

Thesis Project Portfolio

Design of a Light Attack Aircraft for the AIAA Undergraduate Competition
(Technical Report)

Military Funding of 5G Technology and the Spin Around Concept
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Brendan Kroger Schneider
Spring, 2020
Department of Aerospace Engineering

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A Research Paper submitted to the Department of Engineering and Society

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Military Funding of 5G Technology and the Spin Around Concept

Introduction

The U.S. Military and others around the world invest hundreds of millions of dollars a year in research and development of new technologies. The issue with this is where the money is being spent by big governments. Due to the large number of private sector technology companies, the U.S. government is almost forced into utilizing those companies for their own goals through research of new technologies (Amadeo, 2020). This then means that private companies are being funded by the military to produce a product for them rather than for the commercial sector. For the private companies the military is just like another customer but with much larger pockets. It would be beneficial to the private companies to produce products and technologies that benefit their large investor that is the U.S. Military. The question that arises from this situation is would companies produce different products and technologies that would benefit society if their funds were from a source that was not the U.S. Military. Alternatively, what effect does large military funding of research and development in the private sector have on the trajectory of technological development. If the two sectors, government and private, are able to work together cohesively with similar end goals in mind, a successful spin around effect can be achieved in which both parties are mutually beneficial. One new technology that has seen a large investment by the U.S. government and Military is 5G technology. This is an interesting technology to focus on because it has been utilized for military purposes but is also a huge product in the commercial sector. The spin around effects of private company research of 5G technology utilizing military resources could have great outcomes for all American actors involved in the 5G technology revolution.

Background

It is important to understand, first, why The Military invests such a large portion of their budget on research and development of new technologies. The simple answer is that technological superiority has become the U.S. Military's number one form of defense. In *America Inc?* by Linda Weiss she talks about America's "National Security State" (NSS). She states that the NSS goal is to achieve and maintain technological superiority over the world. With this philosophy it can be seen as a way of defense because if The U.S. has the best and most advanced technology, an adversary would not initiate conflict due to having inferior technology to fight the battle. On the surface this sounds like a great way of defending the country without conflict. However, this means that the military must invest tons of money to maintain that technological superiority and that money is given to private sector companies to do the research for the government.

The NSS, since World War II, has driven the pursuit of new technology and emerging industries which in turn has created a high tech commercial sector. It is important to note, though, that the NSS pursues technological innovation to sustain military primacy not to advance commercial success. This motivation combined with the dwindling number of defense contractors and growing number of private sector technology companies meant the NSS needed to update its business model. The NSS was forced to look outside of its normal defense contractors for technological innovation meaning emphasizing commercial opportunity in military research and endeavors. This caused the lines between commercialized and militarized technologies to be intertwined. With this new strategy of funding private corporations, the NSS now has a greater influence than ever on the trajectory of technology innovation (Weiss, 2014).

Investment from the military in the private sector is not necessarily a bad thing, though. Without large investments, technology would not advance at the rate in which it has and given us all the great technologies that we utilize everyday, including 5G. The idea of “spin off” and “spin on” technologies is brought up in *America Inc?*. Spin off refers to technologies made specifically for military application that then found a place in the commercial sector. A great example of this is the vacuuming robot many people have in their homes, the Roomba. The company behind Roomba is iRobot and they did not start out by making helpful tools to clean your house. iRobot’s first products were actually used for space exploration and mine sweeping in war zones. In fact, the same year iRobot’s Packbot was deployed with U.S. troops for the first time is the same year that the first Roomba was released. This shows how research into military technologies can produce spin off products for the commercial sector that are both beneficial and innovative (History of iRobot).

A spin on technology refers to research for a commercial product that can then be utilized for military purposes. Spin on is a more modern term as the idea did not quite exist until the cold war when advanced technology private sector companies were more prevalent. This philosophy encourages private companies to research advanced technologies for commercial profits (Weiss, 2014). However, the research required to develop advanced technologies can very often find a role in military use. In an ideal situation spin on and spin off can be utilized in tandem in a “spin around” system that benefits the military and commercial sector equally (Weiss, 2014). 5G technology can be seen as an example of the spin around system working brilliantly to not only produce an advanced technology that can be utilized by civilians but also a technology utilized by the military to maintain that technological superiority.

