FCC Technology Advisory Council

6G Working Group Position Paper

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Executive Summary

This white paper presents key national and global developments as Industry, Government, Academia and various standardization efforts chart a path towards 6G. We present key recommendations and considerations for the FCC across areas of 6G spectrum needs, security, and Digital Divide

The 6G WG as part of the 2023 FCC Technology Advisory Council identifies key initiatives such as ITU-R/ITU-T IMT-2030,WRC 2023 and WRC 2027 that will identify key input criteria: usage requirements, spectrum needs and technology development areas that will eventually define 6G and serve as input to 3GPP.

We explore and acknowledge the series of agreements and international commitments the US administration has made with nations and other alliances. This will be key to monitor global harmonization and US national competitiveness. The paper identifies spectrum needs from low, mid to high bands including unlicensed and non terrestrial use and makes study recommendations. We identify the security landscape and increased attack surface for 6G networks as ICT and mobile communications converge along with increased use of AI/ML in networks.

Finally, we address the digital divide topic and its impact on education with recommendations on spectrum access, siting and backhaul as well as cost of delivery to close the access gap with 6G technology.

The Road to 6G: National and Global Landscape for 6G

In the US, the CHIPS and Science Act which aims at strengthening the semiconductor industry, has several parts that benefit wireless research[1]. They include the Technology, Innovation and Partnerships (TIP) directorate under NSF, which has wireless research among its priorities[2]. Recently, TIP issued a “dear colleague letter” requesting inputs from potential industry and government agency partners to support “innovations to enhance the various aspects of next generation communications, sensing, networking, and computing systems”[3].

Other relevant parts of CHIPS include the Public Wireless Supply Chain Innovation Fund, with the focus to “drive wireless innovation, foster competition, and strengthen supply chain

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[1] https://www.whitecase.com/insight-alert/president-biden-signs-chips-and-science-act-law
[2] https://new.nsf.gov/tip/about-tip
[3] https://www.nsf.gov/pubs/2023/nsf23090/nsf23090.jsp

resilience”[4]. Also relevant is the Microelectronics Commons, which aims to create a “path to faster lab-to-fab production and strengthen American microelectronics development and production capacity”, and includes 5G/6G among its priorities[5].

It is fitting that 6G has a prominent role in semiconductor-oriented activities. The White House PCAST report on revitalizing the US semiconductor ecosystem recognizes that mobile phones (26 percent), information and communications infrastructure (24 percent) make up half of the total demand[6].

Government actions on 6G

The importance of 6G has been recognized as critical technology by the US and other governments, in light of the increasingly tense geopolitical situation.

In April 2023, the National Security Council (NSC) and NSF organized a workshop on 6G. Following the workshop, NSC issued the document “Principles for 6G: OPEN & RESILIENT BY DESIGN” with 6 principles addressing these topics:[7]

1- Trusted Technology and Protective of National Security
2- Open and Interoperable Innovation
3- Secure, Resilient, and Protective of Privacy
4- Affordable, Environmentally Sustainable, and Globally Connected
5- Spectrum, Novel Materials, Manufacturing
6- Standards & International Collaborations

In addition, the US government is renewing its attention to standards, and issued the national standards strategy for critical and emerging technology in May 2023, with Communication and Networking Technologies featured first among 8 focus areas[8]. The report notes that the US has lagged in participation in ITU, but expects a change with the election of the US candidate as secretary-general. The report identifies an action to work with the private sector to educate and train a new standards workforce.

At the transatlantic level, the US and EU launched the Trade and Technology Council (TTC) in 2021, with the objective “to promote U.S. and EU competitiveness and prosperity and the spread of democratic, market-oriented values by increasing transatlantic trade and investment in products and services of emerging technology, strengthening our technological and industrial leadership, boosting innovation, and protecting and promoting critical and emerging

[4] https://ntia.gov/page/public-wireless-supply-chain-innovation-fund
[5] https://www.defense.gov/News/Releases/Release/Article/3210295/dods-microelectronics-commons-takes-shape/
[6] https://www.whitehouse.gov/wp-content/uploads/2022/09/PCAST_Semiconductors-Report_Sep2022.pdf
[7] https://www.politico.com/f/?id=00000187-b4d1-d5cb-a7a7-b4d396280001
[8] https://www.whitehouse.gov/wp-content/uploads/2023/05/US-Gov-National-Standards-Strategy-2023.pdf

technologies and infrastructure."[9] Of particular interest is Working Group 4 which focuses on information and communications technology and services, security and competitiveness.

