



Updated January 31, 2020

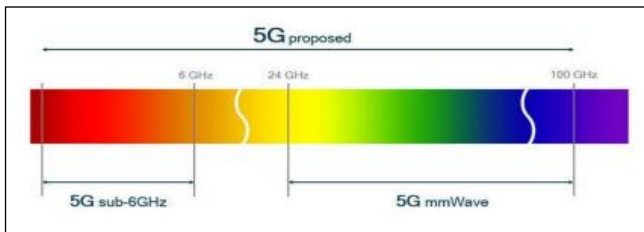
National Security Implications of Fifth Generation (5G) Mobile Technologies

The fifth generation (5G) of mobile technologies will increase the speed of data transfer and improve bandwidth over existing fourth generation (4G) technologies, in turn enabling new military and commercial applications. 5G technologies are expected to support interconnected or autonomous devices, such as smart homes, self-driving vehicles, precision agriculture systems, industrial machinery, and advanced robotics. In the military realm, 5G could additionally improve intelligence, surveillance, and reconnaissance systems and processing; enable new methods of command and control; and streamline logistics systems for increased efficiency, among other uses. As 5G technologies are developed and deployed, Congress may consider policies for spectrum management and national security, as well as implications for U.S. military operations.

Spectrum Management

5G requires deployment of technologies that work in various segments of the electromagnetic spectrum (“the spectrum”): sub-6, which operates below 6 GHz, and millimeter wave (MMW), which operates between around 24 and 300 GHz (see **Figure 1**).

Figure 1. 5G Proposed Spectrum



Source: https://media.defense.gov/2019/Apr/03/2002109302/-1/-1/0/DIB_5G_STUDY_04.03.19.PDF.

Millimeter waves allow for greater bandwidth and faster transfer rates, which some telecommunications companies have argued is required for autonomous vehicles and other data-intensive applications like smart cities; however, MMW travel comparatively short distances and can be absorbed by rain or disrupted by physical objects such as buildings and vehicles. As a result, 5G MMW technologies require installing a higher number of cell sites—at much higher cost and on a much slower deployment timeline than the sub-6 approach. 5G deployment thus relies on MMW for high-speed, high-bandwidth communications and on sub-6 waves for nationwide coverage.

Telecommunication companies around the world are deploying 5G in different ways. Chinese telecommunications companies are focusing on the less expensive sub-6 approach, while some U.S.

telecommunication providers are focused on MMW deployments and others on sub-6.

The Department of Defense (DOD), however, holds large portions of the usable spectrum. Although DOD uses certain MMW frequencies for high-profile military applications such as Advanced Extremely High Frequency satellites that provide assured global communications for U.S. forces, it extensively uses sub-6 frequencies—leaving less sub-6 availability in the United States than in other countries. The Defense Innovation Board (DIB) advised DOD to consider sharing sub-6 spectrum to facilitate the build-out of 5G networks and the development of 5G technologies used in the sub-6 band. While DOD has been moving toward greater spectrum sharing, it has expressed concern that sharing presents operational, interference, and security issues for DOD users. As an alternative to spectrum sharing, some analysts have argued that portions of the sub-6 spectrum should be reserved for commercial use. This would require DOD to relocate certain applications to other parts of the spectrum. The DIB estimates this approach would take around 10 years to complete, as opposed to 5 years for spectrum sharing.

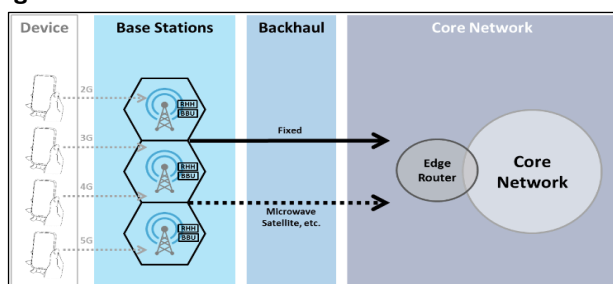
National Security Concerns

According to a DIB assessment, China is the current leader in sub-6 technologies and is likely to deploy the world’s first 5G wide-area network. Chinese companies, which often receive government subsidies (e.g., subsidized land for facilities, R&D grants), are therefore well-positioned as global 5G suppliers. Huawei alone has signed contracts for the construction of 5G infrastructure in around 30 countries, including U.S. allies Iceland, Turkey, and the United Kingdom.

