Virginia Tech · University of Washington

NSF Workshop on U.S. Advancing Leadership in Global Networking Standards (US-ALIGNS)

Final Report

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Executive Summary

A recent NSF-sponsored workshop, U.S. Advancing Leadership in Global Networking Standards (US-ALIGNS), convened on 14–15 May 2026 under awards #2611609, 2611610 brought together domain experts from academia, government, and private industry to chart an operationalizable path for securing U.S. leadership in global telecommunications standards development organizations (SDOs) and promoting U.S. driven disruptive technologies underpinning global networking, that will define the next frontier of global competition in this critical component for national prosperity and security and global technological leadership.

The consensus from the workshop was clear: as 6G/beyond network architectures evolve that are increasingly software-enabled and AI-native, the role and function of existing SDO bodies such as 3GPP, IEEE, and IETF must shift from the erstwhile largely narrower technology specification pursuits over protracted (decadal) time-scales towards innovation at the rate of software updates, commensurate with exerting leverage over markets, national security, and geopolitical influence in a manner consistent with our societal and market-driven innovation imperatives. Shortening these protracted standards cycles is necessary, but it is not the only problem: a mechanism is also needed to convert long-term innovation (for example, massive multiple access) into APIs that will support new services, since an SDO focus limited to building better near-term pipes leaves a bleak economic future for mobile network operators. Participants converged on a broad acceptance of the present challenge: the United States does not suffer from a shortage of innovation, but from relative lack of viable mechanisms to convert that innovation – and the long-term strategic vision built on U.S. strengths – into leadership, whether via existing SDO mechanisms or creation of new disruptive market and policy influences.

Rationale and Imperatives for U.S. Leadership in Global Networking Standards

- **Strategic Necessity:** Technology leadership in 6G and AI-native standards bodies (3GPP, IEEE, IETF et al) is now a first-order lever over markets, security, and geopolitical influence.
- **Innovation-to-Standards Gap:** The U.S. does not lack innovation; it lacks a durable mechanism to convert long-term strategic vision, grounded in U.S. strengths, into standards leadership.
- **Coordination without Centralization:** Lightweight national coordination must amplify U.S. strengths in software, open architectures, and cloud-native networking.
- **Academic Realignment:** Universities should re-engage with their historic role of creating economic value.
- **Sustained Participation:** Continuity is expensive; travel and associated cost-offset support are needed to make engagement continuous rather than episodic. New mechanisms are needed to cultivate and sustain academic engagement with SDOs.
- **Market-Defined Leadership:** Measure success in terms of economic value created.
- **Allied Alignment:** Coordination with trusted partners grows more important, not less, as competitors pursue coordinated national playbooks.

Viewed from multiple lenses, the gap reduces to a simple point: under current structures, innovation that originates outside the largest players – in universities, startups, and small and medium enterprises – has little chance of shaping global standards. Hand-offs between sectors are fragmented, academic and industry incentives are misaligned, the IP regime favors large incumbents, and domestic presence in the working groups that decide the technical substance of future wireless networks is dwindling.

U.S. nonetheless holds decisive advantages: outstanding academic and private industry R&D sectors complemented by Federal labs that continue to be global leaders, along with consummate strengths in software-defined and cloud networking solutions, artificial intelligence (AI)/machine learning (ML) models and *both* market-led and open-source ecosystems that position it to drive disruptions away from legacy constraints. Rather than imitating a centralized, state-directed model, participants called for creative new lightweight coordination mechanisms that amplify these component strengths multiplicatively.

Achieving this vision requires confronting the structural friction across domestic institutions, particularly the misalignment between long-horizon academic research timelines and industry-driven standard release cycles and the imperatives of short-term financial return of investment (RoI). U.S. universities have a long record of creating economic value: land-grant institutions were founded to translate knowledge into regional prosperity, and university research has seeded entire industries – Stanford's role in the growth of Silicon Valley, and the Stanford spin-out Amati Communications, whose discrete multitone technology became the basis of the ADSL standard, are cases in point. The challenge is to amplify that value creation in the networking-standards arena, where the telecommunications industry thrives on a standardize-or-stagnate paradigm that rewards relatively near-term and profitable implementation. Standardization is driven by industry; academic engagement adds value when it is aligned with industry-driven needs rather than pursuing a separate technical agenda. Sustained academic engagement with SDOs nonetheless remains difficult and costly (besides the need for internal-to-university-administration cultural change), contributing to a pronounced national deficit in standards engineering capability and leadership.

Resolving these fractures demands a comprehensive modernization of the incentive structures on one hand, *paired with some form of national level domestic coordination and collaboration for standardization including academia, government and industry on the other*. Specifically, an effective mechanism is needed to allow academia to collaborate/coordinate with industrial SDO experts to work on medium-horizon (3+ years out) emerging standards relevant research projects within an agreed-upon collaboration framework. On the scale of longer-term reform, universities should re-engage with their historic role of creating economic value, and the reforms proposed here should be judged by how much of that value they help create. For example, universities should be encouraged to redefine internal merit (and ultimately promotion/recognition) criteria to include standards contribution/leadership as high-value translational scholarship on par with premier publications. On the other hand, core value propositions need to be clearly identified to incentivize participation in such collaboration from industrial SDO technology leads/standards delegates to pre-emptively shape medium-horizon research agendas and influence upstream university research to align with real industry problems. **To facilitate this, the federal government, via NSF TIP leadership, is encouraged to consider establishing a national center for standards-oriented, strategic and market aware coordination among all relevant parties**, leveraging expertise from NIST, NTIA, OUSW R&E and industry consortium such as ATIS/Next G Alliance. The center will link R&D activities with standards development, enabling academia's early access to real industry problems; this will enable a *novel translation layer* from research to prototyping for early testing and commensurate standards influence. Such a new national coordination center should target beyond 6G Rel-21 networking technology,

market and policy goals to incubate early-stage concepts and provide mechanisms for maturing U.S. led standards-essential innovation, protected by a lightweight Safe Harbor IP framework that lets private entities share technology knowhow without risking patent rights. Such a center must further integrate a low-barrier-to-entry Innovation Hub that enables prototyping, benchmarking and testing of NextG software-defined, open-source, AI-native implementations with a view to accelerate U.S. driven market leadership. Finally, the expertise represented within such a center will also support necessary U.S. strategy and positions at nation-state driven global networking bodies (e.g. ITU-R, World Radio Congress) that significantly impact our ability to influence allies and deter peer competitors.

In summary, the NSF US-ALIGNS Workshop recommended the following two broad consensus:

- Key Recommendation 1: Creation of a new Academic-Industry-Government collaboration center/ mechanism for measurable success by U.S. entities within existing global technical SDOs in beyond 6G standardization; support translation of global standards and their directions to defining positions at national (e.g., FCC, NTIA) and international and regulatory organizations (e.g. ITU, WRC, etc).
- Key Recommendation 2: Creation of a new community-oriented Innovation Hub for academia, small & medium enterprises and Federal Labs to collectively accelerate maturation/adoption of U.S. led software driven, AI-native networking technologies.



Figure 1: Group picture of workshop participants on May 15th, 2026, at Virginia Tech's Academic Building One in Alexandria VA

Motivation and Rationale

Opening remarks at the US-ALIGNS workshop, delivered by senior officials from the National Science Foundation and Virginia Tech, emphasized that strengthening U.S. engagement in global networking standards is not an objective that can be accomplished in a silo. That conviction was reflected in the makeup of the workshop itself, which drew colleagues from across the interagency space alongside academia and the private sector. At NSF, the goal of developing leadership positions and capabilities vis-a-vis standards development and promoting translation of new technology over the `valley-of-death', fits squarely within the TIP directorate's mission to elevate innovations to the point where they can achieve market influence.

The two specific motivating questions for the workshop were:

- How would the U.S. build an academic-industry-government eco-system to strengthen and enhance U.S. participation, influence, and leadership in global standards development organizations such as 3GPP, IEEE, IETF, etc.?
- What are possible U.S. strategies to further new *disruptive* technology-cum-market ecosystem concepts in telecom networks space to achieve global influence beyond traditional SDO processes?

The intended output was to be a set of clear, operationalizable recommendations to NSF that charts a pathway for academia, government, and the private sector to coordinate while leveraging their characteristic strengths towards achieving the goal of U.S. leadership in beyond 6G networking.

Participants framed the present as a dynamic and unusually fluid moment. Amid rapid technological evolution, standards development for 6G is already underway, animated by enthusiasm and shrouded in uncertainty about what networks of the future will look like, what new services will be offered and achieve market traction and the nature of forces that will shape this transition. Such fluidity creates opportunity. Leading voices in academia, industry, and across federal agencies broadly agree that the United States should take a more dominant role in formulating a `national' strategic perspective for future telecommunications and bring complementary (and sometimes mismatched) perspectives to bear on identifying elements of how that ought may be achieved. The workshop constituted a timely opportunity for stakeholders to come together, map out common ground, air non-congruent opinions and ultimately identify broad thematic principles for action that they collectively endorse.

The stakes are high because technical standards for networking have stopped being purely a narrow engineering or technology concern; they are a first-order determinant over markets, national security, and geopolitical influence at once. Standards determine interoperability and therefore which vendors capture scale; network architectures increasingly bake in assumptions about trust, resilience, and supply chains; and participating in standards bodies is a vector towards technological dominance. Further, the ongoing disruptions to future network architecture (both civilian and non-civilian sectors) due to confluence of cloud infrastructure, non-terrestrial networking, integration of sensing and communications and AI-enablement all contribute vectors that fundamentally transforming network operations via greater automation, scale and intelligence. Thus future (6G advanced and beyond) networking technologies will be primary among those shaping the great global geopolitical competition for 21st century. U.S. innovation leadership in all the above remains strong, but without enhancing participation and coordination and a cohesive strategy informed by national interest, the nation risks strategic diminution in the face of fierce peer and adversarial forces.

