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Introduction

Chair Cantwell, Ranking Member Cruz, and Members of the Committee, it is a privilege to appear before you today to discuss the National Science Foundation's implementation of the CHIPS and Science Act of 2022, and how the agency is building upon decades of successful investments in science, engineering, and technology to ensure that the United States remains the global leader in innovation into the future.

Established by the National Science Foundation Act of 1950 (P.L. 81-507), the National Science Foundation (NSF) is an independent federal agency charged with the mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF is unique in carrying out its mission by supporting research across all fields of science, technology, engineering, and mathematics (STEM), and at all levels and settings of STEM education. NSF investments contribute significantly to the economic and national security interests of the Nation, and the development of a future-focused science and engineering workforce that draws on the talents of all Americans.

For more than seven decades, NSF has been a critical component in powering the United States economy, transforming American lives, and securing the national defense. Many of the technological advances from which the Nation is benefiting from today, such as Artificial Intelligence (AI), Quantum Information Science, and Biotechnology, are rooted in sustained NSF investments. However, we currently face intense global competition in the race to develop the next breakthroughs in these key technology areas and to grow the workforce needed to unlock these innovations. Our success in enabling scientific breakthroughs and accelerating these and other

technological developments is central to our economic and national security and our continued global leadership.

With the passage of the CHIPS and Science Act of 2022, Congress put in place a roadmap for meeting this challenge while also spurring innovation in all communities throughout the country. The law codifies NSF's new Directorate for Technology, Innovation, and Partnerships (TIP), and positions the agency to capitalize on the uniquely American research and innovation ecosystem that includes academia, private industry, the government, civil society, and other partners to shape future research directions and quickly translate research outputs into impacts that benefit the Nation. The law also reaffirms our commitment to exploratory-based, discovery-driven research that is foundational to advancing progress. NSF is unique in how the agency invests in research across every STEM discipline, and the CHIPS and Science Act challenges us to invest even more intentionally across all geographic boundaries and socioeconomic groups. Through such investments, NSF plays a major role in inspiring and training the next-generation STEM workforce – through K-12 informal STEM education, technical training, support for master's and Ph.D. students, and adult and continuing education, including experiential learning, enabling reskilling and upskilling of the current workforce. NSF's role in workforce training has become increasingly important with the significant investments in semiconductor manufacturing, which will require strong partnerships between the federal government, academia, and private industry to train the needed workforce. The CHIPS and Science Act provided $200 million for the CHIPS for America Workforce and Education Fund, and NSF is using the $50 million provided over Fiscal Years 2023 and 2024 to leverage additional resources, including more than $145 million in partnerships with the private sector, to address the needs of the semiconductor industry.

Over the past year, with the increased funding the agency received in the FY 2023 Omnibus Appropriations Act, NSF has been able to make significant progress in implementing the CHIPS and Science Act. The agency has moved quickly to expand the TIP Directorate by launching new opportunities for innovation while engaging industry, academia, philanthropies, and others to ensure the broadest possible impact of these critical investments. The agency has also moved swiftly to implement research security measures to safeguard taxpayer investments and has conducted outreach, education, and training throughout the research enterprise while strengthening agency oversight measures. In addition, NSF continues to prioritize engaging talent and inspiring the STEM leaders of the future throughout the Nation – from all geographic and demographic backgrounds – to ensure we are training the domestic workforce needed for our future competitiveness.

Ensuring U.S. Leadership in Innovation

With the support of the Administration and Congress, NSF launched its first new directorate in more than thirty years. The new Directorate for Technology, Innovation, and Partnerships (TIP), which was codified in the CHIPS and Science Act, sits at the crossroads of exploratory, curiosity-driven research, use-inspired, solutions-oriented research, and translational research across all disciplines of science and engineering. The TIP Directorate, in close collaboration with all of NSF's directorates and offices, is focused on advancing the key technology areas and addressing the national, societal, and geostrategic challenges identified in Section 10387 of the CHIPS and Science Act. TIP is fostering new innovation ecosystems throughout the Nation, transforming

regions into national and global anchors in key technologies; accelerating the translation of research results from the lab to the market and society; and cultivating new education pathways for a diverse and skilled future technical workforce comprising researchers, practitioners, technicians, entrepreneurs, and educators. Further, TIP opens new possibilities for research, innovation, and education by catalyzing strategic partnerships linking academia; industry, startups and small businesses; federal, state, local, and tribal governments; nonprofits and philanthropic organizations; civil society; and communities of practice to cultivate 21st-century innovation ecosystems that give rise to future, high-wage, good-quality jobs and enhance the Nation's long-term competitiveness. Over the past year we have seen immense interest from a wide range of institutions, industries, and state and local governments in the new opportunities NSF has unveiled through TIP. For example, nearly 700 teams from every state and U.S. territory responded to the NSF Regional Innovation Engines call for concept papers.

