Essay

Military Leadership in a Technological Age: Management of Complex Technologies and Prospect for Space

By Officer Cadet Harris Siderfin

Biography: Officer Cadet Siderfin is Australian by birth but grew up on the Orkney Islands. He studied International Relations and Psychology at St Andrews University, graduating with a first-class honours degree. Having received a Bobby Jones International Scholarship, he will pursue post-graduate studies at Emory University, Atlanta in August 2023. Siderfin is a member of the East of Scotland University Air Squadron and hopes to join the Royal Air Force as an Intelligence Officer on completion of his studies. With an interest in the militarisation of space, writing on the subject, he has won the Air Vice-Marshal Gray Essay Prize twice.

Abstract: This paper explores the significance of technological innovation within military institutions and proposes effective management strategies for these assets. Drawing on neorealist theory, the paper asserts that advancements in military technology bolsters a state's influence in the international system and provides strategic advantages during warfare. Thus, the continuous development of military technology is deemed essential for both the state and its military institutions. Considering the concept of the 'military technologist', the development of nuclear submarines – under the leadership of Admiral H.G. Rickover, US Navy (USN) – is used as a specific case study. Furthermore, the paper explores the institutional-level management of these technologies to create an optimal environment for their development and utilization. Drawing from these insights, the paper applies the lessons to the emerging domain of militarized space, and its critical role in modern warfare, contending that for militaries to effectively compete in space, these assets should be entrusted to military technologists within a distinct military organization.

Introduction

This paper examines the importance of the continued development of military technology in maintaining a military's competitive advantage during warfare and discusses how these assets should be managed. The essay argues that states should adopt and develop innovative military technologies to maintain their relative power within the international system. It examines the development and management of military technology through the lens of neorealist theory. The essay uses Keith Krause's 'motive forces' for producing military assets to assess if a military technology is worth developing. If a technology fulfils two of Krause's expectations; (1) the technology increases the state's influence within the international system, and (2) it helps achieve victory in war; then the asset is worth investing in to develop further.[1] If the military technology fulfils these conditions, a second discussion of their effective management arises. The second half of this essay examines the importance of military technologists in developing and managing innovative military technology. The paper then applies Clayton Christenson's innovator's dilemma to military management, using the example of the successful development of the United States' (US) fleet of nuclear submarines under the leadership of Admiral Rickover. Finally, the paper applies these arguments to the current innovation of military space assets,[2] discussing how militaries should manage these resources. This essay argues that space assets are essential to modern warfare, where from it concludes that space assets should be under the leadership of military technologists as a small separate service. The paper argues that military leaders managing these assets should be trained and educated about the technology they are managing to become technologists. Moreover, the essay infers that militaries should engage in and manage relationships with civilian counterparts to maximise benefits offered by space assets.

'Control of space means the control of the world'.[3] The words of former US President Lyndon B. Johnson are perhaps more relevant today than during the first space race when he said them. However, the concept of how militaries should act in space has changed dramatically since the Cold War. For example, it is unlikely to find state actors pursuing satellite gunships like the Soviet Union's Salyut 3 in modern space programmes.[4] It is also unlikely to see programmes like 'Project Ithacus', which planned to create intercontinental troop transporters, rocket commandos, and space-launched ballistic missiles, come into fruition.[5] Today, military presence in space revolves around more covert military activities such as intelligence gathering, communication, location technology, and early warning systems.[6] Space constitutes a central part of most major powers' defence capabilities and policy: 'Space has become an area of significant importance since the onset of the revolution of military affairs (RMA)'.[7] RMA refers to the current and ongoing development of military technology and the subsequent change in military practices in relation to these technologies.[8] Military institutions have become increasingly reliant on complex technologies to maintain national security. As this transition occurs, the role of the military officer has also evolved.[9]

The following sections of this essay outline why innovation of military technology is important, applying neorealist theory. It discusses how these technologies should be managed, referring to Morris Janowitz's theory on military technologists and Clayton Christenson's model for managing *disruptive technologies*, concluding that military leaders should possess a technical understanding of their assets.[10, 11] To illustrate this, the essay examines the establishment of the US' nuclear submarine fleet under the direction of Admiral Rickover then extrapolates from this period to demonstrate how the lessons identified could apply to the emerging sector of militarised space.

Why military innovation is important

To begin, the role and purpose of the military, coupled with its methods of improvement, must be established. According to Samuel Huntington, the role of military institutions is to protect a state's national interests from external threats.[12] However, as neorealist theory argues, military capability is also a major determining factor of the influence and power wielded by a state within the international system.[13, 14] As such, military institutions possess two key functions: ensuring the state's survival and maintaining the state's relative power within the international system. Therefore, the state and its military institution are fundamentally linked: the latter's military capabilities are a significant determinant of the former's position within the international system.

As such, through the lens of neorealism, it is in the best interest of a state to maximise its military capabilities. Morris Janowitz argues that states can do this through the development of superior military technology and tactics.[15] Here Janowitz makes a salient delineation, that given the continuous evolution of military technology, military strategy must likewise develop alongside it. Military leaders who do not evolve their strategy together with changing technology risk being overwhelmed during combat. This was exemplified by the fall of the French military during the early stages of the Second World War. The Germans utilised their sophisticated light Panzer divisions with support from motorised infantry to capture French territory quickly and effectively.[16] The French used more traditional armaments and military strategy, relying heavily on the Maginot Line and failing to account for the advancement in German technology, leading to their eventual demise.[17] This example demonstrates the importance of continued military development both in terms of technology and strategy. Without this development, as Huntington argues, states will be at a disadvantage during combat thus jeopardising their national security and their position of power within the international system.[18]

Military expenditure and the development of a state's military technology bear a direct link to its construction of power within the international system. Keith Krause argues that states pursue the development of armaments to increase international influence, which, according to neorealist thought, reflects the pursuit of power.[19] Through coercion and the use of military threats, states with superior military capabilities can force subordinate states into doing things they otherwise would not do.[20] The impact of a superior military capability on a state's relative

power within the international system is evident in the US' rise to global hegemony.[21, 22] During its ascent to superpower status, the US continually invested in its military capabilities, annually spending over 7% of its GDP on the defence budget throughout the 1960s.[23] This spending has continually increased year on year making the US' defence budget the largest in the world with the 2023 budget reaching 816 billion USD.[24] This exemplifies, according to neorealist theory, the direct link between superior offensive capabilities and relative power and influence within the international system.[25, 26] This is similarly reflected by China's increasing power, which, according to Graham Allison, has placed Beijing as a significant challenger to the US' hegemony.[27] Paralleling growing Chinese influence is its sharp increase in military expenditure. Since 1989, China has annually increased military spending bringing its budget from 11.4 to 261 billion dollars, making it the second largest defence budget globally.[28] Specific innovations within military technology feed into this dynamic. Therefore, if a military technology can give a state superior offensive capabilities, this state can use the asset as leverage over subordinate states, increasing its influence within the international system.

