Limits of the Chinese Antisatellite Threat to the United States

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Abstract

The argument that US armed forces are critically dependent on satellites and therefore extremely vulnerable to disruption from Chinese antisatellite (ASAT) attacks is not rooted in evidence. It rests on untested assumptions—primarily, that China would find attacking US military satellites operationally feasible and desirable. This article rejects those assumptions by critically examining the challenges involved in executing an ASAT attack versus the limited potential benefits such action would yield for China. While some US satellites are vulnerable, the limited reach of China's ballistic missiles and inadequate infrastructure make it infeasible for China to mount extensive ASAT operations necessary to substantially affect US capabilities. Even if China could execute a very complex, difficult ASAT operation, the benefits do not confer decisive military advantage. To dissuade China and demonstrate US resilience against ASAT attacks, the United States must employ technical innovations including space situational awareness, shielding, avoidance, and redundancies. Any coherent plan to dissuade and deter China from employing an ASAT attack must also include negotiations and arms control agreements. While it may not be politically possible to address all Chinese concerns, engaging and addressing some of them is the sensible way to build a stable and cooperative regime in space.

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In May of 2013, the Pentagon revealed that China had launched a suborbital rocket from the Xichang Satellite Launch Center in southwest Sichuan province that reached a high-altitude satellite orbit. According

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to Pentagon spokesperson Lt Col Monica Matoush, "the launch appeared to be on a ballistic trajectory nearly to geo-synchronous earth orbit."[1] An unattributed US defense official said, "It was a ground-based missile that we believe would be their first test of an interceptor that would be designed to go after a satellite that's actually on orbit."[2] In fact, the anticipation of this launch had sparked reports in the United States that China would be testing an antisatellite (ASAT) missile that might be able to attack US global positioning system (GPS) navigation satellites orbiting at an altitude of 20,000 kilometers (km).[3] However, the Chinese claimed the launch carried a science payload (a canister of barium powder) to study Earth's ionosphere. Reporting on the launch, China's state-run Xinhua news service announced that "the experiment was designed to investigate energetic particles and magnetic fields in the ionized stratum and near-Earth space. The experiment has reached expected objectives by allowing scientists to obtain first-hand data regarding the space environment at different altitudes."[4] Even though the barium payload release occurred at an altitude of 10,000 km, the Chinese did not clarify how high the missile actually went or what launch vehicle was used.[5]

The launch reignited the perceived threat of Chinese ASAT missile attacks on US military satellites. The growing US concern about Chinese ASAT capability goes back to 2007 when Beijing shot down one of its own satellites in low Earth orbit (LEO). China has also conducted "missile defense" tests viewed as proxies for ASAT missions.[6] These Chinese activities are seen by many analysts as a threat to US space capabilities. The persistent refrain has been that the US military exploits space surveillance capabilities better than any other nation, resulting in an asymmetric advantage to its armed forces on a global scale.[7] Given this US advantage, analysts posit China will find it prudent to directly attack US satellites—executing a space "pearl harbor" that would cripple US military capabilities for years.[8] Without its eyes and ears in space to provide early warning and real-time intelligence, it is argued, the United States would be in a painfully awkward situation should China put direct military pressure on Taiwan.[9]

However, the argument that US armed forces are critically dependent on satellites and therefore extremely vulnerable to disruption from Chinese ASAT attacks is not rooted in evidence.[10] Instead, it rests on untested assumptions—primarily, that China would find attacking US military satellites operationally feasible and desirable.[11]

This article tests those assumptions by critically examining the challenges involved in executing an ASAT attack versus the limited potential benefits such action would yield for China. It first examines which US military satellites are most vulnerable to Chinese ASAT attack and then, by demonstrating the limited reach of China's ballistic missiles and inadequate infrastructure capacity for launching multiple rockets, posits that it would be infeasible for China to mount extensive ASAT operations necessary to substantially affect US capabilities. The article next explores the limited benefits China would achieve from an ASAT attack, arguing that even if it manages to execute a very complex and difficult ASAT operation, the benefits do not confer decisive military advantage. Finally, it suggests policy actions—both unilateral US military-technical innovations and bilateral cooperative measures with China—to dissuade China and to demonstrate US resilience against ASAT attacks.

The Challenges of Antisatellite Attacks

Which US military satellites would China be able to destroy and how easily? The answer to this question gives a clear indicator of Chinese offensive space capabilities.

Arraying the range of potential target satellites—US, allied, and private, operating across a spectrum of orbital space—against the capabilities of Chinese missiles and launch infrastructure clearly shows that China possesses very limited means to conduct an extensive ASAT operation against the United States. To make that case, one must first understand the various US military satellites, their operational parameters, and the services they provide.

