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NSF Engineering Research
Visioning Alliance

AI Engineering

A Strategic Research
Framework to Benefit
Society

Executive Summary



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Executive Summary

The strategic convergence of artificial intelligence (AI) and engineering, envisioned as *AI Engineering*, represents a generational opportunity to supercharge engineering for the benefit of society through enhancements to national competitiveness, national security, and overall economic growth. *AI Engineering* is a nascent field arising from this convergence and synthesis that will advance our nation's interests by leveraging the traditional strengths of engineering disciplines with breakthrough developments in the field. *AI Engineering* will be bidirectional and reciprocal: it evokes a future vision in which an engineering approach makes for better AI while AI makes for better-engineered systems. *AI Engineering* is based on the firm commitment of engineering processes and culture to ethics of safety, health, and public welfare and is a principal term used throughout this report.

Engineering for AI. Engineering disciplines will bring their domain knowledge, techniques, tools, and culture to the creation of new forms of explainable, trustworthy, and reliable AI-enabled cyber-physical systems. Knowledge, tools, and techniques from engineering will revolutionize the hardware on which AI is realized. Building on existing connections between AI and engineering fields such as signal processing, information theory, and control theory, the next generations of AI methods, models, and algorithms will be created. The most important benefits of these interdisciplinary fusions will come via the increased assurances of safety, reliability, and trustworthiness, as well as energy efficiency and environmental sustainability of AI-enabled cyber-physical systems.

AI for engineering. Increasingly capable AI tools can transform fundamental disciplines of engineering science. They will also transform major engineering endeavors of design, manufacturing, and infrastructure. These changes will impact the cost, performance, efficiency, customizability, and sustainability of engineered products and



systems. They will also significantly enhance the productivity and capabilities of engineers across the full spectrum of the discipline: practicing engineers, engineering researchers, engineering educators, and engineering students.

The U.S. engineering enterprise is positioned to lead in the research and education necessary for the creation and development of *AI Engineering*, thereby enhancing U.S. leadership in AI and engineering technologies. Engineering researchers must assist with defining future AI systems through the evolution of existing and new systems, even as they employ existing AI systems to help drive the future of engineering.

AI Engineering has the potential to impact each of the [14 grand challenges](#) articulated by the National Academy of Engineering. To define *AI Engineering*, develop key strategies and initiatives, and identify innovative lines of research, a group of researchers, industry leaders, policymakers, and other stakeholders were brought together on Nov. 7-8, 2023, at a visioning event convened by the [Engineering Research Visioning Alliance](#) (ERVA). During the two-day event, 28 participants generated and refined critical grand challenges at the intersection of engineering and AI that face engineering researchers now and in the next decade. These are listed below and explained in more detail in the full report.

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Grand Challenges

01

Design, Manufacturing, and Operations

- Design safe, secure, reliable, and trustworthy AI systems.
- Transform manufacturing quality, efficiency, cost, and time-to-market through *AI Engineering*.
- Build and operate AI-engineered systems with cradle-to-grave state awareness.
- Overcome scaling challenges in engineering.

02

AI Engineering for Humans and Society

- Construct engineered systems for safe, reliable, and productive human-AI team collaboration.
- Mitigate rare event consequences via AI.
- Incorporate ethics in all facets of *AI Engineering*.

03

National Initiatives for AI Engineering

- Enable collection, curation, and sharing of datasets to advance *AI Engineering*.
- Ensure equitable access to computational resources for *AI Engineering*.
- Develop engineering domain-specific foundation models.
- Establish dedicated research institutes for *AI Engineering*.
- Create new education and training programs for *AI Engineering*.

Taking Action

To realize these visions of progress in *AI Engineering*, it is incumbent upon leaders of government, universities, industry, and nonprofits, as well as professional engineering societies, to seize this generational opportunity, both in their sectors and in cross-sectoral collaborations.

Government

Breakthrough progress in both directions—engineering research for new AI, and AI for engineering research—should be enabled through targeted research and development programs at both state and federal levels, as well as computational infrastructure (e.g., GPU-based supercomputers available for research activities). Establishing new federal government programs (perhaps complemented by those at the state level or by private funders) to create multidisciplinary *AI Engineering* research institutes is both timely and urgent. Engineering leaders in government can also create in-house programs with a focus on *AI Engineering* to achieve their particular missions.

Industry

Industry leaders should create research and development programs to build capacity for breakthrough developments in *AI Engineering* in their specific industry sectors. They will need to bring cross-organizational and multidisciplinary focus on data, design, testing, and operations to both lead and take advantage of *AI Engineering*. This will be crucial for timely delivery of highly efficient, cost-optimized, and high-quality AI-engineered products and systems to market. Leveraging *AI Engineering* will dramatically enhance practicing engineers' productivity and capabilities.

Academia

Academic leaders must enable the full development of *AI Engineering* through their institutions' research, education, and service missions. Creation of multidisciplinary research programs and dedicated research institutes will enable their faculty, students, and staff to create the foundations of *AI Engineering*. They should also create education and training programs (degrees, certificates, continuing education, short courses) for their students and faculty as well as for their industry partners. They can leverage aspects of *AI Engineering* while empowering their local and regional innovation ecosystems.

Sector Convergence

In addition to work within their respective spheres, leaders from government, universities, industry, civil society, and nonprofits must collaborate to ensure successes. Strategic alignments among these sectors will energize collaborative efforts and will be essential to secure the financial, technological, organizational, and human resources needed to fully realize the *AI Engineering* vision. By garnering such resources, progress will be transformative. This sector convergence approach will facilitate a crucial element of the *AI Engineering* enterprise: the computing power and generation, collection, and curation of datasets for engineering-specific AI tools. For example, development of *AI Engineering* would benefit from an educational model in which government, industry and academia join together more tightly and at greater scale to support training for research engineers in this important, emerging discipline. Whether they have just received their bachelor's degree or have been working for decades, this next generation of students will pioneer *AI Engineering* through a training experience marked by crossing boundaries that had previously separated government, industry, and academic research campuses. Given intense global competition, a fully dedicated government-university-industry collaboration will put the U.S. engineering enterprise at a significant advantage. The immense vision and promise of *AI Engineering* dictate that we not miss this generational opportunity.



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Our mission is to identify and develop bold and transformative new engineering research directions and to catalyze the engineering community's pursuit of innovative, high-impact research that benefits society.



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