This also applies to space operations and assets, which give states a strategic advantage during war. Space operations are often the product of international collaboration with an influential state leading the project. For example, many military satellites operated by states such as the United Kingdom and France have been launched by the US, as these states did not have their own launch capabilities.[29] This ability to assist states in launching space assets has helped increase the US' influence within the international system, as space exploration is becoming an increasingly important arena. China too has been using its launch capability to increase its influence, launching assets for many states in the global south. It has even established its own space station, which may challenge the International Space Station's monopoly on international low earth orbit research.[30] Thus, space is becoming an increasingly important arena for states and militaries to both compete and manage.

Having established that military technology and spending is a central 'motor force' for the US' great power status, this essay will turn to a specific example of an innovative technology enhancing the US' relative power: the development of its first nuclear powered submarine. The first nuclear submarine, the USS Nautilus, broke multiple depth, speed and distance records: this meant that the US fleet was able to move faster, further, and longer than its opponents at the time.[31] Potentially more importantly, these new submarines did not need to surface or refuel, unlike their diesel engine counterparts.[32] This enhancement of capability increased the US' influence within the international system by enabling the state to be the first to reach the geographic North Pole without surfacing, increasing the US' global military reach.[33] Six years following the launch of the USS Nautilus, US nuclear submarines were equipped with nuclear-tipped ballistic missiles, again furthering the US' relative power in the international system and military dominance, as it could now launch nuclear weapons covertly anywhere in the world.[34] This significantly increased the US' power within the international system as the threat of nuclear strikes could be used to deter or coerce subordinate states. Thus, the development of the nuclear submarine was an important step

in maintaining global military dominance and enhancing the US' relative influence within the international system.

Krause further evaluates the extent to which technologies can aid militaries in winning wars: although military technologies in some sense are merely the concrete manifestation of power, it compels states to develop internal military capabilities out of the necessity to win in combat.[35] Nuclear submarines not only expanded the reach of the US Navy's nuclear weapons, they also provided significant strategic advantage, enabling more advanced anti-sub and anti-ship warfare missions.[36] However, following the Second World War, very little open warfare on or beneath the seas meant that these military capabilities were never truly utilised.[37] Instead, nuclear submarines have mostly been utilised as deterrents or for covert intelligence operations, contributing obliquely to military efforts across disparate wars.

The development of nuclear weapons has reduced the need for direct conflict between major powers, as war between nuclear powers is unlikely due to mutually assured destruction (MAD).[38] There has been a significant decrease in conventional war between nuclear armed adversaries since the establishment of these weapons.[39] As nuclear protection extends to all NATO members, it is unlikely that major powers will engage one another in conventional warfare anytime soon. Therefore, major power militaries should focus on systems that increase their capabilities outside of direct combat.[40] Today, military technological advancements for major powers are predominantly found in support and automated systems, which enhance intelligence gathering and reduce the chance of human casualties: this is exemplified by the UK's 2021 defence review. This review pledged to reduce the size of the UK's army and use the saved funds to increase investment in autonomous, cyber and space, technologies.[41] This development of modern warfare and strategy has placed an increasing importance on space assets which function as support systems for modern militaries.[42]

There are distinct similarities in the management of space assets and nuclear submarines. Both military technologies function predominantly as support systems for other combat forces: they are both highly complex technologies, and both require careful management to ensure they are utilised effectively as mismanagement could have catastrophic global consequences. As demonstrated in 1962 when a Soviet submarine became engaged in combat with US forces in Cuba and nearly fired a nuclear torpedo, which would have inevitably resulted in a nuclear war between the superpowers.[43] It is essential that officers in charge of these assets understand the risks and ramifications of their technology. Similarly, if an asset in space was destroyed whilst in orbit, the debris created could collide with other satellites causing further debris. These collisions would give rise to more debris and collisions causing a continuing chain reaction of destruction in space, known as Kessler syndrome.[44] If this occurred, it would cause unprecedented damage to satellites, hindering the further use of low earth orbit and causing severe damage to the international system and many lives on earth.[45] This scenario is a no-win situation for both state and non-state actors who rely on low

earth orbit assets. As most major powers rely heavily on space assets conflict in space bears a similarity to MAD. Therefore, it is essential that these assets are managed effectively by the correct type of military leader.

The correct leader for advanced technological assets

The relentless technological progress seen throughout the twentieth century has overhauled the way in which the outcomes of wars are determined: these depend primarily upon a military's technological capabilities and leadership rather than the individual heroic actions of military commanders on the battlefield. As such, the modern military officer should possess knowledge and experience of these emerging military technologies.[46] Classical officers, as described by Huntington, are primarily concerned with the management of violence and combat strategy.[47] Due to the increasing complexity of military affairs and technologies, it is now critical that military leaders have a strong understanding of the technologies they manage as well. Janowitz argues that military institutions should opt for officers with technical expertise (military technologists) over classic war fighters when it comes to the management of complex assets, to ensure the effective usage of these technologies.[48] This emphasis on having military leaders with technical knowledge means that technological officers in charge of complex military technology do not need to fulfil the classic 'heroic' leader archetype.[49] With growing military reliance on complex technology the role of the military technologist is also increasing.[50] There is still a need for heroic leaders within military institutions as war requires acts of bravery, but the need for these leaders has lessened as direct conflict becomes less common. Hence, the development of military technology has simultaneously necessitated an increase in the need for military technologists. It is important to note that heroic leaders could become technologists with the correct training and education. The essay is not arguing that officers must have advanced technical training in all military technology, as the list of these technologies are extensive. However, officers in roles relating to complex technologies should have some technical understanding of them. This would then require militaries to invest in this training. As direct conflict becomes less common among major powers, some kinetic warfare training could be substituted for technical courses relating to the assets officers are tasked with managing.

As science and technology has become further incorporated into military practices, the divide between civilian and military worlds has decreased.[51] The creation of complex military innovation often requires contributions from both military and civilian institutions.[52, 53] This is especially true with respect to space. Throughout the twentieth century, militaries had to work with civilian governmental organisations such as the National Aeronautics and Space Administration (NASA) to operate in space, not only for launching assets, but also when managing assets in orbit.[54] However, in the twenty-first century, privatised commercial actors have become more prevalent in the space domain, having their own assets in space, and companies like Space X, owned by Elon Musk, launching military and governmental assets as well.[55] As the number of different actors in space increases, military leaders must be able to manage relations with civilian actors, both governmental and commercial.