A 6G expert workshop was held under TTC auspices in April 2023, and included 3 panels: Introduction and scene setter; Use case categories and technology visions; and Key enablers. Workshop recommendations on mechanisms for transatlantic collaboration on 6G will be provided to the fourth TTC meeting in Sweden 30-31 May 2023.

The B7 is a group of business associations from the G7 countries (e.g. the US delegation is led by the US chamber of commerce). A B7 meeting was held in Tokyo in April 2023, and issued its recommendations to the G7 political leaders[10]. Under the digital transformation goals, 6G is highlighted as an emerging critical technology, and there was a recommendation to promote research collaboration among the G7 members' initiatives.

As a follow-up to the U.S.-India initiative on Critical and Emerging Technology (iCET) announced in May 2022 to elevate and expand strategic technology partnership between the governments, businesses, and academic institutions of India and the U.S., the National Security Council held a Roundtable to Advance Cooperation on Research and Development in 5G and 6G on June 1 2023 with attendees from academia, industry and government from the two countries. This was followed up by a joint statement[11] emphasizing collaborations on 5G/6G and Open RAN led by the NextG Alliance and the Bharat 6G Alliance.

New Spectrum Needs for 6G

Drivers of Demand for Spectrum Allocation

Long-term demand for increased spectrum allocation to terrestrial and non-terrestrial IMT stems from: 1) Increasing demand from existing use-cases; and 2) novel use cases enabled by next-generation (6G) technologies. From the latest Ericsson Mobility Report (EMR):

- Monthly data traffic per smartphone in North America increased: 13Gb to 20Gb (+54%) from 2021 to 2022 and is expected to triple (to 58Gb) by 2028.
- In those same periods, total monthly mobile traffic (all device types) increased from 4.6 to 6.7 Exabytes (EB) (+46%) and will increase to 21EB (21% CAGR)

Novel use-cases described in any number of 6G white papers published by the industry since 2018 imply a period beyond 2030 during which we can expect this growth to continue. A 20% CAGR would drive an increase of a factor of 6 in or +120GB/device/month (40EB/month overall). The more demanding of these include:

- XR technologies including multi-sensory extended reality (e.g. haptic hologram)
- Cooperative robotics

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[9] https://ustr.gov/useuttc
[10] https://www.keidanren.or.jp/en/policy/2023/028.html#p4
[11] https://www.whitehouse.gov/briefing-room/statements-releases/2023/06/22/joint-statement-from-the-united-states-and-india/

- Distributed and integrated communications & sensing

A sample of quantitative analyses suggests a requirement of 2GHz for terrestrial and NTN spectrum in the next decade:

- A capacity-demand vs. spectrum-supply model normalized by spectral efficiency is summarized in a CTIA-funded study by Brattle Group (April 2023): Requirement of 1800MHz (400MHz in five years, additional 1400MHz in the following five).
- Studies by Qualcomm and by Nokia using capacity/performance-based models conclude incremental needs of 400-500MHz per network.
- Use cases for NTN are described by GSOA and other bodies (6G-Paper-GSOA.pdf (gsoasatellite.com)) It is clear that increased use of NTN technologies for everything from D2D to broadband to backhaul, as well newer services like cislunar require increased access to capacity.

Summary of New Spectrum Bands Under Research and Consideration:

A. Terrestrial Component of 6G: (global perspective): 6-15GHz; 15-24GHz; and >110 GHz.

7-15GHz and 15-24GHz:
Existing FCC Considerations include: 1) 10.0-10.5GHz (in WRC-23 Agenda Item 1.2. The FCC has recommended a positive stance); and 2) The FCC has ruled out 12.2-12.7GHz but has 12.7-13.25GHz for consideration under NPRM (FCC-23-36).

