5G Technology and the DoD: Enabling Joint Logistics for the Future Joint Force

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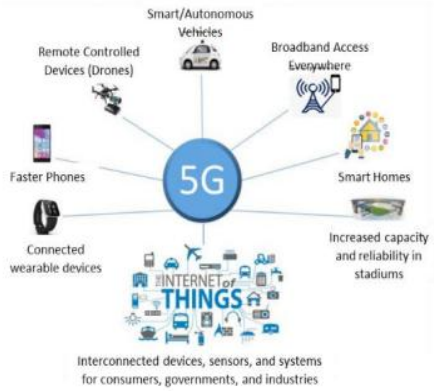
Abstract

An increasing number of countries are establishing and implementing 5G infrastructures to take advantage of the increased responsiveness and agility inherent in the technology. The United States Department of Defense (DoD) should invest resources into 5G to ensure its logistics depots, trusted global supply chain, and joint force systems can operate on a secure 5G spectrum. This article will explore how **5G technology, in conjunction with appropriate physical and virtual infrastructure upgrades, can improve the DoD's ability to provide materiel and commodity solutions quickly and efficiently while simultaneously enhancing the Joint Logistics Common Operating Picture (LCOP).**

Introduction to 5G

In the past decade, smart phone owners around the world have become familiar with the power of 4G and 4G LTE mobile communication technology in their everyday lives. The "G" in 4G represents the fourth "Generation" of wireless mobile communication technology. Starting in the early 1980s, first-generation (1G) was released to provide basic voice services over bulky and expensive mobile phones, as depicted in Table 1. Progressively through subsequent decades, generations of mobile communication technologies have vastly improved, providing new capabilities and functionalities that have changed how we do business, how we communicate, how we travel, and how we access information and entertainment.[i]

Table 1. Generations of Mobile Communication Technologies

	1G	2G	3G	4G	5G
DEPLOYED	1980s	1990s	2000s	2010 -	2018 -
DEVICES					
FUNCTIONS	• First mobile phone • Basic voice services • Limited coverage • Expensive	• Voice and some text • Digital standards offered higher quality voice • More coverage • More affordable	• Voice, data and access to the internet (email, audio and video) • First mobile broadband • iPhone was introduced • People begin using their phones as computers	• Voice, data, high-speed access to the internet on smartphones, tablets, laptops • True mobile broadband; unlimited plans; devices used as hotspots • Streaming, new applications, online gaming	
SPEED	0.002 Mbps	0.064 Mbps	2-10 Mbps	10-100 Mbps	1000-1400 Mbps
TIME TO DOWNLOAD 2-HR MOVIE	N/A	N/A	10-26 hours	6 minutes	3-4 seconds

Source: Created by CRS, adapted from multiple sources, including Frank K. Baneseka and Stephen Dotse, "New Developments and Research Challenges for 5G," *International Journal of Current Research*, vol. 9, no. 2 (February 2017), p. 46627; Stephen Shankland, "How 5G will push a supercharged network to your phone, home, car," *CNET*, March 2, 2015, at https://www.cnet.com/news/how-5g-will-push-a-supercharged-network-to-your-phone-home-and-car/.

In early 2019, Verizon and AT&T[ii] launched the next standard for wireless communications, 5G wireless technology, in four selected U.S. cities. 5G technology promises to "revolutionize"[iii] society in coming years by increasing the data transmission capacity exponentially, enabling low-latency data sharing and real-time collaboration on immense scales. For example, a 5G device on a 5G network will be able to download a two-hour movie in a mere 3-4 seconds whereas a 4G LTE connected device would require about 6 minutes for the same download.[iv]

Although engineers have been developing 5G standards for years, 5G implementation is still in its early stages and extensive implementation is projected to occur through the 2020s, widening its availability. Logisticians across the U.S. Armed Forces stand to gain tremendous efficiencies from employing 5G to increase access to volumes data previously too burdensome to amalgamate and process.

