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Chairman Cruz, Ranking Member Cantwell, and distinguished members of the committee, thank you for the opportunity to testify before the committee on the topic: America Offline? How Spectrum Auction Delays Give China the Edge and Cost Us Jobs.

Summary

The US military will require more, not less, access to the electromagnetic spectrum in the coming decade. Facing numerical and geographic disadvantages against an opponent like China, US forces will need electronic warfare systems that can jam, decoy, and deceive enemy sensors by operating outside traditional US frequencies and inside those used by adversaries. At home, the US military will need to continuously operate high-power sensors and defenses from S through K band to defend US territory from air and missile attack as part of the Trump Administration's Iron Dome for America initiative.

China's leaders want the US government to unilaterally disarm by further constraining the Department of Defense's spectrum access. Beijing disingenuously claims that it has given more spectrum to Chinese telecommunication companies when in fact the People's Liberation Army (PLA) retains the authority and mechanisms to routinely displace commercial spectrum users. Instead of engaging in a unproductive spectrum competition against China in S-band, the US government should ensure military and commercial users can co-exist in US spectrum through sustainable and executable sharing schemes. Telecommunication companies should be prepared for the cost and time needed to implement these approaches, especially as military demands for spectrum are likely to grow.

Winning the Fight for Sensing and Sensemaking

Militaries have always depended on the electromagnetic spectrum to communicate and coordinate operations, navigate over vast distances, and attack or avoid enemies. Starting during World War II, electronic warfare made the spectrum itself a battlefield when jammers and decoys emerged as new tools to prevent an opponent from coordinating operations or sensing and understanding its environment.

The war in Ukraine highlights how the electromagnetic spectrum is now the domain in which

battles—and wars—are often won or lost. Russian and Ukrainian troops routinely use vehicle- and drone-borne electronic sensors to detect enemy forces by their radio transmissions and enable attacks with artillery or rockets. To protect themselves, troops on both sides have developed work-arounds that enable them to transmit on unexpected frequencies where the enemy is not looking, use directional antennas, or avoid radio communications altogether.[1]

Russian and Ukrainian forces are also extensively jamming each other in the spectrum. Traditional radio communications are often impossible near the front lines.[2] Ukrainian forces stopped using US-provided guided weapons like the Excalibur artillery round and Joint Direct Attack Munition until they are modified to be more jam-resistant or incorporate multiple modes of navigation.[3] Both militaries have turned to using radars or cameras on drones for guidance, sometimes augmented by a human operator connected via a fiber-optic cable to avoid radio jamming.

China is a much more challenging electromagnetic adversary for the United States than Russia. The PLA fields a growing array of electronic warfare aircraft, drones, and satellites that can listen and jam across relevant areas of the spectrum at long range.[4] China's navy, coast guard, and maritime militia ships are equipped with electronic sensors to surveil US and allied communications and radar transmissions.[5] And the Chinese government's space-based electronic surveillance architecture over US territory and the Indo-Pacific region is growing faster than its US counterpart.[6]

China's electronic surveillance network in the air, on the water, and in space is part of an overall Reconnaissance-Intelligence System that leaders in Beijing rely on to assess their opponents' operations in peacetime and target enemy forces in wartime. As shown in Figure 1, this system is one of several systems the PLA plans to use in a potential conflict such as an invasion of Taiwan. China's leaders rely on a systems approach to warfare in part due to their well-publicized lack of confidence in PLA commanders' abilities to engage and defeat enemy forces without suffering

