EMERGING INDUSTRIES

Description and Rationale

For more than 70 years, NSF has supported fundamental research across a broad range of science and engineering fields. NSF investment in high-risk, high-reward research has given rise to autonomous vehicles, revolutionary next-generation wireless networks and systems, novel computational platforms, life-saving medical devices, advanced manufacturing, and precision agriculture. As the U.S. faces intensifying global competition for science and technology leadership, NSF is ready to strengthen and scale up investments in breakthrough technologies, innovation, and translation. A foundation of NSF's investment in Emerging Industries is also a focus on nurturing diverse talent, which leverages NSF's deep relationships with over 2,000 of America's leading research institutions.

At the FY 2023 Request level, NSF will accelerate advances in Emerging Industries by strengthening a dynamic, diverse, and well-coordinated portfolio of investments. As outlined below, these investments will scale up existing investments to accelerate outcomes and increase impacts, while also launching new programs that will empower researchers and innovators to collaborate. Support for Emerging Industries will come from across NSF, with the Directorate for Technology, Innovation, and Partnerships (TIP) closely coordinating across all directorates and offices, including the EPSCoR program. TIP's ability to work across all parts of NSF, while also stimulating partnerships with America's leading researchers and prospective innovators, creates an important opportunity to support innovation that can more quickly be brought to market or otherwise translated to improve economic opportunity and quality of life.

Goal of Investment

NSF's Emerging Industries portfolio will align with NSF's broader goals to energize the Nation's economic competitiveness, sustain our global leadership and resilience, expand the geography of innovation, and improve quality of life for everyone. Specifically, NSF will:

- advance science and engineering research and innovation that could lead to breakthrough technologies as well as solutions to national and societal challenges.

- accelerate the translation of fundamental discoveries from lab to market, helping to advance the U.S. economy.

- create equitable education pathways to help ensure every American can pursue high-wage, good-quality jobs.

Building on NSF's longstanding leadership in science and engineering research and education, a key focus will be to help Americans in all regions of the country develop and build new innovation ecosystems that strengthen communities and address vital national needs. NSF will strengthen and scale up use-inspired, solution-oriented research and innovation in a range of technology areas including advanced manufacturing, advanced wireless, artificial intelligence, biotechnology, microelectronics and semiconductors, and quantum information science. These industries will expand the national capacity to advance key Administration and Congressional goals such as

managing challenges associated with climate change and increasing equity throughout society. A key focus of these innovation ecosystems will be to develop strategic partnerships that link academia, industry, government, philanthropy, investors, and civil society.

Potential for Impact, Urgency, and Readiness

The Nation faces a defining moment. Global competition for leadership and talent in science, engineering, and technology is at an all-time high. For the United States to remain a global leader, we must recommit to investing in breakthrough technologies and innovation, fostering dynamic new partnerships, and nurturing talent throughout the country. The Internet, Google, Qualcomm, 3D printing, and economic theory underpinning spectrum auctioning and kidney exchanges were all supported by NSF investments. The COVID-19 pandemic has only reinforced the importance of science and technology in meeting emerging needs; the polymerase chain reaction (PCR) technique, pioneered through NSF investment, has been critical in the fight against COVID-19. The technologies and industries that are the focus of national conversations around competitiveness today, and the ones that will emerge in the future, are rooted in sustained NSF support for research and innovation at the frontiers of science and engineering.

At the FY 2023 Request level, NSF will catalyze research and innovation in emerging technologies through investments in Emerging Industries that address the following research priorities:

- **Advanced Manufacturing.** Accelerate breakthroughs in manufacturing materials, technologies, and systems through fundamental, multidisciplinary research with the potential to transform manufacturing capabilities, methods, and practices.

- **Advanced Wireless.** Fill knowledge gaps and advance innovations in areas critical to future generations of wireless technologies and networks, such as wireless devices, circuits, protocols, and systems; mobile edge computing; distributed machine learning and inference on mobile devices; human-machine-network interactions; and dynamic spectrum allocation and sharing, while ensuring innovation and security for all users.

- **Artificial Intelligence.** Bring together numerous fields of scientific inquiry—including computer and information science; cognitive science and psychology; economics and game theory; education research; engineering and control theory; ethics; linguistics; mathematics; and philosophy—to advance the frontiers of trustworthy artificial intelligence and robotics, including advancing perception, learning, reasoning, recommendation, and action in the context of specific fields and economic sectors.

- **Biotechnology.** Further advances in genomics, bioinformatics and data analytics, structural and computational biology, biophysics, synthetic biology, tissue engineering, and development of new types of biomaterials, bio-inspired data storage and microelectronics, and biomanufacturing, accelerating the ability to harness biological systems to create goods and services that can contribute to advances in agriculture, health, security, manufacturing, and the climate.

- **Microelectronics and Semiconductors.** Address the semiconductor challenges facing our Nation due to technological and global trends, such as the end of Moore's Law and offshoring of

semiconductor fabrication and manufacturing, by supporting future semiconductor discovery, development and fabrication, which can lead to future domestic and related electronics foundries.

- **Quantum Information Science.** Pioneer the development of quantum computing, communication, sensing, and networking to advance information processing, transmission, and measurement in ways that classical approaches can only do much less efficiently, or not at all.

In addition, NSF investments in Emerging Industries would:

- **Innovate for Equity.** Increase equity and help America build back better by showing how innovators and entrepreneurs can create opportunity for Americans from diverse backgrounds and circumstances. Technological transitions can be especially difficult for communities that face structural inequalities. Research that shows how to innovate effectively with the broadest possible participation is a way to draw more Americans to Emerging Industries. Research that reveals more effective ways to support and mentor diverse populations can improve educational outcomes and employment prospects in underserved communities.

- **Strengthen and Scale Up Technology Translation.** Advance understanding of economic incentives, customer discovery, research usability, industrial organization, and supply chains that can increase the rates at which research discoveries are translated into successful companies. By empowering the Nation's next generation of innovators and entrepreneurs, we can increase the rate at which technological discoveries become successful companies.

- **Protect National Security and Economic Resilience.** Support research and education activities that protect U.S. security and strengthen our economic resilience. Notably, NSF investments in cybersecurity research will address the need to protect digital assets and activities; anticipate, deter, detect, resist, and tolerate cyber-attacks; understand and predict cyber risks; and respond and recover effectively at all levels. In addition, NSF investments in cybersecurity education will nurture a future workforce of cybersecurity professionals. NSF investments in economic resilience will additionally advance research ensuring safe, clean, and reliable access to critical products, materials, and minerals, in turn supporting other Emerging Industries like Advanced Manufacturing.

Budget Justification

At the FY 2023 Request level, NSF will support an Emerging Industries portfolio that consists of a broad suite of programs funded from across all NSF directorates and offices. As noted above, investment priorities include Advanced Manufacturing ($421.51 million), Advanced Wireless ($168.56 million), Artificial Intelligence ($734.41 million), Biotechnology ($392.26 million), Microelectronics and Semiconductors ($145.69 million), and Quantum Information Science ($261.0 million). In addition, FY 2023 Request funding for the new Directorate for Translation, Innovation, and Partnerships (TIP) ($879.87 million) will specifically open new possibilities for research and education by catalyzing strategic partnerships linking academia, industry, government, philanthropy, investors, civil society, and communities of practice that in turn cultivate 21st-century local, regional, and national innovation ecosystems. TIP will serve as a cross-cutting platform: by working in close collaboration with all of NSF's other directorates and offices on these priority investments, TIP will work to rapidly bring to the market and to society the innovations that result from all of NSF's investments in Emerging Industries.

Investments made possible by the FY 2023 Request level include:

- The **Future of Semiconductors (FuSe)** activity will invest in new materials, materials processing and characterization, fabrication, devices and systems, and computing, sensing, and communication systems answering both near-term supply chain concerns and longer-term Post-Moore's Law challenges. FuSE will invest in research opportunities in semiconductor-related areas including new materials, fabrication and manufacturing, electronics, and computer systems. FuSE will also consider research infrastructure needs in this domain, particularly improving semiconductor fabrication foundry access for NSF-funded researchers, and how potential partnerships with industry may facilitate such access. Educational needs and opportunities, particularly those coupled to foundries as experiential learning, are also of interest.

- The **Quantum Information Science and Engineering (QISE) National Virtual Laboratory (NVL)**, which will serve as a national, community-driven effort that supports the smooth integration and translation from fundamental science and engineering to use-inspired applications. Building on the continued and sustained support of fundamental research from existing NSF programs, the NVL will draw together expertise and talent from a broad range of disciplines to enable the creation and application of functional quantum devices and systems. Coordination will be provided through a virtual infrastructure that serves much like a laboratory to identify roles and resource needs and establish mechanisms to enable all members of the laboratory to communicate and function together as a whole. In this way, the NVL enables anyone to become engaged and contribute to advances in QISE. A key focus of the activity will be to promote broad participation, diversity, equity, and inclusion in QISE.

- The **NSF Regional Innovation Engines (NSF Engines)** program will simultaneously address major scientific and technological goals while ensuring broad societal benefits and global leadership. The NSF Engines will advance use-inspired, solution-oriented research and innovation in a range of technology areas (e.g., advanced manufacturing, advanced wireless, artificial intelligence, biotechnology, QISE, semiconductors) as well as in a diverse set of national issues (e.g., the bioeconomy and climate change). The NSF Engines will incentivize partnerships that bring together multiple disciplines, institutions, and sectors, to include academia, industry, nonprofits, state and local governments, and venture capital. The NSF Engines will span the Nation's geography and be responsive to regional strengths and needs. They will simultaneously focus on technology and workforce capabilities while contributing to broad societal benefits and global leadership and will serve as hubs for NSF's broader portfolios of investment in their respective areas of focus, including the investments described above.

- The **NSF Lab-to-Market Platform** will be strengthened and scaled by: (i) increasing funding for the highly successful NSF Partnerships for Industry (PFI) program, which offers researchers with prior NSF-funded research the opportunity to explicitly enter into partnerships, especially with industry, to accelerate the transition of discoveries from the laboratory to the marketplace for societal benefits; (ii) increasing funding for the NSF Innovation Corps (NSF I-Corps™) program, building out the I-Corps™ Hubs and Teams, supporting a Coordination Entity to enable coordination across the Hubs, and supporting partnerships with other NSF programs such as the NSF Convergence Accelerator and RIEs; and (iii) increasing flexibilities for the NSF Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. NSF will also explore new pathways for translation, e.g., offering education and training as well as open-source

innovation research grants through the Pathways to enable Open-Source Ecosystems (POSE) program to spur open-source ecosystems.

- Emerging industries such as artificial intelligence, data science, and quantum information science have the significant opportunity to establish equity and inclusion from the outset and should be synonymous with opportunity for all. The new **Technology and Innovation Internships for Experiential Learning (TIIEL)** will work with industry, government, and educational partners to support internships and other experiences, training, and credentialing for diverse learners at every stage of education, from first-time job seekers to experienced workers looking for new opportunities. Complementing NSF's broader portfolio of investments to train a diverse future workforce in Emerging Industries, the TIIEL program will specifically offer students from groups long underrepresented or underserved with opportunities to be prepared for jobs on day one.