5G Capabilities

ENABLING SERVICES AND INNOVATION IN THE U.S. FEDERAL GOVERNMENT

Developed by
ACT-IAC NETWORKS AND TELECOMMUNICATIONS COMMUNITY OF INTEREST
5G WORKING GROUP
Synopsis
This whitepaper serves as a foundational tool in the understanding of 5G and use cases within the federal government. It introduces 5G services, concepts, related technologies, and how federal agencies can effectively apply 5G services to advance their missions and enhance citizen services.

5G services has the potential to help government agencies operate more effectively, save money, and improve the lives of American citizens. This potential derives from 5G’s ability to increase the value of government’s information assets, workforce, and citizen services.

This whitepaper reviews the history of 4G LTE, defines 5G, investigates the budget impacts of 5G, and examines use cases across the federal government.
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Introduction
This whitepaper is an introduction to the fundamentals of 5G technology and how it can be applied to benefit the federal government and improve the lives of American citizens.

Just in the last year, there have been dramatic improvements in the use of 5G technologies in various areas ranging from cell phone connectivity to Wi-Fi deployments.

The Federal government has recognized the importance of 5G technology and has prioritized funding for fundamental research and computing infrastructure, machine learning, and autonomous systems. President Trump’s FY2019 Budget Request was the first in history to designate 5G and autonomous and unmanned systems as Administration Research & Development priorities.

This whitepaper introduces 5G to provide fundamental understanding of the technology, its potential benefits to the federal government, potential use cases and the potential impact of this technology on the future of the government.

Scope
This whitepaper provides government and private sector audiences an overview of 5G technology, budget considerations, and real use cases. The whitepaper also provides examples of different needs 5G can assist to solve, as well as illustrative use cases for government organizations describing where 5G can help agencies.

This whitepaper is not meant to be a technical document and does not provide a deep dive into specific agency capability gaps to recommend solutions.

What is 5G and itsCapabilities?
5G is the 5th Generation cellular wireless technology that was launched in 2018 and continues to expand. It represents new advantages and capabilities over current 4G/LTE (4th Generation/Long Term Evolution) cellular wireless services, which has prompted innovation of smartphones and mobile applications. 5G improvements may include faster download speeds in the range of 1-2Gbs (gigabits per second), lower latency (the time it takes for data to travel from the user, over the network to the central process and back again) at approximately 10 milliseconds (1 millisecond is 1-1000th of a second), and scalability to more connections within an area. The intent is to address new applications such as augmented and virtual reality (AR/VR), autonomous vehicles, and large quantities of Internet of Things (IoT) connections.

5G standards are jointly developed by an international consortium known as 3GPP (3rd Generation Partnership Project), which combines efforts from seven regional telecommunications bodies, of which Alliance for Telecommunications Industry Solutions (ATIS) represents North America. 3GPP completed the first set of 5G standards in 2017.
4G / LTE is the current majority cellular technology with over 90% of U.S. device population and has continued development under 3GPP. An industry known as the “Internet of Things” (IoT) contains a category of sensor-based products that the federal government has used including infrastructure controllers, environmental monitoring, and wildlife tracking. This LTE has its own set of protocols to help manage security and preserve battery life. 4G/ LTE will most likely continue to be offered by service providers with devices that are expected to be dominant for next few years thru 2022.

![Figure 1: ITU IMT 2020 reference architecture of 5G IoT services](image)

**5G Frequency Bands**

Commercial carriers are likely to offer 5G services for smartphones and hotspots with a few flagship devices targeted at early adopters and developers. New devices are expected to be announced to address wider applications in the months to come. Urban centers and large outdoor venues such as stadiums will be outfitted with 5G technology. 5G radio technology comes in three bands: low-band (600MHz (megahertz or 1000 hertz) to 2300 MHz), mid-band (3500-3700 MHz), and high-band (spectrum above 6000MHz or 6Gigahertz, also known as millimeter wave (mmW)). Technically, mmW starts at 30 GHz, up to 300 GHz, 3 to 30 GHz is typically considered to be Microwave bands. One hertz is one cycle per second per signal wavelength. Low band is where current 4G/LTE resides. High band is new frequency band and provides high throughput but over shorter distances (see Figure 2 below). Millimeter wave signals have challenges penetrating through objects and walls. Users may only experience the faster downloads in designated areas with adequate propagation. High-band will require deployment of antennas known as small-cells which are lower to the ground and likely mounted on buildings and lampposts. Low band is addressed through macro cells towers, which range from 100 to 300 feet tall but spaced miles apart. Mid band is not available yet and can be discussed when available.

