

Space Warfare: Protecting the U.S. GPS Satellite as the Threat from China Emerges

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Abstract & Introduction

As the battlefield and scope of warfare evolves, space is the last domain largely untouched by combat operations. The modernization of warfare in the 21st Century relies strongly off satellites. They are essential for communication, reconnaissance, and guidance systems.¹ The United States (U.S.) heavily relies on the GPS satellite in crucial areas such as oil, electricity, financial transactions, telecommunications, etc. As a backbone for modern America, the GPS satellite is vulnerable to attack. As a top threat to U.S. national security, China developed anti-satellite weapons that poses a threat to the GPS satellite. Any attack against a U.S. satellite results in catastrophic damage to the U.S. economy and daily operations.² This report will provide the blueprint for an anti-satellite weapon that protects the U.S. GPS satellite and destroys anti-satellite weapons of hostile nations.

Policy Problem

Economic Digitization

The U.S. GPS satellite is vulnerable without adamant anti-satellite and space weaponry. Society has become more digitized and reliant on technology than previous generations. According to the U.S. Bureau of Economic Analysis, digital economy consists of infrastructure (computers and technology), e-commerce, and digital services.³ The digital economy has grown from 7.3% to 9% of the overall U.S. economy from 2005-2018.⁴ In 2020, the U.S. Digital Economy was \$13.6 trillion.⁵ Digital banking, a crucial area of the digitized economy, increased substantially amongst Americans since 2018.⁶ As of 2021, 75% of Americans will be customers of digital banking.⁷ Modern digitization also includes communications systems for phones, navigation, oil, ATM withdrawals, as well as weather forecasts. All these networks rely on the GPS Satellite.⁸ GPS Satellites contain atomic clocks that are integrated with the transmission and

¹ “Fact File: The Importance of Military Satellites - Latest News - Aerocom Metals Limited,” accessed October 25, 2021, <https://aerocommetals.co.uk/blog/post?s=2015-04-14-fact-file-the-importance-of-military-satellites>.

² Al Phillips, *CNN: War In Space, The Next Battlefield*, 2019, <https://www.youtube.com/watch?v=CqtL1YIsuFM>.

³ “How Does BEA Define the Digital Economy? | U.S. Bureau of Economic Analysis (BEA),” accessed October 29, 2021, <https://www.bea.gov/help/faq/1248>.

⁴ “U.S. Digital Economy GDP Share 2018,” Statista, accessed October 29, 2021, <https://www.statista.com/statistics/961982/digital-economy-gdp-share-usa/>.

⁵ “US Digital Economy Scale Ranks First in the World, While China Has the Fastest Development Speed - Global Times,” accessed October 29, 2021, <https://www.globaltimes.cn/page/202108/1230356.shtml>.

⁶ “U.S. Digital Banking Usage 2022,” Statista, accessed October 29, 2021, <https://www.statista.com/statistics/946109/digital-banking-users-usa/>.

⁷ Insider Intelligence, “US Digital Banking Users Will Surpass 200 Million in 2022,” Business Insider, accessed October 29, 2021, <https://www.businessinsider.com/current-state-of-online-banking-industry>.

⁸ Marshall Shepherd, “Six Ways You Used Satellites Today And Didn’t Know It,” Forbes, accessed October 29, 2021, <https://www.forbes.com/sites/marshallshepherd/2019/04/09/six-ways-you-used-satellites-today-and-didnt-know-it/>.

operation of systems above. Atomic clocks provide precise timing in which systems use to direct the flow of operations. For example, financial firms and ATMs rely on atomic clocks in GPS satellites to direct the flow of transactions.⁹

GPS Satellite Vulnerabilities

The U.S. GPS Satellite is vulnerable to damage, hacking, and lacks a sufficient back up system. Hackers have two main methods to undermine the GPS satellite. The first method is interfering or disturbing the frequency that is transmitted from the satellite. The second method is intercepting the codes transmitted from the satellite to the receiver or object.¹⁰ In 2016, Flight 905 from Hong Kong to Manila had the GPS system hacked. The pilots had no choice but to land the plane without any assistance from GPS or air traffic control.¹¹ For the United States, this is a major threat. In 2017, the Department of Homeland Security had experts hack the GPS system to prove the vulnerability of airplanes.¹² Not since September 11, 2001, had America seen a major attack via airplanes. GPS hacks can shut down major airports, severely affect flight patterns, and may result in planes not being able to land safely.¹³

China Space War Threat

On January 11, 2007, China tested a ballistic missile against one of its satellites.¹⁴ The launch triggered concern amongst U.S. national security. it demonstrated China's increased capability to pose a threat to the U.S. military. Anti-satellite capabilities increase the threat Beijing can attack American satellites. Since the U.S. military and much of America's modern economy and infrastructure relies on satellites, it is a major national security concern between the United States and China.¹⁵ China continues its advancement in space. Beijing achieved major space milestones such as landing on the dark side of the moon in 2019.¹⁶ China is actively building the Tiangong Space Station; set for completion in 2022.¹⁷

⁹ "GPS.Gov: Timing Applications," accessed November 2, 2021, <https://www.gps.gov/applications/timing/>.