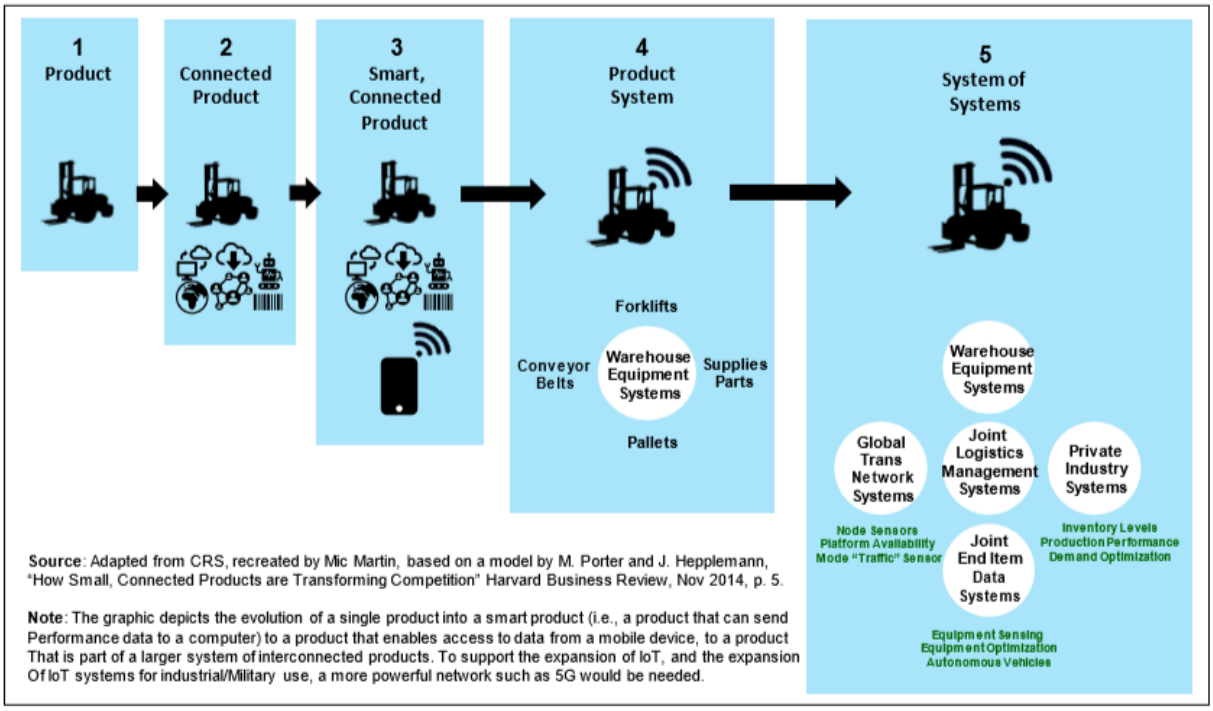
5G networks can improve the Joint Logistics Enterprise of the future by enabling the growth and implementation of three interrelated technologies: The Internet of Things (IoT), supply chain automation, and artificial intelligence (AI).

Capitalizing on 5G through IoT, Automation, and AI in Joint Logistics

"The Internet of Things is a network of physical objects that are digitally connected to sense, monitor and interact within a company and between the company and its supply chain enabling agility, visibility, tracking and information sharing to facilitate timely planning, control and coordination of the supply chain processes."[v]

Harnessing Internet of Things (IoT) technology can significantly improve the Joint Logistics Enterprise (JLEnt) by informing the Joint Logistics Common Operating Picture (LCOP) while operating on 5G networks that can sustain IoT proliferation and device loads. Military logisticians can gain efficiencies via automated systems and AI for part and supply inventory and supply chain management. Automated guided vehicles (AGV) such as drones, forklifts, and robots operating in supply depots and warehouses could collect and feed vast volumes of data to AI, leading to automatic reordering of supplies when stock objectives fall below a threshold and more complicated tasks like monitoring and diagnosing military equipment. Logisticians could harness these data to conduct predictive analysis on what repair parts would be needed, how many, and at what locations, as illustrated in Figure 1.

Figure 1. Internet of Things (IoT): Smart Forklift Example



IoT in Inventory Management

Imagine having a constant, real-time visibility of supplies in transit from the factory floor to the battlefield. Employing the IoT with 5G can make this vision a reality. "The greater bandwidth [of 5G] can accommodate up to a million sensors within a square kilometer at speeds at least 10 times greater than anything else available."[vi] Small electronic tags with years of battery life can be affixed to items in the military stock system and communicate with a cloud-hosted tracking system.[vii] Logisticians can query the system at any time to determine the item's real-time location. "IoT will allow the reduction in the time between data capture and decision-making that enables supply chains to react to changes in real time allowing levels of agility and responsiveness never experienced before."[viii]

In 2018 the Mediterranean Shipping Company (MSC) saw the potential in leveraging the IoT and outfitted 50,000 dry-cargo shipping containers with TRAXENS-brand IoT devices. Now, in addition to end-to-end, real-time visibility of a container's location, MSC is able to track the container's temperature, humidity level, shocks and vibrations experienced (conditions during shipment), and when the doors open and close (tamper-status/security). To provide connectivity at sea, MSC installed base

stations on their ships that relayed communications between the smart containers and off-ship servers.[ix] These tracking and data-collection capabilities provided MSC with multiple competitive advantages over non IoT-equipped companies.

