

Workshop on Software Engineering Grand Challenges and Future Visions

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Dr. Sandeep Neema
DARPA

Dr. Forrest Shull
Carnegie Mellon University /
Software Engineering Institute

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

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Motivation

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.

“The U.S. Air Force (USAF) recognizes that to continue to be a world-class fighting force, it needs to be a world-class software developer.”

Source: National Academies of Sciences, Engineering, and Medicine. 2020. *Air Force Software Sustainment and Maintenance of Weapons Systems*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25817>.

Being a world-class developer will be especially critical for the future as systems will provide greater capabilities, be more data intensive and inter-connected, increasingly utilize AI/autonomy, require larger scale integration, need to be more resilient, and be increasingly edge driven.



Envisioning Success and Impact

Our goal for this workshop: Bring together a broad spectrum of software experts who can challenge or confirm each others' thinking, to:

- Serve as a catalyst for the software engineering community to **create a compelling multi-horizon vision, strategy, and roadmap** for the research and development of next-generation software and software reliant systems on which national security depend.
- Contribute to the development of an ecosystem for software engineering that **engages academic, defense, and commercial communities** to work together on solving future problems and developing critical abilities.
- **Contribute to national security** by informing future decisions, policies, and investments in software engineering.

Future of Software Engineering

1. How will software systems of the future be developed, assured, analyzed, and deployed?
2. What are the major open problems and “grand challenges” that software engineering must address? Examples of open problems include (but are certainly not limited to):
 - *Could humans describe intent and rely on automation to instantiate software that performs as needed?*
 - *What standards are needed – and at what level of granularity – to support easy composability and interoperability among future systems and system behaviors?*
 - *Where will sensors be more commonplace and what will “smart” systems do with their data streams?*
 - *How much can data collection and cleansing be automated to make learning systems truly ubiquitous?*
 - *What will the software engineering workforce of the future look like, and how will we build it?*
3. What software research is needed to invent solutions for these challenges?
4. What role should industry play in adopting those solutions?
5. What role should the government play?
6. How can we incentivize strategic partnerships and collaborations between government, academia, and industry?



Anticipated Outcomes

“Grand challenge statements” and “vision statements”

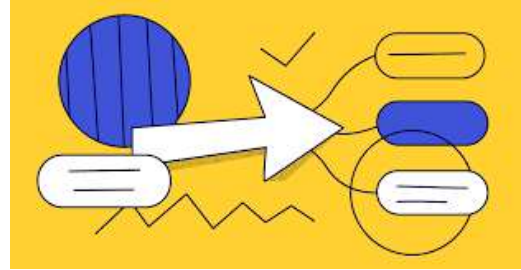
- **What are they?**

Pithy scenarios that describe

- (1) important class(es) of future software- and software-reliant systems and
- (2) the software engineering research areas, methods, tools, and practices that are needed to make those systems feasible.

- **How will they be used?**

- (1) Inputs to ongoing efforts to define new research programs and initiatives in new areas, that can shape the future of software engineering
- (2) Inputs to the SEI research roadmap that will help us close the gap between today’s capabilities and the futures we envision.



Virtual Workshop Overview

- Day 1: **Seeding the Discussion** – Lightning talks from participants on grand challenges and future visions
- Day 2: **Thinking Broadly** – Breakout groups to generate future scenarios, identify many possible research gaps
- Day 3: **Converging** – Deeper dives on the most important research gaps; discussing how we get from here to there



Potential Drivers

What will drive software-reliant systems, and their development and evolution of the next 10-20 years?