¹⁰ Paul Tullis, "GPS Is Easy to Hack, and the U.S. Has No Backup," *Scientific American*, accessed November 1, 2021, <https://doi.org/10.1038/scientificamerican1219-38>.

¹¹ Tullis.

¹² Clive Irving Cox Joseph, "Could Terrorists Hack an Airplane? The Government Just Did.," *The Daily Beast*, November 17, 2017, sec. tech, <https://www.thedailybeast.com/could-terrorists-hack-an-airplane-the-government-just-did>.

¹³ Tullis, "GPS Is Easy to Hack, and the U.S. Has No Backup."

¹⁴ "Chinese_asat_fact_sheet_updated_2012.Pdf," accessed November 1, 2021, https://swfound.org/media/9550/chinese_asat_fact_sheet_updated_2012.pdf.

¹⁵ "China's Anti-Satellite Test," Council on Foreign Relations, accessed November 1, 2021, <https://www.cfr.org/backgrounder/chinas-anti-satellite-test>.

¹⁶ Sarah Pruitt, "China Makes Historic Landing on 'Dark Side' of the Moon," *HISTORY*, accessed November 1, 2021, <https://www.history.com/news/china-plans-historic-landing-on-dark-side-of-the-moon>.

¹⁷ Andrew Jones, "China's Tiangong Space Station," *Space.com*, August 24, 2021, <https://www.space.com/tiangong-space-station>.

Regarding satellites, Beijing continues to develop new anti-satellite weapons. *The 2021 Annual Threat Assessment* report details China's possession of missiles and lasers designed to destroy or disable opposing satellites.¹⁸ One notable anti-satellite weapon is the Shijian-17. Beijing states that it is for communications and debris observance, but the Washington states otherwise. U.S. Space Command is concerned for the security of the U.S. GPS satellite being damaged by the Shijian-17. It has a robotic arm that can capture, or rewire, other satellites.¹⁹ In October 2021, China launched the Shijian-21 satellite. Like the Shijian-17, it too has a robotic arm. The difference is the Shijian-21 can 'crush' satellites.²⁰ The 2021 report for *Chinese Strategy and Military Forces* details locations of space launch sites in China (Jiuquan, Xichang, Taiyuan, Wenchang).²¹ Taking note of that information, this report can inference anti-satellite weapons could have been launched from those sites.

China also plans to use space to conquer foreign policy objectives. One of China's main foreign policy objectives is seizing Taiwan and reuniting it with China. One strategy to accomplish this is with mass satellite production. At a pace of 240 per year, China could place them within the U.S. satellite constellation. This will directly threaten the security of U.S. satellites (especially satellites for communication, navigation, weapons, timing, and warning systems); thus, giving China the advantage to launch an offensive in Taiwan. Threatening U.S. satellites will reduce the ability for the U.S. Military to either respond or intervene if/when China attacks Taiwan. Washington will be preoccupied protecting satellites and divert attention from Taiping.²² Reports confirmed China's test of the hypersonic missile in October 2021. It presents a major concern to U.S. national security; it could lead to an eventual escalated arms race. This report can infer it will likely impact the trajectory of this research and weapon design as details continue to emerge.²³ Hypersonic missiles are faster than Mach 5 speed and can carry nuclear

¹⁸ "ATA-2021-Unclassified-Report.Pdf," accessed November 1, 2021, <https://www.dni.gov/files/ODNI/documents/assessments/ATA-2021-Unclassified-Report.pdf>.

¹⁹ "China Can 'grapple' US Satellites with Robotic Arm, Commander Says," Nikkei Asia, accessed November 1, 2021, <https://asia.nikkei.com/Politics/International-relations/US-China-tensions/China-can-grapple-US-satellites-with-robotic-arm-commander-says>.

²⁰ Dave Makichuk, "Shijian-21: Satellite Crusher or Space Debris Cleaner?," Asia Times, October 27, 2021, <https://asiatimes.com/2021/10/shijian-21-satellite-crusher-or-space-debris-cleaner/>.

²¹ Anthony H Cordesman, "Chinese Strategy and Military Forces in 202," n.d., 191.

²² Brandon Kelley Brian G. Chow, "China's Anti-Satellite Weapons Could Conquer Taiwan—Or Start a War," Text, *The National Interest* (The Center for the National Interest, August 21, 2021), <https://nationalinterest.org/feature/china%E2%80%99s-anti-satellite-weapons-could-conquer-taiwan%E2%80%94or-start-war-192135>.

