Strategic Implications of Emerging Weapon Technologies

Kinetic Bombardment, Antimatter, and Antigravity Technology for U.S. National Security

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Abstract: This article explores the strategic implications of emerging weapon technologies on U.S. national security, focusing specifically on antimatter, kinetic bombardment systems, and antigravity technology. As global military dynamics evolve, it is imperative for the United States to assess and perhaps integrate these emerging technologies to maintain its military superiority. This article examines the accuracy and destructive capability of kinetic bombardment, the immense energy potential of antimatter, and the groundbreaking applications of antigravity propulsion in aerial operations. The findings underscore the critical role that these technologies may play in improving U.S. national security and provide a foundation for additional research on their national security applications and implications.

Keywords: kinetic bombardment systems, antimatter-based weapons, next-generation missiles, antigravity propulsion technology, emerging defense capabilities, precision strike systems, future combat and warfare, strategic defense initiatives

The U.S. national security landscape is rapidly changing due to the emergence of new threats. These changes are driven by swift technological breakthroughs, shifting global politics, and the impact of both nations

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and independent entities. Cyberattacks, particularly from state-sponsored entities like China and North Korea, have become more complex, targeting critical U.S. infrastructure and governmental systems. The 2023 *Annual Threat Assessment of the U.S. Intelligence Community* identifies China as the most persistent and aggressive threat in cyber espionage, targeting U.S. government and private sector networks to further its strategic objectives.[1] In addition to these cyber concerns, the United States must be careful to manage diplomatic relations with nations such as Russia, North Korea, and China to ensure they are never given the opportunity to launch nuclear attacks or exploit political vulnerabilities. The 2022 *Nuclear Posture Review* highlights that these developments have increased the danger of regional instability, necessitating the enhancement of U.S. military capabilities to address growing threats and uphold effective deterrence.[2] Maintaining military technological innovation is essential to addressing today's complex threats. Innovations like cyber capabilities, drones, and precision-guided missiles are increasingly important elements of modern defense.

During this digital era, autonomy in military systems could offer significant advantages by facilitating faster responses, improved efficiency, and enhanced adaptability in rapidly changing situations. Paul Scharre and Michael C. Horowitz highlight that the concept of autonomy in military systems can vary greatly based on the system's complexity and the interaction between humans and machines. They specify various tiers of autonomy—from semiautonomous systems necessitating human involvement (human in the loop) to fully autonomous systems functioning independently of human oversight (human out of the loop)—each bearing distinct ramifications for decision making in military operations.[3] This supports the idea that combining autonomous systems and AI will considerably help the U.S. military by allowing for speedier decision making, improving operational precision, and reducing human risk in high-stakes scenarios.

Future space-based military systems will need to be operated at the speed and scale required by strategic competition, which will require automation and artificial intelligence (AI). AI-driven targeting, on-orbit anomaly detection, and autonomous navigation may enable kinetic bombardment platforms or orbital attack capabilities to locate, follow, and engage targets without continual human supervision. In the commercial sector, such capabilities are already being investigated; examples of software-driven efficiency that could be militarized include Planet Labs' automated imagery processing and SpaceX's autonomous docking systems. These same advancements, meanwhile, will also give American enemies more power. In May 2025, the first 12 of a projected 2,800-satellites were launched by Zhejiang Lab and Chinese firm ADA Space.[4] While in space, each satellite is built to process AI in real time. High-speed laser communications connect this constellation, which serves as a prototype for some-thing revolutionary: the capacity to interpret and act on data in space without the need for ground infrastructure. Following that, real-time threat analysis by surveillance satellites and notifications that can be sent without waiting for confirmation from the ground will soon be available. From a military perspective, it is the origin of orbital decision making. These orbital capabilities are supported by China's expanding domestic computing base, which together comprise an end-to-end, vertically integrated system of AI infrastructure based in both space and on land.

The Western model is not the same as China's. Innovation in AI frequently originates from the bottom up in the United States, propelled by business sector investment and academia. The execution strategy in China is distinctly top-down, coordinating AI infrastructure with a long-term geopolitical stance, military doctrine, and state industrial policy. In 2015, China restructured its military to move beyond land defense and strengthen its ability to project power in space, cyberspace, and distant seas to protect strategic interests.[5] China is probably investigating the use of AI in space operations, including the management of large satellite constellations, the analysis of Earth observation datasets (processing and identifying targets in satellite imagery), and cognitive radio (a "smart" radio that makes space-based communications more efficient by automatically shifting channels to avoid interference and congestion) as well as autonomous satellite operation to compensate for limited communications windows, bandwidth, and long latencies, which lowers the workload of ground satellite operators. The People's Liberation Army (PLA) may find it more difficult to construct decision-support AI systems due to its limited combat experience and the resulting lack of "ground truth" data.[6] In this context, *ground truth* data refers to verified, accurate real-world data used to train and validate AI systems. These developments underscore that U.S. national security depends on ensuring American AI and automation capabilities for space operations remain unmatched, which will require sustained research, rapid development, and deployment of superior AI technologies for space—and on denying technologically ambitious rivals the opportunity to achieve parity or superiority in autonomous space warfare.