National coordination mechanisms are in place in many other countries such as China, Japan and South Korea: tight links between government-managed national technical coordination, persistence across

multiple global fora and meeting cycles, and deliberate use of standards-as-industrial policy to shape dominant market positions. Supporting evidentiary data include acquiring leading positions in SDOs (3GPP and IEEE), rapid growth in IETF (e.g. IETF 125 in Shenzhen in March 2026) and upcoming ITU WRC-27 scheduled for Shanghai (Oct-Nov. 2027). The recurring conclusion is not that the United States should imitate a centralized, state-directed approach, but that it must build lightweight coordination mechanisms that preserves and enhances its competitive strengths in software, AI/ML algorithms, open architectures, cloud networking, non-terrestrial networks (NTN), and unlicensed access (Wi-Fi). The DARPA-to-internet and subsequent generation of web-based services success story serves as a central proof point: sustained government funding as trigger with strategic clarity, academic research and industry adoption of open standards produced global leadership once before — and the time is ripe for a 21st century version of the same principles and playbook to be deployed.

KEY TAKEAWAYS: MOTIVATION AND RATIONALE

Treat standards leadership as strategic infrastructure: worth funding, since interoperability, security, supply chains, and global norms are critical to the nation.

Explore opportunities for disruptive leadership via the conjunction of emerging forces (cloud, AI/ML, non-terrestrial networks) transforming future network operations

Act within a narrowing window: while shaping next-generation network infrastructure is still under debate and AI + cloud is reshaping both the technology and the process that standardizes it.

Coordinate without centralizing: by building organization around lightweight mechanisms that let U.S. actors leverage our core technology strengths into positions of market and strategic dominance.

Keynote Highlights



Figure 2: Senior Vice President of Engineering, Qualcomm Fellow, from Qualcomm Technologies, Dr. Edward G. Tiedemann, Jr., presenting the keynote talk at NSF US-ALIGNS workshop on May 14th, 2026, at Virginia Tech

A Tier 1 industry keynote opened the morning plenary with a comprehensive, multi-dimensional roadmap for establishing global leadership in the sixth generation (6G) era. Its central argument was that capturing the future of wireless requires looking beyond the narrow confines of engineering specifications: true leadership demands an end-to-end strategy that harmonizes fundamental academic research, global standards consensus, ecosystem preparation, and the commercial delivery of high-value products. Referring to a prominent industry maxim, that third-tier companies focus on products, second-tier companies design underlying technology, and top-tier organizations shape global standards[1], the speaker validated the strategic leverage of standard-setting while cautioning that it is only one component of a broader blueprint for success.

From a national perspective, success in the 6G marketplace was defined by three core pillars: capturing the highest possible revenue and profits for domestic corporations; delivering robust, advanced communication architectures to residents at affordable price points; and ensuring the final global technology architecture propagates core democratic values. Achieving this requires mastering a spectrum of variables — technical

[1]Valentina Pop, Sha Hua, and Daniel Michaels, "From Lightbulbs to 5G, China Battles West for Control of Vital Technology Standards," Wall Street Journal, February 8, 2021.

innovation, a unified system-wide vision, ecosystem maturity, and a powerful international market pull for domestic products.

On the technical pipeline, the keynote called for recalibrating the relationship between universities and commercial enterprises. Rather than duplicating the applied engineering already mastered by industry, academic research should dedicate its talent to high-risk, long-horizon, exploratory domains, e.g., cross-technology synthesis and fundamental physical-layer barriers, which corporations lack the time or structural capacity to pursue. To bridge the historical information gap, the speaker urged structural incentives such as streamlined industrial internships and funded corporate sabbaticals for faculty and emphasized that breakthroughs depend on semiconductor advances to lower the cost of millimeter-wave and massive-MIMO arrays, alongside an interconnected weave of device technologies (CPUs, GPUs, and NPUs; environmental and biometric sensors; and complementary protocols such as Wi-Fi, Bluetooth, and Ultra-Wideband).

To characterize the geopolitical composition of the 3GPP landscape, the keynote cited membership data updated as of March 2026[2]. Of 523 distinct participating corporations, European headquarters represented the largest share at 37% (195 companies), followed by North America at 22% (115) and China at 16% (85); at a national level the United States led with 103 distinct corporate entities, followed closely by China with 85. When individual entities are tracked under official Organizational Partners, Europe's ETSI appears dominant with 54% of 823 entities, while China's CCSA holds 21% and North America's ATIS claims 10%. Re-bundling those memberships back to primary corporate headquarters, however, balances the picture considerably: Europe shifts to 30%, China rises to 25%, and North America stabilizes at 22%.

The strategic timeline was anchored to the multi-year 3GPP release schedule. In the mid-2026 landscape, the industry is finalizing 5G-Advanced via Releases 18, 19, and 20; the formal pivot toward 6G commences with Release 21, with initial 6G functional specifications estimated to freeze around late 2028 or early 2029. Advancing a proprietary technology through this pipeline requires concrete proof of concept via system simulations, open testbeds, and verified field demonstrations, in conjunction with a total commitment to ecosystem readiness, including timely and affordably priced spectrum allocations, operator appetite to fund massive deployments, and the simultaneous availability of compatible test equipment and certifications. The keynote closed with tactical recommendations: dissolve information silos through unified policies and public workshops; better leverage collaborative bodies such as the NextG Alliance; ensure government-funded academic testbeds are genuinely usable, open-source, and accessible; target strategic verticals such as Integrated Sensing and Communications (ISAC) for drone detection and tracking; and streamline visa processing so global technical leaders can attend standards conventions hosted domestically.

A startup/SME (Small and Medium-Sized Enterprise) keynote turned to how Wi-Fi standards are created, detailing the operational mechanics of wireless local area network (WLAN) standardization and charting a course for next-generation deployment. Its first and central point was the delicate balance between market scale, collaborative governance, and political-institutional friction that governs wireless innovation. While the current decentralized, bottom-up approach has successfully fostered a multi-billion-dollar global ecosystem that is sustained by unlicensed spectrum and highly affordable consumer products, with over five billion wireless network chipsets sold globally in 2025 alone, it faces mounting structural challenges as the industry transitions toward an AI-native future.

The ecosystem operates on a dual-track organizational framework: a formal engineering standards body manages the core technical specifications, while a corresponding industry alliance handles marketing,

[2]3GPP, "Membership," https://www.3gpp.org/about-us/membership.

branding, and commercial certification. The standards body itself runs on a rigid bottom-up, contribution-driven model with no centralized system-architecture committee; specifications are driven directly by participants under a highly democratic one-person/one-vote rule, in which technical proposals require a strict 75% supermajority to pass through an exhaustive process of draft balloting and systematic comment resolution. Because voting power is distributed among hundreds of active voters, their corporate affiliation naturally mirrors the fragmentation of the global chipset market. Throughout this history the body has maintained a non-negotiable mandate of backward compatibility across both the Media Access Control (MAC) and Physical (PHY) layers, and it manages new additions through a structured pipeline that moves from exploratory venues such as the Wireless Next Generation committee and Topic Interest Groups, to a Study Group, to a Task Group, and finally through Working Group and Standards Association ballots before publication.

A vivid "sausage-maker" analogy captured the "co-opetition" that defines the process, which relies on three pillars with distinct incentives: industry, focused on short-term research, commercial products, and IPR licensing revenue; academia, focused on long-term grants, publications, graduate students, and promotion; and government, concentrated on regulatory bounds, patent policy, and occasionally dual-use capabilities such as Ultra-Wideband. The system is open, transparent, and rigorously quantified through formal consensus, but it typically takes five full years to navigate a specification from inception to ratification. Structural flaws emerge from the rules themselves: the 75% supermajority frequently encourages political horse-trading and the addition of unnecessary features to secure votes, while attempts to bypass block-voting restrictions create friction around patent letters of assurance and global regulatory harmonization.

Looking forward, formal discussions for the next major generation (colloquially "Wi-Fi 9") commenced in early 2026, with more than thirty technical proposals already reviewed. The next generation will be explicitly AI-native, embedding machine learning directly into Channel State Information processing, advanced beamforming, constellation shaping, and real-time interference and congestion management, and demanding tighter MAC–PHY integration. Its target market is diversifying far beyond legacy data transfer toward immersive AR/VR, advanced robotics and agentic-AI networks, ISAC and industrial automation, and next-generation wearables and medical-IoT ecosystems. Because these use cases present unique operating environments, the key performance indicators are shifting away from raw throughput toward ultra-low latency, extreme resilience, and absolute reliability, with a formal study group projected for the second half of 2026 and a ratified standard anticipated between late 2031 and early 2032. The keynote ended with pointed questions: the traditional five-year cycle is too slow to keep pace with AI; it is increasingly difficult to differentiate successive generations; and the field must decide whether more agile, industry-led coalitions should take a more central role, and how to structurally bridge long-term university research with short-term commercial innovation.

A U.S. government keynote examined the intricate relationship between standard-setting and technological innovation. Industries standardize to achieve economies of scale, improve social welfare through interoperability and safety, and signal quality to the marketplace, with standards established through voluntary consensus, *de facto* market dominance, or *de jure* regulatory mandates. Standard-setting is not frictionless however, as it entails direct expenses such as meeting attendance, opportunity costs from technical paths foregone, social-welfare losses from procedural delays, and the financial risk of asset stranding. The talk analyzed these dynamics through four multidisciplinary frameworks: product-development engineering; political science and collective decision-making; corporate and national strategy; and governance of a knowledge commons.