It is, therefore, essential that military officers, who work with advanced military technology such as space assets, can collaborate with civilian counterparts whilst managing military operations. To illustrate this, we can examine the development of the US' nuclear submarine fleet led by Admiral Rickover, who served in the US Navy for over 60 years. Rickover was the archetype for the military technologist. He was able to manage and collaborate with civilian counterparts to develop nuclear technology for the US. Rickover, known as the Father of the Nuclear Navy, was responsible for the creation and development of the first nuclear submarine USS Nautilus, which as discussed previously significantly advanced the US' military capabilities. Rickover was a military technologist; this is not to say he was a scientist nor was he solely an engineer, although he did have an M.S. in electrical engineering from Columbia University.[56] A military technologist is a military leader who has an in-depth knowledge of military technology and emphasises the importance of technological innovation within the military.[57] These officers are essential within military institutions as they push for the development of military capabilities. As stated, this development is critical in maintaining sufficient military capabilities. If military officers were solely occupied with the management of violence as suggested by Huntington, military technology would fail to progress, which could cause significant disadvantage for military forces. Rickover was one of the first military technologists to reach the top ranks within the US military.[58] Crucially, his promotion to a three-star admiral, without previously having commanded a warship in direct conflict, caused a shift in the hierarchy of military institutions as technologists became more valued.[59]

Rickover's success can in part be attributed to his management of both military and civilian institutions. Indeed, he was so civilianised within his role that he often had little regard for naval protocol.[60] However, he was able to command the respect of his military staff and civilian counterparts achieving the desired technological outcome. Rickover successfully worked with both civilian and military institutions and oversaw the creation of the first nuclear submarine four years before the Soviets achieved the same technology.[61] Rickover continued to manage the US' nuclear submarine programme and interviewed every prospective officer considered for a post on a nuclear ship, to ensure they had a sufficient technical understanding of the technologies they were operating.[62] This meticulous management of resources and personnel meant that, under his leadership, there were no reactor accidents in the US Navy, which was a pressing concern among many global civilian leaders.[63] This example demonstrates the importance of having military technologists in senior leadership positions within the military. Evidently, having someone who has an in-depth knowledge of technology overseeing technological project maximises output and good practice. Rickover was not only able to deliver on projects enhancing the US' military capabilities, but he also maximised potential and minimised the risk of a highly dangerous technology through collaboration with civilian institutions.

Modern warfare has dictated that most technological military advancements today are in the form of support and automated systems, as these systems give states the strategic edge during warfare and minimise the potential for casualties. These systems are highly complicated,

existing in the realms of cybersecurity, artificial intelligence, robotics, and space, meaning that military technologists play an important role within modernised military institutions. The UK's military strategy has already shown a preference to use support systems to conduct warfare over traditional ground troops.[64] For example, between 2014-2020 as part of Operation Shader, Royal Air Force jets and drones dropped more than 4,000 munitions, resulting in the deaths of around 4,069 militants without a single British casualty.[65] These strikes utilised laser-guided weapons and remotely piloted drones that are dependent on satellite support systems for navigation, communication, and radar. These strikes did not require traditional ground forces but have been successful in repelling and reducing the influence of Daesh without endangering the lives of British military personnel. This example highlights the importance and value of support systems in conducting modern warfare, and how possessing these assets gives a strategic advantage over adversaries.

Institutional management of innovative technology

Having established that technological innovation is essential to militaries, and that these innovations should be led by military technologists, this essay will explore the management of *disruptive technologies*. The difficulty with innovative technology is precisely that it is innovative: it is original, new, and nearly impossible to predict where and when this technology will occur. Therefore, innovative or disruptive technologies are challenging to manage. Clayton Christenson's 'Innovator's Dilemma' discusses how new innovative technology can cause industry leading companies to be outperformed by smaller competitors, causing the company to 'fail'.[66] Christenson offers several steps that established firms can take to solve the innovator's dilemma. Although this work refers to a commercial company, Christenson's theory can be applied to military institutions and their management of innovative military technology.

Christenson defines two categories of new technologies: *sustaining and disruptive*. *Sustaining technologies* are technologies that build upon established products. These assets are designed through incorporating and utilising user feedback.[67] Sustaining technologies do not bring anything per se to the market. They merely improve upon existing products that have the same function. The alterations to sustaining technology can be incremental, discontinuous, or radical, but the products still perform the same overall function as previous iterations. An example of sustaining technology within a military context would be the development of armoured vehicles. Armoured vehicles are constantly redesigned and improved to maximise combat capabilities. This process utilises field testing and feedback from combat zones. For example, when the Challenger Two tank received its 'streetfighter' upgrade, which improved combat in urban environments, this built upon the existing product. This upgrade enhanced the Challenger's combat capability, making it a more effective piece of military technology.[68] However, this kind of innovation does not change the function or landscape of tank warfare; it merely improves on it. This type of innovation is relatively simple to manage as the goal is to improve the existing product. Therefore, managers can continually invest in product development and research to maximise product output.

Christenson's second class of new technologies are *disruptive technologies*. These are innovations that offer an entirely new service and often develop in niche markets that do not fulfil the needs of mainstream users at the time of conception.[69] Initially, disruptive technologies are not very useful nor efficient; therefore, they are overlooked by large institutions. However, once developed, these technologies change the environment they exist within, and because larger companies over-looked these innovations, they are later outperformed by smaller competitors who designed or used these products initially. It is difficult for even the best managers with vast resources to plan for these developments, as they are difficult to predict, and it is illogical to spend resources on something the market is currently not asking for.[70] Christenson offers initiatives that large corporations can take to mitigate the adverse effects of disruptive technology and how to harness these innovations. Christenson's first principle is to give the task of managing disruptive technologies to a small spin-off group within the primary institution.[71] By doing this, the group can focus on and learn about this asset without other distractions, allowing them to become experts in this field. The following advice given by Christenson is to create this sub-group relative to the importance of the technology.[72] If the technology is not very important, keep the group smaller and if the technology is important the group should be bigger. Further, Christenson argues that those working on these innovative projects should be enthusiastic about them to maximise productivity and management. Christenson argues that creating large groups for small projects will promote lethargy within workers, and therefore, keeping individuals accountable with small groups promotes initiative. Christenson further states that institutions should support this new sub-group by allocating sufficient resources to the project without forcing the central institution's values and processes onto the smaller group.[73] As the new technology becomes more important within a wider context, the team and resources should grow. The team in charge of developing the technology should stay on in leadership roles to ensure the continued development and maximisation of the disruptive technology.

In summary, Christenson argues that the best way to manage disruptive technologies is to set up a semi-autonomous organisation containing experts within the subject. Importantly, this new organisation should have appropriate funding and resources to ensure effective development of the technology. For example, the initial conception of a nuclear propelled submarine came from a small research group in 1939, when they were tasked with solving the practical issue of nuclear fission.[74] This research was halted and eventually transferred to the Manhattan project, which created the nuclear bomb, this was a small team of civilian scientists who were managed by military officers.[75] Rickover led a team of military technologists, civilian engineers, and scientists within the Navy to construct the Nautilus[76]. Using Christenson's theory, this essay argues that Rickover would have been better served had he set up a new branch distinct from the US navy, dedicated to developing and managing submarine capability. Something like the UK's submarine service which is able to stand alone and to focus on issues surrounding submarines, without becoming too entangled in the bureaucracy of the larger Naval institution. Christenson's suggestion can be applied to military institutions, but with one small caveat: the spin-off organisation should incorporate civilian and military

members in the research team. Again, this reinforces Janowitz's assertion that most military innovations stem from civilian counterparts. Therefore, it is essential that militaries can utilise these innovators for military technology.[77] The question is how does this all apply to the new military frontier of space? The next section will attempt to answer this.