Currently, many items in the military stock system have barcodes that personnel manually scan to track the location of items. But that tracking data point is only current at the moment scanned. Who knows where that item is after a day has elapsed? Leveraging IoT concepts with the connectivity of 5G would automate tracking in real-time. Furthermore, the wealth of data that logisticians could collect and analyze would reveal other areas in the supply chain in which there are room for improvement.[x]

Supply Chain Automation

Implementation of the IoT across the U.S. military services' logistics systems would additionally enable automation, leading to integrated joint warehousing. For example, a unit could submit a supply request that is then fulfilled by the most expedient distribution center location, potentially crossing Military Services' inventories. Implementing 5G-connected automated systems within distribution centers would increase efficiency and accuracy in the supply chain while reducing the manpower needed to move, track, and inventory supplies.

The supply chain has two major segments: The first segment is the stocking of appropriate quantities of supplies within a distribution center and the local movement of supplies within distribution centers, including to and from drop points for interfacing with delivery vehicles. The second segment is the transportation of goods from the distribution center drop points to the end users. 5G technology can benefit both segments.

For the items stocked in the distribution centers, 5G's capability to convey large volumes of data rapidly would enable precise inventories in real-time by scanning for electronic tags, continuously maintaining a cloud-hosted database. Unlike its predecessor, 5G also facilitates sub-one-meter positioning accuracy.[xi]

Implementation of 5G networks within distribution centers can transform them into smart distribution centers with automated workflows. Automated guided vehicles (AGVs) could rapidly and efficiently complete the movement of stock from storage locations to drop points. AGV developers are equipping AVGs with computer vision and AI to plan their own movements based on warehouse lay-outs and the human activity around them, maximizing efficiencies in traversing the shortest paths and automatically keeping the inventory database current.[xii]

Once stock departs the distribution center, the second segment of the supply chain begins. Just like supplies in the distribution center, near-real-time location updates from the same electronic tags are also possible during transit via 5G. Military supply chains can be long and the reliable receipt of parts can be critical. Such a tracking system, accessible from the DoD Information Network, would allow distributors and end users to track supplies en route, more accurately predict when they will be received, and plan accordingly.

Of the supply chain automation functionality described, there are limited practical applications via existing 4G, Wi-Fi, and wired networks. But 5G overcomes connection density and latency limitations of 4G, the interoperability challenges in transitioning between Wi-Fi instantiations, and mobility limitations of wired networks. In other words, 5G is a critical component to automating military logistics.

Taking Automation One Step Further

The introduction 5G technology is also contributing to the development of self-driving vehicles, which military logisticians could employ in the second segment of the supply chain. Automotive companies, including Uber, Waymo, Tesla, and Toyota, are already testing autonomous vehicles[xiii] and hope to start limited deployments soon. Extensive development efforts will still be needed, however, before autonomous vehicles become mainstream. Once autonomous vehicles are available, using them for commodities transport could reduce the payroll cost of transport logistics and increase capacity. This dual benefit would be accomplished by removing the limitations of the human element, like fatigue. Ford Motor Company is developing autonomous vehicles and focusing on their employment for delivery services.[xiv] Successful, though limited, deployments of autonomous commodities delivery trucks have already been implemented in the civilian sector by the United Parcel Service (UPS),[xv] United States Postal Service (USPS),[xvi] Uber,[xvii] and others.

Research and development for stock delivery via AGVs is not limited to ground-based vehicles but includes aerial platforms as well. Large distributors, including Amazon and UPS, are researching the feasibility of having drones deliver stock from distribution centers to end users.[xviii] In April 2019, the U.S. Federal Aviation Administration (FAA) granted the first Air Carrier Certification to a drone delivery company, Wing, which plans to begin delivery services in the Fall of 2019.[xix] Its initial customers will include FedEx Express and Walgreens.[xx]

Transport is not the limit, however, of military logisticians employing AGVs. The logistics enterprise can save valuable man-hours by using AGVs to conduct inventories of items not yet tagged with 5G tracking devices. Drones can already conduct inventories more quickly and accurately than humans, flying along distribution center shelves or through storage lots, scanning sensor tags on containers.[xxi]

The retail giant Walmart provides an example of the benefits of AGVs in inventory management. Walmart moves a tremendous volume of inventory each year to stock 75 million distinct products and support 11,300 stores globally.[xxii] Walmart invests in cutting-edge technological research for inventory management, which Walmart credits to its success.[xxiii] In 2016, Walmart began researching and developing drones for their warehouses. The drones were designed canvass a distribution center, scanning and reporting when stock reached low levels or was not in pre-designated storage locations.[xxiv] In 2017, Walmart was granted a patent for drones to transport stock within its stores to restock shelves.[xxv] Moving forward into the 2020s, AGV applications enabled by 5G are likely to become the norm, providing efficiency and accuracy for large distribution centers.

