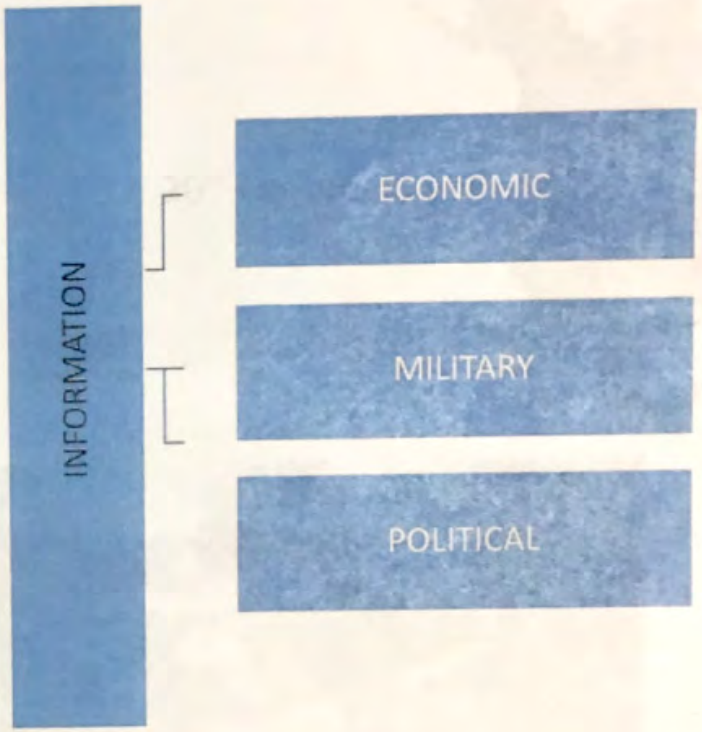
Secure 5G

The Eisenhower National Highway System for the Information Age

The Information Domain is a Key Area of Competition

- Goal: A network that reflects our principles
  - Rule of Law
  - Freedom of Speech
  - Freedom of Religion
  - Fair and Reciprocal Markets



Networks are the Dominant Competition Space

- China is the Dominant Competitor
  - China has achieved a dominant position in the manufacture and operation of network infrastructure
  - China is the dominant malicious actor in the Information Domain
- **We are losing, but…**

20th Century

21st Century

We Can Make a Fundamental Change

1. We are now moving from 4G to 5G
2. <u>MUST</u> take the opportunity to build it securely and go…

From This ➡

To This ➡

- Otherwise, China will win
  - Politically
  - Economically
  - Militarily

How Do We Flip the Script?

- LEAD
  - Inspired Leadership has driven our most significant national accomplishments
    - Without Eisenhower there would be no Interstate
    - Without Kennedy there would be no space program
  - Inspired leadership can build it
    - Assets: Frequency Spectrum, Technology and Talent
- CATALYSE
  - Government and rural broadband provide the business case
  - Tax reform is an accelerator

- Businesses and citizens will choose to join the secure 5G Internet – **If you build it they will come**

Benefits to the American People

- Security
  - Information Domain Counter to Belt and Road
  - Joint and coalition forces seamless Command and Control
- Prosperity
  - Creates Millions of Jobs and Trillions in Economic Growth
  - Rural broadband gets done first!
- Arena of Allied Cooperation
  - Build secure 5G at home and abroad
  - Japan all in
- Information Age
  - This is a requirement for American success

4G vs. 5G

Primer

Today's information space is complex. Data traverses cyberspace through a patchwork transport layer constructed through an evolutionary process as technology matured. This data transport layer resides and is enabled by an infrastructure overlaid by an even more complex cyber threat landscape. Comprised of nefarious actors with varying levels of sophistication and an array of malicious intent, the current cyber threat landscape challenges the ability to secure and ensure a reliable information space. Measures to secure and protect data and information result in an 'overhead' that affects network performance – they reduce throughput, increase latency, and result in an inherently inefficient and unreliable construct. Additionally, the framework under which access and services are allocated is sub-optimal, yielding incomplete and redundant competing networks. Without a concerted effort to reframe and reimagine the information space, America will continue on the same trajectory – chasing cyber adversaries in an information environment where security is a scarcity.

The advent of 'secure' network technology and the move to 5G presents an opportunity to create a completely new framework to safely, securely, and reliably transport and share information. While '4G' was an evolution of '3G,' simply promising faster speeds, '5G' is by no means simply a 'faster 4G' – despite the chronological moniker. This next generation technology, combined with a concerted effort by public and private entities, can position the United States to leap ahead of global competitors and provide the American people with a secure and reliable infrastructure to build the 21st century equivalent of the Eisenhower National Highway System – a single, inherently protected, information transportation superhighway. To do so, it will take strong and focused leadership from USG along with the collaboration of public and private entities to seize this opportunity afforded by the emerging technologies to commit to building a secure 5G network within three years.

Such collaboration promises benefits for American commerce – spurring economic growth and strength; national security – enabling innovation for more resilient and effective operations; and most importantly, the individual – providing American constituents the ability to know, see, and understand how their digital information acts and is acted upon once it is released and transmitted. America is on the edge of a precipice – we can jump into the information age of the future today or continue falling in the spiral of cyber-attacks.

Secure 5G – Flipping the Script

FACT: China is currently poised to lead the global deployment of 5G.

DISCUSSION: Huawei has used market distorting pricing and preferential financing to dominate the global market for telecommunications infrastructure. China sets aside up to 70 percent of its mobile infrastructure market for Huawei and ZTE, only allowing Western vendors to compete for the remainder. The magnitude of the Chinese market reserved to Huawei and ZTE allows the companies to effectively fund their R&D with domestic sales while insulating the companies against global infrastructure spending down turns. The government has also extended an estimated $100 billion line of credit to Huawei to finance deals abroad. Combined with aggressive pricing, diplomatic support, and suspected payments to local officials, Huawei has quickly taken market share in the radio infrastructure market as well as optical and routing, leaving them poised to take market leadership of 5G.

Huawei has gone from a market share in radio infrastructure of roughly 11 percent in 2011 to a share equal to or greater than Ericsson and Nokia, the two largest Western mobile infrastructure suppliers. Similarly, in routing, Huawei more than doubled its market share in an 18-month period, and in several areas or routing it has caught or surpassed market leader Cisco. Europe led 3G deployment, the U.S. led 4G, and with these market altering practices, the Chinese may be poised to lead in 5G Huawei.

