

# NATIONAL SPECTRUM STRATEGY



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President Biden has called radio frequency spectrum one of “our Nation’s most important national resources.” To promote innovation and U.S. leadership in wireless technologies, the Biden-Harris Administration has committed to careful planning and cooperation among government agencies and the private sector. As required by the Presidential Memorandum titled *Modernizing United States Spectrum Policy and Establishing a National Spectrum Strategy*, the Secretary of Commerce, through the National Telecommunications and Information Administration (NTIA), prepared this National Spectrum Strategy to both promote private-sector innovation and further the missions of federal departments and agencies, submitting it to the President through the Assistant to the President for National Security Affairs, the Assistant to the President for Economic Policy, and the Director of the Office of Science and Technology Policy.

The Strategy reflects collaboration with the Federal Communications Commission (FCC), recognizing the FCC’s unique responsibilities with respect to non-Federal uses of spectrum, and coordination with other Federal departments and agencies (referred to collectively here as “agencies”). In carrying out this task, NTIA conducted extensive public outreach through a request for comment, two public listening sessions, two Tribal Nation consultations, and one-on-one meetings with stakeholders. NTIA has made this information, as well as supplemental comments filed by stakeholders, publicly available. NTIA also sought and received written comments and guidance from Federal agencies and hosted a Government-only listening session to gather additional feedback.

The result is a comprehensive strategy to modernize spectrum policy and make the most efficient use possible of this vital national resource to enhance the quality of life for all Americans. This Strategy will expand access to advanced wireless broadband networks and technologies, whether terrestrial-, airspace-, satellite- or space-based, for all Americans. And it will drive technological innovation (including innovative spectrum sharing technologies); boost U.S. industrial competitiveness; protect the security of the American people; foster scientific advancements; promote digital equity and inclusion; and maintain U.S. leadership in global markets for wireless equipment and services, as well as innovative spectrum-sharing technologies—all essential priorities for the Biden-Harris Administration.



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# INTRODUCTION

Radio frequency spectrum plays a significant—but often unacknowledged—role in Americans’ daily lives. The radio waves that carry data and voice communications to smartphones and other devices are, after all, invisible. But consumers, businesses, and governments at every level rely upon spectrum to complete a significant, untold number of tasks, from the mundane to the critical.

Indeed, wireless services have become essential for citizens to function in the 21st Century. Wireless connectivity provides increasingly reliable and affordable high-speed internet access, helping to eliminate coverage gaps and to enable diversity, equity, and inclusion for all Americans, even in hard-to-reach areas, including Tribal Nations, underserved communities, and U.S. territories. Wireless capabilities also have become integral to public safety, medical care, education, multimodal transportation, and an array of industrial operations. Critical U.S. Government services and missions also increasingly depend on spectrum access. Essential government missions rely on wireless systems on the ground, in the air, at sea, and in space to protect our national security and to provide services that deliver important public benefits.

As a result of ongoing innovations in wireless technologies, demand for spectrum access is growing rapidly. In the private sector, next-generation Wi-Fi networks, large satellite constellations in low-Earth orbit, rapidly increasing space launch cadences, aggregated data transfer requirements, 5G and 6G broadband networks, private wireless networks, autonomous vehicles, and other advanced systems drive demand. Dynamic spectrum sharing is one key to meet these growing demands, and the United States is uniquely positioned to embrace a whole-of-Nation approach to advance the state of technology for dynamic forms of sharing.

***The United States needs a comprehensive strategy to modernize spectrum policy and make the most efficient use possible of this vital national resource.***

In general, technological innovations in communications, passive sensors, radars, and other applications are integral to the Federal Government’s priorities for national security, critical infrastructure, transportation, emergency response, public safety, climate monitoring, weather forecasting, scientific discovery, and economic growth. A growing number of applications and technologies, such as Global Navigation Satellite Systems (GNSS) (including the Global Positioning System or GPS), serve both governmental and nongovernmental users. All of these uses and spectrum demands are important to the Nation and must be protected from harmful radio frequency interference to ensure a high level of service availability and to best serve the public interest. Yet spectrum access is not unlimited, which increases the importance of embracing opportunities to expand dynamic spectrum access for all users.



This Strategy draws heavily upon the information received during NTIA’s outreach efforts. It represents a high-level blueprint that articulates our national objectives for spectrum policy and charts a whole-of-Nation approach to achieving those objectives. The Strategy recognizes that its implementation must be consistent with, and in no way limit, (1) the FCC’s statutory role as an independent agency that is the exclusive regulator of non-Federal spectrum use; or (2) NTIA’s statutory role as the sole agency responsible for authorizing Federal spectrum use. The Strategy further recognizes the statutory roles and responsibilities of Federal agencies to carry out missions that rely on spectrum access.

The Strategy adopts and describes four *pillars* with several corresponding *strategic objectives* for immediate and sustained attention and effort:

- Pillar One: A Spectrum Pipeline to Ensure U.S. Leadership in Advanced and Emerging Technologies
- Pillar Two: Collaborative Long-Term Planning to Support the Nation’s Evolving Spectrum Needs
- Pillar Three: Unprecedented Spectrum Innovation, Access, and Management through Technology Development
- Pillar Four: Expanded Spectrum Expertise and Elevated National Awareness

An essential element supporting each of these four pillars and cutting across all aspects of this Strategy will be the creation and execution of an improved national framework for collaboration on spectrum policy. Simply put, the United States needs a better and more consistent process for bringing the public and private sectors together to work through the difficult issues surrounding access to spectrum, including dynamic forms of spectrum sharing. The U.S. Government will build upon existing constructs to enable consistent, robust, and transparent engagement among stakeholders and will publish an implementation plan with details about responsible parties and timelines to achieve specific outcomes associated with each strategic objective identified herein. This will help to address spectrum challenges facing the Nation, including charting a path to satisfy current and future spectrum access requirements.



## Pillar One | A Spectrum Pipeline to Ensure U.S. Leadership in Advanced and Emerging Technologies

U.S. leadership in next-generation technologies and services requires greater spectrum access for both the private and public sectors. To continue our Nation’s economic growth, to maintain and improve our global competitiveness, and to support critical public services and missions, we must make spectrum available for innovative new uses and to meet growing demand. This Strategy considers such a “spectrum pipeline” to encompass spectrum bands that are in various stages of consideration for repurposing (allowing new or additional uses through relocation and/or sharing) to satisfy non-Federal and Federal needs.<sup>1</sup>

The long-term spectrum planning process discussed in Pillar Two will strategically and systematically evaluate and respond to projected private sector and public sector spectrum requirements well into the future. But we must also take immediate action to meet existing and reasonably anticipated near- and mid-term spectrum needs. To that end, this Strategy identifies five spectrum bands totaling 2,786 megahertz of spectrum for in-depth, near-term study to determine suitability for potential repurposing to address the nation’s ever-evolving needs. These spectrum bands are a mix of Federal and shared Federal/non-Federal bands—with an emphasis on mid-band frequencies—that will be studied for a variety of uses, including terrestrial wireless broadband, innovative space services, and unmanned aviation and other autonomous vehicle operations.