Based on military significance, US satellites can be primarily classed as (1) intelligence, surveillance, and reconnaissance (ISR) satellites, (2) GPS satellites, and (3) communications satellites. All three operate from different altitudes dictated by the functions they provide (see table 1).[12] ISR satellites can be further divided into imagery or signals intelligence (SIGINT) satellites. ISR imagery satellites operate in LEOs of around 1,000 km. A plethora of ISR imagery satellites, both government-owned and private, are used by US armed forces to construct a picture of adversary capability. Signals intelligence ISR satellites performing electronic intelligence (ELINT) and communications intelligence (COMINT) collection operate mostly from geosynchronous orbits (GEO) of 36,000 km and are used to develop data on adversary assets and functional capability, particularly during times of peace.

Table 1. US military satellites, missions, and operational parameters

Satellite Orbit	Orbit Altitude	Military Mission	Present and Future Satellite Systems
Low Earth Orbit (LEO)	< 1,000 km	Intelligence, Surveillance, and Reconnaissance (ISR) Imagery	Keyhole (KH) series, IKONOS, SPOT, GeoEye, Landsat
Low Earth Orbit (LEO)	< 1,000 km	Meteorology	Defense Meteorological Satellite Program (DMSP), Joint Polar Satellite system (JPSS), Defense Weather Satellite System (DWSS)
Medium Earth Orbit (MEO)	20,000 km	Positioning, Navigation and Timing	Global Positioning System (GPS)
Highly Elliptical Orbit and Geosynchronous Earth Orbit (HEO and GEO)	36,000 km	Missile Early Warning	Defense Support Program (DSP), Space-Based Infrared System (SBIRS)
Geosynchronous Earth Orbit (GEO)	36,000 km	Communications	Defense Satellite Communications System (DSCS), Ultra High Frequency Follow-On (UFO), Mobile User Objective System (MUOS), Milstar, Global Broadcast System (GBS), Advanced Extremely High Frequency (AEHF), Wideband Global SATCOM (WGS)
Geosynchronous Earth Orbit (GEO)	36,000 km	Signals Intelligence (SIGINT), Electronic Intelligence (ELINT), Communications Intelligence (COMINT)	Chalet, Vortex, Mercury, Rhyolite, Magnum, Mentor, Trumpet, Intruder, Prowler

Source: Lt Col Peter L. Hays, *United States Military Space: Into the Twenty-First Century*, INSS Occasional Paper 42 (USAF Academy, CO: Institute for National Security Studies, September 2002), 10; Federation of American Scientists, "Signals Intelligence," http://www.fas.org/spp/military/program/sigint/; and Federation of American Scientists, "IMINT Gallery," 8 July 2002, http://www.fas.org/irp/imint/.

US GPS satellites operate from an altitude of around 20,000 km. They are an important component to the successful execution of any modern US military operation in addition to their extensive commercial applications. They provide deployed forces with precise positioning, navigational, and timing information that facilitates rapid maneuvering and precise targeting. US military communication satellites operate farthest from Earth in GEOs at an altitude of approximately 36,000 km.

The US military employs a variety of military and commercial communications satellites for different activities.

China's Missiles Will Not Be Enough

The substantial range of orbital altitudes—1,000 km to 36,000 km—across which satellites operate poses a challenge to China's ability to attack US military satellites. Of the three sets of orbiters discussed above, ISR imagery satellites operating at altitudes less than 1,000 km are most vulnerable to ASAT attack by China's intermediate range ballistic missiles (IRBM). This was demonstrated by the 2007 Chinese ASAT test. On 11 January 2007, China launched a two-stage, solid-fuel, medium-range Dong Feng (DF)-21 ballistic missile using a mobile transporter-erector-launcher (TEL) from the Xichang Space Center which slammed into one of its polar-orbiting LEO weather satellites (Feng Yun 1C) orbiting at an altitude of approximately 850 km.[13]

Caution should be exercised, however, in linearly scaling this Chinese ASAT capability to satellites operating at higher altitudes. The DF-21 ballistic missile used in the 2007 test cannot reach either GPS or communications satellites. In fact, even China's most powerful solid-fueled intercontinental ballistic missiles (ICBM) are unable to reach an altitude of 20,000 km where GPS satellites operate. These limitations of Chinese missiles are due to fundamental constraints of physics.

To illustrate: a Chinese ICBM carrying a 2,000 kilogram (kg) payload with a burn-out velocity of 7.0 km/sec (traveling a ground distance of approximately 11,500 km) when launched straight up with a reduced payload of 500 kg reaches a maximum altitude of only 10,500 km. The same ICBM with a reduced payload of 250 kg reaches an approximate maximum altitude of only 15,000 km. This limitation, as discussed above, implies that China would not be able to execute an ASAT attack against GPS satellites operating at 20,000 km or US military communications and SIGINT satellites operating at 36,000 km using its current missile inventory. To reach these higher orbiting satellites, China would have to build new and more-powerful ICBMs. Even if it manages to develop such an ICBM, China certainly will not be able to produce a large number of them without substantial financial stress. Alternatively, it can use its liquid-fueled space launch vehicles; however, this imposes other difficulties discussed below.