A core contribution was unpacking innovation, i.e. meaningful novelty put into practical use, through five distinct lenses: economic change rooted in Schumpeterian creative destruction; applied novelty tracking the translation of ideas into implementation and adoption; competitiveness measuring productivity, job creation, and growth; a multi-level ecosystem view of interconnected networks and collective dynamics; and a capabilities-and-policy view emphasizing institutional support, global linkages, and long-term adaptive capacity. Applied to networking standards, these lenses reveal characteristic frictions: incumbents constrain economic change, so new markets emerge mostly as derivatives of established ones; applied novelty takes the form of slow, committee-driven public product development; traditional market competitiveness sits largely outside the focus of networking standardization; and ecosystem innovation moves slowly because service providers must guarantee strict Quality of Service and Experience while adopting new technologies.

To bridge rigid standards and fluid innovation, the keynote highlighted technical optionality, i.e., features that can be integrated into a product to ensure compliance without being mandatory. Options let standards-compliant products satisfy varied business models and applications and frequently serve as an administrative mechanism to buy consensus. However, they impose a steep penalty by increasing complexity and deterring vendors of rigid, hardware-oriented components. A "Real Options" framework, borrowed from financial literature, quantifies the value of deferring definitive architectural choices until more market data emerges, showing how modular standards design maximizes optionality and compounds the standard's total value.

The practical contrast was drawn between differing approaches to network architecture component designs. Classical TCP/IP internet standards are highly option-friendly: by establishing a relatively "dumb" network core and pushing advanced features to modules at the edge, they let application services develop and evolve rapidly alongside shifting demand, though attracting investment to basic, "vanilla" infrastructure is notoriously difficult. This stands in opposition to monolithic, infrastructure-heavy architectures such as historical OSI or Intelligent Network models. The keynote left the audience with forward-looking questions: how broadly the modular, option-friendly model can apply to other standards; whether it can survive today's far more complex environment; and whether the shift toward software-defined network functions can serve as the ultimate catalyst for breakthrough innovation within standards-based systems.

A second Tier 1 industry keynote made an extended case that the United States should be far more deliberate about claiming a role in writing the rules of future networks. Its framing question, "Who builds the future of the Internet?", is really a question about who gets to lead in architectural disruption and consequent leadership in their specifications (i.e. standards). Technical standards, it argued, have become a first-order lever over markets, national security considerations, and geopolitical influence simultaneously: they determine which vendors capture scale, they encode assumptions about trust and supply chains, and robust participation shapes industrial advantage and global norms. The diagnosis of the American position was pointed but not pessimistic — innovation remains strong, but participation is waning and coordination is lacking, leaving a narrowing window to reestablish leadership.

The industry organizational models also matter as much as the technology. The keynote distinguished two kinds of forums: open, bottom-up bodies such as the IETF and IEEE, with low barriers to entry that leave room for startups and academics and fit naturally with internet and Wi-Fi innovation; and large, industry-driven bodies such as 3GPP that align tightly with major operators and vendors, excelling at scale and disciplined deployment but carrying higher participation costs and a greater risk of domination by large or state-backed players. The conclusion was that the future needs both, and that the United States should

support a plurality of technologies and implementations, that aligns with strengths in software-enabled multi-system integration.

The core American weakness, in this telling, is not a shortage of talent but the absence of a durable mechanism to convert innovation reliably into positions of influence – either in global standards or product leadership. The pipeline from research to industry/government to standards/product influence suffers from fragmented hand-offs, insufficient and incompatible incentives, and general lack of impetus driven by national strategic considerations. A proposed fix is a national coordination framework that aligns R&D priorities, strategy around future networking architectures and implementations, and charts a roadmap for leadership in standards/innovation-for-market. The DARPA-to-internet story anchors the argument as a proof point, as do coordinated regional-scale approaches, e.g., funding-and-standards alignment such as Horizon Europe, and China through tightly coordinated industrial policy, illustrate the strategic choices at stake. Clearly China presents an explicit benchmark, with strong or leading positions across 3GPP, the ITU, and the IEEE, rapid IETF growth, and events such as IETF 125 in Shenzhen in March 2026 as evidence of a coordinated national agenda.

Intellectual property and standard-essential patents were handled with deliberate balance: beneficial when they reward R&D and drive contributions, but harmful when they produce higher licensing costs, barriers for newcomers, complex fair, reasonable, and non-discriminatory (FRAND) negotiations, patent thickets, litigation, hold-up and hold-out games, and the geopolitical weaponization of patents. The path forward is transparent FRAND frameworks, stronger alignment with open source, and balanced, globally coordinated policy. Wi-Fi was singled out as a strategic asset rather than a footnote and proof of American advantage in open networking by virtue of its global scale, fast innovation cadence, enterprise and campus relevance, fit with cloud-managed networking, and natural complement to 5G and 6G private networks. The recommendations pulled everything into four moves: a leadership focus that doubles down where the United States is already differentiated (Wi-Fi, open architectures, cloud-native networking, AI-driven systems); investment that funds standards engagement and long-horizon partnerships, not just lab research; governance reform that broadens participation and lowers barriers for newcomers; and coordination through an enduring framework linking agencies, allies, industry, and universities, with intellectual property right (IPR) and supply-chain factors folded in.

KEY TAKEAWAYS: KEYNOTE HIGHLIGHTS

Standards-making is slow and consensus-driven: multi-year elaborate consensus driven 3GPP releases increasingly mismatched to AI and software timelines.

U.S. advantage lies in software, AI, open ecosystems, and small cell private enterprise: Future strategy should be built on those strengths.

Modular, option-friendly, open interfaces are a natural vector for U.S. innovation: allowing market-driven development on top of a stable standard core.

A coordinated competitor playbook makes a national coordination framework and allied alignment urgent: to convert strong innovation into durable standards leadership.

Plenary Panel Highlights



Figure 3: Panel Discussion at NSF US-ALIGNS workshop: May 14th, 2026, at Virginia Tech

The plenary panels translated the keynote themes into a working agenda. The first panel examined academia–industry collaboration within existing wireless standardization frameworks. The discussion contrasts continuous innovation with the traditional ~10-year generational cycle, examining how academia, industry, and standards bodies can better collaborate amid a maturing technology landscape and the rise of AI. With AI as a potential source of transformative change, industry pressure is shifting toward value-added services while the standards development is under intense time pressure. The transformative aspects of 6G & beyond will rest on integration of new use-driven technologies such as NTN and ISAC within cellular, and the transformative impetus due to AI-native and autonomous operations, responding to human-machine interactions. Responding effectively will require innovations led by U.S. universities and startups/small businesses with the requisite freedom and support. Such innovations will continue to unfold in parallel with the standards process, with present-day misalignments contributing to a lack of productive intersections.

The panel located much of that misalignment in academic incentive structures. The promotion- and-tenure process rests on traditional academic norms that prioritize discovery-based metrics such as publications, and rarely treat standards participation as a meaningful professional metric. Underlying this are philosophical differences: academic research explores frontiers and addresses fundamentals with broad freedom to define questions; whereas, industrial standardization is focused on the necessary steps to integrate working technology into a global system, heavily constrained by hardware, interoperability and scalability, and field-deployment requirements. The disconnect is not universal, as many academics already collaborate productively, and administrators routinely highlight faculty who invent revolutionary technologies, but the panel sought ways to bring the two groups into alignment more systematically.

Intellectual property also emerged as both barrier and opportunity. IP restrictions are frequently the primary obstacle to university–industry collaboration, ironically functioning to keep innovation out of the market. The panel urged universities to decide deliberately how they define success for intellectual property, adoption or maximized royalties, since policies can be optimized for one or the other. Thoughtful financial models can encourage collaboration: pre-competitive work should carry simple, predictable access terms; testbeds can offer a standard membership-fee model; and royalty maximization should be reserved for the most important situations. In this framing, universities have tremendous potential to play the role of a neutral, pre-competitive sandbox.

Concrete strategies for building bridges followed. The panel recommended creating incubators or mechanisms that bring more academic and diverse ideas into industry/standards conversations while encouraging purposeful academic focus alongside frontier exploration that are relevant to standards. Meanwhile, universities should cultivate a culture that values real-world impact by defining new metrics that include standards contributions and industry collaborations, incorporating them into faculty training and internal peer review. More opportunities for cross-pollination such as frequent industry rotations for faculty and students, rewards for industry experience prior to an academic career, and contract vehicles that facilitate collaborative projects, would help. Europe offers strong examples, where industry co-mentoring is a frequent component of doctoral training, and robust joint efforts across industry and government identify key problems and fund university researchers to address them. Workforce development was identified as a natural point of alignment. For the NSF specifically, panelists suggested that solicitations explicitly include standards contributions in broader-impacts language, that reviewers be counseled to treat such impact as an asset to a proposal, that reporting requirements emphasize impact-based metrics, and that successful precedents such as the NSF IUCRC program be mined for what made pre-competitive collaboration effective. The panel also noted a worrying structural drift: a declining proportion of academics with industry backgrounds, alongside a decline in industry research departments that favor doctoral hiring. Overall, the panel discussion set up the stage for the follow-up discussion in various breakout groups, especially breakout group 1, breakout group 2, and breakout group 3.

