RESPONSE TO REQUEST FOR INFORMATION

National Institute of Standards and Technology (NIST)

Submitted via:
www.regulations.gov

Submitted by:
MITRE Engenuity, LLC

In Response to:
Request for Information on Implementation of the United States Government National Standard Strategy for Critical and Emerging Technology (USG NSSCET)

Docket No.: 230818–0199

Submission Date: November 6, 2023

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Response to the RFI on Implementation of the United States Government National Standard Strategy for Critical and Emerging Technology submitted by MITRE Engenuity

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Introduction

NIST is seeking information on behalf of the U.S. Department of Commerce and the U.S. Government (USG) to support the development of an implementation plan for the United States Government National Standards Strategy for Critical and Emerging Technology (NSSCET)[i].

MITRE Engenuity, LLC is pleased to submit this industry-led response to the request for information on behalf of collaborators across industry (small, medium, and large organizations) and academia (community colleges to PhD granting institutions). MITRE Engenuity is a non-profit technology organization that collaborates with the private sector on challenges that require a public interest solution.

We recognize the urgency and importance of the NSSCET and its role in the development of Standards in a broad range of critical and emerging technologies. We support the sentiment by NIST in the RFI that the U.S. Standards development system is unique because it is built upon a wide variety of processes that are open, voluntary, decentralized, and led by the private sector. These processes feature openness to participation by materially interested stakeholders with consensus-based decision making. In brief, we summarize our response in three specific initiatives:

- Investment in the participation and hosting of Standards meetings and the associated preparation, processes, and strategies aligned with the NSSCET.
- Alignment between the NSSCET and the commercial interests of the private sector, including support for innovators and small businesses, which represent the future growth and commercialization of products and services and may not have resources to participate in Standards.
- Development of talent, education, and collaboration between USG and private industry to enhance the workforce for Standards development and subject matter experts whose skills are essential to leadership of Standards development.

Standards have resulted in significant benefits for the participants and for customers of products and services that emerge from those Standards in numerous industries, including semiconductors, telecommunications, manufacturing, biometrics, and cyber-security among others.

Standards support a thriving and dynamic marketplace, where customers have confidence that the products and services are assured to meet certain specifications, performance, and interoperability which would not be achieved in a fragmented environment.

Standards allow markets for products and services to scale and accelerate widespread adoption. Standards that are well supported by industry provide opportunities for the private sector to offer innovative differentiation, speed to market, and competitive pricing while adhering to Standards. CET Standards work may vary based on the complexities and stages of development. For instance, rapidly evolving CET may require a more variable and elastic Standards process, and others may require a more guarded approach to manage ethics, security, and safety concerns.

Standards efforts gather momentum and companies contribute resources to the process when there are valid and predictable business impact and outcomes for the participants. Without business value, industry may not be able to justify the cost to proactively engage.

A collaborative approach among USG entities, academia, and the private sector with the appropriate focus on strategy, awareness, education, funding, and resources encourages U.S. leadership and achievement of the goals of the NSSCET.

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General Questions

1. Are there potential benefits, opportunities, or risks associated with increased U.S. participation in Standards development activities for CET?

Benefits

Standards are integral to innovation and the development of robust and stable platforms, especially regarding new and emerging critical technologies. As our world becomes more connected, it also becomes more flexible, requiring our critical national infrastructure to develop with continual forward thinking to protect our innovation and supply chains. A roadmap of Standards development may enable future innovation to balance growth with openness, transparency, fairness, security, safety, and reliability.

Standards development is a way to enable supply chain resilience, commercial scale, market certainty, fair competition, and robust intellectual property policies create equity in the market to protect our economic and national security and drive innovation. Standards also positively impact safety and the environment. Effective Standards accelerate the path to market, de-risk deployment, and promote adoption of innovations. Economies of scale are gained by leveraging Standards which tend to reduce risks and improve industry participation. Further, they create certain "hooks" or interfaces that allow proprietary extensions to emerging Standards for defense and national security applications versus duplication and proprietary solutions. They provide accessibility for small and medium companies as well as diverse workforce participation, enhanced security architecture, consensus driven practices (arbitration avoidance), and accelerated and richer innovation (e.g., android, open-source software, etc.).

U.S. participation in CET Standards development activities leverages soft power to signal expectations and priorities to international partners, manufacturers, and other stakeholders. Even devoid of specifics or context, the participation of the United States, by both public and private organizations, in the development process lends credence and incentivizes opt-in adoption and participation. Participation and Standards leadership sets the United States at the forefront of the international discussion as a leading voice that is capable of shaping and directing discussions towards cybersecurity and privacy best practices.

In addition, Standards help motivate and drive key stakeholders to increase internal research and investment to better position their organization’s adoption in emerging markets. Start-up companies are enabled to participate in Standards development creating a broader platform to introduce new innovations to the CET process. It is important to integrate requirements of the U.S. government national security priorities into Standards for wide adoption, strengthened regulatory and export control frameworks, and technology democratization.

For critical enabling technologies, standardization of test methods is essential for benchmarking and performing a fair and accurate technology assessment. Benchmarking is a recognized practice to compare the business processes and performance metrics of one instance against established industry norms and accepted practices by one or many other organizations, companies, or institutions. Benchmarking is used to measure performance using a specific indicator (cost per unit of measure, productivity per unit of measure, cycle time of x per unit of measure or defects per unit of measure) resulting in a metric of performance that is then compared to others. For the semiconductor ecosystem, the larger the participation pool engaged in the CET process – the higher the results will be for the optimization of future investments.

An industry example in the semiconductor electronic design automation (EDA) industry – larger EDA companies are acquiring and integrating novel EDA start-ups to have access to innovative R&D; Standards are an important enabler for integrating technology from the acquired companies.

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Standards lower the barrier of entry of new EDA and design start-ups, a major cost in the semiconductor value chain. One example is OpenAccess[ii] (OA). It is a standard applications programming interface (API) used in the semiconductor industry that enables companies to read/write design data in a way that can be accessed by EDA tools from different suppliers. It also permits, in some cases, manipulating the design data without having to re-enter an EDA tool.

