Systems Engineering Research Center (SERC)

A unique DoD UARC developing a Systems Research Network

SYSTEMS ENGINEERING RESEARCH CENTER

Briefing – NDIA Systems Engineering Division

June 2020

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SYSTEMS ENGINEERING RESEARCH CENTER

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— *Peter Beling, UVA*

— *John Colombi, AFIT*

— *Laura Freeman, Virginia Tech*

— *Val Sitterle, GA Tech*




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— *Cliff Whitcomb, NPS*

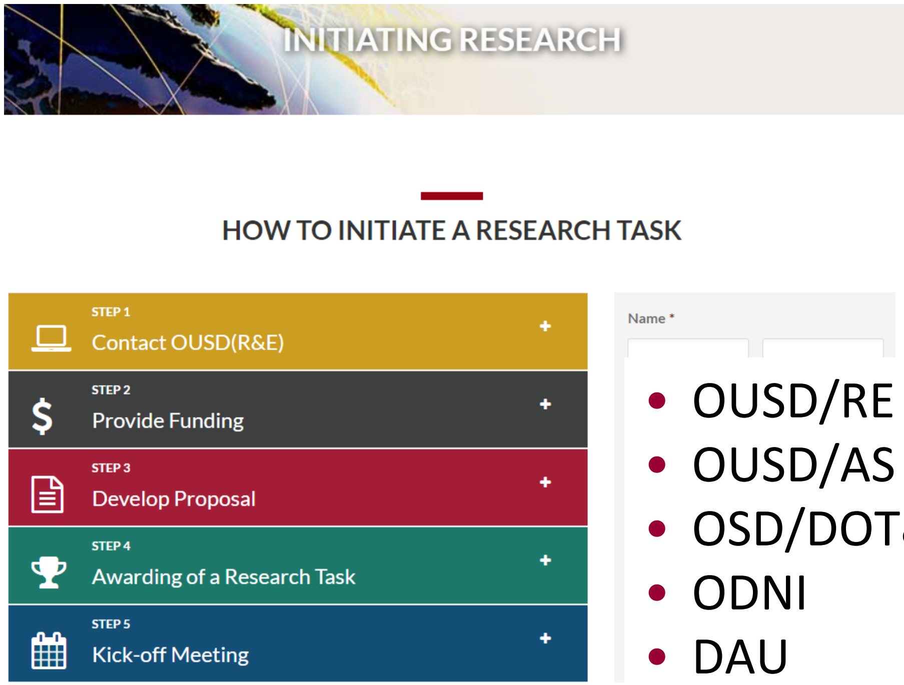
SYSTEMS ENGINEERING RESEARCH CENTER

The Systems Research and Impact Network

The *Networked* National Resource to further systems research and its impact on issues of national and global significance

- ***Catalyze*** SE researchers and end users
- ***Accelerate*** SE competency development
- ***Transform*** SE practice