China's Infrastructure Further Limits Antisatellite Operations

There are other challenges for China in successfully executing an ASAT attack against US satellites. Any operationally relevant ASAT operation will require the destruction of more than one satellite. In the case of ISR imagery satellites, for example, shooting down one would have very little impact upon net US satellite-enabled surveillance capabilities. In real-world scenarios, a chain of ISR satellites orbiting over a location of interest at various times are used to gain information on an adversary. Take for instance US operations in the 1991 Gulf War. An assortment of US military, allied, and private ISR satellites like Landsat, SPOT, Okean, Resurs-F, Resurs-O, Lacrosse, KH-11, KH-12, White Cloud, RORSAT, EORSAT, Almaz, and others were used.[14] In all probability, a US-China engagement in the Taiwan Straits would involve as many or more satellites. It would be exceedingly difficult for China to continue destroying such a number of satellites over a period of time without subjecting its launch infrastructure to counterattack.

A similar challenge exists in the case of GPS satellites. The GPS constellation consists of around 30 satellites. To meaningfully dilute GPS signals in a local area such as the Taiwan Straits would require destroying six or more satellites, as discussed in detail below. Even after a loss of six GPS satellites, the signal degradation lasts for only 95 minutes. For China to force US armed forces to operate without GPS over a sustained period of time would require destruction of 10 or more of these satellites—a very difficult task.

Similarly, a fleet of nine US military communications spacecraft provided coverage over the Persian Gulf area during the 1991 Gulf War. Allied military satellites like the Skynet (UK), MACSAT, and Telecom/Syracuse (France) were utilized as well, as were nonmilitary space communication systems (INTELSAT, INMARSAT, EUTELSAT, ARABSAT, and PANAMSAT).[15] In any future conflict between the United States and China, dozens of communications satellites could be used, making targeting very complicated. To locate and attack these targets, China would likely have to employ its liquid-fueled space launch vehicles performing complex and time-consuming orbit transfer maneuvers to reach the 36,000 km orbit where communications satellites operate.

The time needed to transit from LEO to GEO on a transfer orbit is usually more than five hours. Even direct launches to GEO take several hours. The time delay between launch and actual attack would provide enough time for the United States to relocate its GEO military communications satellites if it suspects an ASAT attack is imminent. Such relocation maneuvers have been done before. For example, to meet growing bandwidth demands during the 1991 Gulf War, the Defense Satellite Communications System (DSCS) reserve West Pacific satellite was relocated from its 180° longitude geostationary parking slot to 65° E to service demands over the Gulf region.[16] Even if Chinese space launch vehicles could reach these higher orbits in time to intercept US military communications satellites, executing dozens of such launches in quick succession is close to impossible. China's infrastructure limits such a venture.

The total number of space launches to orbits higher than LEO by China in 2012 was nine; there were also nine in 2011, eight in 2010, two in 2009 (with one failure), and four in 2008. In the last five years the two quickest back-to-back launches to orbits higher than LEO occurred with a gap of 15 days. However, the average time between launches is close to a month and a half.[17] This launch record suggests that launching dozens of ASATs almost simultaneously as required to cripple US military operations is almost impossible for China. Additionally, China has to date used only one space launch facility for higher-than-LEO launches, the Xichang Space Launch Center, which has only three launch pads. Achieving a number of simultaneous launches using just this one launch site questions the feasibility of China being able to successfully execute an ASAT attack without becoming subject to counterattack. Unlike the ICBMs which can be quickly fired, liquid-fueled space launch vehicles take time to fuel, and these preparations are very visible. If the United States anticipates and observes the preparation for an ASAT attack, it could destroy the launch vehicles during preparation.

Even if China were able to execute such an ASAT operation, would it be willing to weather the collateral consequences? Destroying a US satellite might produce debris fields that invariably affect other satellites. The debris field created by the 2007 ASAT test is now generally seen as the most prolific and severe fragmentation event in five decades of space operations.[18] Additionally, any major US military operation would involve satellites from coalition partners, neutral nations, and private companies. Would China shoot at satellites from neutral nations like Japan, India, or European nations leasing out their capabilities to the United States? In the wake of the 2007 ASAT test, China faced sustained international pressure to explain its actions. Not only did the United States issue its own démarche to the Chinese foreign ministry, it successfully convinced the United Kingdom, Australia, Canada, Japan, and the Republic of Korea to issue similar démarches. France and Germany made their independent protests to Chinese actions.[19] Attacking a third-party satellite during a US-China conflict might impel these actors to side with the United States—an outcome China would certainly want to avoid. The array of factors discussed in this section raises reasonable doubts about Chinese potential to launch an operationally relevant ASAT mission to degrade US military operations.