Notably, the FBI continues to monitor market activity and update its compendium of activities and risks associated with Huawei and ZTE. Apart from the suggestions for a U.S. market strategy provided herein, permanently tasking the FBI to work with other intelligence agencies to monitor and regularly report to Congress and the Administration on the market activities and risks of Chinese infrastructure vendors would be valuable for national security.

FACT: U.S. telecommunications manufacturers have all but disappeared.

DISCUSSION: Today, only a handful of companies are postured to play a role in global 5G deployment; Qualcomm, Cisco, Juniper, Nokia, Samsung, Ericsson, Huawei and ZTE. Qualcomm makes chipsets for mobile devices while Cisco, Nokia, and Juniper provide core and routing technologies, but not radio infrastructure. Nokia, Samsung, and Ericsson offer radio infrastructure as well as other technologies and services essential to mobile broadband. Notably, on the current trajectory, 5G in the U.S. will debut on equipment from just this small group of companies, which would include Chinese suppliers unless informal restrictions against their inclusion in national networks are maintained for 5G networks. Even at that, radio manufacturers other than Huawei and ZTE will face declining market share if conditions do not change.

ASSUMPTION: Whoever leads in technology and market share for 5G deployment will have a tremendous advantage towards ushering in the Massive Internet of Things, machine learning, artificial intelligence, and thus the commanding heights of the information domain.

DISCUSSION: 5G is a fundamental shift in wireless infrastructure. More like the invention of the Gutenberg press than the move from 3G to 4G, it will move the world into the information age. Everything from automated cars and aircraft to advanced logistics and manufacturing to true AI enhanced networked combat. Most communication on the network will move from mobile devices to machine to machine (M2M) traffic. This will help accelerate machine learning and AI development.

The Challenge: Can we flip the script? Can the U.S. conduct a moonshot with secure 5G deployment, and steal the lead position for dominating the information domain?

Answer: Yes, but it will take focused and determined leadership and a commitment to building a secure , high-performance (capacity and coverage) 5G network faster than anyone is currently predicting – 3 years.

DISCUSSION: There are numerous major decisions that affect the answer to this question:

1. What type of network should we build – single-block, or multi-block?
2. What spectrum can we make available?
3. Can we standardize siting requirements?

Other ancillary questions effect the efficacy of the project:

1. Can we rebuild a telecommunications manufacturing base in the U.S.?
2. Can we elicit allies and partners to build with U.S.?
3. Can we elicit allies and partners to jointly grow these networks in the developing world?

Type of Network: Options – 1) Single-block; 2) Multi-block

Single Block: If the U.S. were to build and run one physical network using the Mid Band spectrum it could lease time back to carriers to sell as a service. This would allow the allocation of a large amount of bandwidth for the network by creating one block of spectrum in the Mid Band range.

Pros:

1. Speed – This would enable virtual network slices at the full capacity enabled by combining the bandwidth that would normally be allocated to each. For example, in the 3.7 to 4.2 GHz frequency range there is 500 MHz of spectrum available. That bandwidth could be divided into smaller segments and then apportioned to the carriers to build competing networks. However, if all or most of this spectrum is used as a single block, then the peak and average speeds achieved on such a network would be vastly different. For example, under a single block scenario speed to devices would be in the several Gbps range, while in the multi block scenario it would be in the several hundred Mbps range.
2. Security – In the single block scenario, the network could be built with security as a foundational element enabling the securing of both government and civilian data. The network could also be built for resiliency from physical attack or natural disasters.
3. Speed of Deployment – Building a single block network could take the shape of a 21st Century Eisenhower National Highway System. This would enable deployment on a national scale by using authorities unleashed by the cyber emergency we face on a daily basis. Siting restrictions could be standardized for the nation. Spectrum could be made more easily available by moving some current commercial and federal customers and dynamically sharing dual-use spectrum. Finally, instead of several networks being built, we would only need to build one, which will lead to more efficient deployment of resources.

Cons:

1. New Paradigm – The current market situation involves many carriers who compete at building networks. The single block model would require a single network that is virtually shared by retail providers.

Mitigation:

1. Since the single block network would only cover the Mid Band, other carriers could build High Band networks to the same exacting security requirements if they so choose. This would allow for increased capacity in urban areas and thus product differentiation. All carriers in this scenario could off the Mod Band network for coverage alongside their own separately deployed High Band networks. Note: carriers are already looking at options to free up the 3.7 to 4.2 block for their own use.

Multi Block: Carriers could build and own the network based on 100 MHz spectrum blocks.

Pros:

1. Less Commercial Disruption – Carriers already anticipate rolling out 5G, but at a far slower pace. Getting them to build and own the network will be an easier sell.

Cons:

1. Less Bandwidth – Since there will be numerous networks, the 500 MHz in the Mid Band would have to be divided slowing network speeds.
2. The end-result wouldn't necessarily help the U.S leapfrog the rest of the world in 5G performance.
3. Timing – In order to provide individual blocks that are large enough to be useful for carriers, incumbent satellite users and all of the earth station users (including broadcasters and cable companies) would need to be cleared. Given the ordinary length of regulatory proceedings necessary to accomplish this and the likely legal challenges from the satellite companies and Earth station users, the spectrum is unlikely to be available in the next five years. Clearing and/or repacking to make spectrum available would be uneven and could potentially leave areas of the country, including rural areas where the satellite services are widely used, without spectrum available to underpin a 5G network for as much as 7-10 years. This a potentially fatal challenge of the multi-block, multi-carrier network approach in the 3.7-4.2 GHz band

What Spectrum Can We Make Available?: Currently most equipment manufacturer work is being done in the High Band. In the U.S. this is at 28 GHz. Verizon is the only carrier who owns a nationwide block of spectrum at 28 GHz. AT&T is looking to the FCC to offer more spectrum in this range for their nationwide 5G network. Spectrum sales can take as long as 7 years based on historical timelines. Due to the inability to pass through human bodies, high band will have to be augmented with far more cell sites. This requires more fiber, more approvals and more installations for a given city. The net result is that high band will by its very nature lengthen deployment times. There are some who believe that for

this reason alone 5G will not be built in the U.S., or at the very least it will be one of the last nations to fully deploy. Nevertheless, tested speeds in this frequency band has shown multiple Gbps to the device.