### **Strategic Objective 1.1 | Ensure sufficient spectrum access to support Federal agency missions now and into the future.**

The U.S. Government needs access to spectrum for an array of critical missions that advance America’s economic prosperity, scientific endeavors, technology leadership, public safety, and national security.

This Strategy reaffirms existing U.S. policy, as set forth in relevant statutes, regulations, and Office of Management and Budget guidance, that—when feasible—the Federal Government will procure commercial products and services to support its operations. Similarly, some Government missions depend on nongovernmental, federally supported organizations, activities, and facilities, which also require access to spectrum. However, when relying on nongovernmental entities or services is infeasible or would be materially detrimental to national interests, NTIA (in coordination with the FCC, as necessary) will ensure that sufficient spectrum resources are available to agencies and

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<sup>1</sup> The National Spectrum Strategy’s effort to create new sharing opportunities pertains to bands with Federal allocations that are being newly considered for more intensive Federal or non-Federal use. It will not examine bands that were previously made available for non-Federal use by the FCC, nor will it affect the rights of existing non-Federal users or otherwise constitute a modification of an existing license under 47 U.S.C. § 316 of the Communications Act.



their supporting entities to conduct their missions and to protect their operations from experiencing harmful interference.

When Federal agencies identify requirements for additional spectrum access, NTIA, in collaboration with those agencies, will first assess the spectrum resources (both Federal and non-Federal) allocated to support the particular agency's current and future spectrum-dependent operations. Through this process, NTIA will further consider (1) the agency's operational requirements and the nature of its mission(s); (2) existing authorities and conformity to international allocations for similar applications; and (3) the potential for improved efficiency and mission effectiveness through new technological developments (such as compression and modulation technology) and coexistence techniques.

Several other considerations, in addition to the factors identified above, must be accounted for when making these spectrum requirements assessments. First, Federal operations often do not fully occupy their spectrum assignments at all times; however, the nature of an agency's mission may require constant *availability* of a spectrum assignment for immediate use. Second, the metrics for assessing the "efficiency" of a Federal agency's spectrum usage must be tailored to the operational requirements for the spectrum usage and the agency's mission. Third, decision-makers would benefit from increased transparency and additional data regarding Federal spectrum usage when making these decisions—to the extent permitted by law and subject to necessary operational security protections.

Federal agency collaboration, as well as information and data sharing, is critical to the success of these evaluations. Accordingly, to engage fully in band assessments to ensure the agencies' needs are met (including efforts to improve efficiency of use as well as potential sharing studies), agencies will prioritize and leverage available funding for assessing their spectrum requirements, as well as alternative funding sources where applicable (such as Spectrum Relocation Fund resources).

### **Strategic Objective 1.2 | Ensure spectrum resources are available to support private sector innovation now and into the future.**

Future demand for spectrum-based services and technologies is expected to grow substantially across many, if not all, of our Nation's commercial sectors. According to one estimate, data traffic on macro cellular networks is expected to increase by over 250 percent in the next 5 years, and over 500 percent in the next 10 years. Next-generation wireless technologies such as 5G, 6G, and Wi-Fi necessitate additional spectrum resources with the capacity for wider channels, resulting in benefits beyond increased capacity, including enhanced energy efficiency, improved reliability, and reduced latency. Meanwhile, demand for satellite-based services is exploding, with domestic firms filing license applications for constellations—some with tens of thousands of satellites—to support consumer broadband, in-space assembly and manufacturing, earth observation and imaging, cislunar activities, and a host of other uses.

The U.S. Government is already taking steps to identify spectrum bands for potential repurposing in the near-term to meet these growing demands. Within the past year alone, the FCC has led several notable efforts to repurpose spectrum or study it for potential repurposing (see Table 1).



**Table 1: Ongoing Efforts to Study Spectrum Bands**

Focus	Status
<b>Supplemental Coverage from Space</b>	In March 2023, the FCC proposed a new regulatory framework for supplemental terrestrial wireless coverage from space, through which satellite operators and terrestrial providers would coordinate to operate space stations on currently licensed, flexible-use spectrum to expand coverage to the terrestrial provider’s subscribers.
<b>5030-5091 MHz</b>	In January 2023, the FCC sought comment on service rules to support safety-critical unmanned aircraft system (UAS) communications links, including control and non-payload communication (CNPC) operations in the band, noting that service rules to facilitate UAS likely will require development in phases.
<b>12 GHz</b>	In May 2023, the FCC took steps to expand the use of 1,050 megahertz of mid-band spectrum by a diverse set of users. Specifically, the FCC ensured that current and future satellite services will be preserved and protected in the 12.2-12.7 GHz band (the “Lower 12 GHz band”), while exploring expanded fixed licensed or unlicensed use of the band. The FCC is further considering options for flexible use of the 12.7-13.25 GHz band (the “Upper 12 GHz band”), which has in-band and adjacent-band federal operations that may need to be protected.
<b>42 GHz</b>	In June 2023, the FCC began the next phase of a proceeding to explore how spectrum in the 42 GHz band (42-42.5 GHz) might be made available through one of several innovative, non-exclusive spectrum access models.
<b>60 GHz</b>	In May 2023, the FCC adopted rules expanding opportunities for unlicensed mobile radar operations in the 57-71 GHz band. The new rules permit mobile field disturbance sensor operations throughout the 60 GHz band and established technical rules for pulse radars. The rule changes also allow unlicensed radars to operate on unmanned aircraft in the 60-64 GHz segment of the band when operated at certain low-flying altitudes.

The FCC has recently taken other, broader actions to address spectrum efficiency, including (1) revising its rules to promote spectrum efficiency among non-geostationary satellite orbit, fixed-satellite service systems; (2) issuing a policy statement establishing core principles to inform the FCC’s future actions and stakeholder expectations, including those of Tribal Nations, about interference; and (3) initiating a technical inquiry into how the FCC can obtain more sophisticated knowledge of commercial spectrum usage by leveraging new data sources, methods, and technologies. Federal users also have contributed to efforts to increase spectrum efficiency and effectiveness and to improve access to spectrum resources for both Federal and non-Federal users, including enabling the reallocation and auction of the 3450-3550 MHz band and the ongoing implementation of a sharing framework in the 3.5 GHz band as part of the Citizens Broadband Radio Service.