Artificial Intelligence (AI) in the Joint Logistics Planning System (JLPS)

The U.S. Department of Defense defines AI as:

> *"…the ability of machines to perform tasks that normally require human intelligence – for example, recognizing patterns, learning from experience, drawing conclusions, making predictions, or taking action – whether digitally or as the smart software behind autonomous physical systems."*[xxvi]

Some experts tout AI as the "next Industrial Revolution."[xxvii] The surge of interest in enhancing financial, medical, and military institutions via AI is intensifying radically as more people are seeing the potential benefits. In late 2018, DoD established a Joint Artificial Intelligence Center (JAIC) to "accelerate the

delivery of AI-enabled capabilities, scale the Department-wide impact of AI, and synchronize DoD AI activities to expand Joint Force advantages."[xxviii]

Already, the military has started implementing a wide range of existing AI solutions to improve current operations, including in Iraq and Syria. Fields ripe for AI include cyber defense, command and control, intelligence collection and analysis, logistics, and propagation of robots and drones in medical evacuation, resupply, and surveillance.[xxix]

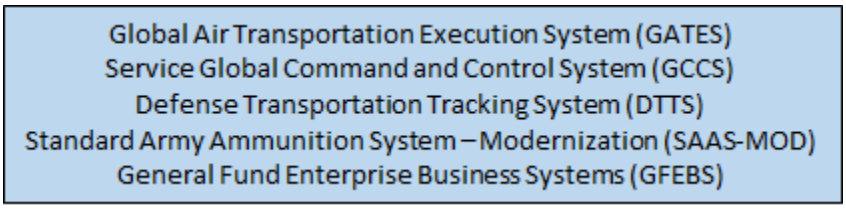
Improving the Joint Logistics Enterprise through the application of AI in its supply chain management systems can ultimately lead to more cost-effective and time-efficient resupply and sustainment of the Joint Force. For example, in late 2017 the Logistics Support Activity (LOGSA) worked with the International Business Machines (IBM) Corporation to apply AI in analyzing all of its repair parts shipping requests; from the efficiencies gained, LOGSA projects a cost savings of over $100 million per year, once the AI algorithms are fully implemented.[xxx]

For AI to function well, it needs lots of relevant data. 5G networks would enable the high-speed data throughput necessary for relaying the massive volumes of data from the ever-growing number of devices connected to the network, including mobile phones, IoT devices (estimated to reach 20 billion devices by 2020), and AGVs.[xxxi] AI in turn provides the methods to analyze and learn from the voluminous data.[xxxii]

Furthermore, 5G, when combined with the IoT, an automated supply chain, and AI, is an enabler of Just-in-Time (JIT) logistics, a system in which logisticians can lower stagnant stock levels, while still accounting for fluctuations in demand.[xxxiii] The ability to track inventories in near-real-time via 5G would permit distribution centers to manage stock levels more efficiently. Thus, JIT logistics in this construct could minimize expensive overhead globally by reducing the need for excess inventory that warehouses currently retain to cover gaps in the Logistics Common Operational Picture (LCOP).

Continued investment in and leveraging of AI in conjunction with 5G and the IoT within the JLPS (of which the components are listed in Figure 2) can ultimately lead to enhanced mission and enterprise performance through gains in the following areas: efficiency of data analysis, streamlining business processes, supply and maintenance prediction, shortening decision cycles, and increasing awareness of the operational environment through collaboration between members of the JLEnt, joint planners, and Commanders.

Figure 2. Joint Logistics Planning Systems



Risk Considerations

There are inherent risks in using wireless communications in any military situation. Risks are the combination of threats and vulnerabilities. In employing 5G communications to support military logistics, detection of the communications and subsequent enumeration of military assets, integrity and

confidentiality of the data communicated, and continued availability of the radio frequency (RF) spectrum for 5G are all concerns to be addressed before implementation.