A second plenary panel examined the balance between global standards (primarily 3GPP) and regional differentiation, the risks of overspecification/mission creep, and how the U.S. can better navigate and influence this landscape. Specifically, the panel noted that the global standards do enable global interoperability, economies of scale, and U.S. innovation leadership. On the other hand, they also bring issues like technology bloat and resource-intensive consensus processes that disadvantage SMEs/academics and difficulty defining a true minimum viable product (MVP). Originally designed in a hardware-centric era; today's software-defined, cloud, and AI/ML-driven industry needs faster, more flexible innovation decoupled from rigid release cycles of current standardization efforts. The panel also discussed the tension between the U.S. preference for competition over coordination and agreed the important and pressing need for U.S. coordination to strengthen influence in global networking standards. Specifically, the panel discussed the lack of coordination and organization in global networking standards as a long-recognized issue for the U.S. and suggested a system-centric approach of jointly implementation of solutions to build momentum through prototypes or real products on top of the white papers generated by organizations like NextG Alliance (NGA). The panel also acknowledged the importance of NSF funding to support related research projects to be aligned with standards needs so that research outputs can be showcased in standard meetings. Greater U.S. government leadership (e.g. via NSF, NIST, NTIA, etc) is needed to convene stakeholders. The second plenary panel set up a solid discussion foundation for the follow-up discussion of various breakout groups, especially breakout group 1, breakout group 4, and breakout group 5.

A third plenary panel addressed standards for private enterprise and the rise of private 5G/6G with enterprise-specific requirements. The discussion focused on adapting commercial (public) wireless technologies—especially in the 6G era—for private-enterprise, public safety, defense, and national security needs, emphasizing resiliency, interoperability, affordability, and the role of standards and government. Specifically, the panel suggested the U.S. government to fund and incentivize research and innovation activities where the pure commercial business case is weak (e.g., resilience, public safety, etc). The panel also suggested prioritizing dual-purpose technologies with clear RoI and exploring vertical markets as starting points. A stronger government-industry coordination mechanism is also called out. The third plenary panel set up the stage for the follow-up discussion of various breakout groups, especially breakout group 1, breakout group 3, and breakout group 5.

A fourth focused on how SMEs can navigate an increasingly complex standards landscape. The panel examined the significant barriers SMEs face in engaging with standards bodies (especially 3GPP) and offered practical recommendations for improving participation and innovation pathways. In the near-term, the panel recommended the U.S. government to fund costs of sustained standards participation for U.S. companies and recognize standards work as a core part of the research-to-development pathway. In the longer-term, the panel suggested that the U.S. government strengthen industry-university collaboration, expand live testbeds, and boost domestic standards participation capacity to leverage U.S. strengths and encourage ethical, collaborative approaches. Overall, the panel agreed that meaningful SME innovation in standards requires reducing structural barriers, providing sustained participation support, defining clear MVPs early, fostering ecosystems/partnerships, and shifting toward more open, extensible approaches. The plenary panel set up the stage for the follow-up discussion of various breakout groups, especially breakout group 5 and breakout group 6.

KEY TAKEAWAYS: PLENARY PANEL HIGHLIGHTS

Most fundamental breakthroughs originate in U.S. universities/start-ups and small businesses: but unfold in parallel with the standards process, so deliberate bridges between the two spheres are needed.

Supporting dual-purpose technologies and SMEs: by funding targeted research and offsetting standards participation costs.

Coordination among industry, academia and government is the key: drive system-centric and standards-relevant research with a clear ROI by expanding collaborative R&D funding among NSF, other federal agencies (e.g., NIST, NTIA, etc), and industry.

Day One Breakout Discussions

Breakout 1: Process-cum-Structure for pre-SDO Academic-Industry-Government Collaboration in the U.S. — Industry-led perspective

The first breakout group, approached from an industry-led perspective, examined structures for pre-SDO collaboration between government and the private sector. Its core finding was that the United States excels at decentralized innovation but struggles with at-scale proof of concept and the coordination required for global standardization. A fundamental incentive mismatch underlies the problem: theorists are driven to publish what is plausible, systems researchers are driven to implement at small scale, while industry delegates are paid to implement what is profitable. Compounding this, there is currently no unified national platform where academia, industry, and government can collaborate, find convergence, or hold dialogue around pre-standards research and development.

Even with such a platform, a coordination deficit would persist, primarily because industry standards delegates face highly complex schedules and severe time and travel constraints; consequently, they lack practical incentives to attend additional meetings merely to share general knowledge or to educate, and be educated by, academia and government. A time-scale mismatch is equally problematic: standards development operates on a short-term operational scale, whereas academic research requires a multi-year horizon, which makes it difficult for academics to contribute to standard items that are already mature, or considered to be.

A new national coordination mechanism is worth pursuing, but with a narrow, well-defined role: the group saw value in a national organization connecting industry, academia, and government around pre-SDO work, that does not duplicate or replace existing standards bodies (3GPP, IEEE, etc.), nor act as a unified national delegation. Its role is early-stage information sharing, agenda awareness, and connecting long-term research and associated strategic aspects to future standardization drivers. AI can lower the cost of this role considerably: companies already use AI to read the full set of 3GPP contributions, compare technical findings, and identify emerging industry consensus on a time scale of days, and the same tools could be used to summarize academic innovation and prepare an agenda for connecting the two.

Industry will only show up if there's clear value. Busy standards delegates won't attend meetings just to "educate" others. Concrete incentives include opportunities for gaining mind share for technical ideas before formal standards discussions, learning other stakeholders' priorities, reducing the burden of tracking hundreds of contributions, R&D or tax credits for standards participation, and C-suite/CFO buy-in, since standards travel is costly and budgets are tight.

The end goal is innovation, not more standardization. Multiple participants warned against measuring success by contribution counts. The emphasis should be on quality, simplification, and translating genuine innovation into standards.

Broader U.S. concerns raised include declining operator technical expertise, a lack of coherent long-term spectrum strategy, weakening student pipelines in core telecom areas, and missed opportunities in which U.S. research leadership did not translate into U.S. industry leadership – polar codes being a recent example, and transformational technologies such as OFDMA the more consequential one. From U.S. government funding agencies (NSF, in particular), the requested support is to fund pre-standards coordination and collaboration instead of isolated R&D, avoid duplicating what industry already does, align academic research with industry needs, help educate academics on how the standards process actually works, and still

leave "room for crazy ideas." Explicitly rejected, on the other hand, is forcing full industry consensus before standards meetings. Companies have competing commercial interests; partial alignment and better awareness is the realistic goal.

KEY TAKEAWAY: NATIONAL COORDINATION FOR PRE-STANDARDS COLLABORATION

Define a pre-competitive, research collaboration-based information-sharing platform that would neither replace formal SDOs such as 3GPP or IEEE, nor attempt to force private companies into a single unified national position. Instead, the platform would act as an incubator focused on early-stage discussions, shared agenda priorities, and connecting long-term academic research to future standardization needs.

Breakout 2: Academic Culture Change for Academic-Industry-Government Pre-Standards Collaboration in the U.S. — Academia-led Perspective

The second breakout group, led from an academic perspective, addressed academic culture change and the rewarding of standards contributions in tenure and promotion tracks. Its central finding was a fundamental misalignment between the long-term, publish-or-perish research cycle and the fast-paced, standardize-or-stagnate industry cycle: traditional academic grants last three to five years, while standards development operates on rapid release cycles measured in roughly eighteen months. Severe financial hurdles compound the problem — participation in formal SDOs such as 3GPP is cost-prohibitive for universities, with expensive membership fees, international meeting travel averaging about $5,000 per trip, and fully supporting a single student's active attendance requiring at least $25,000 annually across multiple years.

Beyond cost, there are steep knowledge and language barriers. Standard specifications are dense, and SDO discussions are highly specialized for industry deployment rather than abstract theory, so doctoral students frequently lack the training to navigate the document repositories or digest rapid-fire ecosystem negotiations, and diverting their attention from their academic careers is counterproductive. There are also nontrivial flaws in academic meritocracy: tenure, promotion, and institutional-ranking systems are heavily weighted toward paper citations and journal publications, forcing faculty to choose between standard-ready engineering and pure scientific research. Finally, intellectual-property anxiety, referred to as a "purity trap" in which researchers fear that openly discussing preliminary ideas with industry delegates will poison future patent applications, further discourages engagement.

To address these, the group recommended modernizing tenure and faculty-evaluation criteria so that standards leadership is explicitly classified as translational scholarship: serving as a committee chair or leading a work item within organizations such as 3GPP or IEEE should be credited as high-level professional service on par with editing a top-tier journal. Universities should establish specialized "Professor of Practice (Standards)" tenure-track or clinical positions that recognize the individuals who act as institutional translators between abstract academic labs and rigid specification committees, and there is merit in embedding formal standards contributions and industry-integration metrics into national university-ranking methodologies. Universities also need standardized, pre-negotiated IP frameworks that create safe harbors, allowing faculty to share problem statements and solution paths with private-sector collaborators without compromising the commercial viability of future standard-essential patents.

On workforce development and curriculum, the group proposed a "Standards-Corps" pilot modeled on the successful NSF I-Corps customer-discovery framework. Rather than interviewing customers, students would interview active SDO delegates to perform "standards discovery," mapping the explicit technical friction points and release timelines where their lab's research could tangibly fit. Standards should be embedded into graduate education through specialized courses on system-level specifications, standards-tracking tradecraft, and negotiation dynamics; through practical assignments in which students read, analyze, and actively track a specific 3GPP or IEEE work item over a semester; and through industry co-mentorship that invites active delegates to lecture on campus and mentor students on navigating standards pipelines. Immersive internships and funding pools should be expanded so that doctoral candidates and postdocs can embed directly into an industrial partner's delegation for a full release cycle, while companies are encouraged to sponsor academic memberships, share centralized accounts, or subsidize travel.