The increasing importance of space assets and their management

The space industry has grown exponentially in the twenty-first century. The world has entered a new age of space exploration with more assets being launched into low-earth orbit and beyond, than ever before.[78] During the twentieth century, there were two major space powers; the US and the Soviet Union; who launched and managed the majority of space assets, during the space race. There were a handful of other minor actors operating in space at the time. These actors (beyond the US and Soviet Union) were predominantly rich western states including Canada, France and the UK.[79] Most minor space players were helped into orbit by the US, as they did not have their own launch capabilities, only satellites. Today, the world is experiencing a space-faring resurgence as more actors than ever are operating within and beyond low earth orbit. In 2018, there were nine countries and one international organisation with independent space launch capabilities.[80] Currently, there are over 90 states and international organisations who have satellites in orbit.[81] The divide between state and non-state actors in space is continuing to decrease as commercial companies play an increasingly important role in both launching and managing space assets. For example, in 2022, there was a record number of space launches, with 180 successful launches.[82] The number of rocket launches has continually increased in recent years (see Figure 1). However, of the US' 67 launches in 2022, 61 of them were conducted by Space X, tying the Soviet Union's

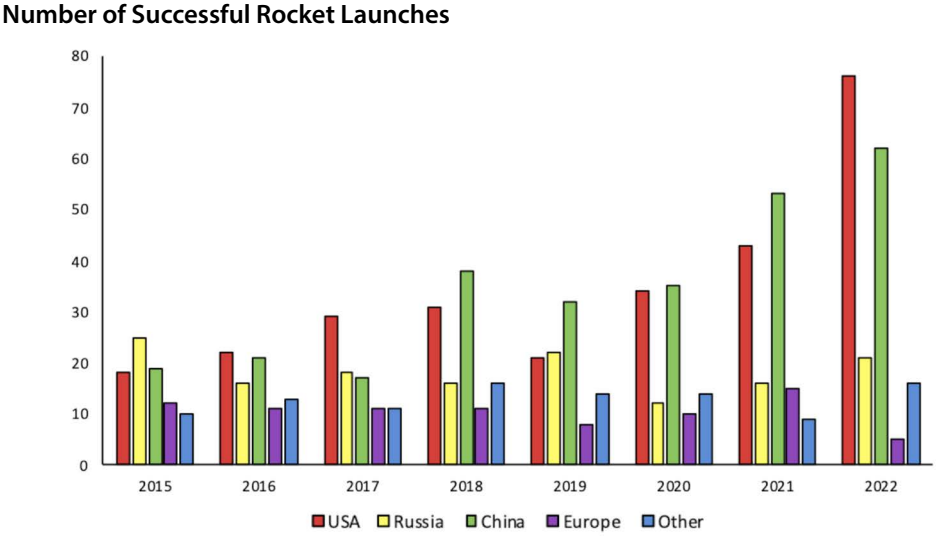

Figure 1: Number of rocket launches by region since 2015 (Adapted from McDowell, 2023).

1980 record and demonstrating the increasing importance of commercial actors in this space. It is likely that the space industry will continue to grow as states and commercial actors look to new opportunities such as resource gathering from astronomical bodies.[83] This essay only focuses on the ongoing space operations that are used to support military operations on earth, but it is important to note that space activities like resource gathering and lunar bases will eventually have some military activity input.

Before discussing the benefits that space technology currently offers militaries, it is essential to distinguish between space militarisation and weaponisation. Although these concepts are interlinked, they are distinctly different. Mathew Mowthorpe defines militarisation of space as the use of space assets to enhance military capabilities without introducing lethal force.[84] This includes satellite surveillance, communication, reconnaissance, and weapon guidance. [85] Space weaponisation refers to weapons based in space or ground-based weapons with intended targets located in space.[86] This distinction is important because space weaponisation is considered by the international community as threatening, while militarised satellites are non-confrontational support systems. The use of space assets for communication and intelligence gathering has long been accepted within the international community. The allowance of militarised satellites was placed into international law during the space race, supporting states in developing and using space assets to enhance military capabilities.[87] The use of weaponised space assets such as ground-to-satellite or satellite-to-earth missiles is more controversial, but they are not banned. The only weapons explicitly banned from being placed in space are weapons of mass destruction, as outlined in the 1967 'Outer Space Treaty'.[88] Although many states, including the UK, have advocated for the ban of all weaponised space assets, major spacefaring actors have continued to develop counterspace capabilities.[89, 90] The US, Russia, China, and India have all successfully shot down their own satellites with anti-satellite weapons (ASAT), despite the danger of causing the Kessler effect as described previously in this essay.[91] Due to the dangers of weaponised space assets and the UK's position condemning such technology, this essay focuses solely on the management of militarised assets.

Militarised satellites are dual use systems, and can be used simultaneously for both civilian and military purposes.[92] They provide a plethora of benefits for the state. They fulfil the purpose of a military enhancing the state's national security, as argued by Huntington, through providing strategic advantage during conflict, while also increasing a state's influence within the international community through, hard and soft power initiatives. Thus, space assets also fulfil both of Krause's expectations for advanced military technology. Military satellites have provided significant benefits for civilian populations globally. Indeed, there are few forms of modern technology that do not utilise satellites to some degree. They have improved the social and living conditions for much of the globe's populations, providing internet, navigation, and enhancing communication.[93] For example, navigation systems like GPS have changed the way in which we travel when operated by both civilians and military personnel. From banking to weather prediction, satellites have become integrated into modern life.[94] Sharing these technologies with global populations is one way to increase a state's influence

within the international community. Joseph Nye's notion of soft power posits that a state can increase its influence through soft power initiatives (helping other states).[95] Nye explains that when a state helps another, through aid programmes for example, this creates a positive image of the assisting state, increasing its popularity and influence within the international system. States can utilise their military satellites to enhance their influence within the international system, thus fulfilling Krause's first condition for effective military technology. They must also provide a strategic advantage during conflict to meet Krause's second condition.

An example of a military asset being used in this dual capacity to help during warfare and increase global influence is the US' Global Positioning System (GPS). GPS is a satellite-based radio navigation system designed by the US and operated the US' Space Force.[96] This system was designed to provide positioning capabilities for the US' armed forces to increase efficiency and success of ground, air, and sea operations.[97] The system consisting of 24 satellites provides location information in the world if an individual has a receiver. These assets provide this information regardless of weather, anywhere in the world, 24 hours a day.[98] This system was created for the sole purpose of the US military. However, in the 1980s the technology was opened globally, meaning anyone could benefit from this asset, military and civilians.[99] GPS has been integrated into modern society improving the lives of civilians where it, for example, is used in everyday commuting, international flights, emergency services, and much more. Without this technology, quick response teams such as ambulances, fire brigade, and coast guard units would be severely hampered.[100] Extending this technology to the world has increased the US' global influence, as individuals and states have grown reliant on the system. From a military perspective, the technology is vital as it provides fast and accurate location information, which is used for navigating hostile terrain, precise munition guidance, and casualty location.[101] As these assets are the US military's, the US could enhance GPS capability for their troops and allies or deny actors from accessing the network, as they did to the Indian military during the Kargil War.[102] Although the practice of blocking actors from GPS no longer occurs, the example demonstrates how space assets can enhance a state's prowess in conflict. The example of GPS demonstrates how space assets can further a state's national interest through hard and soft power initiatives.

