Digital Engineering and Engineered Resilient Systems (ERS)

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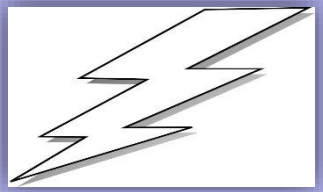
History

1st Industrial Revolution

MECHANICAL

Use of mechanical production powered by water and steam

2nd Industrial Revolution



ELECTRICAL

Use of mass production powered by electrical energy

3rd Industrial Revolution

INFORMATION TECHNOLOGY

Use of electronics and IT to further automation

4th Industrial Revolution

DIGITAL

Use of a digitally connected end-to-end enterprise

1800 1900 2000 TODAY

Traditional Models and Simulations (M&S)

Simulation Based Acquisition (SBA)

Model-Based Systems Engineering (MBSE)

DIGITAL ENGINEERING (DE)

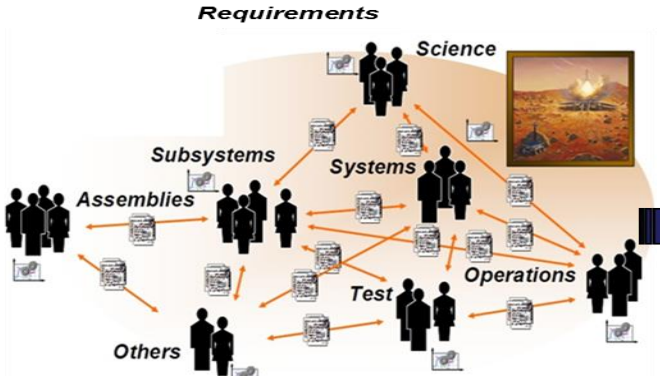
Digital Engineering: MBSE approach for DoD

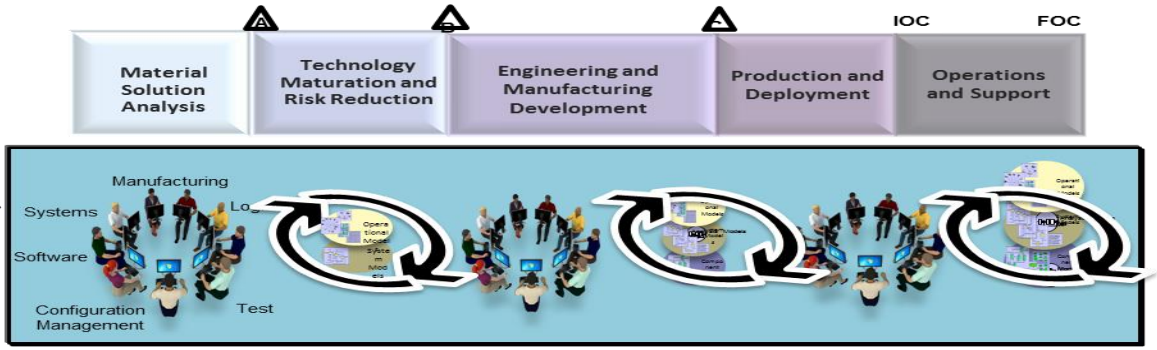
Current State

- Our workforce uses stove-piped data sources and models in isolation to support various activities throughout the life-cycle
- Current practice relies on standalone (discipline-specific) models
- Communication is through static disconnected documents and subject to interpretation

Future State

- Digital Engineering moves the engineering discipline towards an integrated model-based approach
  - Through the use of digital environments, processes, methods, tools, and digital artifacts
  - To support planning, requirements, design, analysis, verification, validation, operation, **and/or** sustainment of a system
- Digital Engineering ecosystem links our data sources and models across the lifecycle
  - Provides the authoritative source of truth