²³ "Visual explainer: How China's Hypersonic Missile Compares to Conventional Ballistic Weapons," accessed November 7, 2021, <https://www.usatoday.com/in-depth/graphics/2021/11/04/china-hypersonic-missile-sputnik-moment-icbm-mach-5-weapon/8581971002/>.

warheads.²⁴ They are long-range weapons with a maneuverable flight pattern to the target.²⁵ The speed of the hypersonic missile makes it increasingly hard to detect via radar. Space based sensors do not have the capability to detect hypersonic missiles gliding at low elevation.²⁶ Currently, the U.S. has developed the National Defense Space Architecture. Comprised of over 500 satellites, its function includes hypersonic detection. The system isn't set for operation until 2025.²⁷ Contrary to China's hypersonic developments, the U.S. slated a February 2022 timeline to escalate successful development.²⁸ According to the 2021 Department of Defense Report on China, projects Beijing's 2049 "rejuvenation" deadline. This includes all three foreign policy objectives (Taiwan, South China Sea, and Hong Kong). This translates to a 27-year timeframe for a potential U.S.-China War.²⁹

Legislative History

World War II

The case for space weaponry originates in Nazi Germany during World War II. One of Germany's top rocket scientists, Werner von Braun, derived and tested sophisticated weapons at the Peenemunde Research Factory. The Wehrmacht's offensive blitzed through Europe and Africa but faced major setbacks following Operation Barbarossa. At Peenemunde, von Braun designed the world's first ballistic missile (V-2). In October 1942, the V-2 was successfully launched.³⁰ From 1943, the war shifted against Germany's favor. Adolf Hitler was determined to win the war. Hitler and others in High Command were proponents of futuristic weapons that would turn the war. From late 1944-1945, scores of V-2s were launched against England.

³¹German scientists also developed designs and/or prototypes for stealth aircraft, Wunderwaffe,

²⁴ "Hypersonic missiles: What are they and can they be stopped?," *Partyard Military* (blog), May 10, 2019, <https://partyardmilitary.com/hypersonic-missiles-what-are-they-and-can-they-be-stopped/>.

²⁵ "R45811.Pdf," accessed November 11, 2021, <https://sgp.fas.org/crs/weapons/R45811.pdf>.

²⁶ Jen Judson, "Congress Wants Answers on How DoD Is Solving a Hypersonic Weapons Detection Gap," *Defense News*, September 13, 2021, <https://www.defensenews.com/pentagon/2021/09/13/congress-wants-answers-on-how-dod-is-solving-a-hypersonic-weapons-detection-gap/>.

²⁷ "IF11623.Pdf," accessed February 10, 2022, <https://sgp.fas.org/crs/weapons/IF11623.pdf>.

²⁸ View Author Archive and Get author RSS feed, "Pentagon Seeks to 'Light a Fire' for American Hypersonic Missile Plans," *New York Post* (blog), January 29, 2022, <https://nypost.com/2022/01/29/pentagon-seeks-to-speed-up-hypersonic-weapons-development/>.

²⁹ "2021-CMPR-FINAL.Pdf," accessed February 10, 2022, <https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF>.

³⁰ History.com Editors, "Germany Conducts First Successful V-2 Rocket Test," *HISTORY*, accessed October 30, 2021, <https://www.history.com/this-day-in-history/germany-conducts-first-successful-v-2-rocket-test>.

³¹ "The Terrifying German 'Revenge Weapons' Of The Second World War," Imperial War Museums, accessed November 7, 2021, <https://www.iwm.org.uk/history/the-terrifying-german-revenge-weapons-of-the-second-world-war>.

supersonic missiles, long range bombers, even jet aircraft.³² There were other futuristic weapons devised by German scientists but listed above are some of the most notable ones. Many of those weapons were developed very late in the war or would not have been operational until after Germany surrendered to the Allies in May 1945.

Cold War

After World War II, tensions between the United States and Soviet Union escalated. The United States became the strongest international power both economically and militarily. America was also the first and sole nuclear power; but it was short lived. The Soviet Union conducted and eventually achieved the nuclear bomb in 1949.³³ To stay ahead of the Soviet Union developing sophisticated weapons, the U.S. Government launched Operation Paperclip. From 1946, scores of Nazi scientists (including Werner von Braun) were extradited to the United States. They modified rockets (innovating the V-2) but served as the backbone in the eventual space race between the U.S. and Soviet Union.³⁴

In 1957, the Soviet Union launched the first orbital satellite, *Sputnik*. It captivated the world but set off major concerns amongst U.S. national security. In 1958, the U.S. launched its satellite into space, *Explorer 1*. Later that year, NASA was officially established.³⁵ In 1960, the Advanced Research Projects Agency launched *Transit*, the first GPS satellite. Its purpose was to provide accurate navigation systems for the U.S. military (especially submarines). The GPS satellite continued to be innovated throughout the decade. From 1967-1968, it was upgraded with the addition of two Chrystal Oscillator satellites.³⁶ Chrystal oscillator simply establishes stabilized frequencies for radio communication.³⁷ By 1974, the atomic clock satellite was added to the GPS.³⁸ Also note the NAVSTAR system was also launched in 1974. This resulted in

³² Savannah Cox, “23 Nazi Superweapons That Were Thankfully Too Crazy To Be Used,” All That’s Interesting, October 18, 2016, <https://allthatsinteresting.com/nazi-weapons>.