Surveillance satellites are another asset which have dual functions. Within military operations, they can be used to gather intelligence about hostile troop movements or to observe the actions of foreign governments.[103] These sophisticated assets can provide militaries with real-world data from around the globe. It has also allowed for the monitoring of global movements, allowing governments to respond quickly to any potential threats.[104] However, these assets could be used to help monitor other factors such as climate change, which is a growing global security issue. The European Space Agency (ESA) operate surveillance satellites to monitor as part of The Copernicus Programme. ESA operates 30 satellites that collect various data used for monitoring issues from environmental management to illegal trawling.[105] The North Atlantic Trade Organisation (NATO) have recently discussed the need to improve the alliance's resilience against climate change. The solution is to use alliance space assets to improve environmental

monitoring and meteorological forecasting, as these issues threaten state security.[106] Issues like climate change further blur the lines between civilian and military operations. Surveillance assets operated by NATO military members and ESA could be utilised in tandem to achieve the goals of both institutions. Combining constellations of NATO and ESA satellites to monitor issues like climate change would enhance these institutions' capabilities, as more satellites leads to greater coverage.[107] This example illustrates how partnering with civilian institutions can enhance military assets to achieve the states' military goals. Ultimately, it shows why military leaders must be able to work with civilian counterparts.

If used in a supporting role, space assets provide a significant strategic advantage in warfare, thus affirming Krause's second condition. Communication Satellites – navigation satellites that provide precise positioning – as well as Space-based Intelligence, Surveillance and Reconnaissance (ISR), bring inestimable advantages to modern warfare. The US' and coalition forces' success in the First Gulf War has been attributed to the use of then-revolutionary space technologies by coalition forces. In contrast, the Iraqi military relied heavily on traditional combat forces. The First Gulf War was later christened the first 'space war' due to important role space assets played in the coalitions' victory in the conflict.[108] At the time of the First Gulf War, Iraq had the fourth largest army with over one million personnel.[109] This military force was well equipped with Soviet military technology and had just experienced a successful war with Iran, suggesting that they should be a proficient fighting force. However, the Iraqi military suffered losses of roughly one thousand to one against the coalition army.[110] There were several advantages the US-led coalition armies had over Iraqi forces, including superior leadership, resource management, and well-trained troops. However, Perry argues that the use of new military technology and space assets in supporting roles contributed significantly to this historic victory, stating that: 'An army with such technology has an overwhelming advantage over an army without it, much as an army equipped with tanks would overwhelm an army with horse cavalry'.[111] Surveillance satellites allowed coalition forces to identify Iraqi forces quickly and eliminate them with minimal casualties. Communication and navigational satellites meant that units could communicate and navigate vast terrain with ease, whilst the Iraqi military was in disarray.[112] The strategic advantages offered by the then-revolutionary space technology helped secure the coalition forces a historic victory over the less advanced Iraqi military, illustrating the ability of militarised space assets to secure victory during warfare.

The continued importance states are placing on space assets is salient. During the ongoing war in Ukraine, satellites have played a key role in Ukraine's defensive successes against the Russian offensive. The US has given Ukrainian forces unprecedented access to intelligence gathered from US surveillance satellites.[113] This access has allowed Ukraine to track Russian troop movements using real-time images. It is evident that Ukraine's access to this intelligence has enhanced the capability and successes of their military. Commercial space actors have also been critical in bolstering Ukraine's defence during the conflict. If the First Gulf War is known as the first space war, the Ukraine conflict may be remembered by some as the first 'commercial satellite conflict'.[114] Commercial space companies have played a critical role in gathering

intelligence and maintaining communication between Ukrainian forces. Russia has even attempted to thwart this support by attacking commercial satellites via cyber-attacks. [115] Commercial imagery companies have been able to provide satellite imagery to Ukrainian fighters, something that only states would be able to do just a few years ago.[116] Another more crucial asset for Ukraine has been Space X's satellite constellation 'Starlink', which has provided internet across Ukraine during the conflict. Through funding from private donators, contracts from the US Foreign Aid Agency, and Department of Defence, Space X has provided satellite internet to Ukrainians since 2022, operating over 4,000 satellites to do this.[117] These assets have been extremely effective in the war. Due to the size of the constellation and small size of the satellites, they were deployed with pace and are extremely resilient against Russian attacks, causing severe issues for Russian forces.[118] This has been critically important to air power efforts in the region. For example, the Turkish Bayraktar TB2S, an unmanned aerial vehicle (UAV) of significant importance in countering Russian air superiority, is reliant upon space-to-ground communications for its operation within an extended operational range. Notably, the Starlink constellation assumes a crucial role in facilitating Ukraine's capacity to carry out attacks in geographically challenged areas where adequate infrastructure or Internet connectivity is limited. Consequently, Ukrainian drones effectively engage enemy forces, while troops engage in the secure exchange of encrypted messages. These operational advancements owe their efficacy to the deployment of Space X's Starlink system.[119] The war has also exposed the weakness of Russia's current space fleet, that is both too small and outdated.[120] Russia is unable to compete with the assets assisting Ukrainian forces from NATO partners: their navigation constellation Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS) is incomplete, limiting their ability to provide precise navigation for their troops on the ground. Further, surveillance satellites operated by the Russians have an estimated maximum resolution of 50 cm per pixel, whilst US Keyhole surveillance satellites have a capacity of 5 cm per pixel, meaning the US' assets can provide images of far higher quality and detail to Ukraine.[121] These assets have given Ukraine significant advantages over their Russian counterparts regarding communication, navigation, and intelligence gathering. The operation of space assets has been essential to Ukraine's ongoing successes in the conflict.