Current: Stove-piped models and data sources

Future: Digital Engineering Ecosystem

ERS Products in Digital Engineering Context

Digital Engineering

- **Digital Engineering vision moves the engineering discipline towards an integrated model-based approach through the use of digital environments, processes, methods, tools, and digital artifacts**
- **Model is a representation of reality**
  - Model is ‘composed of’ data, algorithms and/or processes
  - Computable or used in a computation

ERS

- **Engineered Resilient Systems (ERS) combines advanced engineering techniques with high-performance computing to develop concepts and tools that significantly amplify design options examined**
- **Develop/Integrate advanced engineering tools for efficient, integrated design and development across the full range of the product lifecycle**

Digital Engineering Relationships

Digital Engineering Ecosystem

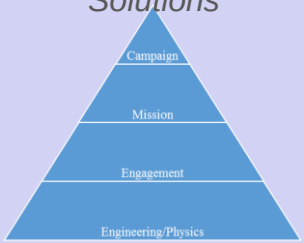
Digital Engineering Strategy

User selected and integrated based on outcome needed

Supporting tools: (Large Tradespace Analytics datasets, Analysis of Alternatives, Virtual Prototyping Evaluation, etc.)

ERS ENGINEERED RESILIENT SYSTEMS

Traditional Mod/Sim Solutions

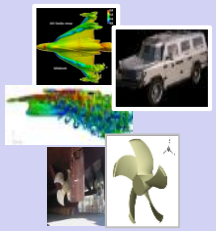


(DoD) Modeling and Simulation Coordination Office (DMSCO)