³³ “29 August 1949 - First Soviet Nuclear Test: CTBTO Preparatory Commission,” accessed November 7, 2021, <https://www.ctbto.org/specials/testing-times/29-august-1949-first-soviet-nuclear-test>.

³⁴ Laura Schumm, “What Was Operation Paperclip?,” HISTORY, accessed November 7, 2021, <https://www.history.com/news/what-was-operation-paperclip>.

³⁵ “The Space Race | American Experience | PBS,” accessed October 30, 2021, <https://www.pbs.org/wgbh/americanexperience/features/moon-space-race/>.

³⁶ “Brief History of GPS | The Aerospace Corporation,” Aerospace Corporation, accessed October 30, 2021, <https://aerospace.org/article/brief-history-gps>.

³⁷ “What Does Crystal Oscillator Mean?,” accessed October 30, 2021, <https://www.definitions.net/definition/Crystal+Oscillator>.

³⁸ “Brief History of GPS | The Aerospace Corporation.”

expanding the GPS to include 24 satellites. Additional work and modifications of the GPS satellite continued through the 1970s.³⁹ They eventually became orbital in 1978.⁴⁰

In 1983, President Ronald Reagan ordered the opening of the GPS system for public use. This directive was a safety measure for air traffic control following the Soviet shutdown of a Korean airliner. Public-private partnerships between the U.S. Government and companies stemmed from 1985 to develop GPS receivers.⁴¹ By 1989, *Block II* was the first fully operational GPS satellite launched by the United States. Handheld GPS also began to emerge in the same year.⁴²

Modernization and the 21st Century

The U.S. Military heavily relied upon GPS satellites during the Gulf War. It was crucial for not only reconnaissance, but the accuracy of airstrikes against Iraqi targets and navigation of U.S. troops.⁴³ The GPS satellite system became fully operational in 1995. It contained 27 satellites; 24 were operational and three were replacements.⁴⁴ GPS was enabled in cell phones by 1999. After the Pentagon removed restrictions on GPS accuracy for civilian usage, it became more widely available after 2000.⁴⁵ In 2005, GPS became even more integrated into civilian life with the launch of *Block II-R*. From 2010-2016, *Block II-F* satellites were launched as an upgrade to the original *Block II*. In 2018, *Block II* was officially replaced with the U.S. Air Force launch of GPS III satellite. The Second GPS III launched in 2019. Also in December 2019, the Space Force was activated as the 6th branch of the U.S. Military.⁴⁶ GPS III-3 was planned to launch in 2020 but was postponed due to the Coronavirus Pandemic.⁴⁷

This development of this weapon aligns with sin-crime distinction. The international Outer Space Treaty of 1967 restricts space from turning into a warzone. Bans on nuclear weapons, military activities on the moon, and guaranteed freedom of maneuver are key policies

³⁹ mcynar, "GPS History : A Timeline of the Facts You Need," May 18, 2018, <https://gpstrackingplans.com/gps-history/>.

⁴⁰ "GPS Goes to War - The Global Positioning System in Operation Desert Storm.," www.army.mil, accessed October 31, 2021, https://www.army.mil/article/7457/gps_goes_to_war_the_global_positioning_system_in_operation_desert_storm.

⁴¹ "The History of Transportation Technology: GPS Satellites and Tracking," Transplace, accessed October 31, 2021, <https://www.transplace.com/knowledge-base/the-history-of-transportation-technology-gps-satellites-and-tracking/>.

⁴² "The History of Transportation Technology."

⁴³ Larry Greenemeier, "GPS and the World's First 'Space War,'" *Scientific American*, accessed October 31, 2021, <https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war/>.

⁴⁴ mcynar, "GPS History."

⁴⁵ "The History of Transportation Technology."

⁴⁶ "History," accessed November 7, 2021, <https://www.spaceforce.mil/About-Us/About-Space-Force/History/>.