The FCC is currently looking at the Mid Band for possible 5G use. The Mid Band range they are looking at is 3.7-4.2 GHz. None of the previously mentioned equipment manufacturers are currently building for this band, but could have a solution in 6-8 months' time based on commitments to make spectrum available for large-scale deployments. There are some U.S. equipment companies who are working in this area, so the U.S. could still claim a lead in the technology. Mid Band would allow for a much less dense network since it is closer in geographical layout to currently deployed networks. All of the current 4G towers could be used for rollout along with an additional 20 percent more towers, reducing the deployment timelines. A 100 MHz block of spectrum gives you around 400 Mbps, and a 500 MHz block gives you multiple Gbps at the device. The only carrier that currently owns spectrum in the Mid Band is Sprint with a 100 MHz block of spectrum at 2.5 GHz.

Low Band provides good coverage, but will not give true 5G speed or low latency. Currently only 600 MHz is designated for 5G, and the only nationwide spectrum block is owned by T-Mobile. 5G deployment will most likely encompass low, mid and high band spectrum for both coverage and capacity. Because of the long distance and penetration capability in Low Band, this spectrum will be used to extend coverage areas to more remote locations.

To recap, only three carriers currently have nationwide spectrum for 5G deployment:

1. Verizon – High Band (28 GHz at 800 MHz spectrum block)
2. Sprint – Mid Band (2.5 GHz at 100 MHz spectrum block)
3. T-Mobile – Low Band (600 MHz at ~20 MHz spectrum block)

As it stands today we could see that Verizon will be the only one with true 5G capability in terms of speed (capacity). Sprint and T-Mobile will provide coverage. Typically, the carriers have fought for both coverage and capacity, and this will likely be the case. This means either more spectrum will have to be made available at Mid and High Bands, or expect Verizon to dominate the 5G market in the U.S. with selective coverage.

Options – 1) Mid Band; 2) High Band

Mid Band: If the FCC were to make 3.7-4.2 GHz available for 5G use and we were to build the network with the full 500 MHz block of spectrum (or the vast majority of it), then we could deploy a true 5G network on existing 4G infrastructure with only about 20 percent more sites required for coverage. If we parceled out the spectrum in 100 MHz blocks this would allow carriers to do the same for coverage, but it would not deliver the full potential of peak speeds as single block of spectrum. It might be possible to set aside 100 MHz of spectrum to cater to incumbents and leverage the remaining 400 MHz as a single block. Either way, physics dictates that mid band is the only spectrum range that allows you to build a network in 3 years, offering high performance in terms of both coverage and capacity.

Pros:

1. Fast Deployment – Opening the mid band range allows network coverage to be built fast since less sites are required for nationwide coverage.

2. 5G Speeds – If the full block of spectrum is used to build one network, the resulting network would generate world-leading 5G speeds.

Cons

1. Current Spectrum Owners – There are currently commercial and federal users of this spectrum who will have to be moved elsewhere. The good news is that most are satellite operators or radars. The satellite operators can easily move to fiber, and dual-use spectrum sharing could work in those situations that won't allow for the customer to move. Nevertheless as is the case with all spectrum reallocation, expect current spectrum owners to argue for the status quo. [Nokia Comment: This is subject to significant disagreement, with satellite operators and some of their broadcast customers arguing that the weakness of the downlink signal will make detection and interference avoidance using current sharing technologies impossible. We believe that there is a path to releasing the full 500Mhz over a phased approach and with a strong sales effort to the incumbents. 4K video becoming prevalent will make some of this easier to navigate.]

High Band: Since we already have one carrier with sufficient spectrum available for deployment in High Band, there is no rush for further spectrum. AT&T wants to buy spectrum to deploy a nationwide network, so the FCC is working through that allocation.

Pros:

1. Competition – Making more High Band available allows for more carriers that can provide true 5G speeds, but does not get the nationwide network built any faster.
2. 5G Speeds – An 800 MHz block of spectrum is available and would generate true 5G speeds in selected areas.

Cons:

1. Due to the onerous process of locating sites, power and transport under current guidelines, the buildout in the high-band could span several years thereby handing over 5G leadership to other countries.

Can We Standardize Siting Requirements?: Options – 1) USG Secured; 2) Industry Secured

USG Owned: If USG secures the network, then much like the Eisenhower Highway System national security becomes an important driver for deployment. Much like concertina wire on a beach facing assault, or a city wall meant to keep out bandits, the case can be made that a nationwide secure network is required to create a defensive perimeter in the information domain. Since we are afforded the benefit of two large oceans for our physical defense, why not build the equivalent situation in the information domain.

Current efforts to build 5G networks in the United States have struggled with local siting requirements. For example, Ericsson is struggling with deployment of a 5G network in Seattle, because each municipality has unique processes for getting approval to deploy. These can include different format for drawings, different pole mounts, and/or different aesthetics for the equipment. Additionally, some municipalities want to charge a fee, thus increasing both expense and deployment time. The bottom line

is that a 3 year deployment time is not achievable without a nationwide standard for siting. Texas has already determined that statewide standards this will be required to get timely deployment in their state.

Pros:

1. Fast Deployment – The ability to use national security to force nationwide standardization of siting requirements.

Cons:

2. None.

Industry Secured: If carriers secure the network, it may still be possible to invoke national security for standardization. Otherwise, it may be possible for industry to convince states to agree to a standardized process. At a minimum, carriers and equipment manufacturers could agree to a set of siting standards. NIST may provide an option whereby USG could set the standards for siting, and carriers would build to that standard.

Pros:

None.

Cons:

1. We must rely on national standards and state and local governments to work with industry to develop standardized siting requirements.

Can we rebuild a telecommunications manufacturing base in the U.S.?

Equipment manufacturers have expressed a willingness to move manufacturing facilities to the United States in support of a 5G effort. This could be accomplished in time to allow for a three year deployment timeline.

Can we elicit allies and partners to build with U.S.?

There are several countries out there that have expressed an interest in partnering with the United States on our 5G network. It is unknown at this time whether they will choose to accelerate their deployment, but at the very least we can expect an interest in deploying a secure 5G network with equipment from a trusted supply chain. Importantly, this will allow for a counter to China's economic model of using market dislocating principles to bind nations into their orbit in the information domain. More broadly it can be the foundation to a democratic counter to the Belt and Road Initiative. We can expect the long term effect to be a lessening of Huawei's global market dominance.

Can we elicit allies and partners to jointly grow these networks in the developing world?

This is currently unknown. If it were possible to assemble such a coalition, then we could grow our secure 5G networks in emerging markets. Joint developmental finance efforts could be merged to provide a one-stop shop for emerging market telecommunications projects. Another alternative would be to have certain allies and partners focus on certain regions for development. Eventually, this effort could help inoculate developing countries against Chinese neo-colonial behavior.