Other Initiatives

Physics-based / Engineering Design Tools

CREATE

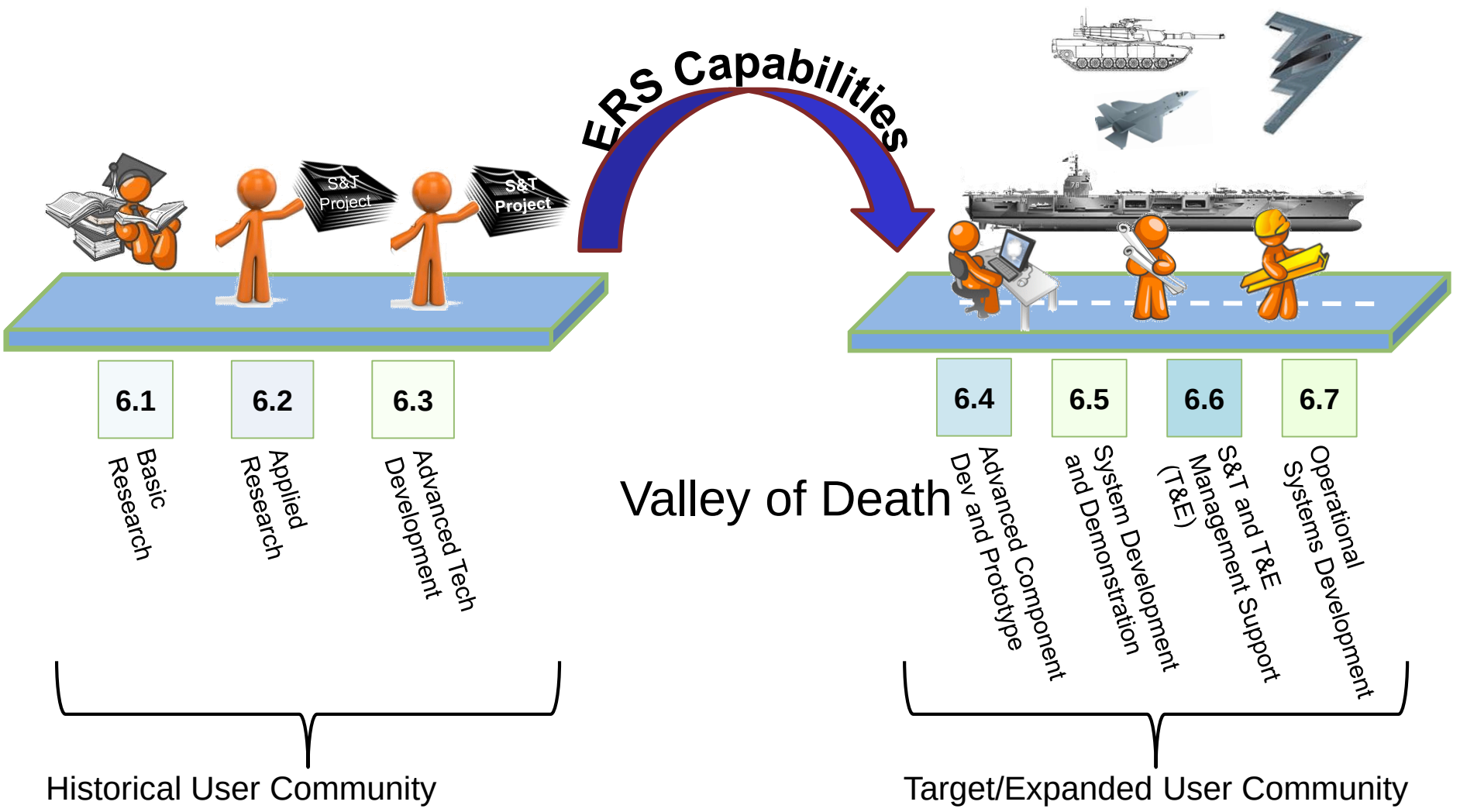


Computational Research and Engineering Acquisition Tools and Environments (CREATE)

World-class Computational Resources (High Performance Computing), Software, Networking

DOD HPC MODERNIZATION PROGRAM

Transitioning S&T to Engineering & Acquisition



DRAFT Vision for ERS, CREATE, et al (crossing the Valley of Death)