⁴⁷ "History of GPS Satellites and Commercial GPS Tracking," Geotab, accessed October 31, 2021, <https://www.geotab.com/blog/gps-satellites/>.

in the treaty. The United States has signed the treaty.⁴⁸ China can challenge the U.S. legal restrictions (previously mentioned in this report) by placing satellites within close range of the GPS satellite. Biblically, sin-crime defines not all sins as crimes. China's deliberate interference to threaten the GPS satellite pushes the U.S. to consider military action. If China were to disable or destroy the GPS satellite, Americans and many others around the world will be directly negatively affected. Earlier, the report acknowledged the U.S. economy (especially financial sectors such as banks) rely on the GPS satellite for transactions and daily operational flow. Attacks against the GPS hurts the economy and directly impacts the wallets of Americans. China is provoking the United States; legally weapons can't be present in space (according to the treaty). Since modern America relies on the GPS, measures such as defensive weapons (despite the treaty) are necessary for U.S. national security, because of the vulnerability of the GPS satellites and major impacts if attacked

China's GPS Satellite

As an alternative to the U.S. GPS satellite system, China is developing one of its own. In a 2016 White Paper, China highlighted the blueprints for its satellite program. Named *Beidou* (BDS), construction began in 1994 and projects to 2020. Evolution of the Beidou expanded to 35 satellites. China's satellite system is intended to fulfill its foreign policy goals of horizontal hegemony. This entails making more countries reliant on China by opening internet access and communication access.⁴⁹

Criteria for Success

Developing this weapon applies to sin-crime distinction. China's space strategies such as interfering with the GPS with weapons like the Shijian-17 or 21 challenge U.S. authority to respond. Internationally, the United States cannot place weapons in space per the 1967 treaty. Beijing circumvented that, and rising threats challenge the current state of U.S. satellites. China continues to test the United States foreign policy with calculated moves. For example, Beijing increased flyovers and invasion threats of Taiwan through 2021.⁵⁰ In space, the United States must be prepared to counteract. China's tests are not easily classified as illegal, because their antisatellite weapons are disguised as observation or standard satellites (according to Beijing's statements).⁵¹ Nevertheless, the United States must treat it as a national security threat. The 2021 Department of Defense report highlights China's ultimate 2049 goal to achieve all foreign policy objectives. Using space is a method for China to achieve major objectives by undermining the United States in the process.⁵²

⁴⁸ "The Outer Space Treaty at a Glance | Arms Control Association," accessed November 3, 2021, <https://www.armscontrol.org/factsheets/outerspace>.

⁴⁹ "White Paper on China's Space Activities Published," accessed November 1, 2021, http://english.www.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm.

⁵⁰ "China-Taiwan Military Tensions 'Worst in 40 Years,'" *BBC News*, October 6, 2021, sec. Asia, <https://www.bbc.com/news/world-asia-58812100>.

⁵¹ Chris Pleasance, "China Launches Possible 'Satellite-Crushing Weapon,'" *Mail Online*, October 26, 2021, <https://www.dailymail.co.uk/news/article-10132577/China-launches-possible-satellite-crushing-weapon.html>.

⁵² "2021-CMPR-FINAL.Pdf," accessed November 18, 2021, <https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF>.

Aside from designing deploying space borne anti-satellite, one area of focus is hacking. The policy problem section of this report acknowledged the vulnerability of the U.S. GPS satellite to hacking. Since the U.S. GPS satellite also lacks an adequate back up system, the Pentagon needs to devise a defense strategy for the Space Force. Not only will this defend satellites, but it would also propel the U.S. advantage over China in any worst-case scenario. On hacking, the U.S. Space Force must develop a cogent cyber strike team to combat hostile actors from interfering in the U.S. GPS Satellite System.

Alternative Policy Options

In the 2020 Department of Defense *Defense Space Strategy Summary* report, freedom of operation and space superiority are top priorities going forward.⁵³ In a 2021 Space Command report titled *Commander's Strategic Vision*, space is acknowledged as a major area of U.S. national security. The report's agenda is for the U.S. to develop coherent strategy with allies to combat threats.⁵⁴

The first task is simply backing up GPS satellite data. The second task for the U.S. Space Force is anti-hacking. Both 2020 and 2021 defense reports admit the national security importance of space, but do not explicitly reference hacking. Space Delta 6 was established on July 24, 2020. It is a joint squadron with the mission of providing the Space Force essential tools to perform cyberspace operations. Though there is not much detail as to what specifically cyberoperations under Delta 6 contains, it does indicate a move toward protecting the operation of satellites.⁵⁵ A cyberwarfare strike team will serve as an essential component for the U.S. Space Force. A Space Force cyberwarfare strike team can be integrated within Delta 6; it will further specialize and narrow anti-hacking capabilities. The strike team can easily deploy emergency containment operations if a satellite were hit, identify, and neutralize the location of the hacker(s), but most of all, analyze GPS satellites for potential weaknesses and develop protective tools.

The U.S. GPS Satellite is crucial to the U.S. economy, infrastructure, and military. China's continued development of anti-satellite weaponry poses a direct threat to U.S. satellites. To protect them from damage, the United States of America must design a deployable anti-satellite weapon. Currently, no weapon exists nor is there any data to analyze its impacts. The following will be this report's early blueprints and Biblical justification for the weapon. This will be a laser guided weapon will either be mounted to a satellite or be present within the vicinity of the GPS satellite system. Main calculation concepts to note is line of sight guidance. Since this is a spaceborne weapon, it must abide by three-point guidance law, because of additional and unknown factors that exceed the weapon and target. The weapon is still in development process with more to come.