Multiple U.S. government funding agencies — OUSW, DHS, NIST and NTIA notably — may have distinct complementary roles in shaping the full response. They could leverage programs such as the NSF TIP Directorate's Accelerating Research Translation track to build dedicated university standards offices that

handle the heavy lifting of travel logistics and technical-contribution formatting; provide agile "release-cycle" supplements of roughly $50,000 to $100,000 that let a researcher shepherd systems research into an active standards work item; establish a centralized, agency-managed fund for the high cost of international SDO travel so the burden falls off individual grants; mandate standardization-impact statements on future 6G-related applications; and institute a "standards help line" staffed by industry professionals alongside democratized, open-source simulation platforms and shared testbeds such as O-RAN Open Testing & Integration Centres (OTICs) or NTIA Public Wireless Supply Chain Innovation Fund (PWSCIF) Testing & Evaluation (T&E) resources such as ACCoRD (led by AT&T and Verizon) and VALOR (led by Viavi) to lower experimental entry barriers.

KEY TAKEAWAYS: ACADEMIC CULTURE CHANGE AND WORKFORCE DEVELOPMENT

Recredit standards leadership as translational scholarship: and create "Professor of Practice (Standards)" roles that bridge labs and specification committees.

Launch a Standards-Corps and embed standards in graduate education: through I-Corps-style standards discovery, work-item tracking, and industry co-mentorship.

Relieve the cost barrier: with release-cycle supplements, a centralized international travel fund, and university standards offices.

Build pre-negotiated IP safe harbors: so faculty can collaborate without compromising future standard-essential patents.

Breakout 3: Challenges to Future SDO Specifications in 6G & Beyond — New Uses

The third breakout group examined challenges to future SDO specifications in 6G and beyond through the lens of new uses. A first source of friction is the arrival of entirely new verticals: traditional wireless focused solely on moving bits from point A to point B, but 6G must also "see the world" through ISAC and NTN. A severe gap exists because radar and sensing engineers have not historically communicated with telecom engineers, resulting in mismatched standards. At the same time, satellite systems that once relied on proprietary, non-standard architectures, creating steep vendor lock-in, are now migrating rapidly toward formal bodies such as 3GPP precisely to gain access to the massive commercial scale of billions of global smartphones. Where 5G treated satellite connectivity as an add-on or emergency fallback, 6G makes space-native integration a "Day One" design requirement.

The competitive and technical stakes are high. Other nations are planning massive constellations of up to 300,000 satellites and competing delegations. Meanwhile, SDOs are moving slowly on NTN and frequently implement simplistic solutions to deeply complex structural issues. Major unmapped or unsolved friction points include satellite handoffs, multi-orbit coordination across LEO, MEO, and GEO, orbital eclipses, satellite-to-satellite interference, and high-fidelity channel modeling.

The group's architectural recommendations centered on flexibility. Rather than defining hyper-granular hardware specifications, standards should prioritize northbound APIs, allowing the rigid standard to evolve slowly while private enterprises build highly customized, software-defined applications on top of a stable 6G core. SDOs should pivot to a "core + extensions" paradigm so that private industrial entities such as automated factories or ports can strip away unnecessary public-network overhead like global roaming and deploy a lightweight "Private Industry 4.0 Profile" optimized for ultra-low latency. Standard interfaces should be forced toward a plug-and-play "Lego component" model, so that a U.S. startup can build a localized sensing module that seamlessly plugs into any vendor's 6G base station. To accelerate adoption, the United States should fund open-source reference stacks through O-RAN and the Linux Foundation because operating a working, physical reference stack pressures global SDOs to adopt those software architectures as the *de facto* standard.

On testing and open infrastructure, the group recommended that funding agencies back an open-source digital-twin framework for LEO and MEO satellite networks, complete with robust channel-emulation models that interface directly with 5G/6G protocol stacks so smaller companies and academics can simulate real-world conditions and demonstrate viability to 3GPP. Agencies such as the NSF TIP Directorate or DHS should sponsor accessible, multi-operator public testbeds for satellite communications that are not siloed inside a single university, but structurally sustained and capable of testing multiple operators and multi-satellite constellations acting as both fronthaul and backhaul.

Finally, the group emphasized dual-use, mission-critical, and regulatory strategies. Commercial 6G hardware must be robust enough for public-safety and government use cases such as border monitoring and disaster response, with Low Probability of Interception and Detection capabilities overlaid on standard 6G/3GPP protocols; systems should use multiple distinct constellations simultaneously for resilience; and seamless terrestrial-to-non-terrestrial mobility must be validated to preserve voice quality and Mission-Critical Push-to-Talk states during infrastructure failures or natural disasters. Spectrum gaps require updated, dynamic sharing and auction models for satellite bands; ISAC "safety zones" should eliminate interference between a facility's localized radar-sensing operations and a public carrier's data transmissions; and strict environmental-privacy standards must define who owns radar data to prevent an integrated sensing network from being weaponized into a tool for mass surveillance. The United States

should form pre-standard alliances with trusted partners such as NATO and European allies to align use cases before global SDO arenas and explicitly fund pre-standardization study items at the ITU and 3GPP to recreate the historic pipeline in which industry consortia and researchers feed pre-standard discovery into active standardization bodies.

KEY TAKEAWAYS: NEW USE CASES FOR 6G: SENSING, SPACE, AND MISSION-CRITICAL NETWORKS

Bridge the sensing–telecom and terrestrial–space divides: with API-first standards, "core + extensions" profiles, and plug-and-play interfaces.

Lead through open-source reference stacks, digital twins, and shared testbeds: that let small players demonstrate viability to 3GPP.

Build dual-use resilience and clear spectrum and privacy frameworks: for NTN, ISAC, and mission-critical operations.

Align trusted allies before the global plenary: and fund the U.S. delegation pipeline at the ITU and 3GPP.

Breakout 4: Challenges to Future SDO Specifications in 6G and Beyond — Structural Aspects

The fourth breakout group examined the structural changes needed in how specifications themselves are written. At its center lies a tension between entities that seek to protect high-value innovations through patent portfolios and those that prioritize deploying practical solutions to immediate market needs. Traditional adoption is hindered by risk-averse carriers and a conservative cellular-infrastructure environment focused on reducing operator costs rather than integrating unproven, standalone features.

A defining metaphor framed the group's analysis: historically, SDOs wrote hyper-detailed hardware specifications — the entire "cookbook" — but in the 6G era artificial intelligence acts as "the chef." Over-regulating AI through rigid standards eliminates its utility, whereas failing to standardize algorithmic boundaries prevents interoperability entirely. Emerging semantic communications, which optimize for transferring contextual meaning rather than raw bits, directly challenge the Shannon limit and push SDOs to consider standardizing shared lexicons instead of traditional waveforms. As 6G moves toward a cloud-native, software-defined architecture driven by DevOps cycles, the traditional 3GPP value-capture model of standard-essential patents — fundamentally tied to physical hardware — risks becoming obsolete, threatening to fracture the market and potentially replace open standardization with the platform dominance of hyperscalers building proprietary, non-interoperable versions of 6G. Underlying all of this is a severe timeline friction: public regulatory cycles take a decade, SDO releases take roughly two years, and modern software development moves in two-week intervals.

The group's guiding recommendation was to "standardize the kitchen, not the secret sauce." SDOs should pivot toward standardizing modular, system-level boundaries and token-based interfaces for control and manageability, allowing networks to implement dynamic agentic architectures while letting private companies protect their proprietary AI algorithms and IP. The U.S. government should fund dedicated liaison officers to manage the structural handshakes between 3GPP, the IETF, and the IEEE so that cellular, internet, and local sensing standards integrate end to end. Architectural specifications should build an open interface for regulators directly into 6G designs, enabling agencies such as the FCC to push real-time spectrum-management policy into the network's Radio Resource Management system. National coordination bodies should also establish clear frameworks defining which tiers of pre-standard research remain fully open to catalyze adoption and which component-level innovations remain protected to secure competitiveness.

On testing and validation, the group urged industry and SDO working groups to deploy telecom-specific large language models and AI agents to auto-generate first drafts of tedious documentation such as test specifications and hardware-targeted pseudo-code, automating work that engineers traditionally lack the time or incentive to write. Funding agencies should establish rapid-iteration living labs and sandboxes optimized for specific verticals, e.g., agriculture versus transportation, to validate complex, multi-vendor capabilities like ISAC, and should recognize that basic RAN-5 conformance testing[3] represents only a small fraction of real-world readiness, so testing infrastructures must integrate AI-driven workplaces that machine-code directly to hardware emulators and spectrum analyzers for operator-specific verification.

Institutional and federal alignment rounded out the recommendations. Universities should create dedicated technical centers staffed by full-time professional standardization engineers, shifting the burden away from

[3] RAN-5 conformance testing refers to standardized testing defined by the 3GPP (3rd Generation Partnership Project) to ensure that mobile devices (User Equipment/UE) correctly communicate with cellular networks.

short-term doctoral students whose incentives conflict with the slow-moving requirements of SDO tracking, and should launch digital matchmaking platforms that connect disruptive academic research with corporate technical needs. The NSF TIP Directorate should supply sustainable, multi-year funding earmarked for collaborative academic-industry platforms that translate foundational research into formal standards, complemented by targeted R&D tax credits that offset corporate engineering hours and licensing costs in designated pre-standardization forums. Finally, agencies such as the Department of Defense and NTIA should issue clear Concept of Operations and procurement requirements for dual-use applications, which include counter-UAS systems, NTN, and GNSS independence, providing a definitive market demand that incentivizes commercial vendors to adhere to unified standards.

KEY TAKEAWAYS: STRUCTURAL CHANGE IN HOW SPECIFICATIONS ARE WRITTEN

Standardize modular interfaces, not proprietary AI: so networks can run agentic architectures while companies protect their algorithms and IP.

Fund cross-SDO liaisons and a regulator-in-the-loop spectrum interface: to integrate 3GPP, IETF, and IEEE and enable real-time policy updates.