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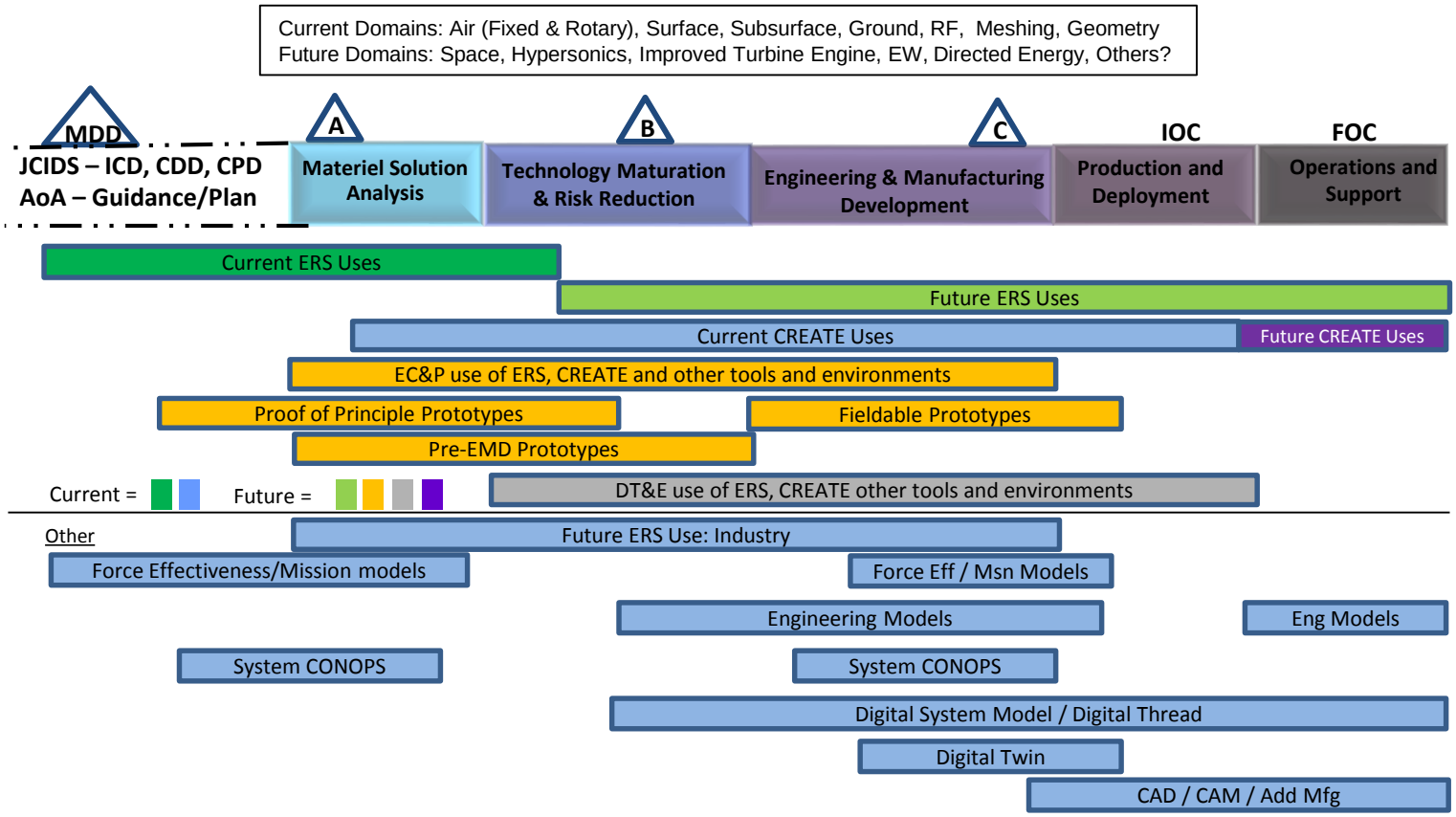
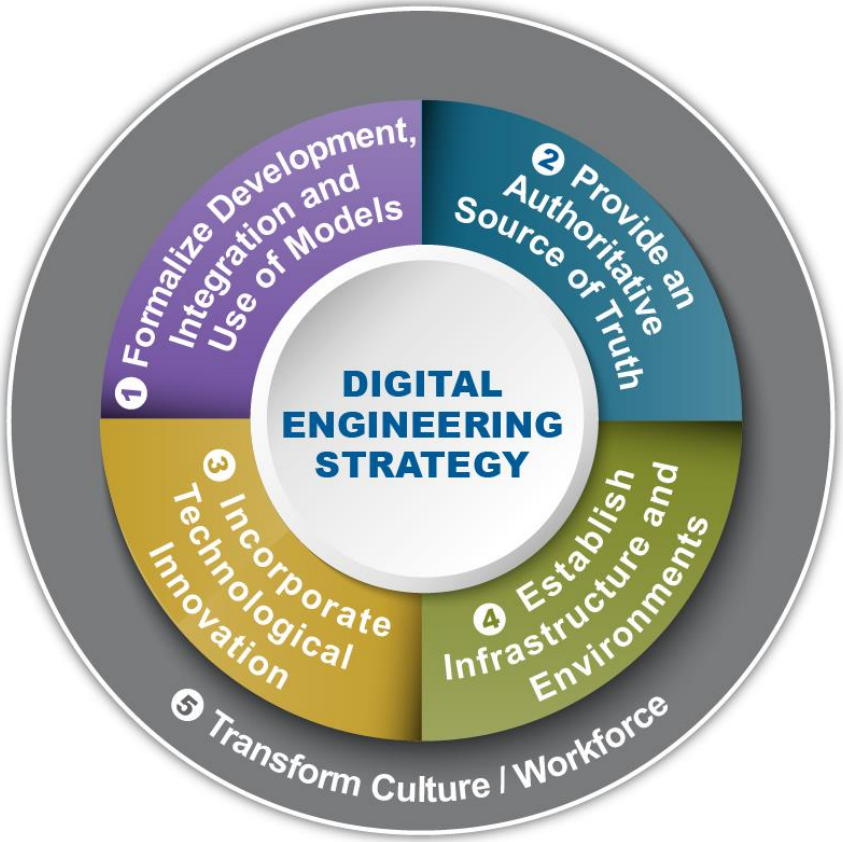