There is almost universal agreement from industry and academia that regulators must address the increasing demand of IMT by opening more spectrum from 7-15 GHz (the range from 15-24GHz is deemed less favorable due to radio-technology state of the art (cost)). Many entities are investing in channel analysis and modeling and advanced radio systems using bandwidths of up to 500MHz to support this.

>110GHz:
The most demanding applications envisioned for 6G imply necessary bandwidths of >10GHz and thus the exploration of frequencies above 110GHz. This presents significant pressure on the state of the art for all related wireless technologies. While research is underway to 1THz, the least impractical subset for 6G communications is also the lowest: 110-170GHz. This remains where the majority of related time and tool investment is devoted today.

B. Non-Terrestrial Component of 6G

Spectrum bands are under consideration today for use by integrated non-terrestrial networks (NTN) for 6G. These range from 900Mhz to upwards of 80 GHz. Because of propagation characteristics, a variety of different bands will be required to meet the diverse 6G user cases.

Perspectives from major non-USA governing bodies:

Among the topics to be covered at the 2023 World Radio Conference (WRC-23) in Dubai in November-December will be the agenda for WRC-27. The WRC-27 preliminary agenda covers proposed spectrum to be considered for use by 6G. Administrations around the globe are preparing country and regional positions on these topics. It is important that WRC-27 be enabled, through this agenda work, to consider the identification and allocation of sufficient spectrum for terrestrial and NTN 6G or it will be difficult to have the required spectrum available at the end of the decade. Bands under consideration in the preliminary agenda:

Terrestrial 6G spectrum:

- 1300-1325 MHz
- 694-960 MHz
- Other under consideration: 7-24 GHz.

NTN 6G spectrum:

- 43.5-45.5 GHz
- 71-76 GHz and 81-86 GHz
- Other under consideration 2-7 GHz for mobile satellite services.

Summary of considerations beyond adding spectrum for terrestrial IMT

The elements of 1) challenges of re-allocation or re-farming; 2) the wide variation in real-time occupation of licensed spectrum over geography and over time (low utilization); and 3) the state of the art of spatial multiplexing all contribute to arguments for better use of existing spectrum:

a) **Flexible Access to Unused Spectrum:** require or incentivize licensees to cede use of spectrum when it is not in use or is under-utilized. (This can also be one avenue to address one facet of the rural digital divide.)
b) **Spectrum Sharing** among different services (e.g., federal radiolocation and commercial mobile or satellite communication), and among same services (e.g., terrestrial and non-terrestrial, including satellite)
c) **Increased Cell Density**: Consider the advantages and disadvantages of increased cell-density.
d) **Spatial Multiplexing Technologies**: Higher-order MIMO and beam-forming have become ubiquitous in C-band 5G systems. This approach to increase bps/Hz/km^2 ensures spatial allocation of a user's signal (RF flux density) is constrained to the user's physical location.

Recommendations For FCC Consideration:

1) Build a longer-term **spectrum pipeline** (add specific areas to consider for NTN and ICT) The 5G Americas group states that the FCC has an inadequate 5-15 year pipeline for spectrum-allocation change considerations. Such a pipeline would be similar to that which yielded the significant changes in spectrum for cellular communications over the past decade. Large-scale long-term changes in radio spectrum usage, analogous to the advent of broadcast radio and TV, are again upon us and increasing demand is

inevitable. The pipeline should begin with considerations of bands in the areas described above with special emphasis on 7-15GHz and 110-170GHz (the latter not being a viable substitute for lack of allocating anything in the former).