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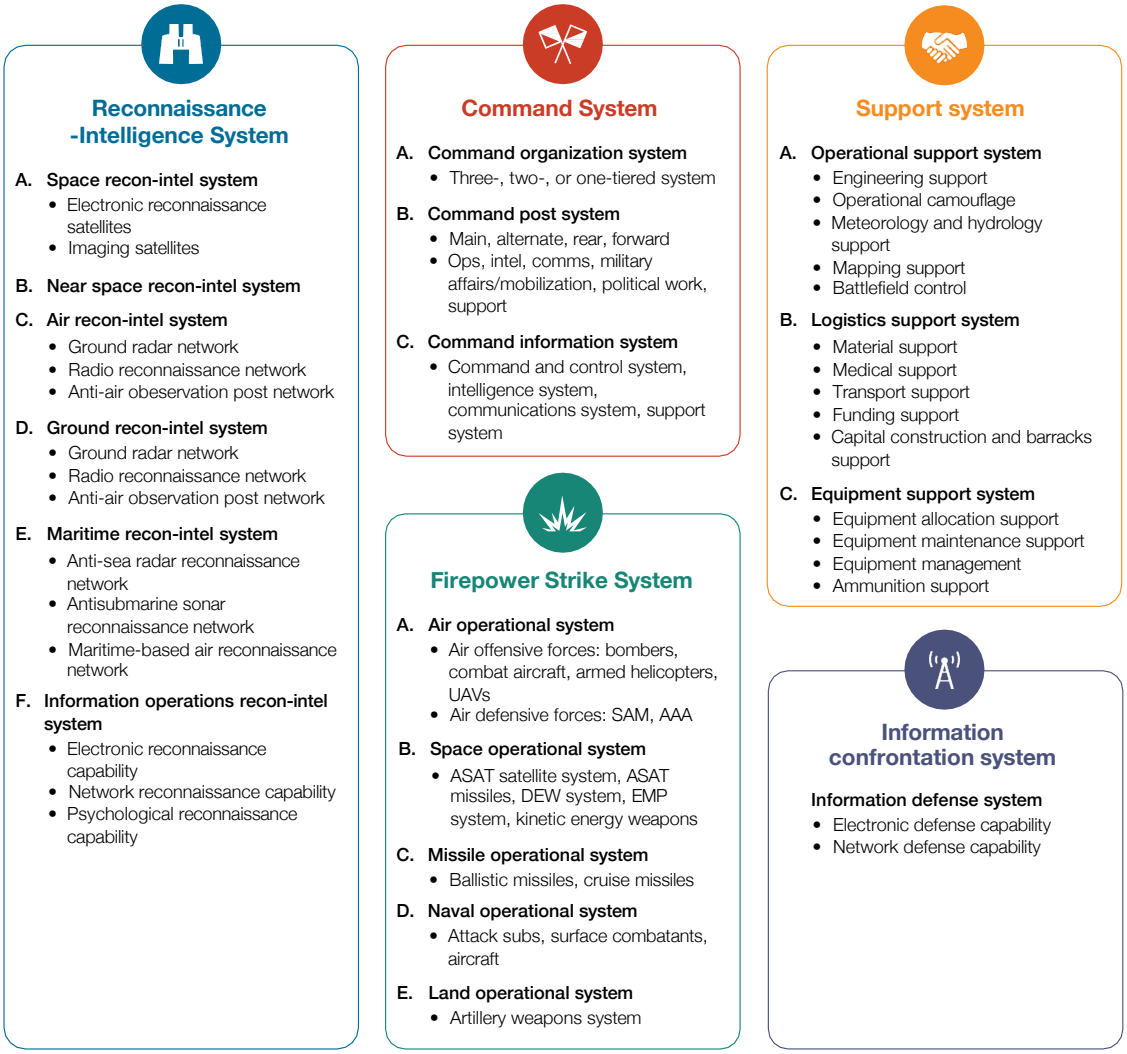
[1] Vikram Mittal, "Ukraine Is Now Dominating The Drone And Electronic Warfare Domains," Forbes, August 21, 2024, https://www.forbes.com/sites/vikrammittal/2024/08/21/ukraine-is-now-dominating-the-drone-and-electronic-warfare-domains/.
[2] Chris Panella, "A 'hidden electronic warfare battle' is raging in Ukraine and demanding more from the soldiers fighting it, special drone unit says," Business Insider, February 8, 2025, https://www.businessinsider.com/hidden-electronic-warfare-battle-demanding-more-of-ukrainian-soldiers-2025-2.
[3] Thomas Withington, "Jamming JDAM: The Threat to US Munitions from Russian Electronic Warfare," RUSI, June 6, 2023, https://www.rusi.org/explore-our-research/publications/commentary/jamming-jdam-threat-us-munitions-russian-electronic-warfare
[4] Kristin Burke, "PLA Counterspace Command and Control" (Montgomery, AL: US Air Force China Aerospace Studies Institute, 2023), https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/PLASSF/2023-12-11%20Counterspace-%20web%20version.pdf.
[5] John Christianson, "Fighting and Winning in the Electromagnetic Spectrum," War on the Rocks, December 5, 2022, https://warontherocks.com/2022/12/fighting-and-winning-in-the-electromagnetic-spectrum/#:~:text=The%20Chinese%20concept%20recognizing%20the,the%20Chinese%20coastline%2C%20is%20a.
[6] J. Michael Dahm, "China C4ISR and Counter-Intervention," Testimony before the U.S.-China Economic and Security Review Commission," March 21, 2024, https://www.uscc.gov/sites/default/files/2024-03/J.Michael_Dahm_Testimony.pdf.