Limited Benefits from Antisatellite Attacks

What benefits might accrue to China from executing an elaborate ASAT operation against US and allied satellites during a Taiwan Straits conflict, assuming such an operation were feasible? How does such an attack impact the outcome of a US-China military engagement? Given existing satellite redundancies and the availability of alternate systems, the benefits to China from attacking US satellites are limited. A Chinese ASAT operation, if successful, would result in differing outcomes depending on the type of satellite targeted. In the case of GPS satellites, the redundancy of the constellation renders any attack fleeting and limited in benefits. As for ISR satellites, the availability of alternate airborne platforms limits the utility of an ASAT attack. Finally, targeting communication satellites imposes the difficulty of managing escalation constraints on an ASAT operation.

Satellite Redundancies Preserve US GPS Capability

The GPS constellation of around 30 satellites orbits Earth at an altitude of 20,000 km in six orbital planes with four satellites in each plane plus some spares. This unique orbital arrangement guarantees that the signal of at least four satellites can be received at any time all over the world. In reality, more than four satellites are accessible from any location, giving high-resolution positioning and timing information to the US military user.

If China decided to launch an ASAT attack against GPS satellites, what might it expect to gain militarily from such an operation? How might the attack affect US operational capability during a naval conflict in the

Taiwan Straits? To answer these questions, a calculation was performed by modeling a hypothetical conflict region for a period of 72 hours—the "China-Taiwan region" (shown in fig. 1) where it is expected conflict between the United States and China is most likely. The region also includes the Chinese East Fleet located in Dinghai and the Chinese South Fleet located in Zhan Jiang.

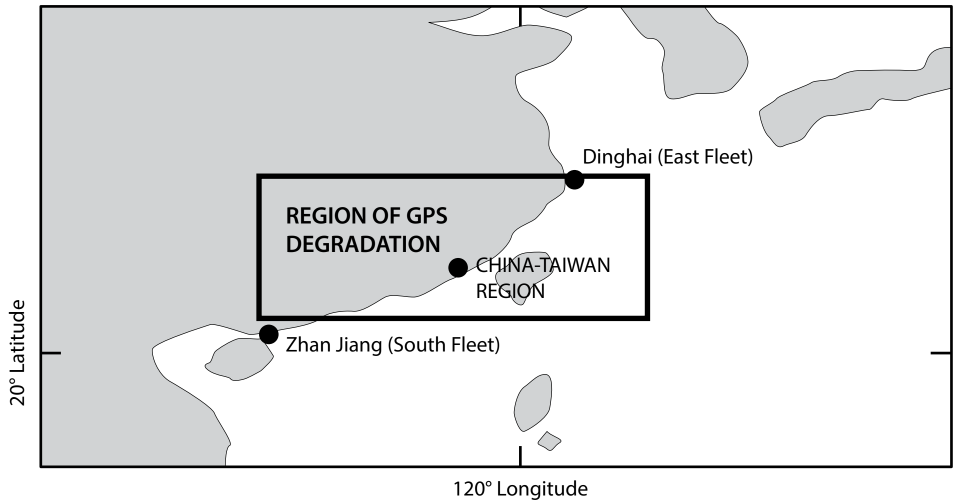

Figure 1. Hypothetical "China-Taiwan Region" in which China might attempt to degrade GPS signals by an ASAT attack

The simulation focused on calculating the effort required by China to degrade GPS accuracy—measured in geometric dilution of precision (GDOP)—in the modeled region. GDOP is a dimensionless measure of GPS 3D positioning accuracy calculated from the geometric relationship between the receiver position and the position of the satellites the receiver is using for navigation. The current GPS satellite constellation is designed to provide a worldwide GDOP value of less than six with at least four satellites visible over any spot. When the GDOP rises above six, GPS satellite constellation coverage over the region is not very good, resulting in positioning errors. Even mildly unfavorable GDOP values can lead to position errors of 100 to 150 meters. As the GDOP continues to rise above six, it is possible that no determination of position can occur.[20]

The average GDOP value for deployed US forces in the entire modeled region before an ASAT attack is consistently below 3 for the duration of the simulation (as seen in top graph in fig. 2). To meaningfully impact US performance—for example, force US ships to operate without access to accurate GPS signals—China would have to decrease accuracy to a GDOP value greater than six. To do that, it would have to successfully attack and disable at least five GPS satellites passing over the region. However, with five GPS satellites removed, the GDOP rises above six for a meager five minutes before the redundancy in the GPS constellation compensates for the degraded signal (see middle graph in fig. 2). Similarly, when six GPS satellites are destroyed, the degradation lasts for a period of only 95 minutes centered around the chosen time of attack (see bottom graph in fig. 2). It should be noted that Chinese users of GPS signals would suffer the same degradation as US armed forces. Other countries around the world would also eventually suffer from varying degrees of loss in GPS accuracy due to this attack.