2) Explore **licensing/sub-let** schemes
   This has been implemented in other nations. The relative level of success should be analyzed to determine appropriateness and approaches for the USA. This could allow for localized/short-term changes to address both under-capacity and under-served areas.
3) Consider further streamlining the **site location** regulatory process since it is likely there will be many more sites for 6G.
4) **Increased Cell Density**: Consider the advantages and disadvantages of increased cell-density. There can be significant gains in spatial spectral efficiency (bps/Hz/km2) by decreasing the "cell size." On the other hand, site acquisition, backhaul, inter-cell interference, increased power consumption, and the resulting operational complications can become limiting factors.
5) Consider initiatives to spur greater geographic-area **spectral efficiency** (bps/Hz/km^2). This has been investigated by the TAC in the past and ruled out due to technical complexities of defining and measuring the associated figures of merit among other issues. However, the rapid expansion of wireless use and of allocated spectrum since those investigations, as well as the expansion and rapid growth of altitude-based spectrum use (e.g. NTN), justifies exploring this idea in this newer context.

Associated Caveats and Risk Areas:

- Sustainability risks must be considered:
  - Increased cell density carries the risks of increasing power consumption and of negative impact on the physical environment.
  - Higher frequencies mean lower energy-efficiency of radio power amplifiers. Most of the energy consumed in mobile networks is dissipated as waste-heat in power amplifiers so moving to higher spectrum always carries this risk.
  - Increased use of NTN continues to crowd orbit resources.
- Complex and non-representative performance metrics
  - The complexity of topics like spectral efficiency and adequate backhaul are such that investigations will require methods of normalizing and averaging by and within use case, geographic areas, spectrum band and bandwidth, population density, time of day, time of year, and long-term changes in these areas.

Security Needs for 6G

As 6G is specified and designed over the coming years, just as with 5G and prior generations of wireless, it is crucial that security be a top priority from the outset. Achieving the appropriate level of security requires collaboration and ongoing work by many commercial and governmental stakeholders in the United States and around the world. In particular, the FCC, taking into account the recommendations and other input from future TACs, CSRIC, and others, including the output from the major wireless standards bodies, will play an important role in ensuring that 6G equipment is fully secure, as it has done with equipment for the prior generations of wireless.

At this point in time, while 6G is in an early discussion phase, it is noteworthy that the NextG Alliance, the North American group working on 6G, has already issued a white paper on 6G Trust, Security and Resilience. Moreover, on an ongoing basis, CSRIC continues to produce recommendations and best practices for security, which have implications for 6G. ORAN Alliance WG11 is focused on open RAN security topics including virtualization, multi-vendor and related topics.

It should be noted that many concerns which are raised as potential security risks such as greater virtualization, open interfaces, multi-vendor, open-source SW, and Post Quantum Compute (PQC) are not specific to 5G or 6G but are general ICT topics. As such there is a list of relevant standards, best practices and specification bodies working in this area that have been listed below grouped by Mobile Telecommunication specific and cybersecurity specific updates.

References: Mobile-Network Specific

Global Standards Bodies

- 3GPP System Aspects TSG Technical Working Group 3 (SA3)
    - SA3 Security Specifications: SA3 has published 246 specifications, studies, and technical reports dating back to 2G systems. 42 of these are specific to 5G. Examples of particular interest and most recent relevance are those relating to:
        - Security Assurance Specification (SCAS) (TS 33.511-33.528)
        - Service Enabler Architecture Layer (SEAL) (TS 33.434)
        - Other 5G-specific:
            - Security architecture and procedures for 5G system (TS 33.501)
            - Security Aspects of Proximity base Services (ProSe) in the 5G System (TS 33.503)
            - Authentication and Key Management for Applications (TS 33.535)
            - Study on 5G security Enhancements Against False Base Stations (TS 33.809)
            - Study on security aspects of 5G network slicing management (TS 33.811)
            - Study on security and privacy of Artificial Intelligence/Machine Learning (AI/ML)-based services and applications in 5G (TS 33.898)
- ORAN ALLIANCE
    - O-RAN ALLIANCE Security Overview
    - O-RAN ALLIANCE WG11: 12 security specifications to date