While these efforts are significant, our economic prosperity, national security, and industrial readiness require still more. To ensure U.S. leadership in spectrum-based services now and into the future, detailed studies of additional spectrum bands must be performed in the near term to determine whether they may be repurposed for expanded or more efficient uses.

In identifying spectrum bands for in-depth study, NTIA evaluated input received through a public-facing process from a variety of sources, including terrestrial wireless broadband providers, the Wi-Fi and unlicensed wireless community, satellite- and space-based service providers, Tribal Nations, academics, public interest groups, and others as to current and future spectrum needs. NTIA also reviewed information from its Federal agency partners on current and future spectrum requirements.

Taken together, this input has led to the identification of the following five spectrum bands meriting in-depth study in the near term. This approximately 2,790 megahertz of spectrum represents a mix of bands for potential expanded governmental and non-governmental use for an array of advanced, next-generation applications and services:

- Lower 3 GHz (3.1-3.45 GHz): Pursuant to the Infrastructure Investment and Jobs Act of 2021, the Department of Defense (DoD) has studied the possibility of sharing this 350 megahertz of spectrum with the private sector. DoD's studies helped to determine whether this band should be reallocated for shared Federal and non-Federal use and licensed through auction. DoD determined that sharing is feasible if certain advanced interference-mitigation features and a coordination framework to facilitate spectrum sharing are put in place. The Departments of Commerce and Defense will co-lead any follow-on studies to the Emerging Mid-band Radar Spectrum Study (EMBRSS) that focus on future use of the 3.1-3.45 GHz band. Additional studies will explore dynamic spectrum sharing and other opportunities for private-sector access in the band, while ensuring DoD and other Federal mission capabilities are preserved, with any necessary changes.
- 5030-5091 MHz: The FCC, in coordination with NTIA and the Federal Aviation Administration, is expected to take near-term action to facilitate limited deployment of UAS in this band. Thereafter, this 61 megahertz of spectrum will be studied so that the FCC can optimize UAS spectrum access across the band while avoiding harmful interference to other protected in-band and adjacent-band operations.
- 7125-8400 MHz: This 1,275 megahertz of spectrum will be studied for wireless broadband use (on a licensed and/or unlicensed basis), though some sub-bands eventually may be studied for other uses. There are, however, a variety of mission-critical Federal operations in this band (including Fixed, Fixed Satellite, Mobile, Mobile Satellite, Space Research, Earth Exploration Satellite, and Meteorological Satellite services) that will make it challenging to repurpose portions of the band while protecting incumbent users from harmful interference.



- 18.1-18.6 GHz: This 500 megahertz of spectrum will be studied for expanded Federal and non-Federal satellite operations, consistent with the U.S. position at the 2023 World Radiocommunication Conference (WRC-23), which would add space-to-space allocations to this band (among others). Fixed Satellite Service downlink operations are currently authorized in the band. In addition, non-Federal Fixed Service is authorized in the 18.1-18.3 GHz segment of the band.
- 37.0-37.6 GHz: Building on prior collaborative efforts of NTIA, DoD and the FCC, this 600 megahertz of spectrum will be further studied to implement a co-equal, shared-use framework allowing Federal and non-Federal users to deploy operations in the band.

Identifying this quantity of spectrum is based (in part) on recognizing that the United States must now invest time and resources into studying spectrum bands that are more encumbered and complex than in the past. Because the spectrum is congested—and as “greenfield” spectrum becomes harder to find—U.S. policy (and stakeholders) must recognize that “studying” a band for potential repurposing to enable more efficient use does not prejudice the outcome of the study (i.e., that all, part, or none of the band ultimately will be repurposed as a result of the study).

### **Strategic Objective 1.3 | Maintain the spectrum pipeline by applying guiding principles and leading program management practices to identify additional bands for study.**

The strategic objectives in Pillar Two of this Strategy, once implemented, will create a permanent framework for conducting activities that support long-term spectrum planning in the United States that will ensure the ongoing viability of the spectrum pipeline. But certain planning components are needed immediately to help assess how the pipeline is satisfying stakeholders’ spectrum needs in the near term and to monitor the success of study and repurposing efforts, including the impact on the mission effectiveness of Federal incumbents in the bands selected for in-depth study. Once developed, these core planning components can be leveraged and carried forward into the framework established under Pillar Two. Specifically, spectrum assessments by the U.S. Government should be guided by certain enduring principles that facilitate a comprehensive, documented, and appropriately transparent, end-to-end process for evaluating incumbent and potential new or different Federal and non-Federal spectrum uses.

One such principle is that relevant and timely information from all stakeholders—with appropriate safeguards for the collection and use of confidential or sensitive data—is often necessary to sustain decision-making processes in support of the pipeline. Data-driven processes are essential for long-term spectrum planning that increases transparency into current and future Federal and non-Federal spectrum use, anticipates and enables technological advances to facilitate spectrum access, and fully accounts for essential Federal missions. Relatedly, spectrum management relies upon unbiased technical, scientific, mission, and economic analyses. To provide greater visibility into, and acceptance of, key studies, and to reduce contention and disputes of findings, the U.S. Government will formalize its best practices for conducting these analyses in support of spectrum management decisions. Studies should be peer-reviewed, and the underlying findings should be published to the greatest degree possible.



Another principle is that once a spectrum band is identified to be repurposed, U.S. spectrum-regulating agencies (i.e., NTIA and the FCC) should seek to follow best practices as they plan for transition of the band, coordinate between incumbents and new entrants, and execute the planned transition. Specifically, the U.S. Government will implement leading program-management practices to plan and monitor the success of spectrum repurposing objectives underpinning the spectrum pipeline, consistent with prior recommendations from the Government Accountability Office. These best practices will involve tracking progress, identifying risks, and addressing issues early to minimize any disruption to implementation.