unsustainable losses.[7] Chinese leaders would prefer to centrally manage a war, using the Reconnaissance-Intelligence System to find enemy forces, predict their future actions and operations, and target them for long-range precision attacks by the Firepower Strike System.[8]

Figure 1: China's warfare systems[9]



[7] Jackson, Kimberly, Andrew Scobell, Stephen Webber, and Logan Ma, Command and Control in U.S. Naval Competition with China. Santa Monica, CA: RAND Corporation, 2020, pp. 23-49. https://www.rand.org/pubs/research_reports/RRA127-1.html; Larry Wortzel, "The PLA and Mission Command: Is the Party Control System Too Rigid for Its Adaptation by China?," Association of the US Army, March 2024, https://www.ausa.org/sites/default/files/publications/LWP-159-The-PLA-and-Mission-Command-Is-the-Party-Conrol-System-Too-Rigid-for-Its-Adaptation-by-China.pdf.

[8] Joel Wuthnow, "System Destruction Warfare and the PLA," Institute for National Strategic Studies, June 2024, https://keystone.ndu.edu/Portals/86/PLA%20Systems%20Attack%20-%20JW%20update%20June%2024.pdf

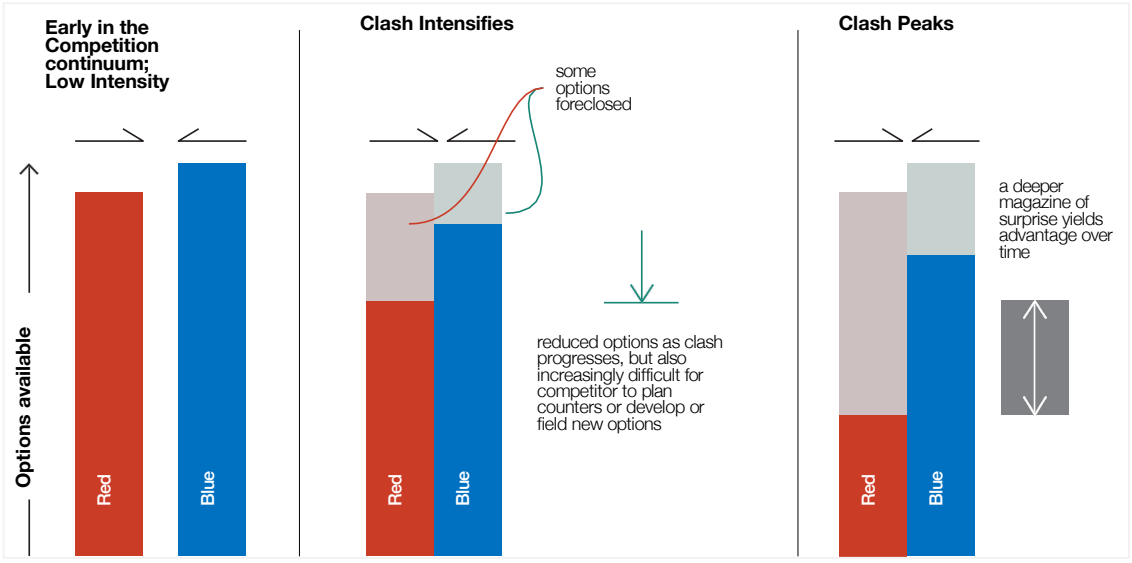
[9] Jeffrey Engstrom, *Systems Confrontation and System Destruction Warfare* (Santa Monica, CA: RAND, 2018), https://www.rand.org/pubs/research_reports/RR1708.html.