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*Advancing Government Through Education, Leadership, and Collaboration*
**Fixed Wireless**
In the near future, fixed wireless services will come to market. Fixed wireless is like wireline DSL services for high-speed internet services where the receiving modem is stationary and can provide access where wireline is unavailable.

**Edge Compute**
One of the potentially key related areas of 5G is edge compute capability. Edge compute helps with applications such as autonomous vehicles, autonomous guided robots and AR/VR that require latency below 10 msec. Edge computing offerings can help government separate data traffic and keeps the data on local premises. In commercial applications, these are being deployed in retail and manufacturing.

**Network Slicing**
One of the future benefits of 5G is a service known as network slicing. Network slicing arranges services according to characteristics such as latency, data rate, availability, mobility position, and density. Network slicing supports Internet of Things services by providing each category with these features. With the expected explosion of Internet of Things devices and connections, 5G has classified the types of services into four categories:

- **Enhanced Mobile Broadband (eMBB)** – characteristics are best effort latency: medium data rate, medium availability, fixed position, and low density;
• Ultra-Reliable Low-Latency Communications (URLLC) – characteristics are very low latency, very low data rate, high availability, fixed position, low density, and critical safety;
• Massive Machine Type Communications (mMTC) – characteristics are best effort latency: very low data rate, best effort availability, fixed position, low density, and Mission critical;
• Vehicle to Everything (V2X) – characteristics are moderate latency: low data rate, medium availability for semi-autonomous vehicles, but very high availability for fully autonomous; high speed vehicular mobility, high density, and critical safety.

<table>
<thead>
<tr>
<th>Enhanced Mobile Broadband (eMBB)</th>
<th>This slice supports mobile broadband applications such as streaming high-quality video, fast large-file transfer, and real-time gaming.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-Reliable Low-Latency Communications (URLLC)</td>
<td>This slice type includes applications that require very high reliability and are extremely sensitive to latency, including autonomous driving, drones, augmented/virtual reality, and public safety.</td>
</tr>
<tr>
<td>massive Internet of Things (mIoT)</td>
<td>The main application scenarios for this slice type have a high density of heterogeneous devices with massive connectivity requirements. Examples include smart cities, smart grids, intelligent agriculture, and other services where networks need to support massive equipment access sending small data. These applications are not highly sensitive to latency.</td>
</tr>
<tr>
<td>V2X</td>
<td>This slice is customized for vehicle-to-everything (V2X) services.</td>
</tr>
</tbody>
</table>

Figure 3: 5G IoT Categories (Source: ATIS) Limitations and Risks

While the 5G capabilities described above have the potential to completely revolutionize the way humans live, work, learn, and communicate, there are still many risks and limitations that must be taken into consideration, in order to effectively utilize these technologies.

One of those considerations is deployment timeline. Major cities are just now seeing 5G deployments, with smaller metro areas to follow, and eventually rural areas. Although the carriers may have aggressive deployment plans, it will still take some time for full geographical distribution of 5G across the country. So, depending on your geographical location, 5G as a solution could be years away.

Another consideration is security. As the number of mobile endpoints increase and applications become more common, the threats and number of bad actors looking to take advantage increase. While 5G has been specifically designed with security in mind, government agencies should remain diligent in their adoption, deployment, and sustainment of 5G networks and complimentary technologies to keep them as secure as possible.
Government Financial Considerations

The direct budget impact of initial basic 5G services – rate plans and device leases and purchases - on Federal users is likely to be minimal, but these services are likely to drive a significant increase in applications that will be enabled by the increased capacity and lower latency of 5G.

There are at least three basic components to mobility pricing:

- **Rate plans** – where the subscriber purchases some amount of telecommunications capacity to be used in a specific time period. This includes minutes of voice and/or bytes (typically megabytes or gigabytes) of data per month. Specific offerings vary – the purchased capacity could include shared or pooled data across multiple user devices or rollover of unused minutes from one month to another, for example.

- **End-user devices** – handheld phones, tablets, “phablets”, computers, smart watches, and other devices used by an individual to access content or send content using a wireless network.

- **Fixed devices** – wireless devices designed to provide telecommunications services to a fixed location such as an office or a remote sensor site where the wireless service offering provides some combination of higher capacity, lower cost, or better availability.

5G is not expected to bring about drastic changes in these plan structures, carriers will most likely try to differentiate using a variety of plans and OTT (over-the-top) offerings. The Federal government will likely be able to mitigate any upward pricing pressure for these consumer-oriented products since the government uses a variety of strategies to optimize budgets for wireless services. Some agencies use a Telecommunications Expense Management (TEM) process to determine the best mix of products for a typical user. Agencies also often subscribe to unlimited plans. Finally, Federal users are not allowed to subscribe to sports or television offerings delivered on government devices – they are prohibited from most of the high-bandwidth, extra-cost OTT offerings.