Finally, similar principles will apply to monitoring the ongoing sufficiency of the spectrum pipeline. U.S. spectrum-regulating agencies will jointly assess the spectrum pipeline on an ongoing basis and periodically will perform a detailed assessment of the pipeline to ensure its sufficiency, suitability, viability, and feasibility for all stakeholders until the long-term spectrum planning process outlined in Pillar Two is established and implemented. If this joint assessment shows that additional spectrum bands need to be studied for potential repurposing, then NTIA will collaborate with the FCC and coordinate with the Federal agencies to develop a transparent and data-driven process to identify and assess potential impacts to incumbent spectrum users. This process, if additional band studies are needed, will evaluate both quantitative and qualitative factors related to incumbent spectrum usage, including Federal agencies' mission requirements.



## Pillar Two | Collaborative Long-Term Planning to Support the Nation's Evolving Spectrum Needs

America's security, safety, technological leadership, and economic growth depend, in no small measure, on sufficient access to spectrum. For more than a century, the Nation has worked to make spectrum resources available for the growing number of spectrum-dependent technologies and services used for both public and private applications. But as the demands for spectrum access continue to increase, the Nation must implement a long-term planning process in which stakeholders work together openly, consistently, and transparently (subject to national security and competition constraints) to address users' current and future spectrum requirements. Establishing a new framework for collaboration will facilitate robust and regular dialogue and interchanges of data, building trust and transparency among all stakeholders. Moreover, setting U.S. band allocation preferences for new or evolving uses through better planning processes and data can also have a positive impact on national planning for international spectrum negotiations and help secure our Nation's leadership in the development of spectrum-related technologies.

### **Strategic Objective 2.1 | Establish a persistent strategic spectrum planning process guided by the best available science and data.**

Several advisory groups have been established to provide input to the Assistant Secretary of Commerce for Communications and Information on a broad range of spectrum issues. These include two Federal-only entities—the Interdepartment Radio Advisory Committee and the Spectrum Advisory Council, which replaces the Policy and Plans Steering Group—as well as a non-Federal committee, the Commerce Spectrum Management Advisory Committee. Additionally, NTIA and the FCC have formalized their cooperative relationship and ongoing coordination through a revised Memorandum of Understanding (MOU) dated August 1, 2022, “to ensure improved and effective communications between the agencies, to emphasize the importance of evidence-based spectrum policymaking and reliance on data, analyses, and engineering best practices, and to promote effective, long-range planning by both agencies, taking into account the implications of spectrum policy and strategy.” This Strategy acknowledges and reaffirms the independent statutory responsibilities of the FCC and NTIA as the U.S. spectrum regulating agencies and the continuing operation of the processes established in the MOU.

NTIA and the FCC have taken similar steps to include the U.S. Department of the Interior, entering a separate MOU dated November 23, 2022, that ensures communication and planning in coordinating policies and developing initiatives to encourage the participation of Tribal Nations and the Native Hawaiian community. This expands spectrum access and promotes the deployment, coordination, and development of broadband and other wireless communications services on Tribal lands and Hawaiian homelands.



The existing advisory structures and interagency coordination mechanisms (Federal and non-Federal, including state, local, and Tribal governments) provide valuable input; however, they operate independently from each other. The United States needs a process for bringing all stakeholders together for advanced planning, so they can generate recommendations earlier, based on the combined knowledge and perspectives of both the Federal Government and the private sector.

The U.S. Government will develop an architecture for a new collaborative framework that leverages these existing advisory groups, identifies new groups that would aid long-term planning, and defines the interactions among them, including roles and responsibilities and desired outputs. The U.S. Government will adhere to existing interagency MOUs and will engage all stakeholders, including unserved and historically underserved populations, Tribal Nations, and the Native Hawaiian community, in this new collaborative process. The collaborative framework, once implemented, will give stakeholders the opportunity to share their perspectives on future spectrum policies that could affect them and engage early and often in national-level spectrum planning. This framework will also build on existing efforts, in which the U.S. spectrum regulating agencies have increased their participation in cross-agency advisory groups as a means of fostering proactive technical exchange and engagement with industry and other Federal agencies.

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Thus, the U.S. Government will establish a national spectrum planning process that better incorporates future, as well as near- and mid-term, spectrum needs into the decision-making process. The goal is to expand opportunities for spectrum access and harmonious coexistence, by whatever licensing or allocation mechanism, for all sectors (e.g., terrestrial, satellite, in-space, launch, aviation, public safety, scientific research, Federal missions). Changes to spectrum allocations and other major spectrum decisions require sufficient lead-time for proper planning and implementation. This process will be informed by long-standing legal responsibilities and, if necessary, technical, scientific, mission, and economic analyses will be peer reviewed.

The U.S. Government will work within the collaborative framework to determine the key elements needed to plan spectrum allocations that will position our country to meet the Nation’s spectrum needs and maintain its place as a global technology leader. This includes implementing an ongoing process for solicitation of new and future spectrum requirements. Users will articulate their future needs through an agreed-to, standardized submission process that includes, at a minimum, a description of requirements, accompanied by supporting data, to ensure they are considered as part of the envisioned long-term planning process. Regularly assessing and optimizing spectrum allocations to address evolving Federal and non-Federal user requirements will help ensure spectrum utilization is providing the greatest benefits to the American people, especially those in rural and Tribal communities.



To ensure the on-going health of U.S. spectrum policy, the U.S. Government—with input gathered through this new collaborative framework—will regularly update the Nation’s spectrum strategy. Updates will be initiated as required, recognizing that a formally documented U.S. spectrum policy promotes a symbiotic relationship between domestic and international technical and policy work in which the United States participates (to support a better-coordinated approach, where possible, and without limiting flexibility in either venue).

### **Strategic Objective 2.2 | Develop and document an evidence-based national spectrum decision-making methodology.**

In today’s increasingly congested environment, there are no easy spectrum allocation choices. The Nation must have forward-looking, robust decision-making based on a full understanding of the operational impacts of allocation decisions, including the risks and benefits of additional spectrum access. Accordingly, the U.S. long-term spectrum planning process, consistent with President Biden’s *Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking*, dated January 27, 2021, will rely on an evidence-based methodology.

Systematic and rigorous analysis of relevant data is required for the timely, evidence-based decision-making needed to best serve the public interest. Leveraging our Nation’s intellectual capacity, the U.S. Government will develop models that use a value-based framework to assess the potential impacts of spectrum reallocation options. The societal value of the spectrum will be calculated based on a quantifiable estimation of the direct and indirect benefits of the different uses of the spectrum to the Nation. This approach will enable clearly articulated national priorities to drive policy decisions, based on trustworthy data, in a manner that balances both near-term and long-term costs and benefits, while also recognizing the inherent uncertainty of the future. Additionally, this methodology will help ensure that reallocation decisions continue to, and are better able to, factor in aspects such as expanding wireless service to unserved and underserved communities, federally recognized Tribes, and the Native Hawaiian community, to help address the digital divide.

