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Re: Request for Information (RFI) Response - Key Technology Focus Areas for the National Science Foundation's Directorate of Technology, Innovation, and Partnerships

Dr. Gianhandani,

IEEE-USA is pleased to submit these recommendations in response to the National Science Foundation's (NSF) request for comments on the 2025 assessment and potential update to the list of 10 key technology focuses for the Directorate of Technology, Innovation and Partnerships (TIP). This update presents an essential opportunity for the U.S. government to review these 10 key technology areas annually and update them based on current information on these technologies, as well as identify any necessary additions to the list.

Since the creation of the TIP at NSF, we have had the opportunity to consider how it operates within the United States' federal research and development ecosystem. Currently, the TIP operates with inherent inefficiencies due to fragmentation, overlap, and duplication across numerous agencies. This decentralized structure has hindered the agile and rapid advancement of critical technologies essential to the future of the United States.

The TIP can serve as a strategic solution to this issue. Its ability to leverage its unique mandate for use-inspired research and technology translation positions the TIP program exceptionally well to identify, coordinate, and optimize for efficient federal investments in key technology areas, transitioning basic research to commercialization. This role would transcend traditional policy coordination, serving as a convener among government agencies and industry, and transitioning to operational oversight to ensure strategic alignment and resource efficiency across the federal research and development ecosystem, to dedicate more time to groundbreaking innovations in all of science and technology. It will also help fortify the innovation ecosystem within the country, while bolstering national security by focusing resources on strategic technological advantages.

IEEE-USA thanks the NSF for considering these comments in the TIP's annual review of these 10 key technology areas. We welcome any further discussions. If you have any questions, please do not hesitate to contact Ryan Cunius (r.cunius@ieee.org) or Erica Wissolik (e.wissolik@ieee.org) or call (202) 360-5023.

IEEE-USA represents approximately 150,000 engineers, scientists, and allied professionals in the United States, many of whom are actively conducting research and development into artificial intelligence, software engineering, cybersecurity, and advanced computing, as well as other foundational and emerging technologies. We are the

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American component of the IEEE – the largest organization of technology professionals in the world, representing more than 400,000 engineers, scientists, and allied professionals worldwide.

Considering how each of the key technology focus areas listed above contributes to America's global technological leadership and drive economic growth and national security

a. **Which**, if any, technology areas currently included in the list **should be revised or refined** to better reflect the scope of a technology area **critical to U.S. competitiveness**? Please include the rationale and suggested revision.

- Revise (1) to “Artificial intelligence with focus on robustness, reliability, and scalability,” to cover the reliability of autonomous systems moving forward. This change highlights the rapid evolution of AI—from large foundation models and real-time edge inference to autonomous systems, accompanied by growing concerns regarding robustness, privacy, human–AI collaboration, and scalability.
- Revise (2) as “Next-Generation Computing Architectures & Co-Designed Systems,” which indicates that strategic priorities should go beyond raw Floating Point Operations Per Second (FLOPS). These should meet tomorrow’s performance, energy-efficiency, and resilience targets, which require new hardware paradigms—such as neuromorphic, photonic, and AI accelerators—and tight hardware–software co-design.
- Revise (4) to read “Advanced manufacturing with the support of robotics and automation,” to emphasize that advanced manufacturing is the main goal for the United States, and robotics and automation are tools for achieving it.
- Revise (5) Natural and anthropogenic disaster prevention or mitigation to “Disaster prevention, mitigation, and resilience.”¹ This would ensure that adaptation & resilience technologies safeguarding critical infrastructure are eligible.
- Revise (8) to be broadened to “Secure Privacy Data Management Systems, including distributed ledger technologies, and cybersecurity, including biometrics,” to reflect technologies that now enable cross-sector

¹ Prevention and mitigation focus on reducing the causes of climate change, while resilience focuses on managing the impacts. Mitigation is essential for long-term climate stabilization, but resilience is necessary even with mitigation efforts because some climate change is already inevitable.

1. Prevention:

- i. Definition: Actions taken to avoid a hazard or risk altogether.
- ii. Example: Preventing deforestation to avoid increased carbon emissions and loss of natural carbon sinks.
- iii. Focus: Avoiding the problem before it arises.

2. Mitigation:

- i. Definition: Actions taken to reduce greenhouse gas emissions and slow down climate change.
- ii. Example: Transitioning to renewable energy sources like solar and wind power.
- iii. Focus: Addressing the root causes of climate change.