Cost per bit is likely to plateau or decrease with the advent of 5G services; it’s possible that certain costs may follow historical market trends and decrease. Service to Federal users is generally provided over the same infrastructure used for consumers and businesses and the market for these services is very competitive. This competition should continue to provide downward pressure on usage prices. Note that one of the features of 5G is more efficient use of spectrum, so relative costs to providers of transporting a unit of service may decrease. However, as is the historical precedent with other telecommunications services, an exponential increase in usage may offset those cost savings.

The impact of plans supporting IoT applications is yet to be determined. This market segment is expanding rapidly, and competition may provide similar downward pressure on prices.

5G services are not likely to replace in-building Wi-Fi unless inbuilding cellular coverage is supplemented. This option is particularly attractive though when an edge computing solution is desired to keep data “local” - meaning it does not “hairpin” out of a building to a network and back. Local edge computing facilitates local processing for applications that require lower latency. However, 5G may provide an attractive solution to augment capacity in a building.
A major potential application for 5G services is where capacity is needed on a temporary basis to support events – sports stadiums, concert venues, convention centers, and other large gatherings all have needs for temporary increases in capacity and increasingly to support high bandwidth applications.

New releases of equipment in the North American market, but not necessarily in other markets, will likely include 5G radios. Therefore, new devices acquired by government agencies as part of periodic refreshes should include 5G radios. The market is likely to continue to support low-end, mid-range, and high-end devices for end users.

It’s possible that the most significant budget impact from 5G will be increased usage and more devices driven by productivity improvements and new applications. 5G-enabled solutions are expected to include healthcare, public safety, sophisticated training with augmented and virtual reality, virtual collaboration for telework, customer service, and countless others.

**Government Business Use Cases and Outcomes**

**5G and the Future of Healthcare**

*Some of the ways that 5G could help overcome agency challenges and empower better, more cost-efficient patient outcomes.*

Healthcare is being reshaped by technology. Providers now have better access to patient data and applications than ever before, implanted devices and wearables deliver critical information about remote and mobile patients, and telemedicine is bringing much-needed care to underserved communities.

Still, true transformation has yet to arrive, but it is on its way. Following are some of the challenges public sector healthcare organizations, such as the Department of Health and Human Services, Department of Veterans Affairs, Department of Defense/Defense Health Agency, face today, and how 5G technology could help solve them.

**Technology challenges facing health organizations**

**Collecting, managing, and utilizing Big Data more efficiently**

Big Data in healthcare – the health data amassed from electronic health records (EHR), medical imaging, payer records, patient portals, and ever-increasing other sources – has advanced the industry on many fronts. However, it has also created a whole new set of challenges as organizations struggle to efficiently collect, manage, secure, and utilize massive volumes of data that’s highly variable in format, type and content.

**Improving patient outcomes**

The pressure to improve patient outcomes grows increasingly intense as the industry continues to move toward value-based care. Potential solutions include making better-
informed diagnoses, reducing medication errors, providing better access to care, and engaging and supporting patients after discharge.

**Securing data and improving compliance**

As technology becomes increasingly enmeshed in healthcare, the difficulty of securing vast amounts of data grows apace. And mishandling data can lead to noncompliance with HIPAA regulations, bringing significant financial penalties and costly, reputation-damaging, data breaches. In fact, healthcare data breaches are the costliest of any industry.

**Delivering better patient experiences**

As patients are urged to assume more responsibility for their wellness, and leverage tools to measure and manage their health electronically, expectations for better health care experiences rise. Today’s healthcare consumer wants a streamlined, connected, healthcare system that provides faster, easier, 24/7/365 access to acute care, follow-up care, personal health information, detailed costs, and other helpful information.

How 5G will help transform healthcare

**Speed**

5G has the potential eventually to deliver peak data rates of up to 10 Gbps, allowing clinicians and researchers to rapidly access and transport massive amounts of data, such as medical imaging and large data tables. This could help clinicians, researchers and others in the field work smarter, faster, and more productively. 5G also has the potential to power a new generation of collaboration and productivity tools. Ubiquitous mobile access to virtual reality, 4K video streaming and haptics could take a teleconference to the next level, enabling distributed care providers, patients, vendors, and partners to work together more effectively and collaboratively.

**Latency**

5G’s eventual ultra-low end-to-end latency is likely to be one of the drivers of true technological change, ultimately bringing data transit speed to many times less than the blink of an eye. This will be transformative for assisted surgery and augmented imaging application.

