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China's Military Space Strategy

Ashley J. Tellis

In the predawn darkness of 11 January 2007, a Chinese medium-range ballistic missile lifted off from a launch site at the Xichang space facility in Sichuan province. Fired from a mobile transporter-erector-launcher, the new two-stage, solid-fuelled missile – designated the SC-19 by the US intelligence community – carried a kinetic kill vehicle that slammed several minutes later into an ageing Chinese weather satellite deployed in low Earth orbit at an altitude of some 864 kilometres. Since the satellite, the *Fengyun*-1C (FY-1C), was heading south at the time of its intercept, and since the azimuth from the interceptor launch point to the target was approximately 346°, the attack involved a virtual head-on collision at extremely high velocity with thousands of blast fragments ejected at speeds of up to some 2,253km per hour into various orbits ranging from 3,800km to 200km in altitude.[1] As of 30 May 2007, over 1,736 objects of trackable debris, each at least 10cm in diameter, had been catalogued and monitored. And NASA's Orbital Debris Program Office has estimated that the explosion produced more than 35,000 shards larger than 1cm, justifying the judgement that this test was undoubtedly the 'worst single debris event ever'[2] since it instantaneously produced a 10% increase in the 50-year total of space artefacts capable of threatening spacecraft flying in low Earth orbits.[3]

This stunning demonstration of anti-satellite (ASAT) capabilities was remarkable for other reasons. To begin with, although the event occurred 'under testing conditions that [China] controlled',[4] there is no evidence that Chinese space managers manipulated the flight parameters of the satellite in any way prior to the mission to render it an easier target; rather, the attack was executed on a spacecraft that was flying as fast – 7.42km per second – as an intercontinental ballistic missile re-entering the atmosphere.[5] Further, the satellite's destruction

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involved the employment of a unitary hit-to-kill payload. This technology – 'intercepting a bullet with a bullet' – demonstrates that China has surpassed the erstwhile Soviet Union, which in its heyday could do little beyond attempting to kill its targets by spraying them with shrapnel from a conventional fragmenting warhead.[6] Finally, the satellite intercept occurred along the ascent trajectory of the offensive missile's flight. This means the overall guidance and control systems as well as the kinetic kill vehicle's own terminal sensors were so accurate that Chinese engineers could forgo the option of exploiting the booster's descent trajectory to give the kill vehicle more time both to observe the target satellite and to manoeuvre as necessary.[7]

The dramatic technological advances Beijing revealed through this test, however, were not immediately reported in either the Chinese or the international media. But the intelligence community in the United States, and likely elsewhere, was fully aware of what had happened, and its significance. As *Aviation Week & Space Technology* later reported,

> U.S. intelligence agencies calculated in advance that the Chinese were ready for the [intercept] and programmed American eavesdropping and space tracking sensors accordingly to obtain maximum information … U.S. Air Force Defense Support Program missile warning satellites in geosynchronous orbit detected the Xichang launch of the ASAT kill vehicle, and U.S. Air Force Space Command radars monitored the FY-1C orbit both before and after the [intercept].[8]

US policymakers, too, were aware of the preparations leading up to the test as well as its successful outcome but, after considerable internal deliberations, chose to keep silent.[9] A week later, when an American scholar, Jerry Lewis, and *Aviation Week & Space Technology* finally broke the story almost simultaneously, the Chinese government responded with a mixture of confusion and denial. Even as it reiterated China's long-standing opposition to the 'weaponisation of space', the Chinese Foreign Ministry declined to either confirm or deny the test. The Defence Ministry, too, claimed to be unaware of the event, insisting that foreign accounts were little other than 'hearsay'.[10] After bobbing and weaving for almost two weeks, an official spokesman finally confirmed that China had successfully tested a new anti-satellite weapon, but wanly and unconvincingly declared that this demonstration 'was not directed at any country and does not constitute a threat'.[11]

Several analysts speculated that this delayed and reluctant admission might indicate that few Chinese leaders outside the military had known about the test

and that its destabilising implications might have escaped their attention, if it was in fact authorised at the highest levels of the government. As Bates Gill and Martin Kleiber summarised this view,

> Put bluntly, Beijing's right hand may not have known what its left hand was doing. The People's Liberation Army (PLA) and its strategic rocket forces most likely proceeded with the ASAT testing program without consulting other key parts of the Chinese security and foreign policy bureaucracy—at least not those parts with which most foreigners are familiar. This may be a more troubling prospect than anything the test might have revealed about China's military ambitions or arms control objectives.[12]

Such speculation inadvertently received a fillip from the reported remarks of US National Security Adviser Stephen J. Hadley, who suggested in an interview with *The New York Times* that senior Chinese leaders may not have been fully aware of the military's plans regarding the test. As Hadley mused, 'the question on something like this is, at what level in the Chinese government are people witting, and have they approved?'[13]

While confusion, disjointedness and dissembling in Beijing's early official responses to US revelations of its anti-satellite test suggest that the Chinese Foreign Ministry was uninformed and certainly was unprepared for the global outcry that greeted this event, the suggestion that the civilian leadership – at the level of the chairman of the Central Military Commission in China – might have been completely unaware of the anti-satellite testing programme is unpersuasive.[14] Although it is possible that senior Chinese leaders did not know beforehand that the test was slated to occur on that particular date, they have certainly authorised the People's Liberation Army's larger investments in anti-access and battlespace-denial capabilities and, most likely, the space-denial components of that programme in particular. Active field testing of different kinds of anti-satellite weapon has been underway in China for several years; in fact, as early as 2003, the Pentagon's annual report on Chinese military power publicly disclosed that China was developing a 'direct-ascent ASAT system' that could be fielded sometime between 2005 and 2010 and, furthermore, such direct-attack weapons were only one element of the larger spectrum of offensive capabilities aimed at vitiating American dominance in space.[15] Even more significantly, the successful 11 January 2007, test was merely the latest in a line of previous efforts: as American officials have now indicated, China had in fact conducted three previous anti-satellite tests between September 2004 and February 2006, all of which failed for one reason or another.[16]

To assert in the face of this evidence that the Chinese civilian leadership could have been wholly unaware of the army's anti-satellite weapons programme would be tantamount to claiming that the Chinese armed forces have been conducting a major military research and development effort – with grave international implications – without the authorisation of, and perhaps even in opposition to, the Standing Committee of the Politburo of the Chinese Communist Party. Such a contention would undercut much of what is known about party–military relations in China and would be difficult to uphold against a weaker alternative explanation, perhaps grounded in bureaucratic politics.[17] And it would certainly be peculiar, given that the resource allocations associated with China's diverse counterspace activities are considerable and that these initiatives have been part of the public record in the West, and hence knowable to the civilian leadership in Beijing, for at least a decade. Finally, and most importantly, the inference that the military might be pursuing a covert counterspace programme unauthorised by the civilian leadership is incredible precisely because the effort is consistent with the other sophisticated anti-access and battlespace-denial programmes that *have* been authorised and have been underway for several years.[18]

The brute reality of these anti-access and battlespace-denial programmes undermines the notion advanced by other commentators that the Chinese anti-satellite test was, in Michael Krepon's words, 'a predictable – and unfortunate – response to U.S. space policies'.[19] This explanation asserts that Beijing's decision to display its emerging counterspace capabilities owes less to blundering or malevolent internal bureaucratic politics and more to the long-standing American opposition toward negotiating a space arms-control regime. By declining to negotiate an agreement governing the 'peaceful' uses of space, the United States may have compelled China's leaders to conclude 'that only a display of Beijing's power to launch … an arms race would bring Washington to the table to hear their concerns'.[20] In other words, the Chinese anti-satellite test was a *cri de coeur* designed to force a recalcitrant Washington to reverse the positions articulated in its National Space Policy and move with alacrity to arrest the creeping weaponisation of space.[21]