China's hierarchical approach to command and control creates vulnerabilities that US and allied forces will try to exploit.[10] Chinese leaders depend primarily on their signals intelligence and imaging satellites to build an operational picture because these space-based systems offer continuous coverage of the Indo-Pacific region and do not depend on the competence of ship, aircraft, or ground-based sensor crews. However, US and allied militaries could confuse these sensors by operating their radars and radios in unexpected areas of spectrum; deploying decoys that simulate signals or radar returns from US ships, aircraft, or ground troops; and using jammers against PLA sensors and communication systems to obscure the location of real US or allied forces and prevent Chinese sensor fusion.[11]

Faced with an unreliable operational picture, China's leaders would turn to ground-based sensors and ships and aircraft to verify real vs. false targets. US and allied forces could use the same counter-sensor approaches against these systems, although with less effect. However, the impact will already be felt as China's leaders begin to question their centrally-controlled "fire and forget" military strategy.

US forces will need to sustain counter-sensing and counter-sensemaking operations over months or years to translate Chinese leaders' temporary doubts into an enduring lack of confidence that could deter them from pursuing aggression against US allies. As shown in Figure 2, the US military will need a large number of diverse electronic warfare tools and techniques to support a jamming and deception campaign.

Figure 2: Importance of a deep magazine of electronic warfare effects in a campaign



[10] Jon Harper, "Counter-C5ISRT is top priority for nominee to lead Indo-Pacific Command," DefenseScoop, February 1, 2024, https://defensescoop.com/2024/02/01/counter-c5isrt-samuel-paparo-indo-pacific-command-nomination/.
[11] This approach is detailed in Bryan Clark, "Winning the Fight for Sensing and Sensemaking," (Washington, DC: Hudson Institute, 2024), https://www.hudson.org/national-security-defense/winning-fight-sensing-sensemaking-fielding-cyber-electronic-warfare-c5isr-bryan-clark.

Electronic warfare techniques are often short-lived in wartime, as demonstrated by the electromagnetic spectrum competition during World War II and more recently in Ukraine.[12] After one side fields a new jammer or decoy, the other side quickly develops a countermeasure or work-around. To sustain the move-countermove competition shown in Figure 2, the DoD will need to develop and test systems, train and certify relevant units, and sometimes conduct operations in the United States to create a deep magazine of diverse electronic warfare effects. These efforts will require access to diverse areas of spectrum not currently or often used by US forces.

China's long con for spectrum superiority

US and allied electronic warfare operations threaten the effectiveness of China's war plans. To prevent the US from fielding these critical capabilities, China is attempting to convince the US government to unilaterally disarm in the spectrum.

Numerous studies and industry white papers have asserted during the last decade that the United States is "losing the spectrum competition" with China. These studies argue that the Chinese government has made more spectrum available for commercial telecommunications use compared to the United States—especially in the 3-5 Ghz band.[13]

Mid-band spectrum in the 2-8 Ghz range is coveted by commercial and military system developers because it offers an attractive combination of range, data rate, and resistance to interference. Higher frequency signals can carry more data or achieve higher resolution in radars but suffer higher attenuation due to atmospheric heating and are more susceptible to interference because they tend to bounce off obstacles rather than passing through them. Lower frequency transmissions can travel much farther distances, but carry less data and achieve lower resolution.

By the mid-2030s, China's government reportedly plans to make up to 1,500 Mhz more mid-band spectrum available for commercial telecommunications use compared to the US government.[14] But this potential disparity is an illusion. In China, all frequency allocations—like all commercial endeavors—are contingent. The government retains the authority to force commercial users off the spectrum when needed, and maintains organizations and processes for doing so.[15]

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[12] John Stillion and Bryan Clark, "What it Takes to Win: Succeeding in 21st Century Battle Network Competitions," (Washington, DC: Center for Strategic and budgetary Assessments, 2015), https://csbaonline.org/research/publications/what-it-takes-to-win-succeeding-in-21st-century-battle-network-competitions.