Another advantage to large military investment in advanced research in the private sector was the creation of the advanced technology field in the commercial sector. Investments and incentives from the military in private sector companies reduced the barriers of entry for companies to start researching advanced technologies. In the 1940s and 50s the military was seeking advancement in the semiconductor and transistor industry (Stowsky, 1991). Companies at the time saw research in advanced technologies as a large risk because if they were unsuccessful and a commercial product was not produced, the company would stand to lose a lot of money and time. This is where the government and military were able to come in and help with the funding for advancements in technology. The Bell company was one in the 50s that benefited immensely from military investment. The Bell company had a guaranteed market (the U.S. military) for their transistors. The investment from the military also allowed companies to scale up production because they had guaranteed government purchases in the form of government contracts. The increase in production was due to the military wanting to make sure that in times of war when they would need large amounts of a technology, the private companies would have the means to satisfy larger production. "In peacetime, however, the resulting excess production capacity created a further incentive for the industry to develop new commercial markets" (Stowsky, 1991). Large investments from the military in technology companies allowed them to take risks to advance technology.

At this same time an example of the military swaying the trajectory of technology was their need for silicon based transistors rather than germanium based in order to withstand the high temperatures undergone in their military application. This, however, opened the door for companies like Texas Instruments to find a market for their semiconductor research. Without large incentives from the military to research and advance new technologies it can be argued that

the advanced technology sector that is so prevalent today would not have advanced at the swift rate it has since the end of WWII (Stowsky, 1991).

The private sector today is dominated by large and small tech companies striving to find the next great breakthrough due to the climate of today's capitalistic economy. Today, tech companies account for nearly 50% of all venture capital dollars (Hecht, 2018). 5G technology is an example of how in order to stay successful and on top in the tech world you always need to be innovating and improving to stay ahead of the competition. On the surface, 5G technology is marketed as a faster more reliable wireless network for your cell phone capable of 10 gigabit per second speed on your cell phone (Kachhavy, 2014). The applications of 5G technology, however, are much broader than just this and pose both concerns and possibilities for the U.S. military. It is important to note the three electromagnetic spectrums that 5G can operate at. There is high, mid, and low band and they all offer different advantages and disadvantages. The goal is to use the high band spectrum because this allows for the fastest network (10 gigabit per second speed). The issue with this spectrum is that it is less reliable over long distances and can be disrupted easily by physical objects such as trees and building. This means many more cell towers need to be installed if wide coverage at the high band spectrum is to be reached (Finley, 2020). If America wishes to achieve countrywide high band 5G coverage a lot of money will need to be invested to produce the large network needed to operate at the high band spectrum. This is where government incentive and investment can once again reduce the barriers to entry for technology companies. The Military has already begun research into how 5G technology can be applied for military use and the race against China and its 5G technology developer Huawei has started.

In early October the DoD announced \$600 million in awards for 5G testing and experimentation at various U.S. military sites. With this budget it represents the largest testing of 5G services in the world. The tests and projects that are planned to run are 5G-enabled augmented/virtual reality for mission planning and training, testing 5G-enabled Smart Warehouses, and evaluating 5G technologies to enhance distributed command and control. Michael Kratsios, the Acting Under Secretary of Defense for Research and Engineering said, “The Department of Defense is at the forefront of cutting edge 5G testing and experimentation, which will strengthen our Nation’s warfighting capabilities.” The Military clearly sees an application for 5G technology but will it allow for a beneficial spin around system, allowing the military to gain new and advanced technologies but also give the commercial sector the benefits and advancements of 5G technology (“DOD Announces”, 2020).

The future of 5G technology does not promise just faster mobile download speeds but a large connected network that can be applied to “smart cities.” 5G will allow many more users or appliances to be connected to the network. Some predictions show that this will be crucial in advancing autonomous vehicle technologies. Due to the large amounts of data at such quick speeds 5G will allow autonomous vehicles to be connected on one large wireless network. The larger amounts of data that a 5G network can handle will also promote the advancement of artificial intelligence. Healthcare will also see an improvement with the availability of ultra reliable low latency communication. Precision surgery, telemedicine, remote surgery, and physical therapy will all see improvements with the advent of 5G technology (Eastman, 2020).

The Military also has a vision for how a large connected 5G network could advance capabilities and effectiveness. “Tomorrow’s warfighters will use local and expeditionary 5G networks to move massive amounts of data to connect distant sensors and weapons into a dense,

resilient battlefield” (Keller, 2020). The large data flow capabilities of 5G will allow commanders to better understand and adapt to ever changing scenarios. The low latency will allow for improved autonomous vehicle and weapon technology. 5G also just provides the military with another communication channel which is always sought after for reliability and adaptability. The Military is always seeking to be a connected network that distributes information between ship, aircraft, weapon system, or soldier. The increased speed of 5G will allow for these communication channels to be improved as well (Keller, 2020). 5G could also be coupled with artificial intelligence and machine learning in order to keep up with other competitors like China and maintain that NSS of technological superiority.