Digital Engineering Strategy: Five Goals

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 improve the engineering practice
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



Drives the engineering practice towards improved agility, quality, and efficiency, resulting in improvements in acquisition

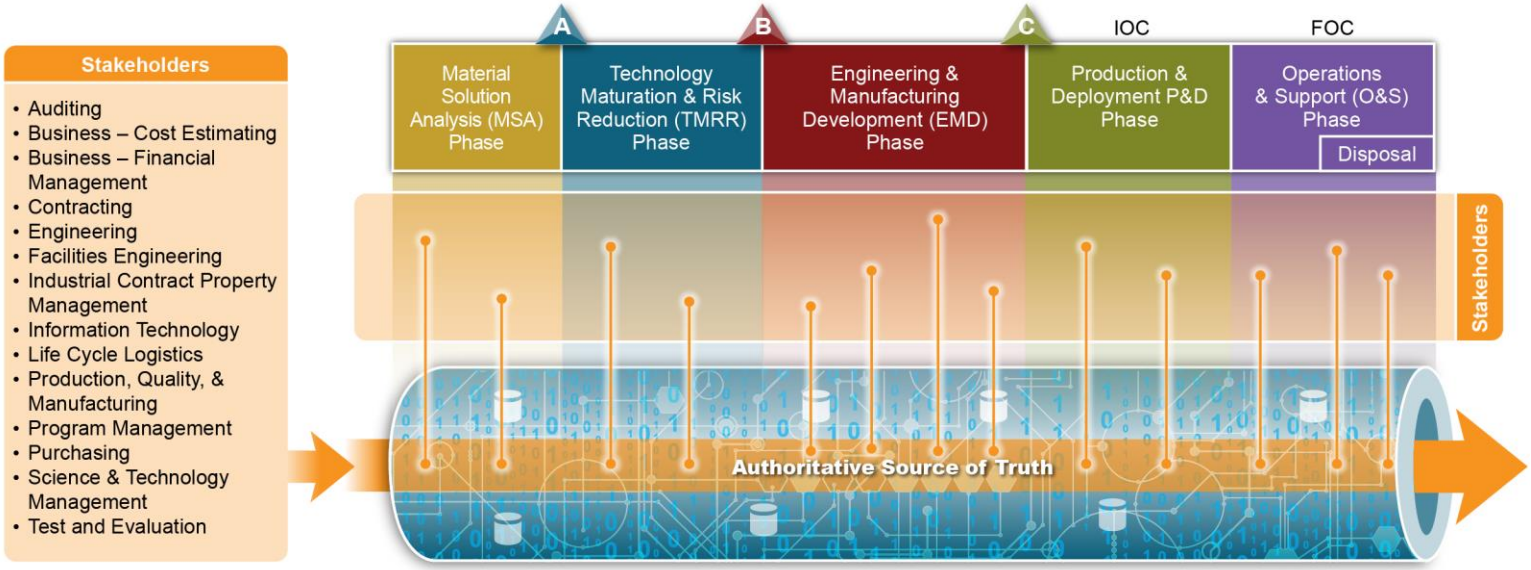
Goal #1: Formalize Development, Integration & Use of Models

ERS in DE Goal 1:

- Use of models to replace the sequential, fixed requirement approach to design
- Use of models will enable prototyping, experimenting and testing of solutions virtually before physical prototypes and full scale systems are available
- Use of evolving models will allow analysis of design options to be shifted left in the lifecycle
- Understand how to defeat a concept through inverse modeling