US Government-Related

- National Security Council position on 6G

- CSRIC- Communications Security, Reliability and Interoperability Council
  - CSRIC VIII report: Promoting Security, Reliability, and Interoperability of Open Radio Access Equipment (Dec 2022)
  - CSRIC VIII report: How Virtualization Technologies Can Be Used to Promote 5G Security and Reliability (Dec 2022)
- CISA
  - CISA Vulnerability Scanning
  - CISA Cyber Resilience Review

Relevant Whitepapers on 6G Security

- NextG Alliance: Trust, Security, and Resilience for 6G Systems whitepaper
- Ziegler, Volker; Schneider, Peter; Viswanathan, Harish; Montag, Michael; Kanugovi, Satish; Rezaki, Ali. "Security and Trust in the 6G Era." https://www.bell-labs.com/institute/blog/trust-thy-6g-network-future-communications-hinges-security-and-privacy/#gref. August 2021

References: Selected General CyberSecurity References

- NIST
  - Zero Trust Architecture (800-207)
  - Bad Security Metrics #1 (problems) and Bad Security Metrics #2 (solutions)
  - Performance Measurement Guide for Information Security Rev 1
  - Measurements for Information Security
- FIRST
  - Common Vulnerability Scoring System
  - Common Criteria: Introduction and General Model
- DoJ: Cyber-Security Assessment and Management program: Offered to Gvt. agencies for "Assessment and authorization application—automated inventory, configuration, and vulnerability management (and data/reports)
  - Cyber-Security Assessments for: Anti Phishing, Threat hunt, Penetration Testing, Security control, Supply chain risk, Vulnerability scanning

We recommend that future TACs continue to monitor and provide input on 6G security and resilience, along with the input to the Commission of other groups as the technology development and standards process matures.

Potential Solutions for the Digital Divide in Education in Emerging 6G

Introduction: In today's digital age, access to the internet is an indispensable tool for acquiring knowledge and skills. Millions of students struggle with digital learning because they don't have quality internet connections or devices - an issue known as the homework gap. Investing in connectivity and technology, digital literacy, and digital learning solutions help connect today's learners with success – in and out of the classroom. Having full-time, mobile access to the internet—at school, on the way to and from school, and at home-- has become an essential ingredient for a comprehensive education. Providing connectivity at home for all students is paramount and should be considered the first priority, which can be accomplished with a combination of technologies including mobile, fiber, Wi-Fi , and Non-terrestrial networks. Closing the digital divide includes focusing not only on access to affordable high-speed internet, but also the skills and community resources that encourage safe and successful adoption. Solving the digital divide for K-12 students in all 50 states, in urban, suburban, and rural areas alike, is a challenging undertaking. Congress and the FCC have recognized this through the enactment and successful implementation of the Emergency Connectivity Fund, the Affordable Connectivity Program, and recent changes and proposed changes to the E-rate program. In the early design and planning for 6G, it's essential that public and private stakeholders build upon this momentum and adopt specific mechanisms aimed to optimize the future 6G for this important objective of ensuring affordable, full-time access to the internet for all students. This document outlines the benefits and reasons for providing students with continuous high-speed internet access related to 6G, acknowledges the potential challenges and concerns associated with its implementation, and. The document concludes with recommendations to the FCC by the TAC.

Benefits of Full-Time Internet Access for Education:

1. Information and Resource Availability- The internet provides an unparalleled wealth of information and resources, enabling students to access a vast array of educational materials, research articles, multimedia content, and interactive platforms. Full-time internet access ensures students can utilize these resources to enhance their learning experiences and deepen their understanding of various subjects. A high-speed internet connection bridges distances and provides access to resources and people enhancing and leveling the educational experience.
2. Collaborative Learning Opportunities- The internet facilitates collaboration among students, both within their own school and with peers globally. Through online platforms and tools, students can engage in virtual discussions, share ideas, work on group projects, and gain exposure to diverse perspectives. Full-time high-speed internet access fosters a collaborative learning environment and prepares students for the interconnected world they will enter.
3. Personalized and Adaptive Learning- Online platforms and educational software offer personalized learning experiences tailored to individual student needs and learning styles. High-Speed Internet access allows students to benefit from adaptive learning technologies, virtual tutors, and online assessments, enabling them to progress at their own pace and receive immediate feedback.
4. Global Perspective and Cultural Awareness- The internet provides access to information from around the world, exposing students to diverse cultures, perspectives, and global issues. Full-time high-speed internet access empowers students to become global citizens by expanding their horizons, promoting tolerance, and fostering a greater understanding of the world.