***“In today’s increasingly congested environment, there are no easy spectrum allocation choices.”***

The methodology will incorporate best practices, developed through the new collaborative framework, for conducting technical and economic analyses that are data-driven, science-based, and peer-reviewed. Best practices will include, at a minimum, greater transparency around reported findings to the extent practicable (subject to information security restrictions). Using best practices developed through collaboration between Federal and non-Federal stakeholders, and in compliance with existing law and policy, will serve to ensure better acceptance and fewer disputes over findings.

In addition, NTIA and the FCC will leverage the commitments in their MOU to foster improved and effective communication on matters that relate to the management of the Nation’s spectrum resources. As set forth in the MOU, they will engage in ongoing engineering collaborations, share information that is of a quality that complies with best engineering practices and any mutually



agreed standards and procedures, and provide relevant and appropriate information in a timely manner, in consultation with Tribal Nations (as applicable). Moreover, NTIA will solicit the views of stakeholder Federal agencies in a timely fashion, providing sufficient time and procedures for agencies to present their views (and supporting technical information) to NTIA as well as written feedback on how agency views will be incorporated into the position that NTIA communicates to the FCC.

### **Strategic Objective 2.3 | Define requirements and implement capabilities to capture essential data and information on spectrum use.**

Spectrum management relies upon trustworthy data. That means validating current uses and representing future access needs in a comparable manner across stakeholders and uses. Evidence-based decisions require standardized, granular data to ensure that requests for expanded spectrum access are justified by current or likely future needs and to understand the criticality of those operations. The U.S. Government will work to modernize spectrum management capabilities that include tools suitable for both public and private sectors, to collect and use higher-fidelity data, including, but not limited to, time of use, waveforms, and area of operation. NTIA's effort to modernize its spectrum management infrastructure represents a positive first step towards this goal.

Data about current real-world usage, the purpose and type of use (active or passive), as well as occupancy in the time, frequency, and geography domains, is needed as the basis for assessing the potential for increased capacity. Using the new collaborative framework, stakeholders also will develop a structured schema for documenting and identifying future spectrum access requirements and a recurring process to solicit future requirements, enabling long-term planning. Such a strategic, forward-looking process is important to provide sufficient lead-time for proper planning and implementation of changes to authorized spectrum use.

Besides improving the available data, compatibility studies will seek to employ new or modified validated models, developed through best practices and real-world measurements as appropriate. If determined necessary, stakeholders (working through the same collaborative framework) will articulate to the research and development community gaps in capabilities and needs related to improved modeling to inform the decision-making process. Using new or upgraded validated models will bolster stronger acceptance of the results of studies assessing the potential for coexistence.

Of course, maintaining U.S. spectrum leadership internationally often requires bold and decisive action. As we work to bolster our modeling and measurement capabilities, we will not let the desire for more perfect information take precedence over this critical national interest.



## Pillar Three | Unprecedented Spectrum Innovation, Access, and Management through Technology Development

Embracing and promoting innovative technologies that can expand the overall capacity or usability of spectrum is vital to our Nation. To accelerate innovation and improve our Nation's understanding of electromagnetic phenomena, it is imperative for the spectrum research community to enhance the coordination of U.S. research and development endeavors and address areas where innovation is critical, including improving spectrum coexistence. As part of a whole-of-Nation endeavor, the U.S. will set measurable goals for advancing the state of technology for spectrum access, with an emphasis on dynamic forms of sharing. Specifically, it will—within 12-18 months—complete a “moonshot” effort, in collaboration with industry, to advance research, create investment incentives, and set forth measurable goals for advancing the state of technology for spectrum access, with an emphasis on dynamic forms of spectrum sharing for all users. By doing so, we can amplify the impact of collective efforts and foster important advancements. Our Nation's spectrum policies also must be designed to optimize flexible use and support emerging technologies. The United States consistently has been a leader in scientific breakthroughs, including in spectrum-based technologies. By pursuing the below objectives, our Nation will uphold and extend its longstanding leadership in this dynamic sector.

### **Strategic Objective 3.1 | Improve spectrum efficiency and bolster coexistence by facilitating investments in new and emerging technologies.**

Improving the efficient and effective use of spectrum requires enhancing the frameworks, processes, and tools for spectrum access and management. Informed investments in emerging technologies will bolster spectrum efficiency and coexistence capabilities of systems utilizing spectrum, as well as those systems that regulate and manage their access. To ensure U.S. economic competitiveness, the U.S. Government will identify key motivating factors that encourage investments in emerging technologies, such as artificial intelligence and machine learning (AI/ML), that can increase secure spectrum access and sharing. Advanced technologies can play a crucial role in enabling real-time, dynamic spectrum sharing and coexistence, as well as facilitating intelligent spectrum management.

The U.S. Government will identify mechanisms that drive Federal investments in spectrum innovation, particularly investments in spectrum efficiency, improved system flexibility, and enhanced adaptability. The overarching goal is to cultivate more resilient and capable radio frequency systems across the U.S. wireless landscape that can be adopted while minimizing developmental risk.

Federal spectrum users must incorporate spectrum efficiency requirements early in their acquisitions of spectrum-utilizing systems. For instance, when developing spectrum-dependent systems to meet mission requirements, agencies should use state-of-the-art technologies and





advanced operational techniques to maximize coexistence with other spectrum users, including heterogenous uses (i.e., communications and non-communications systems, terrestrial systems, satellite- and space-based capabilities, etc.). Non-Federal users should strive to incorporate spectrum efficiency requirements, where possible, in the acquisition of spectrum-utilizing systems.

Spectrum efficiency and the capacity to coexist depend on receiver characteristics in addition to transmitter operations. Through the collaboration framework, stakeholders from across government and industry will build upon FCC and Federal agency efforts to improve receiver performance by conducting a review of receiver requirements and performance parameters to develop a roadmap for improving receivers' resistance to harmful interference. Additionally, the Federal Government will encourage private entities to improve receivers' resistance to harmful interference and develop and offer dual-use technologies and services that are responsive to both commercial and unique Federal requirements. Moreover, the U.S. Government will explore ways to incentivize Federal agencies to procure systems that can operate outside of traditional frequency allocations and across frequency bands, if authorized.

These actions are intended to facilitate investments in efficiency for spectrum-dependent systems with different missions and applications. The U.S. Government will encourage development of technologies that enhance functionality and accelerate the deployment of smart spectrum management capabilities.