⁵³ "2020 Defense Space Strategy Summary," n.d., 18.

⁵⁴ "Commander's Strategic Vision," accessed November 1, 2021, <https://www.spacecom.mil/Mission/Commanders-Strategic-Vision/>.

⁵⁵ "Space Delta 6 Protects Space and Cyberspace," Space Operations Command (SpOC), accessed November 1, 2021, <https://www.spoc.spaceforce.mil/News/Article-Display/Article/2446117/space-delta-6-protects-space-and-cyberspace>.

For effective function, the new anti-satellite weapon will serve as a defense shield for all U.S. satellites. What this means is six of these weapons will operate a 360-degree orbit of U.S. satellites. By establishing a new security field, it ensures satellite protection- to include the possibility of deterrence. Incorporating these anti-satellite weapons with laser technology is crucial for effective function. The laser system will give the weapon a method of precision and accurate targeting of a hostile satellite. In further details, the projectile fired from the weapon will have a more accurate trajectory to engage and destroy the target. In space, lasers must function with faster deliverance (speed of the beam). Utilizing methods such as deuterium fluoride with integrates within the targeting system for the anti-satellite weapon. This must also include fuel capabilities for the laser guidance system.⁵⁶

Using studies from precision bombing and ballistics will serve as the ‘parent’ of this system. Creating a laser guided missile system to be fired from a satellite requires a major understanding of precision strikes. Taking knowledge from the post-World War II bombing developments, advancements in stealth technology, and destruction accuracy. Without these fundamentals, it cannot be determined that the weapon will be effective for America’s most vulnerable satellites. If a projectile were to be fired against a satellite, the laser guidance system prevents increased risk of misfires or collateral damage (including space junk).⁵⁷

Evaluate Policy Options

The U.S. GPS satellite is critical to America’s modern economy and daily operations as described throughout the report. On a national security basis, the U.S. military has been heavily reliant since the Gulf War. Though the GPS has multiple vulnerabilities such hacking, the inability to physically protect satellites is of major concern. If a physical attack by China on a U.S. satellite were to occur, it will be extremely challenging for America’s response to replace the satellite. Satellites contain data and sensitive information. Reducing hacking capability is not the same as physically protecting the object. The new spaceborne weapon will provide physical protection to the U.S. GPS satellite. It will deter China from challenging GPS safety. The ability for the U.S. to engage and neutralize an enemy satellite will also reduce the risk of major consequences following an attack on the GPS satellite.

General Recommendations and Conclusion

The United States of America is heavily reliant on the GPS satellite for communications, economy, and national security. Beijing’s continued space capabilities and escalating tensions with the United States are critical to American national security. America must protect the GPS satellite from attack because the consequences will be detrimental to the country. Economic damage and inability for the U.S. military are two key results of a satellite attack. Therefore, for the U.S. to maintain an advantage in space and prevent an attack against the GPS satellite from hostile nations like China, America must devise a next generation anti-satellite weapon. Either mantling it to the satellite or keeping it within close orbit of the GPS satellite will provide the best protection. Below are the following recommendations for weapons design.

⁵⁶ C. Breck Hitz, James J. Ewing, and Jeff Hecht, *Introduction to Laser Technology* (John Wiley & Sons, 2004).

⁵⁷ “Weapons of Choice - University of Alabama Press,” accessed February 10, 2022, <http://www.uapress.ua.edu/product/Weapons-of-Choice,1776.aspx>.

- The weapon should apply laser and possible missile technology (beyond railgun capabilities) to destroy enemy satellites
- Extra calculations and principles of precision bombing need to be applied because the weapon is space-borne.
- The GPS satellite needs to be further studied on sensitivity and movement operations to determine whether the weapon can be mounted to the satellite.
- Factor in miscellaneous: possible space junk, collateral damage, etc.

In conclusion, the GPS satellite is crucial to America's economic and military operations. Left unprotected, it is vulnerable to attack. China is a major national security threat to the United States and is increasing space capabilities. As the backbone for modern America, the GPS satellite must be protected from attack from China's anti-satellite weapons. Though the U.S. has limits on military operations in space due to treaty, it must be prepared to defend the GPS satellite. With the design of a next generation anti-satellite weapon, the U.S. Space Force will not only destroy enemy satellites but deter China from interfering with or threatening the GPS satellite.