Major EDA organizations support this standard and start-up EDA companies use OA to enable their new products can easily integrate into existing design flows used by customers even if different EDA tools were previously used lowering the barrier to entry for their new products. Notably, most recent adopters of OA have come from outside of the U.S.

Another example in the semiconductor industry of the benefits of U.S. leadership in Standards development is the increasing industry adoption of RISC-V, an open standard instruction set architecture for processor design. RISC-V originated at a U.S. university and has since grown to offer an alternative platform to design chips without requiring licensing or royalty fees. In addition to lowering the cost barrier to chip design, the modularity of the open standard platform enables the innovative design of chips optimized for certain applications. Many top semiconductor companies have since joined to accelerate the development of the RISC-V software ecosystem in an industry alliance called RISE.

Opportunities

Across the full span of critical and emerging technologies, there are numerous opportunities for U.S. leadership by the private sector and academia with alignment to the NSSCET and support from the U.S. Government.

While evolutionary innovation – the next version of a product – is often the focus of large corporations to sustain profits, revolutionary innovation is often enabled by an ecosystem of startup or smaller, more agile organizations. Standards can help level the playing field so that smaller organizations with access to fewer resources (funding, staff expertise, infrastructure, and tools) can move from idea to prototype to production and have more opportunities advance U.S. innovation and subsequent economic growth.

In the field of microelectronics and electronics manufacturing, the U.S. has leading organizations that have succeeded in promoting widespread adoption of Standards. SEMI[iii], the semiconductor industry association has been at the forefront of setting Standards for the microelectronics manufacturing industry[iv], resulting in over 1,000 industry approved Standards and guidelines. IPC[v] has been responsible not only for Standards in packaging for microelectronics, but also certification and educational programs. Promoting existing networks, the Silicon Integration Initiative[vi] (Si2) as an example, is an important building block to empower U.S. companies to interoperate with Standards. In addition, industry bodies that are not Standards organizations, such as iNEMI[vii], develop best practices, guidelines, and tools that facilitate the ability of their members to contribute rapidly and constructively to Standards.

Tools such as modeling, simulation, and EDA provided to start-ups, small business, and academic institutions at market discounted rates or royalty-free access to IP for R&D and prototyping in return for a license commitment to use the IP in production products. This model ties development efforts into basic Standards and supports broad-based innovation. An expansion of incentives or shared development opportunities when coordinated with various funding models could provide deeper access into a broader pool of talented innovators and emerging companies.

A promising emerging candidate for Standards in microelectronics is microprocessor designs which rely on components different geographies. It is critical to enable Standards across the ecosystem (chiplets, performance specifications) with embedded security, Secure-by-Design and Secure-by-Construction, to alleviate security concerns and qualify traceability with trusted provenance. Interoperable computer-aided

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design agnostic Standards must be implemented by EDA vendors; OpenAccess is a good EDA example creating equity across small and large companies. It is provided by Si2 and managed through an OA Coalition (OAC) composed of member companies.

With the CHIPS Act and the formation of the National Semiconductor Technology Center[viii] (NSTC) there is an opportunity to provide the same equity advantage for new efforts. It is vital that NSTC efforts related to chip design follow industry Standards.

Risks

The risks of increased participation are complex. There is potential to disturb the balance and constructive cadence of Standards bodies and processes especially if the result is retaliation by adversaries.

For the private sector, there is a risk of the NSSCET becoming a burden on resources, release of intellectual property, or political influence creating disruption to commercial growth and competition if executed in a way that results in misalignment between the NSSCET and the competitiveness of industry, including possible exposure of ideas, concepts, and intellectual property.

A considerable risk in standardization of CET is increased security vulnerability. Standards publicize the process, parameters, and procedure for compliant operations. Malicious actors can leverage this information, possibly resulting in negative outcomes. For example, since the U.S. implemented controls in October 2022 on the export of certain advanced semiconductor technology, tools, equipment, and resources, some have asserted that adversaries had to shift their focus and instead increasingly rely on open-standard instruction set architecture first developed in the United States, RISC-V, to expand its indigenous capabilities for designing advanced chips. Standards bodies should consider designating a subcommittee to address this vulnerability; considering how to do so without greatly impacting the benefit that standardization brings.

Some national security application areas (e.g., Radiation Hardened technologies) are mission specific and may not benefit from Standards. In national security applications, an approach that assesses, categorizes, and applies Standards to select areas where the benefit outweighs the risk is advised.

2. What are the potential risks or implications of decreased U.S. participation in Standards development activities for CET?

The risks of decreased U.S. participation leave open opportunities for other entities to set Standards agenda and content excluding U.S. interests in emerging Standards resulting in barriers for U.S. entry. A direct consequence would be reduced visibility into new Standards/markets/trends and erosion of leadership creating threats to economic and national security of the U.S.

In 5G, there is a negative impact of reduced U.S. participation in Standards. Standards provide consensus, legitimacy, market momentum, and commitment from the supply chain. The telecommunication industry benefits from deep observation and participation in Standards and mapping, especially related to national security interests. A decline in U.S. participation in this area contributed to multiple parallel developments of technology, causing confusion within the global technology ecosystem, that market forces are indirectly tasked to resolve.

There is a time component in establishing Standards - between the scientific advancement, implementation into products, to adoption in the economic marketplace - so understanding the urgency for immediacy that impacts supply chain is critical. It is difficult to influence Standards in a new direction after they have been widely adopted by industry and implemented in production of devices; or if organizations have moved out with bespoke agendas.

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The primary risk of standardization is the assumption that Standards are static, and the primary focus should be on enforcement rather than improvement. Standards represent a common agreement on how something should be done. However, the true value of having a standard is that once a common means of doing something is understood all organizations can direct their collective efforts in the same direction. This creates faster cycles of improvement across the industry vs. individual company solutions. There are many examples of this not being done correctly which leads to the perception that Standards inhibit innovation.

If certain elements of a product or system (e.g., test methods) are not standardized, there is a risk of fragmentation, and of failure to achieve best practices and the most effective application of technology and innovations.

