Introduction

I write in response to the Defense Spectrum Sharing Request for Information recently issued by the Defense Information Systems Agency, which I do in my capacity as a private citizen with decades of experience as a technology executive and as former chair of the Defense Innovation Board.

The deployment of 5G telecommunications infrastructure in the U.S. is critical both for national security and for American technological competitiveness and leadership. I believe that spectrum sharing by the Department of Defense is a promising avenue by which 5G infrastructure could be quickly and securely deployed in the U.S. This white paper describes why 5G infrastructure is so important and also addresses various technical and other considerations about how DOD could implement shared spectrum to realize 5G infrastructure at scale, quickly, securely, and effectively.

In summary, I propose a 60-day period following the RFI review period in order to ascertain how the DOD — working with private capital and companies — can build a secure, shared, high-speed 5G network for demonstration within one year, starting with our military bases. The eventual goal is a network twice as powerful as other extant 5G buildouts.

What is at stake?

For the past decade, the U.S. has led the global telecommunications industry, on the heels of a rapid and large-scale buildout of LTE infrastructure (largely by putting LTE on the same towers where it had deployed 3G). Technology companies and others then built applications and devices that took advantage of that 10x speed increase over 3G. As LTE expanded to the rest of the world, U.S. mobile services and hardware went with it, which is partly why U.S. internet companies are leaders globally.

If our rivals deploy 5G first and the U.S. lags behind, those countries' applications and hardware devices will be the technology used when 5G is deployed later by others. If other countries' apps and services dominate, consumer data will be hosted by those companies, not American ones. If those other countries' governments have access to that consumer data, they will be able to use it to train AI models that extend their technology leadership in other areas. And if the telecommunications ecosystem becomes dominated by foreign applications, services, and devices, then the U.S. Government will either need to avoid their use, depriving itself of new network capabilities it needs, or use them with the perpetual concern that the technology could be exploited by adversaries in times of crisis.

Aren't we already deploying 5G nationally? Why do people say we are behind?

LTE is already very efficient; 5G's new capability is the ability to use up to 500 MHz of spectrum instead of LTE's 100 MHz. But no operators have that much spectrum in use today on traditional cellular networks. Consequently, most 5G in the U.S. is being deployed in existing macrocell spectrum, the same spectrum used to deploy LTE. These 5G deployments may be

marginally (~30%) faster, but they do not produce a 10X improvement in performance, as the technology enables when utilized at its full potential. Most consumers today are not seeing large speed increases in their normal use of 5G.

We have to go to higher frequencies and smaller cell radiuses to get enough spectrum to see a breakthrough in performance. That can only be done in the mid-band spectrum controlled by DOD.

Why should the DOD agree to share this spectrum?

DOD should share and not auction this spectrum, beginning with a fixed period such as 10 years. In return for this sharing, the DOD should get highly subsidized, very high speed mobile connectivity along with a platform for autonomous systems for development. The initial test and deployment sites could be on large dense military bases so the DOD would see very early benefits. Ownership by the DOD would allow for future unanticipated needs from the DOD and absolute control over the security and prioritization of DOD needs. The DOD could share this system with our allies as part of our national defense strategy.

Isn't DOD already planning to share 100 MHz of mid-band spectrum for the FCC to auction?

Yes, but 100 MHz is not enough to build a truly competitive 5G network.

Much more spectrum could be shared for the purposes of building a 5G network in a way that supports DOD's unimpeded use if DOD adopts dynamic spectrum sharing technology. (Note: in this response, dynamic spectrum sharing and related technologies and methods are used in the sense indicated by DOD in its clarifications to this RFI, i.e., "used in a general sense of active sharing of frequencies in time and space. It does not refer to the 3GPP definition of the term.")

Dynamic spectrum sharing could allow as much as 450 MHz of spectrum to be shared (in the 3- and 4-GHz bands), making for a network twice as fast as that of any global rival. Of course, the 5G network spectrum use would have to be tightly coordinated with use by DOD weapons systems. This would be very difficult for the FCC to control and auction according to its normal practices. Moreover, clearing and relocating that much spectrum would take years, and there are sometimes poor substitutes for the spectrum the radars and systems are using.

