The Eurasia Center

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U.S. Space Architecture at Risk

GPS III/IIIF Generation Satellite. Photo Credit: Lockheed Martin

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HISTORICAL BACKGROUND

USSR technician working on Sputnik 1. Photo Credits: European Space

Space…we often imagine it as an abstract, empty vacuum and yet it holds *Everything Everywhere All at Once*. The USSR launching of Sputnik 1 on October 4th, 1957 at 7:28pm was a historic moment because it not only shifted the dynamics of great-power politics at the time, but it also revolutionized the way we view space: it is something that we can now *own*. Building on this notion that countries can control space, the Outer Space Treaty (OST) of 1967—otherwise known as the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies—was one of the first major multilateral international space agreements. OST still is the dominant space framework today that nearly 200 countries have either ratified or signed. It addresses a wide range of contentious issues such as bans on weapons of mass destruction (WMD) in space, non-appropriation over celestial bodies, environmental regulations, and liabilities for damages caused by space objects.[1]

THE DIGITAL AGE

The space race was ultimately a catalyst for innovation. With the turn of the 21st century, we have been witnessing a boom in cutting-edge technologies, namely telecommunication networks, semiconductors and microchips, artificial intelligence, and more. We can all

[1] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," UNOOSA, 2022, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.

attest that these technologies have become an indispensable part of our daily lives. It is equally important to recognize the far-reaching implications they have within the national security domain as we are now faced with threats never seen before.

USSF Insignia. Photo Credits: U.S. Space Force

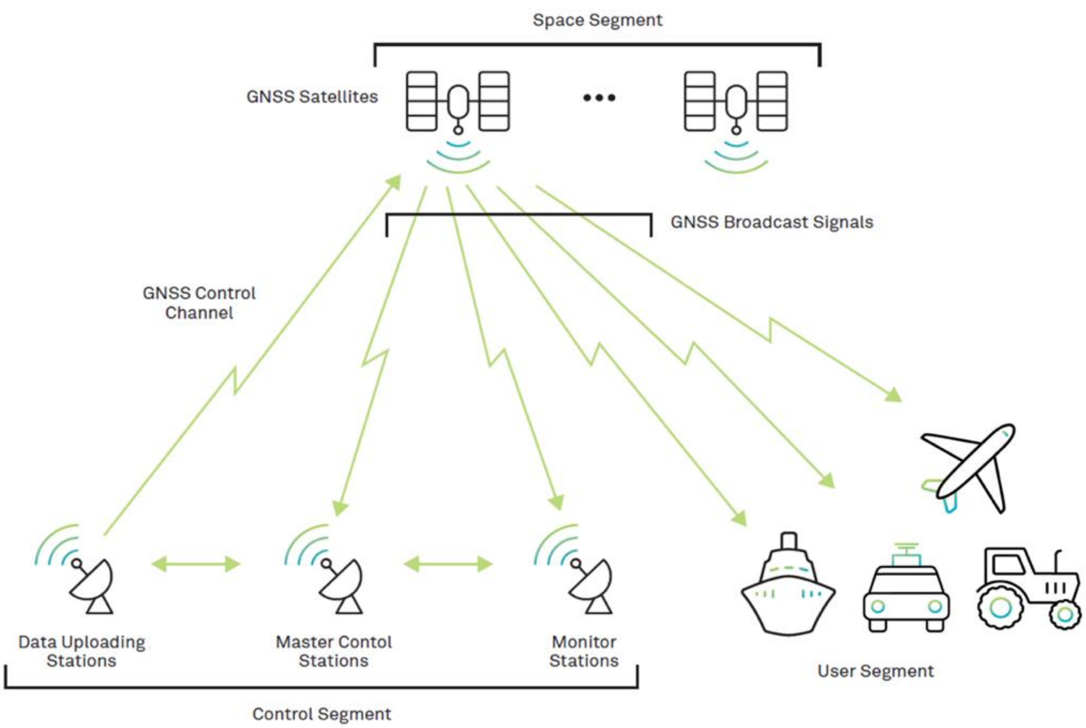
The digital connectivity we all rely on to send texts, stream videos and music, and access social media can all be traced back to a single source (or technically a system of sources): satellites. Modern warfare, especially U.S. military operations, involves the extensive use of satellites for intelligence gathering, communication networks, navigation, missile-defense systems, weather tracking, and more. Recognizing the importance of satellites, under the Trump administration, Congress created the U.S. Space Force (USSF) in December 2019 as an independent branch of the US Armed Services underneath the Department of Air Force. The primary mission of USSF is to train a new generation of skilled military personnel, otherwise known as "Guardians," in protecting advanced military satellites and conducting global space operations.[2]

GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS)

The USSF is faced with formidable challenges as the world enters a modern-day space race. The Global Navigation Satellite Systems (GNSS) that pose the greatest threat to the U.S. Global Positioning System (GPS), and by extension national security, are Russia's Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS) and China's BeiDou

[2] United States Space Force, "United States Space Force Mission," USSF, 2022, https://www.spaceforce.mil/.