The effect of this hypothetical ASAT attack is not consistent throughout the region. Although the average GPS signal degradation in the modeled China-Taiwan region lasts for 95 minutes, locations near the edges of the modeled region are not affected as much. For example, the Chinese Eastern Fleet located in Dinghai suffers GPS signal degradation for only 65 minutes, and the Chinese Southern Fleet located in Zhan Jiang suffers signal degradation for only 15 minutes. This implies that if China wants to hinder US operations in the Taiwan Straits region and at the same time limit the ability of US naval forces to attack its eastern and southern fleet locations where most of the Chinese ships and logistical capabilities reside, it would have to destroy more than six satellites. Also, since the GPS degradation displays a periodic pattern after the attack (see fig. 2), occurring at the same time every 24 hours, US forces would be able to adapt to the effects of the attack.

In reality, however, attacking even six GPS satellites simultaneously would be a daunting military operation for China. As discussed in the previous section, Chinese ICBMs are not capable of reaching the operating altitude of GPS satellites. Given this limitation, China would have to use its liquid-fueled space launch vehicles for attacking GPS satellites, which in turn has its own disadvantages as articulated earlier.[21] Even if China managed to execute the attack scenario outlined above, the actual benefits seem limited. The most that would be gained is 95 minutes of signal degradation, after which the redundancy of the GPS satellite constellation makes up for the effects of the attack and US armed forces will be able to operate GPS assets at normal accuracy.[22]

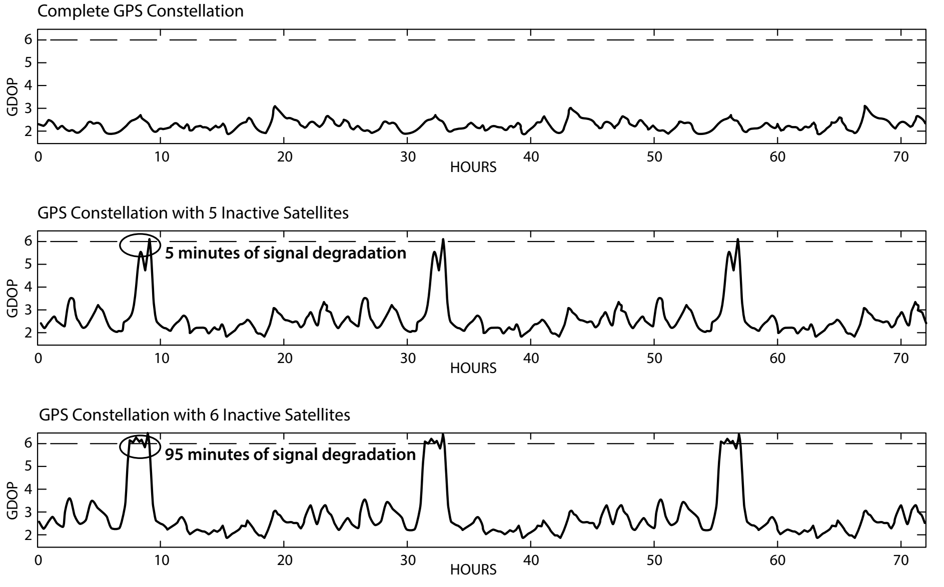

Figure 2. Number of GPS satellites China would have to attack to meaningfully degrade GPS signals in the entire China-Taiwan Region

What would China gain from 95 minutes of GPS degradation in a tactical military operation? US ships and aircraft have accurate inertial navigation systems that would still permit them to operate in the region. As for the ability to use GPS-guided bombs, table 2 below shows that the percentage use of these munitions was around 25 percent in recent US operations. The United States could shift to laser-guided bombs that follow a narrow beam of pulsed energy trained on the target and are more precise than GPS-guided bombs. They also have a capability to attack moving targets like ships that GPS-guided bombs do not.[23] In fact, between Operations Enduring Freedom and Iraqi Freedom, the DoD decreased its use of GPS-guided bombs by about 13 percent and increased the use of laser-guided bombs by about 10 percent.[24]

Table 2. Usage of GPS-guided munition in recent US military operations

Operation	Desert Storm (1991)	Allied Force (1999)	Enduring Freedom (2001–02)	Iraqi Freedom (2003)
Total air-delivered weapons	227,648	23,644	17,459	29,199
Total GPS-guided munitions delivered	0	652	5,000	6,542
% of GPS-guided munitions employed	0%	0.30%	28.64%	22.40%

Source: Walter J. Boyne, *Operation Iraqi Freedom: What Went Right, What Went Wrong, And Why* (New York: Tom Doherty Associates, 2003); "Air Weapons: How Many JDAM is Enough?" *Strategy Page*, 24 September 2008; John A. Tirpak, "Precision: The Next Generation," *Air Force Magazine* 87, no. 9 (September 2004); and Christopher J. Bowie, Robert P. Haffa Jr., and Robert E. Mullins, *Future War: What Trends in America's Post-Cold War Military Conflicts Tell Us about Early 21st Century Warfare* (Falls Church, VA: Northrop Grumman, 2003).