Abstaining from participation in Standards development or restricting adoption of Standards regarding the semiconductor ecosystem may result in the U.S. losing the ability to contribute to the deliberation and creation process of Standards in a variety of disciplines. Semiconductor technologies are related and interdependent, therefore when excusing oneself from a sector of Standards efforts, the indirect cascading effect across multiple industries may be profound and challenging to contemplate at the present but will be cause for remorse in the future. International competitors could asymmetrically craft Standards that disadvantage the United States and its interests. Worse, reduced U.S. participation could be misunderstood internationally as a lack of confidence in necessary Standards and could lead to unintended impacts.

The lack of Standards related to CET can lead to fragmented markets and non-interoperable devices or solutions. This could impact dual-use (commercial/military) adoption by the USG or interoperability when participating in joint missions or exercises with Allied Partners. The impact of non-interoperable devices in national security can lead to degraded mission and information sharing capabilities.

Implementing an underlying or common set of standards across all devices and solutions may enable improved development of innovative final products with enhanced functionalities atop the standardized levels. This enables products that the government integrates into its ecosystem to have the same foundational functionality as commercial products with additional secure specifications or capabilities. The risk of obsolescence is mitigated or reduced if technological advancements enabled in commercial markets become essential elements or components of the NSSCET.

3. What are the most important challenges faced by the private sector (i.e., industry, including start-ups and small-and medium-sized enterprises (SMEs), academic community, and civil society organizations) when participating in Standards development activities for CET, and how can these challenges be addressed?

Central challenges that private industry experience involve the complex nature of driving adoption, continuous improvement of a standard, and resources to participate with the NSSCET:

- Need for incremental resources to support Standards development and contributions.
- Need to cultivate subject matter experts (SMEs) with technical expertise from product and R&D organizations.
- Need for expertise and intelligence to navigate Standards process and overcome the risk of delays or distractions from commercial priorities.

The challenges span all the industries impacted by the broad range of critical and emerging technologies identified in the NSSCET, and the associated markets for products and services, as captured in Figure 1 (below). This illustrates the complexity and scale of the challenges, and the necessity to prioritize.

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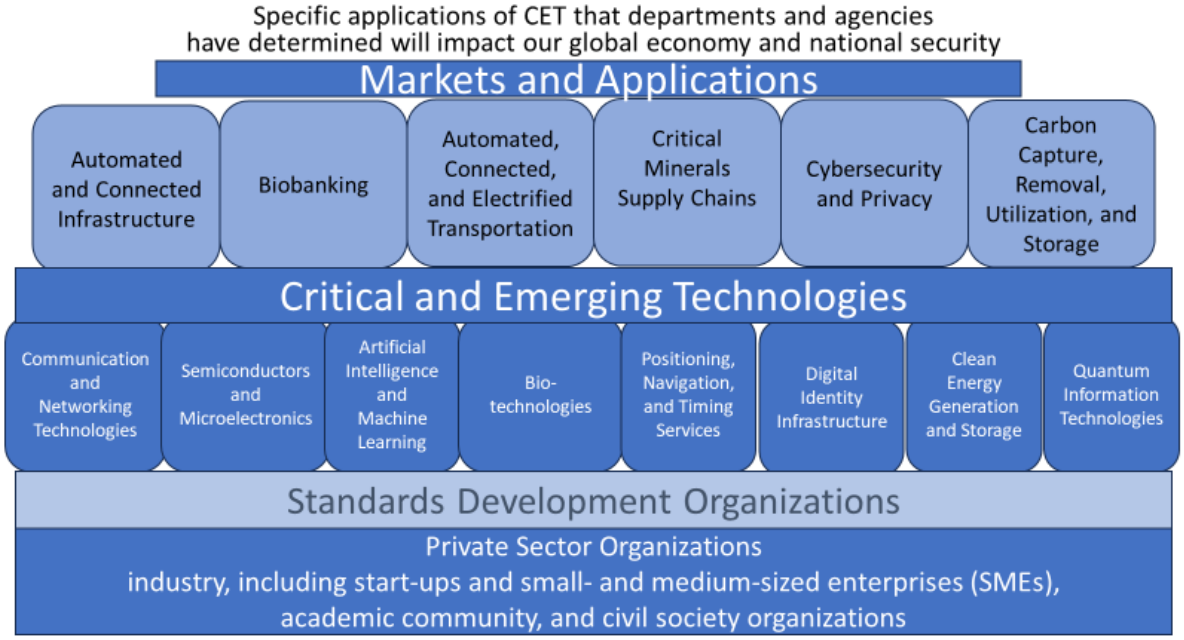

Figure 1: A snapshot of the commercial markets and applications that are based on the critical and emerging technologies identified in the NSSCET, and the role of the private sector contributions to Standards.

For each of the critical and emerging technology areas, there may be numerous different Standards development organizations, and with activities in various stages of development. The industry recognizes typical stages of Standards development and the normal sequence of events.

Typical Stages Of Standards Development And The Normal Sequence Of Events
• Identify Needs • Prioritize Standards • Assess Feasibility/Study • Initiation: Working Group(s) and Committees • Initial Drafting • Review/Comment • Final Voting/Approval • Finalization • Publish/Outreach and Education

Throughout the lifecycle of Standards work there are implications for patents, intellectual property, safety, environmental, regional variations, and timelines and plans for testing and compliance with Standards by Standards Development Organizations ("SDO" or "SDOs") or third parties who take on this role. Outlining these stages illustrates time sensitivity, complexity, and awareness that allocation of resources in each stage is necessary. There should be emphasis on the strategic importance of early-stage participation where decisions on priorities and timelines are determined. In later stages, active participation is required as specific proposals are determined and publication of the Standards is disseminated across platforms.

As a CET matures, a standard may require changes in organizational culture, engineering principles, tools, and infrastructure for adoption. For example, in the case of standardizing on a common design environment, complete standardization may require a participating organization to address one or more of the following:

- **Culture**: The engineering culture is composed of the values and beliefs employees have that are specific to the workplace and guide their work.
- **Engineering Objectives**: e.g., Power, performance, transistor density, and other company specific product targets designed to intercept their market segment.