Additionally, in Asia and Europe, these bands are already commercial bands, meaning the DOD needs to manage its spectrum use in this manner anyway. DOD will need the tools to manage its spectrum use in a much more automated way to deal with operating in these foreign environments.

Can the U.S. Government actually issue a contract like that?

Yes. The Government has the right to allow a contractor-owned, contractor-operated infrastructure to be built under contract. The AT&T FirstNet contract is very similar. AT&T won a contract to build a network that supports public safety, using spectrum that is held by the

Department of Commerce. That network uses federal spectrum to support first responders, but AT&T can also use it to support consumers as well, as long as public safety users are prioritized. The First Responder Network Authority oversees the contract to assure AT&T meets its objectives as defined in the contract.

If the DOD wants to issue an RFP for a national 5G network built using private capital on the Government spectrum, it could consider adopting elements of the FirstNet model, where DOD users are prioritized, and commercial users can use that network for consumer access.

Would this network be used just for very fast mobile broadband?

Ideally, in urban and suburban areas, it would be used to deliver much faster cellular service which could also be used to service people's homes as an alternative cable service. However in rural areas, because of limited propagation, the best use is primarily for fixed communication, to allow rural homes, businesses, schools, and libraries to have broadband access in the several-hundred-megabit range via radios that would be mounted on roofs like satellite dishes are today.

Many wireless service providers provide Internet service using this kind of technology, but using 450 MHz of spectrum could allow large parts of rural America to enjoy speeds that are just as fast as what urban users enjoy today.

What are the technical details of the network, and how does the sharing work?

The network could reasonably be expected to deliver an average of 1 Gbps of outdoor mobility speed, with a minimum of 100 Mbps downlink at cell edge to outdoor users, and cover a minimum of 80% of the U.S. population. The network could further support a minimum of 250 Mbps download service to fixed wireless users (e.g., homes and businesses) in a minimum of 90% of rural areas. Upload speeds could be a minimum of 25% of download speeds. DOD could set a goal of this network operating within three years of contract awards.

The key frequencies between 3-5 GHz are primarily used for radar applications, including Navy and Army radars and Navy and Airforce AWACs. These radars are seldom used and geographically fixed or slow moving. It is easy for modern 5G radios to detect the priority use of this spectrum and instantaneously move to another unused frequency.

Our military operates in foreign ports and areas where these frequencies are already in use by foreign operators so the U.S. has to be able to coexist with the use of these frequencies. Internationally, 3.1-3.7 GHz and 4.4-4.9 GHz are 5G commercial bands.

The CBRS initiative has already created Western 5G systems that perform spectrum sharing with DOD in the same 5G bands (3550-3700 MHz). These can be immediately adapted to provide 5G capability. The FCC, DOD, and industry have developed the joint procedures to manage these systems and protect federal uses. The U.S. technological leadership in deploying CBRS has provided it a unique opportunity to rapidly move into using this underused spectrum resource by leveraging the unique U.S. technology that has been developed over the last six years. Most of

CBRS 5G equipment is really world-wide band 42 (3.4-3.6 GHz). So, an Ericsson or Nokia could be operating almost immediately in the envisioned spectrum with just a minor delay. The CBRS support is available in the radios and in the infrastructure.

Commercial tools to measure spectrum use are available and can be used to map much more precisely what frequencies are used and when and where. Just as we use a Spectrum Access System (SAS) to protect a certain DOD radar in CBRS today, DOD needs to use technology to coordinate spectrum use on a temporospatial basis. Other technologies like ORAN are desirable but not required for this vision to happen. All that is needed is dynamic sharing agreed to on a set of frequencies, and the software to implement the dynamic sharing.

Our global rivals have already made available 600 MHz to their main mobile network operators in this area, and the U.S. needs at least 450 MHz of additional frequency in order to remain globally competitive.

What is the next step?

I propose a 60-day period, following the initial RFI review period, for analysis alongside industry experts to study this approach, with the goal of a one-year demonstration project of an integrated 5G radio system in these frequencies at military facilities. Potentially, the DOD could include National Guard facilities in this demonstration project under its Title 10 and Title 32 authorities.