Actions we must take regardless of the path forward:

1. Develop standards for 5G deployment.
    1. Network Security Standards
        - These will be used to build a network that is inherently secure. While this will not eliminate all cyber security challenges, it will fundamentally alter the cyber threat landscape. In other words, it returns the advantage to the defense.
    2. Infrastructure Standards
        - These will be used to build the physical network infrastructure. First Net has already accomplished most of the work on their standards, and these could be repurposed and modified for a nationwide 5G network.
    3. Wireless Standards
        - The equipment manufacturers who agree to build the network have to agree on the wireless standards they will build to for interoperability. The good news is that the industry group 3GPP has agreed on version 15 standards, which will be a good starting point for reaching consensus.

Additional Considerations (see Appendix 2):

Financing

Even before the passing of tax reform legislation, industry experts were optimistic about the ability to fund secure 5G rollout. The fast rollout timeline provides an opportunity to offset the potential drop in exports due to a strengthening dollar effect by boosting domestic investment spending. Since it relies on private capital, it also does not add to the nation's debt. While the business models for secure 5G are still in development, it is likely that we will have to wait until the network is built to see the network's true value. The network will be transformative for society similar to the iPhone. Similarly, many of the applications will come later. Nevertheless we know some industries transformations, like transportation and self-driving vehicles, require this network to be built before they can be fully achieved.

Fiber Deployment

Estimates show that as much as 200 billion USD will be required for fiber deployment for 5G. That said, these reports are based on High Band deployment. Mid Band will require significantly less. Nevertheless, 5G deployment should be used as a catalyst for unlocking fiber deployment across the nation. An enforced requirement to lay fiber alongside any other construction would help this effort. USG could lead development of a mapping tool which consolidates all available data on dark fiber and conduit locations, which would allow for more efficient planning for fiber laydown.

Labor

Building the network will require new sources of skilled labor. This is an effort that government will need to get in front of in order to develop new sources of training. Department of Education can take the lead in developing training programs that ensure an adequate supply of skilled labor. Like the space race, the

transition to the information era will require increased investment in both STEM education as well as increased funding for research and development.

Air and Space 5G

For a truly resilient 5G network, serious consideration should be given to creating air and space layers. Certain equipment manufacturers have explored an air layer using airline traffic to create a mesh network for air to air and air to ground 5G capability. Commercial space providers are working on constellations of satellites which would provide the capability for alternative backhaul options. Eventually, these constellations could provide service to mobile devices for remote locations or crisis/disaster situations. With air and space layers, coverage could extend internationally providing service for both government and private sector connectivity.

Rural Broadband

By initially focusing on rural broadband, the network would guarantee a revenue stream while further business models develop. There is at least one offer to build a rural broadband capability under a carrier built and owned network model. This capability would provide 100 Mbps speeds to approximately 80 percent of rural customers, or somewhere around 24 million homes. If the network were single block, the speeds would be greater. This capability could easily be built within the first term.

Why build a [secure] 5G network in three years?

On September 15, 2017 the Secretary of Defense named information a joint function. The memorandum states:

"The advent of the Internet, the expansion of information technology, the widespread availability of wireless communications, and the far-reaching impact of social media dramatically impacted operations and changed the character of modern warfare."

In the 21st Century freedom is won and lost in the information domain. Our citizens and companies live in relative peace and security in all other domains, because of our powerful military. Yet, every day they face a warzone in the information domain. State and non-state actors steal intellectual property and private data, sow division and obscure bad behavior, slander and defame the innocent, prey on the weak and plant the seeds for total darkness in the event of all-out war. There is no more pressing need for a change in strategy than in the information domain.

Yet, for the most part the 700 billion USD defense budget does very little for the American people in the information domain. We promise the world's greatest air, land, sea and space force, but say look to thyself for the information domain. We even highlight cyber warriors in advertisements for military recruitment. Left unsaid is the fact those cyber warriors for the most part are looking after DoD networks. To be honest, even DoD is unprepared for the information age. The vaunted F-35 is incapable of being used to its full potential, because the data rates on our current networks preclude the full use of its data collection. Soon it will be joined by other advanced aircraft that are similarly data monsters.

The President unveiled his National Security Strategy on December 18, 2017. In it he portrayed the world as it is, not as we wish it to be. Embedded within the strategy was a short but powerful phrase: "We will improve America's digital infrastructure by deploying a secure 5G Internet capability

nationwide." This was not an afterthought, nor was it an additional item to answer some constituency. It was meant to be foundational.

Rebuilding the Internet

The coming 5G revolution represents the first great leap into the information age. It is a change more like the invention of the Gutenberg Press than the move from 3G to 4G. More network traffic will be dedicated to machine to machine communication than ever before. 5G will transform industries by ushering in exponentially expanded system capacity, higher data rates, lower latency, higher reliability, and lower power consumption. The impact will be pervasive throughout the economy where almost no sector or industry will go unchanged. Manufacturing, farming, transportation, medicine and financial industries to name a few will transform, creating millions of new jobs and billions if not trillions in economic growth.

The transformative nature of 5G is its ability to enable the Massive Internet of Things. Technology and spectrum capacity enable connectivity far beyond current capabilities. Beam forming, multiple-input and multiple-output (MIMO) and software defined networking will allow for faster Internet speeds and longer battery life to support the device ecosystem. Unfortunately, if built using the current Internet's unsecure architecture model, this network will also exponentially expand the threats. On the current trajectory, the 5G world will offer opportunities to use the useful sensors and tools on the network as weapons.

Information Security

We have the technological capability to secure a 5G network. This technology was invented in America, and will be built here as well. Added assurance can be gained by ensuring we recreate an IT and telecommunications manufacturing base. By securing the supply chain we can be assured that our network is built with safe components. By ensuring the network is built with security as a foundational principle, Americans can concentrate on living their lives without fear of walking dangerous digital streets. America did not design two big oceans and two friendly borders to ensure its physical security, but our citizens benefit nonetheless. The information domain must be designed with the same natural characteristics.

That is why the network must be built from the ground up with security and resiliency in mind. Not only must the network continue to function in the event of physical attack, it must repel attacks to personal and commercial data on a daily basis. Once built, this capability must be shared with democratic allies to ensure they remain viable and strong economic and security partners to support the free world.

Deterrence of State Adversaries

States are not deterred from attacking our democracy by indicting their citizens or sanctioning their companies. This type of enforcement allows them to absorb the cost of bad behavior while the threats overwhelm our system. Rather, cyber-attacks must be met at a minimum on a one-to-one basis. An attack on our citizens and companies should be met with a fierce response that forces the state actor in question to rethink the value of illicit activity in the Information domain. The network itself must be built with active defense in mind. As we learned in the wars in Iraq and Afghanistan the first step in asserting control over chaos is to take away anonymity. A network that identifies the adversary and responds to attack is fundamental requirement of the information age.