Risks in Telecommunications Equipment

The greatest threat to achieving and maintaining secure communications over 5G networks seems to reside in the telecommunications equipment provisioning the communications media. The Chinese telecommunications company Huawei is highly suspected to be connected with and subsidized by the Chinese Government. As such, Huawei's systems likely contain virtual backdoors that China could exploit for espionage purposes or to affect telecommunications services.[xxxiv,xxxv] With Huawei's initiative in deploying 5G networks faster than its competitors, it is possible that U.S. forces would need to operate in an area with established Chinese-built 5G networks. This is not a reason to avoid 5G employment within the U.S. Military, but it is a necessary consideration when analyzing the operational environment and mitigating the risk.

Detection and Enumeration

Whenever there is an active RF transmitter, there exists a capability for both intended and unintended recipients to receive that signal. The physics involved in wave propagation through an environment determine how signal strength decreases as range from the transmitter increases. Essentially, any receiver can listen to a transmitted signal when within a sufficient range. Detectable signals may or may not be a problem for military installations. In populated areas where there are relatively high concentrations of 5G devices, these military logistics devices would not likely stand-out as something abnormal; however, if a cluster of 5G devices suddenly pops up in the desert, it could draw attention to a clandestine operation.

When the U.S. Military operates in an area that is not friendly to the U.S. (whether rooted in politics or network equipment manufacturer), malicious actors could employ multiple receivers to triangulate the position of each 5G device and enumerate the devices. When plotting these device locations on a map, especially over time, an actor could then discern characteristics like supply staging areas, resupply and convoy routes, and troop locations, thus potentially inferring the U.S. force laydown. Regardless, one may counterargue that the U.S. is already vulnerable to this type of enumeration because of blue force tracking systems, in which many personnel and equipment already have transmitter-equipped trackers.[xxxvi] When operating in hostile areas, commanders should have the option to effect a transmit-inhibit state for any transmit-capable devices.

Data Confidentiality and Integrity

Data confidentiality can also be a concern, especially given the prevalence of 5G network equipment coming from companies with questionable motives; however, the data can be encrypted relatively easily. Cryptographers primarily assess encryption strength by the quality of the algorithm and the length of the key (a longer key length is more difficult to crack). Although sufficient encryption may ensure data confidentiality, a malicious actor could discern simply from changes in patterns in the volume of traffic when the U.S. Military increases its operational tempo in an area.

Having data integrity is like having a tamper seal on a container. If data integrity controls are in place, then the recipient can discern whether the data are unchanged from what the sender transmitted. Even if the signal was hacked and data corrupted, if data integrity measures are in place, the unauthorized modification would not result in incorrect items being dispatched or to an incorrect location. Instead,

the device receiving the data that fail the integrity checks would request retransmission. In the worst case, all of the retransmitted data would also fail the integrity checks, thus effecting a denial of service. Mitigating this type of jamming vulnerability that reshapes the signal in the electromagnetic spectrum requires mostly engineering-level improvements,[xxxvii] improvements that DoD could require for its 5G device acquisition contracts.

Spectrum Availability

There are also significant hurdles in adopting 5G. The most significant hurdle is the requirement for new infrastructure to operate in the radio frequency spectrum bands allocated for 5G communications. This hurdle will be overcome once telecommunications companies build sprawling 5G network infrastructures. In the meantime and in any location lacking 5G coverage, including at sea and in the air, DoD could acquire and establish military-operated 5G base stations that act as intermediaries, converting the signal to some other military communications medium, like a satellite communications signal.

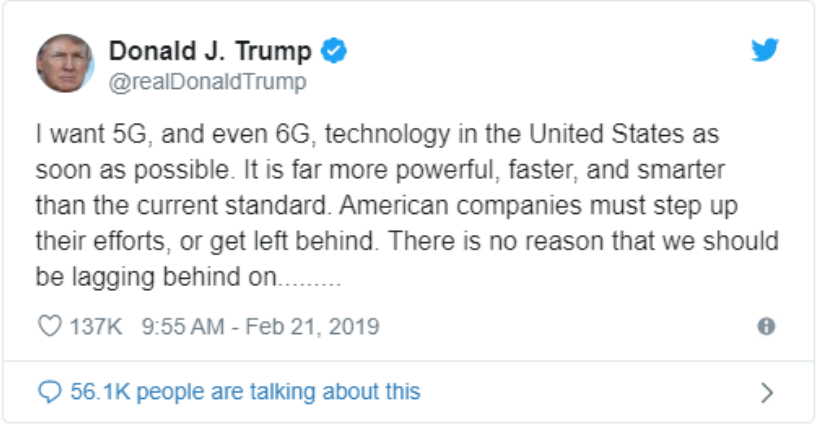
Vulnerabilities to the U.S. Military utilizing the 5G spectrum can include adversary activity to effect a denial of service. What if the local telecommunications provider's headquarters is in a country that is not friendly to the U.S.? Outside of U.S. telecommunications companies' 5G coverage, the U.S. Military needs to consider the availability of 5G communications to be an assumption, rather than a fact, in operational planning. As an assumed capability, military planners, communicators, and logisticians need to consider alternative means of communications to mitigate the loss of 5G, which may include using an alternate 5G provider or establishing a military-operated 5G base station.