Challenges and Concerns: While the proposal for full-time high-speed internet access for all K-12 students presents numerous benefits, it is important to acknowledge and address the following challenges and concerns associated with its implementation:

1. Infrastructure and Connectivity: Practicality- Achieving full-time internet access for every K-12 student requires infrastructure and connectivity, especially in remote or underprivileged areas. The end-to-end cost and logistical challenges of establishing and maintaining such infrastructure may be economically impractical and resource intensive. Public-private partnerships can increase broadband penetration in the short-term while setting the stage for long-term success. The TAC proposes to investigate ways in which newly designed 6G-based infrastructure and connectivity can be tailored to the needs of education and which can be delivered at acceptable costs.

2. Digital Literacy and Online Safety- Potentially Dangerous: Granting unrestricted internet access to students without proper digital literacy and online safety education may expose them to potential risks such as cyberbullying, online predators, misinformation, and excessive screen time. The Commission's recent proposal to dedicate E-rate funds for enhanced cybersecurity initiatives and the funding for digital literacy programs in the federal infrastructure law highlight the importance of this point. Parents play an important role in helping today's connected students safely engage in online learning. Ensuring adequate training and support for students, parents, and teachers in navigating these risks is essential. Digital literacy resources are needed for students and their parents to get the skills they need to effectively use the internet and technology. Programs are needed that help people and communities develop digital literacy skills to thrive in our modern world.

3. Equity and Accessibility- Economics: Bridging the digital divide and providing full-time high-speed internet access to all students at reduced cost or without charge, particularly those from economically disadvantaged backgrounds, is likely to be a costly endeavor, as Congress itself recognized in establishing the one-time $7.2 billion Emergency Connectivity Fund. The TAC proposes to investigate ways in which a combination of in-kind subsidies (such as low-cost/no-cost spectrum use and access to infrastructure such as towers and cell sites) can make dedicated delivery of educational connectivity an economically acceptable enterprise opportunity.

4. Distractions and Dependency- Potentially Dangerous: Unrestricted internet access may lead to distractions and potential addiction to social media, online gaming, or other non-educational activities, negatively impacting students' focus, productivity, and overall well-being. Balancing internet usage and fostering responsible digital habits are essential considerations. Again, the Commission and the educational community has recognized this in the context of the E-rate program.

5. Education as a Use Case- In designing and deploying 5G, the wireless industry focused on various use cases (massive IoT, ultra low-latency, reliable communications, etc) and various technologies and network topologies (non-terrestrial networks, vehicle-to-vehicle

communications, etc). In the early design and planning phases of 6G, the TAC believes the wireless industry, educational groups, and regulators should prioritize development of an end-to-end 6G solution optimized to provide low-cost, full-time internet access for all K-12 students. Making this a top objective in the early design of 6G is important from the outset.

6. Spectrum: Emerging 6G architectures are expected to continue to utilize, at least in part, higher bands such as cm/mmWave and mmWave, and emerging sub-THz and THz bands. These bands have tremendous value related to throughput and capacity however, they have limited propagation characteristics. The FCC should be aware of these physical characteristics and explore spectrum and technical solutions that would address the specific needs of providing high-speed internet access to devices to leverage the connectivity with the latest software and security. The FCC should consider the end-to-end needs related to providing access to all.

7. Backhaul/Transport Gaps- Consider initiatives to address backhaul/transport gaps. Without adequate backhaul {e.g. fiber, Integrated Access and Backhaul (IAB) and satellite} more spectrum or higher spectral efficiency will not result in the expected business, service, and experience improvements.