The Joint Force

Using current acquisition processes, DoD is sure to be left behind in the information domain. Building a secure resilient layered and global 5G network will transform how the Joint Force operates and allow for the full use of data intensive weapons systems like Aegis, P-8, F-35 and B-21. Currently, stovepiped communication programs not only create easily identifiable targets, but they often over promise and under deliver in capability, cost and speed of deployment. Each service or component seeks a different path, and ineffectual workarounds are the norm for integration. In the Air Force alone, efforts to get the F-22 and F-35 to communicate require purpose built gateways. An advanced resilient and secure network that is shared with the public will allow Federal communications to blend in with other traffic increasing security, improving joint synergy and reducing program costs. Continuing to ride on our own networks is like building two Eisenhower National Highway systems, one for civilian traffic and one for military traffic. We couldn't afford that in the 1950s physical domain, and we can't afford in the 21st Century information domain.

The AI Arms Race

Using efforts like China Manufacturing 2025 (CM 2025) and the 13th Five Year Plan, China has assembled the basic components required for winning the AI arms race. CM2025 will provide indigenous innovation and market dominance for 10 critical American industries including Artificial Intelligence, robotics, fintech and commercial aviation, to name a few. Data is the oil of the 21st century and China has built the world's first strategic reserve. Complete elimination of privacy standards combined with a strong firewall has enabled China to transform its "great firewall" into a "great ocean" of data. The current algorithm battles are slowly drifting in China's favor as companies like Google build AI research centers inside China's information sphere and world class data scientists mine the data (ours and theirs) without restraint. China has already catapulted into the lead for facial recognition to support its authoritarian regime. Much like America's success in the competition for nuclear weapons, China's 21st Century Manhattan Project sets them on a path to getting there first. This AI will be harnessed to power a global social credit system currently being rolled out in China to ensure individual and corporate compliance with CCP edict through all levels of society. Building a nationwide secure 5G network sets the condition for future success in the information domain. Not building the network puts us at a permanent disadvantage to China in the information domain.

Conclusion

It is necessary and possible to build a secure, high-performance, world-leading 5G network platform by the end of the first term. Covering the Top XXX metro areas in the country, this platform will enable higher-order innovation on a scale that no other country is currently planning towards. In order to do so, USG must provide clear direction and strong leadership. The best network from a technical, performance and security perspective will be single block, USG secured, and have the highest probability for project success. Still achievable, but with more risk to cost and schedule are multiple carrier built and secured networks. To ensure success, we must move quickly to make 3.7-4.2 GHz spectrum available. We must move quickly to standardize the wireless, network and infrastructure standards. We must standardize siting requirements and advance the nationwide deployment of fiber. We must strongly signal to equipment manufacturers our intent to build a secure supply chain. For the greatest effect, we must elicit allies to cooperatively build similar networks in their countries and work together to build

them in emerging markets. If we do, the U.S. will reap the benefits of 3% GDP growth, millions of ne jobs and a dominant position in the Information domain.

Appendices:

1. Secure 5G Strategic Principles
2. Speeding up Deployment
3. Bandwidth Relationship to Network Performance
4. Low, Mid, High Band Comparison
5. 5G New Radio (NR) Coverage and Capacity
6. Current U.S. 5G State of Play
7. Project Timeline
8. Possible Industry Reactions
9. 5G Government and Industry Team and Roles
10. Huawei LTE Market Share
11. Huawei vs. Cisco Core Routing

Appendix 1 – Secure 5G Strategic Principles

Mission Statement: First nation in the world to deploy and operate a secure high-performance 5G Internet for information dominance in the 21st Century.

Project Goals:

Initial Operational capability (IOC) 18 Months (Top 15 markets)

Expanded operational capability 24 months (Top 30 markets)

Full Operational Capability (FOC) 3 Years (Top xx markets)

Project Principles:

We will prioritize speed (speed drives momentum):

1. Speed of Deployment
2. Speed of the Network

We will minimize risk (de-risking eliminates roadblocks):

Risk will be minimized by defining tradeoff priorities in the following order:

1. Security
2. Coverage
3. Resiliency
4. Capacity

When making trade-off decisions where two priorities conflict, we will ensure full implementation of the higher priority until that priority is fulfilled.

Spectrum

National 5G requires high, medium and low frequency bands for wireless spectrum. These bands currently are furthest developed and carry the least risk:

1. H 28 GHz
2. M 3.7-4.2 GHz
3. L 600 MHz

Supply Chain

A secure Internet requires a trusted supply chain for IT equipment. We will use the deployment of 5G to reintroduce production for the full vertical stack into the United States.

Legal

Rapidly rolling out 5G nationwide will present the following potential legal and political challenges:

1. Eminent Domain for installation
2. Spectrum allocation

3. Reconstituting the IT Industrial Base.

Market

There are three potential models for deployment:

1. Single Block, USG Secured
2. Single Block, Industry Secured
3. Multi Block, Industry Secured

Build

There are numerous challenges that slow the deployment of a network:

1. Standardization: State and local requirements force network installers to go through onerous permitting requirements and produce designs for differing aesthetic standards. Leveraging national security requirements to provide full equipment design standardization prior to deployment will speed installation.
2. Right of Way: Eminent domain for national security requirements will help speed installation.
3. Maps: Installers need one national map which credibly displays existing conduit and dark fiber.
4. Identifying strategic locations for deployment will provide a roadmap which meets national and economic security requirements for rollout.

Use Case:

Aligning GSA and IT purchasing standards for the 5G network will ensure the Federal government and some state and local governments are prepared to begin harnessing the secure network as soon as it is available. Corporate governance standards can ensure the same for large and publically traded private entities.

Network Management:

The secure 5G network will require both public and private management and control functions. These organizations needed to be identified and resourced early, so they are prepared to assume their functions.

Layers:

The secure 5G network will consist of Air, Terrestrial and Space layers:

1. Terrestrial – a wireless 5G network with a blend of fiber and wireless backhaul
2. Air – an air layer utilizing airline carriers and other public/private UAS
3. Space – A space-based backhaul.