3. Resilience:

- i. Definition: The ability of a system to absorb disturbances, cope with impacts, and recover from climate-related events.
- ii. Example: Developing early warning systems for extreme weather events to allow for timely evacuations.
- iii. Focus: Building capacity to withstand and recover from climate impacts.

See,

- <https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction>
- <https://unfccc.int/topics/introduction-to-mitigation>
- <https://www.eea.europa.eu/en/about/contact-us/faqs/what-is-the-difference-between-adaptation-and-mitigation>
- <https://www.dlapiper.com/en-us/insights/topics/cop-conference-of-the-parties/mitigation-adaptation-and-resilience>
- <https://www.lse.ac.uk/granthaminstitute/explainers/what-is-the-difference-between-climate-change-adaptation-and-resilience/>
- https://www.fairfaxcounty.gov/environment-energy-coordination/sites/environment-energy-coordination/files/assets/documents/resilient%20fairfax/cm-vs-cr_factsheet_05-05-2022_final.pdf
- <https://www.worldwildlife.org/stories/what-s-the-difference-between-climate-change-mitigation-and-adaptation>

data sharing while protecting sensitive information. This change would also ensure secure, lawful, and trusted data flows.

- Revise (9) to “Advanced energy and industrial efficiency technologies,” which also includes conventional energy equipment at higher manufacturing capacities. The US power sector would benefit significantly from a stronger domestic supply chain of substation equipment, including high-voltage power transformers, switchgear, protection devices, and monitoring/sensing equipment for synchronized measurements (phasor measurement units, waveform measurement units, advanced SCADA, etc.). High-capacity power electronics, such as HVDC and FACTS, could also be included in the exact definition.

b. **Which**, if any, technology areas currently included in the list **are no longer critical** for U.S. technological competitiveness and why?

None of the existing areas should be removed. Each remains foundational to U.S. global competitiveness, although relative funding levels may shift with time. Eliminating any area risks ceding leadership in a tightly-coupled and competitive innovation ecosystem.

c. **What**, if any, technology areas not currently included in the list are critical for U.S. technological competitiveness and **should be added** to the list? Why?

- **“Advanced space technologies, including advanced satellites, cislunar and lunar technologies, on-orbit servicing², and in-space manufacturing.”³** Assured space access underpins modern society through communications, navigation, earth-observation, and deterrence.⁴
- **“Human-Computer Interaction, including neuroscience, neurotechnology, and brain-computer interfaces”⁵** as an emerging transformative domain with profound implications for health, defense, and workforce productivity.⁶ Neurotechnologies have been described as the “next technology frontier” by IEEE⁷
- **“Hypersonics including national security defense and commercial innovation.”** Leadership in this area will have a significant impact on national security and possibly on economic development. See, for instance, <https://www.peraspera.us/p/hypersonics>.

2. Among the 10 key technology focus areas listed above and any proposed additional areas pursuant to 1.c., **what are the three most important** based on each of the following considerations? Please list three technology areas for each category and **include a short rationale**.

² See <https://www.nasa.gov/mission/on-orbit-servicing-assembly-and-manufacturing-1/>

³ See <https://ntrs.nasa.gov/api/citations/20190033503/downloads/20190033503.pdf>

⁴ Importance of Space, see <https://media.defense.gov/2022/Feb/22/2002942522/-1/-1/0/CSPO-VISION-2031.PDF>

⁵ See <https://www.gao.gov/products/gao-22-106118>

⁶ See,

- <https://nam.edu/perspectives/neurotechnology-and-noninvasive-neuromodulation-case-study-for-understanding-and-anticipating-emerging-science-and-technology/>
- <https://braininitiative.nih.gov/vision/nih-brain-initiative-reports/brain-20-neuroethics-enabling-and-enhancing-neuroscience>
- <https://thebulletin.org/2020/04/neurotechnology-overview-why-we-need-a-treaty-to-regulate-weapons-controlled-by-thinking/>
- <https://news.vt.edu/articles/2025/05/sa-corps-neuro-science-war-brain.html>
- <https://www.chathamhouse.org/2019/08/human-control-essential-responsible-use-military-neurotechnology>

⁷ See <https://pmc.ncbi.nlm.nih.gov/articles/PMC10827995/>

a. Geopolitical technology competition.

