

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

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CMU SEI is Leading a Study that Will Redefine How Software is Developed

- **Software is vital** to America's global **competitiveness, innovation, and national security**.
- Our ever-growing **dependence on software** systems makes it **imperative to maintain our nation's leadership and strategic advantage** in software engineering.
- **Future systems** and **fundamental shifts** in software engineering **require new research focus**.
 - Rapidly deploying software with confidence requires fundamental shifts in software engineering.
 - New types of systems will continue to push beyond the bounds of what current software engineering theories, tools, and practices can support, therefore **CMU SEI is leading a study that will redefine how software is developed**.
- SEI's mission includes **anticipating current and future needs of DoD in software engineering**.
- Prior to the NDAA FY20 Section 255 mandate, SEI kicked off the National Agenda for Software Engineering R&D Study **to address the future challenges of software engineering**:
 - How will software systems of the future be developed, assured, analyzed, and deployed?
 - What are the major open problems and "grand challenges" that software engineering must address?
 - What software research is needed to invent solutions for these challenges?
 - What role should industry play in adopting those solutions? What role should the government play?
 - How can we incentivize strategic partnerships and collaborations between government, academia, and industry?

Architecting the Systems of the Future

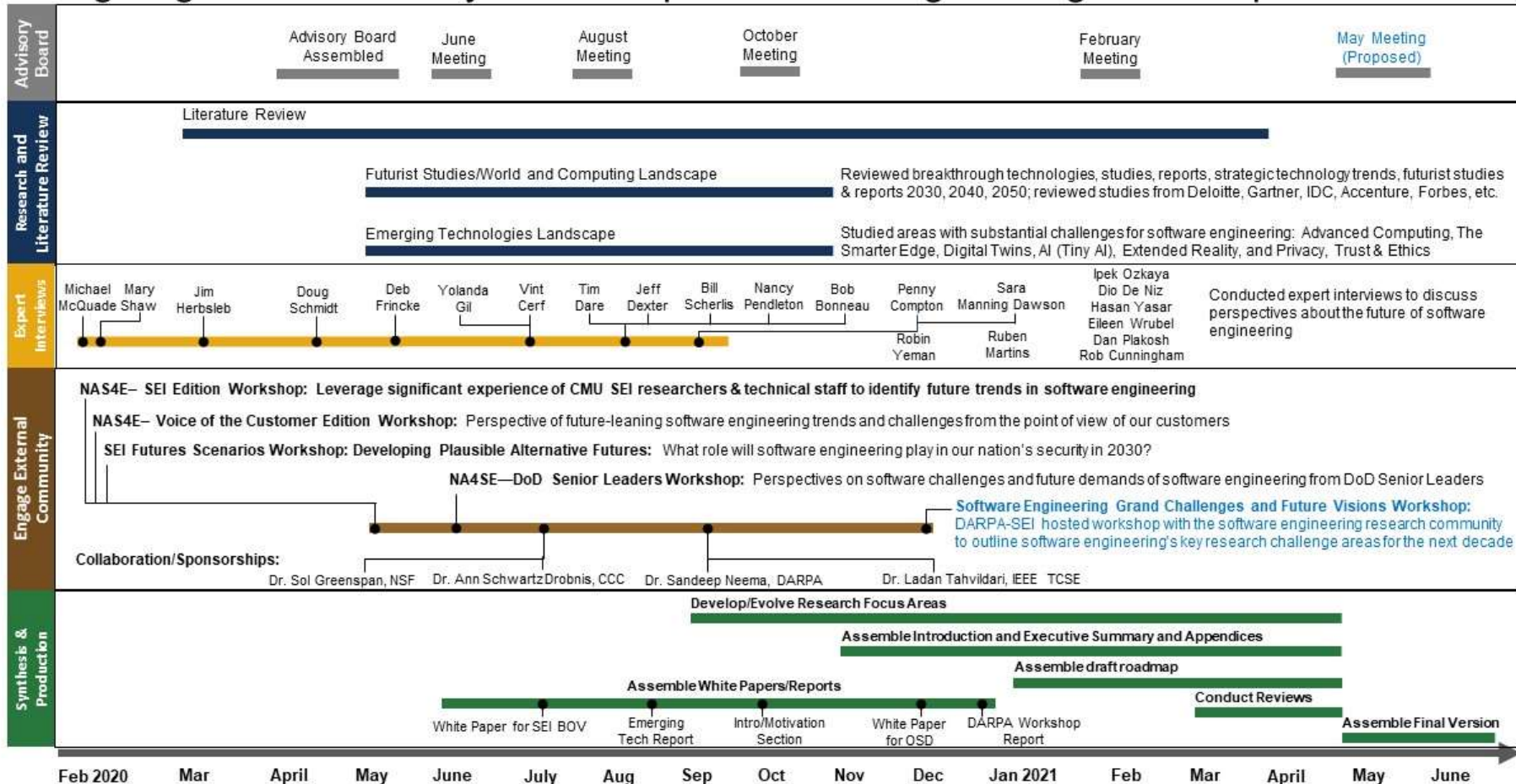
Software is vital to America's **global competitiveness**, **innovation**, and **national security**. The economy, the nation's infrastructure, education, and healthcare all depend on software.