Issue	Potential Remedies
• Access for Transport (Fiber) Placement	• Remove ability to obstruct pole or ROW sharing or create incentives to encourage sharing. • Mandate strict time limits to approve attachment or locations. • Remove unfair conduit and ROW leasing practices and standardize/regulate unit lease rates. • Also – add in all ROW into National Site Clearinghouse Database.
• Permitting & Zoning for Construction	• Municipal Governments and DoT's apply same guidelines, fees and rapid turnaround limitations Nationally. • Required to accept outside assistance to handle load - Federal support to add resources to Permitting/Zoning staff and DoT staff experiencing overload. • Municipalities & DoT's to allow new Construction methods. e.g. Micro trenching
• Skilled Crew Capacity for Tower & Fiber Work	• Assist w/ National Training Programs and/or incentives for schools & companies to train in these areas. • Government aid for education of this nature. • Train former or reserve military personnel. This is 'Shovel Ready'.
• Engineering Capacity for Planning, Designing	• We should do what is possible to train/educate U.S. based engineers on new IoT/5G networks. • Selective use of Off-Shore Engineering skills will be needed to avoid cost overruns and time delays • Evaluate threats and risk on the system (Risk Assessment of system)
• Supply of Materials	• U.S. Based manufacturers have made public commitments to expand production based on key investments from major operators (e.g. Verizon and Corning) but this will not likely solve the problem for all materials or for smaller operators who will not get preferred supply. • We need to have a backup plan for required materials if the U.S. cannot keep up with demands.
• Sites Access for Dense Networks	• National Site Clearinghouse Database. Several companies claim to have databases – none are comprehensive, few are kept current hence every Operator must research/survey available horizontal & vertical assets independently in every market. • Consider regulation of the pricing and process for obtaining leases or attachment rights in public domain or ROW (street lights, signs, utility poles).

RF Channel Width (MHz)	Peak Data Rate (Gb/s)	Average Data Rate (Gb/s)
40	1.2	0.3
100	3.0	0.8
200	6.0	1.6
400	12	3.2

[2](ref: 5G PPP response to CEPT questionnaire)

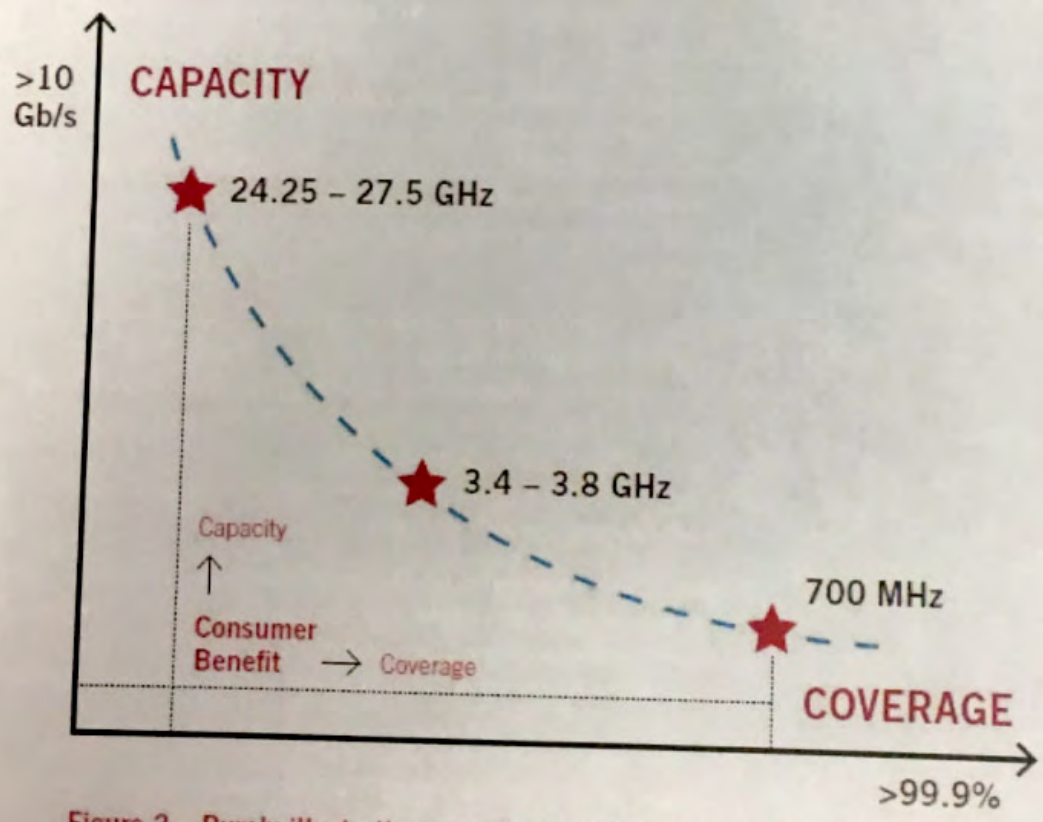


Figure 2 – Purely illustrative curve to show how the spectrum band choice shapes the network capacity or coverage outcome.

Appendix 4 – Low, Mid, High Band Comparison:

