CHINA'S SPACE CAPABILITIES AND THEIR IMPACT ON U.S. NATIONAL SECURITY

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Mr. Chairman and Members of the Commission,

Thank you very much for your invitation to testify on China's military space capabilities. The Chinese ASAT test of January 2007 reminded the international community of some of the more problematic dimensions of these emerging capabilities and I am grateful to the U.S.-China Economic and Security Review Commission for the opportunity to reflect on China's space program and its military component in particular. In response to your letter of invitation, my testimony will focus on briefly assessing three issues: (i) key characteristics of China's space program; (ii) China's military space capabilities; and (iii) the impact of China's space and counterspace investments on U.S. national security and its military operations.

Key Characteristics of China's Space Program

China's space program represents a major investment aimed at enabling Beijing to utilize space in expanding its national power. The expansion of comprehensive national power, which has been China's grand strategic objective since at least the reform period initiated in 1978, is critical to recovering the greatness that China enjoyed internationally for most of the last millennium. Recovering greatness, in turn, requires China to sustain high levels of economic growth, preserve internal stability, and neutralize the external threats to its national security.

It has been clearly recognized in China that a space program helps to advance all these three goals simultaneously. As in the United States, Chinese investments in space are judged—correctly—to contribute to enhanced economic growth in multiple ways: They stimulate innovation; they produce technology spinoffs that can be utilized in diverse sectors far removed from their origins; they create demand for new derivative technologies and services; and, they produce fresh opportunities for export. Since space contributes to accelerating economic growth in this way and, by implication, helps China meet its vast developmental challenges, it also aids the state in maintaining internal stability. China's space programs advance this goal either through the direct application of space-related technologies for discharging law-and-order functions or for providing disaster relief, or through the more indirect, but nonetheless equally important, means of sustaining the "social contract" that enables continued Communist rule. China's space achievements also providing the requisite symbolic gains that enable China's rulers to justify their continued rule. Finally, space technologies have become critical to the successful conduct of military operations: they enable China to use its armed forces more effectively either because they permit better collection, transmittal and exploitation of information or because they support the development of new weapons such as responsive directed energy and other non-kinetic technologies.

China's space program is intended to advance all these objectives seamlessly and synergistically. Consequently, its space policy goals could be characterized as simultaneously focused on securing economic and development benefits, enhancing national military capabilities, and procuring symbolic benefits that both aid regime survival at home and enhance Chinese prestige abroad.

China's space program writ large is marked by three distinguishing characteristics. First, it is *comprehensive*. Unlike some other developing countries which are involved in a few

discrete activities, China is a major space-faring nation pursuing endeavors that span the entire spectrum. Today, almost fifty years after China formulated its first space development plans, Beijing is deeply involved in space science; it possesses an inclusive space research, development and manufacturing base that produces everything from launch vehicles to satellites; it has a large ground segment that oversees space launches and includes an extensive telemetry, tracking and control (TT&C) network; it possesses a diverse set of space launch vehicles, currently consisting of some ten variants of four basic Long March boosters, now also complemented by newer mobile launch systems; it owns a diverse set of orbital assets, primarily indigenous satellites that provide communications, meteorological, navigation and positioning, remote sensing, reconnaissance, and electronic intelligence services; it has recently embarked on a manned space program that besides being a source of great national pride also represents its most difficult space endeavor, one that promises however to push Beijing to the limits of technology innovation; it has an emerging space services industry that is aimed at offering hardware, launch services, and space-derived products to domestic and international clients; and, finally, China is engaged increasingly in various activities involving international collaboration, be they scientific, technical, or diplomatic. China's space presence is thus marked by the possession of an end-to-end capability. While Beijing still lags behind advanced space powers such as the United States, Russia, and key European states, it nonetheless has laid the foundations for a major presence in space.