The war in Ukraine demonstrates the continued importance of space assets in warfare. It has also shown the increasing importance commercial space actors are playing in warfare. Further, this example emphasises how the gap between the worlds of military and civilian space operations is continuing to reduce. It also illustrates the continued importance actors are placing onto space assets. Today, there are around 7,900 satellites in various orbit around the earth.[122] This number is set to increase exponentially over the next decade with various new state and commercial constellation programmes in the works[123]. This demonstrates that space will only become more critical to military institutions as space capabilities continue to increase.[124]

The essay has established that space assets are essential to modern warfare, and they are likely to continue to grow in importance. A brief discussion on how these assets should be managed

from a military perspective now follows. The management of space assets bears a resemblance to the development and management of the US' nuclear submarine fleet. Both technologies played a supporting role during warfare, changed how warfare occurred, performed intelligence gathering operations, and are innovative technologies that require careful management. Using Admiral Rickover as a case study, it is evident that the officers in charge of these assets should fulfil the criteria of the military technologist. This is to say, senior officers should have a grounding in the technical aspects of the technology they are commanding. Regarding space, this does not mean that they must have a doctorate in astrophysics, but a basic understanding of how these assets function is essential; this could for example be delivered through accelerated staff courses. This would allow senior leadership to make informed decisions regarding space assets, alongside subject matter experts. This is essential because if these assets are not managed correctly, the benefit will be greatly depleted.
The second reason behind why these assets should be managed by technologists rather than managers of violence is to prevent space becoming weaponised. The weaponisation of space would not only cause the state's soft power - and its influence on the international system - to deteriorate but could also potentially cause irreversible damage to the world as a build-up of space debris could prevent the use of satellites. Therefore, space assets must be managed by individuals who understand the technology and the ramifications of using force in this domain. It would also be beneficial for leadership to have genuine interest in the space domain, as argued by Christenson and exemplified by Admiral Rickover's successes with the nuclear fleet.[125]

Christenson's theory would further argue for the creation of a semi-autonomous Space Force, with an inclusion of a separate budget relative to the organisation size. Thus, ensuring that the development of space technology is maximised. The US' Space Force has embodied this, requesting a budget of around $30 billion for the 2023/24 fiscal year, which is a sizable investment into a relatively new venture.[126] Christenson's theory would advocate for allocating separate resources to this small new branch to maximise the development of this disruptive technology. This demonstrates the importance that the US is placing on space assets. However, as this essay has demonstrated, space blurs the lines between civilian and military organisations, and therefore Space Force will further benefit from the support of other governmental space organisations like NASA and their budgets. The importance of these assets has also been established and they do deserve high investment and priority from military institutions. Finally, it has been established that commercial space actors are becoming increasingly important within space operations. Therefore, it is critical that military leaders are not only able to work collaboratively with civilian organisations when developing and operating satellites as Rickover was able to when creating nuclear reactors. Military leaders must be able to also work with commercial actors like Space X, whose assets, like the re-usable launch systems and satellites, are vital to continued military operations.[127]

Conclusion

To conclude, the continued development of military technology is essential for maximising

a state's military capabilities. Using neorealist theory, this essay has established that military technology directly influences a state's relative power within the international system. By examining the classic military case study of nuclear submarines, it has also been established that leaders of complex technology should have a grounding in the technology they manage, embodying Janowitz's military technologist theory. As military institutions become more reliant on complex support technology, it is increasingly vital that these assets are managed by individuals who can fill the role of a military technologist. The second half of this essay discussed how military institutions should manage innovative technologies to maximise their development and use. The essay argued that Christenson's 'Innovator's Dilemma model' for disruptive technologies within business could be applied to military technology. Following, this theory it argued that creating a semi-autonomous organisation - dedicated to this technology - is pivotal to maximising military innovation. The essay then applies these arguments to the emerging sector of militarised space. It established that space assets are essential to fulfilling the role of a military, expanding a state's influence and protecting its national interest. Further, it demonstrated that these technologies also fulfilled Krause's conditions of effective military technology: (1) increase the state's influence within the international system through hard and soft power initiatives and (2) help militaries achieve victory in war. To establish this, the essay examined the use of space assets in the First Gulf War and the current Ukraine conflict, as well as discussing how these assets have been used to improve the lives of civilians. Having established that space assets are critical to modern warfare, the essay recommends that future leaders of space forces should be military technologists and learn about the assets they are managing. This could be achieved through advanced learning courses provided by military staff colleges and subject matter experts. Space is critical to future war and must be managed effectively.

Notes

[1] Krause, Keith. *Arms and the state: Patterns of military production and Trade*. Cambridge: University Press, 1992, pp. 12-13.

[2] Christensen, Clayton M. *The innovator's dilema: When new technologies cause great firms to fail*. New York, New York: Harvard Business School Press, 1997.

[3] Johnson speech to Democratic Causus, Jan 7, 1958, Statement file, Box 23.

[4] Marshall, Future of geography: How power and politics in space will change our world. London: Elliott and Thompson Limited, 2023.

[5] Bono, Philip, and George C. Goldbaum. 'Ithacus' - a New Concept of Intercontinental Ballistic Transport (ICBT). DTIC, May 28, 1964. https://apps.dtic.mil/sti/citations/AD0605208.

[6] Cooper, Helene. "A Space Force? The Idea May Have Merit, Some Say." The New York Times, June 23, 2018. https://www.nytimes.com/2018/06/23/us/politics/trump-space-force-military.html.

[7] Khan, Zulfqar, and Ahmad Khan. "Chinese Capabilities as a Global Space Power." *Astropolitics* 13, no. 2–3 2015: 185–204. https://doi.org/10.1080/14777622.2015.1084168, p. 185.

[8] Neuneck, Götz. "The Revolution in Military Affairs: Its Driving Forces, Elements, and Complexity." *Complexity* 14, No. 1 (2008): 50–61. https://doi.org/10.1002/cplx.20236, p. 50.

[9] Janowitz, Morris. *The professional soldier: A social and political portrait*. New York, New York: Free Press, 2017, p. 24.
[10] Ibid.
[11] Christenson, 1997.
[12] Huntington, Samuel P. *The soldier and the state: The theory and politics of civil-military relations*. New York, New York : Vintage Books, 1964, p. 1.
[13] Waltz, Kenneth N. Theory of international politics. Long Grove, Illinois: Waveland Press, 2010, 88-93;
[14] Mearsheimer, John J. The tragedy of great power politics. New York, New York: W. W. Norton & amp; Company, 2014, p. 3.
[15] Janowitz, 2017, p. 24.
[16] Land, Graham. "How Did Germany Defeat France so Quickly in 1940?" History Hit, August 8, 2018. https://www.historyhit.com/how-did-germany-defeat-france-so-quickly-in-1940/.
[17] Janowitz, 2017, p.25.
[18] Huntington, 1964, pp. 1-3.
[19] Krause, 1992, p. 26.
[20] Mearsheimer, 2014, pp. 42-46.
[21] Ibid.
[22] Ikenberry, G. John. "Liberal Internationalism 3.0: America and the Dilemmas of Liberal World Order." *Perspectives on Politics* 7, no. 1, (2009): 71–87. https://doi.org/10.1017/s1537592709090112, p.74.
[23] Roser, Max, Esteban Ortiz-Ospina, Hannah Ritchie, Edouard Mathieu, and Bastian Herre. "Military Personnel and Spending." Our World in Data, August 3, 2013. https://ourworldindata.org/military-spending.
[24] United States Committee on Armed Services. "Summary of the Fiscal Year 2023 National Defense Authorization Act." Armed Services Senate , December 15, 2022. https://www.armed-services.senate.gov/imo/media/doc/fy23_ndaa_agreement_summary.pdf.
[25] Waltz, 2010, p. 88-93
[26] Mearsheimer, 2014, p. 3
[27] Allison, Graham. *"Destined for War?" The National Interest*, no. 149 (2017): 9–21. https://www.jstor.org/stable/26557386.
[28] World Bank. "Military Expenditure (Current USD) - China." World Bank Open Data, June 10, 2022. https://data.worldbank.org/indicator/MS.MIL.XPND.CD?locations=CN.
[29] Marshall, 2023, pp. 167-193.
[30] Ibid pp. 101-118.
[31] Brimelow, Benjamin. "How the US Navy's Nuclear-Powered Submarines Have Quietly Dominated the Seas for 67 Years." Business Insider, January 29, 2021. https://www.businessinsider.com/how-us-navy-nuclear-powered-submarines-dominate-the-seas-2021-1?r=US&IR=T.
[32] "Atomic Submarine Engine Runs 66 Days at Full Power." *Electrical Engineering* 75, No. 10 (1956): 961–62. https://doi.org/10.1109/ee.1956.6442222.
[33] Blair, Clay. The atomic submarine and admiral rickover. New York, New York : Holt, 1954.