The US military could also shift to conventional nonprecision munitions if unable to use GPS-guided bombs. Although this may cause some problems for the United States, it would likewise affect China. Uncertainty in what is being targeted and where weapons will fall can have a significant psychological effect on an enemy. For example, interviews of Iraqi soldiers captured during the Gulf War revealed that their greatest fear was being attacked with B-52s, each dropping 38,250 pounds of conventional nonprecision munitions. The shock, noise, and disruption of a large-scale, wide-area air attack can have a paralyzing and demoralizing effect out of proportion to the amount of physical destruction achieved.[25] It may not be in China's interest to attack GPS satellites and force the United States to revert to a wide-area bombing campaign.

Along with the considerable operational difficulty in successfully executing an ASAT attack on GPS satellites, there seems to be limited military benefit for China in such an operation. These findings raise reasonable doubts about the validity of the claim that China would find US GPS satellites a highly valuable target in a future Taiwan Straits conflict.

Alternate Systems Preserve US ISR Capability

The availability of alternate systems limits the possible gains from an ASAT attack on ISR satellites. The unique advantage of ISR satellites is that they do not have overflight restrictions and are able to fly over hostile territory and collect information unhindered by air defense systems. This makes them a viable target for ASATs. However, most ISR satellites in LEO travel at a velocity of approximately 7.5 km/sec, completing one revolution around the earth in 90 minutes; therefore, they have very little persistence over a particular location. Airborne ISR platforms, on the other hand, can provide focused coverage and longer endurance over a particular location and at the desired time. Airborne platforms play a very active role in local battlefield ISR. The United States possesses an extensive array of airborne platforms that can duplicate and likely outperform certain missions conducted by ISR satellites. A few of these airborne platforms are described below.

- The U-2 provides continuous day and night, high-altitude, all-weather surveillance and reconnaissance in support of ground, naval, and air forces. Its main payload is an ASARS-2 synthetic aperture radar (SAR), which in moving-target-indicator mode provides a view of dynamic targets against a SAR or a cartographic back-ground. In spot mode against stationary targets, the radar provides a higher degree of detail and finer target discrimination.[26]

- The E-8C Joint Surveillance and Target Attack Radar System (JSTARS) is an airborne battle management, command and control, intelligence, surveillance, and reconnaissance aircraft. Its APY-3 ground moving target indicator (GMTI) radar allows it to provide ground and air commanders with detailed and persistent information on adversary forces to support attack operations and targeting.[27]
- The RC-135 Rivet Joint is an electronic reconnaissance aircraft that supports theater military commanders with near-real-time intelligence. It can passively monitor and record signals across a wide spectrum, geolocate them, and analyze their modulations with very high accuracy.[28]
- The EP-3E (Aries II) is the Navy's SIGINT reconnaissance aircraft. Its sensitive receivers and high-gain dish antennas allow it to detect a wide range of electronic emissions from deep within targeted territory from A-band to J-band, and possibility up to K-band.[29]
- The E-3 Sentry is an airborne warning and control system (AWACS) that provides all-weather airspace surveillance, command, and control. Its APY-2 surveillance radar provides three-dimensional surveillance of a massive volume of airspace and direction of aerial operations within that space. This capability leads to accurate positioning and tracking information on enemy and friendly aircraft and ships.[30]
- The E-2C Hawkeye is used for airborne early warning (AEW). From an operating altitude above 25,000 ft., it warns the naval task force of approaching air threats and provides threat identification and positional data to fighter aircraft. It is capable of tracking more than 2,000 targets and controlling the interception of 40 hostile targets.[31]

In addition to these and other airborne platforms, UAVs like the RQ-4 Global Hawk, MQ-1 Predator, MQ-SX, MQ-9 Reaper, MQ-1C Grey Eagle, MQ-5 Hunter, MQ-8 Firescout, and RQ-7 Shadow also perform a range of signal intelligence, communications relay (theater), wide-area and full-motion video surveillance, armed reconnaissance/

attack, and jamming missions.[32] In fact, it seems these airborne platforms and UAVs are more important and perform the bulk of battlefield intelligence collection, whereas ISR satellites serve to monitor adversary capabilities and developments prior to the conflict.