[13] Accenture, "The Case for Global Spectrum Harmonization," CTIA, January 2024, https://api.ctia.org/wp-content/uploads/2024/01/Advancing-US-Wireless-Excellence-Global-Harmonization.pdf; James Lewis, "Spectrum Allocation for a Contest with China," (Washington, DC: CSIS, 2023), https://www.csis.org/analysis/spectrum-allocation-contest-china.

[14] Clete Johnson, "Next Steps to Close the Gap with China on Licensed Spectrum for Commercial 5G," Center for Strategic and International Studies, February 12, 2024, https://www.csis.org/blogs/strategic-technologies-blog/next-steps-close-gap-china-licensed-spectrum-commercial-5g.

[15] Ministry of Industry and Information Technology (MIIT), "Radio Regulation of the People's Republic of China (2016 Revision)," http://106.15.139.130/Law/LawShowEn?id=222067.

Under the concept of military-civil fusion, China's regional radio management centers are charged with clearing spectrum to enable military and civil defense operations whenever needed for training, exercises, system development, or crisis response. To enable rapidly removing commercial users, each radio management center includes a PLA reserve frequency management unit. These units are led by a core of active-duty PLA officers and mainly comprised of reserve soldiers whose civilian jobs are in the telecommunications industry. Their civilian experience is intended to enable these reserve operators to quickly kick commercial users out of needed spectrum in support of PLA or other government needs.[16]

At the same time its government reserves the right to use any spectrum at will, China's political and industry leaders suggest that China is building a lead in 5G and future communication technologies because the country makes more spectrum available to national champions like Huawei and ZTE. The US government should not unilaterally disarm by taking mid-band spectrum away from US military uses in an effort to win this non-existent spectrum race against China.

Another argument for making more US mid-band spectrum available for commercial use is to align with the frequency allocations of other countries, including numerous US European and Indo-Pacific allies. The World Radio Congress (WRC) has recommended that wide swaths of spectrum in relevant frequency ranges for 5G and potential future 6G communications, which many countries have adopted in their own radio regulations.

However, this argument incorrectly assumes each country has similar needs for spectrum outside of commercial functions. As the world's most sophisticated force and the largest one outside of China, the US military incorporates a more numerous and diverse portfolio of electromagnetic spectrum systems than any of its allies. For example, the US Department of Defense (DoD) maintains more than 100 high-power jamming aircraft, which is more than its European and Indo-Pacific allies combined. The US Navy and Air Force include more than 100 airborne radar surveillance aircraft and nearly 100 air defense destroyers and cruisers carrying high-power radars. To follow through on its alliance commitments, the US military requires access to spectrum across large areas of the country for training, concept development, maintenance, and operations.

Enabling the Iron Dome for America

The most challenging driver of US military spectrum access requirements will be the Trump Administration's initiative to establish a comprehensive missile defense architecture for the United States. Announced by executive order last month, the "Iron Dome for America" is intended to field a system of systems that can defeat hypersonic, ballistic, and cruise missiles as well as emerging airborne threats such as drones. The proposed architecture would include weapons to engage enemy missiles soon after launch, in mid-flight, and in the terminal phase

[16] John Dotson, "Military-Civil Fusion and Electromagnetic Spectrum Management in the PLA," Jamestown Institute, October 8, 2019, https://jamestown.org/program/military-civil-fusion-and-electromagnetic-spectrum-management-in-the-pla/.

when they near a target in the United States.[17]

The US military already maintains a ballistic missile detection and tracking system as part of the national missile defense system, which mainly uses infrared satellites to detect launches overseas and radars in Alaska, Canada, and Greenland to track ballistic missiles coming over the North Pole. The Iron Dome architecture would build on this existing network by adding satellite-borne sensors that the DoD is already developing for tracking ballistic and hypersonic missiles.[18] These space-based and forward-deployed sensors would probably not require new frequency allocations to the DoD.