Models as the cohesive element across a system's lifecycle

Goal #2: Provide an Authoritative Source of Truth



ERS in DE Goal 2:

- Models are inherently more adaptable across mission sets and environments
- The authoritative sources of truth means ground truth
- ERS is fast and accurate enough to understand and mitigate risk in large, complex, and integrated data set

Right information, right people, right uses, right time

Goal #3: Incorporate Technological Innovation

- ❖ **Big Data and Analytics**
- ❖ **Cognitive Technologies**
- ❖ **Computing Technologies**
- ❖ **Digital-to-Physical Fusion Technologies**

ERS in DE Goal 3:

- Explore new concepts to integrated advanced engineering models
- Replace intensive manual processes to stitch data and artifacts together with workflow automation
- Explore new decision analytics that generate real alternatives that reflect the entire lifecycle demanded by increased digital engineering use
- Utilize machine learning to analyze massive and complex datasets containing a variety of data types from a multitude of sources
- Architecturally integrated with knowledge management

Harness technology, new approaches, and human-machine collaboration to enable an end-to-end digital enterprise

Goal #4: Establish Infrastructure & Environments

ERS in DE Goal 4:

- Architect an overall data ecosystem on HPCs
- Build generalized and reusable workflow engine
- Build enterprise-level web portal
- Organize software tools around the data
- Create visualization techniques that support decision makers

Foundational support for Digital Engineering environments

Goals #5: Transform Culture and Workforce

ERS in DE Goal 5:

- Understand that migrating to a digital ecosystem does not remove the responsibility from the users to select, manage, govern and use the tools appropriately
- Gain confidence in performing activities in a collaborative, integrated, digital model-based environment
- Learn to articulate the problem, workflow, and model boundary conditions to a third party
- Build understanding in how to appropriately reduce reliance on physical experimentation

Institutionalize Digital Engineering across the acquisition enterprise

There Is Much More to Do…

- **Publish the Digital Engineering Strategy**
  - Support development of implementation guidance/direction in Services/Agencies
  - Follow with policy?
- **Finish the Digital Engineering Starter Kit**
  - Continue development; share/obtain feedback on digital artifact use
- **Engage with Acquisition Programs**
  - Establish criteria for use of Digital Engineering artifacts for decision points
- **Update Competencies across Acquisition Curricula**
  - Identify Digital Engineering education and training outside of acquisition curricula
- **Update Policy and Guidance (Engineering, et al)**
  - Develop/update governance processes, policy, guidance and contracting language
- **Transform Acquisition Practice**
  - Engage acquisition users
  - Incorporate rigor from Digital Engineering practices and artifacts into system lifecycle activities

Instantiation of Digital Engineering practice is necessary to meet new threats, maintain overmatch, and leverage technology advancements

Systems Engineering: Critical to Defense Acquisition










Defense Innovation Marketplace
http://www.defenseinnovationmarketplace.mil

DASD, Systems Engineering
http://www.acq.osd.mil/se

For Additional Information

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Digital Engineering Overview

- **Background**
  - Dynamic operational and threat environments
  - Growth in system complexity and risks
  - Linear acquisition process that lacks agility and resiliency
  - Cost overruns and delayed delivery of capabilities to the warfighter
  - Current practices can't keep pace with innovation and technology advancements

Digital Engineering: 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.

- **Need**
  - Outpace rapidly changing threats and technological advancements
  - Deliver advanced capabilities more quickly and affordably with improved sustainability to the warfighter
  - Foster a culture of innovation

Digital Engineering transforms the way the DoD innovates and operates

Digital Models Have Incredible Potential

DoD needs:

- **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 in order to respond to multiple stakeholders**
- **A balance between agility in acquisition and rigorous analysis and data**
- **Critical information appropriately protected while designing for interoperability**
- **Support in significantly diverse domains**

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

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

Models are advancing the STATE OF PRACTICE of SE