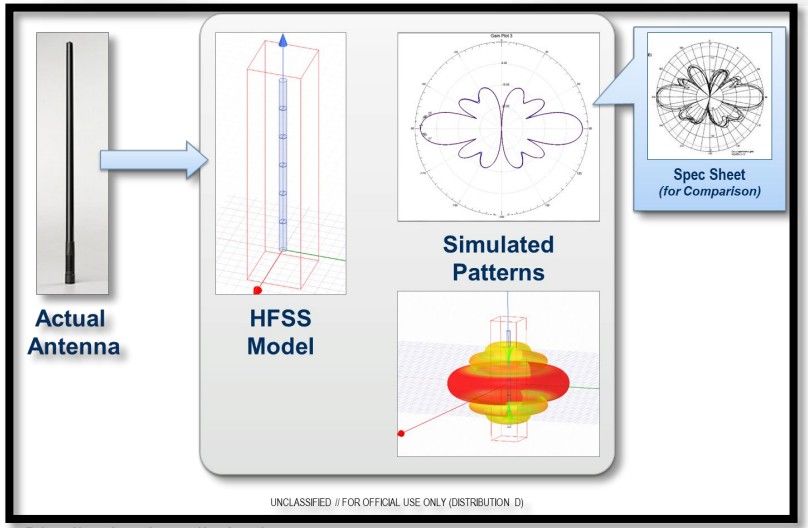
Precision Strike Missile (PrSM) is the next-generation, long-range precision-strike missile. PrSM is using "**new digital engineering tools, process automation and advanced technologies** that have improved PrSM's producibility, quality and performance. Additive manufacturing technologies are also playing a key role in development and helping the company address many of the challenges associated with accelerated timelines and flight test schedules.

Some Navy Examples:

Return on Investment (System-Level Examples)

- **Producing Installation Design Plans (IDPs) w/ Building Information Modeling (BIM) & Revit**
  - Estimated $850K in cost savings in Command & Ops Center Div
  - MAJOR time savings (several months of critical path saved)
  - Improved design quality and customer design reviews
  - Examples:
    - USSPACECOM Design – delivered design ~6 months ahead of time, saved ~$500K
    - P621 Tech Control Cable Trays – were placed in the wrong location, saved ~ $200K and two months by identifying issue with NAVFAC
    - P621 AV Design – found issue w/ displays mounted in wrong location, saved ~$25K, one week
- **Using antenna modeling (ANSYS) to streamline development & integration of new antennas on vehicle platforms**
  - Before: Copy/paste 50-60 pages over 1+ week in manner that was not presentable; Used to take 2-3 days of testing to conduct analysis w/ Poseidon Park having 3 month lead time
  - Now: Done in < 30 min & displays detailed radiation patterns; Generate results within 1-2 weeks using M&S





Some USAF examples:

"To inspire companies to embrace the possibilities presented by digital engineering, today the Department of the Air Force is announcing a new weapons system designator—the 'e' series," Barrett said. "Aircraft, satellites, weapon systems and more that are digitally engineered will receive an 'e' prefix."
The first U.S. Air Force aircraft designed using the digital approach, the eT-7A Red Hawk, embraced model-based engineering and 3D design tools which reduced assembly hours by 80% and cut software development time in half. The aircraft moved from computer screen to first flight in just 36 months."

"AFRL research project: model F-15 airframe structure to address repeated structural failures….. Modeling each tail number permits planning on a per-airframe basis, e.g., timing of inspections and restricted speed placarding"

"Re-Engining the B52: The Air Force is also looking at the B-52 re-engining as a pathfinder program to explore ways to speed up contracting. Instead of an elaborate, paper-intensive comparison of candidate engines—in which the government makes educated guesses about capability—the service plans to conduct a "digital fly-off" between power plants, using computer simulations. This virtual fly-off will compare engines for fuel efficiency, maintenance requirements, and performance under a wide variety of conditions."