Modernize testing with AI agents and vertical sandboxes: and treat conformance as only a fraction of operator-certification readiness.

Staff university standards centers and send clear procurement demand signals: to sustain participation and pull vendors toward unified standards.

Breakout 5: Enhancing U.S. Leadership through Regional Coordination for Disruptive Technologies

The fifth breakout group focused on enhancing U.S. leadership through better regional coordination and the adoption of disruptive technologies. Its foundational finding reframed the very definition of leadership: it cannot be measured by academic output or the raw volume of standard contributions but must be defined by actual market position and a dominant share of the global wireless-infrastructure arena. Writing complex features into standards that are never implemented or deployed by carriers represents a major failure and a waste of engineering resources.

The group identified a "monolithic hardware trap." Traditional bodies such as 3GPP are trending toward monolithic architectures, creating a severe risk that 6G will be captured or held hostage by legacy infrastructure vendors even though the next-generation network will natively run in the cloud; hardware components such as the User Equipment and the Radio Unit remain closed, acting as major constraints on end-to-end innovation. The inherent strength of the United States, by contrast, lies in software-defined networking, cloud architecture, and AI, not in building legacy hardware. Key vectors for U.S. value creation include edge-AI systems optimized for complex verticals such as healthcare, and softwarizing the network via open source to lower iteration costs and drive competition-based innovation. This supports an "innovate first, standardize later" blueprint: rather than wasting years fighting over paper features within slow-moving SDOs, the United States can build, implement, and popularize a working software stack across a wide user base first, since once a technology becomes a de facto market success it is extremely difficult for international bodies to resist. The group also named a stark standards engineer gap, as the nation boasts thousands of the world's most brilliant AI and software researchers but only a small handful of expert standards delegates capable of translating that code into global specifications.

On structure and alliances, the group recommended leveraging ATIS and the NextG Alliance as pre-standardization filters that forge a unified North American consensus on highly disruptive concepts, such as an AI-native air interface, before delegates arrive at the 3GPP floor, preventing U.S. industry from showing up fragmented. Rather than agonizing over slow global consensus, the United States should pivot toward establishing regional interoperability standards and modular profiles alongside trusted allies such as Japan, South Korea, the United Kingdom, and the EU, building a unified alternative market with regional SDOs explicitly defining software-defined networking profiles for rapid local experimentation. The group also urged a full pivot to open-source bypasses, funding and championing open-source network software so that disruptive features can be built into active repositories within two years rather than debated for five.

Incubation, vertical testing, and procurement formed the next cluster. Regional incubation hubs should trial and prove next-generation concepts through live field trials to prove capabilities first and standardize only if absolutely necessary, while defining strict Minimum Viable Products targeted at specific industrial verticals to give Mobile Network Operators the deployment confidence they require. Government procurement and national-security anchors should serve as immediate market stimulants; for example, the government could fund deployment of ISAC networks as localized "surveillance bubbles" around military installations, providing immediate commercial demand for dual-use 6G innovations. A structured mentoring ecosystem should also be built so that large, established telecommunications companies directly partner with and shield smaller, agile startups, helping them deploy specialized applications and survive global SDO dynamics.

Finally, the group called for agile federal funding models: "Standards Lifespan Fellowships" that support technical experts through the entire longitudinal lifecycle of a technology, from initial study item to final

work-item adoption, rather than funding isolated short-term papers; a rapid-response fund, run through the NSF TIP Directorate or NTIA, capable of deploying capital within weeks to help U.S. small and medium enterprises mount technical counter-proposals against coordinated foreign pushes; and a mandatory, recurring federal competitiveness audit that systematically maps the global telecom landscape, pinpointing exactly where the United States commands an absolute lead, where it is merely treading water, and where it has critically fallen behind.

KEY TAKEAWAYS: REGIONAL COORDINATION AND MARKET-DRIVEN LEADERSHIP

Measure leadership by deployed market share: not by academic output or the volume of contributions that never reach deployment.

Use ATIS and the Next G Alliance as consensus filters and build allied market scale: with trusted partners to drive legacy standards to adapt to Western software designs.

Pivot to open-source bypasses and an "innovate-first" blueprint: building working stacks quickly rather than debating specifications for years.

Fund lifecycle fellowships, rapid-response capital, and recurring competitiveness audits: to sustain a credible, well-mapped U.S. presence.

Breakout 6: Disruptive Innovation for SDO: Era of Open-Source Hardware and Software

The sixth breakout group considered the impact of open-source hardware and software on traditional SDOs, a new generation of what was once referred to as a "software-driven standard." It observed a major structural shift toward a build-first paradigm, in which widely adopted open-source repositories, such as a 6G AI-native core, may become more critical de facto standards than written 3GPP specifications. Open-source projects like Open Air Interface (OAI) or the O-RAN Software Community create a "reference implementation loop." By providing the first living version of a specification, they force traditional bodies to reconcile theoretical models with real-world code, dramatically reducing technical ambiguity. Such deployments can transition directly into formal industry standards, historically mirrored an early university implementation ultimately shaped the Border Gateway Protocol.

Significant constraints temper this promise. A key technical roadblock is the "silicon gap": true end-to-end "Open 6G" innovation is impossible if the underlying silicon and hardware remain proprietary. Major industry software stacks depend heavily on proprietary hardware, and certain Department of Defense project codes suffer similar lock-in, so while some network components can be open-sourced, others remain strictly closed. Sustainability poses a further challenge: open-source wireless networks cannot survive as a "one-company show" and require broad vendor support to reach critical mass, yet commercial entities and carriers are often hesitant to maintain open-source stacks or participate in open testbeds, creating a severe "maintainer-of-last-resort" problem. Cost barriers compound the issue, as small businesses and startups are generally unwilling or unable to invest in expensive physical hardware; although carriers are ultimately required for final certification, open-source emulation platforms and digital twins are vital for low-cost, first-level verification.

On testbed democratization and validation, the group recommended that federal agencies invest heavily in software-simulation platforms and digital twins alongside physical hardware, letting small players validate code without the real-time constraints and capital expenditure of physical systems, and that they establish a centralized open-source hardware library and carrier-grade open stack accessible to any qualified U.S. or allied researcher. A standardized validation-testbed suite, modeled on the Wi-Fi Alliance and continuously updated, would let vendors constantly verify their software against evolving baseline models, while open-source projects should mandate that contributed code be optimized for both functionality and performance, enforcing strict minimum performance metrics to avoid fragmentation.

On strategic SDO interplay and IP protections, the group urged building legal and technical defensive frameworks to protect U.S. open-source contributions from IP poisoning, ensuring that foreign entities cannot capture or restrict open wireless codebases through predatory patent claims during the transition from repository to formal standard. It also recommended standardizing customization itself, an "IKEA Billy bookcase" approach, to avoid losing economies of scale to over-customization, allowing modular software extensions to attach safely to uniform hardware baselines, and it argued that SDOs should standardize clear, open interfaces rather than over-specifying internal processing logic.

Institutional shifts and workforce alliances completed the picture. The group recommended expanding the scope of NSF TIP funding so that it is not exclusive to academia, using it instead to support hybrid industry-academic open-source maintenance and critical-codebase upkeep, and building academic-industry mobility pipelines that intentionally produce a hybrid class of "software-savvy standard delegates" and "standard-savvy software engineers." Mirroring successful European models, the NSF should supply dedicated

funding to support the mobility of faculty and graduate students directly into active industry roles to promote technology transfer and direct collaboration.

KEY TAKEAWAYS: OPEN-SOURCE HARDWARE AND SOFTWARE AS A STANDARDS STRATEGY

Treat reference implementations as de facto standards: since a living open-source stack drives SDOs to reconcile theory with working code.

Close the silicon gap and fund sustainable maintenance: to avoid the "maintainer-of-last-resort" problem in open wireless stacks.

Democratize testbeds with digital twins and a Wi-Fi-Alliance-style validation suite: so small players can verify designs at low cost.

Protect open codebases from IP poisoning and build mobility pipelines: that produce hybrid software-and-standards talent.

Day Two Breakout Consolidation

On the second day, all six Day One breakout groups reported their findings and summaries to the plenary session. Subsequently, cross-group sessions consolidating the six Day One breakout groups into two larger breakout groups were organized, focusing on the following two key themes of the workshop:

(1) an academia–industry–government collaboration ecosystem aimed at strengthening U.S. participation, influence, and leadership within existing global standards bodies such as 3GPP, IEEE, and IETF;
(2) a new disruptive-technology-cum-market ecosystem aimed at achieving global influence beyond traditional SDO processes.

These two larger breakout groups provided a comprehensive discussion on the topics covered and summarized the recommendations focusing on the two key themes of the NSF US-ALIGNS workshop.

Breakout 1: Building Academic-Industry-Government Collaboration Eco-system for Existing Global Networking Standards

The first track focused on the question of how to build a cross-sector ecosystem for existing global networking standards such as 3GPP, IEEE, IETF, etc. Specifically, breakout groups 1 – 3 in Day One were regrouped into the breakout group 1 of Day Two to focus on the theme 1 of the workshop. The deliberations could be mapped into the following three bins.

1. Roadmap Framing: The group recommended a mapping effort to develop a national technology R&D roadmap, culminating in a defined action plan within five years, along with a corresponding research proposal. The group specifically called for establishing an NSF Engineering Research Center (ERC) type of translational and workforce development effort on existing global networking standards that implement a funding and coordination mechanism, one that must include incentives for all participating parties; meanwhile, the group suggested that NSF convene and fund a semi-open discussion on needs in standard development. Finally, the group raised the issue of strategic IP protection, noting that companies are sometimes hesitant to work with academics and that a new model for handling proprietary data may be needed.

