DEPARTMENT OF DEFENSE

ELECTROMAGNETIC SPECTRUM STRATEGY

2013

A CALL TO ACTION

DEPUTY SECRETARY OF DEFENSE
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The Department of Defense's (DoD) air, land, maritime, space, and cyberspace operations increasingly depend on electromagnetic spectrum access. All Joint functions – movement and maneuver, fires, command and control, intelligence, protection, and sustainment rely on capabilities that use the spectrum. The growth in the complexity of modern military systems and the demand for more and timely information at every echelon is driving an increase in DoD's need for spectrum management. Moreover, adversaries are aggressively fielding electronic attack and cyber technologies that significantly erode DoD's ability to use the spectrum to conduct military operations. Finally, the global wireless broadband industry is seeking to reallocate spectrum from defense use to commercial use to meet consumer demand for greater mobility and more data-rich applications.

DoD must act now to ensure access to the congested and contested electromagnetic environment of the future. Specifically, the Department must adapt how it acquires and uses spectrum resources. Our approach must include acquiring more efficient, flexible, and adaptable systems while developing more agile and opportunistic spectrum operations to ensure that our forces can complete their missions.

The enclosed DoD Electromagnetic Spectrum Strategy presents a framework for how the Department should rapidly adapt to the changing spectrum environment and to assess and respond to spectrum regulatory changes. The DoD Chief Information Officer (CIO), in partnership with the Defense Information Systems Agency, has begun development of an Action Plan to provide specific tasks and milestones to implement the strategy's goals. Although technology is emphasized in this strategy, other activities (e.g., organization, policy, doctrine, personnel education, and training) are also needed to achieve the strategy's vision and will be addressed in the Action Plan.

This strategy requires the active participation of the entire DoD community, including industry partners, to achieve its intended results. Key insights gained during implementation and changes in DoD spectrum needs, will inform future revisions to the strategy. Your support in these efforts will ensure our warfighters have the spectrum access required for mission success in the congested and contested spectrum environment of the 21st Century.

Ashton B. Carter

INTRODUCTION

Electromagnetic spectrum (EMS) access is a prerequisite for modern military operations. DoD's growing requirements to gather, analyze, and share information rapidly; to control an increasing number of automated Intelligence, Surveillance, and Reconnaissance (ISR) assets; to command geographically dispersed and mobile forces to gain access into denied areas; and to "train as we fight" requires that DoD maintain sufficient spectrum access. Additionally, adversaries are aggressively developing and fielding electronic attack (EA) and cyberspace technologies that significantly reduce the ability of DoD to access the spectrum and conduct military operations. Concurrently, the global wireless broadband industry's demand for spectrum is driven by consumer demand for greater mobility and better data access. These competing requirements for finite spectrum resources have changed the spectrum landscape, nationally and internationally, for the foreseeable future. Going forward, our national leaders will be challenged to make decisions that balance national security with economic interests.

VISION

Spectrum access when and where needed to achieve mission success

Mission success, dependent on sufficient access to the EMS, is the overriding requirement for this strategy. DoD recognizes that the electromagnetic environment (EME) will be increasingly congested and contested wherever military operations occur. DoD's spectrum access will continue to be challenged by adversaries on the battlefield and debated in national and international forums where leadership will need to balance national defense, economic, and other national interests. DoD must be able to address these challenges to provide spectrum access when and where needed by the warfighter.

> "…therefore, we are shaping a Joint Force for the future that will be smaller and leaner, but will be agile, flexible, ready, and technologically advanced." – **Secretary of Defense –"Sustaining U.S. Global Leadership: Priorities for 21st Century Defense" - 5 January 2012**

To achieve mission success, DoD Components must be able to assemble mission-tailored capabilities to meet a combatant commander's requirements and trust that systems will be compatible with each other and be able to adapt to a continuously changing EME. Accordingly, DoD must improve the way in which it accesses spectrum and must also improve its ability to deny adversary use of spectrum without degrading its own use. To realize these improvements, DoD systems must become more ***spectrally efficient, flexible, and adaptable,*** and DoD spectrum operations must become more ***agile*** in their ability to access spectrum in order to increase the options available to mission planners[1] . In addition to these improvements, DoD must work closely with spectrum regulators, nationally and internationally, to ensure these spectrally efficient, flexible, adaptable, and agile capabilities are authorized for use.