- (as revised) Artificial intelligence with a focus on robustness, reliability, and scalability
 - Keeps the United States at the forefront of establishing global norms and technological influence within AI technologies, primarily due to increased international competition (specifically from China).
- Quantum information science and technology
 - This technology can revolutionize global cybersecurity encryption with advances in this field. This would alter global security and deterrence by changing the perception of our country if we do not lead in this space in the future.
- High-performance computing, semiconductors, and advanced computer hardware and software
 - We require this infrastructure to advance several technological innovations across multiple areas of study, including AI and quantum computing. With increased international technology competition, the United States must continue to lead in these crucial areas.

b. Potential to power significant economic growth.

- (as revised) Advanced manufacturing with support by robotics and automation.
 - To expand the economic base, advanced manufacturing is crucial for creating workforce opportunities for Americans nationwide, which will lead to economic growth and prosperity as the global economy continues to evolve.
- Biotechnology, medical technology, genomics, and synthetic biology
 - Biotechnology is rapidly expanding, providing not only better health outcomes, but also expanding economic growth in areas such as biomanufacturing that can shore up national supply chains and provide greater employment opportunities
- (as revised) Artificial intelligence with a focus on robustness, reliability, and scalability
 - AI is already demonstrating extraordinary economic growth and is expected to continue as an area of economic expansion into the future. To maintain this growth, however, investments into the hardware “backbone” of large, complex AI models also need to be pursued.

c. Ability to advance national security capabilities.

- (as revised) Secure Privacy Data Management Systems, including distributed ledger technologies, and cybersecurity, including biometrics
 - In an ever-increasingly connected world, data management and security are critical to safeguarding national interests and providing the United States the capability to protect its citizens, economy, and infrastructure from external influence and attacks.
- Advanced energy and industrial efficiency technologies, such as batteries and advanced nuclear technologies, including but not limited to, for electric generation
 - Energy is the key resource that enables the United States’ technological advantage. Without the ability to locally provide domestic energy resources, national security forces, economic growth, and necessary infrastructure are dependent on external sources that could be interrupted at will.
- (proposed) Hypersonics

- Provides much faster offensive and defensive missiles that are more difficult to destroy; supports the "Golden Dome" anti-missile system, and addresses technology that our adversaries lead in.

d. Likelihood to experience significant talent gaps or workforce availability risks.

- Quantum information science and technology
 - Science, Technology, Engineering, and Mathematics (STEM) training trails behind demand, but this is especially true in quantum information science, which is considered particularly challenging to learn.
- Advanced energy and industrial efficiency technologies, such as batteries and advanced nuclear technologies, including but not limited to, for electric generation
 - There are not enough trained engineers specializing in energy science who can continue their academic and professional careers. Additionally, there is a shortage of trade careers within the energy industry due to a lack of opportunities for certifications and other professional development programs that support the everyday upkeep and maintenance of essential energy infrastructure.
- Advanced manufacturing with support from robotics and automation
 - US advanced manufacturing industries are not currently scaled up, which should incentivize industry to create professional development opportunities and certifications within these industries to fill future gaps as industries reshore.

e. The need for use-inspired and translational research to mature the technology.

- Advanced energy and industrial efficiency technologies, such as batteries and advanced nuclear technologies, including but not limited to, for electric generation (Advanced nuclear technologies - demonstration reactors and licensing pathways)
 - Create more public-private partnerships to advance new demonstration technologies for vital energy sources. Focus on advanced energy technologies, such as demonstrating advanced reactors and streamlining regulations for licensing these technologies as they mature towards commercialization.
- Biotechnology, medical technology, genomics, and synthetic biology (safe, scalable bio-foundries and regulatory regimes).
 - To reap the benefits of advanced biotechnologies and their economic and health impact, streamlined methods are needed to allow safe and reliable innovative techniques to be rapidly deployed within the industry.
- Advanced materials science, including composites, 2D materials, other next-generation materials, and related manufacturing technologies applied to (4, as revised) Advanced manufacturing, to include robotics and automation.
 - Invest in research and development to explore opportunities for substituting rare earths and other elements dominated by potential adversaries. This will help ensure that the U.S. remains the global leader in material sciences, while protecting national security interests due to the high percentage of rare earth and other elements held by potential adversaries worldwide.