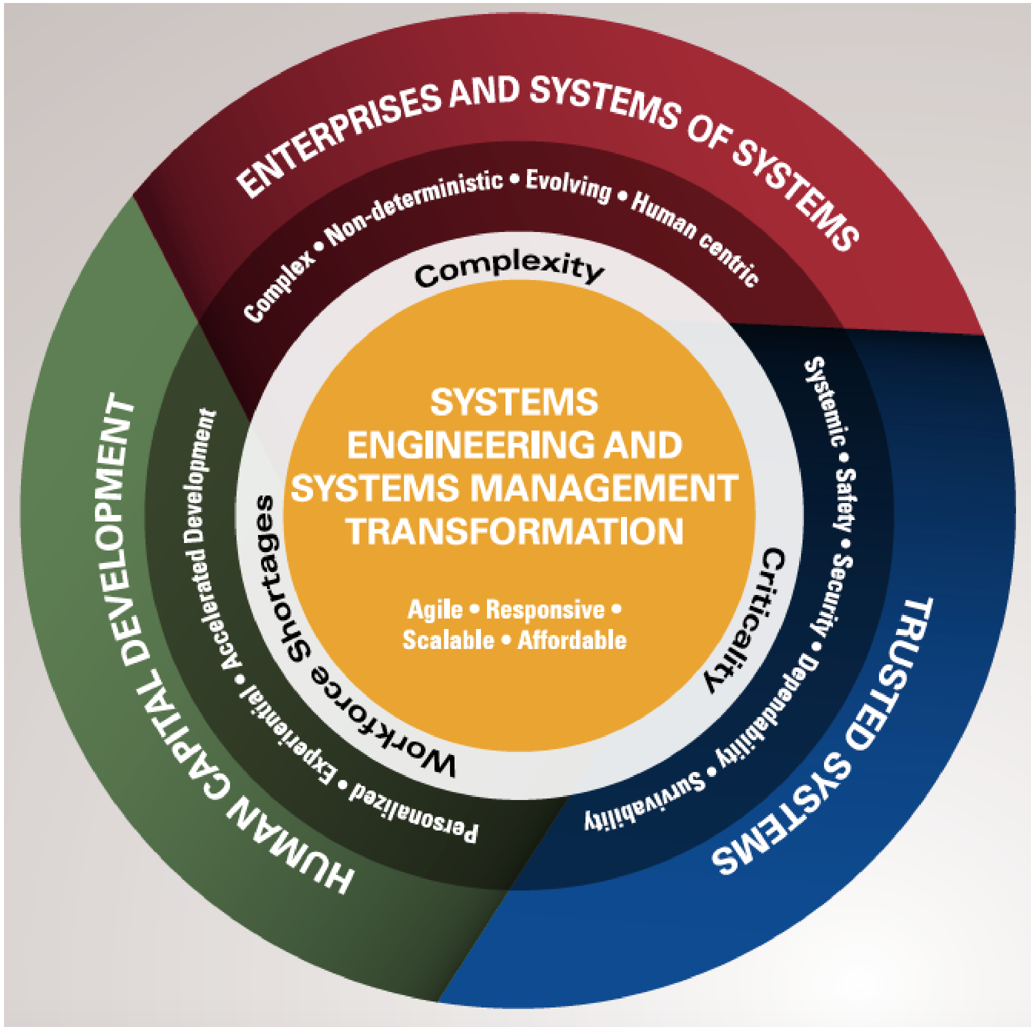
SERC Recent (2018-2020) Sponsors



- OUSD/RE
- OUSD/AS
- OSD/DOT&E
- ODNI
- DAU
- DARPA
- MDA
- NRO

- Army CCDC/Armament Center
- Army CCDC/Aviation & Missiles
- JPEO-CBRND
- Naval Air Systems Command
- Naval Surface Warfare Center
- US Naval Observatory
- AFRL Rome Labs
- AF Space & Missile Command
- Missile Defense Agency
- NASA (pending)
- DHS (new - pending)

SERC Research Thematic Areas



Enterprises and SoS

- *Comprehensive Enterprise/ SoS Modeling and Analysis*
- *Mission Engineering*
- *Digital Enterprise Transformation*

Trusted Systems

- *Systemic Security*
- *Systemic Assurance*

Human Capital Development

- *Evolving Body of Knowledge*
- *Experience Acceleration*
- *SE and Technical Leadership Education*
- *Emerging/Critical Human Capital*

SE & Systems Mgmt Transformation

- *Systems Engineering for Velocity and Agility*
- *Digital Engineering*
- *SE Methods for AI and Autonomous Systems*

SERC Research Areas and Missions

Mission Engineering

TRUSTED SYSTEMS

ENTERPRISES AND SYSTEMS OF SYSTEMS

SYSTEMS ENGINEERING AND MANAGEMENT TRANSFORMATION

HUMAN CAPITAL DEVELOPMENT

V

VELOCITY
Developing and sustaining capabilities that support emergent and evolving mission objectives (deter and defeat emergent and evolving adversarial threats and exploit opportunities, affordably and with increased efficiency)

S

SECURITY
Designing and sustaining the demonstrable ability to safeguard critical technologies and mission capabilities in the face of dynamic (cyber) adversaries

A

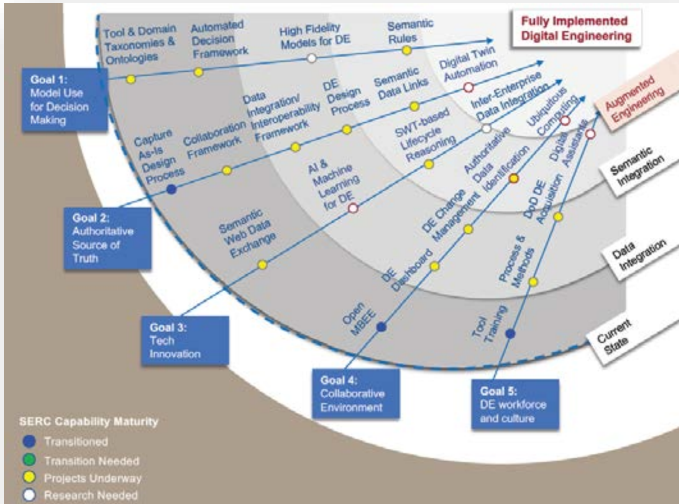
AI & AUTONOMY
Developing and supporting system engineering MPTs to understand, exploit and accelerate the use of AI and autonomy in critical capabilities