Paul Scharre raises a crucial point.[7] Although increasing financing for defense research and development is beneficial, it does not change the fact that most new technological advancements take place outside of the military. The Defense Department's new budget calls for major investments in AI and autonomy, including undersea drones, drone swarms, and autonomous "wingman" aircraft. The U.S. Air Force leads these efforts, requesting $789 million for its Collaborative Combat Aircraft program, which will deploy unmanned fighter drones alongside piloted jets. By 2029, the Air Force plans to invest about $28 billion in the program.[8] Although additional funding for defense research is undoubtedly beneficial for national security, the military must collaborate with the civilian technology sector to remain informed about the most recent advancements. To remain competitive, the Department of Defense requires Congress's assistance in terms of its ability to adapt, act quickly, and collaborate with nontraditional technological businesses. To address the increasing complexity of catastrophic threats, the United States must prioritize the establishment of comprehensive security frameworks. It is imperative to invest in advanced weapon technologies, including antimatter, antigravity technology, and kinetic bombardment to safeguard national security and preserve global strategic influence in the presence of emerging threats.[9]

Research Objective

This study aims to evaluate cutting-edge weapon systems that could significantly strengthen U.S. defense capabilities. This evaluation is crucial for the U.S. military to sustain its strategic advantage amid rapidly evolving geopolitical challenges. This article reviews pertinent studies on emerging technologies and proposes approaches to improve U.S. national security. The main aim is to assess the strategic implications of kinetic energy weapons, antigravity technology, and antimatter weapons for national security. During the Vietnam War, the United States employed "Lazy Dog" explosives, which were small, fast-falling projectiles that could achieve speeds of up to 500 mph. These kinetic bombardment weapons were capable of penetrating nine inches of concrete when dropped from a height of only 3,000 feet.[10] Daniel C. Sproull states that kinetic energy weapons can create craters about 100 feet deep at Mach 10 and more than 150 feet deep at Mach 50, making them extremely devastating to subsurface infrastructure, surpassing the destructive capacity of certain nuclear weapons.[11] This makes kinetic energy weapons an essential instrument for the deliberate destruction of fortified subterranean facilities during future conflicts.

Despite being primarily theoretical, antimatter possesses an immense potential as a result of the substantial energy released during matter-antimatter annihilation. Recent National Aeronautics and Space Administration (NASA) research indicates that antiproton annihilation with heavier nuclei releases substantial energy, with roughly 10 percent of the annihilation energy converted into kinetic energy for nuclei as heavy as silicon, and up to 20 percent for very heavy nuclei such as uranium.[12] Antigravity technology, although predominantly theoretical, is garnering interest due to its potential to revolutionize military aircraft and space exploration. Some recent studies suggest that a natural antigravity force may exist, although it is not yet fully comprehended.[13] Harnessing such a repulsive force could facilitate the development of advanced propulsion systems, allowing for swift, fuel-efficient, and exceptionally maneuverable aircraft and drones. These developments would provide the U.S. military with a substantial advantage in aerospace operations and strategic defense, ensuring a preeminent role in future combat situations. In the end, this article will be instrumental in the advancement and encouragement of future research endeavors in this rapidly evolving discipline.

Kinetic Bombardment (Rods from God) in U.S. Defense Strategy

Kinetic bombardment, commonly referred to as "Rods from God," is a space-based warfare system in which satellites deploy tungsten rods to strike terrestrial targets with significant destructive force. A kinetic energy weapon operates at hypersonic velocities, converting a portion or the entirety of its mass into energy at collision. The concept of deliberately harnessing this effect has been contemplated by the United States since the 1950s, when the Rand Corporation first proposed the deployment of tungsten rods on intercontinental ballistic missiles (ICBMs).[14] This technique, still theoretical, proposes a weapon system of a pair of satellites orbiting hundreds of miles above Earth. One satellite oversees targeting and communication, while the other contains several tungsten rods, each measuring up to 20 feet in length and 1 foot in diameter, prepared for deployment within 15 minutes. On order, the targeting satellite directs its counterpart to deploy a rod, which thereafter descends through the atmosphere at velocities comparable to meteors, reaching 36,000 feet per second, and impacts its target with catastrophic force, even when situated deep underground.[15] Tungsten rods traveling at hypersonic speeds could cause catastrophic damage to a city, but they would not wipe out humanity or necessarily kill everyone within the target area. This concept was part of Jerry Pournelle's argument in favor of such weapons, since unlike nuclear devices, they would not produce radioactive fallout. That said, deploying multiple tungsten projectiles could completely level a city much like several nuclear strikes would. Because they can penetrate hundreds of feet into the ground, they are particularly effective as bunker-busting weapons. Rather than being a traditional weapon of mass destruction, orbital tungsten strikes can be seen as a less extreme alternative to full-scale nuclear warfare.[16]

A tungsten rod–based kinetic energy weapon can be compared to the GBU-43/B Massive Ordnance Air Blast (MOAB), the largest precision-guided conventional munition in the U.S. Air Force arsenal, which has an estimated blast radius of 150 meters. Assuming a tungsten rod with a mass of 169,000 kilograms—approximately 90 percent of the payload capacity of an Ares V rocket—the destructive potential at various reentry velocities is considerable.[17] At Mach 10, the kinetic energy released on impact would be comparable to the detonation of 10 MOABs, or roughly 300,000 pounds of TNT, concentrated at a single point. At Mach 50, the release would approximate the yield of 247 MOABs, equivalent to nearly 4 kilotons of TNT. At impact, much of the tungsten rod would vaporize, producing vapor and particulates capable of spontaneous combustion at temperatures exceeding 6,000 degrees Fahrenheit. In confined environments such as underground bunkers, this combustion would generate an intense fireball, compounding the destructive effects of the initial strike.[18]

With their high precision, rapid deployment, and global reach, these weapons could be employed to target fortified underground facilities, missile silos, or command centers with minimal warning. A primary benefit of this technology is its capacity to penetrate deeper into the Earth, resulting in significant underground damage. Kinetic bombardment presents a nonnuclear alternative to nuclear weapons, capable of delivering comparable destructive power against fortified targets while minimizing collateral damage and reducing the risk of escalation. There are significant difficulties and technical barriers that prevent kinetic bombardment techniques from being used effectively. A principal barrier is the high expense of deploying and maintaining these systems in orbit, particularly due to the substantial costs associated with bringing massive tungsten rods into space.[19] One additional significant issue is the accumulation of space debris. The deployment of kinetic energy weapons in space could significantly exacerbate the existing issue of orbital debris. For instance, the 2011 antisatellite test that resulted in the destruction of the Fengyun-1C satellite produced 3,037 fragments of trackable debris, underscoring the potential for such systems to exacerbate this issue.[20]

It is important to recognize that efforts to mitigate orbital debris are already underway, with Japan playing a leading role. Such initiatives indicate that the challenge of space debris extends beyond national security concerns and is being addressed through technological and commercial innovation. A key example is the (Active Debris Removal by Astroscale-Japan) mission, operated by Astroscale-Japan, a subsidiary of Astroscale Holdings—the world's first private enterprise dedicated to space debris removal. Founded in 2013, the company has developed collaborative partnerships with organizations including JAXA and the UK Space Agency, with the objective of commercializing debris-removal services by 2030.[21] Through committed research and funding, these difficulties could be overcome.