Assuming the demonstration project network operates well and passes its interference tests, the network would be scaled with commercially available equipment very quickly. The handsets are already available and the commercial towers will easily accommodate these new radios. We would involve our defense industrial base in the build out of the demonstration network and the overall solution to assure capability with commercial 5G solutions.

Eric Schmidt
Founder, Schmidt Futures

A. How could DOD own and operate 5G networks for its domestic operations? What are the potential issues with DOD owning and operating independent networks for its 5G operations?

There are multiple potential models by which the DOD can safely and securely make use of various radiofrequency spectra under its control in order to accelerate spectrum sharing decisions and 5G deployment. It can do so in a way that simultaneously protects national security imperatives, promotes a rapid rollout of 5G data capacity for the benefit of all U.S. citizens, and bolsters our national competitiveness.

One model of 5G development that has strong potential would involve the DOD issuing, via a competitive bidding process, one or a number of leases for use of spectra within its control to consortia of bidders, at low or no cost. In exchange, bidders would be required to:

- Build, at their own cost, the physical infrastructure necessary to deliver a 5G network meeting certain specifications (e.g., an average of 1 Gbps of outdoor mobility speed; a minimum of 100 Mbps downlink at cell edge to outdoor users; and cover a minimum of 80% of the U.S. population; minimum of 250 Mbps download service to fixed wireless users in a minimum of 90% of rural areas) according to a pre-agreed schedule, with strict delivery milestones;
- Operate (on behalf of DOD) and maintain the network, again at their own cost.

Under this model, a successful bidder or bidders could gain economic returns sufficient to attract the capital necessary to finance the required buildout from a range of different sources, including not only traditional corporate finance sources, but potentially also sources that typically fund utility investments, for example. If done well, this contract could also ensure the buildout is achieved in a timely manner. Unlike normal FCC auctions, such a contract could come with a deployment schedule and financial penalties for not building comprehensively, or building only in the most profitable areas.

DOD could make use of the 60-day review period proposed herein to determine if it would be optimal to issue the entire block of spectrum to a single successful bidder, or to carve up the block into multiple segments for award to multiple successful bidders.

This model is advantageous for several reasons:

- No additional budgetary allocations are necessary.
- Because the contract value would be null or negligible — i.e., no DOD funds are being disbursed to successful bidders — contract oversight could likely be streamlined and the scope for award protests that might further delay 5G development could be minimized.
- Contractors are motivated to meet infrastructure delivery deadlines.
- Contractors will own underlying infrastructure, but DOD retains control of the underlying spectra, and can stipulate priority use in advance.
- Data and network services could be provided at preferential or zero price to DOD.
- Both DOD and prospective bidders can focus on their respective core competencies.

Recently, a concerned group of U.S. Senators wrote to the President regarding this RFI, stating, in part:

"We write today to express our concerns about a Request For Information (RFI) released by the Department of Defense (DOD) that contradicts the successful free-market strategy you have embraced for 5G. Rather than rely on private industry and market forces to foster multiple, facilities-based 5G networks, the RFI seeks information on a government-managed process for 5G networks.

"Nationalizing 5G and experimenting with untested models for 5G deployment is not the way the United States will win the 5G race."

The model outlined herein addresses these concerns:

- I, too, believe that private industry and market forces can deliver results that best serve our national interest. This proposal does not shun private industry; quite the opposite. Indeed, the proposal entails private sector participation at every step of the way. A 5G network built to use DOD's spectrum could be designed, financed, built, supplied, operated, and maintained by the private sector. This is a thoroughly free-market strategy, and should the DOD choose to adopt this model, it will induce more private sector involvement in 5G development — to DOD's benefit — than would otherwise exist.
- 5G will not be nationalized under this proposal; quite the opposite. Under this proposal, civilians will gain access to a high-speed 5G network that they would not otherwise have. And of course, this proposal does not in any way preclude or restrict 5G development in other parts of the spectrum.
- The process outlined in this proposal is not excessively government-managed; quite the opposite. We recommend this model specifically with the aim to minimize the approval and regulatory burden so that 5G services can be deployed for secure defense use as well as civilian use as quickly as possible.