**Data volume**

The 5G standard is designed to support up to 10 TB/s/km². This means that a 5G network can carry a massive amount of data for many simultaneous users. So, users in high-density areas – like hospitals – could all experience the fast speeds and lower latency of 5G service.

**Massive connectivity**

5G is designed to be capable of supporting up to 1 million devices in a square kilometer, which could greatly expand the use of wearables and portable monitoring.

**Enhanced data security and privacy**

Security has improved with each successive wireless network evolution and 5G is designed to deliver even more robust security for mobile devices, helping organization better manage HIPAA compliance through:

- **Communications security**

  5G will encrypt signaling traffic, and use established security algorithms, such as separation of keys, backward and forward security for keys at handovers, idle mode mobility, and secure algorithm negotiation. New features will include automatic recovery from malicious algorithm mismatches and fast synchronization of security contexts in...
access and core networks. SIM-based authentication, which differs from wi-fi, could also see expanded use.

- **Identity management**
  With secure identity management and a new authentication framework, 5G is designed to allow more flexible and robust authentication. It will also facilitate reuse of existing public keys and certificate infrastructure for network access authentication.

- **Privacy**
  Subscriber privacy for data traffic, phone call and text message are designed into 5G, by using state-of-the-art encryption. The devices and the network will mutually authenticate each other and use integrity-protected signaling.

- **Security assurance**
  This is expected to help ensure that network equipment meets security requirements and is implemented following secure development and product life-cycle processes.

- **Resilience**
  5G is expected to be more resilient to cyberattacks and non-malicious incidents, because the core network architecture is designed to support network slicing, continuous secure connectivity for mobile devices and lower latency.

**How 5G could empower healthcare innovation**

5G is not just the next step in cellular communications networks. It promises to ultimately be a transformative platform supporting healthcare technologies and use cases that were previously unimaginable, by utilizing:

- **Artificial intelligence**
  The use of artificial intelligence (AI) is likely to skyrocket with 5G, as 5G’s speed, lower latency, bandwidth, and potential use with edge computing will enable the rapid collection, processing, and analysis of massive amounts of data. Leading-edge organizations are already using AI to create more intuitive EHR interfaces and automate record keeping and data security processes, as well as to gain unprecedented insight into diagnostics, care processes, treatment variability and patient outcomes. It can also potentially be used for risk scoring, infectious disease management and control, and in the development of next-generation drugs, tools and treatments for cancer and other diseases.

  In the future, brain-computer interfaces (BCIs) backed by AI could also help to restore speech and movement, improving quality of life for patients with spinal cord injuries, ALS, strokes, locked-in syndrome and other neurological diseases and injuries.

- **Intelligent video**
  Video technology integrated with analytical software promises to take telemedicine, remote care, collaboration, training, and hospital management to the next level. Intelligent video can recognize objects, behavior and anomalies and then deduce how best to act upon them. This could enable faster, more accurate remote diagnostics, more effective real-time collaboration, and improved remote and post-operative patient care. It could also improve onsite patient care by alerting staff when patients require assistance or have been left alone beyond a specified timeframe. It could also be used to analyze and improve staff performance and
training and optimize staffing by tracking behavior and activity throughout the facility during different times of day.

**Internet of Medical Things**

With 5G, connected devices – particularly wearables and implants – will likely become even more pervasive, transmitting a wide variety of critical information to care providers. We’re already seeing stories of doctors alerting patients with implants of potential impending problems and consumer wearables warning people of irregular heartbeats. Other types of Internet of Medical Things (MIoT) devices could be used for disease prevention, remote intervention, and wellness promotion, and include home-use medical devices, point-of-care kits, and mobile healthcare applications. In the future, ingestible, wireless-enabled, digital tools could help monitor healing and treatment and drug efficacy.

**Edge computing**

Edge computing enables cloud servers to run closer to endpoints, reducing latency and speeding local processing. That means most of the computing can take place at the network edge, rather than on devices. This could lead to the creation of low-cost, lightweight wearables and medical devices that leverage complex capabilities such as analytics, AI, computer vision and mapping located at the edge. Plus, adding data centers to the edge can reduce transmission and processing time, so clinicians can respond more quickly to changes in condition. It can also help organizations more effectively deliver applications and services, such as telemedicine, to remote areas where network services are limited. And local edge computing reduces exposure of personal health information and other critical data, by minimizing how often it’s transmitted to the cloud.

**Robotics**

Robotics have been used in healthcare for over 30 years, ranging from industrial robots that perform routine tasks, like sterilizing rooms and delivering supplies and equipment, to devices that assist with and perform surgeries. They can also transport dangerous substances and aid in the care of patients with highly contagious diseases like COVID-19. With 5G – and in concert with AI – their uses could potentially radically expand, making them more ubiquitous in diagnostics, surgery, physical therapy and rehabilitation, telemedicine, home care, and elder care. In the future, robotic nanodevices might be injected into the body and automatically guided to deliver treatment payloads, take samples, or make repairs.

**Virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR)**

With 5G, immersive technologies are expected to be transformed from entertainment platforms to valuable healthcare tools. From hyper-realistic training environments to rapid prototyping, 3D modeling and printing, data visualization, and patient care, 5G is expected to ultimately unleash the power of immersive technologies, empowering new capabilities, instilling new levels of understanding and empathy, and enabling improved efficiencies across the healthcare ecosystem. In the realm of patient care, they promise to reduce anxiety before and during treatment, ease pain, advance physical therapy, speed recovery and aid in end-of-life care.
5G is coming to the healthcare industry
The advent of 5G will be pervasively felt across entire agencies impacting professional staff, agency processes, and their related policies. 5G is likely to materially impact the ways in which agencies accomplish their core mission objectives enabling entirely new approaches while obsoleting others. To realize the full potential of 5G, forward-looking agencies are proactively engaging their trusted consultants, systems integrators, and communications service providers to prepare for the opportunities ahead and facilitate their arrival. Early-adopter agencies are finding it beneficial to move forward with mission-impacting proof-of-concept use cases to help establish quantitative measures of value for their agencies to accelerate the transition. The key message from early adopters is the importance of simply getting started on the journey: we are all in this together.

5G and the Future of Public Safety
5G could enable new communications and data-sharing opportunities for emergency services, law enforcement, and first responders.

Technology is reshaping public safety. Emergency services providers, law enforcement, and first responders have better communication through access to mobility services. The introduction and adoption of 5G technology will provide new capabilities to further support the mission of federal agencies like the Department of Homeland Security, Customs and Border Protection, Department of Energy, Department of the Interior, Federal Emergency Management Agency, Federal Bureau of Investigation, and US Coast Guard that have emergency, law enforcement, and first responder responsibilities.

The First Responder Network Authority (FirstNet), under the National Telecommunications and Information Administration (NTIA), created the first dedicated high-speed nationwide wireless broadband network for first responders. This network was established to provide consistent network and application performance under even the most extreme conditions. Technology never stands still though, and the FirstNet Authority recently noted its support for exploring how 5G could meet the continued and changing needs of public safety. The FirstNet Authority Board recently gave the FirstNet Authority the green light to pursue investments in this area.

Technology challenges facing emergency services, law enforcement, and first responder organizations

Providing timely and effective communication
During a crisis, timely and effective communication is critical to protecting citizens and maintaining command and control. Relevant and time-sensitive information needs to be securely delivered to the proper emergency services, law enforcement, and first responders without interruption or delay.

Collecting, managing, and sharing data more effectively and efficiently
Public safety, resource protection, and emergency services information resides in disparate systems at the local, state, and federal levels. This information needs to be effectively, efficiently, quickly, and securely shared across various jurisdictions during an emergency.
Securing data and improving compliance
As technology enables data to flow more freely across jurisdictions, securing that data becomes more complex. Mishandling that information could potentially put responders and the public at risk, and/or violate laws and statutes.

5G can empower public safety innovation
5G could support use cases that were previously unimaginable for emergency services, law enforcement, and first responders. Here are four technologies that could be integrated with 5G to enable new capabilities.

Artificial intelligence
The use of artificial intelligence (AI) is likely to skyrocket with 5G, as 5G’s speed, ultra-low latency, and edge computing power enables the rapid collection, processing, and analysis of massive amounts of data.

First Responder and Public Safety
AI-enabled applications can assist first responders in mitigating the impact of natural disasters by saving lives and property, and lowering the cost impact caused by floods, wildfires, and other natural disasters. Examples of AI-enabled applications can include fire and flood-line detection, damage assessment, navigation, and route-planning algorithms.

Law Enforcement
AI-enabled applications can assist law enforcement to better allocate and manage limited resources in response to emergencies. For example, route-planning algorithms could analyze data from location-aware emergency and law enforcement vehicles and surrounding infrastructure (i.e., traffic signal lights, cameras, etc.) and accelerate emergency response times and provide real-time traffic management.

Intelligent video
Video technology with AI-enabled applications and powered by 5G can take support for public safety, law enforcement, and surveillance to the next level.

First Responder and Public Safety
Intelligent video can assist first responders by improving search and rescue, aerial aid drops, and evacuation efforts in the aftermath of a disaster. For example, multiple interconnected 5G drones with high-resolution cameras could provide real-time HD imaging and video feeds from aerial scans to meticulously map disaster areas for search and rescue and damage assessment.