The United States is now facing the possibility of a space-based missile threat from low-Earth orbit, in addition to the already overwhelming threat posed by China's quickly growing arsenal of conventional and nuclear missiles deployed from the air, land, and sea. China could deploy dozens of orbiting missiles with nuclear warheads within 10 years, according to a 13 May 2025 Defense Intelligence Agency assessment that was reported by Bloomberg.[22] Compared to conventional ICBMs, these systems may strike the mainland United States faster than conventional, Earth-based weapons. Among the several sophisticated missile threats highlighted, the most significant may be China's potential development of a Fractional Orbital Bombardment System (FOBS). FOBS is defined by the Defense Intelligence Agency as an ICBM that enters a low-altitude orbit before reentry, allowing for significantly shorter flight durations along traditional routes or the choice to approach over the South Pole to avoid missile defenses and early warning systems. The payload is deployed prior to the spacecraft completing an entire orbital revolution. Although such a capacity has significant strategic implications for both conventional and nuclear payloads, no state has yet to fully develop or implement such a system. China may have up to 60 operational FOBS missiles by 2035, while Russia is only expected to have 12.[23] The emergence of the FOBS demands that the U.S. Air Force rapidly intensify its research efforts to design either a resilient countermeasure or a more sophisticated system capable of neutralizing such threats.

At the same time, the United States could pursue a comprehensive sanctions strategy that extends beyond conventional economic measures to directly target the technological underpinnings of adversarial weapons development. This would include restricting access to U.S.-origin semiconductors, satellite components, advanced sensors, precision guidance technologies, and dual-use equipment critical for space and missile programs. Sanctions could also bar American firms, research institutions, and investors from any form of collaboration or knowledge transfer that might indirectly enhance FOBS-related capabilities. Moreover, U.S. policy could be broadened to penalize third-party states that provide material, technological, or logistical support to China or Russia in this domain. Such measures might include secondary sanctions against companies or governments that export restricted components, limit enforcement of export controls, or facilitate financial transactions linked to aerospace or missile research. By leveraging its central role in global technology supply chains and financial systems, the United States could not only weaken the direct development capacity of its rivals but also dissuade partner nations from enabling the proliferation of advanced orbital strike systems.

In modern geopolitical environments, nonnuclear states that are looking for a nuclear-style deterrent or are concerned about the deterioration of security assurances from conventional nuclear partners can theoretically seek orbital kinetic bombardment capabilities, such the so-called "Rods from God." For example, Brazil, which does not possess nuclear weapons but has demonstrated the capability to launch satellites and maintains the resources to expand such programs, represents a compelling case. As a nonnuclear state with a well-developed space agency—the largest in South and Central America—and a history of nuclear research that was pursued under the military regime but later abandoned, Brazil retains the technical foundations necessary to pursue advanced strategic systems if it so chose. It is also one of the largest and wealthiest countries with minimal nuclear defense capabilities, having forsworn nuclear weapons under the terms of the Nuclear Non-Proliferation Treaty. In a deteriorating security environment, a state such as Brazil might theoretically declare the deployment of a small constellation of satellites equipped with tungsten projectiles—Rods from God—as a retaliatory mechanism against strategic or tactical threats. Such an orbital kinetic bombardment system could provide a novel form of strategic deterrence while technically remaining outside the formal restrictions of nuclear nonproliferation regimes, offering a means of achieving deterrence without the complications of radioactive fallout. A move like that would immediately prompt questions about how the world would react: Would Brazil be subject to export restrictions, diplomatic isolation, or economic sanctions akin to those imposed for nuclear proliferation, or would governments be reluctant to act for fear of legitimizing the capability as a new kind of deterrent?

This dynamic is likely to drive the parallel development of antikinetic bombardment defense systems over time. These systems combine electronic warfare, high-power laser dazzling, kinetic- or directed-energy interceptors, and space-based early warning systems to detect, track, and neutralize incoming projectiles prior to atmospheric entry. When developed, such systems would offer some protection to a possible victim state, which would lessen orbital kinetic weapons' strategic coercive value and possibly restore equilibrium in deterrence relationships. It is important that the United States prioritize protective measures for space and prioritize significant investment in kinetic bombardment systems. This strategy is essential for enhancing military capabilities and securing leadership in space operations. By safeguarding space assets and enhancing technology, the United States can attain a strategic advantage in a world where space increasingly impacts global security and defense.