SERC Technical Plan Roadmaps

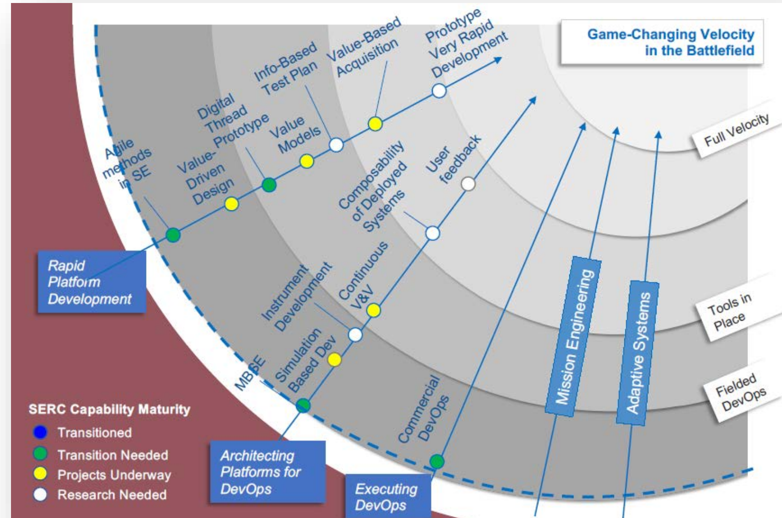
Digital Engineering

SERC Research Roadmaps

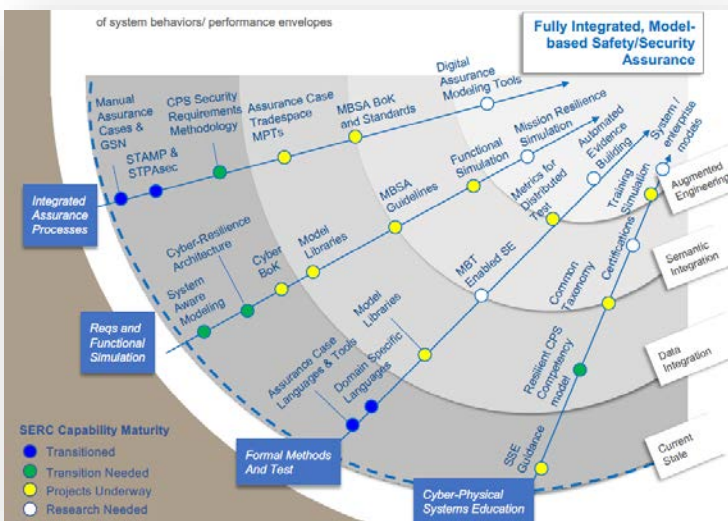
Digital Engineering



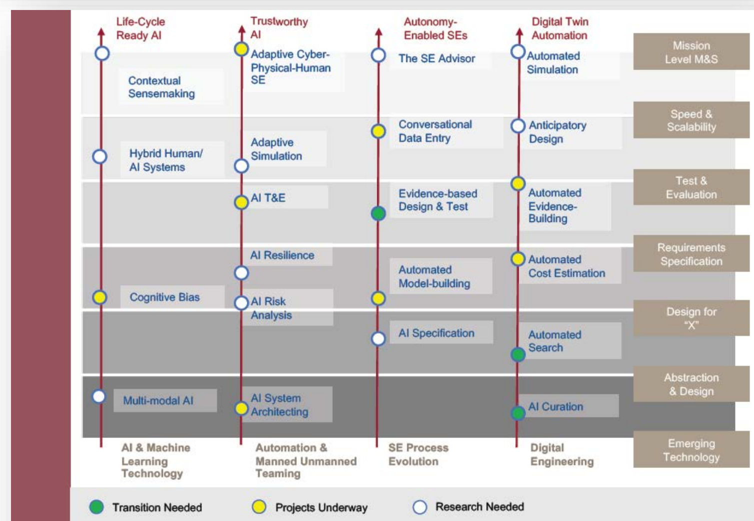
Velocity



Security

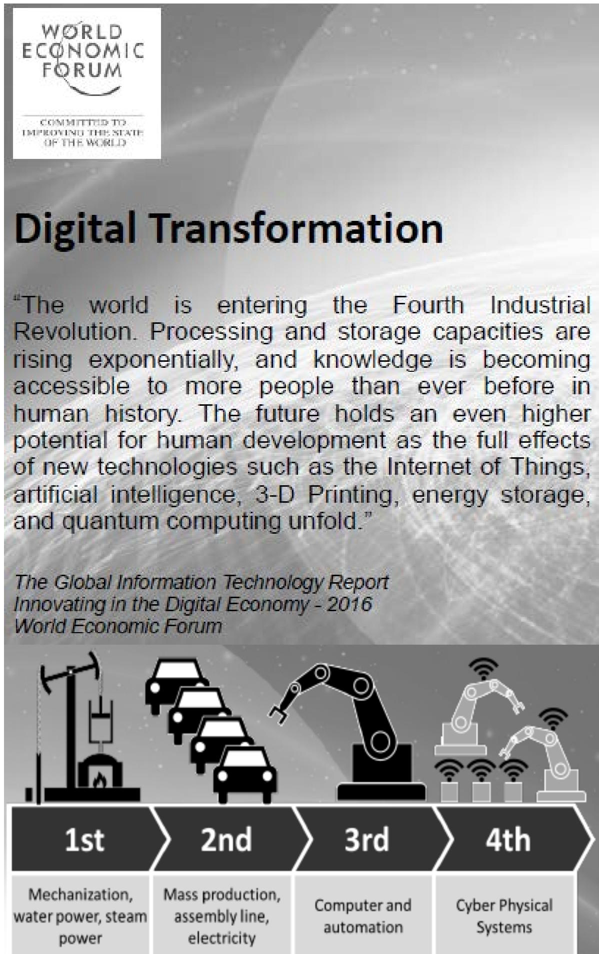


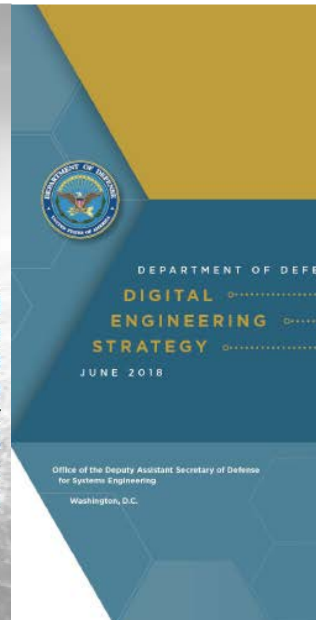
AI & Autonomy

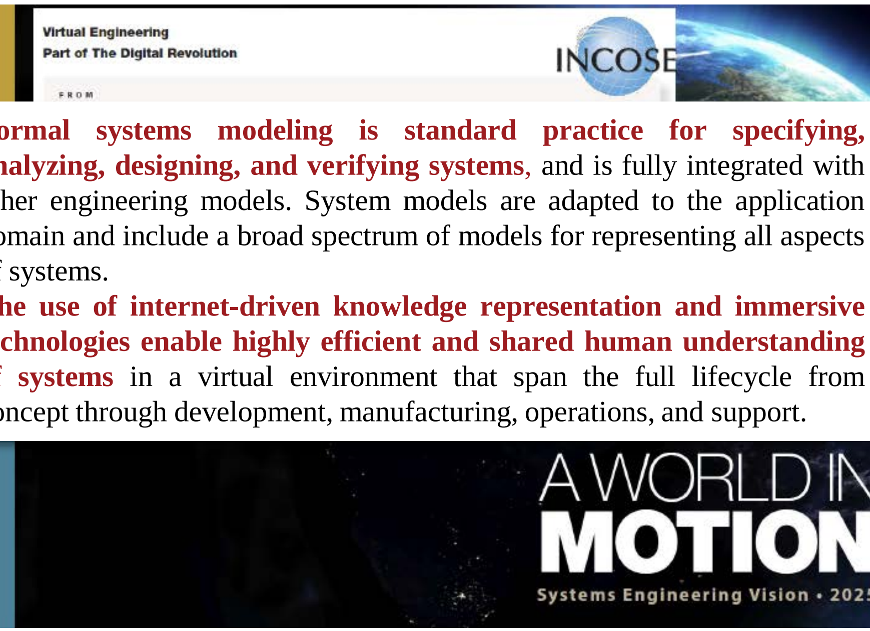


Digital Engineering: Moving from Hype to Transformation

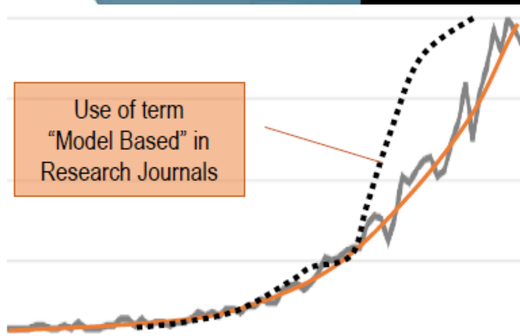
- DoD DE Strategy: "modernize how the Department designs, develops, delivers, operates, and sustains systems…using authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal."



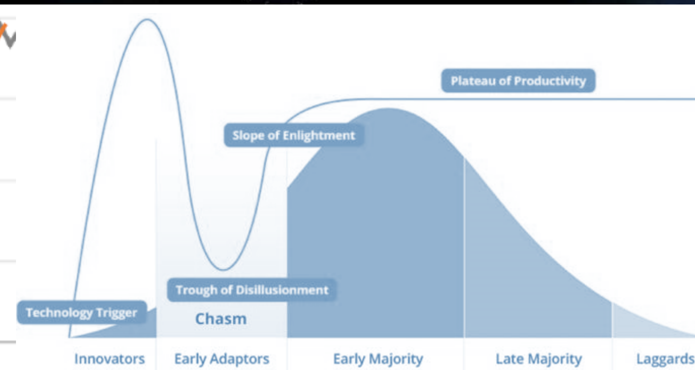




Formal systems modeling is standard practice for specifying, analyzing, designing, and verifying systems, and is fully integrated with other engineering models. System models are adapted to the application domain and include a broad spectrum of models for representing all aspects of systems.
The use of internet-driven knowledge representation and immersive technologies enable highly efficient and shared human understanding of systems in a virtual environment that span the full lifecycle from concept through development, manufacturing, operations, and support.



Troy Peterson, INCOSE Transformation Initiative



Gartner Hype Cycle

Digital Engineering Transformation

- Will change the way **Engineering** is done

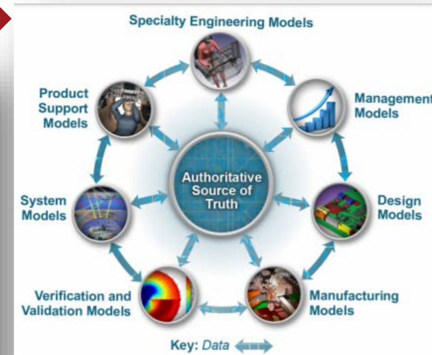
Systems engineering will lead the effort to **drive out unnecessary complexity** through well-founded architecting and deeper system understanding

A **virtual engineering environment** will incorporate modeling, simulation, and visualization to support all aspects of systems engineering by enabling improved prediction and analysis of complex emergent behaviors.