Second, China's space program is *integrated*. Unlike the United States, for example, where a significant divide exists between civilian and military space activities, and where diversity, heterogeneity, and atomistic competition are the norm in both realms, civilian and military space programs in China are not only centrally directed but are also mutually reinforcing by design. Although specific activities in the Chinese space program may be biased towards civilian or defense applications, the entire enterprise, strictly speaking, is a strategic program with no firewalls whatsoever between the civilian and the military. This "unity-in-difference," centered on the primacy of military considerations which suffuse even the scientific, domestic, and commercial elements of the space effort, is protected at the programmatic level by the organizational structure of the Chinese system. Although a now-civilianized Commission on Science, Technology, and Industry for National Defense (COSTIND) sits at the apex of the Chinese defense-industrial complex, it is responsive to both the Central Military Commission of the Chinese Communist Party and the General Armaments Department of the Peoples Liberation Army (PLA) on whose behalf it coordinates the activities of the major aerospace holding companies, the principal research academies, and the third-line industrial organizations that perform work on contract to these institutions. In this context, the China National Space Administration, which is sometimes depicted as China's National Aeronautics and Space Administration (NASA), is essentially a civilian front for international cooperation and a liaison between the military and Chinese defense industry. The military interests of the Chinese state in the space program are thus affirmatively protected, even though Chinese policymakers rarely, if ever, own up to the military dimensions of their space endeavors. As Kevin Pollpeter summarized it succinctly, "China's space program is inherently military in nature…. Indeed, China's space program is a military-civilian joint venture in which the military develops and operates its satellites and runs its infrastructure, including China's launch sites and satellite operations center."[1] The

[1] Kevin Pollpeter, *Building for the Future: China's Progress in Space Technology During the Tenth 5-Year Plan and the U.S. Response* (Carlisle Barracks, PA: Strategic Studies Institute, 2008), 44-45.

policy consequence of this fact, from an American perspective, is that any collaboration with China's "civilian" space program inevitably ends up aiding its military.

Third, China's space efforts are *focused* in multiple ways. To begin with, although some Chinese activities are intended to procure symbolic benefits that enhance the control or legitimacy of Communist rule, these gains are usually conceived of as positive externalities that derive from some other material benefits of exploiting space for specific economic, political or military aims. To that degree, Beijing's space investments are in fact conservative: Given its relative under-development, China has consistently sought to avoid frittering its resources on showcase projects that provide few tangible gains, preferring instead to invest in those activities that provide highest value within what are acknowledged fiscal constraints. Given the desire to secure the most while spending the least, even more controversial initiatives such as the manned space program have been authorized mainly because it is expected that this effort would push the frontiers of innovation, create a new quality control culture across the space program, generate new demands for technical education, and produce spin-offs that would benefit the economy more generally. China's space program is focused in other ways as well. Beijing abundantly recognizes that for all its impressive space achievements in recent years, it still operates in a milieu characterized by emerging political competition with a technologically dominant United States. Consequently, given the differences in cultural ethos, political systems and comparative advantage, the Chinese space program has deliberately avoided either replicating the American endeavor or attempting to compete with it across the board. Rather, Beijing's space efforts have been characterized by two different orientations in this regard. To the degree that raising its technological standards to American levels is judged necessary, China has embarked on a quite calculated "buy, copy, or steal" approach in regards to procuring various critical technologies. Where competing with the United States is deemed necessary, China has focused its space programs not on mustering any comparable superiority but by aiming at Washington's "soft ribs and strategic weaknesses." In any event, and irrespective of the endeavor in question, Beijing's space efforts have been marked by deliberation and purposefulness.

A net assessment of China's space program would, therefore, justify the following conclusions: (i) China is a major space-faring nation with an impressive end-to-end space capability that serves substantially military ends. (ii) China's remarkable space achievements, however, mask important weaknesses in technological sophistication, gaps in capability, and operating regimes. (iii) China's limitations in space capability will compel it to look for foreign technology—bought, copied, stolen or acquired through joint ventures—as solutions designed to overcome its weaknesses. And (iv) China's real constraints notwithstanding, it is poised to become an international player at least in the launch services market and perhaps as a niche provider of low-cost satellites to other developing countries.