- Scale
- Speed of evolution
- Data
- Multi-level reflection
- Socio-technical perspective
- Personalization
- AI
- Heterogeneous tiered workforce
- Uncertainty
- Heterogeneity

Enduring principles

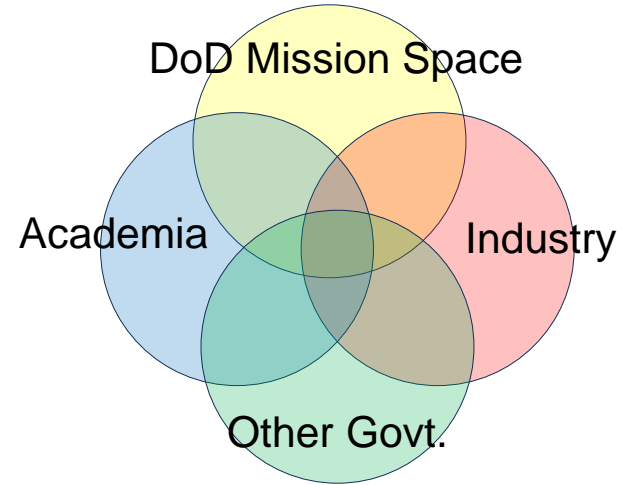
- **Architecture**
- **Assurance**
- **Automation**



Please Keep in Mind...

Remember that we have many different communities participating

- Avoid jargon, insider terms, acronyms...
- Be open to different perspectives & look for connections
- Think strategically and help others do the same
- Recognize that we all have our blinders
- Try to abstract up from specific context and concerns
- Think broadly – Try to represent the work of others in your field



Above all – Please engage and participate fully!

Communication Channels

- Feel free to use the Zoom chat to start side discussions with participants – Can help surface other topics and important points
- Any technical difficulties during the workshop – contact Michele Falce: mbaker@sei.cmu.edu
- General comments, feedback – contact me: fjshull@sei.cmu.edu



Discussion Session 1: Scenarios of Future Software Needs

45 minutes

Random assignment to groups – Check your agenda.

Expected output:

- 3-5 different types of systems that will be important in the future, with some notion of important characteristics, to set the context for future discussion
- 5 minute presentation back to the larger group

Discussion Session 1: Scenarios of Future Software Needs

45 minutes

Focus questions:

- What kinds of systems and/or capabilities will be built in the future?
- What “ilities” will be most challenging: Security? Reliability? Sustainability? ... What will be the new concerns as we look 10-plus years ahead?

Discussion Session 2: Identifying a broad set of research priority areas and challenge problems

1 hour

Random assignment to groups – Check your agenda.

Expected output:

- High-level descriptions of as many different research challenge areas as desired.
 - E.g., *AI-enabled edge systems can be relied on to collect potentially noisy data from which context dependent inferences and decisions are autonomously made. This requires computational mechanisms to ensure privacy, integrity and timeliness; to predict potential consequences of decisions; and to understand when to ask for human assistance.*
- 5 minute presentation back to the larger group
- Outcomes will be combined with those of other groups and we will vote to select a few for a deep dive.

Discussion Session 2: Identifying a broad set of research priority areas and challenge problems

1 hour

Focus questions:

- Why can't we build the types of systems described in the previous session today? What research will be needed before we can?
- Who are the key stakeholders? (Who has the problem? Who would fund? Who can evaluate feasibility of solutions?)
- Are there key challenge statements that could be formulated, which if addressed would be effective milestone markers to show researchers are on track to solve these problems?

Discussion Session 3: Deep dive on research priority areas and challenge problems

45 min (Wed) + 1.25 hr (Thurs)

Go to whichever discussion topic sounds most interesting to you!

Expected output:

- Notes on an embellished description of the priority area: What does success look like; what kind of challenge could show we are making progress; what dependencies exist; what national strategic benefits will be affected?

Discussion Session 3: Deep dive on research priority areas and challenge problems

45 min (Wed) + 1.25 hr (Thurs)

Focus questions to embellish the research challenge description:

- How will we know when or if we have success? What is a plausible timeframe?
- What dependencies exist (e.g., progress on other research that would make this breakthrough more likely)?
- What capabilities will be available? What national strategic benefit and/or risks would be associated?
- Could being successful at this challenge lead to follow-on effects that would require additional research to address?

Discussion Session 4: How We Get from Here to There

1 hr

Plenary discussion

Focus questions:

- How will the needed work be done? What new kinds of research methodologies will need to be employed or developed?
- Can university research (or private companies) close the gap if they continue operating as today?
- What are the potentials for collaborative work? What kind of resources would help (e.g., data repositories, testbeds, etc.)?
- What level and types of funding are needed?