Lead a community effort to:

1. **Identify future challenges** in engineering software-reliant systems.
2. Develop a **research roadmap** that includes important research milestones in meeting the anticipated software challenges of the future.
3. Devise a plan for **creating an ecosystem** where policy makers, practitioners, research funders and researchers are incentivized to cooperate in a way that simultaneously advances the states of the art and practice in software engineering resulting in more trustworthy software-reliant systems.

Energizing the Community to Develop Software Engineering Roadmap



Guided by an Advisory Board of Visionaries and Senior Thought Leaders



- **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**
[Previous] 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

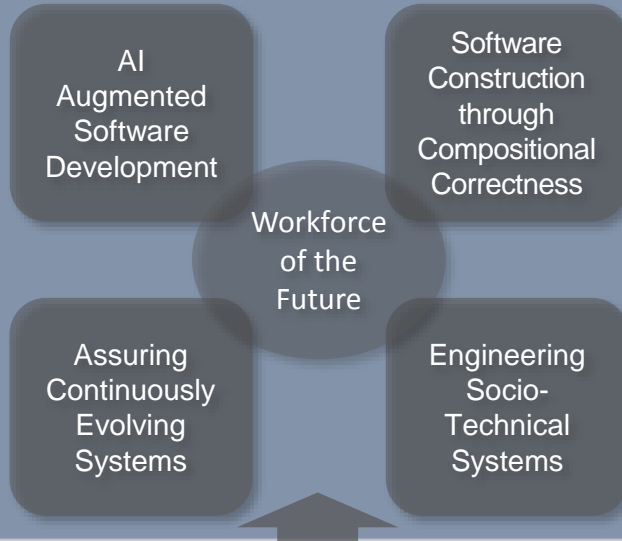
Roadmap Vision and Research Focus Areas



Fundamental Shifts Driving Research Focus

- **AI-inspired automation**
- Impact of **cyber-social platforms** on social behavior
- **Continuous evolution**
- **Evidence-based assurance** that a system behaves as intended
- **Scale** motivating the need for software composition
- Addressing **workforce gap in software talent**
- Primacy of data—**data is becoming as important as code**

Software Engineering Research Focus Areas



Foundations and Enablers of Current Software Engineering Practice

- | | |
|-------------------------------------------------------------|---------------------------------------|
| Flexible, Evolving Architectures | Measurement and Analysis |
| Technical Debt Analysis | Model Checking |
| DevSecOps | Software Verification |
| Model-Based Software Engineering | Assurance Practices |
| Causal Modeling for Cost Prediction & Control | New Acquisition Pathways for Software |
| Cyber-physical, edge-enabled, real-time, multi-core systems | |

Guiding Vision

The current notion of software development will be replaced by one where the **software pipeline consists of AI and humans collaborating to continuously evolve the system.**

- Software-enabled systems are even more **pervasive** than today with **levels of trust commensurate with the importance of the decisions they make.**
- **Software and humans become mutually trustworthy peers** comprising socio-technical ecosystems **where human expressions of intent are reliably understood.**
- **Socio-technical platforms enable collaboration** at scale leading to socially resilient, ethical, and unbiased behavior.
- **Compositional correctness and continuous reflection** allow intelligent systems **to learn from experience** and continuously (mostly) **automatically improve.**