China's Military Space Capabilities

China's military space capabilities cannot be understood outside the context of its military strategy which today is summarized by the phrase "active defense." As David Finkelstein has so illuminatingly described, although this approach is oriented towards defense at the strategic level—meaning that China would unleash violence only in the context of the threat of force materializing against it first—Beijing's actions nonetheless would be offensive, with these activities not being limited by the preferences of the adversary, undertaken at times and under conditions of China's choosing through the exclusive use of its own forces, and directed not at the opponent's strengths but at his

2 David M. Finkelstein, *Evolving Operational Concepts of the Chinese People's Liberation Army: A Preliminary Exploration* (Alexandria, VA: The CNA Corporation, 2001).

weaknesses, through the simultaneous use of offensive and defensive maneuvers designed to maximize China's military advantages.[2] Beijing's current military strategic guidelines require the PLA to prepare for such an active defense in a specific context, namely what is now labeled, "Local Wars Under Modern *Informationalized* Conditions."

This particular locution is meant to convey the insight gained from recent Chinese reflection that possession of information superiority will be *the* critical ingredient making the difference to winning or losing the kinds of wars that Beijing will most likely be confronted by in the prospective future. In this struggle to collect, process, and disseminate information about the adversary's capabilities, disposition, and intentions to one's own forces, while simultaneously denying such data to the enemy, space—along with the electromagnetic and the cyber dimensions—is seen as a critical medium whose control permits its possessor to shape the earthly battlespace to its advantage. Because space has acquired such a privileged position, Chinese military thinkers appear to be gravitating towards three broad conclusions.

First, China must develop the entire spectrum of capabilities required to exploit space in the manner necessary to advantage its conventional military operations against a wide range of potential adversaries.

Second, China must prepare to deny space to superior adversaries who could otherwise use their vulnerable but sophisticated space systems to multiply the conventional military advantages they already enjoy vis-à-vis Beijing.

Third, the centrality of space to information dominance and the pivotal significance of information dominance for producing victory in war imply that a struggle for space control is inevitable and, consequently, China must prepare itself for such rivalry by fully integrating space into its own military operations and, as required, developing its own space-related deterrent and warfighting capabilities.

China's current military space program takes its bearings from these three conclusions in varying degrees. Since Beijing is still a relatively weak, although rising, power, its publicly visible military space activities today have been manifested primarily through programs associated with utilizing space in support of its conventional military operations. Yet, even as these efforts continue apace, China has quietly and with no acknowledgement pursued a wide variety of counterspace investments aimed primarily at the United States, but which could be brought to bear with equal felicity against its regional rivals in Asia, such as Japan, India, and Russia. While current Chinese programs suggest that Beijing continues to emphasize investing in space support, force enhancement, and space denial in order to advance its three immediate security goals—preserving internal security, deterring regional adversaries, and defeating American intervention in a conflict over Taiwan—it nonetheless continues to prepare in more incremental ways for geopolitical rivalries that may materialize over the longer term. This includes coping with American military power in scenarios which transcend Taiwan, managing the rise of regional rivals such as Japan, India, and Russia in the context of preserving a pacified periphery, and utilizing China's emerging military capabilities to protect its extended interests in the larger global system. China's utilization of space to advance these objectives is, for the moment, largely nascent. However, as Larry M. Wortzel has described, it has begun to debate internally a quite ambitious space doctrine centered on the necessities of preparing for space warfare, while simultaneously investing in theoretical, basic, and applied research in a variety of cutting-edge space combat technologies such as satellite jamming, space body collisions, kinetic energy weapons, space-to-earth attack

[3] Larry M. Wortzel, *The Chinese People's Liberation Army and Space Warfare* (Washington, D.C.: American Enterprise Institute, no date), 7ff.

weapons, trans-space attack aircraft, high-power lasers and microwave weapon systems, particle beam weapons, and electromagnetic pulse systems.[3]

China's military space capabilities currently are manifested in five distinct areas: (i) space launch capabilities; (ii) the TT&C network; (iii) space orbital systems; (iv) connectivity to military operations; and (v) counterspace technologies.