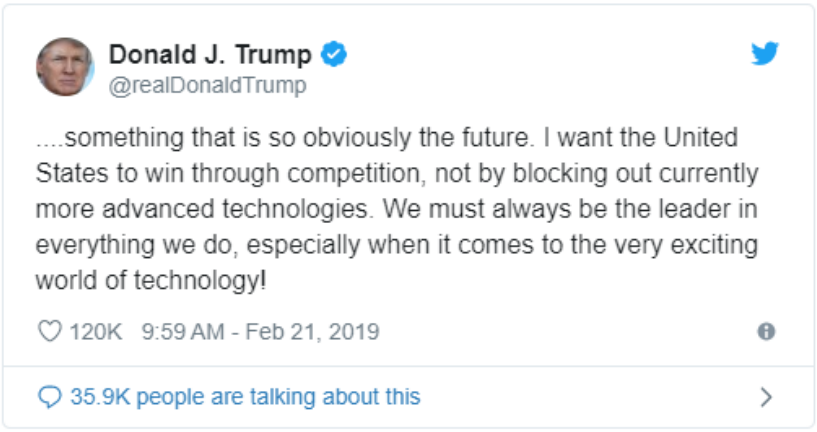
5G and the U.S. Government

Encouragingly, over the past two years, the U.S. Government has been attempting to create government structure and partnership with private industry to support the development of 5G, AI, and Autonomous Systems. For example, the Army's new Futures Command has partnered with one of the preeminent world institutions for computer science and robotics, Carnegie Mellon University, on AI and robotics research and development.[xxxviii] The continued efforts of Defense Advanced Research Projects Agency (DARPA), through its two-billion-dollar investment in the AI Next Campaign and the Defense Innovation Unit, continue to conduct groundbreaking work on research and development as well.[xxxix]

The current Administration and Congress have demonstrated bipartisan support toward implementing 5G in the U.S. by passing 23 legislative items in the past year.[xl] In addition, the White House hosted a 5G summit in September 2018, substantiating its importance and President Trump further expressed his support in a pair of February 2019 Tweets shown in Figure 3 for the U.S. to be the global leader in 5G and other emerging technologies.

Figure 3. Presidential Tweets Regarding 5G





Work remains in making 5G a truly robust and viable network in the U.S. and world-wide. The Defense Innovation Board (DIB) released a report in April 2019 detailing the proposed adoption of 5G and the opportunities, threats, and strategic decision points that come with it. Before investing in 5G infrastructure and devices, the DoD must choose which of the two 5G frequency bands it will utilize. The decision may affect the cost of implementation, the time until 5G can be operational, and whether the U.S. standard will be interoperable with the worldwide standard. Increased cooperation with private industry and competitors is necessary to drive the quicker adoption of viable 5G infrastructure and networks for DoD.[xli]

Conclusion

Implementation of 5G technology in the DoD can provide improved Joint Logistics responsiveness, accuracy, flexibility, and economy around the globe, both now and increasingly so in the future, by enhancing inventory control, reordering, supply analytics, maintenance analytics, autonomous warehouses, and the method by which the Joint Force conducts resupply. These gains collectively outweigh 5G limitations. As with any new technology there is a degree of risk, but the risk can be mitigated if networks, hardware, and devices are designed with the inherent risks considered and appropriately addressed. Many U.S. allies as well as competitors have already begun implementation of 5G technology for various purposes, leaving the U.S. and DoD lagging behind the 5G implementation curve. The DoD should make a concerted effort with other government agencies and private industry to

execute a viable way forward for 5G that can provide a Joint Logistics advantage for the U.S. when projecting power across the globe.

References

[i] Congressional Research Service, Report #45485, Fifth-Generation (5G) Telecommunications, by Jill C. Gallagher and Michael E. DeVine

[ii] Clark, Don. "What Is 5G? Here's What You Need to Know About the New Cellular Network." *The New York Times*, December 31, 2018, sec. Technology. https://www.nytimes.com/2018/12/31/technology/personaltech/5g-what-you-need-to-know.html.