Bibliography

- “29 August 1949 - First Soviet Nuclear Test: CTBTO Preparatory Commission.” Accessed November 7, 2021. <https://www.ctbto.org/specials/testing-times/29-august-1949-first-soviet-nuclear-test>.
- “2020 Defense Space Strategy Summary,” n.d., 18.
- “2021-CMPR-FINAL.Pdf.” Accessed February 10, 2022. <https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF>.
- “2021-CMPR-FINAL.Pdf.” Accessed November 18, 2021. <https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF>.
- Al Phillips. *CNN: War In Space, The Next Battlefield*, 2019. <https://www.youtube.com/watch?v=CqtL1YIsuFM>.
- Andrew Jones. “China’s Tiangong Space Station.” Space.com, August 24, 2021. <https://www.space.com/tiangong-space-station>.
- Archive, View Author, and Get author RSS feed. “Pentagon Seeks to ‘Light a Fire’ for American Hypersonic Missile Plans.” *New York Post* (blog), January 29, 2022. <https://nypost.com/2022/01/29/pentagon-seeks-to-speed-up-hypersonic-weapons-development/>.
- “ATA-2021-Unclassified-Report.Pdf.” Accessed November 1, 2021. <https://www.dni.gov/files/ODNI/documents/assessments/ATA-2021-Unclassified-Report.pdf>.
- Brian G. Chow, Brandon Kelley. “China’s Anti-Satellite Weapons Could Conquer Taiwan—Or Start a War.” Text. The National Interest. The Center for the National Interest, August 21, 2021. <https://nationalinterest.org/feature/china%E2%80%99s-anti-satellite-weapons-could-conquer-taiwan%E2%80%94or-start-war-192135>.
- Aerospace Corporation. “Brief History of GPS | The Aerospace Corporation.” Accessed October 30, 2021. <https://aerospace.org/article/brief-history-gps>.
- Nikkei Asia. “China Can ‘grapple’ US Satellites with Robotic Arm, Commander Says.” Accessed November 1, 2021. <https://asia.nikkei.com/Politics/International-relations/US-China-tensions/China-can-grapple-US-satellites-with-robotic-arm-commander-says>.
- Council on Foreign Relations. “China’s Anti-Satellite Test.” Accessed November 1, 2021. <https://www.cfr.org/backgrounders/chinas-anti-satellite-test>.
- BBC News. “China-Taiwan Military Tensions ‘Worst in 40 Years,’” October 6, 2021, sec. Asia. <https://www.bbc.com/news/world-asia-58812100>.
- “Chinese_asat_fact_sheet_updated_2012.Pdf.” Accessed November 1, 2021. https://swfound.org/media/9550/chinese_asat_fact_sheet_updated_2012.pdf.
- “Commander’s Strategic Vision.” Accessed November 1, 2021. <https://www.spacecom.mil/Mission/Commanders-Strategic-Vision/>.
- Cordesman, Anthony H. “Chinese Strategy and Military Forces in 202,” n.d., 191.
- Cox, Clive Irving, Joseph. “Could Terrorists Hack an Airplane? The Government Just Did.” *The Daily Beast*, November 17, 2017, sec. tech. <https://www.thedailybeast.com/could-terrorists-hack-an-airplane-the-government-just-did>.
- Cox, Savannah. “23 Nazi Superweapons That Were Thankfully Too Crazy To Be Used.” All That’s Interesting, October 18, 2016. <https://allthatsinteresting.com/nazi-weapons>.
- Editors, History.com. “Germany Conducts First Successful V-2 Rocket Test.” HISTORY. Accessed October 30, 2021. <https://www.history.com/this-day-in-history/germany-conducts-first-successful-v-2-rocket-test>.