China maintains a robust space launch capability centered on ten different *Long March* booster configurations capable to deploying various payloads from low-earth to geosynchronous orbits. These launch vehicles use three launch sites: recoverable satellites and manned spacecraft are launched from the Jiquan Satellite Launch Center in Gansu Province; orbital platforms headed for geostationary orbit are launched from Xichang Satellite Launch Center in Sichuan Province; and satellites intended for polar orbit are launched from the Taiyuan Satellite Launch Center in Shanxi Province. China intends to construct a new spaceport on Hainan Island, which would be optimal for launches aimed at equatorial orbits, but it is unclear when this facility will become operational. Because fixed launch sites are inherently vulnerable, the recent Chinese demonstration of a mobile launch capacity exemplified by the Pioneer rocket represents a significant innovation insofar as it would bestow on Beijing a responsive launch capability even if its fixed bases were destroyed. A summary assessment of China's launch capabilities is that they are adequate for its national purposes. The prospective development of the Long March 5 booster, with its modular design, will provide China with a versatile system capable of carrying a variety of payloads reliably into orbit. The heaviest versions of this booster will permit China to reach the moon and deploy its planned space station in orbit. China's launch performance has improved considerably in recent years, even though some variants of the Long March booster have not enjoyed success rates comparable to the international standard.

China possesses an extensive network of ground stations and data reception and processing centers, some dedicated to operations involving specific satellite systems, as well as numerous TT&C facilities spread throughout the country. Beijing also has a fleet of four space event support ships and two other vessels capable of supporting space tracking. There is little information available about the robustness of this capability though the fact that it sustains a large number of orbital systems suggests at least its adequacy in peacetime.

China has launched scores of satellites since its first launch in 1970, though the number currently operational is unclear. What is certain is that the satellites associated with its military-civil program are quite diverse. The largest number of satellites and perhaps the most impressive capability seems to reside in China's communications platforms: these include satellites in the Chinasat, APStar, Asiasat, and Sinosat series, which are either owned by China or are privately-owned regional systems that lease transponders to Chinese users. These quintessentially dual-use systems serve both Chinese civilian and military customers through the transmission of telephone, data, television and very small aperture terminal (VSAT) signals. China also utilizes foreign satellite systems such as Intelsat and Inmarsat. China operates a series of earth surveillance satellites capable of providing imagery intelligence, remote sensing data, oceanographic information, synthetic aperture radar (SAR) imagery, and environmental monitoring: the Ziyuan, China Brazil Earth Resources Satellite (CBERS-2), Haiyang-1, JianBing 5, and Huanjing series respectively, represent examples of such capability. China also has access to Landsat data and uses foreign commercial satellite products extensively for military intelligence purposes. Most analysts agree that while China

has made progress in developing a space-based imagery collection capability, it has not invested heavily in these programs historically, preferring to collect its intelligence by other means.

China is known to possess space-based electronic intelligence (ELINT) or signals intelligence (SIGINT) capabilities, though the specific platforms associated with these missions are not identified. China does possess a space-based meteorological and weather assessment capability provided through its Fengyun series satellites and it has reception centers to receive foreign meteorological data. It has now moved ambitiously into the navigation and positioning segment through its Beidou satellite constellation which, though not as precise at the U.S. GPS system, could nonetheless be used to improve the accuracy of China's conventional weapons. China's space systems also include other scientific satellites and an orbital module associated with its manned space program. China does not possess any dedicated early warning satellites, largely because its nuclear strategy is not predicated on the necessity for tactical warning of adversary missile launches. While some Chinese communications satellites perform data relay functions, Beijing still appears to lack a dedicated data relay satellite—a limitation certain to be rectified in coming years.