[iii] POLITICO. "5G Explained." Accessed October 20, 2019. https://www.politico.com/sponsor-content/2018/11/5g-explained.

[iv] CRS Report #45485, Fifth-Generation (5G) Telecommunications, January 30, 2019, by Jill C. Gallagher and Michael E. DeVine

[v] Ben-Daya, Mohamed, Elkafi Hassini, and Zied Bahroun. "Internet of Things and Supply Chain Management: A Literature Review." *International Journal of Production Research* 57, no. 15–16 (August 29, 2019): 4719–42. https://doi.org/10.1080/00207543.2017.1402140. p. 4,721.

[vi] Guillot, Craig. "5G: The Great Warehouse Enabler." *Supply Chain Dive*, April 2, 2019. https://www.supplychaindive.com/news/5g-warehouse-enabler-connectivity-IoT/551749/.

[vii] "Wireless Sensor Tags." n.d. http://wirelesstag.net/.

[viii] Ben-Daya, Mohamed, Elkafi Hassini, and Zied Bahroun. "Internet of Things and Supply Chain Management: A Literature Review." *International Journal of Production Research* 57, no. 15–16 (August 29, 2019): 4719–42. https://doi.org/10.1080/00207543.2017.1402140. p. 4,720.

[ix] Mediterranean Shipping Company (MSC). "MSC Accelerates Deployment of Smart Containers for Customers," October 15, 2018. https://www.msc.com/usa/press/press-releases/2018-october/msc-accelerates-deployment-of-smart-containers-for.

[x] TRAXENS. *How Importers and Exporters Benefit from Smart Containers by TRAXƎNS*, 2016. https://vimeo.com/155658816.

[xi] Koivisto, Mike, Mario Costa Hakkarainen, Petteri Kela, and Mikko Valkama. 2017. "High-Efficiency Device Positioning and Location-Aware Communications in Dense 5G Networks." *IEEE Communications Magazine*, 2017. https://tutcris.tut.fi/portal/files/13520343/main.pdf.

[xii] "Autonomous Forklift Trucks Which Will Work with Humans Are Being Developed." 2017. PHYS ORG. November 3, 2017. https://phys.org/news/2017-11-autonomous-forklift-trucks-humans.html.

[xiii] Khosravi, Bijan. 2018. "Autonomous Cars Won't Work - Until We Have 5G." Forbes. March 25, 2018. https://www.forbes.com/sites/bijankhosravi/2018/03/25/autonomous-cars-wont-work-until-we-have-5g/#5578cddb437e).

[xiv] Markman, Jon. 2019. "Autonomous Delivery Trucks Are On Their Way." Forbes. January 28, 2019. https://www.forbes.com/sites/jonmarkman/2019/01/28/autonomous-delivery-trucks-are-on-their-way/#66761aaf1fa7.

[xv] O'Kane, Sean. 2019. "UPS Has Been Quietly Delivering Cargo Using Self-Driving Trucks." The Verge. August 15, 2019. https://www.theverge.com/2019/8/15/20805994/ups-self-driving-trucks-autonomous-delivery-tusimple.

[xvi] O'Kane, Sean. 2019. "US Postal Service Will Use Autonomous Big Rigs to Ship Mail in New Test." The Verge. May 21, 2019. https://www.theverge.com/2019/5/21/18633904/usps-postal-service-autonomous-big-rigs-ship-mail-test.

[xvii] Newcomer, Eric, and Alex Webb. 2016. "Uber Self-Driving Truck Packed With Budweiser Makes First Delivery in Colorado." Bloomberg: Technology. October 25, 2016. https://www.bloomberg.com/news/articles/2016-10-25/uber-self-driving-truck-packed-with-budweiser-makes-first-delivery-in-colorado.

[xviii] Vanian, Jonathan. 2017. "Drones May One Day Buzz Inside a Walmart Near You." Fortune. March 17, 2017. https://fortune.com/2017/03/17/walmart-drone-delivery-patent/.

[xix] Fisher, Christine. 2019. "Alphabet's Wing Drones Will Soon Deliver FedEx and Walgreens Packages." Engadget. September 19, 2019. https://www.engadget.com/2019/09/19/alphabet-wing-drone-delivery-fedex-walgreens/.