Air Force Ground Based Strategic Deterrent: Integrating requirements, design, and architecture to substantially shorten analysis cycles on key trades

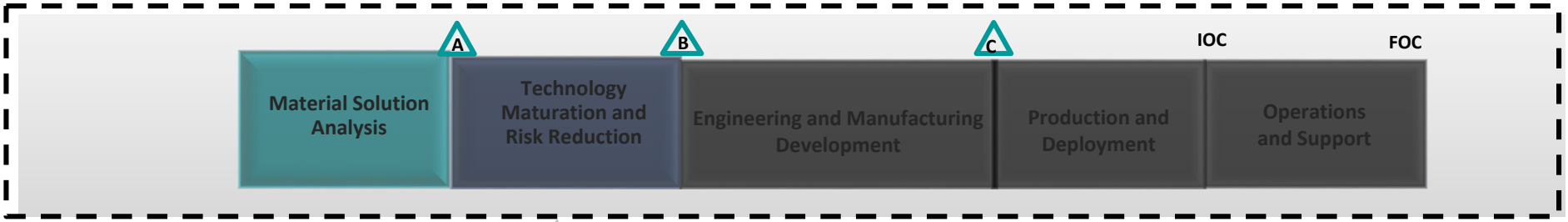
A10 Rewinging: "I think new technologies like digital engineering allow us to change how production and design are done, and I think … [digital engineering] will allow us to not raise the cost of sustainment for very heterogeneous Air Force," he said last month during the annual McAleese & Associates conference.

In this Competitive World, Imagine if…

- Acquisition decisions were based on competing proposed models inside a synthetic multi-domain battlespace environment
  - *improving performance and saving money*
- Every fielded system had a "digital twin" that reflected the actual experiences of the system throughout its lifecycle
  - *enabling planned maintenance and situational upgrades*
- Joint training was conducted via distributed simulations and immersive environments representative of anticipated battlespaces
  - *and available wherever and whenever needed*
- An ongoing campaign of experimentation was established for every mission scenario to develop new concepts/CONOPs
  - *engaging warfighters and motivating innovation*
- Senior leadership routinely participated in 'Strategic Gaming' to identify shortfalls in existing capabilities and explore new options
  - *informing their decisions in the competitive national security environment*

Proper adoption and use of GEMS can enable these important capabilities in support of the National Defense Strategy

Digital Engineering - Framework for Communication



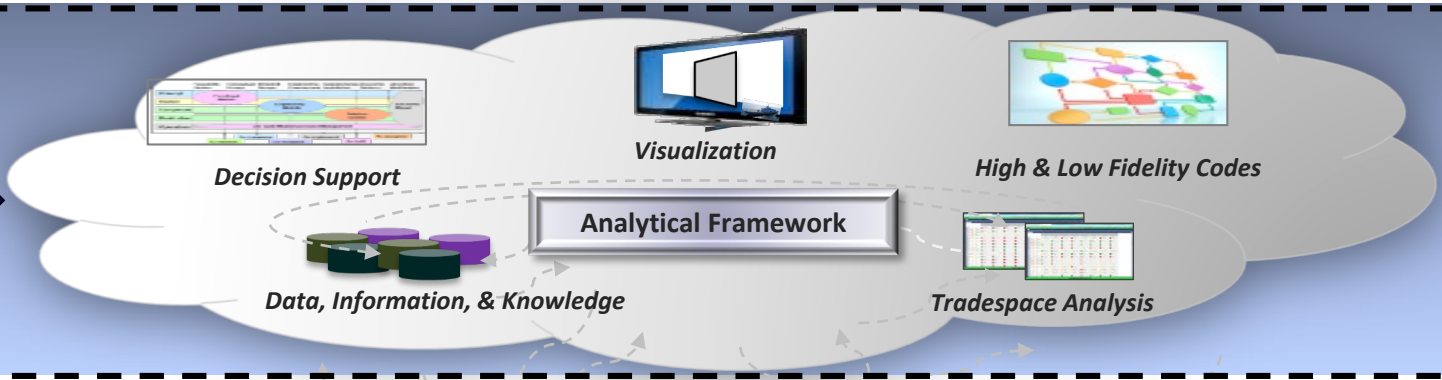
Digital System Model Weapon System Engineering Data

Eq. Data: Size, Weight, Power, Performance, etc.