(BDS).[3] While they differ in their specifications, GNSS constellations all can be broken down into three main parts: space segment, control segment, and user segment.



The Three Main Segments of GNSS. Photo Credits: Hexagon

In the space segment, satellites float approximately 20,000 km above the earth, orbiting the planet about every 12 hours. They are constantly sending transmissions back to earth at the speed of light through radio carrier waves.[4] In the control segment, monitor stations strategically scattered along the earth's surface collect these radio signals and transfer the information to master control stations.[5] Master control stations analyze the transmissions to track the location of the satellites and upload orbit and time corrections to their positions as necessary. In the user segment, devices containing GNSS receivers (smartphones, vehicles, sat nav, etc.) receive signals from at least three satellites to calculate the user's position and speed through a process called trilateration.[6]

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[3] "Other Global Navigation Satellite Systems (GNSS)," GPS.gov, https://www.gps.gov/.
[4] "GPS and GNSS for Geospatial Professionals," Penn State College of Earth and Mineral Science, https://www.e-education.psu.edu/geog862/node/1407.
[5] Ibid.
[6] Ibid.

Global Positioning System (GPS)

GPS Insignia.
Photo Credits: GPS.gov

As it stands today, GPS is the most widely used and accurate GNSS constellation in the world. The first GPS satellites were launched in 1978 under the Department of Defense and were then authorized for public use in 1983 by Former President Reagan.[7] For years, GPS had been the gold standard for global navigation systems in terms of its orbiting speed and its precision accuracy of 3.5-7.8 meters.[8] GPS satellites use the L1 (1575.42 MHz), L2 (1227.60 MHz), and L5 (1176.45 MHz) frequencies to send signals to the earth's surface.[9] There are currently 30 operational GPS satellites in orbit. However, the advantage that the U.S. once had is now rapidly diminishing with the rise of GLONASS and BeiDou.

Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS)

GLONASS Insignia.
Photo Credits: GPS.gov

The first GLONASS constellation was launched in 1982, just four years after GPS, and was fully operational with 43 satellites by 1991. Following the dissolution of the USSR in 1991, the new government failed to maintain the system and it had deteriorated to just 8 satellites by 2002. However, ever since 2001, the Russian government was committed to restoring the constellation and now has 24 operational satellites in orbit.[10] GLONASS is highly concerning because, despite its financial struggles in the early stages of development, the Russian constellation is now comparable to GPS. GLONASS satellites can orbit the earth every 11 hours and 16

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[7] "A Brief History of GPS," Aerospace, 2021, https://aerospace.org/article/brief-history-gps.
[8] Rob Rutkowski, "What's the Differences Between the GNSS Constellations?," Bliley Technologies, 2022, https://blog.bliley.com/the-differences-between-the-5-gnss-satellite-network-constellations
[9] NovAtel, "What are Global Navigation Satellite Systems?," Hexagon, https://www.google.com/search?q=hexagon+novatel&oq=HEXAGON+novatel&aqs=chrome.0.0i512j46i175i199i512j0i22i30l5j0i390.2018j0j7&sourceid=chrome&ie=UTF-8
[10] "GLONASS Development History," GIS Resources, https://gisresources.com/glonass-development-history/.

minutes (GPS is 11 hours and 58 minutes) with a precision accuracy of 5-10 meters, which essentially parallels GPS capabilities.[11] The constellation transmits carrier waves through the L1 (1598.0625-1605.375 MHz), L2 (1242.9375-1248.625 MHz), and L3 (1202.025 MHz) frequencies.[12]

BeiDou (BDS)

BeiDou Insignia.
Photo Credits: GPS.gov

The third major player is China's BDS system, which began in 2000 with only 3 operational BeiDou-1 satellites. Between 2000 and 2012, China managed to grow their arsenal to 16 operational BeiDou-2 satellites that offered greater coverage than BeiDou-1 but still only extended across the Asia-Pacific region. However, with the development of BeiDou-3 satellites that could provide global coverage, BDS officially became a GNSS in 2020 and today stands at a total of 35 satellites, making it the largest constellation in the world.[13] There is little information on the exact speeds and accuracy of 3rd generation BDS satellites but for reference BeiDou-2, which was designed in 2011, could orbit the earth at 12 hours and 38 minutes with a precision accuracy of 10 meters.[14] Ran Chengqi, the director general of the China Satellite Navigation Office, announced that BeiDou-3 supposedly has a precision accuracy of just 2-3 meters, better than both GPS and GLONASS.[15] BeiDou satellite broadcast signals are