While full-time high-speed internet access for all K-12 students offers numerous benefits, it is crucial to acknowledge and address the challenges and concerns associated with its implementation. Balancing the need for access to information and collaborative learning opportunities with the considerations of infrastructure, digital literacy, equity, and potential dangers is key to ensuring a safe, effective, and inclusive educational environment. It is imperative that society approaches the implementation of full-time internet access with a comprehensive strategy that addresses these concerns and safeguards the well-being of our students. Education is a societal equalizer and is critical to the future success of America-providing all an equal opportunity.

The FCC alone cannot solve the digital-divide challenge. No one public or private sector stakeholder can do so. This is why extensive, deep technical collaboration in the early design of 6G is necessary so that the goal of ensuring that affordable full-time internet access is available to all students. The FCC should encourage industry (vendors, providers, etc), as well as the Department of Education, to focus on creating 6G based solutions that extend connectivity to all students.

Summary: A complete education today requires that students have affordable full-time high-speed internet access. Many students in the U.S. lack such access either because there is no access to broadband services where they live, or they can't afford access fees for such service. It is proposed that a future TAC continue to explore possible technological solutions with the objective of making specific actionable recommendations to the FCC. Of special interest is the possibility that private enterprise can assist in providing full-time access to students at low cost (for example, $5-10 per month per student) if subsidized with available shared/free spectrum use, low-cost/free siting, and possibly low-cost/free backhaul and interconnect options.

Recommendations to the FCC for continuation of TAC initiatives on solving the digital divide.

1) Encourage private stakeholders working now on the early design and planning for terrestrial and non-terrestrial-based 6G to consider making the provision of low-cost, full -time internet access for K-12 students a paramount goal for 6G.
2) Explore technology interoperability and options to solve last mile, mid-haul and back-haul needs such as terrestrial and satellite-based technical solutions that may use existing spectrum in conjunction with technologies such as MIMO and Open-RAN to lower the end-to-end cost of providing rural broadband. Encourage public and private sector research and development in these areas.
3) Encourage specification/standards and industry organizations to focus on technical solutions aimed at reducing or closing the digital divide.
4) In making spectrum allocations and in considering technical rules for existing and new spectrum bands (including power levels), the FCC should prioritize solutions aimed at reducing or closing the digital divide. Likewise, in their ongoing collaborations over spectrum policy, the FCC and NTIA should work together to identify spectrum and on other policies aimed at reducing or closing the digital divide.
5) Investigate creative policy and technical tools to drive down the cost of backhaul.
6) Speed and Connection to Service: Agencies should prioritize the completion of fiber projects to student locations or cell sites for last mile connectivity. Including the removal of construction barriers, support for construction or support for long-term operations cost specific to the needs of education. Address high cost of fiber drop placement in rural or remote areas.
7) Encourage much greater technical collaboration and seek public/private partnerships between terrestrial and non-terrestrial wireless industry technical experts and the educational community to establish use cases and to qualify and quantify the bandwidth needs for K-12 students during the lifespan of 6G.
8) Consider solutions to the need for full-time access that make use of local siting opportunities like schools, libraries and other public facilities and the opportunity to utilize school and other government-owned assets for infrastructure placement and use. Survey infrastructure manufacturers seeking specific solutions that drive down the cost of providing internet access to students in rural and other areas (for example, Use of advanced massive MIMO to optimize capacity and range including mid/backhaul (IAB), or simplifying infrastructure to tailor it to the needs of students/education.
9) Explore availability of unused, desirable spectrum in rural areas and how rural areas can acquire access via spectrum bands that may offer broader geographic coverage. For greater coverage the 600 MHz, 700 MHz and 850 MHz bands provide the greatest reach especially when enhanced with multi-user MIMO technology.
10) Explore the availability of unused, desirable spectrum that can be used for non-terrestrial technologies to offer greater capacity to offer higher speed capabilities.
11) Explore the use of advanced spectrum sharing techniques across various frequencies in the rural areas with the goal of significantly increasing spectrum efficiency by allowing for access to a wider range of bandwidth.
12) Ensure that the FCC broadband maps include accurate and updated information on internet access at all schools, libraries, and other educational institutions.