Digital System Model Supporting Data (Program and System)

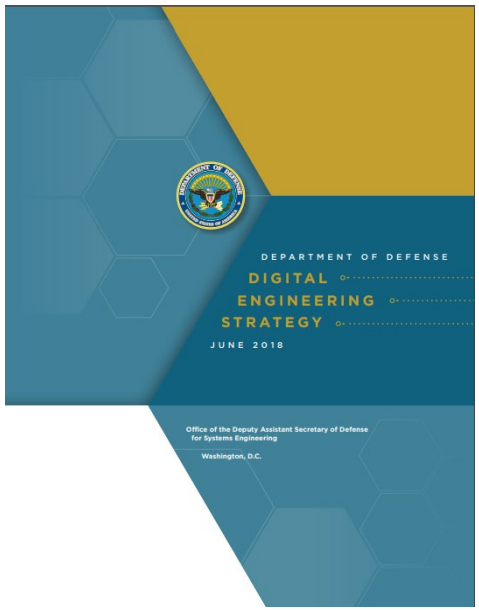
Data Rights *RAM* *Cost* *Training*
Manufacturing *Sustainment* *Facilities*
Test and Evaluation *Schedule*

Digital Thread Tools Analytics Processes Governance



Digital Engineering in Practice

DoD DES



1. Drive implementation
2. Gain leadership commitment
3. Engage workforce
4. Discern resource allocation
5. Measures Results

Digital Engineering is a catalyst for change in the techniques we use to engineer our systems……

Digital Engineering Implementation

Dr. Griffin

"This strategy describes the "what" necessary to foster the use of digital engineering practices. Those implementing the practices must develop the "how" – the implementation steps necessary to apply digital engineering in each enterprise."

Service Strategies and Plans

Outlines DoD's five strategic goals for Digital Engineering initiatives

Enterprises

U.S.ARMY

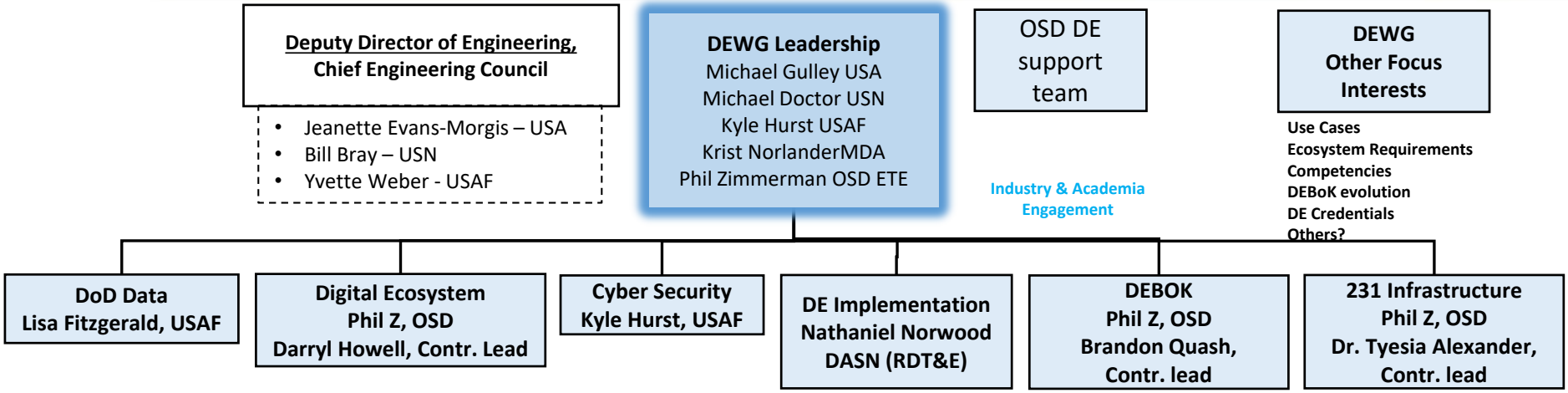
U.S. AIR FORCE

Collaborative Activities

- Collaboration
  - Digital Engineering Working Group / Community of Practice
    - Tiger Teams
  - Systems Engineering Research Center
  - INCOSE/NDIA Digital Engineering Information Exchange Working Group; Conferences, etc
  - Engineering WF Task Force
- DoD Digital Engineering Body of Knowledge (DEBoK)
- Align understanding of Modeling and Simulation with Digital Engineering