A summary assessment of China's satellite capabilities suggests that its indigenous systems, combined with its access to foreign platforms or services, provides its military forces with sufficient capability as far as communications, remote sensing/reconnaissance, navigation, and meteorological services are concerned within China's borders or at some distance around them. The new SIGINT/ELINT platforms, electro-optical and SAR imagery satellites, and dedicated data relay satellites likely to be launched within the next decade would enable the PLA to expand its battlespace awareness and targeting capabilities tremendously, support its regional presence and projection operations in East and Southeast Asia and in the Indian Ocean, and fill the missing links required to complete its area and access denial strategy vis-à-vis the United States across the entire western Pacific.

China has invested heavily in recent years in strengthening the connectivity between its space systems and the military users tasked with performing different tasks such as intelligence collection, force planning, military operations, and battle assessment. Beijing's space capabilities have in fact now become central to its regular global intelligence collection activities and the comprehensive modernization of the national military information networks in the past several years has made it possible for the PLA to rapidly fuse and distribute space-derived data to multiple echelons at various headquarters and in the field. The network used for this purpose employs multiple phenomenologies, enjoys significant redundancy, and is secure, survivable, and interoperable among multiple users. As China increases the number and quality of its space collection systems over the next decade, the quality of the information reaching down to the tactical levels of command will further improve. A summary judgment about China's ability to share space-derived information with its combatant forces must therefore conclude that it has been nothing short of transformational and is poised for even more improvement.

Finally, and not surprisingly, China has made enormous investments in developing counterspace capabilities. While its other space acquisitions serve the purpose primarily of enhancing China's own combat capabilities, the counterspace programs, which have been accelerated since the 1991 Gulf War, have been directed primarily at being able to interdict or hold at risk those critical space assets that permit U.S. conventional forces to operate with superlative effectiveness. China's counterspace programs today are remarkable for their diversity, depth, and comprehensiveness. They include major investments in: upgrading China's space object surveillance and identification systems; developing direct attack

[4] Ashley J. Tellis, "China's Military Space Strategy," *Survival*, Vol. 49, No. 3 (Autumn 2007), 62-63.
[5] Ibid., 59-60.

weapons to include direct ascent and co-orbital capabilities; exploring directed energy weapons for dazzling or damaging orbiting satellites; acquiring various technologies for electronic attack against space platforms and their associated links as well as against conventional forces and their warfighting operations; and, improving kinetic and non-kinetic forms of ground attack aimed at the control segments of an adversary's space infrastructure. These counterspace programs continue to persist even after China's infamous ASAT test in January 2007—an event that demonstrated, if nothing else, that all satellites traversing the Chinese mainland in low earth orbit are at risk. While the ASAT test certainly served to highlight the existence of these dangers, it also unfortunately obscured the larger panoply of Chinese counterspace capabilities. In point of fact, direct attack systems remain only one component of a much larger stable of Chinese counterspace assets and, hence, must not be overemphasized to the disregard of the rest.

While it is no doubt easier to assess the impact of any specific element in China's counterspace quiver on U.S. military operations, it is much harder to evaluate the compound effect of all (or some of) these systems when employed synergistically. In any event, a summary judgment about China's counterspace programs ought to suggest, as I have argued elsewhere, "that the U.S. dominance of space, which underwrites both America's civilian and military advantages, and which is often taken for granted, is at serious risk like never before" for reasons that are unique to Sino-American competition.[4] This does not imply, however, that China is "certain to wrest control of space during any future war with the United States. [Beijing's counterspace] programs, while real, are not all mature and will not end up being equally successful. Moreover, the United States still has immense counter-counterspace capabilities, and many of these emerging threats can be countered, albeit at significant cost."[5]

On balance, the evidence suggests that although China is continuing to modernize and expand its military space capabilities, and although Beijing's dependence on space for both civilian and military purposes will progressively increase during the next ten years, China's dependence on space relative to that of the United States will remain considerably lower. In great measure, this is a function of China's limitations: the Chinese space program is relatively small (various sources suggest that its budget ranges between $1-5 billion); China's space efforts continue to remain handicapped by significant deficiencies in technology; and China still remains constrained by the quality of its manpower base. However, the relatively lower Chinese dependence on space prognosticated for the future is also deliberate. Despite its efforts to improve its military space capabilities along the entire spectrum, Beijing appears conscious of the need to avoid becoming overly dependent on space. Given its fears of vulnerability to U.S. counterspace capabilities—which remain formidable—China will be careful never to rely solely, or even dominantly, on space for the success of its military operations. Consequently, space will remain for some time to come one supporting element among many others, at least as far as force enhancement efforts in China are concerned.