Antimatter's Possibilities for Future Weapons and Space Propulsion

The potential application of antimatter as a weapon remains primarily theoretical, motivated by its distinctive capacity to unleash vast energy through the annihilation of matter, as defined by Albert Einstein's $E=mc^2$ equation.[24] In 1983, the Rand Corporation conducted a study for the U.S. Air Force, examining the feasibility of harnessing matter-antimatter annihilation for its significant energy output. The research sought to examine the viability of using this energy for realistic military purposes.[25] The Antihydrogen Laser Physics Apparatus team at the European Organization for Nuclear Research (a.k.a. CERN) has successfully measured antimatter to the highest precision to date, revealing the spectral details of antihydrogen atoms with extraordinary clarity. This milestone, which was achieved after three decades of dedicated research, marks the beginning of a new era in the comparison of matter and antimatter.[26] In contrast to armaments, the application of antiprotons as a propulsion propellant is a promising area. The antiproton is more advantageous than the antielectron for propulsion systems. On collision with a proton or neutron, an antiproton generates three to seven pions rather than emitting immediate gamma rays.[27] The charged pions, traveling at 94 percent of the speed of light, persist for approximately 70 nanoseconds, enabling them to cover roughly 21 meters, which facilitates their capture in a magnetic thrust chamber. This framework converts the energy produced by the micro explosion into thrust. As these pions decay, they generate energetic muons that can continue to contribute to propulsion for an extended period.[28] A muon is an unstable lepton, similar to an electron but about 207 times heavier and negatively charged.[29] CERN physicist Rolf Landua clarifies that although antimatter bombs possess considerable theoretical potential, the expense of antimatter production makes them extremely impractical. Landua predicts that the production of a single gram of antimatter may incur costs up to one quintillion dollars, deeming the development of such weapons economically unfeasible currently.[30] It is reasonable to anticipate a future scenario in which associated costs are reduced. Physicists at University of California-Riverside have successfully synthesized molecular positronium, a novel state of matter consisting of two electrons and two positrons bound together. Formed through collisions between positronium atoms—hydrogen-like systems of an electron and positron—this molecule represents a transient yet significant step in the study of matter–antimatter interactions. The work advances fundamental understanding of annihilation processes and offers new methods for generating antimatter ensembles, with potential implications for future scientific and technological developments.[31] China is actively contributing to antimatter research, demonstrating that it is not lagging in this advanced scientific field. An important development in antimatter research was made when a team of Chinese and foreign scientists used a heavy ion collider in the United States to detect a new type of antimatter hypernucleus. In a report published in *Nature*, the researchers, headed by the Chinese Academy of Sciences' Institute of Modern Physics, discovered antihyperhydrogen-4, the most enormous antimatter hypernucleus yet seen in lab studies.[32] Researchers with the STAR Collaboration have detected the antimatter hypernucleus antihyperhydrogen-4—made up of an antihyperon, one antiproton, and two antineutrons—during atomic nucleus collisions at the Relativistic Heavy Ion Collider at the U.S. Department of Energy's Brookhaven National Laboratory.[33] This underscores that the United States cannot remain idle but must undertake intensive research on antimatter technology with the goal of integrating it into military capabilities by 2050.

A Proposal for U.S. Innovation in Antimatter Missile Technology

To provide the United States with significant advantages in both offensive and defensive capabilities, this study suggests the development of advanced antimatter-based missiles. These advanced missiles, which are intended to deliver controlled antimatter explosives, can be manufactured in a variety of configurations, including stealth, high precision, and adaptability to a variety of deployment strategies. The potential game-changing aspect of antimatter technology lies in its ability to unleash vastly greater destructive power from an extremely small quantity of material, making it far more energy-dense and efficient than conventional or even nuclear weapons.[34] The ultimate objective is to avert conflict by demonstrating strength, thereby discouraging potential adversaries from engaging in hostile behavior. A substantial financial investment is essential to make this technology viable and to secure enduring U.S. dominance in this sector. The production and containment of antimatter is presently incredibly costly and poses significant technological obstacles that need to be addressed. It is important to conduct research that concentrates on the production of antimatter at a low cost, as the current methods are both inefficient and costly. Investments should prioritize the expansion of production, the improvement of storage methods, and the strengthening of containment systems to reduce costs without compromising safety. Equally critical are persistent research and financial investment in the integration of antimatter systems with missile technology. This involves the creation of precision autonomous targeting systems and compact containment units to guarantee the safe and precise delivery of antimatter payloads.

In addition, the proposed recommendation also emphasizes the significance of the BASE-STEP device, which was developed by CERN's BASE collaboration. This device is a significant advancement in the safe transportation and containment of antimatter for emerging missile technology. By carefully using electric and magnetic fields to keep antimatter secure, this advanced device—an upgraded version of the Penning trap—ensures safe, regulated transfers by keeping it from contacting regular matter while being transported. A Penning trap uses combined electric and magnetic fields to confine charged particles. BASE-STEP improves this system by including a robust 1-Tesla superconducting magnet to mitigate external disturbances and a liquid helium buffer to maintain the requisite low temperatures for secure transport.[35] However, Penning traps alone are insufficient for neutral antiatoms. In such instances, magnetic bottle traps are employed, leveraging the magnetic fields generated by superconducting magnets to more efficiently confine neutral particles.[36] The difference underscores the complexity of antimatter confinement, as each kind necessitates specific tools for safe handling. In the case of missiles, integrating antimatter technology poses both significant opportunities and unique technical challenges. Advanced missiles benefit from their larger payload capacity.[37] The extra space in advanced missiles allows for the integration of powerful magnetic fields and containment systems, supporting robust energy sources and stable antimatter storage until detonation. These missiles can also be equipped with advanced guidance systems and remote detonation capabilities, enabling precise targeting and controlled antimatter explosions at critical moments. To initiate antimatter explosions, meticulously controlled procedures are necessary to ensure that antimatter contacts with matter at the exact moment, resulting in annihilation. This can be accomplished by deactivating the magnetic fields that confine the antimatter, bringing matter into the containment, or employing remote signals. To guarantee a controlled detonation, each method necessitates precise control of containment fields and timing. Nevertheless, there are still significant obstacles to overcome, such as the development of energy sources that are both potent and efficient to keep vacuum chambers and strong magnetic fields in compact, advanced missile systems.

To safeguard U.S. national security, it is crucial for the United States to retain complete control over the development of antimatter-based missile technology. To prevent any foreign access, whether from allies or adversaries, all related patents and intellectual property must remain under exclusive U.S. jurisdiction. This technology must be rigorously prohibited from being shared or sold to reduce the risk of proliferation or misuse. Research opportunities in this field should be restricted to U.S. citizens with top secret clearances, thereby mitigating the risk of intellectual property theft or espionage. Additionally, it is vital to prevent technology transfers or collaborations that involve foreign nationals, international students, or foreign governments to maintain security. By limiting antimatter missile development to U.S. territory and restricting access to authorized personnel, the United States can safeguard its strategic superiority and maintain secure control over this revolutionary technology. This strategy is crucial for increasing national security and averting potential misuse that could threaten global stability.