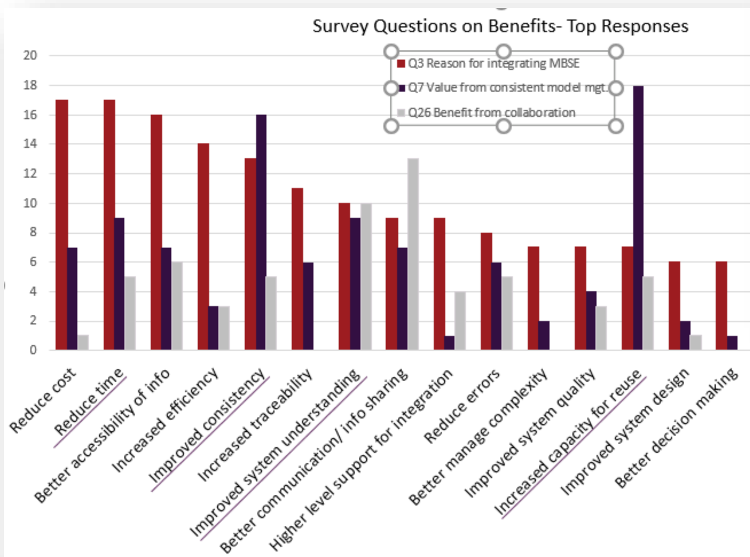
Composable design methods in a virtual environment **support rapid, agile and evolvable designs of families of products**. By combining formal models from a library of component, reference architecture, and other context models, different system alternatives can be quickly compared and probabilistically evaluated.

INCOSE SE Vision 2025/

- Will change the way DoD **Acquisition** is done

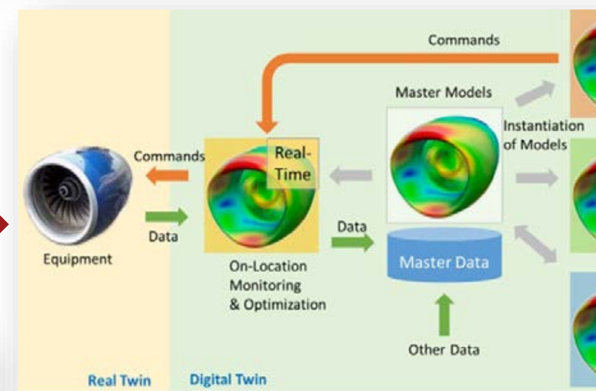


DoD Digital Eng. Strategy

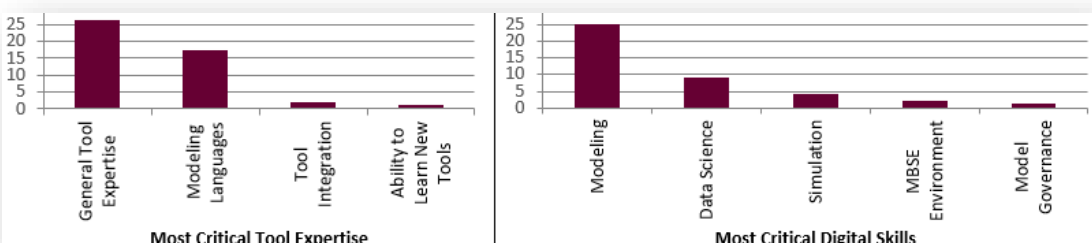


- Will change the way we view **quality** and **agility**

- Will change the way systems get **deployed**



Report: Industrial Internet Consortium: Digital Twins for Industrial Applications.



Data from SERC-SR-2020-001, Benchmarking the Benefits and Current Maturity of MBSE

- Will change our **workforce**

Goal 5: Transform the culture and workforce to adopt and support digital engineering across the lifecycle

Focus Areas

1. Improve the digital engineering knowledge base
2. Lead and support digital engineering transformation efforts
3. Build and prepare the workforce

Challenges

Topic	Short Description
Workforce Skills Training	Limited incentives workforce skills, insufficient training capacity and resources to meet the demand
Policy, Guidance, & Standards	Limited policies, guidance, and standards to comprehensively address digital engineering activities
Metrics	Lack of a common set of metrics that serve as leading indicators of adoption and effectiveness

Research Tasks – Phase 1

The SERC researchers shall perform the following tasks:

1. Define the digital engineering activities – and supporting competencies (knowledge, skills, and abilities) – required to support lifecycle phases from concept through disposal. These activities form the foundation of the Digital Engineering Competency Framework.

2. Building on task 1, identify aspects of the digital engineering lifecycle activities and competencies – that are specific, unique and relevant to the acquisition engineering (ENG) workforce.

3. Develop a Digital Engineering Competency Model, using the DoDI 1400.24 vol.250 "Competency Taxonomy."

4. Based on the work done in Task 1, map each competency set identified in task 3 to the lifecycle phase. This completes the Digital Engineering Competency Framework.

Research Tasks – Phase 2

5. Conduct a gap analysis comparing Defense Acquisition University's (DAU) current curricula against the competency requirements.