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- **Guiding Principles**: Guiding principles create a bias in favor of one of several acceptable engineering approaches. If the engineering group's guiding principle is to maximize operating frequency it may not want to utilize full scan circuits and Standards.
- **Work Model**: The work model describes how the engineering work is planned and executed.
- **Method (Flows)**: Methods are the sequence of tasks used by engineers to do their work. Engineering methods are often documented in the form of a flow. Methods also include the specifications that itemize what must be specified and how it is measured.
- **Tools**: A tool is software that executes complex engineering algorithms that would be too difficult or unproductive to do by hand.
- **Scripts**: Scripts are a list of commands executed by other programs that are used to automate tasks. These often start out as a productivity aid for one person and are shared among others.
- **Collateral**: Input collateral is the intellectual property (IP) like circuits, design rules, and functional models used to enable methods and tools. The output collateral is the IP generated from the engineering work (e.g., the circuit diagram) that may be used by another party.
- **Data**: The data describes the design information. For example, logic model of the IC uses a specific set of terms, syntax and format that allows it to be used by different engineering tools.
- **Infrastructure**: The infrastructure includes the hardware, OS's, databases, and data management systems used to store and manage the engineering data so it can be used by tools during execution.

Standards-essential patents (SEPs) are important for industry. These designations allow for the private sector to aid in the market wide adoption of products (such as multivendor products like HDMI[ix] or MPEG[x] or WiFi[xi]) with opportunity to introduce SEPs into Standards in adjacent markets. Adoption by either direct or adjacent markets creates industry consistency that increases the potential for legal protections.

Many organizations lack experience on how to navigate the governance structure, voting rights, and resources required to navigate an SDO. The implementation of the NSSCET may become a national resource for the private sector to support these organizations. These challenges are more likely to affect start-ups and smaller companies as they do not typically allocate resources to monitor or participate in Standards development activities as they do not lead to immediate sources of revenue or capital. An effective way to increase stakeholder engagement is to improve proactive outreach and education efforts that prioritize accessible, digestible, and actionable information.

Additional areas of concern may include mandatory compliance with a standard that prevents greater functionality, higher quality and/or improved performance; poorly constructed Standards with unintended negative consequences; and unequal or outdated access to source code/tools at academic institutions creating negative workforce development outcomes.

USG NSSCET Objective 1: Investment

4. How can the U.S. Government establish policies that promote Standards development for CET as a critical component of U.S. innovation culture?

Policies should support free and open market principles, protection of intellectual property (data security) and provide opportunity for participation by innovators, academia, small businesses, and diversity of innovators, as well as large corporations in an inclusive stakeholder engagement process with adherence to "best in class" practices.

Along with establishment of policies, consideration should be placed on markets and technologies that are of importance to the U.S. and global connectivity/security. Communication of the market size and the impact of Standards must be conveyed to the private sector with the policies to have impact.

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Government policies should focus on identifying and communicating critical important and specific standardization efforts for industry collaboration. The benefit derived must exceed the opportunity cost for industry participation, government policies should focus on enabling a shared infrastructure that reduces the legal, business, and technical obstacles that increase the cost of participation.

The USG can lead the way in establishing policies by furthering dual-use commercial and government/national security innovation creating extended revenue opportunities by ensuring that Standards serve both sectors, where feasible.

Multi-stakeholder engagement is vital to any voluntary and most regulatory frameworks. However, there must be an achieved balance between incentivizing leading industry stakeholders to develop, adopt, implement, and promote the Standards and preventing financial, technological, or regulatory barriers to entry that would inhibit SMEs, disruptors, or other market entrants.

Specific focus on defining the CETs at a granular level, and a comprehensive database of Standards that map into the CETs that is communicated effectively would allow the private sector to participate with the level of urgency and resources to achieve successful outcomes for the U.S. There are numerous lessons learned from prior and current Standards efforts, and we encourage that implementation of the NSSCET leverage industry experience from JEDEC[xii], OCP[xiii], Si2, and numerous other Standards across all the critical and emerging technology areas. We encourage a survey of the established SDOs, Public Private Partnerships ("PPP" or "PPPs")[xiv], civil society organizations, and a selection of the industry associations that inform the preparatory work that feeds into Standards. There are also many Standards or de facto Standards that emerge from open-source communities, such as the Linux Foundation[xv], for example. There are international, regional, and national SDOs and each has its own structure of governance, leadership, membership, legal requirements, voting rules, and fees. In parallel, industry could identify for the USG the current and near-term Standards where immediate implementation and action could be taken. Given the large scope of the NSSCET, a few specific test programs for co-operation between the private sector and the U.S. government should be selected for immediate planning and action, based on their importance to the USG and industry.

Policies that inform U.S. industry about the relevance and importance of Standards would create awareness and motivation an incentivization. Standards development and link to patents and SEPs and possibly assistance from the United States Patent and Trademark Office[xvi] (USPTO) to companies and research institutions to expedite SEPs through the patent prosecution process. Also, some companies may avoid Standards to enhance their competitive position by balancing proprietary solutions and features vs Standards. Overcoming some of the skepticism or lack of knowledge with policy seminars and education would be of value to allow commercial companies to make informed decisions about their position on intellectual property, Standards, and competitive interests.

5. How can the U.S. Government utilize Federal spending on research and development to drive technical contributions for CET Standards development activities?

The NSSCET opens an opportunity for R&D innovators to take leadership on Standards setting. This can be done through programs that will be associated with the recently awarded and/or announced regional technology hubs[xvii]. A requirement of future projects may include adherence to Standards for prototype projects funded by government contracts, and development and publication of recommended Standards for CET as a requirement for government funded basic and applied research programs. Reducing the cost of collaboration is very important, directing federal spending to create environments within the hubs that have access to shared tools, facilities, infrastructure, and IP for R&D programs is essential.

Requiring Standards development participation as part of grants and funding could increase engagement provided it does not disincentivize stakeholders from applying for those opportunities. There should be

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consideration for programs to deliver not just patents, prototypes, and products but also high quality quantitative and qualitative metrics and data for Standards contributions which may promote Standards adoption and the introduction of SEPs into Standards.

6. How can the U.S. Government facilitate the adoption of Standards-based CET by industry stakeholders, including start-ups and small-and medium-sized enterprises (SMEs)?