Myth to Reality: The Role of the "Chariot of God" Antigravity Technology and Propellantless Propulsion in the U.S. Air Superiority Strategy

Antigravity is a force that repels two massive objects from one another. The expansion of the universe is believed to be influenced by this repelling force.[38] Antigravity technology and propulsion systems, which are envisioned for advanced aircraft such as the legendary "Chariot of God," feature cutting-edge physics that surpasses conventional physics and propulsion techniques. By using non-reactive forces, these antigravity systems offer a completely unique method of lift and movement.[39] The Chariot of God is often a symbolic or mythological reference, most famously in the Biblical account of the prophet Ezekiel's vision, where a divine chariot appears to descend from the heavens, moving in ways that defy natural laws. It has sometimes been interpreted in modern thought as a metaphor for advanced or otherworldly technology. The analogy to antigravity derives from the notion that, similar to the chariot's extraordinary and seemingly impossible movements, antigravity technology would enable vehicles to transcend gravitational constraints and operate beyond the boundaries of conventional physics. To detect obvious gravitational effects with a moderate quantity of mass, it is necessary to have matter that is highly dense. This underscores the potential importance of researching degenerate matter, which may provide methods to generate and manipulate gravitation effectively.[40] Degenerate matter arises under conditions of extreme density, where the Pauli exclusion principle governs its behavior. Electrons or other fermions are forced into such proximity that they cannot share identical quantum states, producing a degeneracy pressure that prevents further collapse. In a high-temperature superconductor (HTSD), the minuscule pull of each atom is amplified by the collective effect of the multitude of atoms within the disk. According to Dr. Ning Li, her device could produce a force field that is sufficiently powerful to counteract gravity over a one-foot-wide area, extending from the Earth's surface to outer space, with only approximately one kilowatt of electricity.[41]

In 2001, British electrical engineer Roger Shawyer introduced the concept of a propellantless drive. Known as the EmDrive, this device claimed that it could operate without propellant, thereby challenging the known laws of physics, specifically the law of conservation of momentum. This revolutionary device, the EmDrive, is composed of a conical cavity that is filled with microwaves. As the microwaves bounce around inside, they generate a difference in radiation pressure, which generates thrust toward the narrow end of the cone.[42] This hypothesis challenges known physics by proposing that propulsion can occur within a closed system without the need for external reaction mass. Dr. Charles Buhler's team, comprising specialists from NASA, Blue Origin, and the Air Force, dedicated decades to investigating propellantless motors before redirecting their attention to electrostatics. Their devices initially generated only a negligible amount of thrust; however, each new version demonstrated improvements. By 2023, their "New Force" initiative produced sufficient thrust to offset Earth's gravity.[43] Dr. Franklin Felber posits that a mass traveling at a rate exceeding 57.7 percent of the speed of light generates a gravitational repulsion, or an antigravity beam, that directly affects other masses in its vicinity.[44] This beam intensifies as the object's velocity nears that of light. His findings address how this repelling effect could be leveraged to rapidly accelerate large spacecraft while minimizing internal tidal forces, so safeguarding the cargo from potential damage.[45] The concept may facilitate revolutionary propulsion technology, transforming not only space exploration but also the defense strategies of the U.S. military on Earth and in space.

Petar K. Anastasovski, in his research on superluminal relativity, suggests the possible existence of elements with atomic numbers (Z) extending up to 145, where Z denotes the number of protons in an element's nucleus. Within this extended range, certain elements—particularly those near $Z = 145$—are hypothesized to exhibit unique properties, including potential antigravitational effects. His study demonstrates that curved space-time, exhibiting both gravitational and antigravitational properties, exists not just surrounding but also within atomic nuclei. He classifies elements into two categories: those with $Z < 64$, possessing nuclei with solely gravitational mass, and those with $63 < Z < 145$, whose nuclei demonstrate both gravitational and antigravitational characteristics in various regions of curved space-time.[46] Anastasovski's theory asserts that antigravity elements have the potential to expand the boundaries of physics, enabling innovative advancements in energy, transportation, and gravity manipulation. If further researched and experimentally advanced, this theory could contribute to significant progress in antigravity technology research. The objective of achieving interstellar travel within a human lifetime remains unattainable using even the most advanced technological implementations grounded in current physics. Constraints such as the exhaust velocity and propellant mass dictated by the rocket equation, or the immense power requirements for photon-based momentum transfer, place this goal in the realm of the seemingly impossible.[47] However, solar sails offer a low-cost way to achieve high-speed exploration of the outer solar system and beyond. By slingshotting close to the Sun (2–5 solar radii), they could push lightweight cubesats to >0.1% of light speed (>300 km/s). This would turn the Sun into a launch pad, enabling missions to outer planets in months, interstellar space in a few years, and 1,000 AU in under 20 years.[48] Nevertheless, history demonstrates that sustained advanced research, coupled with substantial investment, can overcome formidable technical barriers; humanity's successful mission to the Moon serves as a testament to what dedicated effort and innovation can achieve.

To further explore the concept of antigravity technology, this study examines an unidentified anomalous phenomena (UAP) incident which—although often dismissed as pseudoscience—may nonetheless offer insights worthy of scientific consideration. UAPs are inexplicable space or airborne events that occasionally exhibit flight characteristics that seem to violate accepted aerodynamics, such as severe acceleration and silent hovering. Theories regarding cutting-edge technology like propellantless propulsion and antigravity have been stoked by these observations, as they may one day allow for similar maneuvers without the use of traditional fuel or lift systems. Although UAP sightings are frequently reported, no definitive data currently confirms their existence as extraterrestrial in origin; however, one such observed object was described as exhibiting apparent antigravity characteristics and a propellantless propulsion system. Retired U.S. Navy commander David Fravor testified before a U.S. House Representatives subcommittee on UAP about his experience commanding a Boeing F/A-18F Super Hornet squadron onboard the USS *Nimitz* (CVN 68) on 14 November 2004, when he encountered an unidentified object off the coast of Southern California. Fravor said radar equipment on board the USS *Princeton* (CVL 23) spotted several anomalous aerial vehicles that descended from about 80,000 feet in less than a second. Redirected from training activities, Fravor and Lieutenant Commander Alex Dietrich saw one such thing, about the size of an F/A-18F, with no wings, markings, or exhaust, making quick movements, including an acceleration that made it disappear from view. In less than a minute, the object was claimed to have been reacquired on radar approximately 60 miles away.[49]