There is no arms-control solution to this problem

Concerns about an arms race in space ought to be taken seriously, as a threat to both American and global security, but there is, unfortunately, no arms-control solution to this problem. China's pursuit of counterspace capabilities is not driven fundamentally by a desire to protest American space policies, and those of the George W. Bush administration in particular, but is part of a considered

strategy designed to counter the overall military capability of the United States, grounded in Beijing's military weakness at a time when China considers war with the United States to be possible. The weapons China seeks to blunt through its emerging space-denial capability are not based in space: they are US naval and air forces that operate in China's immediate or extended vicinity. What are in space are the sensory organs, which find and fix targets for these forces, and the nervous system, which connects the combatant elements and permits them to operate cohesively. These assets permit American forces to detect and identify different kinds of targets; exchange vast and diverse militarily relevant information and data streams; and contribute to the success of combat operations by providing everything from meteorological assessment, through navigation and guidance, to different platforms, weapon systems, and early warning and situational awareness.

There is simply no way to ban or control the use of space for such military purposes. Beijing's diplomats, who repeatedly call for negotiations to assure the peaceful use of space, clearly understand this. And the Chinese military appreciates better than most that its best chance of countering the massive conventional superiority of the United States lies in an ability to attack the relatively vulnerable eyes, ears and voice of American power. The lure of undermining America's warfighting strengths in this way prompts Beijing to systematically pursue a variety of counterspace programmes even as it persists in histrionic calls for the demilitarisation of space.[22] China's Janus-faced policy suggests it is driven less by bureaucratic accident or policy confusion than by a compelling and well-founded strategic judgement about how to counter the military superiority of its opponents, especially the United States.

The strategic logic of Chinese counterspace efforts

Beijing's investments in counterspace technology are driven by uncompromisable strategic concerns. In the near term, Beijing focuses on developing all possible means of defeating the superior US conventional forces it expects to encounter in any war over Taiwan.[23] Over the longer term, China is preparing for prospective geopolitical rivalry with the United States.[24] This is most likely to arise from the pressures associated with power transitions in an 'anarchic' international system. Anticipatory moves by China should therefore not be surprising, since, as Michael R. Chambers has astutely observed,

> Beijing is clearly worried about a hegemonic and unilateral United States … This is because the United States, as the 'lone superpower' in the world today, is the sole country with the military and economic wherewithal to

Table 1. **US Space Systems and Chinese Attack Options for Various Missions**

	Communications	**Early warning and nuclear detection**	**Intelligence, surveillance and reconnaissance**	**Meteorology**	**Navigation and guidance**	**Remote sensing**
Representative US space systems **[orbits]**	Defense Satellite Communications System (DSCS) [GEO] Air Force Satellite Communications (AFSATCOM) and Fleet Satellite Communications (FLTSATCOM) [GEO] Military Strategic Relay Satellite System (MILSTAR) [GEO]	Defense Support Program (DSP) [GEO] Space-Based Infrared System-High (SBIRS-H) [GEO/HEO] Space-Based Infrared System-Low (SBIRS-L) [LEO]	Electro-Optical Imaging Satellites [LEO] Infrared Imaging Satellites [LEO] Synthetic Aperture Radar Imaging Satellites [LEO] Signals Intelligence Satellites [GEO]	Defense Meteorological Satellite Program (DMSP) [LEO] Geostationary Operational Environmental Satellite (GOES) [GEO]	NAVSTAR Global Positioning System (GPS) [MEO]	LANDSAT [LEO]
Feasible Chinese attack options in the near and medium term	Electronic attack Ground attack	Direct ascent attack [LEO] Ground attack	Direct ascent attack [LEO] Directed energy weapons [LEO] Ground attack	Direct ascent attack [LEO] Ground attack	Electronic attack Ground attack	Direct ascent attack Ground attack Directed energy weapons
Feasible Chinese attack options in the long term	Direct ascent attack Co-orbital attack Directed energy weapons	Direct ascent attack Co-orbital attack Directed energy weapons	Direct ascent attack [GEO] Co-orbital attack	Direct ascent attack Co-orbital attack Directed energy weapons	Direct ascent attack Co-orbital attack Directed energy weapons	Co-orbital attack

> thwart China's rise to great power status not only within the Asia-Pacific region but also globally. Based on American political, economic, and military influence, it is feared that Washington might attempt to contain the [People's Republic of China's] rise, particularly through strategically encircling it.[25]

To prepare prudently for such a possibility as growing economic strength moves it closer to the core of the global political order, Beijing needs a comprehensive security strategy encompassing everything from protecting the homeland and its peripheries, the governing regime, and the prospects for sustained economic growth to safeguarding China's exterior and interior lines of communication and its access to foreign raw materials and energy resources, and managing myriad internal development and security challenges as well as non-traditional threats such as depleting water resources and environmental degradation.[26] The specifically military component of this strategy, however, requires the capacity to:

- control the areas adjacent to its terrestrial and maritime borders to prevent American standoff attacks on the Chinese heartland;
- protect its evolving nuclear deterrent from neutralisation by current and emerging US theatre and national missile defence systems; and
- construct a regional system that prevents its local adversaries from challenging China under the cover of American protection, while simultaneously enabling Beijing to shape the political choices made by the major states located along its frontiers.[27]

While the near-term objective of preventing Taiwanese 'secession' from the mainland – and defeating any US expeditionary forces that might be committed in support of the island – remains the dominant consideration underlying Chinese military development, acquisition and integration goals, the capabilities thus obtained are intended to mutate gracefully into servicing other, more ambitious geostrategic aims as China's economic power increases over time. As David Shambaugh has persuasively argued, 'China's military modernization cannot be explained by Taiwan contingencies alone',[28] but is driven by a congeries of factors that includes the desire to become a consequential global power; cope with regional security threats; respond to the American military presence around its periphery; and secure the critical access routes to its energy supplies.

For the moment, these near- and long-term objectives converge admirably, in that they require Beijing to develop all the military resources necessary 'to implement an area-denial maritime strategy in China's littoral areas'.[29] This strategy aims to, first, prevent superior US forces from entering the relevant theatre of operations and then, should that prove more or less unsuccessful, restrict their freedom to operate. Whether the theatre of action is a limited geographic area like the region immediately around Taiwan or a wider expanse like the western Pacific, the tasks facing the Chinese military remain the same.[30]

Since China is confronted by formidable American military superiority, any effort to defeat the United States through an orthodox force-on-force encounter, centred on simple attrition, is doomed to a sorry end. Ever since the dramatic demonstration of American prowess in *Operation Desert Storm* in 1991, Chinese strategists have struggled to find ways of overcoming US conventional might.[31] Drawing on China's indigenous military tradition, which emphasises stealth, deception and indirect approaches to warfare, and opportunities offered by emerging technologies, which enable effective asymmetric strategies focused on attacking an adversary's weaknesses, the Chinese military has concentrated on developing a wide range of material and non-material capabilities that would make 'defeating the superior with the inferior' possible.[32] After a decade of carefully assessing the sources of potency and frailty in American capabilities, Chinese planners concluded, in Michael Pillsbury's apposite formulation, that 'U.S. military forces, while dangerous at present, *are* vulnerable – and can be defeated by China with the right strategy'.[33]

Among many complex and diverse lessons, Chinese analyses of US military operations in the Persian Gulf wars, Kosovo and Afghanistan have yielded one critical insight: the United States is inordinately dependent on its complex but exposed network of sophisticated command, control, communications and computer-based intelligence, surveillance and reconnaissance systems operating synergistically in and through space.[34] In other words, while American military power derives its disproportionate efficacy from its ability to leverage critical space assets, these very resources are simultaneously a font of deep and abiding vulnerability. Chinese strategists concluded, therefore, that any effort to defeat the United States would require a riposte against its Achilles heel: its space-based capabilities and their organic ground installations.[35] The ability to neutralise American space systems quickly would permit a weaker Chinese military to deter, delay, degrade or defeat the superior warfighting capabilities of the United States and 'level the playing field' in a shooting war. As one Chinese military scholar described his country's calculus,

> An effective active defense against a formidable power in space may require China to have an asymmetric capability against the powerful United States. Some have wondered whether a defensive policy applied to space suggests that China's possession of a robust reconnaissance, tracking, and monitoring space system would be sufficient for China to prevent an attack in space and would be in line with China's 'doctrinal' position of 'defensive' capabilities. An effective active defense strategy would include the development of these systems but would also include anti-satellite capabilities and space attack weapon systems if necessary. In essence, China will follow the same principles for space militarization and space weapons as it did with nuclear weapons. That is, it will develop anti-satellite and space weapons capable of effectively taking out an enemy's space system, in order to constitute a reliable and credible defense strategy.[36]

Another analyst, Wang Hucheng, puts it more succinctly: American dependence on space constitutes 'the U.S. military's "soft ribs" and strategic weaknesses'; consequently, 'for countries that can never win a war with the United States by using the method of tanks and planes, attacking the U.S. space system may be an irresistible and most tempting choice. Part of the reason is that the Pentagon is greatly dependent on space for [the success of] its military action.'[37]

The implications are devastating for arms-control theorists who believe that Chinese counterspace investments are primarily bargaining chips aimed at creating a peaceful space regime. In fact, they are the opposite. For China to give up its emerging counterspace capabilities, whether through unilateral abnegation or a negotiated arrangement, would be to condemn its armed forces to inevitable defeat in any encounter with American power. This would mean, among other things, risking the 'loss' of Taiwan, with all the attendant consequences for the unity of China and the survival of the Communist leadership. Inability to successfully stave off American forward operating forces in the western Pacific, assure the ability of Chinese nuclear forces to penetrate emerging US strategic defences; and sustain a buffer zone along its peripheries also implies the eventual demise of any hope of being able to defend its interests against the United States in the larger global context. Because these goals are so critical to China as a rising power, and are relatively conservative from Beijing's point of view, China cannot be expected to trade away its counterspace capabilities for an arms-control regime that would further accentuate its competitors' military advantages.[38]

These goals are so critical to China as a rising power

This is why arms-control advocates are wrong even when they're right. Weaponisation of space would indeed be costly and especially dangerous to the United States, which relies most heavily on space for military superiority, economic growth and strategic stability. Space arms-control advocates are correct when they emphasise that advanced powers stand to gain disproportionately from a universal regime capable of protecting their space assets. Yet they are wrong when they believe such a regime is attainable and therefore ought to be pursued. Weaker but significant challengers such as China simply cannot permit the creation of a space sanctuary because of its consequences for their own interests. Even though a treaty protecting space assets would be beneficial collectively and particularly to Washington, its specific costs to Beijing in terms of national military strategy would be remarkably high. Not surprisingly, then, the Central Military Commission of the Chinese Communist Party has authorised counterspace programmes remarkable for their comprehensiveness and diversity.

China's counterspace programmes

Several analysts have echoed Theresa Hitchens's argument that 'there is little evidence to date that any other country … possesses both the mature technology and the intention to seriously threaten American military or commercial operations in space – and even less evidence of serious pursuit of actual space-based weapons by potentially hostile actors'.[39] However, the recent testimony of General James E. Cartwright, Commander, US Strategic Command, before the Senate Armed Services Committee suggests otherwise. Declaring that the Chinese 'have undertaken what we would call a very disciplined and comprehensive continuum of capability against space – our space capabilities', Cartwright noted that these efforts range 'all the way from [achieving] temporary and reversible effects' to permanent damage exacted 'through direct ascent ASAT … [and] eventually … co-orbital [weapons]'. Further, the lower-end capabilities, he emphasised, were 'not only demonstrated' but actually 'fielded … into their forces'. This, he concluded, 'demonstrates … that they have a very comprehensive [vision for] what they want to be able to do as a nation in their region'.[40]

This assessment is not surprising, given China's incentives to deny the United States its sanctuary in space. Close observers of Beijing's military modernisation have pointed out that recognition of technological weaknesses relative to the United States led to the creation of the 998 State Security Project—the 'Assassin's Mace' programme – to develop a series of 'trump card' weapons that would enable China to simultaneously harness advanced emerging tech-

nologies for civilian use, pursue the on-going revolution in military affairs, transform the People's Liberation Army into a fighting force capable of winning high-technology wars under modern conditions, and provide the asymmetric means by which the weak could defeat the strong. The project, established at the behest of then-President and Chairman of the Central Military Commission Jiang Zemin, was directed by a Leading Group that included Jiang and the most senior members of the Chinese Communist Party and the military.[41] Acting under the imperative, in Jiang Zemin's words, of 'enhancing the innovation in advanced national defense technology, stressing the development of military/civilian dual-use technology and mastering as quickly as possible the new *shashoujian* [assassin's mace] needed to safeguard our national sovereignty and security',[42] the 998 Project appears to have provided new focus to earlier efforts such as the 863 and Super 863 Programmes, which concentrated on developing advanced capabilities in biological warfare, space technology, information technology, laser weaponry, cybernetics and automation technology, and exotic materials, as well as to newer initiatives which aim to produce a range of new advanced capabilities in a variety of areas including aviation, missiles, space, multi-dimensional naval warfare, directed-energy systems, and electromagnetic, ultrasonic and plasma systems.[43]

The comprehensiveness of this effort, especially insofar as it is focused on space and counterspace activities, has led some observers to charge that Chinese military planners, far from merely seeking space-denial capabilities, have been pursuing significantly more ambitious objectives.[44] Mary FitzGerald, a scholar who analyses Russian and Chinese military writings for the US Department of Defense, for example, has declared forthrightly that 'for more than a decade, Chinese military strategists and aerospace scientists have been constructing a blueprint for achieving *space dominance*'.[45] This assessment concludes that the Chinese vision of space warfare involves not just denying space to its adversaries but using space for affirmative ends such as the intercept of ballistic and cruise missiles through space-based combat platforms; strikes by space systems on terrestrial targets; and attacks by land, air, sea, aerospace and space vehicles on an adversary's space platforms and space-based command and control assets and their associated terrestrial nodes.[46]

That, at any rate, seems to be the direction in which recent Chinese *theorising* on space warfare appears to be moving. As Senior Colonel Yao Yunzhu, one of the Chinese military's most thoughtful officers on nuclear and strategic issues, recently stated at a World Economy Forum dinner, 'My wish is we really want to keep space as a peaceful place for human beings ... But personally, I'm pessimistic about it ... My prediction: Outer space is going to be weaponized

in our lifetime'.[47] Consistent with these expectations, Chinese military writings emphasise the need for dedicated space forces and for advanced space weapons and support capabilities designed to prosecute the full spectrum of 'space safeguard', 'space support' and '[space] attack' operations.[48] Simultaneously, military theorists appear to be developing the legal foundations for such warfare: reflecting on how to extend the laws of war to space and beginning to develop legal theories that would justify treating the spacecraft, satellites and space stations of an adversary as acceptable targets in much the same way as naval and maritime assets on the high seas. Treating space as another domain of the global commons in which warfare is permitted, then, enables China to conceptualise it as the ultimate high ground which must be dominated in order to secure favourable political outcomes terrestrially.[49]