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1 Spectrum efficiency is the use of the minimum amount of EMS resources necessary to ensure maximum operational effectiveness in fully accomplishing the required mission while taking all practicable steps to minimize impacts to other systems in the EME. Spectrum flexibility and adaptability is the capability of a spectrum-dependent system (SDS) to exploit various opportunities to access spectrum – e.g., multi-band operation, increasing the ability to share spectrum with other systems (domestic or foreign, federal, or non-federal), becoming more tolerant of interference. Agile spectrum operations will enable DoD systems to utilize their flexibility and adaptability to achieve mission success in rapidly changing EMEs.

SCOPE

This DoD Electromagnetic Spectrum Strategy is designed to address near-term, as well as far-term, spectrum challenges. It provides guidance for current and longer-term initiatives to ensure our military has spectrum when and where needed to meet the objectives in the National Military Strategy and the primary missions listed in the President's strategic guidance "Sustaining U.S. Global Leadership: Priorities for 21st Century Defense." This strategy identifies what must be accomplished, via goals and objectives, to achieve the vision. Although it emphasizes advancing promising spectrum-dependent technologies, other initiatives, including improving the integration of DoD spectrum activities, improving the ability to assess and respond to spectrum regulatory changes, and addressing associated policy and governance are identified.
A governance structure will be developed along with a Roadmap and Action Plan to fulfill this strategy and will provide the actions, associated lead organizations, estimated costs, schedule, deliverables, and metrics needed to implement and monitor the progress of the strategy goals and objectives. In addition, the Roadmap and Action Plan will address other fundamental underlying DOTMLPF[2] activities (e.g., doctrine, personnel education, and training) needed to implement the strategy. This strategy and associated Roadmap and Action Plan will be updated periodically to reflect lessons learned, changing DoD spectrum needs, and the evolving spectrum community.

STRATEGIC ENVIRONMENT

The National Military Strategy states: "The Joint Force must ensure access, freedom of maneuver, and the ability to project power globally through all domains." Like air, space, land, maritime, and cyberspace domains, military forces maneuver within the EMS to gain tactical, operational, and strategic advantages. The EMS transcends all these domains and enables mission execution within each and ensures overall operational superiority. It cannot be overstated that all joint functions – including movement and maneuver, weapon engagements (fires), command and control, intelligence, protection, sustainment, and information are enabled by spectrum-dependent system (SDS) capabilities. Further, for these SDSs to be effective, DoD requires access and control of the EMS, which is obtained by conducting joint electromagnetic spectrum operations (JEMSO) i.e., those activities consisting of electronic warfare (EW) and spectrum management operations used to exploit, attack, protect, and manage the electromagnetic operational environment to achieve the commander's objectives.

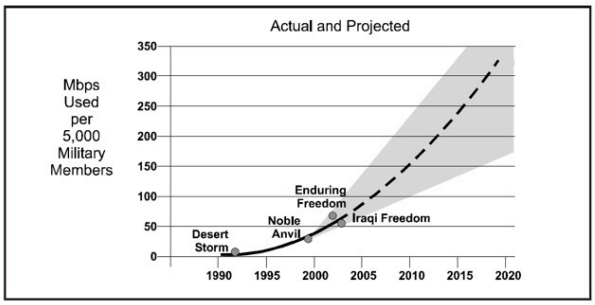
Growth in DoD Spectrum Requirements

DoD SDSs address specific mission requirements such as detection, communications, and command and control, where the specific range of frequencies used is driven by the associated physical characteristics of the spectrum. For example, higher frequencies are required for accurate target location, and lower frequencies for mobile communications. Within the United States and its possessions, DoD testing, training, and first responder support dictate the Department's spectrum usage. When deployed, missions and force structure (platforms/equipment) in a given operational environment determine DoD spectrum usage.

The demand for more and timely information at every echelon is driving an increase in DoD's need for spectrum. Increasingly lower echelons, including individual soldiers, require situational awareness information resulting in more spectrum-enabled network links. The growth in the complexity of modern military systems has similarly led to an increase in spectrum requirements. Some examples include: the increased reliance on unmanned vehicles to collect ISR information and relay communications; the requirement to detect smaller,

2 DOTMLPF - doctrine, organization, training, materiel, leadership and education, personnel and facilities

stealthier targets at greater distances; and increased data rates required for increasingly sophisticated tests of progressively more complex weapons systems such as the F-35.