[xx] Fisher, Christine. 2019. "Alphabet's Wing Drones Will Soon Deliver FedEx and Walgreens Packages." Engadget. September 19, 2019. https://www.engadget.com/2019/09/19/alphabet-wing-drone-delivery-fedex-walgreens/.
[xxi] Wollenhaupt, Gary. 2018. "Move over Delivery Drones, Warehouse Drones Are Ready for the Spotlight." Supply Chain Dive. August 28, 2018. https://www.supplychaindive.com/news/move-over-delivery-drones-warehouse-drones-are-ready-for-the-spotlight/531038/.
[xxii] "60 Amazing Walmart Statistics and Facts (2019) By the Numbers." 2019. DMR Business Statistics. September 6, 2019. https://expandedramblings.com/index.php/walmart-statistics/).
[xxiii] Greenspan, Roberta. 2019. "Walmart's Inventory Management." Panmore Institute. February 21, 2019. panmore.com/walmart-inventory-management.
[xxiv] Wollenhaupt, Gary. 2018. "Move over Delivery Drones, Warehouse Drones Are Ready for the Spotlight." Supply Chain Dive. August 28, 2018. https://www.supplychaindive.com/news/move-over-delivery-drones-warehouse-drones-are-ready-for-the-spotlight/531038/.
[xxv] Vanian, Jonathan. 2017. "Drones May One Day Buzz Inside a Walmart Near You." Fortune. March 17, 2017. https://fortune.com/2017/03/17/walmart-drone-delivery-patent/.
[xxvi] Department of Defense, Summary of the 2018 Department of Defense Artificial Intelligence Strategy
[xxvii] Robot Revolution-"Global Robot & AI Primer", Bank of America Merrill Lynch, December 15, 2015, http://www.bofaml.com/content/dam/boamlimages/documents/PDFs/robotics_and_ai_condensed_primer.pdf
[xxviii] Department of Defense, Summary of the 2018 Department of Defense Artificial Intelligence Strategy
[xxix] Congressional Research Service, "Artificial Intelligence and National Security" report #R45178, by Daniel S. Hoadley while he was a U.S. Air Force Fellow at the Congressional Research Service. It has been updated by Kelley M. Sayler.
[xxx] Adam Stone, "Army Logistics Integrating New AI, Cloud Capabilities," September 7, 2017, https://www.c4isrnet.com/home/2017/09/07/army-logistics-integrating-new-ai-cloud-capabilities/.
[xxxi] IEEE Future Networks, IEEE Future Networks Transmissions Podcast, 5G for Large Scale Wireless Communications Between Autonomous Vehicles, 19 July 2018.
[xxxii] Dobariya, Pinal. 2019. "AI-5G Introduction Part - 1." VIAVI Solutions. October 13, 2019. https://www.blacktechnoguys.com/2019/10/ai-5g-introduction-part-1.html.
[xxxiii] Juneja, Prachi. n.d. "Inventory Management and Just In Time (JIT)." Management Study Guide. https://www.managementstudyguide.com/inventory-management-and-just-in-time.htm.
[xxxiv] "Huawei: Why Has UK Not Blocked Chinese Firm's 5G Kit?" *BBC*, November 28, 2018. https://www.bbc.com/news/technology-46370014.
[xxxv] Borghard, Erica, and Shawn Lonergan. "The Overlooked Military Implications of the 5G Debate." Council on Foreign Relations. *Net Politics and Digital Cyberspace Policy Program* (blog), April 25, 2019. https://www.cfr.org/blog/overlooked-military-implications-5g-debate.
[xxxvi] Bailey, Kathryn. "Soldiers 'fight on Arrival' with New Blue Force Tracking System." *U.S. Army*, February 27, 2015. https://www.army.mil/article/143595/Soldiers_fight_on_arrival_with_new_blue_force_tracking_system/.
[xxxvii] Marojevic, Vuk. "5G NR Jamming, Spoofing, and Sniffing: Threat Assessment and Mitigation." n.d. https://www.nitrd.gov/nitrdgroups/images/7/77/5G-NR-Jamming-Vuk-Marojevic.pdf.
[xxxviii] Scharre, Paul. *Army of None*. p.219, 1st ed. Norton, 2018.
[xxxix] "AI Next Campaign." Accessed October 22, 2019. https://www.darpa.mil/work-with-us/ai-next-campaign.
[xl] Lawfare. "What Congress Is (And Isn't) Doing on 5G," August 28, 2019. https://www.lawfareblog.com/what-congress-and-isnt-doing-5g.
[xli] Medin, Milo, and Gilman Louie. "The 5G Ecosystem: Risks & Opportunities for DoD," 2019, 33.

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