Law Enforcement
Intelligent video can provide law enforcement with an extra pair of “eyes and ears” in support of their duties. For example, high-resolution cameras mounted on law enforcement vehicles could provide real-time monitoring of patrol activities to determine if an officer requires backup and assistance without the need to radio in. These video feeds could analyze the activities, body language, and facial expressions of potential suspects, potentially detect crimes occurring in real time, send out auto-notifications, and continuously track suspicious individuals as they move from the field of view of one camera to the next.
Internet of Things
With 5G, connected devices, including wearables and other elements of the Internet of Things (IoT), can enrich communication and information sharing for emergency services, law enforcement, and first responders.

First Responder and Public Safety
IoT can help ensure public safety by providing timely notification during natural or man-made disasters. For example, 5G sensors placed at strategic locations to detect or predict earthquakes could send nearly instant notifications to impacted individuals, emergency services, and first responders to take appropriate actions such as slowing trains, taxing airplanes, or preventing cars from entering bridges and tunnels. IoT 5G sensors could also be used to detect biological, chemical, nuclear, or other hazards, and send real time auto-notifications.

Law Enforcement
IoT can assist law enforcement in processing, receiving, and sending relevant and timely information at the scene of an event. For example, 5G sensors could locally scan in fingerprints of potential suspects at a crime scene and perform a real-time comparison of the fingerprints to a criminal database or any other records system. IoT sensors could be mounted on a gun holster or gun mount that would trigger a notification to dispatch upon weapon deployment. IoT wearables could also be used to monitor the physiological status of law enforcement personnel so dangerous tasks are assigned to those who are mentally and physically best able to perform.

Virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR)
With 5G, immersive technologies like virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR) could be transformed to provide valuable support and training tools for emergency services, law enforcement, and first responders.

First Responder and Public Safety
AR and VR delivered through lightweight 5G headsets could help first responders better prepare for actual incidents through simulated and/or augmented reality training. These incidents could range from the routine to life-or-death. For example, bomb squad personnel could use AR to simulate realistic Improvised Explosive Device (IED) exercises to better prepare for real life scenarios. These technologies could also be used during actual, live emergencies to assist responders. A firefighter helmet incorporating an AR display could provide an overlay of building schematics, for example, and leave digital signposts to help firefighters get out of the building even when smoke is obscuring their physical view.

Law Enforcement
AR technology can have significant impact on law enforcement by creating innovative methods for combating crime and terrorism. Examples of AR applications include real-time intelligence about crimes and criminals in the patrol area; facial, voice, and other biometric data of known criminals to allow for instant identification; and real-time language translation to include data on cultural norms and traditions.
5G Customer Experience – Future Microservices

5G is expected to have a major part in the “Publish/Subscribe” microservices industry. These services all using high speed and high capacity data will allow companies to work together to form microservices alliances to exchange customer experience context and provide various services to customers. There will be a “master” orchestration system managing all the interactions between the disparate services provided to enable a frictionless customer experience.

As a future example, a customer may step foot in an autonomous vehicle and at the time of entry the vehicle might not know anything about the person – it could be a rideshare service. The person will have to authenticate via biometrics or other methods to allow the vehicle to continue. As soon as the person is authenticated through the security microservice, the autonomous vehicle will embark leveraging microservices that are part of the consumer’s subscription plan. For example, there will be bronze, silver and gold plans that work together to leverage traffic, weather, toll road (gold plan will allow faster travel at a premium). Or, if the passenger requires 10 minutes of prep time to do their work in the vehicle, the vehicle will plan a route that conforms to the amount of time the passenger needs to leverage the work environment established in the vehicle. For example, large, medium, or small monitors, high speed or lower speed networks, etc. While in-route the passenger will also leverage shopping, services subscribed to by the rideshare company, the passenger, and perhaps even the automobile manufacturer. There will be an intersection of vendors and capabilities provided that the passenger will be able to leverage to make all the transitions smooth and frictionless. If at any time the vehicle “senses” that the passenger is getting frustrated the sentiment analysis detection microservices will trigger offers and/or discounts to reward the passenger for the minor or major inconveniences.

All of this will require an end-to-end journey and microservices orchestration system that can be distributed to the most logical point in the architecture. For example, if there are 3 “tiers” or layers of capability, each layer will have the ability to receive an “upload” of rules from the core orchestration services running in the cloud. Higher speed calculations and events will be pushed closer to the consumer/passenger to minimize traffic on the 5G Network even though the 5G network may have the ability to accommodate the traffic. Response times in milliseconds will be possible at the edge whereas 10s of milliseconds will be possible from the adjacent edges. The user should be able to perform their biometric security authorization scan at the edge, but if they require a human to help in real time in the vehicle after the automated BOT fails, the user will need to go into the cloud to reach out to the next available person who can help”.