It is important to note that while the extent of China's progress in antigravity research and development remains unclear, evidence suggests that some crucial work in this area is actively underway. Closely monitoring China's progress in this area is crucial to safeguarding U.S. national interests and ensuring strategic advantage. A hypergravity facility known as the Centrifugal Hypergravity and Interdisciplinary Experiment Facility (CHIEF) was recently opened in China. It can generate 1,900 g-t, or a gravity that is 1,900 times greater than that found at the surface of the Earth. By surpassing the U.S. Army Corps of Engineers' 1,200 g-t facility, CHIEF is now the most potent hypergravity research station in the world. CHIEF is ranked among the top 10 national scientific and technology infrastructure projects in China. In 2020, the facility's development started in Hangzhou, Zhejiang province. Hypergravity, however, is a costly endeavor. For example, the Chinese will have to pay an astounding $276.5 million (2 billion yuan) for CHIEF before it is even operational. Currently, the facility currently houses three giant centrifuges—large radial arms that rotate at high speeds to generate an outward-pushing effect known as centrifugal force. In rotating systems, this force can mimic the effects of gravity and is therefore referred to as artificial gravity.[50] In rotating systems, this force functions similarly to gravity and is called artificial gravity. In contrast to natural gravity, which diminishes with increasing distance from the Earth's center, centrifugal force is dependent on both radius and rotational velocity. Although there is currently no method to augment Earth's natural gravitational pull, scientists can generate artificial gravity that is significantly stronger than natural gravity by greatly increasing centrifugal force simply by adjusting the spinning arm's radius and rotational speed.[51] Even while China's advancements seem remarkable, the U.S. Air Force's persistent and rigorous study in this area may result in unmatched antigravity technology that can repel enemies on a never-before-seen scale.

Strategic Superiority through Next-Generation Antigravity Aircraft and Humanoid Robotic Warfare Systems

The author of this article recommends the United States should invest in the development of advanced antigravity aircraft to gain a substantial strategic advantage in air and space operation. Should antigravity technology develop, these aircraft may attain unprecedented speed and agility, enabling rapid, unpredictable maneuvers that would be exceedingly difficult to track or counteract.

This study also suggests the development of silicone-based humanoid robots and specialized vehicles, each having superior antigravity propulsion, to strengthen the United States' military capabilities beyond antigravity aircraft. Because of silicon's advantageous qualities—lightweight yet durable structure, thermal resistance, and the ability to integrate seamlessly with advanced sensors and electronics—silicon-based humanoid robots and specialized vehicles, each equipped with advanced antigravity propulsion, could offer unique advantages.[52] The soft robot can be safely handled while in operation, and its silicone body is naturally durable, withstanding harsh conditions such as snow, water, brief exposure to flames, and even the pressure of being run over by a car.[53] The successful development and integration of advanced antigravity technology would be a prerequisite for the creation of a fully operational, flyable humanoid robotic combat system. In theory, a system like this may replace some of the strategic deterrents that nuclear weapons have historically provided, providing a similar strategic impact without the radioactive fallout. With enhanced propellantless maneuverability, these robots could navigate through dangerous areas, hit specific targets with accuracy, and avoid defenses, assuring their survival. In contrast to traditional large-scale weapon systems, their accuracy and mobility could reduce or even eliminate civilian casualties while still accomplishing important military goals. These proposed robots and vehicles, presumably launched from warships in warfare, would be engineered for multifaceted combat missions, competent in engaging on land and in the air with exceptional precision. Antigravity propulsion systems would make the robots exceedingly challenging to target and defeat, as their exceptional maneuverability would enable them to make rapid, multidirectional movements, evade enemy fire, and effortlessly navigate intricate terrains. The robots would rely on nonnuclear weaponry for targeted engagements, while the carrier vehicle could be equipped with a reserved nuclear device for critical situations. To address emerging threats, this approach would substantially improve strategic response capabilities by emphasizing precision, flexibility, and survivability.

The robots and their vehicles would be remotely controlled from U.S.-based command centers via a secure satellite communication system, facilitating real-time tactical updates and preserving control even in hostile circumstances when alternative connections may be compromised. The satellite connection ensures reliable and consistent command, facilitating rapid reactions. Even while the ideas presented in this proposal might seem futuristic at first, it is essential to remember that three centuries ago, modern propulsion technologies and conventional airplanes would have been considered unrealistic. Past experiences show that persistent, well-funded research can turn seemingly imaginary concepts into practical realities, speeding up technical advancement and producing significant strategic advantages. China might have completely autonomous military weaponry on the battlefield in as little as two years. According to defense analyst Francis Tusa, China is not hampered by ethical concerns over so-called killer robots and is developing autonomous weapons systems faster than any other country.[54] Although China has shown a significant investment in robotics and propulsion research, there is no public evidence that it has pursued this particular silicon-based, antigravity-integrated platform, possibly due to technological barriers, material supply constraints, or strategic prioritization of other defense technologies. Attaining this innovative technology in the near future necessitates intensive scientific research and more financing. As global threats escalate and other nations progress, prioritizing this innovation will enable the United States to maintain its competitive edge. To safeguard national security and preserve exclusive strategic advantages, it is essential that this technology is not traded, shared, or transferred to any foreign nations, including allied countries and NATO-allied countries, after it has been developed. The United States must ensure that only U.S. citizens possessing top-secret clearance participate in antigravity research and development. This additional security measure would serve to safeguard against potential intrusions and bolster the nation's position as a leader in advanced defense technologies.