2. Outreach and prototype testing: These included an SDO-specific outreach program to academic institutions inclusive of development of standards-oriented curricula, and tactile training opportunities delivered through testbed development on standards and technology. The group emphasized that these activities need to happen throughout the United States rather than being concentrated in a few locations.

3. Funding: The group proposed funding for academics, industry partners, and other organizations to jointly address an NSF-identified problem, as well as to support participation in standards bodies. It also recommended helping to fund a Joint Development Program that would support a "standards in a box" capability.

Breakout 2: Building New Disruptive Technology-cum-Market Eco-system

The second track focused on the question of how to build a new disruptive technology-cum-market ecosystem capable of achieving global influence beyond traditional SDO processes. Specifically, breakout groups 4 – 6 in Day One were regrouped into the breakout group 2 of Day Two to focus on theme 2 of the workshop. The deliberations could be mapped into the following three bins.

1. Open Innovation Stack: The group devoted considerable attention to open source as a foundation, with OCUDU serving as the base. Participants discussed an open-core model that would bring in other open-source projects and coined the term "open innovation stack" to describe the result, with a key insight that the value lies not just in the stack itself but in the overall approach. The group identified gaps that currently constrain end-to-end innovation, e.g., no open-source UE, a closed RU, missing reference signals for use cases such as ISAC, and the absence of an open information model, without which open APIs are not possible. It was recommended that NSF supplement OCUDU by bringing in more radios and platforms, investing in an additional production-quality layer, and leveraging existing testbeds such as NSF PAWR sites and NTIA PWSCIF NOFO1 labs (ACCoRD and VALOR). Companies should be encouraged to contribute components that plug into NSF testbeds so that academics can innovate on them, and, as Red Hat demonstrated for Linux, a management entity is essential for the stack to be sustainable.

2. Agile SDO/RDO: The group called for creating, and for NSF to fund a prototype of, an agile, regionally (U.S.) oriented SDO or regional development organization (RDO) whose output is working code rather than specifications. In this model, companies, universities, and principal investigators (PIs) bring ideas into an open, governed process; innovations are validated through gated roadmap milestones, digital twins, and field trials; and the market, rather than standard-essential patents alone, determines the value of a contribution, with FRAND terms preserving rights to monetize. The guiding principle was to prove the value first and then drive it into the global SDOs, with use-case clusters, particularly those of prime U.S.-government concern such as ISAC-based drone detection, scoped with mission agencies to keep the effort manageable.

3. Sustainability and Value Validation: The group stressed making the effort sustainable and ensuring genuine business value, since many open-source projects fail; the open innovation stack must be validated with a focus on end-to-end value, clear business cases, and clusters of use cases. Participants suggested the Linux Foundation as a good home (a reasonable starting point though not sufficient on its own), called for a more enlightened IP management plan, and highlighted the role of academics and small businesses in validating, scaling, and improving the quality of open-source projects, with sustained emphasis on translating the work into practice in the field and then pushing demonstrated value and impact into the global SDOs.

Overall Recommendations & Next Steps

Taken together, the keynotes, panels, and breakout sessions converged on a diagnosis striking in its consistency: the United States does not suffer from a shortage of innovation, but from the absence of a durable mechanism to convert that innovation into standards leadership and market dominance. The same gap was described from multiple vantage points — as fragmented hand-offs and uneven institutional incentives within the emerging software-defined, AI-native infrastructure; as misaligned academic incentives in the academia–industry panel; as the structural disadvantage of small enterprises and universities that cannot field large standing delegations; and as a dwindling domestic presence in the working groups that decide the technical substance of future networks.

A second point of agreement is that standards have become strategic rather than merely technical. Speakers, panelists, and breakout contributors repeatedly framed standardization as a first-order lever over markets, security, supply chains, and national influence, and contrasted the decentralized, competitive U.S. model with the coordinated national playbooks pursued by competitors. The recurring conclusion is not that the United States should imitate a centralized, state-directed approach, but that it must build lightweight coordination that preserves its competitive strengths, such as software, algorithms, open architectures, cloud networking, and multi-radio access technologies (including unlicensed such as WiFi) and provide coherence to pull in the same direction when and where it matters. Finally, the proceedings reflect a shared sense of timing: because the next generation of wireless is still unsettled/in-definition and AI and autonomy will reshape the processes that standardize and implement it, participants treated the present as a narrow but real window of opportunity.

Lowering the barriers to sustained participation. The most frequently repeated and most immediately actionable theme was that effective standards influence depends on continuity, and that continuity is expensive. Influential corporations field large delegations and attend near-monthly global meetings, whereas academics, startups, and government participants generally cannot. Participants urged direct support for participation itself, for example, cost offsets and travel support for delegates, and faster, more reliable visa processing for those attending standards meetings hosted in the United States, so that domestic engagement becomes continuous rather than episodic, and argued that participation should be treated as a fundable research output rather than administrative overhead.

Repairing the academia–industry interface for standardization. A second theme addressed the cultural and incentive gap between universities and the firms that ultimately deploy technology. Recommendations include creating collaboration and technical exchange opportunities between academic researchers and standards delegates, moving beyond purely publication-centric evaluation by crediting technology transfer, standards participation, deployed systems, open platforms, and patents; enabling faculty rotations and sabbaticals inside industry, standards bodies, and government laboratories; expanding co-advised projects, industrial residencies, and practitioner-in-the-loop programs; and encouraging industry experience before or alongside academic careers. The intent is not to redirect academia toward near-term engineering but to couple its frontier work — the "first ninety percent" of a problem — more deliberately to the "final ten percent" that industry must solve for commercialization, treating real-world constraints as legitimate research questions rather than implementation details.

Rethinking roles of intellectual property and open architectures/interfaces. A third theme reframed intellectual property and system interfaces as architecture rather than tollbooths. Participants recommend that collaborative university-industry consortia access terms for any pre-standards proprietary IP to promote sharing of data, software, and testbeds; that the objective of such arrangements be participation, adoption,

and influence rather than maximized royalties; and that the financial model match the collaboration's intent, with simple, predictable terms for pre-competitive work and membership-fee models for shared testbeds. On the technical side, several speakers advocated open, extensible interfaces that allow market-driven innovation on top of a base standard, defining clearly bounded modules with fully specified interfaces, requiring vendors to support all variants of an interface they implement, and requiring federally funded projects to deliver specifications for such open, modular boundaries.

Coordinating without centralizing. The fourth called for lightweight national coordination among all stakeholders – academia, industry and cognizant federal labs/agencies via a new and clearly scoped standards-relevant research center/forum where domestic actors can align on higher-level priorities vis-à-vis future standardization and commit to research/developing/prototyping/testing of new open architectures and interfaces and their adoption via industry consortia and national efforts. Participants recommended building durable domestic capacity based on testbeds/data/code that are made available to all certified U.S. and allied nation entities and are supported via targeted market-development incentives.

KEY RECOMMENDATION

Key Recommendation 1: Creation of a new Academic-Industry-Government collaboration center/ mechanism for measurable success by U.S. entities within existing global technical standards development organizations (SDOs) in beyond 6G standardization; support translation of global standards and their directions to defining positions at national (e.g., FCC, NTIA) and international regulatory organizations (e.g. ITU, WRC, etc).

Key Recommendation 2: Creation of a new community-oriented Innovation Hub for academia, small & medium enterprises and Federal Labs to collectively accelerate maturation/adoption of U.S. led software driven, AI-native networking technologies.

Appendices

List of Participants

Organizers

Lingjia Liu, Virginia Tech
Sumit Roy, University of Washington

Industry Participants (33)

Alex Hamilton – Nokia
Ali Khayrallah – Ericsson
Anton Monk – Cohere Technologies
Asha Keddy – Cisco
Bishal Thapa – RTX/BBN Raytheon
Bryan Helmick – Rohde & Schwarz
Chengjin Zhang – Qualcomm Technologies
Chris Boyer – AT&T
Clara Li – Intel
David Young – ATIS
Edward Tiedemann – Qualcomm Technologies
Nicolas Fetchko – Verizon
Hugh Harney – Axiom Inc.
Ian Pannell – GSMA
Ian Wong – VIAVI Solutions
James (Jim) Lansford – DeepSig
Jaydee Griffith – ATIS/NGA
Jennifer Manner – AST SpaceMobile
John Baker – MDA Space
Judith Azcunes – GSMA
Kuntal Chowdhury – NVIDIA
Mehmet Yavuz – Celona
Jeffrey A. Metzger – InterDigital
Nandan Das – Viasat
Sastry Kompella – Nexcepta
Sridhar Rajagopal – Ennoia Technologies
Tim O'Shea – DeepSig
Tracy van Brakle – Praxeum/WINLAB
Venki Ramaswamy – MITRE
Vijitha Weerackody – Johns Hopkins University Applied Physics Laboratory (JHUAPL)
Wei Zeng – Apple
William Davenport – Cisco Systems
Yan Xin – Samsung Research America

Government Participants (29)

Amanda Toman – NTIA
Bevin Ashley Vanderley – NSF
Brian Todd Kelley – OUSW(R&E)/FutureG
Chaitan Baru – NSF
Cuong Luu – DHS
Dimitrios Meritis – U.S. Department of State
Erwin Gianchandani – NSF/TIP
Florence Rabanal – NSF/TIP
Hang Liu – NSF
Huaiyu Dai – NSF
Jonathan Lu – FCC
Lauriston Hardin – NTIA
Lou Anne DeMattei – ANSER/DoD CIO
Manu Gosain – NTIA
Mark Lipford – FirstNet Authority/NTIA
Mark Norton – ANSER/DoD CIO
Martin Doczkat – FCC
Martin Goldberg – NSA
Martin Weiss – OUSW(R&E)/FutureG
Nada Golmie – NIST
Natalia Sitnikov – U.S. Department of State
Rich Greel – U.S. Army
Richard Rouil – NIST
Sarah Skaluba – NTIA
Scott Fox – OUSW(R&E)/FutureG
Sridhar Kowdley – DHS
Sudharman K. Jayaweera – NSF/TIP
Yiannis Argyropoulos – OUSW(R&E)/FutureG
Yishen Sun – NIST