Additionally, the chairs of the House Committee on Energy and Commerce and its sub-committee on Communications and Technology have raised questions about DOD's authority to construct, operate, or maintain a communications network or lease its assigned electromagnetic spectrum.[1] Fortunately, these concerns can also be addressed.

The concerns regarding the Anti-Deficiency Act and the Miscellaneous Receipts Act could be assuaged if, for example, spectrum sharing requires no additional budgetary allocation or repurposing of a prior allocation and no payment or receipt of money between DOD and contractors, as is suggested in this proposal. Whether and how the FCC or NTIA would be involved in DOD's sharing of spectrum is more of a political than a legal issue, and a solvable one at that. The urgency and public interest at stake here is significant, and if the President wishes for the FCC to grant a license to undertake this project, it can get done.

[1] See this Oct 9, 2020 letter to the Comptroller General of the U.S. Government Accountability Office.

The DOD's exploration of how to use the tools at its disposal to deliver 5G infrastructure quickly for civilian and government benefit should be promoted, not polemicized. Government is so often criticized for being slow, bureaucratic, and inefficient. To prevent DOD from pursuing an innovative, cost-effective, technology-forward solution to a critical issue of national security and competitiveness because of byzantine regulations would be unfortunate.

B. While the Department has made available the 3450-3550 MHz spectrum band for 5G, are there new technologies or innovative methods as to how additional mid-band spectrum currently allocated to DOD can be made available for 5G faster?

Yes. A model based on sharing — not auctioning — additional DOD-controlled mid-band spectrum offers a faster path to 5G deployment.

Proven technology exists today that would allow DOD to coordinate and prioritize different users on the same band of spectrum in close to real-time. Dynamic allocation of spectrum in this manner is likely possible using modern base station equipment — the 1-year demonstration project proposed herein could rigorously test this in the field.

Dynamic spectrum sharing would therefore help implement 5G faster in two ways. First, because it isn't necessary to wait for the development of new technologies and algorithms; the technology is available now. And second, because dynamic spectrum sharing obviates the need to develop and implement overly prescriptive static sharing rules for each discrete defense system, while still preserving DOD prioritized, dedicated, and secure use and also affording telecommunications operators a baseline of connectivity.

DOD would remain the incumbent, priority user of the band, so other users would be limited by the Spectrum Access System (SAS), which ensures that there is deconfliction. The SAS gives DOD priority in the band but keeps the band open for commercial users when not occupied.

DOD could encourage other government agencies to incentivize industry to adopt a common 5G network for sub-6 deployment through accelerated depreciation, tax incentives, low interest loans, and government purchase of equipment and services. Further, recognizing that not all DOD spectrum can or should be shared, DOD could conduct a thoughtful but candid analysis of the cost and schedule associated with sharing different spectrum bands.

C. What are other innovative ideas as to how 5G can share spectrum with high-powered airborne, ground-based, and ship-based radar operations in the 3100-3550 MHz spectrum band?

In 2015, the FCC formally authorized the 3.5 GHz band for shared wireless access in an area that was previously utilized by the U.S. Navy and DOD. This precedent may serve as a guide for future spectrum sharing between DOD and the commercial sector. By offering up its own bandwidths to share, DOD can also encourage a system of "bi-directional" spectrum sharing in which civil and federal users could access one another's spectrum with varying prioritization.

This would increase the amount of spectrum available to DOD on a secondary level, while maintaining priority access in its own bandwidths.

DOD stands to benefit significantly from 5G development. 5G has the capability to combine DOD's current fragmented networks into a single network to promote improved situational awareness and decision-making. This expanded capability will enable new technologies like hypersonic weapons and hypersonic defenses to be deployed, and has the potential to strengthen existing missions like nuclear C3. At an enterprise level, 5G can vastly improve day-to-day tasks such as logistics and maintenance, elevating the efficiency and speed of work across DOD.