Proposal for Advancing UAV Propulsion Systems through Antigravity Technology

This article proposes the development of drones using an antigravity propulsion system, potentially representing a significant advancement in aerospace technology, transforming airborne mobility with remarkable efficiency and agility for defense and surveillance operations. Although antigravity technology has yet to be discovered, its future developments could transform drones into a powerful asset for military operations. An antigravity technology-powered drone could provide an innovative alternative to the limitations of traditional propulsion systems that depend on rotor blades, fuel, or batteries for thrust.[55] This innovation has the potential to improve the maneuverability and stability of drones, allowing them to operate in challenging environments such as urban areas, adverse weather, and high altitude. The effective use of antigravity propulsion in drones has the potential to revolutionize the fields of logistics, surveillance, emergency response, and even interplanetary exploration, thereby expanding the limits of drone and propulsion technology. It is crucial to participate in further scientific research on the incorporation of antigravity propulsion systems into drones to enhance U.S. national security.

Ensuring Accountability and Oversight in Advanced Weapons Development

As next-generation weaponry technology progresses, it is imperative to regulate it carefully to mitigate any potential risks. It is important to prioritize global safety and ethical standards as the United States contemplates pursuing powerful technologies such as antimatter weapons, kinetic bombardment, and antigravity technology. The implementation of oversight can serve to prevent unintentional escalations, safeguard against the widespread distribution of these technologies, and ensure compliance with international regulations. The Massachusetts Air National Guardsman alleged to have leaked top-secret military documents is a concerning example of a vulnerability in the way the United States protects sensitive information.[56] This incident underscores the dire need for increased cybersecurity and supervision in military and intelligence environments, as it emphasizes actual concerns regarding the potential security risks associated with new technologies and digital platforms. These types of disclosures not only undermine public confidence but also pose a threat to critical operations and national security. It is important to establish specific responsibilities among the government, defense contractors, and research institutions to prevent the misuse of advanced weapons technology and ensure that it is consistent with U.S. security objectives. Effective oversight and frequent audits are crucial for preventing unintended damage and ensuring accountability. To avoid transferring sensitive technology overseas, defense contractors must also adhere to rigorous standards, face stringent audits, and follow strict guidelines. By achieving a balance between accountability and innovation, it will be possible to maintain stability and security. Without comprehensive governance, these potent technologies could pose significant risks, which could affect national security in unpredictable ways.

Conclusion: Preparing for the Next Era of Warfare

Kinetic bombardment is the most instantly practical and strategically disruptive of the new space technologies. Orbital tungsten Rods from God might be used immediately, delivering devastating precision hits without radioactive fallout, in contrast to antimatter systems or sophisticated propellantless propulsion, both of which are still decades away from being fully developed. Such a capability could destabilize current deterrence architectures and encourage wider adoption by allowing a nonnuclear state to achieve a nuclear-level deterrent effect while technically avoiding violations of current nonproliferation agreements, as demonstrated in the hypothetical Brazil scenario.

Although still more distant from practical implementation, antigravity technology and propellantless propulsion, along with antimatter weapons, hold even greater transformative potential: the former could enable rapid, unpredictable, and sustained maneuvering throughout the battlespace, while the latter promises an unmatched energy density. As observed in this study, China is making significant strides in the fields of antimatter and hypergravity research, as well as the development of a FOBS. It is worth noting that a United States committed to long-term, well-funded research through the Air Force Research Laboratory, DARPA, and the national laboratories could attain operational leadership in all three areas by 2050, thereby influencing the strategic landscape rather than merely reacting to enemy developments. It is also important to develop advanced antikinetic bombardment defense systems in parallel, incorporating directed-energy systems, rapid interceptors, and space-based surveillance to ensure the comprehensive defense of the homeland against potential enemy deployments.

While the development of an advanced kinetic bombardment system should be the first priority for the United States, the creation of an antikinetic bombardment defense system should also be pursued, with the goal of achieving operational capability by 2030 through intensive research and sustained funding. The United States may use severe economic sanctions and other coercive measures against nations that attempt to abuse such capabilities until a strong antikinetic bombardment defense system is completely developed and put into place to defend the American homeland from any enemy strikes. It is also critical to reiterate that, once operational maturity is reached, no advanced kinetic bombardment or antikinetic bombardment defense system, antimatter technology, or antigravity and propellantless propulsion technology developed by the United States should be traded, shared, or transferred to any foreign country, including allied and NATO member states—to protect national security and maintain exclusive strategic advantages. Furthermore, it is imperative that no foreign nationals be allowed to work on the research, development, or testing of these systems because there is a considerable chance that technical expertise, design processes, or operational ideas will be transferred—directly or indirectly—for use in other nation-states' defense programs.

Moreover, while strategic inaction in these areas could lead to the loss of U.S. technological supremacy, sufficient investment could lead to long-term dominance of the United States and the potential to establish standards for these potent technologies well into the second half of the twenty-first century. As other nations continue to enhance their capabilities, the United States must seriously contemplate the development of these technologies to guarantee an everlasting military superiority. History has consistently shown that those who invent and develop a technology first secure a decisive first-mover advantage. In China, for example, "The PLA also aims to surpass the U.S. in modernization, capabilities, and power projection capacity by 2049."[57] This aligns with other People's Republic of China's strategies to leapfrog other major powers technologically, using the United States as a benchmark: "The plan involves a 'leapfrog development' strategy, integrating mechanization, informatization, and 'intelligentization' (AI) to achieve dominance in weaponry, training, and military theory, ensuring it can win wars and safeguard peace."[58] This article advocates leapfrogging Chinese technologies to overcome current and future developments by planning and funding for technologies that enable the United States to maintain technological superiority over its most powerful competitor.

Achieving these new capacities is not merely an issue of innovation but an essential strategic priority in an age where technology supremacy is crucial to national defense, as evidenced by the strategic priorities of the People's Liberation Army. By implementing proactive planning, oversight, and innovation, the United States can maintain its position as a leader in military power in a global landscape that is becoming increasingly complex and competitive.

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How Drones Fight: How Small Drones Are Revolutionizing Warfare. By Lars Celander. Havertown, PA: Casemate Publishers, 2024. Pp. 208. $24.95 (paperback); $14.95 (ebook).