DoD Spectrum Requirements are Changing and Increasing

In addition, advances in adversary command, control, communications, and computers; ISR; improvised explosive devices (IEDS); and area denial weapon systems require the development, fielding, and integration of complex EA, electronic support (ES), and electronic protection (EP) technologies – all of which require access to spectrum. Finally, an underlying challenge that any band identified for new commercial wireless use becomes a band in which DoD must test, train, and employ the use of EW systems to counter advances in enemy usage of IEDs.

Wireless Broadband Growth and the Increasing Consensus to Repurpose Spectrum

Consumer demand for wireless devices like smartphones and tablet computers, and the associated data-intensive applications, is growing on a global basis. As a result, mobile network traffic is rising dramatically and outpacing efficiency gains. The Federal Communications Commission (FCC) estimated that wireless broadband providers would need an additional 275 MHz of spectrum by 2014 to meet conservative data demand estimates. The Administration and Congress are considering methods to make more spectrum available, including repurposing spectrum from Federal government use to wireless broadband use even though Federal agencies have exclusive use of only a small percentage of the spectrum. For example, about 18% of the spectrum between 300 MHz and 3 GHz (the spectrum most highly desired by the wireless community) is for Federal exclusive use. Further, spectrum auctions are being considered by Congress and the Administration to be potential revenue sources to reduce the Federal government deficit.

> "This new era in global technology leadership will only happen if there is adequate spectrum available to support the forthcoming myriad of wireless devices, networks, and applications that can drive the new economy. To do so, we can use our American ingenuity to wring abundance from scarcity, by finding ways to use spectrum more efficiently. We can also unlock the value of otherwise underutilized spectrum and open new avenues for spectrum users to derive value through the development of advanced, situation-aware spectrum-sharing technologies. – **President Obama, Unleashing the Wireless Broadband Revolution, June 28, 2010**

In June 2010, President Obama directed the National Telecommunications and Information Administration (NTIA) to work with the FCC to "make available a total of 500 MHz of federal and non-federal spectrum over the next 10 years, suitable for both mobile and fixed wireless broadband use." To meet the President's goal, NTIA is identifying bands for repurposing. A recent study by the President's Council of Advisors on Science and Technology stressed the need to expand the development and use of new spectrum-sharing technologies since moving Federal systems to new bands will be costly and time consuming.

Around the world other nations are conducting similar actions to make additional spectrum available for wireless broadband. For example, the International Telecommunication Union (a United Nations treaty organization) has put spectrum allocations for wireless broadband on the agenda for its 2015 World Radiocommunication Conference with the goal of harmonizing international use of spectrum bands for commercial wireless.

As a result of these pressures on the spectrum, in the near term, there is a high probability that DoD could lose dedicated access to portions of spectrum available to it today.

Spectrum Access Innovation

The revolution in wireless broadband technology is being fueled by consumer demand for more information. Although carriers are finding creative ways to meet this demand by offloading traffic to low power unlicensed Wi-Fi hotspots and deploying smaller wireless cells, they expect more improvements will be needed and continue to develop more capable wireless devices and applications. Consequently, DoD has the opportunity to leverage commercial technologies and wireless services to meet DoD requirements, where appropriate. In addition, DoD investments in spectrum technologies will augment commercial innovation, which will benefit the overall national wireless ecosystem.

Opportunistic use of the spectrum is one of the promising approaches being pursued by both DoD and the wireless community. Cognitive radio systems, improved spectrum sensing, and geo-location databases are among new opportunistic use technologies being considered. The success of these new access techniques will almost certainly create regulatory pressure to share Federal spectrum via dynamic access or other similar technologies. Conversely, DoD's adoption of these technologies may provide opportunities for DoD to operate in government and commercial spectrum that would otherwise be unavailable.

SPECTRUM STRATEGY

The strategic environment – the warfighter's expectation of a robust information environment, increasing commercial and DoD demand for spectrum, rising proliferation of adversary anti-access technologies, and spectrum access innovation – provides the impetus for DoD to change how it uses spectrum. DoD must become more efficient, flexible, adaptable, and agile in its spectrum use in order to have the spectrum access required when and where needed to achieve mission success, particularly in the face of competition for access.
DoD will pursue the following goals and objectives to address the global spectrum challenges that face DoD today and at least through 2020. A significant part of this strategy requires advancing and adopting spectrum-dependent technologies that will lead to more spectrally efficient, flexible, and adaptable SDS capabilities. DoD will explore promising technologies, assess the technologies' military utility, and include the most promising in key acquisition programs. DoD will also continue to adopt new tools and techniques to manage the spectrum more effectively, making our spectrum operations more agile. Finally, DoD must improve its understanding and assessment of proposed regulatory and policy changes, and the associated impacts, to arrive at informed decisions that balance national defense and security with economic interests.

Naval Research Laboratory

Goal 1: Expedite the Development of SDS Capabilities with Increased Spectrum Efficiency, Flexibility, and Adaptability

To meet the warfighter's growing demand for spectrum access, DoD will exploit technology to increase DoD

spectrum access efficiency, flexibility, and adaptability. This approach is intended to increase DoD capabilities while minimizing EME impact and improving upon today's spectrum sharing opportunities. For example, DoD will exploit technology advances to access less-used spectrum and seek to use commercial services and technologies to meet DoD requirements where possible. Concurrently, DoD will explore increased spectrum sharing technologies. Finally, DoD will improve its oversight of spectrum use at the enterprise level to ensure spectrum availability risks are identified and managed at the early stages of SDS requirements, planning, programming, and development.

Objective 1: Expedite development of technologies that increase an SDS's ability to: access wider frequency ranges; exploit spectrum efficiency gains; utilize less congested bands; and adapt rapidly to changing EMEs

DoD will investigate leveraging mature, advanced, and affordable technologies that exploit multi-dimensional access opportunities of spectrum use, increase spectrum efficiency, and move some functions to uncongested portions of the spectrum. DoD will also develop operational scenarios to evaluate, through modeling, simulation, and testing, the performance and vulnerabilities of advanced technologies to various techniques of attack, denial, interference, and deception. Investments will focus on flexible spectrum usage and interference mitigation technologies to enable continued operational capabilities within more dense and contested EMEs.

Objective 2: Accelerate the fielding of technologies that enable spectrum sharing and improve access opportunities

Technology innovation will overcome some of today's challenges associated with spectrum sharing, such as the risk of harmful interference. DoD will pursue promising technologies, establish policies, and adopt standards to improve interference mitigation while preserving the capabilities of DoD systems. DoD will also identify systems that can share spectrum and/or operate compatibly with systems in adjacent spectrum bands without affecting system effectiveness or compromising operational safety.

Objective 3: Cultivate and adopt commercial service capabilities

Emerging commercial hardware, applications, and operating systems provide SDS capabilities in small, low cost, adaptable packages. DoD will evaluate commercial capabilities, such as smartphones and 4th Generation wireless, for mission use and to meet other spectrum requirements. DoD will also participate in national, international, and industry-specific standards bodies associated with wireless innovation to collaborate on emerging technologies and their adoption, including national security preemption and priority mechanisms for commercial wireless systems. DoD expects that military investments in spectrum technologies will both leverage and augment commercial innovation to the benefit of DoD operations and the national wireless ecosystem as a whole.

Objective 4: Strengthen enterprise oversight of DoD spectrum use

DoD will improve enterprise oversight and enforcement of spectrum use at the earliest stages of SDS development to ensure future systems align with this spectrum strategy, ensure spectrum technology investments are synchronized across DoD Components, and ensure that spectrum availability risks are identified and managed. This will include: expanding and requiring adoption of spectrum standards and protocols; establishing policy requiring spectrum sharing, efficiency, flexibility, and adaptability be addressed in DoD requirements, acquisition, and procurement processes; conducting reviews of Component spectrum-related research and development portfolios; and establishing a spectrum risk review board to support Defense Acquisition Board decisions.

Goal 2: Increase the Agility of DoD Spectrum Operations

DoD's spectrum use will become more agile. DoD will be able to assemble mission-tailored capabilities to meet a combatant commander's requirements, enable EMS superiority through JEMSO, and ensure SDS compatibility and adaptability within continuously changing congested and contested EMEs. To accomplish this, DoD will improve its capabilities to plan, manage, and control all dimensions of spectrum use to preserve access to and maneuver within the EME. Maintaining a comprehensive spectrum data repository is essential to access and maneuver in the EME. DoD will explore new spectrum use paradigms such as sharing, and engage in national and international discussions to take advantage of spectrum use opportunities while advocating for exclusive spectrum access for military capabilities that still require it.

Objective 1: Develop the ability to perform near-real-time spectrum operations

DoD will develop the ability to manage SDS in near-real-time by developing the tools and techniques required to quantify spectrum requirements and the EME, and to identify and mitigate spectrum issues and limitations that could affect operations. This includes: the ability to identify and model the spectrum "footprint" of SDSs - frequency used, location space, time, use parameters (e.g., signal coding), etc. - at any point in time; a policy-based management system or system-of-systems to control SDS parameters (e.g., signal coding, power) as a function of real-time location to meet mission performance requirements while also preventing harmful interference; improving situational awareness of the EME; developing the ability to assess mission impacts due to denial of spectrum quickly; improving DoD's ability to deny adversary use of spectrum without degrading use by friendly forces or non-aligned entities; and improving the integration of spectrum management, network operations, EW, cyberspace, and intelligence operations.

Objective 2: Advance the ability to identify, predict, and mitigate harmful interference

To operate more efficiently and effectively in a congested and contested EME, DoD will improve its ability to predict, identify, and mitigate harmful interference in planning and during operations. This includes: implementing interference hardening requirements in DoD systems; establishing definitions of mission limiting interference specific to DoD missions and SDSs; implementing advanced interference mitigation technologies, and implementing battlefield interference detection technologies, reporting processes, enforcement policy, and resolution mechanisms. These methodologies will also be extended, in collaboration with NTIA, FCC, and industry, to establish non-battlefield harmful interference, spectrum etiquette, detection, and enforcement governance.

Objective 3: Modify policies, regulations, and standards to enable DoD to exploit improvements to SDS spectrum flexibility and facilitate sharing spectrum

DoD, national and international policy and regulatory changes are needed to improve spectrum access, including DoD access to spectrum allocated in the United States for non-federal use. DoD will identify and evaluate incentives for spectrum sharing while developing spectrum policy (spectrum rights, service level agreements, and enforcement mechanisms) to share spectrum through agreements and on an on-demand basis with an understanding of potential risks spectrum sharing entails. This will include amending DoD processes pertaining to spectrum use and increasing collaboration with NTIA, FCC, and industry to develop and enforce spectrum regulations that are comprehensive, flexible, and support increased access for DoD SDSs.

Goal 3: Sharpen the Responsiveness to On-going Spectrum Regulatory and Policy Changes

Although SDS capability and spectrum operations improvements will eventually reduce the impact of regulatory and policy change on the military, DoD will sharpen its ability to assess, contribute to, and adjust to worldwide regulatory and policy changes being proposed (e.g., repurposing spectrum to accommodate wireless services). Assessments include quantifying the technical, operational, budget, and acquisition impacts of spectrum reallocations. DoD will propose innovative alternatives to military capability versus commercial interest discussions. Finally, DoD will improve the ability to implement directed spectrum changes in an orderly and non-disruptive manner.

Objective 1: Reform DoD's ability to assess regulatory proposals

DoD will reform its ability rapidly to assess impacts, determine equities, and evaluate the potential effect on missions of proposed national and international regulatory and policy changes. The impact assessment will span all spectrum processes, from programming through equipment employment. DoD will improve awareness of impacts on investments, acquisition, military tasks, and operations. Acquisition delays due to impacts on testing will be considered as well as the effect of training constraints on unit readiness. These impact assessments will be based on: improving DoD's ability to quantify spectrum requirements of current and planned military capabilities; developing a map of frequency, SDS, and supported military tasks to be able to assess mission impacts quickly due to potential denial of spectrum; developing cost assessment frameworks to evaluate costs associated with spectrum repurposing; and developing improved tools and processes to decrease the time it takes to assess technical, operational, cost, and schedule impacts to DoD.

Objective 2: Expand DoD's participation in and contributions to regulatory and policy discussions

DoD will mitigate the impact of regulatory and policy proposals by developing alternatives that are acceptable to DoD and other interested parties and proactively engaging directly in decision forums. From a national security perspective, DoD must not experience an unacceptable loss of capability as a result of regulatory and policy changes; while from an economic perspective, the cost and schedule to implement the changes must be feasible. This includes: developing innovative alternatives that consider both DoD and commercial equities where possible; increasing collaboration with the Administration, national regulators (NTIA and FCC), other Federal bodies, and international spectrum regulators in order to increase the understanding of DoD operations and the potential impacts of regulatory changes; and improving DoD's ability to understand economic implications of proposed changes to spectrum regulations and policy in order to develop better alternatives.

Objective 3: Institutionalize DoD's ability to adapt to and implement regulatory and policy changes

Once a regulatory or policy change has been directed, DoD will develop executable transition plans that accommodate new spectrum uses while maintaining full military capability. DoD will engage with spectrum regulators regarding rules for spectrum use during any period when new entrants will be authorized to operate while DoD operations are still on-going.

Governance

An effective DoD spectrum governance structure begins with strong leadership to establish direction and sustain momentum within the Military Departments, Services, and other government organizations. This governance includes the structures and processes for setting direction, establishing standards, and prioritizing spectrum technology investments. Proper governance will enable DoD to leverage a framework for accountability in enforcing compliance with decisions about spectrum technology. An Integrated Project Team of all vested organizations will be established to provide implementable recommendations for a governance structure that will focus DoD on meeting the goals of this strategy. Existing governance structures, such as, Defense Acquisition Boards and Science and Technology forums, will be leveraged to ensure optimum use of resources.

SUMMARY

DoD operations – in the air, on land, on and under the sea, in space, and in cyberspace – are fundamentally dependent on our use and control of the electromagnetic spectrum. All joint functions – movement and maneuver, fires, command and control, intelligence, protection, sustainment, and information – are accomplished with systems that use spectrum. The safety and security of U.S. citizens, the effectiveness of U.S. combat forces, and the lives of U.S. military members, our allies, and non-combatants depend on spectrum access more than ever before. This DoD Electromagnetic Spectrum Strategy sets the vision for DoD spectrum use – ***spectrum access when and where needed to achieve mission success*** – and provides the goals and objectives needed to achieve this vision.

In pursuing the vision, DoD systems must become more spectrally ***efficient, flexible, and adaptable,*** and DoD spectrum operations must become more ***agile*** in their ability to access spectrum in order to increase the opportunities available to mission planners. This includes many factors such as: increasing the operating frequency range of systems; increasing the ability to share spectrum with other systems (domestic or foreign, Federal or non-federal); amending DoD processes pertaining to spectrum use; increasing the speed of system adaptation; becoming more tolerant of interference and EA; and developing near-real-time spectrum operations that integrate spectrum management, network operations, EW, cyberspace, and intelligence operations.
This strategy is a call to action. Existing technologies as well as research and development activities will be driven

Spectrum access when and where needed to achieve mission success

Goal 1: Expedite the Development of SDS Capabilities with Increased Spectrum Efficiency, Flexibility, and Adaptability	*Goal 2:* Increase the Agility of DoD Spectrum Operations	*Goal 3:* Sharpen the Responsiveness to On-going Spectrum Regulatory and Policy Changes

Governance

to be affordable and available to acquisition and sustainment. DoD will also seek to utilize commercially available wireless technologies, systems, and services where appropriate to meet mission requirements. In addition, DoD expects that military investments in spectrum technologies will augment commercial innovation not only to benefit DoD operations, but to benefit the national wireless ecosystem as a whole.

Although the strategy emphasizes advancing promising spectrum-dependent technologies, other initiatives are identified, including improving the integration of DoD spectrum activities, improving the ability to assess and respond to spectrum regulatory changes, and addressing associated policy and governance. A Roadmap and Action Plan will be developed to supplement this strategy and will provide the actions, associated lead organizations, cost, schedule, deliverables, and metrics needed to implement and monitor the progress of the strategy goals and objectives. In addition, the Roadmap and Action Plan will address other fundamental underlying DOTMLPF activities (e.g., doctrine, personnel, education, and training) needed to implement the strategy. Strong leadership across DoD focused on the electromagnetic spectrum is required to establish structures and processes for setting direction, establishing standards, and prioritizing spectrum technology investments. Proper governance will enable DoD to leverage a framework for accountability in enforcing compliance with decisions required to meet the objectives of this strategy. SDS capabilities and associated challenges with accessing the electromagnetic spectrum must be highlighted in plans, budgets, research, training, and operations to inform decision makers.

With defined actions and leadership, DoD will improve spectrum-dependent capabilities while increasing the warfighter's ability to operate in the complex spectrum environment of tomorrow. This strategy and associated Roadmap and Action Plan will be updated routinely to reflect lessons learned during the implementation and the changing DoD spectrum needs, spectrum environment, and spectrum community. Additionally, the principles of this strategy will serve as the basis for DoD engagement with the Administration, other agencies, NTIA, and FCC regarding national-level strategic planning needed to reduce uncertainty in spectrum access for the future.

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