Customer Experience Orchestration Applications will invoke multiple microservices and will act like “automated answering services.” These automated answering services will receive requests from humans and respond to humans, requests from humans and respond to microservices, etc. They will take the “question” – “What should I do next, eat now or later with the customer.” It will invoke microservices to find the best answer to the question and respond by invoking other microservices or even ask for clarifying questions from the passenger or another human in the interaction chain. All these high-speed transactions will now be possible at scale because of the promise of 5G.
The Customer Journey Flows built in the cloud will also be able to be pushed to the disparate execution points, all the way to the edge. Since every Journey transaction is tracked in the cloud, correlative analysis can now be performed based on the satisfaction of the passenger in the vehicle. If the Customer Journey Flow executed in the vehicle had a positive outcome (based on customer experience sentiment, spending, feedback (surveys), or social media interactions) then the specific Customer Journey Flow will be highly rated and will rise in the offer ranking for the next customer who wants to execute a similar customer journey.

5G Research in Department of Defense

The Department of Defense has started 5G research with the following main goals:

- **Accelerate** - Hasten DoD’s adoption of 5G. With at-scale test facilities that enable rapid experimentation and dual-use application prototyping.
- **Operate Through** - Ensure US Forces can operate through wherever and whenever deployed. Tools include Dynamic Spectrum Utilization and Zero Trust architectures.
- **Innovate** - Enhance 5G technology and invest in future “Next G” technologies.

Four use cases for the DoD as follows:

1) **US Army**: AR/VR high fidelity training for US Army. The Army’s objective is to demonstrate how 5G can support realistic distributed training and develop fieldable equipment and systems to develop integration into ongoing combat training systems.

2) **US Air Force**: Dynamic Spectrum Sharing for US Air Force between government radars and 5G cellular equipment. The Air Force plans to construct a 5G testbed at Hill AFB to evaluate impact of 5G network on airborne radar system and vice versa, employing both active and passive to enable sharing and coexistence.

3) **US Navy**: The US Navy’s plan is to utilize 5G to improve processes and automation for warehouse operations to support warfighters. Smart warehouse technology is the key enabler in improving processes and increasing efficiency, accuracy, and fidelity of over-all logistic operations in support of readiness.

4) **US Marine Corps**: The USMC are seeking to develop and demonstrate prototypes to advance and leverage 5G-enabled technologies to improve warehouse operations. 5G enabled smart warehouse technologies are desired to improve the efficiency, accuracy, security and safety of material and supply handling, management, storage, and distribution.

Transformation

The decision to use 5G is not just technical. It is a decision that, if planned for and responsibly adopted, can be transformational to an agency’s stakeholders, workforce, and long-term mission trajectory. Agencies planning to embark on the 5G journey should consider the following factors while developing implementation strategies or else run the risk of slow or impeded adoption.
Demystify 5G for Executives. The marketing hype is in full force and it is incumbent upon agency leaders to learn the key terminology, relevant use cases, timing, and characteristics of particular 5G technologies, and how 5G differs from previous analytic tools. Understanding the skills needed, development approaches, and characteristics of a successful 5G implementation will help organizations and selection committee members navigate the landscape of available 5G solutions, machine learning frameworks, and the large ecosystem of 5G carriers, OEMs and startups to determine what is real, and just as important, what is not.

Prove Mission Value Incrementally. It can be very difficult to discern which 5G technologies and use cases will bring value to a mission and by when. Taking time to outline agency aspirations, assess existing value chains, and explore opportunities for where 5G could solve specific mission problems can help prioritize where to start. Additionally, agencies should look to not create major disruptions to their mission; focus instead on narrowly scoped process improvements that are deployed into production environments to get executives, users, and stakeholders motivated to move onto the next 5G opportunity.

Invest in Talent. 5G talent is scarce and the battle for hiring and retaining experts can be fierce. Agencies will need to explore and implement strategies that balance between partnering with research and academic organizations, contracting for talent, and investing in building 5G talent in-house. Most agencies are not likely to have large pools of in-house technical 5G experts but can upskill those employees who have technical competencies through online and in-person technical courses. Those employees who are not technical should be trained to have a basic digital literacy, i.e., be familiar with what 5G is, how it works, and how to interact with it.