U.S. spectrum regulating agencies, Federal agencies, U.S. commercial industry, academia, and technology developers will work collaboratively to encourage dynamic spectrum sharing that employs spectrum management technologies and techniques that increase spectrum-use efficiency and enhance U.S. competitiveness, while taking issues such as cybersecurity into account. These technologies may include, but are not limited to, cloud-based spectrum management, AI/ML, advanced antenna technology, open and interoperable network architectures, cognitive transceiver technologies, advanced RF microelectronics, simultaneous transmit and receive, and edge intelligence. U.S. spectrum-regulating agencies will also explore modernizing rules and regulations to facilitate dynamic spectrum access and coordinate to develop automated spectrum management and analysis tools that could be made available to Federal agency partners and commercial stakeholders.

***“Embracing and promoting innovative technologies that can expand the overall capacity or usability of spectrum is vital to our Nation.”***

Both Federal users and wireless industry operators are relying on improved spectrum access techniques and technologies to meet growing requirements for spectrum access. Technologies alone will not suffice to ensure that spectrum sharing is successful, however—it is equally important that sharing regimes incentivize commercial investment and innovation. Thus, updating the incentives of all spectrum users is a critical component for U.S. economic growth and technological



competitiveness. NTIA, in collaboration with the FCC and industry, will study the commercial incentives associated with different approaches to spectrum sharing to ensure that approaches to dynamic spectrum sharing incorporate economic considerations.

Spectrum sharing opportunities are also a consideration when reallocation decisions are proposed. Whenever possible, and ideally early in the process of considering potential repurposing, NTIA will encourage collaboration between Federal agencies, non-Federal users (including Tribal Nations), and prospective new users of a spectrum band to consider coexistence mechanisms that leverage technology, expertise, and knowledge of the involved parties to safeguard incumbent missions—whether Federal or non-Federal. Evolving to a “designed to share whenever feasible” mindset will accelerate efficient and effective use of spectrum for all users.

In addition, U.S. spectrum-regulating agencies will consider establishing targeted engagements with agencies affected by potential repurposing and provide them enterprise capabilities for modeling electromagnetic compatibility. Consistent with the *National Standards Strategy for Critical and Emerging Technology*, the U.S. Government will prioritize collaboration with industry to advance spectrum-sharing approaches and technologies in global standards bodies, where appropriate.

Finally, NTIA, working with Federal agencies, will continue to pursue development of an enduring, scalable mechanism to manage shared spectrum access, including through the development of a common spectrum management platform. Federal agencies will cooperate to support the common platform and, to the maximum extent feasible, transition Federal-to-Federal sharing to the common platform. Furthermore, the common platform will be considered for the sharing of spectrum among Federal and non-Federal uses, including Tribal Nations, any time spectrum repurposing is assessed.

### **Strategic Objective 3.2 | Commit to improving collective understanding of the electromagnetic spectrum through coordinated, focused, and sophisticated research and development (R&D).**

As a Nation, we must deepen our collective understanding of the electromagnetic (EM) spectrum—including radio frequency spectrum and beyond—if we are to meet the demands of our spectrum-dependent world. The U.S. Government will encourage and promote research and development that optimizes spectrum utilization, drives technological advancements, bolsters national security, informs effective policies, and advances scientific discovery. Real-world testing of dynamic sharing principles and the evolving technologies supporting them will provide a baseline for wider deployment and a way forward to develop shared spectrum methods, standards, technologies, and trust mechanisms in order to make dynamic sharing of spectrum scalable.

The U.S. Government, through the White House Office of Science and Technology Policy and in coordination with the Federal agencies, will develop a National Spectrum Research and Development Plan. This plan will identify key innovation areas for spectrum research and development and will include a process to refine and enhance these areas on an ongoing basis.

The R&D Plan will consider recommendations developed through the collaborative framework outlined in Pillar Two. Specifically, stakeholders working through the framework will provide recommendations for conducting spectrum research that minimizes unnecessary duplication and helps to ensure all essential spectrum research areas are sufficiently explored. Increasing coordinated



investment in research and development among government, academia, civil society, and the private sector will result in measurable advancements in state-of-the-art spectrum science and engineering. These efforts will further development of new methods for improving spectrum efficiency, advancing dynamic and secure spectrum access regimes, expanding use of cognitive radios using AI/ML-based techniques, and in other research areas. Additionally, the U.S. Government will work to strengthen spectrum science and engineering initiatives by encouraging greater participation by public and private organizations in spectrum activities like the National Science Foundation’s Spectrum Innovation Initiative.

Through the collaboration framework, stakeholders will assess analytical and statistical modeling of EM interference and propagation (particularly for mid-band and millimeter wave spectrum) used to perform data-driven, risk-informed spectrum sharing compatibility and coexistence analyses. The assessment will include recommendations on approaches to improve modeling and mitigate potential harmful interference among Federal and non-Federal uses of the spectrum. In conjunction with these assessments, stakeholders will develop guidance on the best use of well-established and widely used EM compatibility modeling software and tools. This will bring needed clarity to the proper application of these models and support efforts to establish best practices for conducting spectrum studies.

***“As a Nation, we must deepen our collective understanding of the electromagnetic (EM) spectrum... if we are to meet the demands of our spectrum-dependent world.”***

The U.S. Government will establish a national testbed for dynamic spectrum sharing. This testbed will be a critical part of the U.S. Government’s effort to advance the technology for spectrum access within 12-18 months, in collaboration with industry, with an emphasis on dynamic spectrum sharing. Specifically, this testbed will enable the identification, in collaboration with national policymakers, of short-term access for experimentation in Federal and non-Federal spectrum segments. The testbed will serve as a technical demonstration platform, enabling national policymakers to identify and assess spectrum access technologies through experimentation in Federal and non-Federal spectrum segments.

This national testbed for dynamic sharing will take into consideration specific areas for testing and measurement to improve study efforts going forward across other bands. The overall intent of the initiative is to assess some of the Nation’s most pressing spectrum access challenges as part of a “band-agnostic” and technology-neutral approach, so that solutions are extensible across a range of possible bands. This program will enable Federal agencies and national policymakers to work cooperatively with industry, researchers, and academia to objectively examine new technologies that can improve management of the Nation’s airwaves. To reduce or eliminate duplication of other efforts, this initiative will synchronize other relevant research and engineering activities already under way across the government with respect to AI/ML, zero-trust networks, data-source management, autonomy and autonomous systems, and advanced radar technologies. NTIA will take ownership of the testbed following the initial demonstration period.



To increase available data for fine-tuning or validating EM models, the U.S. Government will encourage real-world measurements through field testing whenever possible and increase awareness and availability of outdoor wireless testbeds. Moreover, the U.S. Government will consider deploying such measurement campaigns on Tribal lands with consent from Tribal governments and consistent with Executive Order 13175 of November 6, 2000, *Consultation and Coordination with Indian Tribal Governments*, to gather better information regarding spectrum access for Tribal communities and spectrum utilization or buildout on Tribal lands.

The U.S. Government also will promote and facilitate the research community's continued exploration of dynamic and secure spectrum sharing to improve coexistence among spectrum-utilizing systems (e.g., radar, passive scientific measurements, and wireless broadband communications technologies) and to advance the effectiveness of dynamic spectrum management systems (e.g., Spectrum Access Systems and Automated Frequency Coordination).

The U.S. Government will better leverage existing innovation areas, as well as consider establishing spectrum "sandboxes" or geographic areas where spectrum research can be performed and technologies can be assessed with expedited approval of experimental licenses. Such efforts could explore research in spectrum efficiency or the use of underutilized spectrum bands such as sub-terahertz frequencies (e.g., above 100 GHz), which could help address the rapidly growing demand for spectrum.

### **Strategic Objective 3.3 | Pursue spectrum policies that maximize flexible use of spectrum, accommodate new and innovative technologies, and identify opportunities to expand spectrum access.**

A national spectrum policy that maximizes flexible use of spectrum will foster U.S. technological innovation and global leadership, reduce barriers to expanding spectrum access (especially for historically underrepresented rural communities), stimulate industry and government research, provide access to state-of-the-art technologies and services, and allow Federal agencies to pivot when new mission requirements are contemplated. Such a policy must respect current spectrum users, ensuring incumbents are protected from harmful interference and avoiding risks to national security, public safety, scientific research, or commercial operations. Policies should facilitate opportunities for conducting research and development to address dynamic spectrum sharing possibilities, maximizing the flexible use of spectrum innovation. This could include considering legislative changes to the Spectrum Relocation Fund to make payments for costs associated with general spectrum coexistence and compatibility research and development by Federal entities across all spectrum access models.

Maximum flexibility requires the U.S. Government to pursue policies that respond to changing conditions to accommodate new and innovative technologies. This applies to both Federal and non-Federal users that can demonstrate improved efficiency or more-intensive spectrum use. The U.S. spectrum-regulating agencies, benefiting from the improved collaboration framework, will jointly oversee a periodic, targeted assessment of U.S. spectrum policy to determine if it fosters U.S. technology development, incentivizes implementation of new technologies, and maximizes benefits for all Americans, especially to increase spectrum access for rural and underrepresented groups.



Potential improvements to promote the opportunistic and spectrally efficient use of spectrum bands should be considered to expand access to new users in underrepresented communities, including small and non-traditional internet service providers, enterprises, schools, libraries, Tribal communities, and other community anchor institutions in underserved areas.



## Pillar Four | Expanded Spectrum Expertise and Elevated National Awareness

Preparing a well-trained U.S. workforce is essential to the policy proposals, potential investments in technologies, and research initiatives described in this Strategy. All stakeholders, including industry, academia, state, local and Tribal governments, as well as the Federal Government, must have a spectrum workforce with the necessary skills to work across current and emerging technologies. We must also prepare the spectrum workforce of the next generation for a globally competitive environment where innovation is a key to successful national economic growth and spectrum access in support of critical Federal missions. We are committed to a diverse, broad-based workforce that enables the United States to maintain its global leadership.

### **Strategic Objective 4.1 | Attract, train, and grow the current and next-generation spectrum workforce.**

Modernizing the spectrum workforce and preparing for the future is essential to foster innovation and to keep up with technological advancements, meet the growing demand for spectrum access, navigate our complex policy landscape, and maintain the Nation's continued economic growth. A well-trained workforce that can fill critical spectrum-related jobs across all relevant sectors is essential to ensuring that the spectrum ecosystem remains effective, efficient, and responsive to the evolving needs of the wireless ecosystem and society at large. Nurturing a skilled and diverse workforce will pave the way for long-term success and leadership in the spectrum domain, positioning the Nation at the forefront of emerging wireless technologies and their associated benefits. This Strategy will promote collaboration among industry stakeholders, academia, and government entities and serve as a catalyst for the development of specialized expertise.

Because a whole-of-government approach is necessary, the U.S. Government will develop and periodically update a National Spectrum Workforce Plan to prioritize development of, and enhancements to, the spectrum ecosystem workforce (including the full range of operational, technical, and policy positions involved in spectrum-related activities). As a first step, human resources professionals should conduct an analysis of the human capital needs for spectrum management and spectrum-related positions. This will help assess the need for modifications to Federal career series or enhancements to retain and attract quality talent.

Through the collaboration framework, academic institutions, Federal agencies, Tribal Nations, and private entities will identify needed education and training programs to equip the current workforce and prepare the future workforce to meet evolving and growing spectrum-related workforce demands. Organizations should encourage participation in conferences, trade shows, and other opportunities for informal collaboration and cross-stakeholder network building, such as through participation in technical and professional organizations. They should consider partnering with colleges and universities to develop programs that offer training in engineering skills to support



analysis of spectrum issues, including a work-study program that could result in employment and leverage existing collaboration efforts.

Additionally, stakeholders should work with professional societies to define and update the knowledge needed to teach at different levels and to establish or expand new fellowship programs that place doctorate-level scientists in the U.S. Government and in organizations, as applicable. This would be particularly beneficial for U.S. spectrum-regulating agencies. Similar efforts should be undertaken to engage trade schools to develop and implement certification programs for targeted, spectrum-related skills sets.

*“Modernizing the spectrum workforce and preparing for the future is essential to foster innovation... and maintain the Nation’s continued economic growth.”*

The Administration will proactively engage agencies that invest in science, technology, engineering, and math (STEM) education to introduce spectrum topics at an early age and to stimulate students’ interest in these careers through secondary education and beyond. It will be a priority to ensure more diversity by focusing educational development and recruitment efforts towards underrepresented groups, especially for young engineers. It is important to target outreach to underserved populations, such as Tribal communities, where a lack of internet access has disadvantaged many. In total, these efforts to attract top talent and develop spectrum expertise will benefit and serve the public interest at local, state, and Federal levels.