- “Fact File: The Importance of Military Satellites - Latest News - Aerocom Metals Limited.” Accessed October 25, 2021. <https://aerocommetals.co.uk/blog/post?s=2015-04-14-fact-file-the-importance-of-military-satellites>.
- www.army.mil. “GPS Goes to War - The Global Positioning System in Operation Desert Storm.” Accessed October 31, 2021. https://www.army.mil/article/7457/gps_goes_to_war_the_global_positioning_system_in_operation_desert_storm.
- “GPS.Gov: Timing Applications.” Accessed November 2, 2021. <https://www.gps.gov/applications/timing/>.
- Greenemeier, Larry. “GPS and the World’s First ‘Space War.’” *Scientific American*. Accessed October 31, 2021. <https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war/>.
- “History.” Accessed November 7, 2021. <https://www.spaceforce.mil/About-Us/About-Space-Force/History/>.
- Geotab. “History of GPS Satellites and Commercial GPS Tracking.” Accessed October 31, 2021. <https://www.geotab.com/blog/gps-satellites/>.
- Hitz, C. Breck, James J. Ewing, and Jeff Hecht. *Introduction to Laser Technology*. John Wiley & Sons, 2004.
- “How Does BEA Define the Digital Economy? | U.S. Bureau of Economic Analysis (BEA).” Accessed October 29, 2021. <https://www.bea.gov/help/faq/1248>.
- Partyard Military. “Hypersonic missiles: What are they and can they be stopped?,” May 10, 2019. <https://partyardmilitary.com/hypersonic-missiles-what-are-they-and-can-they-be-stopped/>.
- “IF11623.Pdf.” Accessed February 10, 2022. <https://sgp.fas.org/crs/weapons/IF11623.pdf>.
- Intelligence, Insider. “US Digital Banking Users Will Surpass 200 Million in 2022.” *Business Insider*. Accessed October 29, 2021. <https://www.businessinsider.com/current-state-of-online-banking-industry>.
- Judson, Jen. “Congress Wants Answers on How DoD Is Solving a Hypersonic Weapons Detection Gap.” *Defense News*, September 13, 2021. <https://www.defensenews.com/pentagon/2021/09/13/congress-wants-answers-on-how-dod-is-solving-a-hypersonic-weapons-detection-gap/>.
- Makichuk, Dave. “Shijian-21: Satellite Crusher or Space Debris Cleaner?” *Asia Times*, October 27, 2021. <https://asiatimes.com/2021/10/shijian-21-satellite-crusher-or-space-debris-cleaner/>.
- mcynar. “GPS History : A Timeline of the Facts You Need,” May 18, 2018. <https://gpstrackingplans.com/gps-history/>.
- Pleasance, Chris. “China Launches Possible ‘Satellite-Crushing Weapon.’” *Mail Online*, October 26, 2021. <https://www.dailymail.co.uk/news/article-10132577/China-launches-possible-satellite-crushing-weapon.html>.
- Pruitt, Sarah. “China Makes Historic Landing on ‘Dark Side’ of the Moon.” *HISTORY*. Accessed November 1, 2021. <https://www.history.com/news/china-plans-historic-landing-on-dark-side-of-the-moon>.
- “R45811.Pdf.” Accessed November 11, 2021. <https://sgp.fas.org/crs/weapons/R45811.pdf>.
- Schumm, Laura. “What Was Operation Paperclip?” *HISTORY*. Accessed November 7, 2021. <https://www.history.com/news/what-was-operation-paperclip>.

- Shepherd, Marshall. "Six Ways You Used Satellites Today And Didn't Know It." Forbes. Accessed October 29, 2021. <https://www.forbes.com/sites/marshallshepherd/2019/04/09/six-ways-you-used-satellites-today-and-didnt-know-it/>.
- Space Operations Command (SpOC). "Space Delta 6 Protects Space and Cyberspace." Accessed November 1, 2021. <https://www.spoc.spaceforce.mil/News/Article-Display/Article/2446117/space-delta-6-protects-space-and-cyberspace>.
- Transplace. "The History of Transportation Technology: GPS Satellites and Tracking." Accessed October 31, 2021. <https://www.transplace.com/knowledge-base/the-history-of-transportation-technology-gps-satellites-and-tracking/>.
- "The Outer Space Treaty at a Glance | Arms Control Association." Accessed November 3, 2021. <https://www.armscontrol.org/factsheets/outerspace>.
- "The Space Race | American Experience | PBS." Accessed October 30, 2021. <https://www.pbs.org/wgbh/americanexperience/features/moon-space-race/>.
- Imperial War Museums. "The Terrifying German 'Revenge Weapons' Of The Second World War." Accessed November 7, 2021. <https://www.iwm.org.uk/history/the-terrifying-german-revenge-weapons-of-the-second-world-war>.
- Tullis, Paul. "GPS Is Easy to Hack, and the U.S. Has No Backup." Scientific American. Accessed November 1, 2021. <https://doi.org/10.1038/scientificamerican1219-38>.
- Statista. "U.S. Digital Banking Usage 2022." Accessed October 29, 2021. <https://www.statista.com/statistics/946109/digital-banking-users-usa/>.
- Statista. "U.S. Digital Economy GDP Share 2018." Accessed October 29, 2021. <https://www.statista.com/statistics/961982/digital-economy-gdp-share-usa/>.
- "US Digital Economy Scale Ranks First in the World, While China Has the Fastest Development Speed - Global Times." Accessed October 29, 2021. <https://www.globaltimes.cn/page/202108/1230356.shtml>.
- "Visual Explainer: How China's Hypersonic Missile Compares to Conventional Ballistic Weapons." Accessed November 7, 2021. <https://www.usatoday.com/in-depth/graphics/2021/11/04/china-hypersonic-missile-sputnik-moment-icbm-mach-5-weapon/8581971002/>.
- "Weapons of Choice - University of Alabama Press." Accessed February 10, 2022. <http://www.uapress.ua.edu/product/Weapons-of-Choice,1776.aspx>.
- "What Does Crystal Oscillator Mean?" Accessed October 30, 2021. <https://www.definitions.net/definition/Crystal+Oscillator>.
- "White Paper on China's Space Activities Published." Accessed November 1, 2021. http://english.www.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm.