MITRE's Response to the OSTP RFI Seeking Comments on the Draft National Strategy on Microelectronics Research

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About MITRE

MITRE is a not-for-profit company that works in the public interest to tackle difficult problems that challenge the safety, stability, security, and well-being of our nation. We operate multiple federally funded research and development centers (FFRDCs), participate in public-private partnerships across national security and civilian agency missions, and maintain an independent technology research program in areas such as artificial intelligence, intuitive data science, quantum information science, health informatics, policy and economics, trustworthy autonomy, cyber threat sharing, and cyber resilience. MITRE's 9,000-plus employees work in the public interest to solve problems for a safer world, with scientific integrity being fundamental to our existence. We are prohibited from lobbying, do not develop or sell products, have no owners or shareholders, and do not compete with industry. Our multidisciplinary teams (including engineers, scientists, data analysts, organizational change specialists, policy professionals, and more) are thus free to dig into problems from all angles, with no political or commercial pressures to influence our decision-making, technical findings, or policy recommendations.

MITRE has supported microelectronics (uE) research for multiple federal agencies for several years, as well as performed independent research aimed to support national efforts in the development of new architectures and manufacturing technologies. Focusing on critical supply chain risks, MITRE is investing in rapid prototyping and integrated circuit design to push the development and production of key technologies on U.S. shores. Most recently, our tech foundation for public good, MITRE Engenuity, convened a cross-sector collaboration (The Semiconductor Alliance) of leading U.S. semiconductor companies to help ensure that U.S. taxpayer investments in uE will achieve national economic growth and technology leadership for decades to come.[1]

Introduction and Overarching Recommendations

> "Three technology battlegrounds today – **microelectronics,** fifth-generation wireless technology (5G), and AI—tell the story of a nation (and its allies) coming perilously and unwittingly close to ceding the strategic technology landscape and along with it the capacity to shape the future."[2]

The economic, military, and commercial sectors in the United States are entirely dependent on advanced uE. At present, the United States is the world leader in uE fabless and system chip design' we have leading logic, memory and analog manufacturers; and lead the development and production of tools and semiconductor process equipment. We also lead the world in a range of uE technologies such as optical materials, advanced materials for radio frequency sensing, and communications. The United States also has notable weaknesses in other regards, however, such as workforce, supply chain security, significant foundry capacity, semiconductor packaging manufacturing, flexibility to adjust production capacity across vendor lines, raw materials supply

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[1] Intel, Micron and Analog Devices Join with MITRE Engenuity's Semiconductor Alliance to Define Principles for Joint Research and Collaboration for a More Resilient U.S. Semiconductor Industry. 2022. MITRE, https://mitre-engenuity.org/blog/2022/04/06/intel-micron-and-analog-devices-join-mitre-engenuitys-semiconductor-alliance/. Last accessed September 30, 2022.

[2] Mid-Decade Challenges to National Competitiveness. 2022. Special Competitive Studies Project, https://www.scsp.ai/wp-content/uploads/2022/09/SCSP-Mid-Decade-Challenges-to-National-Competitiveness.pdf

and key materials for semiconductor processing, and limited or no manufacturing capacity for some cutting-edge tools.[3]

We are dwarfed by Taiwan, where foundries manufacture the majority of the leading-edge silicon chips for customers across the globe: "All high-end chip manufacturing [is] done by a few companies located in East Asia. 98 percent of the chips the Pentagon needs are now built, assembled, or packaged in the PRC's shadow."[4]

Although the United States continues to lead in world-class R&D in our academic, industrial and governmental institutions, a chasm also remains between fundamental research and commercialization of uE technologies, which impedes capitalizing on these advanced technologies within the United States.

MITRE has studied these issues in detail so that we can properly scope our independent and Alliance activities to best support national-level objectives. It is with this foundation that we reviewed the draft *National Strategy on Microelectronics Research*. Overall, we found the document to be accurate, comprehensive, and without major omissions, and we provide recommendations to further enhance the document and its impact in the remainder of this document.

Questions Posed in the RFI

2. What additional approaches should be considered to develop and expand the microelectronics workforce at all levels, including advanced degrees?

We have identified six primary challenges in creating the required workforce for national security objectives:

(1) Federal investments are more likely to meet the needs of the private sector, which is often better positioned to recruit and retain talent, while not meeting the needs of the Federal Government, particularly national security needs. Much of our federal investment in Science, Technology, Engineering, and Math (STEM) occupations is from the Department of Defense (DOD) under the assumption that generalized STEM funding will meet the DOD's objectives. In many cases the funding has the intended impact of growing the workforce, but many of the benefits go to the private sector, not fully addressing the needs of the DOD. Given that growth in demand for microelectronics in 2021 was 26.2%, and there is no evidence of that rate waning,[5] the Defense Industrial Base faces strong competition from the private sector, which often can offer higher salaries and stronger employer brands. Moreover, the DOD workforce needs are not specifically known due to the lack of data on the size of workforce gaps within critical occupations (e.g., material scientists, chemical engineers, mechatronics, physicists).

(2) Federal funding is not managed to maximize return on the investment due to both gaps and redundancies in targeted audiences. For example: as there is no centralized organization point,

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[3] C. Ford, C. Clancy, and D. Blackburn. A "Horizon Strategy" Framework for Science and Technology Policy for the U.S. Innovation Economy and America's Competitive Success. 2021. MITRE, https://www.mitre.org/sites/default/files/2021-11/prs-21-1440-horizon-strategy-framework-science-technology-policy.pdf.

[4] *Mid-Decade Challenges to National Competitiveness.*

[5] S. Davis. Nearly $11M in Additional DOD Funds Expands Purdue-led Microelectronics Workforce Program. 2022. Semiconductor Digest, https://www.semiconductor-digest.com/nearly-11m-in-addtional-dod-funds-expands-purdue-led-microelectronics-workforce-program/. Last accessed October 13, 2022.

funding efforts are often duplicative (e.g., multiple efforts targeting the same handful of Historically Black Colleges and Universities [HBCUs]) and fail to be collectively exhaustive (e.g., leaving out the majority of the 140 HBCUs).

(3) Generalized funding may not address career fields needed only in the federal sector, such as acquisition professionals with proficiency in microelectronics-related contracts and defense technology strategies.

(4) Current strategies ignore structural changes in applied science education, such as the need for more applied materials scientists, quantum engineers and masters level quantum physicists, and mechatronics specialists. Longstanding educational stovepipes also hinder the cross-cutting work (converging applied science with both theoretical science and engineering) that is required for this topic.

(5) The workforce is global in nature, and foreign workers from "friendsourcing" countries will be needed to meet the U.S. workforce demand, at least in the short-term.

(6) The United States requires foreign talent to bridge the gap between the current U.S. based workforce and the one that can be built over the next decade. Incentives to retain foreign talent should be considered, as it will be a challenge to maintain a well-trained workforce without them. As more fabs are being built around the world, they will be looking for the same semiconductor related talent. Historically, the United States has benefited from issuance of H1-B visas enabling foreign talent to work in the United States. India accounts for 74.5% of total H1-B visas (China holds an additional 11.8%).[6] With India recently announcing a $25 billion investment for semiconductor fab(s), existing H1-B visa holders in the United States may be looking to return to India. In addition, future H1-B visa applications may be reduced, further limiting the U.S. talent pool.

These issues could be further analyzed through a workforce study of the requirements of the Defense Industrial Base, measuring gaps both five and ten years into the future with appropriate strategies to address the gaps.[7] Such a study could help tie DOD efforts[8] to demand signals by occupation that specifically address the requirements of the Defense Industrial Base—the workforce most critical to address national security concerns in microelectronics. In similar studies, MITRE estimated the size of the workforce in critical occupations and then adapted futuring techniques to project gaps between supply and demand. Data from such studies can be used to prioritize the gaps and view those gaps in the context of other critical technology areas, as many of the occupations will overlap. This analysis would then inform selection of effective strategies in K–12, higher education, and the skilled technical workforce, as well as estimate needs for foreign talent.

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[6] H-1B Petitions by Gender and Country of Birth Fiscal Year 2019. 2020. U.S. Citizenship and Immigration Services, https://www.uscis.gov/sites/default/files/document/data/h-1b-petitions-by-gender-country-of-birth-fy2019.pdf

[7] MITRE has completed similar studies for the Undersecretary of Defense for Research and Engineering in quantum information science, biotechnology, and 5G.

[8] Example: the Scalable Asymmetric Lifecycle Engagement Microelectronics Workforce Development program, which targets the university, K–12, and community college levels.

3. Are there additional mechanisms that should be considered to ensure rapid transition of R&D to industry?

While it has been noted that "Research protection remains paramount" within the document, cases will occur in which decisions will have to be made regarding the control of newly discovered materials that may have significant impact on national security systems. Such materials should be controlled from the earliest point during research to minimize intellectual property sharing of potentially critical information. To this end, a risk-related framework for identifying the technology, the current state of research, and potential risk versus benefit of continuing without special controls should be considered. Such a framework could enable quicker decision-making on the releasability of the material for rapid transition to industry through predetermined processes and vetting with appropriate subject matter experts.

4. Do you have any additional suggestions on how the final National Strategy can help ensure the success of the broader CHIPS efforts and ensure continued U.S. leadership in this important area?

The national strategy requires a national approach. Meeting the nation's research needs for uE requires a national-level effort: a synergy between government, industry, and academic activities to holistically address our nation's most critical science and technology (S&T) priorities—while safeguarding the intellectual property, privacy rights, and autonomy of all participants and stakeholders. This new partnership will need to prioritize and steer federal research and development (R&D) funding to overcome weaknesses in the current innovation model and to bring the requisite integrative, "system-of-systems thinking" to bear.[9]

Better collaboration between the Federal Government and non-governmental entities requires enhanced Federal Government coordination, setting new expectations for federal S&T programs, and creating a framework to speed delivery of new discoveries and technological advances into the hands of American consumers; enterprises; and state, local, and national leadership. The National Science and Technology Council (NSTC) has been quite influential in coordinating the Federal Government's R&D efforts on priority topics for several decades but has predominantly focused internally throughout its existence—but not always.[10] Given the criticality of uE research and the clear need for public-private research collaboration, MITRE strongly recommends that OSTP extend the NSTC's focus beyond internal federal coordination and into also supporting strategic public-private collaboration. As the NSTC's work continues to expand and mature, OSTP may want to consider creating a supporting coordination office to both support the subcommittee's work and to serve as a central location to help coordinate public-private collaboration.

Ensure an adequate workforce. Given that this workforce is largely located overseas, implementation of a streamlined work visa program to attract international talent while the nation builds the permanent U.S. workforce could allow the United States to more rapidly fill the immediate workforce need while still addressing long-term requirements. A survey conducted in 2017, for instance, found that 82% of semiconductor industry executives reported a shortage of

[9] *A "Horizon Strategy" Framework for Science and Technology Policy for the U.S. Innovation Economy and America's Competitive Success*

[10] D. Blackburn and M. Garris. A National Science and Technology Council for the 21st Century. 2021. MITRE, https://www.mitre.org/sites/default/files/2021-09/pr-21-2388-national-science-technology-council.pdf.

qualified job candidates, driven by an insufficient number of U.S. students completing advanced degrees in relevant fields and possessing relevant skills, as well as difficulty recruiting foreign students trained at U.S. universities.[11]

Address supply chain security appropriately and systematically. MITRE has supported supply chain security research and assessment for many federal agencies for decades, as well as worked with industry and standards groups to evolve our national capabilities in addressing supply chain security. We developed the Supply Chain Security System of Trust Framework[12] to support the challenge of addressing the appropriate supply chain risks in a consistent, scalable, and evidence-based manner. This framework is aimed at defining and addressing the specific concerns and risks that stand in the way of organizations' trusting suppliers, supplies, and service providers—a facet of increasing relevance in the uE sector. More importantly, it offers a comprehensive, consistent, and repeatable methodology for evaluating both suppliers and service providers. MITRE recommends that any organization that procures technology for critical industries like uE explore the application of this framework when analyzing and addressing their supply chain risks.

Adopt time-based strategies. The investments being made via the CHIPS Act and elsewhere have the strategic goal of continuing U.S. leadership in this domain, but greater focus is needed on anticipating and coordinating the time to maturity and lifetime sustainability of the investments. For example, CHIPS Act investment in increasing availability of domestic state-of-the-art microelectronics manufacturing will lead to ground being broken today, but facilities that do not come online for two to three years—these will have operational lifetimes extending beyond the support of the CHIPS Act. Similarly, R&D investments in semiconductors typically take ten to fifteen years to transition to high-volume commercial availability; even if CHIPS Act investment accelerates this timeframe, commercial solutions will not materialize in the market until after the current tranche of funding is spent.

Develop a detailed implementation plan. The most effective NSTC Subcommittees usually craft implementation plans to accompany their published strategies. These plans articulate the planning and forethought required to materialize the parallel investments in R&D, commercialization, mass manufacturing, finance, and workforce, each of which has differing requirements in scale, lead time, and sustainment. They also often assign roles and responsibilities to federal agencies for each outcome in the critical path, which not only helps set expectations but also provides OSTP and OMB a roadmap to ensure adequate resources and attention will be given as the Subcommittee pursues its work. MITRE recommends developing a supporting implementation plan for this strategy.

[11] C. Richard, K. Ramachandran, and I. Pandoy. Looming Talent Gap Challenges Semiconductor Industry. 2018. Semiconductor Industry Association, https://www.semi.org/en/workforce-development/diversity-programs/deloitte-study. Last accessed September 30, 2022.

[12] Supply Chain Security System of Trust. 2022. MITRE, https://sot.mitre.org/. Last accessed: October 13, 2022.