A number of these airborne platforms also have stand-off functioning capability and do not need complete air superiority to operate. For example, JSTARS has the capacity to detect, precisely locate, and track thousands of fixed and mobile targets on the ground over an area larger than 20,000 square km from a stand-off distance in excess of 250 km.[33] The ASARS-2 radar in the U-2 aircraft can take pictures of the battlefield to a range of 162 km.[34] The E-3 AWACS S-band surveillance radar can survey, in 10-second intervals, a volume of airspace covering more than 500,000 square km around the AWACS (i.e., 400 km in any direction).[35] The RC-135 Rivet Joint can collect and rapidly analyze signals within a 460 km range.[36] The E-2C Hawkeye is capable of detecting aircraft approaching at a distance greater than 550 km.[37] All of these platforms should therefore be able to operate outside of China's inland air defense systems in a hypothetical conflict in the 180-km-long Taiwan Straits.

These airborne systems certainly do not make ISR satellites irrelevant. Satellites still perform some battle roles along with aerial platforms. However, when analysts claim that US forces would be lost without ISR satellites during a military engagement, there seems to be an incongruity between reality and perception. Commanders rely heavily on airborne assets during battlefield operations. For example, during the 1991 Operation Desert Storm, Gen Chuck Horner, commander of the coalition air forces, pulled in and used every airborne platform, including the high-flying TR-1/U-2R aircraft, the RF-4C for tactical information, the RC-135 Rivet Joint to monitor electronic emissions, the Boeing E-3B/C AWACS, the EC-130E Airborne Battle Command and Control Center (ABCCC) for combat management, the E-8A JSTARS to find ground targets, and Navy F-14s equipped with TARPS (tactical air reconnaissance pod system).

This trend has persisted. Recent US military operations continue to extensively employ airborne ISR systems. In the 2003 Operation Iraqi Freedom, for example, coalition air forces employed 80 aircraft (including the RC-135, C-130, E-2, E-3, E-8, EC-130, EP-3, and U-2) that flew nearly 1,000 ISR sorties during the initial weeks, collecting 42,000 battlefield images and more than 3,000 hours of full-motion video.[38] The airborne systems also provided 2,400 hours of SIGINT coverage and 1,700 hours of moving-target-indicator data.[39] In fact, the MC-12W Liberty aircraft was developed during Operation Iraqi Freedom specifically to intensify data collection, including real-time, full-motion video and SIGINT to support battlefield decisions of military troop leaders.[40]

All of these platforms, some in more advanced versions, are still in service with US forces and would be used in a conflict in the Taiwan Straits, raising questions as to the value of attacking US reconnaissance and intelligence satellites. Why would China choose to attack ISR satellites when airborne platforms pose a much greater threat and would be easier to attack? In fact, one could argue that these aerial platforms would be more attractive targets tactically and would have the additional advantage of not escalating the conflict.

Communication Satellites and Escalation Control

In an ASAT attack, communications satellites present another problem: escalation control. The Naval Telecommunications System (NTS) that would support the US Navy in a hypothetical conflict with China in the Taiwan Straits is very elaborate. It comprises (1) tactical communications among operating afloat units aggregated around a battle group, (2) long-haul communications between shore-based forward naval communications stations (NAVCOMSTA) and forward-deployed afloat units, and (3) strategic communication connecting NAVCOMSTAs with the national command authorities.[41] Of the three, strategic communication is the only component that is primarily dependent on satellites and therefore susceptible to ASAT attacks.

Tactical communication needed to coordinate movements between ship-to-ship, ship-to-air, air-to-ship, and air-to-air elements of a forward-deployed battle group are predominantly serviced by high frequency (HF), very high frequency (VHF), and ultra high frequency (UHF) radio nets.[42] Close formations use "line-of-sight" (LOS) radio, which will carry out to 25–30 km, depending on the size of ships concerned and the heights of their antennas. Communication with picket ships and between formed groups will require "extended line-of-sight"—also known as "over the horizon"—radio, which will carry out to 300–500 km. Another type of LOS circuit operated between ships in a battle group is the data link, which automatically connects tactical computer systems at a high data rate. These data links allow ships to share information and weapon control orders to be passed automatically.[43] Long-haul communications between the shore-based NAVCOMSTAs and forward-deployed afloat units are normally conducted in distances ranging from 750 to 11,000 km using both HF and UHF radio links as well as UHF and super high frequency satellite communications (SHF SATCOM).[44] Although long-haul communications are dependent on SATCOM, they can also be conducted, albeit with reduced data rates, using HF and UHF radio links.