A key step in proliferating adoption of a new CET Standard is to demonstrate economic benefits, technical superiority, enhanced interoperability, safety, and security. The USG can facilitate this by providing funding or engineering resources to document and disseminate this information within USG agencies or through other organizations. Education, training, and expert advice from U.S. industry and Standards representatives' leaders is required regarding identification of key Standards and Standards development bodies and a map of critical streams and decisions. Cataloging and mapping existing Standards for use and identification of Standards "gaps" and where new Standards are of value. This is critical for the smaller participants since larger organizations have more capacity to develop this collateral on their own independent of the standardization effort. The non-profit, iNEMI has a track record of developing guidelines, best practices, and tools, which result in contributions by their member companies to Standards in electronics manufacturing.

Both a top-down and a bottom-up approach is necessary to enable Standards development participation and adoption. Start-up and SME stakeholders primarily follow market leaders, so identifying and incentivizing market leader participation in a way that does not offer barriers to entry for smaller stakeholders. Additionally, financial incentives, education campaigns, and participation opportunities that are designed specifically for start-up and SME stakeholders will best enable Standards development participation, adoption, and adherence.

As with any critical or emerging technology, Standards are enabled by defining "the killer application(s)." Although it is important to keep Standards generic so they can be useful in all cases, there must be an awareness of where the commercial demand for the CET will come from and the technical functionalities these end-sectors require. Standards bodies must be aware of the emerging use cases and reach out to industry stakeholders, academics, and researchers to survey the demand landscape and emphasize the benefits for all of Standards.

7. How can the U.S. Government better support publicly funded and private research in Standards development activities for CET?

The USG can map CETs against U.S. and global Standards and publish in an open information portal. The site could be used to provide an overview of Standards development and an accessible means of pending updates or opportunities for engagement. Landing pages dedicated to each CET could host specific publicly available data and opportunities for stakeholder participation. A series of virtual public forums, discussions, and webinars that are each tailored to one specific CET could help to disseminate information, solicit feedback, and improve adoption.

The following are additional suggestions in the CET areas of semiconductors and microelectronics, artificial intelligence, and clean energy:

Semiconductors and Microelectronics

In the semiconductor and microelectronics industry identifying revenue and funding sources is critical. The process of designing a microchip runs into the 10s of millions of dollars at the low end. When designing at the critical edge at sizes in the 3 to 5nm range with billions of computing gates, the cost is well into the 50s of millions of dollars. Besides the technological expertise needed to design a chip, the cost of tools and access to intellectual property to enable the process is also costly. There can be

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restrictive licensing or expenses for process design kits and securing access to fabrication facilities may create barriers to tape-out and manufacture their designs. Start-ups and SMEs are forced to carry this cost as an investment without use case adoption and revenue guarantees. The USG can partially mitigate this risk by funding development efforts into technologies that will be government use and providing access to end-to-end fabrication and packaging facilities. Tied with its dual-use incentives, the risk across the development environment is lessened and innovation spurred. In addition, efforts to promote access across the chip design ecosystem, including access to EDA tools (e.g., OpenAccess), open standard instruction set architectures (e.g., RISC-V), and process design kits, may lower barriers to entry.

In the context of Lab to Standards (similar to ME Commons Lab to Fab[xviii]), it is necessary to examine the role of novel fabrication technologies (nano-fabs, additive manufacturing etc.) and impact on Standards for emerging technologies, where a wide variety of prototypes at relatively low scale can be built at small scale nanofabrication facilities, there is an opportunity to take early positions in Standards and metrology, based on a rapid path from experimentation to Standards, ahead of scale-up to high volume manufacturing.

Consideration for maximizing CHIPS Act investments by integrating R&D efforts across DoD and NIST/Commerce/NSTC PPP initiatives should be evaluated. For example, enablement of a wide availability of semiconductor security capabilities and tools to support dual use commercial and trusted-assurance use cases; and create a Standards and IP marketplace environment where trust, security and provenance are valued, in the same way as performance and interoperability are valued in the marketplace for products and services.

Artificial Intelligence

Implementation and broad adoption of the National Security Commission on AI's recommendation to create a DoD/IC foundation for AI assurance within industry will encourage AI threat sharing and in discovering and codifying AI assurance approaches. This ultimately becomes the nationally recognized driver of assurance for high-stakes AI applications. In addition, the development of standard tools and methods to quantitatively evaluate, for example, the amount of computational power used to train large AI models may provide a transparent foundation to better understand the role of computer hardware in AI progress and better enable regulatory efforts for national security.

Clean Energy Generation and Storage

Provide data and quantitative insights to inform climate adaptation and mitigation decisions and measure their impact. Provide mission-focused advanced energy systems engineering for data-driven analysis and modeling, technology evaluation and development, and operationally driven deployments and exercises.

USG NSSCET Objective 2: Participation

8. How can the U.S. Government increase the amount and consistency of private sector (i.e., industry, including start-ups and small-and medium-sized enterprises (SMEs), academic community, and civil society organizations) engagement in Standards development activities for CET?

Multi-stakeholder engagement is best accomplished through collaborative engagement opportunities that offer an informative discussion, provide detailed technical and non-technical publications, and that lead to visible incremental impacts and actions. In brief, the three areas of most value and impact are:

- Education and information
- Actionable data
- Resources and mentorship

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The USG could follow a campaign approach with market analysis and planning approach for each CET. This includes a survey of industry organizations and associations in these fields and academic institutions for direct outreach. The outreach should have a unique value proposition defining the benefits of engagement and participation. A campaign approach typically has the following phases: awareness, consideration, preference, participation, retention, and growth. In the earlier stages, target audiences may not even be aware that the USG or SDOs are defining Standards or looking for participants. In the middle stages, potential participants are determining the value of engagement. In later stages, participants are active and determining long-term participation or not and how they may recruit new collaborators.

For events, it is recommended for wide participation to implement hybrid options (both virtual and in-person) for those with limited travel budgets; establish a digital SME network for peer-to-peer collaboration and asynchronous work; provide a web-based (.gov domain) system to address each area. This system will realize a communications and collaboration portal focused on tangible measurable efficacy.

The USG can perform more pervasive outreach to potential innovators by broadening their outreach through activities more visible than posting to USG sites. The principal method is by educating industry, investors, associations, and academia with events, marketing, and social media campaigns (listening sessions, focus groups, podcasts, webinars, co-sharing events). At events, consider offering innovation awards for achieving certain goals (different for academia vs start-ups vs corporations) or certifications/credits for people trained to represent contributions to Standards. Where possible provide incentives, funding, grants, or scholarships to generate high quality data and for participation in support of Standards development to enable equitable representation of perspectives from all ecosystem members.