Academic Participants (22)

Alex Sprintson – George Mason University
Alhussein Abouzeid – Rensselaer Polytechnic Institute
Ashutosh Dutta – Johns Hopkins University
Aylin Yener – Ohio State University/IEEE
Bo Han – George Mason University
Danda Rawat – Howard University
David Simpson – Virginia Tech
Hongwei Zhang – Iowa State University
John Baras – University of Maryland
Josep Jornet – Northeastern University
Kostas N Oikonomou – Rutgers University
K. K. Ramakrishnan – University of California, Riverside

Kirk Cameron – Virginia Tech
Lance Collins – Virginia Tech
Nick Laneman – University of Notre Dame/SpectrumX
Robert Calderbank – Duke University
Rose Hu – Virginia Tech
Stephan Fuss – Georgia Tech Research Institute
Steven McKnight – Virginia Tech
Tommaso Melodia – Northeastern University
Zhengdao Wang – George Mason University
Zhi-Li Zhang – University of Minnesota

Workshop Agenda

Information about the event was made available via the workshop webpage located at:
https://lingjialiu.ece.vt.edu/index/research/US-ALIGNS.html

Day 1: Thursday, May 14, 2026

08:00 AM – 8:30 AM Registration

08:30 AM – 8:50 AM Welcoming Message

Erwin Gianchandani, Assistant Director for TIP Directorate, NSF

Lance Collins, VP of the Greater Washington, D.C., Area of Virginia Tech; Member, NAE

08:50 AM – 9:00 AM "Why This Workshop & Why Now?"

Sudharman K. Jayaweera, Program Director, TIP Directorate, NSF

09:00 AM – 9:05 AM Workshop Goals and Objectives

Lingjia Liu, Virginia Tech

Sumit Roy, University of Washington

09:05 AM – 9:55 AM Morning Keynote: "How Wi-Fi Standards Get Created, Now What Comes Next"

Jim Lansford, DeepSig Inc.

09:55 AM – 10:00 AM Break

10:00 AM – 11:00 AM Plenary Panel 1: "Academia-Industry Collaboration within Existing Wireless Standardization Frameworks"

11:00 AM – 12:00 PM Plenary Panel 2: "Regional versus Global Standardization Efforts for Existing Wireless Standards"

12:00 PM – 1:00 PM Lunch Break

01:00 PM – 1:55 PM Afternoon Keynotes:

"Reinvigorating Innovation in Standards Setting"; Martin Weiss, OUSD(R&E)

"A Framework for U.S. Leadership for AI-ML (Intelligent) 6G Infrastructure"; Asha Keddy, Cisco

01:55 PM – 2:00 PM Break

02:00 PM – 3:00 PM Plenary Panel 3: "Standards and Commercial Wireless for Private Enterprise"

03:00 PM – 4:00 PM Plenary Panel 4: "Networking Innovation for the Small & Medium Enterprise: Navigating Standards Landscape"

04:00 PM – 4:15 PM Coffee Break, Formation of Breakout Groups

04:15 PM – 5:45 PM Round 1 Breakout Sessions:

Breakout Group 1: Process-cum-Structure for pre-SDO Academic-Industry-Government Collaboration in the U.S. (Industry-led perspective)

Breakout Group 2: Academic Culture Change for Academic-Industry-Government Pre-Standards Collaboration in the U.S. (Academia-led perspective)

Breakout Group 3: Challenges to Future SDO Specifications in 6G & beyond — New Uses

Breakout Group 4: Challenges to Future SDO Specifications in 6G and beyond — Structural Aspects

Breakout Group 5: Enhancing U.S. Leadership through Regional Coordination for Disruptive Technologies

Breakout Group 6: Disruptive Innovation for SDO: Era of Open-Source Hardware and Software

06:00 PM – 7:00 PM Pre-Dinner Networking Social / Reception

07:00 PM – 9:00 PM Breakout Group-Based Working Dinner

Day 2: Friday, May 15, 2026

08:30 AM – 09:00 AM Light Breakfast/Networking

09:00 AM - 10:30 AM Review and Finalization of Day 1 Breakout Sessions (Breakout Groups 1–6)

10:30 AM - 12:00 PM Day 2 Cross-Group Consolidation Sessions:

New Breakout Group 1: Building an Academic-Industry-Government Collaboration Ecosystem for Existing Global Networking Standards

New Breakout Group 2: U.S. Strategies for New Disruptive Technology-cum-Market Ecosystem Concepts Beyond Traditional SDO Processes

12:00 PM – 12:45 PM Reviewing/Finalizing Summary of Round 2 Breakout and Discussion

12:45 PM – 12:55 PM Workshop Summary and Next Steps

12:55 PM – 01:00 PM Closing Remark

Kirk Cameron, Associate Vice President and Managing Director of the Institute for Advanced Computing, Virginia Tech

List of Breakout Session Questions

Day One Breakout Sessions

Breakout Group 1: Process-cum-Structure for pre-SDO Academic-Industry-Government Collaboration in the U.S. (Industry-led perspective)

Challenge: *There is no 'national' mechanism for academia-industry-Government collaboration for dialog and convergence around pre-standards R&D. Furthermore, industry standard delegates are busy and lack incentives to attend meetings to "educate" academia and government.*

- How can industrial standard delegates be incentivized to attend a 'national' platform to conduct knowledge sharing and discussion/coordination?
- How might the Next G Alliance / ATIS evolve to implement such a platform, or are new coalitions necessary (and if so, what should these look like)?
- What can funding agencies do to facilitate and enable this?

Breakout Group 2: Academic Culture Change for Academic-Industry-Government Pre-Standards Collaboration in the U.S. (Academia-led perspective)

Challenge: *There are no strong incentives for academic researchers to participate in standardization-related research: (1) the knowledge barrier and (2) the travel costs, work pace, and other demands associated with standardization-related work are high.*

- How can academic researchers be incentivized to engage in standardization-related research and contribute to a national platform?
- What potential academic structural changes (within academic meritocracy) are needed to facilitate this?
- What are strategies to incubate a standards stream in workforce development (e.g., an I-Corps for Standards)?
- What can funding agencies do to facilitate and enable this?

Breakout Group 3: Challenges to Future SDO Specifications in 6G & beyond — New Uses

Challenge: *NTN/Space Networks and ISAC are key use cases for 6G and beyond. However, existing SDO-led technical specifications are aligned only to some verticals and not others — private networking may dominate early use cases.*

- How can we bridge gaps between (private) product-centric innovation and public SDO-led open networking standards?
- How can mission critical uses beyond commercial; inherently global nature of enabling technology (e.g satellite access, global monitoring/sensing) be adopted in 6G and beyond?

Breakout Group 4: Challenges to Future SDO Specifications in 6G and beyond — Structural Aspects

Challenge: *There is a clear gap and tension between innovation for market and innovation for IP. For new use cases of emerging NextG technologies — such as AI-native networking, semantic communications, NTN, and ISAC — the potential structural disruptions to the existing standards process may offer a new modus operandi.*

- How can these two (innovations for market and innovation for IP) co-exist in the 6G era?
- How can we provide inputs to regulatory processes to balance other interests (Federal, private networks), enhancing rate of innovation beyond present processes?
- What can funding agencies facilitate?

Breakout Group 5: Enhancing U.S. Leadership through Regional Coordination for Disruptive Technologies

Challenge: *Existing international standards are heavily complicated by backwards/legacy compatibility, and the associated market and financial considerations dampen the potential of new/disruptive technology adoption. The U.S. innovation model is largely decentralized and competition-driven, excelling when platforms are modular and support open interfaces. It is therefore important to identify strategies aligned to U.S. strengths that enable innovation on top of 3GPP through more open, software-driven networking concepts.*

- What roles can regional SDOs and regional coordination mechanisms play in enabling disruptive technologies in 6G and beyond?
- What are possible structural changes that enhance U.S. leadership in the above?
- What U.S.-led coordination and collaboration mechanisms can enable rapid deployment of disruptive technologies beyond the SDO standardization pathways?
- What can funding agencies do to facilitate and accelerate this?

Breakout Group 6: Disruptive Innovation for SDO: Era of Open-Source Hardware and Software

Challenge: *Most standards seek a balance between specifying interfaces and sub-system objectives (primary) and granular implementation details (secondary). With open-source hardware and software increasingly available, how can U.S.-led innovation leverage new methods based on such technologies to impact and shape standardization for 6G and beyond?*

- What are the potential interplays between open-source hardware/software and existing standards bodies such as 3GPP, IEEE, and IETF?
- How should open hardware/software-driven innovation fundamentally inspire more rapid innovation cycles, compared to the present (slower) IP-centric approach?
- What can funding agencies do to strengthen this beyond what is done currently?

Day Two Breakout Sessions

New Breakout Group 1: Building an Academic-Industry-Government Collaboration Ecosystem for Existing Global Networking Standards

- How would the U.S. build an academic-industry-government ecosystem to strengthen and enhance U.S. participation, influence, and leadership in global standards development organizations such as 3GPP, IEEE, and IETF?

New Breakout Group 2: U.S. Strategies for New Disruptive Technology-cum-Market Ecosystem Concepts Beyond Traditional SDO Processes

- What are U.S. strategies to further new disruptive technology-cum-market ecosystem concepts to achieve global influence beyond traditional SDO processes?