This increasing but still minimized dependence on space, coupled with its significant conventional inferiority vis-à-vis the United States (and in specific realms vis-à-vis Japan, India, and Russia as well), suggest that while Beijing will be cautious about the easy use of its direct attack counterspace weapons, it is unlikely to surrender its counterspace options anytime soon. The responsive developments arising from this fact imply that China will inevitably, even if only reluctantly, move further in the direction of taking space warfare

seriously, if for no other reason than to protect its emerging space assets and neutralize the offensive capabilities possessed by an adversary.

The Impact of China's Space and Counterspace Investments on U.S. National Security and its Military Operations

The cumulative consequences of China's space and counterspace investments for U.S. national security will become manifest over the years in multiple ways. To begin with, Chinese military forces will experience significant increases in operational effectiveness as they become capable of exploiting their space systems to provide either the information or the capabilities critical to successful warfighting. The Chinese military will also enjoy greater real-time situational awareness at longer and longer ranges, thus enabling it to avert strategic, operational and tactical surprise and better cope with an adversary's actions. Finally, China will be able to increasingly disrupt the U.S. ability to maintain the superior situational awareness required for the success of its military operations at the lowest cost in human lives and tactical burdens. China's investments in both space and counterspace will thus affect U.S. national security and its military capabilities in consequential ways.

These consequences will be manifest most clearly in the increased burdens imposed on the United States in regards to discharging its security obligations in Asia, burdens that may be discerned as materializing along five different dimensions.

First, China's space and counterspace programs presage an increase in the vulnerability of key U.S. military assets. The emergence of new Chinese long-range precision attack capabilities, exemplified by highly accurate ballistic and cruise missiles exploiting information derived from various sensors including space-based assets, has already sharpened the dangers facing fixed U.S. and allied bases in the Asia-Pacific. As China's anti-ship ballistic missile capability matures—something that is certain to occur in the policy-relevant future—the threats posed to mobile power projection assets, especially aircraft carriers, which have been the capital ship symbolizing the reach and puissance of American power since at least World War II, would increase dramatically. China's emerging space capabilities will be critical to the success of this area denial innovation: today, Chinese satellites can be used mainly to localize and classify its intended targets, but as time goes by, Beijing's space assets would become critical to the entire detection-to-engagement kill chain with significant operational consequences. The maturation of such innovative area and access denial technologies would not only increase the tactical burdens facing the most important ship of the line and the lynchpin of American power projection throughout Asia, but would also progressively erode the credibility of U.S. security commitments which would be at risk in any case as China's growth in national power gathers steam.

Second, the expansion of China's space and counterspace capabilities is an ineluctable part of the change in the balance of power in the Asia-Pacific and in the Asian continent more generally. To the degree that emerging Chinese capabilities make the discharge of U.S. security obligations more burdensome, they undermine the one important advantage that the United States enjoyed with the fall of the Soviet Union: unencumbered strategic access to the Asian rimlands. The rise of new Chinese space-supported denial capabilities promises to erase this gain—perhaps permanently. Until these capabilities can be neutralized either through technical counter-innovations or new operating stratagems, U.S. power projection operations will be confronted by two challenges: first, overcoming the barriers to entry surrounding a region of interest and, thereafter, overcoming the adversary's forces within the tactical area of operations itself. The collapse of the Soviet Union had

ensured that the success of U.S. power projection was guaranteed so long as American military forces were capable of mastering the latter challenge; the rise of new Chinese space-supported denial capabilities presages a return to an older era when the United States had to overcome both problems in order to make good on its security guarantees and, to that degree, signifies a more extensive contest that is to America's disadvantage.