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[11] Anurag Bisht, "What is GLONASS and How it is Different From GPS," Beebom, 2016, https://beebom.com/what-is-glonass-and-how-it-is-different-from-gps/.
[12] NovAtel, "What are Global Navigation Satellite Systems?," Hexagon, https://www.google.com/search?q=hexagon+novatel&oq=HEXAGON+novatel&aqs=chrome.0.0i512j46i175i199i512j0i22i30l5j0i390.2018j0j7&sourceid=chrome&ie=UTF-8.
[13] Raymond McConoly, "China's BeiDou GPS is a Strategic Challenge for the U.S.," Naval Post, 2021, https://navalpost.com/chinas-gps-beidou-is-a-strategic-challenge-for-the-u-s/#:~:text=China's%20BeiDou%20experienced%20three%20phases,satellites%20covering%20Asian%2DPacific%20regions.
[14] Priya Pedamkra, "GNSS vs GPS," EDUCBA, https://www.educba.com/gnss-vs-gps/.
[15] Tang Shihua, "China's Beidou-3's Positioning Accuracy is Now World Class, Official Says," Yicai Global, 2020, https://www.yicaiglobal.com/news/china-beidou-3-s-positioning-accuracy-is-now-world-class-official-says.

B1I (1561.098 MHz), B1C (1575.42 MHz), B2a (1175.42 MHz), B2I and B2b (1207.14MHz), and B3I (1268.52 MHz).[16]

CURRENT SITUATION

With GLONASS and BDS becoming increasingly more technologically advanced, the U.S. is losing its space dominance and leverage over Russia and China. When GPS was the sole GNSS constellation, Russian and Chinese military assets were extremely constrained because their missile systems, drones, marine navigation tools, radar, and communications were reliant on GPS as the core operating system. For example, during the Taiwan Strait Crisis in 1995-1996, China launched three GPS-guided ballistic missiles into Taiwan. One missile reached its target while the other two veered off course because the U.S. disabled the GPS signal to the Pacific.[17] The U.S. can no longer leverage GPS as we are now in a world with rival GNSS systems. While GPS is still widely used since GNSS constellations often coordinate with each other, Russia and China, more so the latter, effectively have the capability to become independent of GPS if needed. It is even more concerning that earlier this year on February 4th, just moments before the outbreak of the Russo-Ukraine War, Putin and Xi Jinping met in-person and released a joint statement. In their meeting, they adopted a package consisting of 16 documents outlining steps for promoting regional cooperation to counter Biden's Indo-Pacific Economic Framework. One of the major agreements was to enhance cooperation and complementarity between the GLONASS and BeiDou constellations, a move that could overthrow GPS as the world's leading and most widely-used GNSS.[18]

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[16] NovAtel, "What are Global Navigation Satellite Systems?," Hexagon, https://www.google.com/search?q=hexagon+novatel&oq=HEXAGON+novatel&aqs=chrome.0.0i512j46i175i199i512j0i22i30l5j0i390.2018j0j7&sourceid=chrome&ie=UTF-8.

[17] Minnie Chan, "'Unforgettable humiliation' led to development of GPS equivalent," South China Morning Post, 2009, https://www.scmp.com/article/698161/unforgettable-humiliation-led-development-gps-equivalent.

[18] Doug Messier, "Roscosmos and China Signed Agreement to Ensure GLONASS and BeiDou Satellite Navigation Systems are Complementary," Parabolic Arc, 2020, http://www.parabolicarc.com/2022/02/06/roscosmos-and-china-signed-agreement-to-ensure-glonass-and-beidou-satellite-navigation-systems-are-complementary/.

NEXT STEPS FOR THE U.S.

"Meadowlands" satellite jammer. Photo Credits: L3Harris

If the U.S. wants to reclaim space dominance, the Biden administration must increase the offensive and defensive capabilities of the Space Force. Considering how satellites are the backbone of modern warfare, there should be increased efforts in satellite jamming technologies. L3Harris is currently contracted to developed 26 "Meadowlands" systems, otherwise known as Counter-Communications Systems (CCS) Block 10.2, to disrupt Chinese and Russian space-based capabilities.[19] Rather than seeing Meadowlands as the solution, the system should instead be viewed as the first step of many to build satellite jamming capabilities. At the same time, there should be greater investments into expanding the number of satellites in the GPS constellation and into developing countermeasures to anti-satellite weapons. China just announced at the end of May that they are accelerating anti-satellite capabilities to destroy Elon Musk's Starlink

[19] Nathan Strout, "This is what the Space Force will use to jam enemy satellites," C4ISRNET, 2020, https://www.c4isrnet.com/electronic-warfare/2020/04/08/this-is-what-the-space-force-will-use-to-jam-enemy-satellites/.

constellation.[20] This should be seen as a wake-up call for the Biden administration. If the United States does not immediately strengthen the resiliency of its satellites then the GPS constellation, a system that is the foundation for U.S. national security and its allies, could become vulnerable and destroyed at any moment.

[20] Eamon Barrett, "China's military researchers are thinking of ways to take down Elon Musk's Starlink network," Fortune, 2022, https://fortune.com/2022/05/26/china-destory-elon-musk-starlink-satellites-military-research/.

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