Much of the current Chinese writing on this subject is still purely aspirational, yet is important insofar as it provides a leading indicator of what the Chinese consider significant and worthy of research and development investment. But Beijing has been pursuing a diverse and comprehensive portfolio of space warfare investments since at least the late 1980s. The status of these concrete programmes runs from advanced concept development and testing, through product engineering evaluation, line-level manufacturing and acquisition from foreign sources, to integration as warfighting capabilities into the Chinese armed forces. The evidence suggests these programmes are protean: they lend themselves to steady evolution across the spectrum from space denial to space dominance if Beijing's political goals change over time, though at present and for the foreseeable future they are optimised for the space-denial mission.[50]

Beijing has pursued a diverse portfolio of space warfare investments

Space object surveillance and identification

Nullifying American space systems, either kinetically or by denying them the information they seek to obtain or transmit, requires that an adversary first know the capabilities of the platform it seeks to defeat, its orbital parameters and its spatial relationship to other orbiting bodies.[51] The importance of such information for space-denial or counterspace operations is self-evident, but its significance for camouflage, concealment and deception activities goes beyond the demands of space warfare narrowly understood. Beijing's interest in space-awareness capabilities is intimately linked with, in particular, denying the United States the targeting data that would enable it to interdict China's land-based

strategic nuclear platforms and key elements of its conventional forces.[52] The former are relatively few in number and rely on secrecy, mobility and limited redundancy rather than on huge inventories, hardened overt deployment sites or active interdiction of attacking weapons for their survival. Accurate information about US and third-party space reconnaissance assets and over-flight patterns would permit Chinese commanders to issue the appropriate notifications to their field components in regard to movement and dispersal operations, which would be timed to occur outside the window of observation.[53]

Given the importance of space awareness for military operations, Chinese planners have been developing and maintaining an increasingly comprehensive catalogue of relevant space objects.[54] This effort has been aided by the vast amount of information on US space systems openly available through astronomy societies, international regulatory organisations and universities, in addition to covert intelligence gathering. Moreover, a variety of technical investments to detect and track orbital bodies passing over China have been made in recent years, including specialised optical telescopes and theodolites, laser satellite-tracking devices such as rangefinders, large phased-array radars, various ground- and space-based signals intelligence systems, and radars associated with surface-to-air missile systems, all of which are capable of searching, acquiring, tracking and classifying objects of interest to Chinese strategic planners.[55] The US Department of Defense declared as early as 2002 that 'China probably has a thorough knowledge of U.S. and foreign space operations, based, in part, on access to open-source information on U.S. space systems and space operations'.[56]

Direct attack weapons

Although the 11 January test should lay to rest any claim that 'there is no explicit evidence of a concerted ASAT program in China',[57] such direct ascent-weapons represent only one facet of the Chinese counterspace programme. Direct-ascent weapons are particularly effective against satellites in low Earth orbit, where most of America's remote-sensing, meteorological and electro-optical, infrared and radar-intelligence satellites, and their associated relays, currently operate.[58] A missile-borne direct-ascent weapon of the kind China tested in January 2007 would, therefore, be able to interdict any such satellite whose orbital track passed over the Chinese mainland so long as its position and velocity were known.

Direct-ascent systems can be equally devastating, provided the attacker has a sufficiently powerful booster, against spacecraft in medium Earth orbit and geosynchronous orbit. This is where US navigation and guidance satellites, military communications platforms and early-warning and nuclear-detonation detec-

tion systems currently operate. Several Chinese launch vehicles, and ballistic missiles like the new DF-31 ICBM, could easily carry an anti-satellite payload to geosynchronous orbit, where the stationary location of targets makes them relatively easy prey. Since the current generation of Chinese civilian rockets consists of extremely large, comparatively fragile and fairly immobile boosters, it is most likely that the military would use its new longer-range ballistic missiles, with their inherent robustness, mobility and responsiveness, for direct-ascent anti-satellite missions above low Earth orbit. It is not unreasonable to expect such dedicated capabilities in the future, particularly since no further 'hot' tests would be necessary if Chinese engineers simply marry their existing and proven kinetic kill vehicle to a more powerful rocket. Geoffery Forden, an analyst at the Massachusetts Institute of Technology, has already concluded that the payload used to intercept the FY-1C 'could be used to destroy geostationary satellites in a direct ascent mode'.[59]

China has also embarked on a programme to develop a co-orbital anti-satellite interceptor, launched from Earth into a temporary parking orbit from which it then manoeuvres to attack its specific target.[60] Co-orbital anti-satellite systems can deploy at low or high altitudes and can passively operate in their pre-attack phase for short or long durations. Such a capability would give the Chinese military three significant benefits: it would allow attacks on spacecraft whose orbital tracks might not normally traverse the Chinese mainland; it would provide a covert 'sleeper' space attack option that could unfold over a period ranging from hours to days to months, unlike direct-ascent systems whose operations are overt and conclude in a matter of minutes; and it would provide insurance for anti-satellite attack options in the event direct-ascent systems were destroyed early in a conflict. There is evidence of Chinese interest in various predatory systems for the co-orbital mission, but their emerging capabilities in the realm of agile micro- and nano-satellites are most problematic from an American perspective.[61] Such satellites can be launched quickly by small mobile boosters, or covertly as secondary payloads on large boosters committed to what are otherwise peaceful space missions. Once in orbit, micro- and nano-satellites are extremely difficult to detect and track, lending them splendidly to co-orbital anti-satellite missions.[62]

Finally, US military planners worry about non-directional attacks involving nuclear explosions in space.[63] A high-altitude nuclear detonation affects the ground segment of a space system by generating an electromagnetic pulse that rapidly degrades and permanently damages unprotected electrical systems within its range. It can also have a devastating effect on all kinds of spacecraft: satellites in line of sight of the explosion could be destroyed immediately, as

direct radiation damages their electronics or key components. Satellites outside line of sight would also be susceptible to damage because excitation of the Earth's Van Allen radiation belts would result in an increase in the ambient electron flux levels, reducing spacecraft life. The radiation released from a single high-yield nuclear weapon detonated in low Earth orbit, for example, would destroy every satellite at that altitude over a few weeks to a few months. In the interim, many of these spacecraft could cease operating entirely.[64] Chinese capabilities and intentions in this regard have been a subject of great speculation in the analytical community.[65] There is little doubt that Beijing is technically capable of prosecuting such operations, but it is unlikely to do so except in extreme conditions because of the indiscriminate effects of such attacks, including the consequences for China's own space systems. Anti-satellite operations involving high-altitude nuclear explosions thus truly represent a counterspace 'Samson option'. They might be justified on the grounds that they produce no direct casualties, but their serious consequences suggest that they would most likely occur along the pathway to a general all-out war, possibly involving wider use of nuclear weapons.

Directed-energy weapons

As part of a larger effort to develop 'new concept weapons',[66] China has devoted considerable resources to directed-energy systems, particularly ground-based high- and low-energy lasers, for counterspace purposes. Other technologies that have been discussed in China for such missions include radiofrequency weapons, high-power microwave weapons, electromagnetic railguns and particle-beam systems. Unlike these more exotic technologies, however, China's laser programme is mature and its domestic research and development efforts, which have focused on developing different kinds of chemical and solid-state lasers, associated optical systems, and beam directors and other control elements, have long been recognised as world class. Public reports have repeatedly identified the Dalian Institute of Chemistry and Physics, the Southwest Institute of Fluid Physics, the Shanghai Institute of Optics and Fine Mechanics, the Anhui Institute of Optics and Fine Mechanics, the Institute of Optoelectronics, the Institute of Applied Physics and Computational Mathematics, the China Academy of Engineering Physics and the Northwest Nuclear Weapons Research and Design Academy as being at the forefront of laser research and development, adaptive optics and theoretical modelling of atmospheric effects for ground-based laser weapons.[67]

Ground-based lasers are particularly attractive counterspace weapons because they give an attacker the flexibility to cause varying levels of damage.

A low-power laser, for example, could be used to temporarily blind or, under some conditions, damage an imaging intelligence collector by over-saturating the receptors on the focal plane of its electro-optical or infrared sensors. For such attacks to be effective, however, the laser must be located within the sensor's field of view and its wavelength must lie within the sensor's pass band. Appropriate intercept geometry thus becomes critical when an attacker seeks to dazzle or damage the sensor rather than physically destroy the satellite.[68] A high-power laser, on the other hand, is not limited by the elements of intercept geometry that matter in the case of sensor dazzling. Such systems could be used to inflict structural damage on a spacecraft by irradiating it with sufficient persistent energy to cause catastrophic failures to key subsystems like power generation, thermal management and communications. Inflicting such 'out-of-band' damage merely requires the target satellite to pass within the broader arc of reach of the attacking laser system, which for all practical purposes means in proximity to the ground-based laser complex. Satellites in any orbit could be attacked by ground-based lasers, though the power required would vary with the altitude of the spacecraft, on the assumption that beam quality, the aperture of the director, and atmospheric distortion effects are not at issue.[69] China is known to have lased US reconnaissance satellites, and its capability to inflict damage will only grow over the next decade.[70]

Electronic attack

Chinese military planners have concentrated on electronic attack methods to stymie critical US space assets located in medium, geosynchronous and eccentric Earth orbits where these other technologies are less effective. The most important targets are the tactical communications platforms in geosynchronous orbit and the Global Positioning System (GPS) constellation in medium Earth orbit.[71] The latter provides location and timing data to diverse military operators and enables precise weapon system employment, targeting and terminal guidance. China's emphasis on electronic attack in the case of such platforms is not simply a function of their orbital altitude, because many of China's current direct-attack systems could reach distant orbits without great difficulty if dedicated to that purpose. It is more likely that cost and mission effectiveness as well as political considerations have driven Chinese planners towards electronic attack methods in such instances.

To begin with, the number of spacecraft in the tactical communications and navigation and positioning constellations is relatively large. The US military, for example, uses at least five separate dedicated satellite constellations for its defence connectivity needs, each with several primary platforms and associ-

ated relays.[72] In recent years, American dependence on allied, commercial and civilian space satellites for military communications has also increased tremendously, confronting Chinese planners with a plethora of targets that must be neutralised to comprehensively disrupt the tactical communications of their potential adversary.[73] Because the US tactical military communications network is highly diversified, with numerous alternative and redundant channels of connectivity, the most effective option for a Chinese military strategist is not discrete anti-satellite attacks but large-scale 'sky clearing' operations. Such actions would of necessity embroil the People's Republic of China not merely in a war with the United States, but with the entire international community, and are unlikely to be the military option of first resort.

American dependence on space satellites has increased tremendously

A similar situation obtains with regard to physically neutralising the global positioning system constellation. The precision navigation and timing data provided by this system are vital for military and civilian purposes worldwide. Both rely on the system for accurate location information, but military users also depend on it for accurate weapons delivery, synchronisation of operations requiring precise coordination, and successful search and rescue. Highly accurate three-dimensional location information requires four or more satellites to be within the field of view of the receiver. Since the global positioning system constellation comprises 24 spacecraft (plus spares) at 20,000km, where it takes each satellite 12 hours to complete one orbit, at any given time there are usually 5–12 satellites in view of most users, depending on topography. Physically destroying the constellation to deny the US military the precision navigation and timing data it has come to rely on would, therefore, require more than discrete attacks on a few satellites. Even more substantial attacks would only deny navigation and timing data for a part of the day.[74]

The United States could, albeit painfully, compensate for spacecraft losses by either changing the orbits of the surviving satellites, or by relying on other positioning constellations, such as those operated by the Russians or eventually the Europeans, or by minimising the use of coordinate-seeking weapons in favour of other precision systems. Any loss of capabilities that compelled the United States to rely on such alternatives would no doubt be extremely costly in military terms, but it would not be pain free for China either: it would make Beijing the object of international opprobrium and would increase the prospect of American escalation, both of which China would presumably want to avoid.[75]

China's current research, development and acquisition programmes therefore seek to neutralise the space-based US tactical communications and global positioning constellations not by physical attacks but by a 'denial of service' approach. This has the advantage of avoiding larger conflicts with the international community while promising to impede the US military's ability to communicate tactically and secure precision navigation and timing data effectively. Chinese tacticians have focused their efforts on neutralising the uplinks and downlinks (and, possibly, even the crosslinks) of these space-based systems through diverse forms of electronic attack.[76] Tactical communications and navigation systems dominate the UHF band that provides the backbone for military operations. Beijing has relentlessly focused on acquiring sophisticated jamming technologies operating in this band that would permit it, firstly, to enforce information blackouts at critical moments and, secondly, to prevent US global positioning system receivers from acquiring or reacquiring the data stream.[77] Electronic attack is a transitory yet potent form of 'mission kill' that Chinese military planners seem determined to exploit in instances where counterspace 'hard kill' capabilities appear disadvantageous or beyond reach.

Ground attack

Perhaps the easiest form of counterspace operation consists not of exotic attacks on space systems but rather mundane physical assaults on the ground segments associated with telemetry and control; data reception, analysis and distribution; and assembly and launch facilities. Since these nodes are usually fixed, identifiable and vulnerable to a range of instruments from computer network penetration to physical interdiction, it is not surprising that Chinese military theorists consider kinetic and non-kinetic attacks on ground installations to be a particularly effective form of space denial.[78] Given that many of the important ground elements associated with US military space, especially the situational awareness and satellite control network components, are located outside the continental United States, on allied territories or isolated islands, they are particularly inviting targets for China's highly accurate late-generation conventional ballistic and cruise missiles.[79]

The unpredictability of escalation will weigh heavily on Chinese military planners

Kinetic attacks using these instruments, other general-purpose military forces, or unconventional delivery methods, especially on space-related sites in the East Asian and Indian Ocean regions, do not have the same escalatory risk as attacks on the US heartland and must at least be anticipated in any putative

Sino-American conflict over Taiwan. Because the unpredictability of escalation will weigh heavily on the minds of Chinese military planners, however, it is likely they would seek to avoid such attacks to the maximum extent possible. The most probable method would be computer network and electronic attacks on *all* elements of the US space system, whether within the continental United States or overseas. The US Department of Defense has already asserted that 'the PLA is … building capabilities for information warfare, computer network operations [CNO], and electronic warfare, all of which could be used in preemptive attacks'.[80] It further notes that

> China's CNO concepts include computer network attack, computer network defense, and computer network exploitation. The PLA sees CNO as critical to achieving 'electromagnetic dominance' early in a conflict. Although there is no evidence of a formal Chinese CNO doctrine, PLA theorists have coined the term 'Integrated Network Electronic Warfare' to prescribe the use of electronic warfare, CNO, and kinetic strikes to disrupt battlefield network information systems. The PLA has established information warfare units to develop viruses to attack enemy computer systems and networks, and tactics and measures to protect friendly computer systems and networks. In 2005, the PLA began to incorporate offensive CNO into its exercises, primarily in first strikes against enemy networks.[81]

The US intelligence community tends to be sanguine that the most secure American communication and data-exchange networks are immune to penetration by attacks of the kind commonly mounted by individual Chinese hackers or patriotic collectives.[82] This is likely true today. Yet it is equally certain that, as China's current investments in information warfare bear fruit, Beijing's capacity to develop customised penetration tools to infiltrate the presently secure American networks, perhaps aided by insider elements, will only increase.[83] This avenue of attack on the ground elements of America's space system poses the greatest potential risk, even as Beijing's capabilities for executing precise kinetic strikes on this segment also expand.

Implications

China is by no means certain to wrest control of space during any future war with the United States. These programmes, 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. China's recent anti-satellite test is not an anomaly, however, but an exemplar of a wide-ranging endeavour to develop multiple warfighting instruments to constrain America's ability to exploit space to produce a rapid and decisive terrestrial military victory over China. When viewed in their entirety, these programmes reveal China's counterspace investments to be diverse, comprehensive, rapidly improving and deadly serious, exceeding even those of the Soviet Union at its peak. They should leave no doubt that Beijing is determined to negate as far as is possible the operational advantages that accrue from Washington's space-enabled conventional military dominance. Although the strategic consequences of China's emerging counterspace capabilities will only be appreciated over time, as current programmes succeed or fail in warfighting terms, three important policy repercussions stand out immediately.

Firstly, the history and focus of Chinese investments in counterspace technologies clearly indicate that they are rooted in strategic necessity and not capricious state choices. A programme of such complexity, employing the resources and personnel of some of China's best scientific institutions and state enterprises, cannot be rationalised as the unintended product of either bureaucratic politics or inefficient state planning. When all is said and done, the United States, and its superior military power, remains the biggest objective constraint on China's ability to secure its own political interests, whether related to immediate concerns over Taiwan or more remote challenges of constructing a Sinocentric order in Asia and perhaps globally. It should not be surprising that Chinese leaders, who have demonstrated a remarkable capacity for strategic rationality since at least Deng Xiaoping, if not earlier, have tasked their military forces to develop means to defeat the power-projection capabilities of the United States, and thereby protect their national interests.

Given that the effectiveness of the American warfighting machine depends heavily on its superior space capabilities, which include assets that are both highly sophisticated and relatively defenceless, preparing to attack these nodes is, from Beijing's point of view, an operationally optimum solution and the acme of good strategy. In this light, the administration ought to treat cautiously admonitions like Congressman Edward Markey's that Bush move urgently to guarantee the protection of American space assets 'by initiating an international agreement to ban the development, testing, and deployment of space weapons and anti-satellite systems'.[84] Although well intentioned, such recommendations are illusory, because China, its rhetoric notwithstanding, will not conclude a space-control agreement that eliminates the best chance it may have of asymmetrically defeating American military power.

Beijing's attitude to space arms control will change only when one or more of the following conditions are met:

- China acquires the capacity to defeat the United States despite America's privileged access to space.
- The investments in Chinese counterspace begin to yield diminishing returns because the United States consistently nullifies these capabilities through superior technology and operational practices.
- China's own strategic and economic dependence on space intensifies to the point where the threats posed by any American offensive counterspace programmes exceed the benefits accruing to Beijing's own comparable efforts.
- Sino-American rivalry disappears entirely and the risks of war between China and the United States (or any other conventionally superior military power) approaches zero.

Because none of these conditions will be realised any time soon, Washington should not invest time, energy and resources in attempting to negotiate space-control arrangements of the kind advocated by Markey and others. Such regimes are destined to be stillborn because the larger strategic logic conspires against them. This does not imply that the United States should not discuss space security with China and others. Far from it: Washington should seek a better understanding of China's intentions and the details of its counterspace programmes through conversations with Beijing. It should also encourage other spacefaring nations in Asia – Russia, Japan and India – and elsewhere whose space assets are also at risk because of China's evolving counterspace capabilities to enter into a dialogue with Beijing about its strategic direction. If the United States is ambitious, it could even contemplate negotiating informal 'rules of the road' or 'codes of conduct' governing activities in space, but these mechanisms ought to be appreciated for what they are.[85] They are, and will always be, primarily confidence-building measures, not verifiable agreements that would in any way limit China's evolving space warfare programmes.

The US might negotiate 'rules of the road' for space

Even if all sides invested in the endeavour, however, it is not at all clear that a meaningful space arms-control agreement could be consummated. As Cold War experience suggests, any global attempt to ban the development and deployment of space weapons is likely to fail, first and foremost, because of the elementary problem of defining what these artefacts actually are. If US–Soviet

conversations are any indication, advanced powers like the United States are likely to affirm the position that space 'weapons' are those, and only those, which are built with destructive intent and deployed in space with the objective of attacking other space objects or terrestrial targets.[86] Weaker powers, in contrast, are likely to take the position that any space technology that has the capacity to support military operations ought to be treated and regulated as a space weapon, leading quickly to the *reductio ad absurdum* that communication satellites, intercontinental ballistic missiles, and space transportation systems, among others, ought to be considered 'space weapons'.[87] Even if all such problems of definition could be satisfactorily resolved, the challenge of verifying any space arms-control agreement involving China would be formidable and could result in an environment where the reciprocal fear of counterspace breakout led both Beijing and Washington to covertly engage in the destabilising actions they were publicly committed to abjure. As the former Under Secretary of State for Arms Control and International Security, Robert G. Joseph, argued in his remarks during the release of the Bush administration's 2006 National Space Policy, 'this is a case where no arms control is better than bad arms control'.[88]

Moreover, the successful Chinese anti-satellite test serves as a stark reminder that the US 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. Chinese space-denial programmes exceed those pursued by Moscow at the height of the Cold War in diversity, depth and comprehensiveness. Beijing's reliance on such operations to provide a prospect of military victory has no precedent in the Soviet case, given the Soviet Union's conventional capabilities and its own considerable reliance on space for the effectiveness of its strategic nuclear deterrent and conventional forces. The two superpowers then enjoyed a rough equivalence of *overall* military capabilities and could pursue 'attrition', where battlefield victory ultimately derived from how adroitly strategy, firepower and manoeuvre were combined to overwhelm the comparable resources possessed by the adversary, as opposed to 'asymmetric' military strategies. Both nations were also highly dependent on space for verifying various arms-control agreements. Neither side had an incentive to attack the other's space systems, even though both developed modest instruments for this purpose, because the costs to each individually far outweighed the benefits. Finally, when the Cold War began, the United States and the Soviet Union were full-blown peer competitors, each gradually acquiring the capacity to inflict comprehensive societal destruction upon the other. Neither country was hostage to the fears that accompany the power transition that could occur in the case of China and the United States, where both the dominant and the

rising power have good, albeit different, reasons for concern: the former because it fears incipient loss of power, standing and influence, and the latter because it fears being denied the opportunity to finally secure hegemonic status.[89]

This has led some observers, such as US Senator Jon Kyl, to conclude that the solution to redressing emerging American space vulnerabilities in the context of competition with China lies in developing, among other things, US offensive counterspace capabilities.[90] These will almost certainly be required, if for no other reason than to deter Beijing's use of anti-space weaponry and to hold at risk its own emerging assets in space, which are likely to become even more important for both economic and military purposes as China evolves into a great power.[91] Offensive American counterspace instruments serve the limited but critical purpose of raising the costs of China's evolving space-denial strategy, increasing the probability that Beijing will desist from asymmetric attacks on US space assets.

The United States must also accelerate investment against the possibility that such deterrence might fail. The kinds of solutions relevant to the defensive counterspace mission are diverse and numerous, but three elements stand out. Firstly, the United States must improve its space situational awareness to be able to comprehensively identify and assess all orbiting objects, better anticipate the sources and capacity for counterspace attacks, and effectively identify the origin of any attack. Secondly, a programme to enhance the survivability of space platforms though systems hardening, increased manoeuvrability, autonomous operations options, integrated organic attack-reporting technologies, and possibly on-board active defences, is long overdue. Thirdly, 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 centres.[92]

The 'final frontier' will no longer remain a sanctuary

Above all is the need for a longer-term change in the American approach to space. Recognising 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 specialised 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. Such investments would offer Washington the highest payoffs even in comparison to

offensive capabilities, which are more useful for deterring attacks rather than for nullifying them or remedying their consequences.[93]

Finally, the growing Chinese capability for space warfare implies that a future conflict in the Taiwan Strait would entail serious deterrence and crisis instabilities. If such a clash were to compel Beijing to attack US space systems at the beginning of a war, the very prospect of such a 'space Pearl Harbor'[94] could, in turn, provoke the United States to contemplate pre-emptive attacks or horizontal escalation on the Chinese mainland. Such outcomes would be particularly likely in a conflict in the next decade, before Washington has the opportunity to invest fully in redundant space capabilities. Already, US Strategic Command officials have publicly signalled that conventionally armed *Trident* submarine-launched ballistic missiles would be appropriate weapons for executing the prompt strikes that might become necessary in such a contingency.[95] Such attacks, even if employing only conventional warheads, on space launch sites, sensor nodes and command and control installations on the Chinese mainland could well be perceived as a precursor to an all-out war. It would be difficult for all sides to limit the intensification of such a conflict, even without the added complications of accidents and further misperception.[96]

* * *

The emergence of potent Chinese counterspace capabilities makes US military operations in Asia more risky than ever. The threat has not arisen due to a lack of a space arms-control regime, or because of the Bush administration's disinclination to negotiate an accord that bans the weaponisation of space. Rather, it is rooted entirely in China's requirement that it be able to defeat the United States in a regional conflict despite its conventional inferiority. This strategic challenge has compelled Beijing to exploit every anti-access and battlespace-denial technology potentially available. The threat posed by this Chinese effort cannot be neutralised by arms-control agreements, even though all countries stand to profit from the absence of threats to their assets in space. There is a temptation, especially in the United States, to view China's counterspace programmes in moralistic terms. This approach is undesirable and best avoided: Beijing's desire to defeat the stronger by asymmetric means is not a reflection of its deviousness, nor provoked by mendacity on the part of the United States or the Bush administration. It is grounded in the objective conditions that define the relationship between the two countries: competing political goals, likely to persist whether or not the Taiwan conflict is resolved. In such circumstances, the United States should seek, as the Bush administration's own National Space Policy declares,

to protect the 'use of outer space by all nations for peaceful purposes and for the benefit of all humanity'. But if this fundamental goal is threatened by Chinese counterspace activities aimed at American space assets, the United States has no choice but to run an offence–defence arms race, and win.

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Notes

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2 Frank Morring, Jr, 'China Asat Test Called Worst Single Debris Event Ever', *Aviation Week & Space Technology*, 11 February 2007.

3 'Chinese ASAT Test', Center for Space Standards & Innovation (CSSI), 30 May 2007, available at http://www.centerforspace.com/asat/. A satellite's orbit is the path traversed by the spacecraft around the earth. Low Earth orbits (LEO) are those extending from the Earth's surface up to an altitude of 2,000km. Since spacecraft flying below approximately 200km are likely to decay rapidly, LEO is commonly defined as between 200km and 2,000km above the Earth's surface. A medium Earth orbit (MEO), sometimes called an intermediate circular orbit (ICO), refers to the region of space around the Earth between 2,000km and 35,786km. A geosynchronous orbit (GEO) is a circular orbit 35,786km above the Earth's surface, where a spacecraft's orbital period matches the Earth's sidereal rotation. This means that a satellite in GEO returns to exactly the same place at exactly the same time each day from the point of view of an observer at a fixed location on Earth. A geostationary orbit is a special case of a geosynchronous orbit: it refers to a satellite's location that is directly above the Earth's equator with an orbital eccentricity of zero and thus appears motionless in the sky when viewed from the ground. Highly eccentric orbits, or highly elliptical orbits (HEO), are those characterised by a low-altitude perigee and a high-altitude apogee: these orbits are designed to permit satellites to enjoy long dwelling times relative to certain points of interest on Earth during their approach to and descent from apogee.

4 Shirley Kan, 'China's Anti-Satellite Weapon Test', *CRS Report for Congress*, RS22652, 23 April 2007, p. 3.

5 Geoffrey Forden, 'A Preliminary Analysis of the Chinese ASAT Test', Massachusetts Institute of Technology, no date, available at http://web.mit.edu/stgs/pdfs/A%20Preliminary%20Analysis%20of%20the%20Chinese%20ASAT%20Test%20handout.pdf, 4.

6 Clarence A. Robinson, Jr, 'Antisatellite Weaponry and Possible Defense Technologies against Killer Satellites', in Uri Ra'anan and Robert L. Pfaltzgraff, Jr (eds), *International Security Dimensions of Space* (Hamden, CT: Archon Books, 1984), pp. 70ff.

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8 Covault, 'China's Asat Test'.
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13 David E. Sanger and Joseph Kahn, 'U.S. Tries to Interpret China's Silence Over Test', *New York Times*, 21 January 2007.
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15 US Department of Defense, *Annual Report on the Military Power of the People's Republic of China [2003]* (Washington DC: DoD, 2003), p. 36.
16 Mure Dickie, Stephen Fidler and Demetri Sevastopulo, 'Satellite Kill Likely to Have Equal Impact on Terra Firma', *Financial Times*, 20 January 2007.
17 Mulvenon concludes that the most plausible explanation and one that corresponds most closely with the limited external evidence available thus far is the hypothesis that the chairman of the Central Military Commission, Hu Jintao, was aware of the programme, but did not know about the specific date of the test. In other words, Mulvenon's scenario involves a variation of bureaucratic politics rather than a claim that the PLA's space-denial programmes embody some violation of the Central Military Commission's directives relating to China's national military strategy. See Mulvenon, 'Rogue Warriors?', p. 5.
18 For a good survey of Chinese anti-access strategies and investments, see James C. Mulvenon, Murray Scot Tanner, Michael S. Chase, David Frelinger, David C. Gompert, Martin C. Libicki and Kevin L. Pollpeter, *Chinese Responses to U.S. Military Transformation and Implications for the Department of Defense* (Santa Monica, CA: RAND, 2006); Roger Cliff, Mark Burles, Michael S. Chase, Derek Eaton and Kevin L. Pollpeter, *Entering the Dragon's Lair: Chinese Antiaccess Strategies and Their Implications for the United States* (Santa Monica, CA: RAND, 2007); and Ronald O'Rourke, 'China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress', *CRS Report for Congress*, RL33153, 29 May 2007. The history of the authorisations connected with these programmes is detailed in Jason Bruzdzinski, 'Demystifying Sha Shou Jian: China's "Assassin's Mace" Concept', in Andrew Scobell and Larry Wortzel (eds), *Civil–Military Change in China: Elites, Institutions and Ideas After the 16th Party Congress* (Carlisle, PA: Strategic Studies Institute, 2004), pp. 309–64.
19 Marc Kaufman and Dafna Linzer, 'China Criticized for Anti-Satellite Missile Test', *Washington Post*, 19 January 2007.
20 Theresa Hitchens, 'U.S.-Sino Relations in Space: From "War of Words" to Cold War in Space?', *China Security*, vol. 3, no. 1, Winter 2007, p. 16.

21 The American positions that the Chinese anti-satellite test was intended to confront, in this reading, were the two principles articulated in the most recent, unclassified version of the US National Space Policy:

> The United States considers space capabilities – including the ground and space segments and supporting links – vital to its national interests. Consistent with this policy, the United States will: preserve its rights, capabilities, and freedom of action in space; dissuade or deter others from either impeding those rights or developing capabilities intended to do so; take those actions necessary to protect its space capabilities; respond to interference; and deny, if necessary, adversaries the use of space capabilities hostile to U.S. national interests;
>
> The United States will oppose the development of new legal regimes or other restrictions that seek to prohibit or limit U.S. access to or use of space. Proposed arms control agreements or restrictions must not impair the rights of the United States to conduct research, development, testing, and operations or other activities in space for U.S. national interests.

See Office of Science and Technology Policy, Executive Office of the President, The White House, *U.S. National Space Policy*, 31 August 2006, released 6 October 2006, available at http://www.globalsecurity.org/space/library/policy/national/us-space-policy_060831.htm.

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24 Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy* (Santa Monica, CA: RAND, 2000), pp. 151–241; John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York: W.W. Norton, 2001), pp. 360–402; Yong Deng, 'Hegemon on the Offensive: Chinese Perspectives on U.S. Global Strategy', *Political Science Quarterly*, vol. 116, no. 3, Fall 2001, pp. 343–65.

25 Michael R. Chambers, 'Framing the Problem: China's Threat Environment and International Obligations', in Roy Kamphausen and Andrew Scobell (eds), *Right Sizing the People's Liberation Army: Exploring the Contours of China's Military* (Carlisle, PA: Strategic Studies Institute, 2007), pp. 9–10 (forthcoming).

26 Swaine and Tellis, *Interpreting China's Grand Strategy,* pp. 97–150.

27 On the imperative of protecting the periphery to prevent standoff attacks, see *ibid.*, pp. 121–9; on protecting the Chinese nuclear deterrent against US missile defences, see Bradley Roberts, 'China', in James J. Wirtz and Jeffery A. Larsen (eds), *Rocket's Red Glare: Missile Defenses and the Future of World Politics* (Boulder, CO: Westview, 2001), pp. 183–211; and, on preserving a stable peripheral system, see

Swaine and Tellis, *Interpreting China's Grand Strategy*, pp. 9–20. A superb overview of China's national military strategy, which speaks to these core components and others, can be found in David M. Finkelstein, 'China's National Military Strategy: An Overview of the "Military Strategic Guidelines"', in Kamphausen and Scobell, *Right Sizing the People's Liberation Army*, pp. 50–122.

28 David Shambaugh, 'China's Military Modernization: Making Steady and Surprising Progress', in Ashley J. Tellis and Michael Wills (eds), *Strategic Asia 2005–06: Military Modernization in an Era of Uncertainty* (Seattle, WA: National Bureau of Asian Research, 2005), p. 69.

29 Chambers, 'Framing the Problem', p. 11.

30 For a survey of the operational-technical issues implicated in such missions, see Mulvenon et al., *Chinese Responses*; Cliff et al., *Entering the Dragon's Lair*; O'Rourke, 'China Naval Modernization'; and Andrew Krepinevich, Barry Watts and Robert Work, *Meeting the Anti-Access and Area-Denial Challenge* (Washington DC: Center for Strategic and Budgetary Assessments, 2003).

31 See the discussion in James R. Lilley and David Shambaugh (eds), *China's Military Faces the Future* (Armonk, NY: M.E. Sharpe, 1999), particularly the essays by Paul H. B. Godwin, Michael Pillsbury, Richard D. Fischer, Jr and Wendy Frieman.

32 The application of this aphorism, attributed to Sun Tzu, is explored in some detail in Michael Pillsbury (ed.), *Chinese Views of Future Warfare* (Washington DC: National Defense University Press, 1998).

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36 Bao Shixiu, 'Deterrence Revisited: Outer Space', *China Security*, vol. 3, no. 1, Winter 2007, p. 9.

37 Wang Hucheng, 'The US Military's "Soft Ribs" and Strategic Weaknesses', *Liaowang*, vol. 27, reprinted in *Xinhua Hong Kong Service*, 5 July 2000, in FBIS-CHI-2000-0705, 25 July 2000.

38 As one prominent Chinese scholar, Dingli Shen, has candidly admitted, China's anti-satellite test was undertaken 'purely for the purpose of breaking the U.S. space hegemony'. Securing this objective, even in the limited context of protecting Chinese interests regarding Taiwan, Shen argues, requires that the PLA's military operations 'cannot be confined to the Taiwan Strait, [since] all political forces and weapons platforms that might support "Taiwan independence" are obstacles to realizing our country's core interests and must be removed on our way forward'. See Dingli Shen, 'The Logic of Hegemony', published as 'Shen Dingli Rebukes Pentagon Report on PRC Military Power, Questions Its Logic', Open Source Center (CPP20070530050001) Shanghai *Jiefang Ribao (Internet Version-WWW)* in Chinese, 29 May 2007.

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40 Transcript of the testimony of General James E. Cartwright, Commander, US Strategic Command, before the Strategic Forces Subcommittee of the Senate Armed Services Committee, Russell Senate Office Building, Washington DC, 28 March 2007.

41 The best survey of 'Assassin's Mace' – and there is some debate about whether this locution refers to a unifying concept or to a specific programme – can be found in Bruzdzinski, 'Demystifying Sha Shou Jian', and in Michael Pillsbury, 'China's Military Strategy towards the U.S.: A View from Open Sources', paper prepared for the US–China Economic and Security Review Commission, 2 November 2001, available at http://www.uscc.gov/researchpapers/2000_2003/pdfs/strat.pdf.

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52 Chinese strategic nuclear forces and their relative weaknesses are surveyed in Hans M. Kristensen, Robert S. Norris and Matthew G. McKinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning* (Washington DC: The Federation of American Scientists and the Natural Resources Defense Council, 2006).

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58 Jeffrey Richelson, *The U.S. Intelligence Community* (Cambridge, MA: Ballinger Publishing Company, 1989).

59 Forden, 'A Preliminary Analysis of the Chinese ASAT Test', p. 29.

60 Cartwright, Testimony before the Strategic Forces Subcommittee.

61 Adams and France, 'The Chinese Threat to U.S. Space Superiority', p. 21.

62 As the Federation of American Sciences report on American Space Security noted, 'Although the United States has a missile launch detection capability that would almost certainly detect the launch of any rocket capable of placing a satellite in orbit, its capability to detect and track a small satellite released from such a rocket is less robust. The United States currently employs a range of optical and radar sensors for tracking objects in space. Although the US space surveillance system currently tracks over 8,000 objects in orbit, the lower limit on the size of objects it can detect is frequently described as being about 10 centimeters and it is "currently limited in its ability to detect and track objects smaller than 30 centimeters." Thus some small satellites may be able to avoid detection and tracking – particularly if they have been intentionally designed to have reduced radar and optical signatures.' See *Ensuring America's Space Security: Report of the FAS Panel on Weapons in Space* (Washington DC: Federation of American Scientists, 2004), pp. 17–18.

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75 For a comprehensive overview of these issues, see Scott Pace, Gerald P. Frost, Irving Lachow, David R. Frelinger, Donna Fossum, Don Wassem and Monica M. Pinto, *The Global Positioning System: Assessing National Policies* (Santa Monica, CA: RAND, 1995), pp. 45–91.

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