Since the enactment of the CHIPS and Science Act just over a year ago, NSF has moved expeditiously to realize the law's vision for TIP. In that time, NSF has made more than 760 new awards and partnered with 10 different federal agencies and more than 10 industry groups or nonprofits through the TIP Directorate. These efforts span a wide range of activities, ranging from regional innovation to supporting the next generation of entrepreneurs.

As authorized by the CHIPS and Science Act, the NSF Regional Innovation Engines (NSF Engines) program is a major new undertaking that will catalyze new businesses and economic growth in diverse regions of America that have not fully participated in the technology boom of the past several decades. Understanding that not all communities and proposed collaborations will be immediately ready to launch full-scale NSF Engines, the program comprises two tracks: Type-1 NSF Engines Developmental Awards and Type-2 NSF Engines. The Type-1 awards invest up to $1 million to help organizations create connections and develop their local innovation ecosystems over a two-year period to prepare strong proposals for becoming future NSF Engines. The Type-2 NSF Engines could receive up to $160 million over 10 years. When successful, an NSF Engine will lead to its region becoming a nationally and potentially globally renowned, self-sustaining, technology and innovation-driven hub of economic activity for the topic in which it specializes. Each NSF Engine's status and overall progress will be assessed annually, with metrics and milestones that will determine whether NSF will continue to support the NSF Engine year over year. Through these two tracks, NSF is seeding the future for communities to grow their regional economies by fostering partnerships that will unleash ideas, talent, pathways, and resources to create vibrant innovation ecosystems across the United States.

When the NSF Engines program released its first funding opportunity, NSF received nearly 700 concept papers from every state and U.S. territory. In May of this year, NSF announced the first-ever Type-1 NSF Engines Developmental Awards consisting of 44 unique teams spanning 46 states and U.S. territories. Then, in August, NSF announced 16 finalists for the first full-scale Type-2 NSF Engines. NSF anticipates announcing the NSF Engines awards this winter, with each awardee initially receiving approximately $15 million for the first two years. Through these two tracks, NSF will have invested nearly $200 million in regional innovation throughout the country by the end of this calendar year.

While NSF is excited by the broad geographic distribution and extensive engagement across academia, industry, and other sectors, we also know that more must be done to fully engage the talent that exists throughout the Nation. That is why NSF launched the Enabling Partnerships to Increase Innovation Capacity (EPIIC) program. EPIIC will build capacity among minority-serving institutions, two-year institutions, undergraduate institutions, and other emerging research institutions in regional innovation ecosystems, with the hope that they will go on to participate in an NSF Engine or similar regional innovation activity. NSF recently announced its first-ever EPIIC investment of $19.6 million to 49 institutions (via 47 awards) at U.S. institutions of higher education (IHEs), including teams from historically Black colleges and universities (HBCUs), Tribal colleges and universities (TCUs), and minority-serving institutions, including Hispanic-serving institutions (HSIs), and community colleges. Importantly, in this inaugural cohort of NSF Engine Development Awards, NSF Engines finalists, and EPIIC awards, NSF is touching 48 states plus multiple U.S. territories.

NSF and the Department of Commerce are collaborating closely together on regional innovation efforts. NSF and the Economic Development Administration (EDA) share a mutual commitment to regional innovation and economic development in communities across the nation. The CHIPS and Science Act authorizes both agencies to implement programs to enable regional technology development and economic and job growth through the NSF Engines and the EDA Regional Technology and Innovation Hubs programs. In July, NSF and EDA signed a memorandum of understanding to officially enable cross-agency coordination on these critical programs to ensure they contribute to regional economic growth and U.S. competitiveness in key technology areas.

In addition to incubating regional innovation, NSF has also prioritized investing in the workforce the Nation needs to be successful today and into the future. NSF invests in the entire spectrum of STEM education and training, from K-12 students and teachers; to technical and vocational training; to undergraduate, graduate, and postgraduate researchers across all fields of science, engineering, and technology. For example, NSF's Experiential Learning in Emerging and Novel Technologies (ExLENT) program will support inclusive experiential learning opportunities designed to provide cohorts of diverse learners with the crucial skills and support services needed to succeed in the key technology focus areas and prepare them to enter the workforce ready to solve the Nation's most pressing societal, , national, and geostrategic challenges. NSF just recently announced the first-ever ExLENT awards to 27 teams at U.S. institutions of higher education and nonprofits, including teams led by historically Black colleges and universities and minority-serving institutions, representing a total investment of $18.8 million.

Equally important to the Nation's competitiveness is NSF's commitment to funding exploratory-based research that creates new knowledge and seeds the industries of tomorrow. For example, many of the AI advancements making news today – both the innovative products and the talent that is developing them – are made possible by NSF's long history of investments dating back decades. From reinforcement learning, which supports more effective chatbots, inventory managers, and self-adjusting thermostats, to the deep learning techniques that have led to generative AI, NSF's investments built the foundation for the AI tools and applications of today. This technical foundation has also been critical for our defense and intelligence communities, translating into capabilities that underpin national security. Over the past three years, NSF has established 25 National AI Research Institutes, or AI Institutes, in partnership with other federal

agencies and industry. This $500 million investment touches almost every state, supporting cutting-edge research that is applying AI to key economic sectors like agriculture, weather, and public health.

Another example of NSF's commitment to investing in foundational breakthroughs is the recent announcement of a $162 million investment in nine new Materials Research Science and Engineering Centers (MRSECs) that will each receive $18 million over six years. The centers aim to transform fundamental scientific breakthroughs into tangible benefits for multiple sectors of the U.S. economy and innovations that can be produced on tomorrow's factory floors – from being tough enough to withstand the heat of a fusion reactor to processing information at the quantum level. Since the 1970s, NSF's MRSECs have yielded countless breakthroughs, from shape-morphing materials to plastics that conduct electricity. NSF now supports 20 MRSECs and these most recent investments expand the centers' portfolios to pursue a broad range of research projects to unlock new capabilities in several areas: semiconductors, artificial intelligence, biotechnology, sustainable energy sources and storage, advanced manufacturing, quantum computing and sensing, and other areas critical for U.S. leadership in materials research.

Early last month, NSF announced four new Science and Technology Centers (STCs) that will enable advances in fields ranging from cell biology and complex materials to new applications of sound waves and environmental change. Since it was established in 1987, the STC program has supported exceptionally innovative, complex research and education projects that have opened new areas of science and engineering and developed breakthrough technologies. STCs conduct world-class research through partnerships among institutions of higher education, national laboratories, industrial organizations and other public or private entities, and via international collaborations. They provide a means to undertake groundbreaking investigations across disciplines and highly innovative approaches within disciplines. They also play a fundamental role in engaging, recruiting, retaining, and mentoring the next generation of scientists and engineers from groups underrepresented in STEM.

The CHIPS and Science Act reiterated the importance of NSF's mission to invest in exploratory, curiosity-driven research. NSF will continue to make significant investments in center-scale research such as the MRSECs and STCs, as well as in the individuals all across the Nation to ensure we are exploring the frontiers of science and engineering and leading the world in innovation.

Safeguarding Taxpayer Investments

The future of U.S. competitiveness requires that we safeguard these critical investments and take steps to address research security while also cultivating vibrant international partnerships that are critical to success. NSF plays a leading role in federal efforts to address research security and is expanding capabilities and competencies to protect the U.S. science and engineering enterprise. In January 2022, the National Science and Technology Council's Research Security Subcommittee, which is co-chaired by NSF, issued implementation guidance for National Security Presidential Memorandum 33 (NSPM-33) on National Security Strategy for United States Government-Supported Research and Development. In addition, the CHIPS and Science Act contains several research security provisions that NSF is in the process of implementing. NSF has engaged in robust

discussions with the U.S. research community and with like-minded international colleagues through groups like the G7 and bilaterally to develop common frameworks for understanding and addressing research security.

NSF has prohibited our staff from participating in any foreign talent recruitment programs and updated and clarified our guidelines and requirements for institutions and individuals requesting funding from NSF so that senior/key persons identified on proposals cannot participate in malign foreign talent recruitment programs. NSF has also established new analytic capabilities to proactively identify conflicts of commitment, vulnerabilities of pre-publication research, and risks to the merit review system. NSF will scale up the use of these analytics to analyze all NSF awards and contribute to NSF's Small Business Innovation Research (SBIR) due diligence process in FY 2024.

As required by the CHIPS and Science Act, NSF is in the process of establishing a Research Security and Integrity Information Sharing and Analysis Organization (RSI-ISAO), called SECURE, to provide needed information and tools to the research community. Full proposals for SECURE are due at the end of October. NSF is confident that we will be able to establish an innovative entity that will build the capacity of the research community to make risk-informed decisions and create a trusted partnership between research-awarding agencies and the research communities, which strengthens the security of our national research enterprise.

NSF is also leading efforts through a partnership with the federal government interagency community to develop research security training modules for the research community. These modules will be available in the coming months, and NSF plans to fund the delivery of these modules and their evaluation to help researchers understand and avoid research security risks. In addition, NSF has also put in place research security training for all of our staff, which is required to be completed on an annual basis.

NSF is developing the system for reporting by institutions of higher education of foreign financial transactions with countries of concern above $50,000 as mandated in CHIPS and Science and will be coordinating closely with our Office of Inspector General on these reports. NSF will do appropriate due diligence to assess these reports.

NSF takes very seriously the need to safeguard the investments the agency makes on behalf of the American taxpayer while also contributing to a vibrant global research community based on shared values with like-minded partners. We will continue to partner with other agencies, the intelligence and law enforcement communities, and the research community to take all necessary steps to do so.

CHIPS for America Workforce and Education Fund

The CHIPS and Science Act included $200 million for the CHIPS for America Workforce and Education Fund. NSF is investing those resources in an effort to train upwards of 100,000 new semiconductor researchers, practitioners, technicians, and educators over the next five years, fulfilling a key need of the semiconductor industry and further building a skilled U.S.

semiconductor workforce. The CHIPS and Science Act provided $25 million in each of FY 2023 and 2024, and $50 million in each of FY 2025, 2026, and 2027.

NSF has focused the FY 2023 funding to leverage existing investments to address the immediate needs of the semiconductor industry. For example, $10 million was provided to the TIP Directorate to fund scalable partnerships with the private sector, including Intel, Micron, Ericsson, IBM, and Samsung to enhance research traineeships and skilled semiconductor manufacturing workforce programs. This NSF investment will be matched by the companies. For example, in the case of Intel, the investment is part of an already-announced 10-year NSF-Intel partnership to invest $100 million to address semiconductor design and manufacturing research and workforce development throughout the country.

NSF also invested more than $6 million of the FY 2023 funds in the new Future of Semiconductors (FuSe) program. The objective of this investment is to cultivate a broad coalition of researchers from across science and engineering communities to utilize a holistic, co-design approach to fundamental research and education and training, to enable rapid progress in new semiconductor technologies. Last month, NSF announced 24 research and education projects with a total investment of $45.6 million through a public-private partnership spanning NSF and four of the companies named above: Ericsson, IBM, Intel, and Samsung. These awards support novel, transdisciplinary research that will enable breakthroughs in semiconductors and microelectronics and address the national need for a reliable, secure supply of innovative semiconductor technologies, systems, and professionals.

In FY 2024, NSF will focus on supporting a national-level clearinghouse that brings together academia, industry, and government to grow capacity and reduce barriers to grow a diverse workforce capable of ensuring U.S. competitiveness across all facets of microelectronics. Such a microelectronics workforce development clearinghouse will offer a proving ground for reliable, practicable, evidence-based, industry-aware curricula leading to new educational programs spanning secondary schools, two-year community and technical colleges, and minority-serving institutions across all 50 states, the District of Columbia, and U.S. territories. In doing so, NSF will enhance industry and career awareness among a diverse array of potential entrants to the industry, develop professional and technical skills, and provide work-based, experiential learning opportunities (e.g., internships, apprenticeships) that inspire prospective students to enroll in industry-related programs at community colleges and four-year universities. This approach has been recommended by coalitions of academia and industry as they have imagined how best to address the needs of the future semiconductor workforce.

Put simply, this clearinghouse will foster high-quality and affordable training pathways aligned with the Administration's workforce approach, benefiting workers as much as they benefit employers, by setting workers on pathways to success in higher-quality careers in the long run.

As the Federal Government's leader in STEM education, with a strong track record in fostering public and private partnerships, NSF is uniquely positioned to design, implement, scale, and sustain this clearinghouse. Moreover, success in the semiconductor and microelectronics sector will provide an evidence base for extending other key technology areas authorized in the CHIPS and Science Act. NSF is committed to investing the $200 million provided for the CHIPS for

America Workforce and Education Fund and leveraging public-private partnerships to have the most impactful outcomes for the Nation.

Innovation Anywhere, Opportunities Everywhere

NSF is fully committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, in every region of the country. The CHIPS and Science Act authorizes NSF to support broadening participation at the individual, institutional, and jurisdictional levels. At the individual level, CHIPS and Science authorizes programs that empower individuals through scholarships, fellows, traineeships, and project activities that enrich STEM education at all levels. At the institutional level, awards to minority-serving institutions, including community and technical colleges, will lead to greater opportunities for all students and faculty. Finally, at the jurisdictional level, NSF is working toward more geographical diversity across the entire NSF portfolio, especially to rural and urban institutions that serve diverse students.

An important component of these efforts is NSF's Established Program to Stimulate Competitive Research (EPSCoR). EPSCoR enhances the research competitiveness of targeted jurisdictions by strengthening science, technology, engineering, and mathematics (STEM) capacity and capability through a diverse portfolio of investments from talent development to local infrastructure. The CHIPS and Science Act requires NSF to increase the percentage of the agency's investments in EPSCoR jurisdictions over a seven-year period, reaching 20% in FY 2029. For FY 2023, the EPSCoR target was 15.5%. We are pleased to report that NSF has met and slightly exceeded that target in FY 2023. In addition, as required by the CHIPS and Science Act, NSF is prioritizing activities that enable sustainable growth in the research competitiveness of EPSCoR jurisdictions. For example, in May, NSF released two new programs to further support EPSCoR jurisdictions in building sustainable research capacity. The EPSCoR Research Incubators for STEM Excellence (E-RISE) program supports incubation of research teams and products in scientific topical areas linked to a jurisdiction's scientific priorities. The EPSCoR Collaborations for Optimizing Research Ecosystems (E-CORE) program provides funding to support targeted research infrastructure cores that underlie the jurisdiction's research ecosystem, including development, enhancement, and/or sustainability of research facilities, higher education pathways, workforce development, economic development, and use-inspired research.

NSF recognizes that building sustained research capacity in all states and territories is critical to our long-term competitiveness. NSF's Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED) program will improve the Nation's research support and service capacity at emerging and underserved research institutions. Last week, NSF announced an investment of $9.2 million in funding for a collaborative project between Emory University and the National Organization of Research Development Professionals (NORDP), a professional nonprofit association dedicated to advancing the research capacity and impact of colleges and universities. Together they will expand support to 16 minority-serving institutions by providing extensive consulting time from experienced NORDP consultants over the next two years and access to an array of tools and services to improve research development. This investment will provide direct research development services to participating institutions, including grant writing assistance, team building, strategic research planning, outreach activities, and student training. The

program is specifically designed to provide a significant investment to intentionally small cohorts of institutions to ensure a lasting impact.

Conclusion

At a time of intense international competition, NSF's ability to generate more breakthroughs and foster more innovations that strengthen our economy and national security is critical to keeping the United States a global leader in science, engineering, and technology. As NSF continues to implement the CHIPS and Science Act, we are doing so with a focus on expanding opportunities for all types of institutions, in every geographic region, in every key technology area, and for everyone who wants to engage in STEM –while through leveraging partnerships with industry and philanthropies.

Thank you for the opportunity to testify before you today. With the continued support of this Committee and Congress, and through successful implementation of the CHIPS and Science Act, NSF stands ready to strengthen our national and economic security and create innovation anywhere and opportunities everywhere.