#### **Strategic Objective 4.2 | Improve policymakers’ understanding of spectrum considerations.**

Making decisions for our Nation about the allocation and authorized uses of spectrum is a heavy responsibility. These decisions drive the development and deployment of new systems and technologies, so they have long-term and significant consequences. They require complex, cross-cutting understanding and knowledge of the technical aspects of spectrum use, the economic and legal implications of spectrum allocations, and the potential impacts to critical Federal missions. Weighing the trade-offs between current uses and impacts on incumbents against potential future applications is complicated, with many competing national interests at play.

Spectrum management is an interdisciplinary process that covers multiple intertwined factors, and few, if any, policymakers (e.g., regulators, legislators, community leaders, and spectrum managers) have expertise in all of the relevant fields. But leaders at all levels of government, including Tribal governments, need to understand spectrum issues holistically and have access to spectrum managers and professionals that understand the complexities relative to their interests. Recognizing this need and providing policymakers with foundational information and tools will serve the Nation well as we implement a more strategic spectrum planning process.



The Administration will encourage policymakers at all levels to increase their understanding of spectrum topics such as electromagnetic propagation, spectrum science, spectrum engineering, spectrum management, and spectrum monitoring and measurements. U.S. spectrum-regulating agencies will generate avenues for decision-makers to enhance their understanding of spectrum policy and regulation, including the full range of spectrum management techniques such as spectrum sharing methodologies and licensing schemes, as well as knowledge of non-technical topics such as business models and economics associated with spectrum markets. Ensuring policymakers understand the value-based methodologies being created and their appropriate application will also be important.

Federal organizations that rely on spectrum to perform their missions will be encouraged to ensure sufficient spectrum expertise on their staffs and to train them to communicate in plain language with decision-makers. This will ensure that decisions are made after considering the full range of applicable technical and operational factors.

### **Strategic Objective 4.3 | Improve the public’s understanding of radio frequency spectrum and raise awareness of its role in everyday life.**

The radio frequency spectrum, while critical to our everyday lives, remains a complex resource often misunderstood by everyday users. Spectrum plays a vital role in Americans’ daily activities, from education and emergency services to mapping and navigation systems, banking, e-commerce, and telemedicine, as well as for entertainment and staying connected through social media. The U.S. Government will prioritize educating the public about spectrum and the role it plays in their everyday lives and will consider a public service initiative. In addition to highlighting how citizens rely on, and benefit from, everyday spectrum usage, outreach could spotlight the crucial role of spectrum in critical government missions—especially those involving public safety, scientific endeavors (including weather and climate), and security. Ideally, showcasing the complexities and challenges of spectrum management will spark an interest among a broader community and attract multi-faceted problem solvers to the field.

The U.S. Government will work to raise the public’s overall understanding and appreciation of spectrum and how this complex resource needs to be managed for everyday essential activities, both now and in the future. The more informed the public is, the better equipped it will be to weigh-in and have a voice in determining priorities for competing interests for spectrum access.





# CONCLUSION

## A Plan for Implementing the Strategy

The National Spectrum Strategy provides a roadmap of strategic objectives that will set a course for prolonged U.S. leadership in advanced wireless technologies and services. In identifying strategic objectives, the Strategy recognizes the broad range of stakeholders, inside and outside of government, whose expertise and contributions will be instrumental in reaching its goals. Consensus in ideas may not always be possible, but unity of purpose in meeting America’s spectrum needs is possible. To successfully implement the Strategy, a renewed effort for trust, transparency, technological innovation, and open communications is imperative.

The Strategy is also forward-looking. As a high-level policy statement, the National Spectrum Strategy is only the beginning. Achieving these strategic objectives will require commitments from stakeholders to meet specific outcomes on established timelines. Agencies will leverage existing resources, including the Spectrum Relocation Fund, as applicable, to achieve the goals set out in this Strategy. Agencies will also take the National Spectrum Strategy into consideration during the development of their annual budget submissions. Agencies, industry, academia, and technology developers can use the Strategy as a guidepost for directing technical expertise and overall American ingenuity to make unprecedented progress in the development and use of dynamic spectrum access capabilities.

*“Consensus in ideas may not always be possible, but unity of purpose in meeting America’s spectrum needs is possible.”*

NTIA, in collaboration with the FCC and in coordination with other Federal agencies, will prepare and publish an Implementation Plan that establishes specific outcomes associated with each strategic objective. For each outcome, the plan will name a responsible party, other contributing stakeholders, the anticipated start date for work on the objective, and the estimated amount of time needed to achieve the objective. Agencies will collaborate to develop necessary project management plans as appropriate.

The Strategy will be implemented consistently with existing statutory responsibilities, the Federal trust responsibility to Tribal Nations, and other Administration policies and priorities, including those related to the economy, national security, climate, AI, health care, science, immigration, diversity, equity and inclusion, and restoring America’s global standing. This Strategy will also work in tandem with, and further the objectives of, relevant executive orders and Presidential memoranda, strategies, and other directives.



The National Spectrum Strategy reflects an ethic of continued reassessment and adjustment of implementation efforts. This will be a living process as governments and the private sector engage and work together, and as new challenges prompt new initiatives and solutions. Our approach to implementing and executing on the unprecedented strategic objectives set forth in the Strategy must be as agile and dynamic as the U.S. wireless innovation ecosystem, with all its complexities and opportunities. The Strategy's four pillars are inherently collaborative; therefore, only through collaboration can the United States ensure that it will reap the massive benefits of advanced wireless technologies and maximize efficient use of our Nation's spectrum resources.

### **Seizing the Opportunity**

The United States has historically been a global pioneer in developing and implementing wireless services. World-changing technologies, including the early developments of terrestrial wireless and space-based systems used for various services, were conceived on our shores, revolutionizing the lives not only of Americans but also millions of others around the globe. America's technological leadership has been accompanied by a willingness to pursue daring regulatory and policy ideas such as spectrum auctions, unlicensed spectrum access, and dynamic spectrum sharing. The complexity of America's wireless environment, and the high demand for spectrum resources, have proven to be a competitive advantage, prompting our companies, policymakers, and regulators to be more agile and creative in producing new innovations.

And yet, the circumstances that forged America's early leadership in wireless technologies once again present new challenges. Today, we stand at a crossroads in implementing the spectrum policies necessary to ensure that the United States continues to exemplify competitive and technological leadership and achieves our national goals for economic opportunity and equity, climate stewardship, infrastructure rejuvenation, and national security.

In this National Spectrum Strategy, we reaffirm our Nation's legacy of boundless innovation, and we honor those who have pioneered it, by seizing the opportunity to lead the next era of wireless discoveries.