Contract Differently. Given the state of the current 5G technology and the availability of 5G talent, contracting 5G expertise or consultants can be an option for agencies that have strategies in place, use cases identified, and project goals well defined. In these scenarios, it is important that agency acquisition officials and contracting officers allow bidders to demonstrate their capabilities instead of telling you. Contracting labor-based 5G support services could be done in a phased approach where a Firm-fixed Price RFP is issued asking vendors to produce an initial operating capability based on the agency’s data, and then switch the model to allow for more development and enterprise scale. It might also be in the government’s best interest to consider buying 5G solutions at cost, rather than labor at level of effort. In this scenario, contracts would need to be set up to buy a mix of labor and 5G solutions/software in either a subscription or consumption-based buying model.

Do Not Let Culture Constrain the Pace of Adoption. Implementing 5G is no different than other technologies except that current hyperbole is creating additional anxiety and risk across an organization. To mitigate the concern, agencies should design a change management program that communicates both a common goal and the importance of 5G in empowering the workforce, not replacing them. This is essential to overcoming internal and external resistance to the adoption of 5G. Equally important, is being transparent with employees about the technology and involving them in the design of how they will ultimately collaborate with a machine.
Concluding Observations

- 5G is the next wireless revolution which most likely will affect all government agencies
- The three main application areas addressed are enhanced mobile broadband, ultra-reliable and low latency communications, and massive machine types
- It promises to enable many new and enhanced capabilities, such as augmented reality/virtual reality to improve field, medical, and military missions for improved citizen services and service delivery
- Applications, present and future, include 3D video, work in the cloud, augmented reality, industry automation, mission critical applications, self-driving cars, smart cities, voice, smart home buildings, gigabit communications, and many others
- However, 5G will be a gradual deployment nationally
- 4G / LTE will still be around for the long term, and 5G coverage will likely be deployed first in metropolitan areas in the short-term
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Glossary

Derived from a broad search of the available literature, these are the most commonly accepted definitions of the terms of the terms related to 5G technology (and which are included in the scope of 5G for this report).

**Artificial Intelligence (AI):** The field of computer science that deals with the simulation of intelligent behavior in computers or the capability of a machine to imitate intelligent human behavior. It is used broadly to refer to any algorithms, methods, or technologies that make a system act and/or behave like a human and includes machine learning, computer vision, natural language processing, cognitive, robotics, and related topics.

**New radio frequencies (NR)** – This simply refers to new radio frequency bands in which 5G networks can operate. These frequency bands are designated by the 3GPP in each of their releases.

**Antenna and Multi-user MIMO (MU-MIMO)** – MIMO means “Multiple-input and Multiple-output.” Antenna and Multi-User MIMO refer to methods by which data signals can be sent and received simultaneously.

**Small cells** – Small cells are special, low-powered wireless radio access nodes which have a short range from 10 meters to several kilometers. They are used as an alternative to larger macrocell towers for a variety of reasons.

**Beamforming** – This refers to a signal processing technique which is used to receive directional signals without interference, increasing throughput by allowing more wireless connections.

**Radio convergence** – This refers to the ability of 5G to “converge” with Wi-Fi, providing a more seamless experience when used in dense, indoor deployments.

**NOMA (Non-Orthogonal Multiple Access)** – NOMA is a method by which signals from multiple users can be separated and processed to support more connections and increase bandwidth and throughput.

**3rd Generation Partnership Project (3GPP)** – A consortium of global telecom organizations, which works to define the requirements of the 5G networks and standardize global telecommunications.

**Real-Time Communications (RTC)** – This refers to the simultaneous or near-simultaneous communication of data between two points, with negligible latency.

**Ethernet** – Ethernet is a family of cables and technologies used for LANs (local area networks), physically connecting computers to networking devices.

**VLAN (virtual LAN)** – Virtual LANs are defined using special software, allowing for network segmentation, traffic filtering, and the splitting of network traffic.

**Latency** – Latency is the time, usually measured in milliseconds, in which it takes for a signal to reach a destination and return to the user.
Spectrum – This refers to a specific set of broadband frequencies – measured in Hz – in which a wireless network operates.

Millimeter wave – This is an Extremely High Frequency (EHF) broadband technology, using wavelengths of 1-10 millimeters, which provide extremely high data throughput rates.

Full duplex – This term refers to a communication system which allows for simultaneous transmission and reception of data between two parties, such as between two people speaking on a telephone.

Fiber-only transmission – This term refers to wireless networks which exclusively use fiber-based cables to transmit data, without the use of older technologies like copper electrical cabling.

IP multimedia subsystems (IMS) – This refers to a specialized type of architectural framework, designated by the 3GPP, which is used to deploy multimedia services to mobile devices.

References


2 3GPP. December 22, 2017. First 5G NR Specs Approved. https://www.3gpp.org/news-events/1929-nsa_nr_5g


