

National Agenda for Software Engineering Research & Development: *Architecting the Systems of the Future*

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Imagine a Future...

- Ecosystem for Software: strategic partnerships and collaborations drive innovation among researchers, practitioners, government, funding agencies, policy makers, contractors, and commercial entities
- DevXOps is long gone; systems are well on their way to updating themselves.
- The edge is everywhere; everything has sensors; the natural and artificial worlds are mirrored in data.
- We learn from data with confidence.
- Autonomous everything is trusted.
- Software engineering creates strategic advantage for national security through rapid deployment with confidence across most systems.



CMU SEI Leadership on Impactful Studies

Defining & Using Software Measures

- **Motivation:** DARPA sponsored (Dr. Barry Boehm) measurement research program for SEI to lead and define a measurement standard for the DoD to facilitate data driven decision-making.
- **Impact:** Resulted in measurement policy and guidance for DoD programs: led national program to specify core metrics & measurement definition frameworks; developed measurement courses and training; and created a National Software Data & Information Repository.

A Process Research Framework

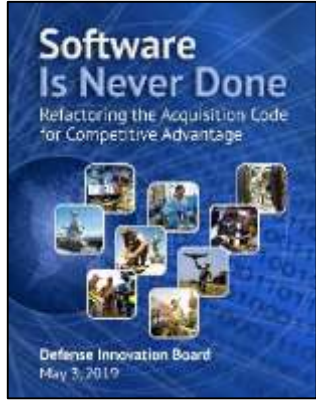
- **Motivation:** Conduct a community-wide extensive examination of software process management research.
- **Impact:** Universities, industry, and FFRDCs used the research framework to establish research programs in software process management/software development process worldwide.

Ultra-Large-Scale Systems

- **Motivation:** ASA ALT sponsored (Claude Bolton) study to design an ULS systems research agenda to enable understanding of how to construct and evolve socio-technological systems effectively.
- **Impact:** Led to new research thrusts and university curricula worldwide.



Leveraging Recent Related Studies



- 2019 Contribution:**
Software acquisition modernization
- Refactoring regulations
 - Digital infrastructure
 - Digital talent
 - DevSecOps



- 2019 Contribution:**
Roadmap for AI research and transformation
- National AI Infrastructure
 - Core AI programs
 - Workforce training



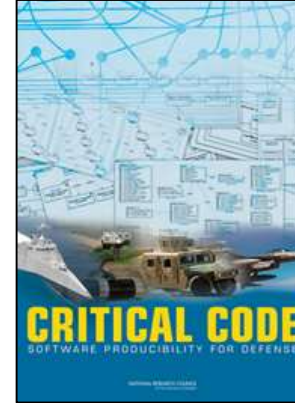
- 2019 Contribution:**
Coordinate and guide federal R&D for cybersecurity



- 2018 Contribution:**
Guide DoD digital transformation
- Formalize modeling
 - Collaborative digital infrastructure
 - Transform culture



- 2016 Contribution:**
DSB study on the applicability of autonomy to the DoD



- 2010 Contribution:**
Enable software production
- Advances for continuous improvements

Advisory Board Chosen to Maximize Success and Impact



- **Dr. Deb Frincke, Advisory Board Chair**

Associate Laboratory Director, DOE Oak Ridge National Laboratory

- **Dr. Michael McQuade**

Carnegie Mellon University Vice President for Research; Defense Innovation Board Software Action Plan Co-Chair

- **Mr. Vint Cerf**

Vice President and Chief Internet Evangelist for Google

- **Ms. Penny Compton**

Vice President for Software Systems, Cyber, and Operations, Lockheed Martin Space

- **Mr. Tim Dare**

Deputy Director for Prototyping and Software, Office of the Under Secretary of Defense for Research and Engineering; Lead of National Defense Authorization Act Section 255

- **Mr. Jeff Dexter**

Senior Director of Flight Software & Cybersecurity, SpaceX

- **Dr. Yolanda Gil**

President of the Association for the Advancement of Artificial Intelligence (AAAI); Co-author of the 20-Year Artificial Intelligence Roadmap; Director of Knowledge Technologies at the Information Sciences Institute at University of Southern California

- **Ms. Sara Manning Dawson**

General Manager, Microsoft Critical Infrastructure Engineering

- **Mr. Tim McBride**

President, Zoic Studios (Zoic is a leading visual technology firm that started out as a Hollywood special effects and visualization company and are now supporting the DoD. ZOIC is also engaged in COVID-19 tracking and visualization.)

- **Ms. Nancy Pendleton**

Vice President and Senior Chief Engineer for Mission Systems, Payloads and Sensors, Boeing Defense, Space and Security

- **Dr. William Scherlis**

Director DARPA Information Innovation Office

Approach: Designing an Effort that Leads to Execution



Soliciting Broad Engagement and Diverse Perspectives



Envisioning Success and Impact



Devising Future Scenarios Based on Key Drivers, Software Engineering Foundations, and Uncertainties

Key Drivers

- Innovation
- Deployment speed
- Vulnerability
- Reaction speed
- Global competitiveness
- ...

Software Engineering Foundations

- Architecture
- Assurance (e.g., formal methods, testing)
- Automation
- Lifecycle Approaches (e.g. DevOps)
- ...
- System types (e.g., safety-critical, AI/ML, data-intensive, real-time, distributed, ...)

Uncertainties

- Level of international collaboration/cooperation across nations
- Supply chain – software research, talent
- AI/ML (driving software automation and innovation; including access to data and privacy)
- Software producibility for a broader array of people
- Funding and partnership (industry-driven research; government investment in research)
- Data as a strategic asset
- Societal consequences of software deployment
- Engineering of systems
- Access to technology and connectivity
- ...

Potential Agenda Components*

Roadmap

Motivation

Focus

Alternative futures

Software engineering challenges

Research priorities

Research infrastructure

Action plan

*Inspired by, Gil, Yolanda, and Bart Selman. "A 20-Year Community Roadmap for Artificial Intelligence Research in the US." *arXiv preprint arXiv:1908.02624* (2019).



Moving Forward



Feedback Requested

Please send your ideas about the National Agenda for Software Engineering R&D, or respond to the questions below, by emailing **info@sei.cmu.edu**.

1. How will software systems of the future be developed, assured & analyzed, and deployed?
2. What are key technical challenges and breakthrough ideas in software engineering? (for example, in areas such as architecture, assurance, acquisition, model-based software engineering, autonomy, DevSecOps, AI, resilience, etc.)
3. What other types of advances aren't on our radar yet – but should be?
4. Discuss ideas for a research roadmap: How can we energize and coordinate needed constituencies to achieve the desired future?

As part of the software engineering community, we would appreciate your ideas, feedback, and input.