D. Are there other spectrum bands that can be made available to share quickly in the low and high band spectrum ranges?

For a path to fast 5G deployment that can capture 5G's transformative value and enable high-throughput, low-latency applications, DOD should prioritize sharing its mid-band spectrum — focusing on the bands of the sub-6 GHz spectrum that are already being used for commercial deployment. Chinese 5G systems and infrastructure operate in the 3.2-3.6 GHz range, as well as the 4.8-5.0 GHz range. As a result, the commercial world has developed semiconductors and handsets that are configured for that range, and DOD should angle for the most developed market to expedite 5G sub-6 GHz deployment in the U.S. It takes approximately two years to add new frequency bands to complex multiband transceivers, and the U.S. would be able to avoid those two years of development by using subcomponents and devices already on the market for more mature spectrum usage, such as existing Qualcomm products with functionality in the bands used by our global rivals.

Specifically, DOD currently occupies approximately 500 MHz of bandwidth in the 4 GHz spectrum. DOD should take action to share parts of this spectrum, which is a material amount of bandwidth that could make a substantial impact on 5G development. 5G functions most optimally on large amounts of consecutive bandwidth, and this range could provide the spectral "real estate" to drive 5G development forward.

For additional spectrum availability, DOD could recommend that the NTIA, FCC, and Department of State reallocate of the C-band satellite spectrum to IMT-2000 5G use, and take measures to adopt sharing in all 500 MHz of the band in the U.S. on an accelerated basis for fixed operations. While this will have limited impact on the U.S. 5G mobile ecosystem, sharing in this band could provide broad coverage at 100 Mbps and above for fixed broadband service to a large section of the rural U.S.

E. What types of technologies exist, or are anticipated, that will allow civilian users to share spectrum faster?

A range of spectrum sharing solutions and technologies are already under development that DOD can use in this model to share its spectrum via a SAS. Verizon and AT&T have begun to roll out DSS (in the 3GPP sense) between 4G or LTE networks and new 5G deployments. According to public reporting, the winners of DARPA's Spectrum Collaboration Challenge

(SC2) harness reinforcement learning to optimize available spectrum for AI-based radios. Of particular interest is DOD's new 5G experimentation project at Hill Air Force Base, Utah, insofar as it seeks to develop prototypes for Spectrum Coexistence or Sharing (SCS) between airborne radar systems and 5G deployments in the 3.1-3.45 GHz band. If successful, these prototypes, working with Ericsson, Nokia, General Dynamics, BAH, Key Bridge Wireless, and Shared Spectrum Company can provide a basis for fast sharing of key DOD mid-band spectrum through dynamic spectrum access.

F. Do you foresee any national security concerns/issues with DOD sharing with commercial 5G?

A poor implementation of DSS could increase interference with DOD systems or allow adversaries to manipulate the SAS controller to create DDOS attacks on the commercial network or raise the noise floor for our radar systems. A well-implemented version of DSS can greatly reduce these risks. It should be noted that for much of the rest of the world, the DOD will need to find a solution to address 5G interference with these bands regardless of domestic activity. Setting a standard for the U.S. and its allies' systems that reduce this class of risk up front simplifies the problem. We recommend that the SAS controllers should only be run on government systems and that civilian systems are informed which frequencies, time blocks, and locations are allowable for use. It is equally important that the USG have much more accurate 3D geospatial maps for better spectrum modelling.

G. Is industry aware of any statutory, legal, regulatory or policy hurdles that need to be altered or reconsidered to allow DSS? If so, what are those?

We are not aware of any such hurdles relevant to DOD's consideration of spectrum sharing applications for spectrum it controls.

However, coordinating spectrum management across government agencies has produced bureaucratic hurdles — for example, with regard to the FCC spectrum award to Virginia-based Ligado, which DOD has challenged on the basis of a risk of interference with GPS satellite operation. As DOD contemplates sharing sensitive and critical frequency bands of its spectrum using a near real-time, dynamic access model, the degree to which additional U.S. Government entities are involved in such sharing increases the degree of complexity and also the potential for such hurdles to slow the propagation of 5G networks for government and/or civil use.

The aforementioned CBRS SAS model provides a sound framework for spectrum sharing, however the process by which this spectrum was opened to the commercial sector for sharing took more than five years, a timeframe that is incompatible with fast 5G adoption for U.S. national competitiveness.

The Spectrum IT Modernization Act of 2020 (S. 3719/HR.7310), for example, anticipates some of the policy and bureaucratic hurdles in managing spectrum across the interagency. The Act calls for the standardization of federal spectrum management and use in modernized infrastructure across data models, electromagnetic spectrum analysis tools, databases, and

simulation technologies — improvements, to be sure, but ones which cannot be the preconditions for mid-band DOD spectrum sharing.

H. What are other current and perceived barriers that industry is aware of to DSS?

T-Mobile has claimed that spectrum sharing (in the 3GPP sense, between 4G and 5G networks) reduces the capacity of the network due to the need for more network resources being allocated to the control plane. AT&T and Verizon do not report this capacity issue as a problem, likely due to their greater available bandwidth. According to public reports, T-Mobile is using DSS solely with its 600 MHz holding, while Verizon is likely to deploy DSS in its 850 MHz, PCS, and AWS bands. AT&T has rolled out DSS in some of its low-band deployments, but has yet to specify in which bands. Additionally, T-Mobile cited lags in vendor roll-out DSS earlier this year, but since then both Ericsson and Nokia have advanced DSS solutions, and additional research and development efforts are underway.

Using dynamic and near real-time spectrum sharing under prototype by DOD across multiple bands can address capacity issues, so the more spectrum DOD is able to make available for a sharing or coexistence model, the easier any capacity issues may be to overcome.

I. How would DSS work with existing commercial spectrum bands?

DSS is already part of the current 3GPP definitions and planned enhancements. U.S. carriers are still planning to begin to roll out DSS by the end of this year. Dynamic spectrum sharing in the military bands could be adapted to make sure there is non-interference. If the DOD standardizes on a single technical solution for dynamic spectrum sharing, the complexity of the implementation would be greatly reduced, made more secure, and would have better performance and improved co-existence with military systems.

J. Could multiple DSS technical solutions coexist and under what conditions?

Yes. In some ways, they already do with CBRS with multiple SAS providers. The disadvantages of having multiple dynamic and near real-time DSS technical solutions are increased complexity and potentially decreased reliability of the overall network. The advantages are increased competition (thus more choice), more capacity for innovation, and perhaps greater resiliency. There are multiple ways dynamic and near real-time DSS technical solutions could co-exist: for example, by separation in space (geography) or by segmentation of the available frequency.

The aforementioned CBRS approach uses a more static allocation system. DOD should adopt a more “fine-grain” approach by utilizing a near real-time dynamic spectrum allocation approach. A near real-time dynamic spectrum system would dynamically allocate and move usage based on priority, congestion, availability, and current environmental conditions. Given the DOD’s potentially sensitive needs, unlike with CRBS, the DOD would need to control the SAS. The DOD SAS algorithms could be classified and could be tied into radar, weapons, and communication systems. This approach would allow DOD to optimize its military transmitters and receivers while coordinating with civil 5G use. Since the bulk of work is done in the SAS,

the commercial systems only need to know the frequency and power for the system to function effectively and securely.

K. How can spectrum modernization, including spectrum Information Technology (IT) modernization and automation, help facilitate faster spectrum sharing?

Innovative technological capabilities including cloud-based databases, artificial intelligence technologies, automation, and improved modeling and simulation capabilities can help facilitate faster spectrum sharing in the dynamic fashion indicated.

Standardization of spectrum management would smooth and speed up implementation. Such standardization could include electromagnetic spectrum analysis tools, modeling and simulation processes and technologies, and databases for a common spectrum management infrastructure.

L. Are there standards, including data standards, which could accelerate spectrum repurposing decisions? If so, what are they?

Any sharing model of complexity requires interoperability through the development of standards. In building out this proposal, DOD must balance two competing objectives: on the one hand, standardizing a dynamic, near real-time spectrum coexistence and sharing technology and data handling practices can incentivize commercial development of frontier and pipeline technologies for DOD to use. On the other hand, while standards development pays dividends in the long run, it can take time on the front end — particularly in the case of coordinating data standards across the interagency. Given that rival nations have a first-mover advantage on 5G, when contemplating standards initiatives, DOD's bias should be towards simplicity and rapid deployment. The perfect should not be the enemy of the good.

Ultimately, sharing spectrum via the model discussed in this proposal versus relying on a cost- and time-intensive auction, clearing, and reallocation process can yield the greatest gains to accelerating the use of mid-band spectrum for commercial 5G.

M. Previously, when federal spectrum has been reallocated, federal operations have been required to share or relocate to other bands and commercial licensees have received exclusive licenses via auction. The following questions relate to the above statement:

1. **Should DOD consider spectrum leasing as an alternative to reallocation? If so, how could it be implemented?**

Yes. Please see the answer to question A above. Traditional spectrum auctions are not the most efficient use of the spectrum, and new spectrum sharing technology makes a dynamic and automated sharing model more attractive. A competitive bidding process for spectrum sharing with DOD assets would allow DOD to share more defense-sensitive bands of the spectrum with industry while ensuring protections for critical military applications in radar and C2.

Leasing spectrum and using spectrum sharing technology is a faster route to 5G deployment. To relocate DOD from its bands of spectrum in order to repurpose that spectrum for a traditional auction would take years to execute. By that time, the U.S. will have capitulated in the 5G race that necessitated the repurposing in the first place, and DOD risks compromising the use of its bands. Moreover, DOD can't simply relinquish its spectrum; it would then need to find new viable bands of spectrum (which are scarce), test its various systems on those bands, and then upgrade those systems to ensure reliable operation. Clearing and relocating the 450 MHz of spectrum needed to realize 5G's benefits would take a decade and cost many billions of taxpayer dollars, and there are sometimes poor substitutes for the spectrum the radars and systems are using. So aside from the high fiscal cost, the switching cost presents risks to national security preparedness and could damage the Pentagon's global operations. In short, in the timeframe it would take to clear and repurpose this spectrum, the U.S. would fall further behind its technological rivals in 5G deployment.

Instead, DOD should share its sub-6 spectrum bands with the commercial sector. Sharing spectrum could take just 2-3 years instead of the 5-10 years that vacating requires, would cost millions of dollars instead of billions, and would not put national security operations at risk. Sharing spectrum provides the strongest path forward for the U.S. in the race to 5G.

Building on lessons learned with Citizens Broadband Radio Service shared spectrum, which now provides 150 MHz of mid-band shared military radar spectrum to commercial users, DOD can be even more effective in sharing additional mid-band spectrum blocks.

Since the Pentagon already shares spectrum abroad, it has many incentives to pursue spectrum sharing within the U.S.

2. **What, if any, legal, policy, statutory and regulatory changes would be required to implement the proposed leasing approach?**

None that we are aware of. The National Telecommunications and Information Administration (NTIA) grants licenses to the DOD for DOD use, and any licenses or leases issued by DOD for purposes of spectrum sharing would need to allow for this private/public partnership.

3. **How could revenue be shared with DOD under a DSS leasing agreement or any type of leasing agreement?**

In theory, DOD could generate revenue from license fees, lease payments, or via a share of revenue or profit streams generated by lessees (e.g., for the provision of data and network services on to end users). To receive such revenue streams could require significant changes in DOD contracting practice or organizational structure, including extensive legal and regulatory review. While DOD should explore all viable options to deliver rapid, competitive, secure 5G infrastructure, options that would require significant modifications to practice or policy could necessitate significant additional delays in implementation. This would undermine the formidable strategic objectives underpinning the need for rapid adoption of 5G infrastructure in the first place.

For the purposes of the financial model described in Question A above, we assume no revenue will be collected by DOD. Instead, we have attempted to outline a structure wherein any potential revenue streams are redirected into the development of the infrastructure, in order to ensure a rapid buildout. We expect that the savings DOD realizes from preferential pricing alone will be substantial, to say nothing of the incalculable value of maintaining military readiness and capability and U.S. technological leadership through the coming generation of telecommunications development.

A note on the use of DSS: Throughout this proposal, we envision a dynamic and near real-time spectrum coexistence and sharing of DOD's mid-band spectrum between incumbent military users and commercial 5G deployment. By contrast, dynamic spectrum sharing (DSS) as defined in the Third Generation Partnership Project (3GPP) standard refers instead to the sharing of spectrum between 4G and 5G.