During Standards development activities live in person or on-line (live or asynchronous), it is important that the activities are led by experience facilitators who have planned thoughtful engagement to generate productive problem-solving and dialog as participants may have diverse viewpoints which may detract from making progress in a group environment. For hybrid environments, using modalities that are inclusive of real-time engagement from all participants.

As part of the process, have the facilitator hold engagement sessions with the USG or SDO to document and understand goals of the Standards process overall, each individual activity, and hold lessons-learned to learn what works well, what doesn't which may be different for each CET. Collaborative engagement among diverse people with unique perspectives, expertise, and experience is essential to solve new global challenges for CET.

Examples of areas to assess for successful engagement: goals of sponsoring organization; guidelines/parameters for the activities (logistics, fees, scheduling); identification of tasks, deliverables, and roles and responsibilities; document any known constraints; agreement on how to move forward if there is conflict; communication norms for participation equity; and time management and planning.

9. How can the U.S. Government improve communications among the public and private sector (i.e., industry, including start-ups and small-and medium-sized enterprises (SMEs), academic community, and civil society organizations) to address potential participation gaps in Standards development activities for CET?

A sustainable process for real-time and asynchronous communication, interactions, peer-to-peer collaboration, and align this with the common and unique interests of the private sector and academic community to understand the value proposition for each segment will improve participation and lessen potential gaps. Targeted outreach and engagement in collaboration with neutral, conflict-free associations and broadly attended conferences and events allows the USG to promote awareness of programs, avenues for participation, and opportunities for funding and incentives.

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Implementation of a web-based collaboration portal with registration requirements for CET Standards Development enables bilateral exchange. The USG can update users via the portal and users or contributors or collaborators can post feedback. Components of the system could include:

- CET Standards Development participation gap identification – web portal view
- CET Standards Development participation gap identification – email update reports
- CET Standards Development participation gap closure/closure rate tracking over time

The USG could partner across government with the various agencies and departments that have awarded regional tech hubs; ask for a call for participation to support a national working group for Standards - for instance DoD ME Commons for Microelectronics and Semiconductors or EDA Technology and Innovation Hubs across many of the CET areas; another option is to partner with individual state economic development agencies.

10. How can the U.S. Government foster early collaboration with private sector (i.e., industry, including start-ups and small and medium sized enterprises (SMEs), academic community, and civil society organizations) stakeholders to identify Standards for CET that would encourage market and regulatory acceptance as needed? At what stage is early collaboration most effective?

Collaboration between the USG and the private sector and other organizations should begin as early as basic or applied research whether at academic institutions, on government contract, or a private company using their internal research and development funds and continue iteratively throughout the technology evolution and maturation – as part of the marketing campaign process noted in question 8 at the awareness and consideration phase. In early stages, organizations are thinking more broadly in terms of guardrails, best practices, and lessons learned to advance market acceptance and opportunity. Early dialog informs and guides the USG on the benefits and burdens of Standards, regulation, or policy.

Within the government contracting community, there are well established processes and contracts to work with the USG on critical technology for national security applications. However, non-traditional contractors and new entrants have challenges with access and understanding of mission requirements. Use of regional hubs and associated consortiums and coalitions could allow a pathway where ideas may be incubated and mentored at early stages. For new programs that are funded within a hub, as part of the prototyping process, a requirement to document and identify Standards for CET for market and regulatory acceptance could be implemented.

11. What roles do the academic community and civil society organizations play in Standards development activities for CET, and how can they increase their contributions to a private sector-led system?

Academic Engagement

Thought leaders and researchers at academic institutions tend to have deep technical expertise foundational to CET's that can complement market initiatives of industry. Academic institutions should be tapped to provide a long-term perspective of innovations, research directions and act as a sounding board for commercial corporations. Close collaboration between the technical subject matter experts in industry and academic institutions can expand the technical resources that can be applied to Standards in alignment with the NSSCET. Often universities can be instrumental in providing modeling, simulation, test data to support the work of Standards bodies, resulting in robust and well-researched contributions.

Universities should include a “standardization” segment in science, engineering, business, and other disciplines that relate to the CETs to educate/promote the importance of standardization. Academic institutions should be encouraged to research the impact, importance, risks, and benefits of Standards from multiple perspectives including technical innovation and economic outcomes. They should generate and share data and support policies that directly align with Standards development.

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Both the academic community and civil society organizations can be the auditor of CET Standards effectiveness. In other words, they can help create and strengthen the accountability model. Civil society organizations can evaluate the impact of Standards usage post implementation and academics can project the future for emerging Standards.

To involve community colleges, adult education institutions, or continuing education programs, an opportunity to receive a certification/certificate program or Continuing Education Units (CEUs) from accredited institutions should be considered. This allows professionals with needs to maintain licenses or certifications a new or enhanced skillset.

Private Sector Engagement

Annual Report and Tax Return filings for all Corporations, LLCs, etc. can be leveraged as opportunities to engage (and remind) CET-designated (To be identified per the latest EOP Critical and Emerging Technologies List, February 2022) entities of the value and need for their active engagement with the CET-SD platform. Furthermore, the system can also be leveraged to announce USG-sponsored incentives, opportunities, accomplishments, and accolades for participating entities.

Civil Society Organizations (CSOs)

Civil Society Organizations and non-profits have a primary responsibility for ensuring that CET Standards are informed and developed based on a neutral, free from conflict and non-biased approach. These organizations enable voices to be heard across the ecosystem and resulting in equity and access in the process.

12. How can the U.S. Government better support state, local, and tribal governments in participating in Standards development activities for CET?

The U.S. Government's participation with state, local, and tribal governments may provide a level of equity between their efforts and international Standards. Some examples for how to do this include the following. A partnership approach is recommended where the USG educates and collects feedback from the states at the governor or state economic development agency or through regional tech hubs while the states or regional tech hubs educate and collect feedback from local and tribal governments. Deliberate outreach to these communities with a unique value proposition increases participation and collaboration. Establishing value propositions for Standards is important and impactful, a survey and/or focus groups with representative leaders is recommended so each community can determine value and benefit from the CET and their Standards. Where possible USG contracts, grants or incentives for state, local, and tribal governments participation is encouraged to increase equitable access to all communities. State or local Governments could implement "match grant" programs to supplement and tailor to communities with announcements of incentives, opportunities, accomplishments, and marketing/press releases for participating entities.