Discussion

5G technology has shown the potential to be a world changing innovation with the ability of cities and infrastructure all connected to one fast and reliable network. However, to reach the highest potential 5G technology has to offer, a large amount of money and research needs to be put in to fully develop the infrastructure necessary. The investment and research being done by the DoD at the moment shows a great example of the spin around concept working perfectly. 5G has the promise to bring great benefits to both the military and civilian world and the best way for these goals to be reached is the two sectors working together. The current research and investment by the military in October of 2020 shows that this is happening. When the DoD announced their \$600 million investment in research and experimentation of 5G technology, they also announced the five sites of experimentation and the various companies involved in the research. The testing at the various sites is partnered with various private companies including AT&T, Nokia, Deloitte Consulting LLP, and Federated Wireless to name a few. This testing shows a huge opportunity for both the military and commercial sector to benefit from each

other's resources ("DOD Announces, 2020). The spin on in this case is early 5G technology initially made for commercial use that has found a beneficial place for military use. The spin off in this case is the money and research being done by the private companies on behalf of the military that should not only yield great applications for the military but also push forward research and development on 5G technology for the commercial sector. The advancement of 5G technology is also poised to have a very positive economic impact. According to an IHS Markit Study, it is estimated that \$13.6 trillion in global economic value will be made possible by 2035 along with 22.3 million jobs created in the 5G global chain (Galal, 2020). The military is also in a unique spot to be able to expedite the research process. For a private sector company to do the same research, it would require a longer process that includes negotiating with state and local officials, obtaining permits, and constructing antennas. According to Michael Kratsios, U.S. Chief Technology Officer, "At the DoD, we already have personnel, operational capacity, facilities, scale and regulatory greenlight to get the job done" (Tadjdeh, 2021).

With 5G and more advanced technology also comes new national security concerns that further show how important cooperation between the private and military sectors will be the most beneficial for both parties. At the moment, China is the worldwide leader in 5G technology and is poised to launch the first 5G wide-area network. At the heart of this new infrastructure and technology is Chinese company Huawei. Huawei has finalized more 5G contracts than any other company including around 30 countries in Europe ("United States, Congressional Research Service, 2020). Huawei is ahead of any U.S. company when it comes to 5G technology and implementing the infrastructure to make it a reality, so one might wonder why does the U.S. not just spend its money on having Huawei set up the infrastructure for the U.S.. This is because of China's National Intelligence Law enacted in 2017. Under this law, Huawei, like all Chinese

companies, is legally required to conduct intelligence work on behalf of the Chinese government. Combine that with the vast amounts of data that will be using the 5G networks set up by Huawei and a security concern is very evident. Another concern is that once Huawei sets up a country's 5G network, that country is likely to stick with Huawei when there is an upgrade available for the technology. This poses an economic concern as it leaves less opportunity for an American company to build the network for another country (Sacks, 2021). Regardless, it is evident that the U.S. needs to rely on American companies to provide the 5G infrastructure and technology to maintain data privacy. This can also be seen as a large motivation behind the large military funding of 5G research and experimentation. Still, private companies are benefiting due to the fact that they will be the ones enacting a wide area 5G network in America despite being slightly behind another company (Huawei). A large reason other countries, including many allies, are still choosing Huawei is that the U.S. cannot offer an alternative themselves. Yet another reason why it is so important to the U.S.'s NSS to have American 5G technology developed as quickly as possible. This would also give the opportunity for American private companies to benefit economically by partnering with other countries before Huawei or another foreign company gets the chance first.

The case of 5G technology and The Military's investment in research and development is an example of how funding of advanced technology, even if that source is The DoD, can be beneficial for not only private companies and The Military but society as well. As stated previously, 5G technology has the potential to bring great benefits to citizens of America in the commercial sector. It also has the potential to fulfill the desire of the NSS to maintain technological superiority. All actors in this scenario, The U.S. Military, private American companies, and American citizens all stand to benefit from successful 5G technology. The

Military and the private sector companies do have different motivations for researching 5G technology, but does that really matter if the end goal for both parties is the same. Research of advanced technologies will always be an important area of research for both The U.S. Military and American society. Society will benefit from the U.S. Military maintaining technological superiority in the form of security and safety. Society will also benefit from successful teamwork between the DoD and private companies in the form of spin off and spin around products. Knowledge is power and the U.S. Military and U.S. private companies should continue to invest and research advanced technologies for the country's and societies benefit.

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