Some experts are concerned that vulnerabilities in Chinese equipment could be used to conduct cyberattacks or military or industrial espionage. These experts claim vulnerabilities were introduced through the poor business practices of many Chinese companies. However, they note that vulnerabilities could also be intentionally introduced for malicious purposes. China’s National Intelligence Law, enacted in June 2017, declares that “any organization and citizen shall, in accordance with the law, support, provide assistance, and cooperate in national intelligence work, and guard the secrecy of any national intelligence work that they are aware of.” Some analysts interpret this law as requiring Chinese telecommunications companies to cooperate with intelligence services to include being compelled to install backdoors or provide private data to the government.

Other analysts argue that the risks posed by Chinese telecommunications equipment vary depending on the equipment's location within the cellular network architecture. Most cellular networks are broken into two groups: the core network, which provides the gateway to the internet and ensures devices meet the provider's standards, and the radio access network, composed of the cellular towers that broadcast and receive radio signals (see **Figure 2**). These analysts state that, while the risks posed by Chinese core networks are significant, the risks posed by Chinese radio access networks could be managed. Still other analysts have argued that having any Chinese equipment in the network could pose potential security concerns. Such concerns have prompted some analysts to argue that the United States should limit intelligence sharing with any country operating Chinese-supplied 5G equipment.

Figure 2. Cellular Network Architecture



Source: <https://medium.com/@miccowang/5g-c-ran-and-the-required-technology-breakthrough-a1b2babf774>.

Implications for Military Operations

5G technologies could have a number of potential military applications, particularly for autonomous vehicles, command and control (C2), logistics, maintenance, augmented and virtual reality, and intelligence, surveillance, and reconnaissance (ISR) systems—all of which would benefit from improved data rates and lower latency (time delay).

Autonomous military vehicles, like their commercial counterparts, could potentially circumvent on-board data processing limitations by storing large databases (e.g., maps) in the cloud. Safe vehicle operations would, in turn, require 5G's high data rates and low latency to quickly download off-board information and synthesize it with on-board sensor data. Likewise, 5G could be used to transfer sensor data between operators and uninhabited vehicles and to network vehicles, potentially enabling new military concepts of operations, such as swarming (i.e., cooperative behavior in which vehicles autonomously coordinate to achieve a task).

5G technologies could also be incorporated into ISR systems, which increasingly demand high-bandwidths to process, exploit, and disseminate information from a growing number of battlespace sensors. This could provide commanders with timely access to actionable intelligence data, in turn improving operational decisionmaking. Similarly, 5G could reduce latency in other data-intensive activities, such as logistics and maintenance, and could

additionally enable augmented or virtual reality environments that could enhance training.

Finally, command and control systems could benefit from the high speed, low latency capability of 5G. For example, the U.S. military currently uses satellite communications for the preponderance of its long-distance communications. However, satellites on orbit can significantly increase latency due to the amount of distance a signal needs to travel, causing delays in the execution of military operations.

Although DOD is in the initial stages of testing and experimentation for 5G applications, it has selected four military installations as test beds. A draft request for prototype proposals (RPP) has been issued for Marine Corps Logistics Base Albany, Georgia (smart warehouses), and Hill Air Force Base, Utah (spectrum sharing). DOD has also announced plans to issue RPPs for Joint Base Lewis-McChord, Washington (augmented and virtual reality), and Naval Base San Diego, California (smart warehouses).

Potential Questions for Congress

- What approach to spectrum management (e.g., spectrum sharing, spectrum reallocation) will best protect DOD missions while meeting growing commercial demands?
- What are the risks to U.S. national security posed by Chinese 5G infrastructure in allied and partner nations? Can that risk be managed and, if so, how?
- What impact would the use of Chinese 5G infrastructure by allied and partner nations have on military effectiveness and interoperability? Should the United States limit intelligence sharing with countries operating Chinese-supplied 5G equipment?
- Are any changes to operational concepts, force structure, doctrine, or posture required as a result of developments in or applications of military 5G?

CRS Products

CRS Report R45485, *Fifth-Generation (5G) Telecommunications Technologies: Issues for Congress*, by Jill C. Gallagher and Michael E. DeVine

CRS In Focus IF11155, *Defense Primer: Military Use of the Electromagnetic Spectrum*, by John R. Hoehn

Other Resources

Defense Innovation Board, *The 5G Ecosystem: Risks and Opportunities for DOD*, April 2019, https://media.defense.gov/2019/Apr/03/2002109302/-1/-1/0/DIB_5G_STUDY_04.03.19.PDF

Defense Science Board, *Defense Applications of 5G Network Technology*, June 24, 2019, https://dsb.cto.mil/reports/2010s/5G_Executive_Summary_2019.pdf.

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