USG NSSCET Objective 3: Workforce

13. How can the U.S. Government leverage existing or develop new digital tools and resources that facilitate access to Standards development processes, and increase engagement by private sector (i.e., industry, including start-ups and small and medium sized enterprises (SMEs), academic community, and civil society organizations) CET stakeholders?

Communication and awareness are critical for successful Standards engagement. Easily accessible resources and effective communication of actionable information to the relevant CET ecosystem stakeholders will prove the most effective in enduring participation. The NSSCET should provide communications tools that enable timely access to CET. We recommend a multi-media and multi-tiered

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information distribution platform to make Standards initiatives visible to all potential stakeholders and contributors. We recommend sourcing content and contributions from Standards experts, educators, and industry to illustrate the critical role of Standards in the ecosystem and their impact on innovation and economic and national security.

There are many examples from social media, open source, and crowd sharing sources that represent models for how to implement modern information sharing to facilitate rapid sharing across the ecosystem. These tools could include timely targeted messaging to specific communities, searchable databases, and cooperation or co-sharing with professional and industry associations. The tools should be assessed and tested based on accessibility for alignment with the goals for CET Standards, then implemented based on best match and benefit.

A dimension of Standards development is timing or lifecycle. Certain Standards bodies, such as 3GPP[xix], have a well-established set of phases/stages for Standards. However, with the broad range of CETs, organizations may find it difficult to be aware of and enable their Standards activities to align. To reduce inefficiencies and avoid duplication, the USG can create a Standards portal that provides analyses, information, deadlines, and solicitations to encourage participation in Standards from a broader community than those who can afford to do the whole process themselves.

Tools using AI/ML, similar to that in drug discovery, could be useful for corporations to identify key "concentration points" in a product and where Standards may have significant impact (e.g., speech coding Standards in wireless communications for interoperability, a critical single global standard). Using search and large-language models an information repository may be a valuable way of illustrating strategic opportunities for Standards contributions to understand more complex relationships. These tools curate content and make insights frictionless.

Standards will require supporting documentation for data on testing, tools, performance, metrology, modeling, simulations, and procedures that may be used for assessing compliance. The tools required to produce this data may be complex and expensive. To facilitate production of high-quality Standards contributions from U.S. entities, the USG should consider low to no-cost efforts to develop and provide availability to these tools to academic, non-profit, and emerging businesses at regional tech hubs. Within the semiconductor industry, the establishment of a platform for EDA tools from different software manufacturers is highly desired. There are analogies for other CETs where tools and resources can aid the ecosystem to speed innovation and provide opportunities for competitive differentiation. Affordable access to tools and associated training reduces this risk and creates opportunities for small and medium enterprises to participate in Standards and then for adherence to Standards in resultant products and solutions.

14. How can the U.S. Government incentivize the modification of existing curricula and/or the creation of new curricula, to include faculty professional development, by educational institutions for pedagogy to support Standards development activities for CET?

The framework for faculty to adapt curricula to include Standards across the CETs is in place today, recognized by curricula following ITU[xx], IEEE[xxi], IETF[xxii], ATIS[xxiii], etc. or teachings of FISMA[xxiv], HIPAA[xxv], GDPR[xxvi], and other Standards and for example in the field of telecommunications and networking with 3GPP and WiFi Standards and their evolution. If CET-related Standards are easily and freely accessible, they will be included in new or updated curricula.

Courses in a degree, certificate, or CEU based program with existing or anticipated high enrollments are more enduring for academic institutions. A key to adoption and implementation is helping to justify how Standards development assists course enrollment data and employment opportunities for students. Online Certificate and CEU programs could be used to broadly expand and attract CET domain experts

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(technologists, business leaders, policy practitioners). These programs could be in partnership with industry workforce development programs.

15. What Standards development activities for CET can U.S. government and private sector (i.e., industry, including start-ups and small and medium sized enterprises (SMEs), academic community, and civil society organizations) stakeholders promote or develop to encourage increased participation by students and trainees?

Adult learners within industry and transitioning veterans are an ideal talent and professional development pipeline for Standards-oriented careers. We suggest scholarships and existing programs such as tuition or CEU/certification reimbursement allow for participation in Standards development courses. This will enable equitable representation from all ecosystem organizations. SDOs could offer CEU credit for material participation at Standards working groups and events, this also benefits the industry overall with more participants and greater networking.

The evolution of early STEM education (K – 12) should include modules on Standards. Today's youth are excited to participate in programs like Model United Nations, in the future they could be excited to participate in Model Critical and Emerging Technology Standards.

16. How can the U.S. Government support both private sector and public sector recognition for Standards development expertise and how can this recognition be utilized to increase Standards development activities for CET?

In a similar way to recognition for accomplishments in advances in sciences and engineering or contributions to important industry initiatives, inventions and innovations, recognition of the contributions to Standards by institutions and individuals would serve to reward and create awareness of the importance of CET Standards.

Certified recognition and awards are important for industry and talent. Within industry, it demonstrates adherence to global Standards like ISO and for individuals it demonstrates desirable skills for career mobility and advancement. Recognition of organizations and individuals at events and conferences by SDOs, associations, and civil society organizations could improve awareness and visibility of the importance of Standards participation and development. Participation and training in the field of Standards development can be recognized via Digital Certifications and Badges for websites, social media, and resumes.

USG NSSCET Objective 4: Integrity and Inclusivity

17. How can the U.S. Government work with private sector (i.e., industry, including start-ups and small and medium sized industry, including start-ups and small and medium sized enterprises (SMEs), academic community, and civil society organizations) stakeholders to more effectively coordinate with international partners and reinforce private sector-led Standards development activities for CET?