[34] Brimelow, 2021.
[35] Krause, 1992, p. 17.
[36] Brimelow, 2021.
[37] Zimmerman, Dwight. "Submarines at War: From the Turtle to U-Boats, Nuclear Submarines, and Unmanned Systems." Defense Media Network, April 5, 2020. https://www.defensemedianetwork.com/stories/submarines-war-turtle-u-boats-nuclear-submarines-unmanned-systems/.
[38] Muller, Richard, and Henry Sokolski. " The Origins of MAD: A Short History of City Busting." Essay. In Getting Mad: Nuclear Mutual Assured Destruction, Its Origins and Practice, 13–15. Pennsylvania: Strategic Studies Institute, U.S. Army War College, 2004, p. 14.
[39] Boehlefeld, Kathryn. "Sticks and Stones: Nuclear Deterrence and Conventional Conflict." Journal of Indo-Pacific Affairs, November 24, 2020.
[40] Neuneck, 2008, p. 51.
[41] Ministry of Defence. "Defence in a Competitive Age." GOV.UK, July 30, 2021. https://www.gov.uk/government/publications/defence-in-a-competitive-age.
[42] Bowen, Bleddyn E. "From the Sea to Outer Space: The Command of Space as the Foundation of Spacepower Theory." *Journal of Strategic Studies* 42, No. 3–4 (2017): 532–56. https://doi.org/10.1080/01402390.2017.1293531.
[43] Krulwich, Robert. "You (and Almost Everyone You Know) Owe Your Life to This Man." Culture, May 3, 2021. https://www.nationalgeographic.com/culture/article/you-and-almost-everyone-you-know-owe-your-life-to-this-man.
[44] European Space Agency. "The Kessler Effect and How to Stop It." ESA, 2022. https://www.esa.int/Enabling_Support/Space_Engineering_Technology/The_Kessler_Effect_and_how_to_stop_it.
[45] Moltz, James. "The Changing Dynamics of Twenty-First-Century Space Power." *Journal of Strategic Security* 12, No. 1 (2019): 15–43. https://doi.org/10.5038/1944-0472.12.1.1729, pp. 16-17.
[46] Janowitz, 2017, p. 25.
[47] Huntington, 1964, p. 12.
[48] Janowitz, 2017, p. 31.
[49] Ibid, p. 20.
[50] Ibid, p. 21.
[51] Ibid, p. 422.
[52] Janowitz, 2017, p. 25.
[53] Krause, 1992, p. 56-58.
[54] Davenport, Christian. *The Space Barons: Elon Musk, Jeff Bezos, and the quest to colonize the cosmos*. New York, New York : PublicAffairs, 2019, pp. 204-207.
[55] Ibid, pp. 247-248.
[56] Atomic Heritage Foundation. "Hyman G. Rickover." Nuclear Museum, 2022. https://ahf.nuclearmuseum.org/ahf/profile/hyman-g-rickover/.
[57] Janowitz, 2017, p. 164.
[58] Blair, 2004.

[59] Janowitz, 2017, p. 164.
[60] Janowitz, 2017, p. 165.
[61] Larson, Caleb. "K-3 Leninsky Komsomol: The Nuclear Submarine Workhorse of the Soviet Navy." The National Interest, May 10, 2021. https://nationalinterest.org/blog/buzz/k-3-leninsky-komsomol-nuclear-submarine-workhorse-soviet-navy-137277.
[62] Atomic Heritage Foundation, 2022.
[63] Time. "Denmark: Stay Away from My Door." Time, September 1, 1958. https://content.time.com/time/subscriber/article/0,33009,863714,00.html.
[64] Sheridan, D. (2023) *Ben Wallace pushes ahead with Army cuts despite Ukraine War*, *The Telegraph*. Available at: https://www.telegraph.co.uk/politics/2023/05/12/ben-wallace-army-troop-cuts-ukraine-war/ (Accessed: 08 June 2023).
[65] Graham-Harrison, Emma, Sanjana Varghese, and Julia Nueno. "Multiple Civilian Deaths Linked to 2016-17 British Airstrikes against Is in Mosul." The Guardian, March 21, 2023. https://www.theguardian.com/world/2023/mar/21/multiple-civilian-deaths-linked-to-2016-17-british-airstrikes-against-is-in-mosul.
[66] Christensen, 1997.
[67] Ibid, p.xv.
[68] Lye, Harry. "Streetfighter and the Future of the Challenger 2." Army Technology, July 29, 2020. https://www.army-technology.com/features/streetfighter-challenger-2/.
[69] Christensen, 1997, p.xv.
[70] Ibid, pp. 29-42.
[71] Ibid, p. 99.
[72] Ibid, p. 121-124.
[73] Ibid, p. 103-104.
[74] Oliver, Dave. *Against the tide: Rickover's leadership principles and the rise of the Nuclear Navy*. Annapolis, Maryland: Naval Institute Press, 2018.
[75] Atomic Heritage Foundation, 2022.
[76] Oliver, 2018.
[77] Janowitz, 2017, p. 25.
[78] Marshall, 2023.
[79] Ibid.
[80] U.S. Department of Defense. "Competing in Space." U.S. Department of Defense, December 2018. https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.pdf.
[81] N2YO.com. "Satellites by Countries and Organizations." n2yo.com, January 18, 2023. https://www.n2yo.com/satellites/?c=&t=country.
[82] Witze, Alexandra. "2022 Was a Record Year for Space Launches." Nature News, January 11, 2023. https://www.nature.com/articles/d41586-023-00048-7.
[83] Marshall, 2023.
[84] Mowthorpe, Matthew. *The militarization and weaponization of space*. Lanham: Lexington Books, 2004.
[85] Association Aéronautique et Astronautique de France (3AF) Strategy and International

Affairs Commission—Writers' Group. "The Militarization and Weaponization of Space: Towards a European Space Deterrent." *Space Policy* 24, no. 2 (2008): 61–66. https://doi.org/10.1016/j.spacepol.2008.02.001, p. 61.

[86] Mowthorpe, 2003, p. 3.