Third, the growth of China's space and counterspace capabilities contributes to raising the costs of American victory in any future conflict with Beijing. Should the United States find itself in an unlimited war with China, the outcome cannot be in doubt: Washington will win such a conflict and perhaps even win "decisively," if there are no restraints imposed on its use of force. The presence of nuclear weapons, however, ensures that such unlimited conflicts are thankfully unlikely. Assuring victory in a limited war with China, however, becomes more problematic not because the United States suddenly loses all its military advantages in such a scenario but because a limited conflict, over Taiwan or elsewhere, would involve restrictive rules of engagement and other political-operational constraints which, even if not ultimately subversive of victory, would nonetheless increase its burdens. Because most future conflicts that can be envisaged with China involve limited wars of some kind or another, Beijing's increasing space and counterspace capabilities—if well used—could become critical, if not decisive, in some quite representative scenarios.

Fourth, China's evolving space and counterspace capabilities promise to expand the dimensions of the battlespace—virtually and physically—in the context of any future Sino-American conflict. Because space-supported conventional operations will become critical for victory for both sides; because the space component of military actions—that is, the space, ground, and link segments in their totality—is conspicuous, highly valuable, vulnerable, and contains relatively few nodes; because defensive and offensive counterspace operations may be hard to distinguish especially in the early phases of a conflict; because both sides will seek to competitively use space to expand their situational awareness while denying the same advantage to the adversary; and, because Chinese operational planning, given its overall conventional weakness, calls for counterspace operations as an integrated element of its military response, it is likely that a future Sino-American conflict, even if intended to be limited in a political sense, will be unable to either bound its offensive operations to the local battlefield alone or resist the temptation to launch crippling attacks first. The demands of victory, even in limited wars, will thus require that the force applied—in both material and virtual senses—range far beyond the physical battlefront to the "rear": in the adversary's homeland, possibly in territories of third-parties, and certainly in the realms of space, electronic combat, and computer network operations. Moreover, it may create strong incentives for "first strikes" because of the perceived benefits to conventional operations arising from being able to blind an adversary decisively, even if only for a short time. In such circumstances, ensuring that a future limited war between China and the United States stays restricted will itself become a significant challenge.

Fifth, and finally, the rise of China's space and counterspace capabilities poses specific challenges to the dominance traditionally enjoyed by the United States in the heavens. The list of antidotes required to mitigate these challenges are long and have been detailed elsewhere. But at the very least the United States must pursue a variety of defensive solutions complemented by some limited offensive options. The kinds of solutions relevant to the defensive counterspace mission are diverse and numerous, but three elements stand out: the United States must improve its space situational awareness to be able to comprehensively identify and assess all orbiting objects, better assess anomalies and anticipate the sources and capacity for counterspace attacks, and effectively identify the

origin of any attack; a program to enhance the survivability of space platforms though systems hardening, increased maneuverability, autonomous operations options, integrated organic attack-reporting technologies, and possibly on-board active defenses, is long overdue; and the United States must increase its capacity to recover from space attacks by investing in reserve satellites either on-orbit or on the ground, in rapid and responsive space-launch capabilities, and in redundant, preferably mobile, control stations capable of seamlessly managing space operations in case of damage to primary control centers. Above all is the need for a longer-term change in the American approach to space. Recognizing that this "final frontier" will no longer remain the sanctuary it has been, the United States must move away from reliance on a few, large, highly specialized space platforms supported by a complex but narrow ground segment—all of which are disproportionately vulnerable to enemy action and are difficult and costly to replace in case of interdiction—and shift towards smaller and flexible distributed capabilities both in space and terrestrially.

The maturation of China's space and counterspace capabilities reflects in a larger sense the challenges facing the United States as it reacts to the rise of Chinese power. How well Washington responds to this development will determine not only its future capacity to dominate the high ground but also a variety of outcomes terrestrially.