However, the Iron Dome for America will require a dramatic increase in radar surveillance and tracking in the S and X bands to support terminal defense against ballistic and hypersonic missiles. Terminal defense systems like SM-6 or PAC-3 interceptors engage ballistic and hypersonic missiles in the atmosphere at ranges of only 100 to 200 miles, which requires that they be positioned near the targets they defend. Planned space-based sensors can detect and initially track incoming hypersonic and ballistic missiles, but they cannot provide interceptors the target missile's position and movement precisely or quickly enough for an engagement.[19] Existing surveillance radars used to manage commercial air traffic lack the responsiveness and precision needed to track ballistic and hypersonic missiles. To guide terminal defense interceptors, the DoD will need to operate military radars such as the US Navy's SPY-1, 6, and 7 or carried by airborne warning and control aircraft including the E-2D or E-3 in the interior of the United States.

Greater spectrum access will also be needed to defeat cruise missiles and "other next-generation aerial attacks," which could include advanced drones like those Russia is using against Ukraine. The DoD may need to use airborne or ground-based S and X-band radars to track these threats.[20] But the more significant challenge will be shooting them down. As recent operations in the Middle East, Ukraine, and around the United States suggest, an opponent could attack US bases, government facilities, or public gatherings using hundreds of drones and cruise missiles.[21] To defeat these large salvos the DoD would likely need to turn to high-power microwave (HPM) systems that generally transmit pulses across the X through K (8-27 Ghz) bands also used by

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[17] Donald J. Trump, "The Iron Dome For America," January 27, 2025, The White House, https://www.whitehouse.gov/presidential-actions/2025/01/the-iron-dome-for-america/.
[18] Center for Arms Control and Non-Proliferation, "Fact sheet: U.S. Ballistic Missile Defense," Center for Arms Control and Non-Proliferation, June 12, 2023, https://armscontrolcenter.org/fact-sheet-u-s-ballistic-missile-defense/.
[19] Planned space-based radars or infrared sensors cannot precisely determine the elevation of missiles they are tracking, which is needed to direct an interceptor to the target, and they lack a mechanism for sending target information to the interceptor in flight in real-time.
[20] Cruise missiles and drones are generally too small to be tracked by space-based radars to track and too slow to generate an infrared signature that could be detected by satellite sensors. Space-based electro-optical sensors could track cruise missiles and drones, but would need to be cued to the threat's exact location. Existing civilian air surveillance radars can often track cruise missiles and drones, but are not dedicated to that mission and do not provide data in the form needed for an interceptor to engage the target.
[21] Jim Garamone, "Reports of Drone Incursions Taken Seriously, DOD Spokesman Says," DoD News, December 17, 2024, https://www.defense.gov/News/News-Stories/Article/Article/4008836/reports-of-drone-incursions-taken-seriously-dod-spokesman-says/.

some mid-band and millimeter-wave 5G networks.[22]

The commander of US Northern Command testified earlier this month that one of his most significant challenges was air domain awareness.[23] Closing that gap and establishing the Iron Dome for America will require operations by military systems in multiple commercially-relevant frequency ranges across large parts of the United States. In contrast to today's needs for episodic military training, testing, and certification, these missions would create a continuous need for spectrum access.

Reconciling spectrum demands

The US military will need to operate in additional areas of the electromagnetic spectrum to address an increasingly challenging threat environment. To overcome its numerical and geographic disadvantages against China, US forces will need to develop, test, and train on systems that emit outside traditional US military frequencies and inside adversary bands as part of its effort to undermine Chinese sensing and sensemaking. The DoD will also need to operate radars and HPM systems in S through K bands across the United States as part of a comprehensive domestic air and missile defense architecture.

However, the DoD's growing need for spectrum does not preclude commercial uses in the same or adjacent frequencies. For example, some regions of spectrum like 6 Ghz could be more efficiently segmented between government, commercial, and unlicensed users. In these frequencies, the government could apply the approach demonstrated by the 2020 White House-DoD America's Mid-Band Initiative Team (AMBIT) initiative.[24] Using the results of AMBIT, the Federal Communications Commission established procedures that allow military and commercial users to both operate in the 3450-3550 Mhz range by separating their emissions in time and geographically.[25] Advances in the spectral efficiency of military and commercial systems could allow static allocation models like AMBIT to be implemented in additional geographies or frequencies.