[87] United Nations. "General Assembly, 16th Session ." United Nations, November 15, 1961. https://digitallibrary.un.org/record/744203?ln=en, pp. 6-7.

[88] Wickramatunga, Robert. "United NationsOffice for Outer Space Affairs." The Outer Space Treaty, 1967. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

[89] United Nations. "Open-Ended Working Group on Reducing Space Threats." United Nations Office for Disarmament Affairs, February 2022. https://meetings.unoda.org/open-ended-working-group-on-reducing-space-threats-2022#:~:text=The%20third%20session%20of%20the,des%20Nations%2C%20Geneva%2C%20Switzerland.

[90] Bingen, Kari A., Kaitlyn Johnson, Makena Young, and John Raymond. "Space Threat Assessment 2023." CSIS, April 14, 2023. https://www.csis.org/analysis/space-threat-assessment-2023.

[91] Smith, Mark. "Anti-Satellite Weapons: History, Types and Purpose." Space.com, August 10, 2022. https://www.space.com/anti-satellite-weapons-asats.

[92] Doboš, Bohumil. *Geopolitics of the outer space a European perspective*. Cham: Springer International Publishing, 2019, p. 64.

[93] International Space Exploration Coordination Group (ISEG). Benefits stemming from Space Exploration, September 2013. https://www.nasa.gov/sites/default/files/files/Benefits-Stemming-from-Space-Exploration-2013-TAGGED.pdf.

[94] Ibid, pp. 63-66.

[95] Nye, Joseph. *Soft power: The means to success in world politics*. New York, New York: Public Affairs, 2004, p. 5.

[96] United States Department of Defence. "Global Positioning System Standard Positioning Service Performance Standard." United States Department of Defence, September 2008. https://www.gps.gov/technical/ps/2008-SPS-performance-standard.pdf.

[97] Ibid.

[98] Canadian Water Board. "Fact Sheet 6.1.2.0 Global Positioning System (GPS) Fact Sheet." Waterboard CA, 2020. https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/6120.pdf.

[99] Ibid.

[100] Doboš, 2019, p. 62.

[101] Jaenicke, Rich. "Military Embedded Systems." Securing military GPS and PNT systems, December 2, 2022. https://militaryembedded.com/comms/communications/securing-military-gps-and-pnt-systems.

[102] Rana, Ratika. "India's Mega Projects: Denied GPS during Kargil War by US, ISRO Developed NavIC." The Logical Indian, January 31, 2022. https://thelogicalindian.com/trending/navic-isro-33649#:~:text=NavIC%20was%20developed%20partly%20because,data%20for%20the%20Kargil%20region.

[103] Abbany, Zulfikar. "Modern Spy Satellites in an Age of Space Wars – DW – 08/25/2020." dw.com, August 26, 2020. https://www.dw.com/en/modern-spy-satellites-in-an-age-of-space-wars/a-54691887.
[104] Frąckiewicz, Marcin. "The Use of Spy Satellites in Surveillance and Reconnaissance." TS2 Space, May 16, 2023. https://ts2.space/en/the-use-of-spy-satellites-in-surveillance-and-reconnaissance/.
[105] European Space Agency . "Europe's Copernicus Programme." European Space Agency, 2023. https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Europe_s_Copernicus_programme.
[106] Lukačevič, Jan, Katarina Kertýsová, and Rene Heise. "The Climate-Space Nexus: New Approaches for Strengthening NATO's Resilience." NATO Review, August 18, 2022. https://www.nato.int/docu/review/articles/2022/08/18/the-climate-space-nexus-new-approaches-for-strengthening-natos-resilience/index.html.
[107] Marshall, 2023.
[108] Greenemeier, Larry. "GPS and the World's First 'Space War.'" Scientific American, February 8, 2016. https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war/.
[109] MacroTrends. "Iraq Military Size 1985-2023." MacroTrends, 2023. https://www.macrotrends.net/countries/IRQ/iraq/military-army-size.
[110] Perry, William J. "Desert Storm and Deterrence." *Foreign Affairs* 70, No. 4 (1991): 66. https://doi.org/10.2307/20044914, p. 67.
[111] Ibid, p. 66.
[112] Anson, Peter, and Dennis Cummings. "The First Space War: The Contribution of Satellites to the Gulf War." *The RUSI Journal* 136, No. 4 (1991): 45–53. https://doi.org/10.1080/03071849108445553, pp. 45-50.
[113] Krutov, Mark, and Sergei Dobrynin. "In Russia's War on Ukraine, Effective Satellites Are Few and Far Between." RadioFreeEurope/RadioLiberty, April 11, 2022. https://www.rferl.org/a/russia-satellites-ukraine-war-gps/31797618.html.
[114] Massa, Mark. "Commercial Satellites Are on the Front Lines of War Today. Here's What This Means for the Future of Warfare." Atlantic Council, August 31, 2022. https://www.atlanticcouncil.org/content-series/airpower-after-ukraine/commercial-satellites-are-on-the-front-lines-of-war-today-heres-what-this-means-for-the-future-of-warfare/.
[115] Corera, Gordon. "Russia Hacked Ukrainian Satellite Communications, Officials Believe." BBC News, March 25, 2022. https://www.bbc.co.uk/news/technology-60796079.
[116] Massa, 2022.
[117] Roulette, Joey, and Mike Stone. "SpaceX's Starlink Wins Pentagon Contract for Satellite Services to Ukraine." Reuters, June 1, 2023. https://www.reuters.com/business/aerospace-defense/pentagon-buys-starlink-ukraine-statement-2023-06-01/#:~:text=SpaceX%2C%20through%20private%20donations%20and,of%20the%20war%20in%202022.
[118] Massa, 2022.
[119] Miller, Christopher, Mark Scott, and Bryan Bender. "Ukrainex: How Elon Musk's Space Satellites Changed the War on the Ground." POLITICO, June 9, 2022. https://www.politico.eu/article/elon-musk-ukraine-starlink/.

[120] Krutov and Sergei, 2022.
[121] Ibid.
[122] Orbiting Now. "Active Satellite TLE Data and Information." orbit.ing, June 18, 2023. https://orbit.ing-now.com/.
[123] Marshall, 2023.
[124] Bowen, 2017, p. 532.
[125] Hill, Robert. "Admiral Hyman G Rickover USN and the UK Nuclear Submarine Propulsion Programme ." *The Thomas Lowe Gray Memorial Lecture*. Lecture presented at the The Thomas Lowe Gray Memorial Lecture, April 19, 2005.
[126] Lopez, Todd. "Space Force Focuses on Partnerships, Spirit, Combat Readiness." U.S. Department of Defense, March 15, 2023. https://www.defense.gov/News/News-Stories/Article/Article/3330161/space-force-focuses-on-partnerships-spirit-combat-readiness/#:~:text=The%20U.S.%20Space%20Force%27s%20%2430,%2C%20development%2C%20testing%20and%20evaluation.
[127] Davenport, 2021, pp. 227-230, pp. 247-248.