Implementing Digital Engineering Across the DoD

Digital Engineering Working Group Community of Practice



Services Prioritized DE Pain Point centric Tiger Teams (6)

DoD Data – DoD lacks the enterprise data management to ensure Authoritative Data & Models are widely available to or accessible

Digital Ecosystem – DoD needs technical solutions to provide collaborative, agile, secure, interoperable, & responsive digital ecosystems

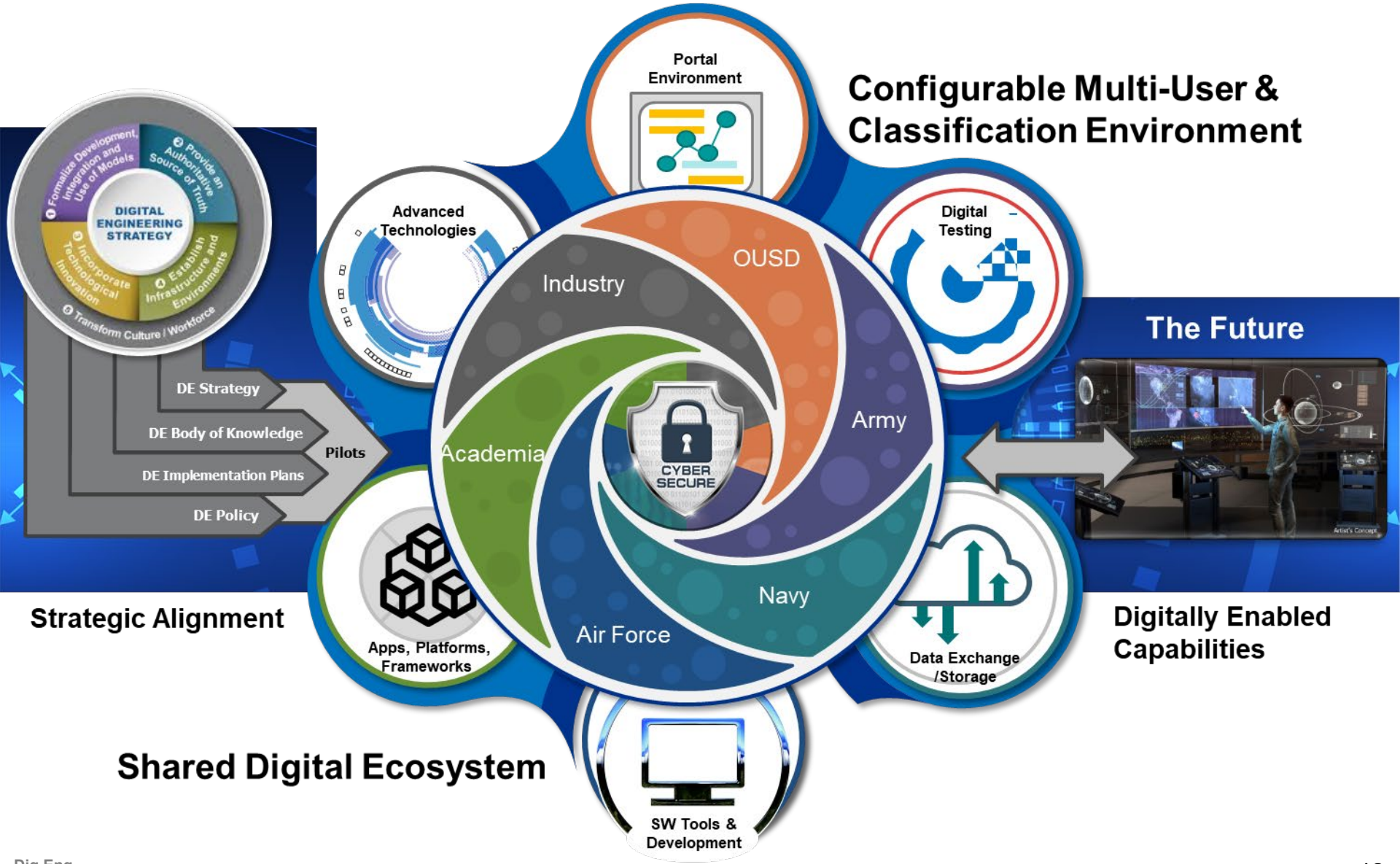
Cyber Security - DoD needs cybersecurity protection to data, networks and hosting environments while managing access controls, data at rest, spillage control and exfiltration mitigation.

DE Implementation – DoD lacks applied, useful and shared examples of incremental DE/MBSE implementation and execution. Applied Methods/Road-Maps for DE/MBSE Implementation.

DEBoK – The DoD lacks a uniform and common understanding of what the DEBoK should be and what it should contain. There needs to be a structured, shared knowledge that is existent and accessible to the Engineering community.

231 Infrastructure – The National Def Authorization Act (NDAA) for FY20, Section 231 (Public Law 116-92) directs the Sec of Def to establish a DE capability to support automated approaches for testing, evaluation, and deployment throughout the defense acquisition process

Digital Engineering USE Basics



Summary/Next Steps

- **Driving Digital Engineering transformation through a focus on implementation**
  - Addressing challenges, shares best practices, and facilitates tiger teams
  - Sponsoring research on metrics, curation, and tool innovation
  - Shaping initiatives across industry to drive digital engineering transformation
- **Shaping the Digital Engineering Community of Practice/Practitioners**

For Additional Information

Ms. Philomena M. Zimmerman

Deputy Director, Engineering Tools and Environments

DDR&E(AC)

Office of the Under Secretary of Defense
for Research and Engineering

571.372.6695

Philomena.m.Zimmerman.civ@mail.mil

Digital Engineering Collaborations

- **Digital Engineering Working Group**
  - Interagency, DoD Services/Agencies, industry, and academic collaboration
  - Addresses challenges, shares best practices, and facilitates tiger teams to develop strategy, implementation, policies, and guidance
- **Systems Engineering Research Center**
  - Sponsors research on metrics, curation, and tool innovation
- **NDIA / INCOSE**
  - Shapes initiatives to drive digital engineering transformation
  - **NDIA/INCOSE Digital Engineering Information Exchange Working Group**
- **Engineering Workforce Competency refresh**

Using the Digital Ecosystem

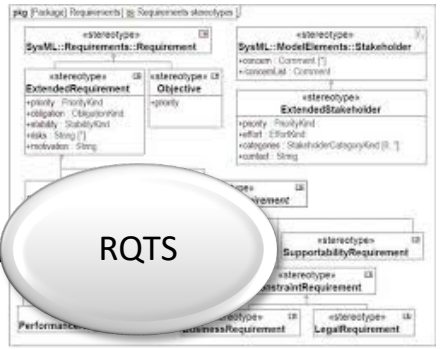
WORKFLOW

- Storage
- Tools
- Compute

ACCESS

- DoD
- Classification
- Accessible to stakeholders

RQTS



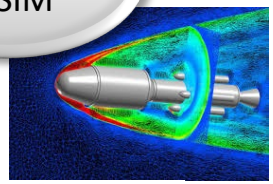
DESIGN & ANALYSIS

- Tools
- Software Development

INNOVATE

- Data Mining
- Machine Learning
- GPGPUs Available

MODEL & SIM



FUN3D
Fully Unstructured Navier-Stokes

TEST & EVAL

- Data Collect
- ASoT Available