New technologies can also allow for dynamic spectrum sharing between commercial and military users. For example, the Citizen's Broadband Radio Service (CBRS) allows military, civilian, and commercial users to share spectrum from 3550-3700 Mhz in some regions using a combination of procedures and automated controls that move priority and general access

[22] Office of Naval Research Code 35, "Directed Energy Weapons: High Power Microwaves," Office of Naval Research, https://www.onr.navy.mil/organization/departments/code-35/division-353/directed-energy-weapons-high-power-microwaves.
[23] Gregory M. Guillot, "Testimony on the Posture of United States Northern Command and United States Southern Command in Review of the Defense Authorization Request for Fiscal Year 2026 and the Future Years Defense Program," February 13, 2025, https://www.armed-services.senate.gov/hearings/to-receive-testimony-on-the-posture-of-united-states-northern-command-and-united-states-southern-command-in-review-of-the-defense-authorization-request-for-fiscal-year-2026-and-the-future-years-defense-program.
[24] C. Todd Lopez, "AMBIT Gambit Pays Off, Advances U.S. 5G Efforts," DoD News, August 10, 2020, https://www.defense.gov/News/News-Stories/Article/Article/2306902/ambit-gambit-pays-off-advances-us-5g-efforts/.
[25] Federal Communications Commission, "Second Report And Order, Order On Reconsideration, And Order Of Proposed Modification," Federal Register, March 21, 2021, https://docs.fcc.gov/public/attachments/FCC-21-32A1.pdf.

commercial or private users to other frequencies when incumbent government users are detected in the band. This process allows periodic military operations in the spectrum while minimizing the impact on commercial applications.[26]

Models like CBRS could be employed in other tranches of spectrum, such as 6Ghz, or other geographic regions where military and commercial users could share spectrum. However, as identified by the 2023 DoD Emerging Mid-Band Radar Spectrum Sharing (EMBRSS) study, the government will need to evolve the CBRS model to enable the industrial base to experiment with and test new electromagnetic systems, accommodate fast-moving airborne radars, and ensure coordination in more complex electromagnetic environments compared to the current applications of CBRS.[27]

The challenge for regulators and Congress will be creating spectrum sharing schemes that protect necessary DoD access while remaining financially attractive for the telecommunications industry. Time and geographic constraints such as under AMBIT or the need to periodically relocate to other frequencies under CBRS will require companies to maintain access to additional frequency bands, establish automated sensing and control systems, and manage a patchwork of different frequency coverage and control mechanisms across the nation. The time and investment needed to implement these approaches will reduce the value of spectrum at auction. This cost and complexity will only grow as the DoD's need for spectrum increases as a result of new operational concepts and missions.

Conclusion

The Congress should not fall victim to China's disinformation. China's telecom companies suggest they are winning the 5G race because they can use more frequencies than their competitors in the United States and Europe. However, the PLA retains access to the electromagnetic spectrum whenever and wherever needed, enforced by military personnel at China's radio management centers and in its telecommunications industry.

The US government should not unilaterally disarm in militarily important segments of the spectrum. Chinese leaders want to degrade the DoD's ability to conduct electronic warfare and radar operations that could undermine China's Reconnaissance-Intelligence System and protect the US homeland from air and missile attack. Spectrum sharing schemes could allow the US government to protect its military operations and support commercial uses, but companies and US policymakers should ensure they account for the associated costs and complexity.

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[26] National Telecommunications and Information Administration, "An Analysis of Aggregate CBRS SAS Data from April 2021 to July 2024," NTIA, November 18, 2024, https://www.ntia.gov/report/2024/analysis-aggregate-cbrs-sas-data-april-2021-july-2024.

[27] DoD Chief Information Officer, "Emerging Mid-Band Radar Spectrum Sharing (EMBRSS) Feasibility Assessment Report," (Washington, DC: US DoD, 2023), https://dodcio.defense.gov/Portals/0/Documents/Library/DoD-EMBRSS-FeasabilityAssessmentRedacted.pdf.