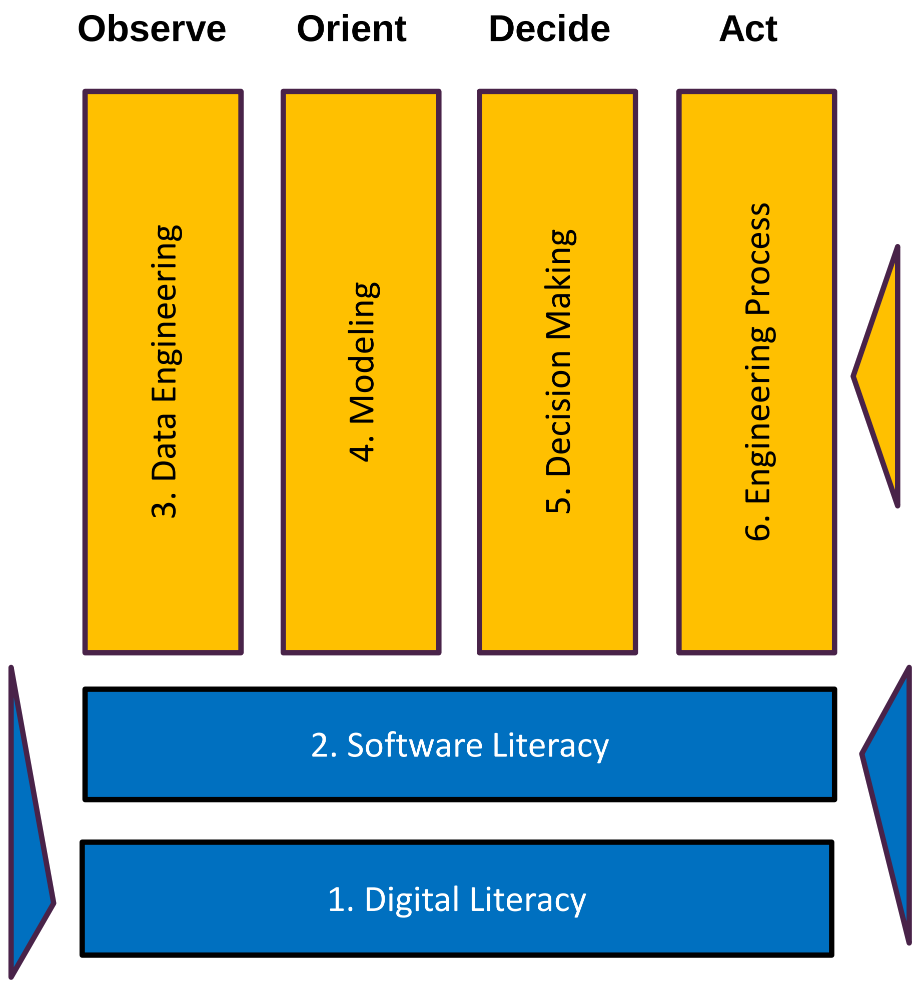
6. Provide recommendations on creating a digital engineering curriculum as well as modifying the applicable acquisition career fields' curricula to build interdisciplinary digital engineering knowledge and abilities.

7. Map digital engineering knowledge and abilities to commercial job titles and job descriptions and requirements of Digital Engineering.

DECF

- DECF Partitioned into 6 Top Level Competencies
- Each Competency Partitioned into Proficiency Levels 1-5
  - Awareness
  - Basic
  - Intermediate
  - Advanced
  - Expert
- Each competency has KSAB elements mapped to proficiency levels
- Considering Limiting KSAB Verb Choices

DE Competency Groups



a. Manage/Lead
b. Architect
c. Develop
d. Support
e. Use

a. Collaboration
b. Communication
c. Authentication
d. Information Sharing
e. Security

a. Environment
b. Principles
c. Development
d. Processes
e. Use

Standard SE Process Methodology for Designing Resilience into Cyber-Physical Systems

System Model

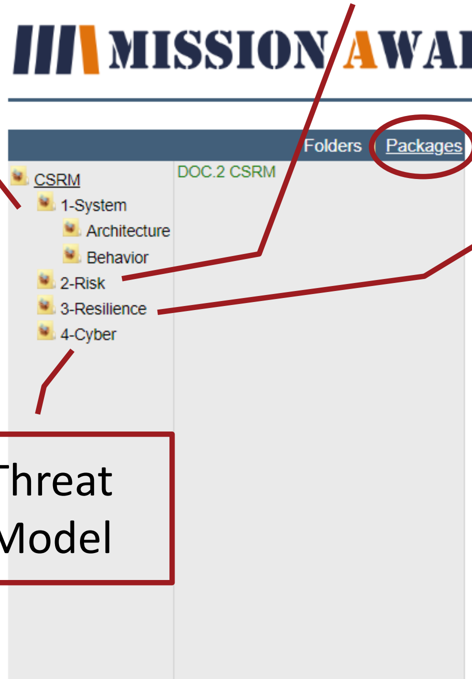
Assurance Model (STPA)

System Aware Model (Resilience modes and Sentinel patterns)

Project: ART-004: Pipeline - Metrics Project

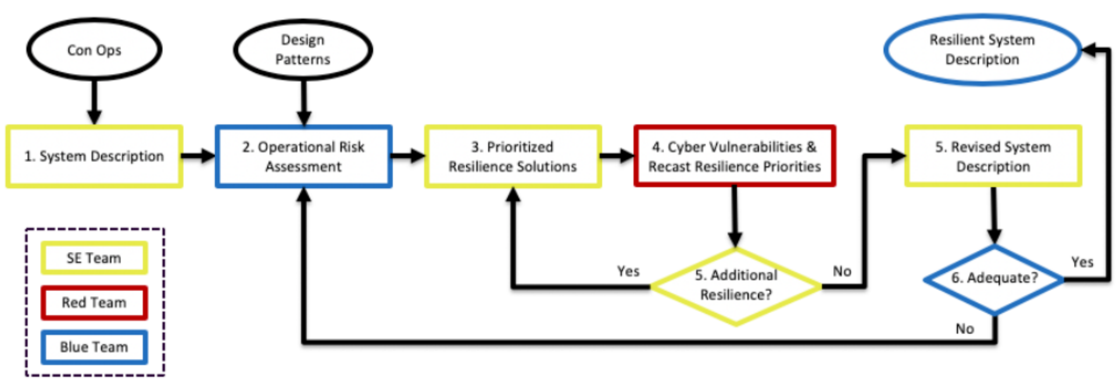
Contact: Tim Sherburne

Powered By GENESYS. Generated 14 February 2020.



Threat Model

Cyber-Security Requirement Methodology (CSRM)



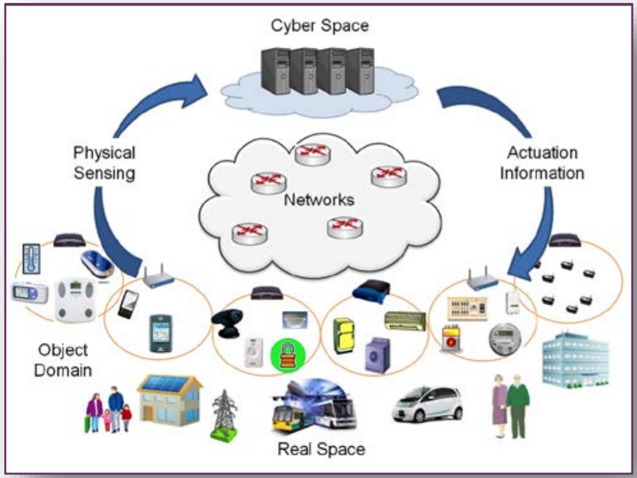
Select "Packages" -> "CSRM" to navigate model per CSRM Steps
NOTE: click package icon to expand section

Ready for Transition

Project: ART-004: Pipeline - Metrics Project

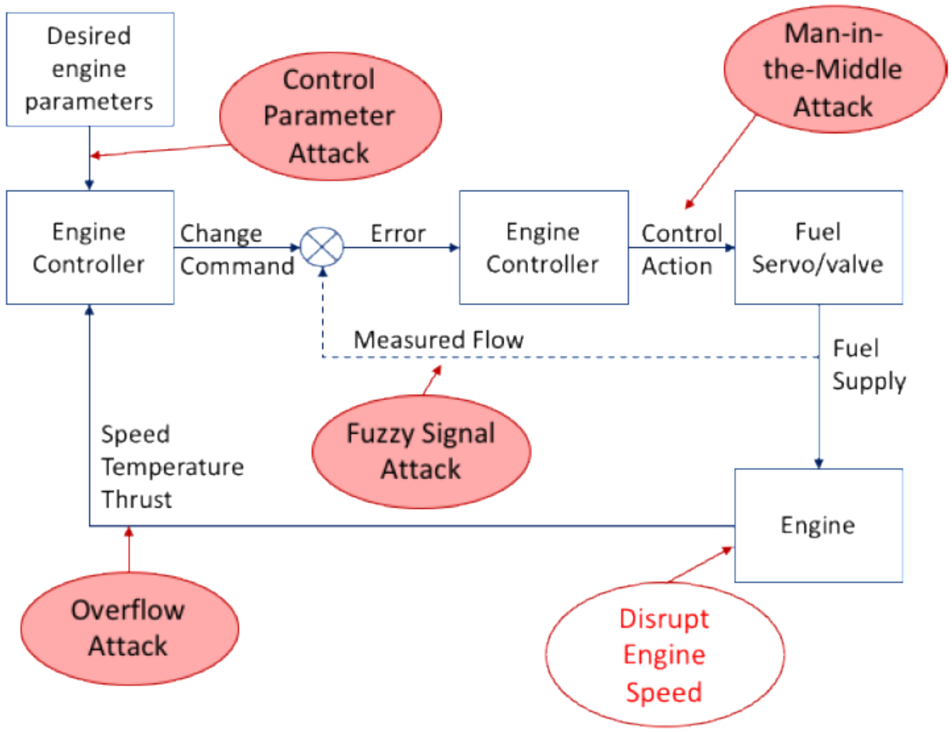
Background: Securing Physical Systems

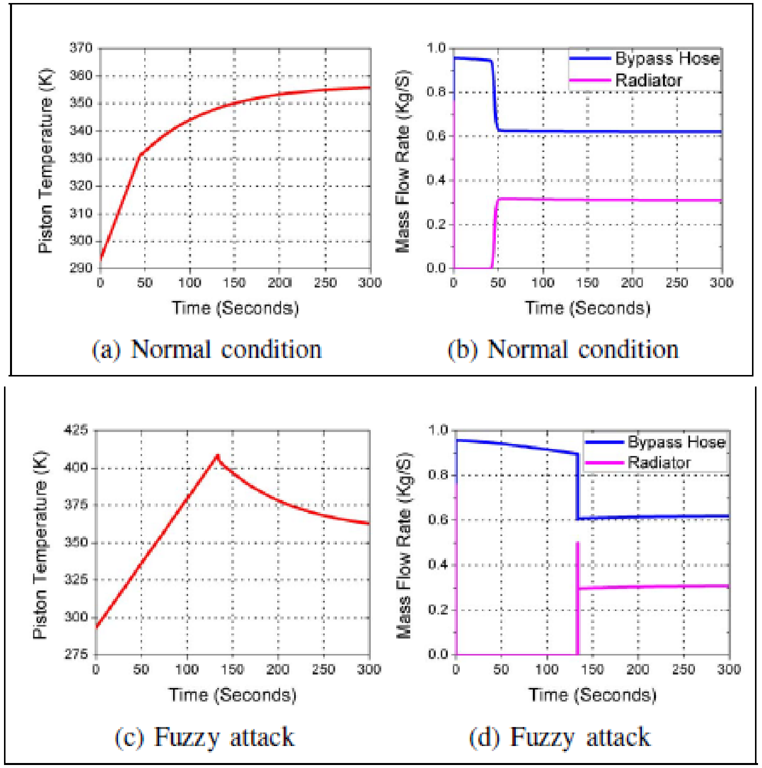
- Standard cybersecurity approaches are infrastructural in nature
- There is little emphasis on protecting the applications within specific information systems: **Cyber-physical processes are apps**
- The cybersecurity community has limited experience in securing system application functions, especially physical system control functions
- And system application designers, in general, do not have experience with designing for better cybersecurity, especially physical system designers



Example CPS Threat Pattern

The key is to create “safe” designs, not respond to known threats.





Rashid, Wan, Quiros,Canedo, Al Faruque; Modeling and Simulation of Cyberattacks for Resilient Cyber-Physical Systems

A CPS Systems Engineer must master:

- Concepts of secure access control to and use of the system and system resources (domain of system security engineering)
- Understanding of design attributes that minimize exposure of vulnerabilities to external threats (systems security engineering and dependable computing)
- Understanding of design patterns to produce effects that protect and preserve system functions or resources (dependable computing)
- Approaches to monitor, detect and respond to threats and security anomalies (cybersecurity)
- Understanding of network operations and external security services (information systems)
- Approaches to maintain system availability under adverse conditions (all of the above)

Workshop Gap Identification

Engineering education gaps related to cybersecurity

- Security concerns emerging in today's embedded systems & CPS
- Fundamental security practices
- Domain & context knowledge
- Comprehension of tools
- Software assurance
- Security evaluation & test
- Adversary pace of change
- Lack of a BoK
- Sharing of data and use cases
- HW & SW supply chain issues

Workshop 6 (Jul 31– Aug 2 2018)
State of the Engineering Workforce; Cybersecurity Engineering

Goal: Identify skill sets and curriculum needs for our current and future engineering workforce

- **Understand engineering education gaps related to cybersecurity**
- **Develop Need's for today's engineering workforce**
- **Develop Need's for tomorrow's engineering workforce**
- **Identify efforts to meet anticipated EO on America's Workforce**

Education and Training

- At the professional level:
  - —best level to introduce different disciplines and domains to the adversarial and subversion characteristics afforded by cyberspace
  - —need for development of a professional certification tailored to the needs of the CPS domain – hardware & software engineering certifications
- At the university level:
  - —teach engineers how to produce higher quality secure software, introduce fundamentals, and good coding practices in every discipline
  - —a core cybersecurity 101 course that is tailored to the discipline of interest, but cybersecurity principles should be embedded into existing curricula
- At the High School and STEM levels
  - —introduce cybersecurity hygiene and good early coding practices
  - —foster interest in secure cyber-physical systems, programs such as robotics challenges could include security challenges
  - —those with interest in coding should begin practicing safe versus vulnerable coding practices early in education

Talent Pipeline in support of the National Security Ecosystem

Selected Themes

- Talent Identification and Recruitment - Domestic and International - Protect and Promote;
- Could we identify selected 2nd Tier Universities and support them to preeminence in strategic areas;
- Engaging and nurturing promising high schoolers towards STEM, and perhaps National Security application domains;
- Modeling Policy Instruments to better understand short and long term impacts (positive and negative) on the US talent pipeline.

Talent Identification & Recruitment - Domestic and International - Protect and Promote

- We need models to identify and classify current and potential talent among students and faculty members, as well as people in industry and government
- We need multi-attribute recruiting models that reflect tradeoffs between attributes important to potential recruits and attributes of interest to organizations
- We to understand the identification and recruitment models used by others such as technology and consulting companies, including how to compete with these models

Could we identify selected Universities and support them to preeminence

- There are many ways that universities can be categorized, e.g., enrollment, revenue, endowment, brand, etc.
  - —We will use data from the Center for Measuring University Performance to explore alternative models.
- We need to understand the organizational behaviors that are to be incentivized in order identify candidates
  - —Faculty hired, programs initiated, enrollments recruited
- It is quite possible that tiering is not the best mechanism for matching behaviors & candidates

Engaging and nurturing promising high schoolers towards STEM, and National Security application domains

- We need a behavioral economics model of student decisions to apply to STEM programs, elaborating the students' tradeoffs between brand value, tuition, other costs, and career potential
- We need an institutional model to understand the economics, including incentives, for universities to develop and support STEM curricula relevant to National Security
- We need to consider the K-12 educational outcomes needed for students to apply to and succeed in STEM programs, including incentives for K-12 schools to deliver these outcomes

Modeling Policy Instruments to better understand short and long term impacts (positive and negative)

- We need policy simulators to represent and explore the dynamics of the US talent pipeline as a function of behavioral economics of students and institutions
- Key issues include the supply of students capable of entering this pipeline, the inventory of relevant programs that can educate this talent, and competing opportunities that also seek this talent
- We need to understand the policy levers available for affecting this pipeline, e.g., tuition assistance, program support, hiring standards, salaries, etc.

Questions and Discussion