Broadly speaking, private industry, academia, and civil society organizations in the U.S. have extensive collaboration and coordination with their global counterparts on technology, products, and Standards areas. However, in the context of the NSSCET, the USG can provide policy guidance and education to private industry on U.S. national strategy and objectives as an additional factor in strengthening long-term planning and global ecosystem partnerships by the private sector. In particular, the NSSCET should focus on identification of priorities, key events, and specific needs for new Standards in existing SDOs or even the formation of new Standards bodies to address critical and emerging technologies. Where possible the USG can offer diplomatic channels to promote cooperation and collaboration with global stakeholders.

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18. How should the U.S. Government share information on Standards development activities for CET with like-minded partners and allies?

Where possible the USG should share openly at global conferences and events information on priorities for Standards development. At a working level, a secure data exchange process for the CET and Standards with like-minded partners and allies preserves confidentiality, builds trust, and preserves IP. The U.S. should promote a mutual exchange of information with like-minded partners and allies. This happens today with DoD CRADA[xxvii] efforts, these agreements could be extended to more USG Departments and allied partners.

19. What Standards information and tools can the U.S. government develop and promote to ensure U.S. exporters can compete in global markets for CET?

Existing publicly available Standards information is shared today by SDOs. Some of this information is only accessible to entities who are official members of the SDO, and others are more open and flexible. As a result, there is no central repository of searchable or navigable information for the broad range of Standards encompassed by the NSSCET. This can be an economic disadvantage to U.S. exporters who may be directly impacted by those Standards and associated regional regulations.

The key tool is to create free and open sources of information between the NSSCET and the broad range of Standards so private industry and exporters or importers can gain visibility on the evolution and trajectory of Standards and their impact on products and services globally. The scale and complexity of this task should not be underestimated, as illustrated in Figure 1.

Instances where a searchable database spanning the full range of CETs, ideally with artificial intelligence or automation, could aid the U.S. exporter community navigate the Standards landscape:

- Visibility into international Standards development discussions assists industry from unexpected or disproportionate market barriers as standardization creates interoperability.
- Open sources of information educate how SDOs support a specific protocol, evaluating interoperability or interconnectivity may have regional differences between the European Union (EU), Asia, and the U.S.
- Insights into the relationship and interplay between Standards and international regulations should be included in the NSSCET with educational materials for industry. An example, GDPR in the EU is a regulation and sets a standard for what and how data can be stored, transported, accessed, and used as well as protocols for permissions. The different regulations in the U.S. and EU create additional requirements and costs for companies in all geographies.

20. How can the U.S. Government further advance the design and implementation of technical assistance programs for CET that enable broad and inclusive participation by developing countries in international SDOs?

We encourage the inclusive participation of developing countries in the development of Standards as contributors and beneficiaries in the role of consumers of the products and services that emerge from the Standards. Global collaboration and proactive outreach are valuable building blocks for inclusivity and participation. Long-term communications and planning with developing countries are beneficial to the U.S. and developing nations in supporting innovation, and national and economic security. The U.S. is in a critical position to act as a convener where world-wide impact from a critical enabling technology is expected and the role of Standards enables positive impact for all parties. To achieve maximum global participation, collaboration must start at the governmental level, but also extend to industry, academia, and multiple tiers of cooperation.

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A pragmatic approach is to sponsor national and state trade delegations to targeted developing nations with leaders from U.S. and state government, private sector, academia who are experts on the NSSCET. This includes hosting nations within the U.S. and trade missions abroad. The delegations should have a common understanding of the CET area, USG national priorities, business priorities, and a comprehension of the nation's role in the ecosystem and their benefits of economic and innovation cooperation to promote growth, prosperity, security, social, and environmental values.

It is anticipated that developing nations will have their own innovations and technology that may align with or are outside the scope of the NSSCET. The need for mutual collaboration and understanding with developing nations is paramount.

21. How can the U.S. Government work with international partners to ensure that Standards for CET are developed in a way that supports U.S. interests, including a commitment to free and fair market competition in which the best technologies come to market?

The U.S. Government coordinates with allied countries and international partners today, so including the topic of critical and emerging technologies and the need for cooperation on Standards is a natural extension of existing relationships. This process could be facilitated through an educational campaign with the participation of industry and academic leaders, as well as U.S. government representatives. This is a valuable way to emphasize the impact and urgency of CETs and Standards and inspires routine collaboration.

A sustainable approach to long-term strategic alignment on key principles of relevant Standards can be achieved by learning and understanding the areas of agreements and differences with our allies. The U.S. has historically succeeded by focusing on innovation and a commitment to free markets. We suggest that the principles of innovation and free markets are keep at the center of our alignment discussions with international partners, since these principles will lead to sustainable and mutually supportive outcomes.

In national security technologies and platforms, the Foreign Military Sales (FMS)[xxviii] process should be extended to include CET. A requirement of the FMS investment would be to adhere to U.S. supported Standards.

22. How can the U.S. Government make the United States a more desirable location to hold international Standards meetings, events, and activities for CET?

Standards meetings, events, and activities are typically coordinated by each Standards body on a global scale, where the contributors can participate in a convenient and cost-effective way. Many SDOs accommodate virtual or hybrid participation but in-person meetings are perceived to be the most effective, especially at critical points of the Standards development process.

The U.S. is a desirable location for Standards events and activities with worldwide credibility for transparency, including legal frameworks, intellectual property, and free and competitive markets. The consistent output of emerging technologies from the U.S. is an additional incentive towards reinforcing our role as a desirable location with market potential.

The USG will encourage hosting at U.S. locations by confirming the meeting host is an inclusive organization such as a PPP, CSO, or non-profit to mitigate concerns by some nations of USG oversight. Attendance options should include both virtual and in-person components to enable accessibility and incentivize engagement. For in-person, there needs to be enough notification to enable that visas are obtained, and travel is economically arranged for maximum participation. A facilitator with experience leading multicultural groups should facilitate the meetings to enable equity and access to alleviate any communication or collaboration barriers.

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To allow for high quality participation and critical mass of U.S. entities from the private sector, funding for scholarships for participation for those that would not otherwise be able to participate, such as students and trainees, and start-ups is encouraged; and funding for technology R&D grants could also broaden remote participation.

Lastly, we recommend continuing the listening sessions between NIST experts and the private sector ecosystem. These could take place before and after key Standards meetings and at the same location as Standards meetings to prepare for or debrief Standards events.

End-Note Citations

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