Cyber Wargaming: Research and Education for Security in a Dangerous Digital World. Edited by Frank L. Smith III, Nina A. Kollars, and Benjamin H. Schecter. Washington, DC: Georgetown University Press, 2023. Pp. 240. $164.95 (hardcover); $54.95 (paperback and ebook).

Author Lars Celander and editors Frank L. Smith III, Nina A. Kollars, and Benjamin H. Schecter compiled two distinct works that both consider the impact of emerging disruptive technologies on battlefields and national security. Both books provide valuable content in a condensed form. However, the book and edited volume take fundamentally different approaches. Lars Celander describes his book as "only about how things actually work, offering no recommendations on policy, acquisition, training, or organizational matters. Suitable conclusions are left to the reader" (p. ix). Celander is a former Swedish military systems engineer with a master of science in physics. In contrast, *Cyber Wargaming* comprises contributors and editors from multiple backgrounds and recognized experts, "whereas many cyber experts do not interact with wargamers, this book brings together innovative voices from across professional military education, civilian agencies, private industry, think tanks, and academia" (p. 3). Editors Frank L. Smith III, Nina A. Kollars, and Benjamin H. Schecter all have current or previous affiliation with the U.S. Naval War College and are recognized experts in the cyber domain.

How Drones Fight is organized into three distinct parts. The first part pres-

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ents an overview of the engineering and technical knowledge associated with drones. The second part examines the current and historical applications of drones in warfare. In the third part, the discussion shifts to the future of drone technology in conflict. Additionally, the book features a preface, glossary, introduction, 16 chapters, three appendices, a bibliography, and an index to provide a comprehensive resource.

The chapters in the book follow a logical progression, beginning with concise technical information. They cover various topics, including types of drones, navigation methods, drone sensors, and communication systems. The second part delves into weapons, drone tactics, antidrone strategies, and combined arms operations. Chapter 7 stands out as a particularly impactful section, where Celander delves into countering drones through the concept of "soft kill" (p. 59). Despite its brevity, spanning only two and a half pages, this chapter effectively tackles essential topics such as disrupting navigation, interfering with communications, and eavesdropping.

In the final one-third of the book, the author effectively connects technical information from earlier chapters to modern situations. Chapter 12 covers the use of drones in the Global War on Terrorism in just seven pages. Chapters 13 and 14 focus on the 2020 Armenia-Azerbaijan conflict and the 2022 Russia-Ukraine conflict, respectively, and are the highlights of the book. Chapter 14 is the longest and features maps, images from both conflicts, insights into command-and-control dynamics, and evolving drone tactics. While the practical applications are a significant strength, the narrative could benefit from more examples. Overall, the content and writing style are accessible, but inconsistencies in chapter length and subheadings may frustrate readers. Some subheadings include only a few sentences, creating a disjointed reading experience.

The bibliography includes sources, but the book lacks traditional citations apart from a few photographs. Celander downplays the necessity of source listings, stating, "Much of what is said in this book is based on various engineering textbooks. They are not listed as sources here as they all say the same thing. Ultimately, everything is just physics" (p. 175). While some photographs mention citations, many diagrams do not have corresponding references. The absence of a thorough conclusion addressing the potential impact of drones on the future of warfare presents the most significant challenge for readers. In the concluding chapter, Celander remarks that "the book is reluctant to draw conclusions. It is not its purpose. The purpose is to provide the reader with an understanding of how drone warfare works; the reader is expected to draw his or her conclusions" (p. 153).

Cyber Wargaming is a unique book; it focuses on cyber wargaming, not on specifics of cyber warfare technical knowledge, "contrary to popular belief, cybersecurity is also about human decision making: not just hardware, software, network, and data" (p. 2). The authors divide the book into thirds. The book begins with an introduction, followed by the first one-third of the book discussing research games, the second one-third on educational games, and a final conclusion. While *How Drones Fight* builds on each chapter, leading to a disappointing conclusion, *Cyber Wargaming* takes an independent chapter approach. Readers can navigate much easier between chapters and only read chapters they find of interest.

As *Cyber Wargaming* illustrates, wargaming is a technique used for both research and education in a wide variety of environments: "Fortunately, as a general-purpose tool, wargaming is interdisciplinary. When used correctly, cyber wargaming can bridge the gaps between social and technical knowledge in university classrooms, corporate boardrooms, and military headquarters" (p. 3). The editors note in the introduction that, while wargaming is expanding as a technique, most cyber wargames remain shrouded in mystery.

After the introduction, the book's first one-third concentrates on research games or analytical games. Chapter 2 on cyber wargames as synthetic data is an excellent supplement to the introductory chapter. While the introductory chapter explains why cyber wargaming is a valuable technique, chapter 2 provides more information on cyber wargames as a tool to generate data and provides examples of wargames with alternative approaches to generate research data. The chapter concludes by stating, "It is our hope that the library of cyber wargames and the new knowledge they can create will continue to grow" (p. 34). Chapter topics in the book's first one-third include cyber and nuclear crises, wargaming international and domestic crises, imperfect information games, cyber kill chains, and games within games and critical infrastructure.

The most innovative chapter in the book is chapter 5, which discusses the topic of imperfect information in games. Many wargames assume near-perfect information processing and retrieval, which is a flawed method, as the editors explain: "In this chapter, we argue that the role of information—specifically imperfect information and the means to degrade information—is foundational to any realistic wargame. Imperfect information has always been important to real life" (p. 67). Specifically, in a wargame, the authors used videoconferencing, voice chat, text messaging, and maps, and those capabilities could be degraded based on various cyber or kinetic actions.

The second one-third of *Cyber Wargaming* focuses on educational wargames. It covers topics such as creating enjoyable cybersecurity games, the Cyber 9/12 Strategy Challenge, the North American Electric Reliability Corporation Grid Security Exercise (GridEx), private sector cyber wargames, prototyping virtual cyber wargames, military doctrine, and using matrix games for strategic cyber and information warfare.[1] This section offers numerous examples of lessons learned from various cyber wargames. It includes several graphics de-