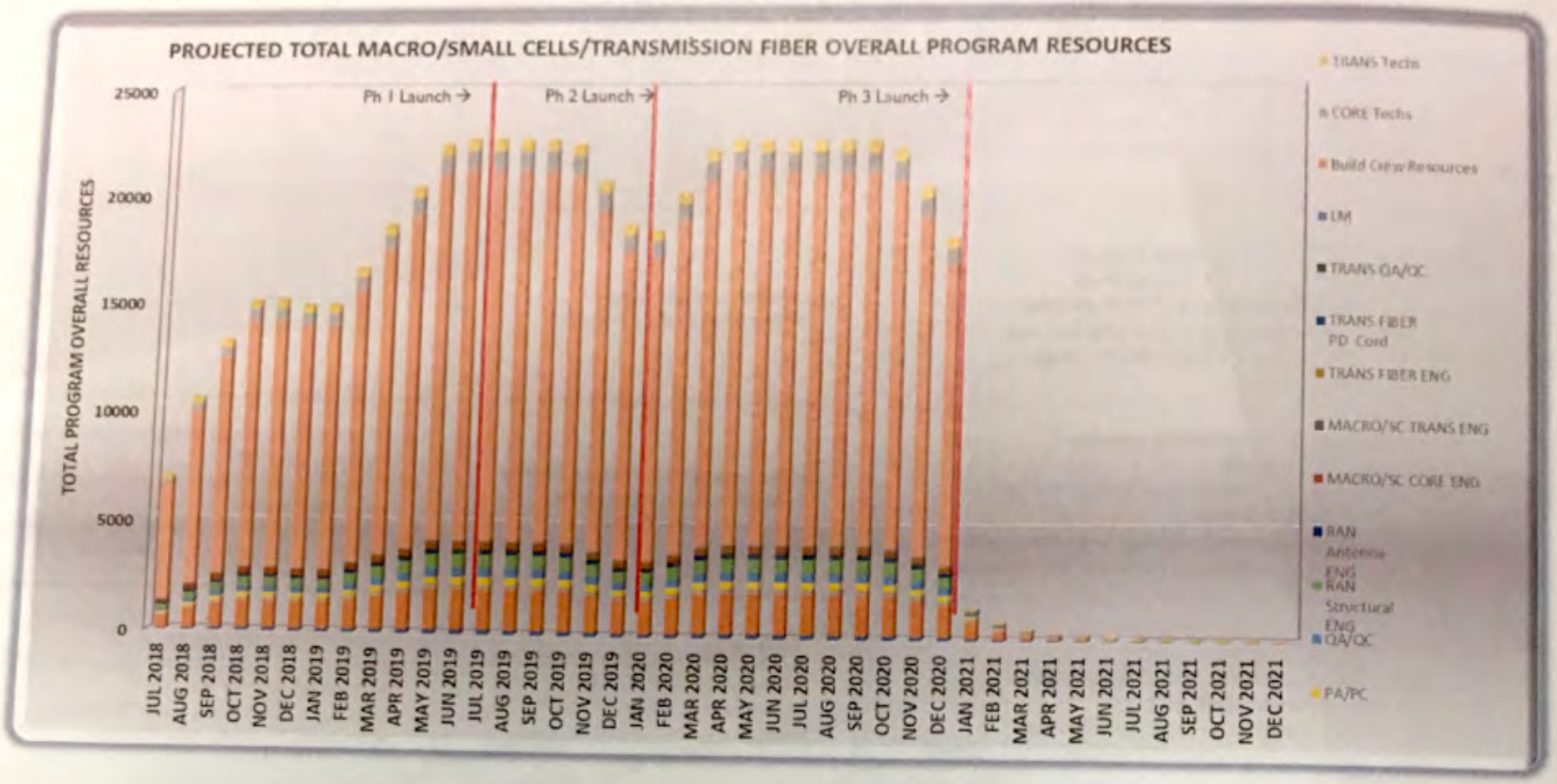
Appendix 5 – 5G New Radio (NR) Coverage and Capacity

Criteria	1.9 GHz 20+20 MHz	2.6 GHz 20 MHz	3.7-4.2GHz 400 MHz	3.7-4.2 GHz 100 MHz
Technology	LTE	LTE	5G NR	5G NR
FDD/TDD	FDD	TDD	TDD	TDD
Deployment Type	Macro Urban	Macro Urban	Macro Urban	Macro Urban
Max BS EIRP [dBm]	63	63	77	77
BS TX/RX branches	4	64	64	64
Peak DL Throughput (4X4 / 2X2 MIMO)	NA / 0.3 Gbps	NA / 0.2 Gbps	4 / 2 Gbps	1 / 0.5 Gbps
Single User (SU) / Multi User (MU) MIMO	SU-MIMO	MU-MIMO	MU-MIMO	MU-MIMO
Average Sector Throughput (Multi User-MIMO)	0.07 Gbps (SU-MIMO)	0.1 Gbps	2.5 / 1.25 Gbps	0.6/0.3 Gbps
Cell Edge DL/UL Throughput (@ cell radius)	5/0.5 Mbps (@0.83 miles)	5/0.5 Mbps (@0.36 miles)	100 / 10 Mbps (@0.36 Miles)	50 / 5 Mbps (@0.43 miles)
# MBB Users/sector (@ 8GB/Month)	1400	2000	50,000/25,000	12,500/6,000

Appendix 6 – Current U.S. 5G State of Play

• Gigabit LTE (LAA) and FirstNet (36/56 Opted-in) • DirectTVNow momentum to complement DirectTV • Using C-Band to receive programming via satellite • Trials at 28 GHz for fixed applications in 4 markets	• Challenges in deploying small cells for LTE • No significant 5G spectrum in 28 GHz or 37-40 GHz • Asking FCC to accelerate 28 & 37-40 GHz auctions to enable 2018 5G launch • TimeWarner approval pending	• Close the 5G spectrum gap with mid band spectrum • Launch 5G Mobility Services competitive with Verizon • Provide a 5G roadmap for FirstNet customers • Leverage media assets to provide a unique wireless consumer experiences • Extend LTE leadership to advance smart cities and emerging IOT business opportunities
• Pure Wireless connectivity company • Largest holder of 2.5 GHz spectrum • Massive MIMO trials on 2.5 GHz spectrum • Views 5G deployments in 2.5 GHz spectrum • Re-focusing after T-Mobile deal breakdown	• Inconsistent CAPEX strategy • Challenges in deploying small cells	• Launch 5G Mobility Services competitive with Verizon, AT&T and T-Mobile • Stronger 5G device ecosystem vs. 2.5 GHz
Pure Wireless connectivity company • Gigabit LTE (LAA) • Limited mmWave spectrum in select markets • 5G testing at 28 GHz • Consistently strong subscriber and revenue growth • Top bidder of 600 MHz to provide deep coverage	• Lacking spectrum for 5G macro coverage • Challenges in deploying small cells • Inability to bundle with Fixed	• Launch 5G Mobility Services competitive with Verizon and AT&T • Complement current low-band strategy with strong mid-band position • Extend LTE leadership to advance smart cities and emerging IOT business opportunities
• Gigabit LTE (LAA) • Leader in mmWave spectrum ownership • Extensive fiber investments • Trials at 28 GHz for FWA in 11 markets • Announced Commercial FWA launch in 3-5 markets verizon	• FiOS footprint reduced to north east only • Lacking spectrum for 5G macro coverage • Challenges in deploying small cells for 5G FWA	• Launch 5G Mobility Services • Improve CAPEX efficiency by complementing 28 GHz with mid band for FWA • Extend LTE leadership to advance smart cities and emerging IOT business opportunities

Appendix 7 – Project Timeline:



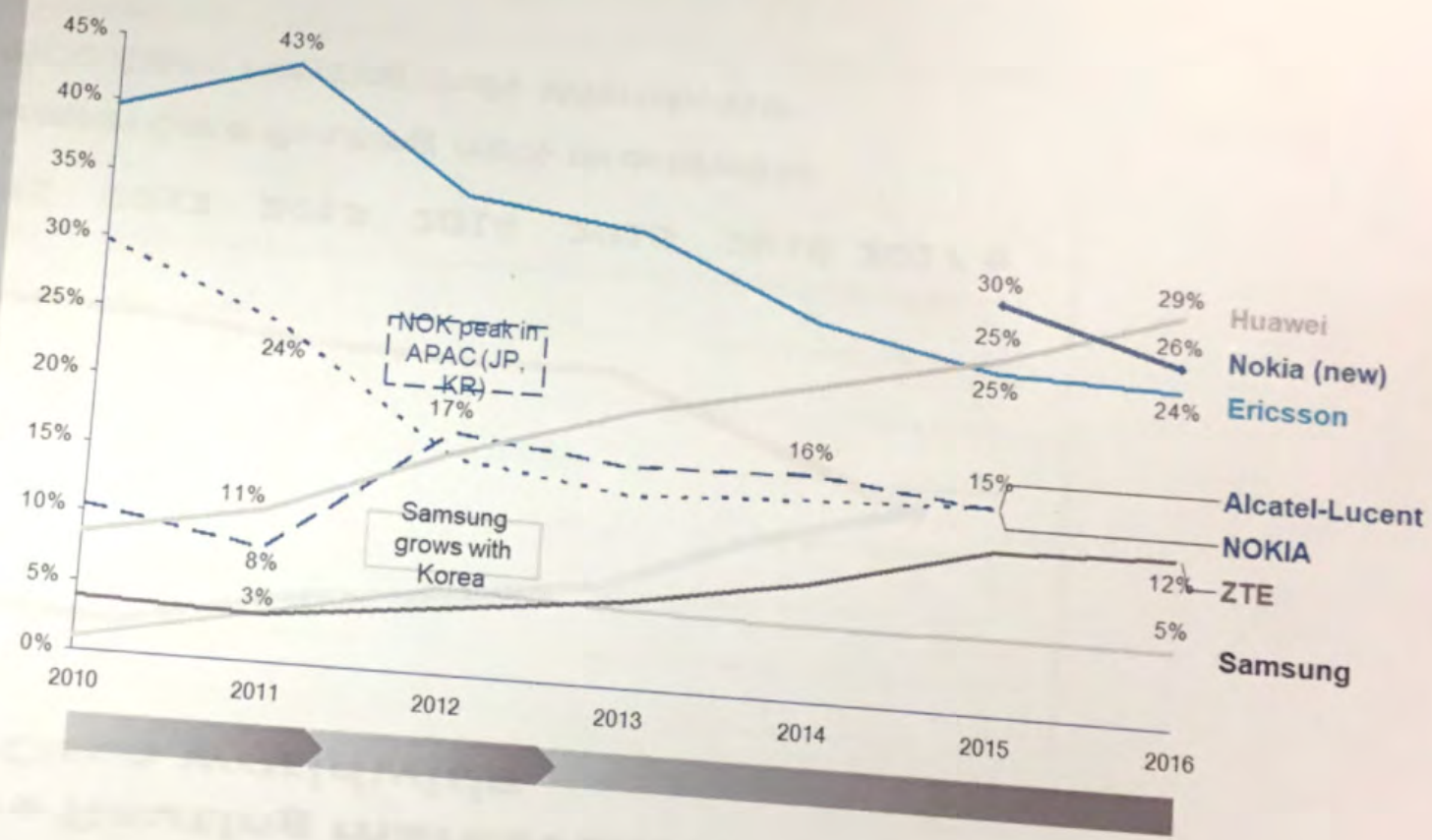
Appendix 8 – Possible Industry Reactions:

- AT&T: Mixed =>Will support faster/cheaper 5G buildout but will resist any disruption to its satellite business from mid-band spectrum clearing
- Verizon: Mixed =>Will support faster/cheaper 5G buildout but will perceive aspects of the proposal as marginalizing its advantage on spectrum and fiber assets
- Sprint: Mixed =>Has strong 2.5 GHz spectrum position already but would welcome more level playing field with T/VZ
- T-Mobile: Strong support =>lacks rich spectrum for nationwide 5G and would welcome more level playing field with T/VZ
- Comcast&Charter: Neutral to Negative =>Fixed wireless use case directly competitive with its core high speed internet product; suitability of fiber assets for 5G backhaul unclear
- CenturyLink: Neutral to Support =>Provides an opportunity to monetize its Fiber-rich network; less reliance than cable on high speed internet product
- Google: Neutral to Support =>Might push for flexible CBRS-style sharing, but will generally approve because faster/more pervasive broadband means they can sell more advertising.
- Satellite Industry: Negative =>Mid band used primarily for content distribution by Media Networks; gradual migration to Fiber; Intelsat / Intel proposal to manage spectrum between Wireless and Satellite

Appendix 9: 5G Government and Industry Team and Roles

Team Member	Strategic Framing	Network Security Standards	Infrastructure Standards	Wireless Standards	Domestic manufacturing	USG Organization	Financing/ Anchor Tenant	Technology Validation	Air and Space	Workforce Development	International Partners
AppenDoD Strategic Capabilities Office (SCO)	X	X	X	X				X			
Air Force	X										
Ericsson	X	X	X	X	X	X	X		X		
Wells Fargo	X										X
Samsung	X	X	X	X	X		X				
Qualcomm		X	X	X	X			X	X		X
Oracle		X	X			X		X			
Nokia		X	X	X	X						X
Space X									X		
OneWeb									X		
Department of Education										X	
Google	X	X		X	X		X		X		
OSTP	X										
NEC	X										
NSC/NSS	X										
NSC/ASIA	X										
NSC/TNT	X										
NSC/CYBER	X										
NSC/STRAT	X										
DHS	X										
NTIA	X										
Department of Commerce	X										

Team Member	Strategic Framing	Network Security Standards	Infrastructure Standards	Wireless Standards	Domestic manufacturing	USG Organization	Financing/ Anchor Tenant	Technology Validation	Air and Space	Workforce Development	International Partners
DoD/CIO	X	X	X			X					
USEMB Japan											X
Amb Glazer											X
OPIC											X
Department of State											X
EX/IM Bank											X
GSA	X						X				
Navy	X										

Huawei's road to number #1 is not solely driven by China
2010-16 LTE market share

- Huawei gained 21pp of LTE market share in 6 years driven by market share gains in all regions except North America
- Seen from a Huawei perspective, excluding North America where they have restrictions, Huawei would have roughly 40% global LTE market share everywhere else, twice that of both Nokia and Ericsson combined.
- The North America (US) market is the clear target of the Chinese government and Huawei.