It is the strategic portion of naval communications that is largely dependent on SATCOM. HF and UHF radio links can perform some of the strategic naval communication, however, SATCOM accounts for the bulk of it. Therefore, the component of the NTS that China would be aiming to disrupt with its ASATs is strategic communications that would connect the National Command Authority (NCA) with the forward-deployed battle group. This poses a unique problem. Normally, China should prefer to disrupt and disable the communication capabilities of the forward-deployed naval battle group near Taiwan and then negotiate with the US NCA to have it withdrawn or stand down. However, it can only accomplish the opposite. By using ASATs, China would cut off the forward-deployed battle group from its NCA and still might not significantly disable or disrupt the battle group's ability to execute its naval mission. China could hope that such an attack might force the battle group to stand down. However, it must also have to contend with the possibility that the battle group commander might act more rashly in the absence of direct guidance from the NCA, particularly if combat maneuvers have been initiated. Would China be willing to take such risk? Arguably, the risk might not be worth the potential escalation it might trigger.

Dissuasion through Technological Innovation

Redundancies and alternate systems give a large measure of operational security to US forces, enabling them to operate in an environment with degraded satellite services. This can be further improved by developing additional redundancies and alternates. The commander of US Strategic Command, Gen C. Robert Kehler, expounding on one of the goals of "mission assurance" in the 2011 *National Security Space Strategy*, called for actions to prepare US forces to "fight through" any possible degradations or disruptions to US space capabilities.[45] Pursuing such actions will enhance deterrence against ASAT attacks by demonstrating the resilience of US forces and thereby diminishing the incentive for an adversary like China to target US space systems.

The United States should also study and improve its ability to use measures like satellite sensor shielding and collision avoidance maneuvers for satellites. These would dilute an adversary's ASAT operation and increase the apparent uncertainty of the consequences of an ASAT attack.[46] Monitoring mechanisms—both technical and nontechnical—that provide long warning times and the ability to definitively identify an attacker in real time should also be a priority. The US Air Force has started to invest in such capabilities on a small scale. Gen William Shelton, head of Air Force Space Command, announced on 21 February 2014 the upcoming launch of the geosynchronous space situational awareness (SSA) system designed to "have a clear, unobstructed and distinct vantage point for viewing resident space objects."[47] Such systems will help in attributing an ASAT attack. Similarly, the ground-based Rapid Attack, Identification, Detection, and Reporting System (RAIDRS) is a valuable US asset to identify, characterize, and geolocate attacks against US satellites.[48]

However, these unilateral measures offer no direct positive inducement for the Chinese decision maker to desist from taking an aggressive posture on space security. Such inducements will require more cooperative ventures that integrate China more deeply into the global space community. The United States could, for example, make available its data on satellite traffic and collisions, which would help China streamline its space operations. Such gestures demonstrate a modicum of goodwill which can encourage further cooperation. The United States has already put in place policy actions to share SSA data with allies. The latest guidance document on US space policy, the *National Security Space Strategy* released in 2011 by the Office of the Secretary of Defense and the Office of the Director of National Intelligence, states that "the United States is the leader in space situation awareness (SSA) and can use its knowledge to foster cooperative SSA relationships, support safe space operations, and protect US and allied space capabilities and operations."[49] However, the United States has been more forthcoming and willing to ink data-sharing arrangements with allies than with China. The US Strategic Command (USSTRATCOM) has signed SSA data agreements with Japan, Australia, the UK, Italy, Canada, and France.[50] Although there may be security reasons behind this preference to engage primarily with allies, it is important to realize that China is the nation that most needs to be induced to contribute to the peaceful development of space operations. The United States should use all available diplomatic leverage to partner with China and share SSA data to make it a part of the global space community.

Dissuasion through Cooperative Engagement

Any coherent plan to dissuade and deter China from employing an ASAT attack will have to also include negotiations and arms control agreements. While a comprehensive arms control agreement in space may suffer verification issues,[51] even a limited agreement will endow the principals with several benefits. An arms control agreement may not completely prevent the covert development of Chinese capabilities, but it will significantly reduce the confidence of the Chinese military in an ASAT weapon system that an otherwise meticulously designed testing program would give it.

An arms control agreement or even the negotiating process over such an agreement will convince any potential adversary, including China, of important thresholds. These processes can provide a valuable forum to develop ground rules for space operations, including during periods of war. For example, US military satellites that provide missile early warning have a tactical utility, but more importantly, they also serve to maintain the stability of nuclear deterrence between the United States and China. Rules should be explored to eliminate any consideration of targeting these satellite systems. While serving as the US deputy assistant secretary of state for space and defense policy in 2012, Frank A. Rose claimed that "there has [*sic*] been a number of Chinese defense intellectuals arguing that shooting down American nuclear early warning satellites is de-escalatory. We want to have a discussion with them so that they understand that this is not the case."[52] That discussion will not occur unless there is direct contact and an inclination to engage in reaching middle ground. Engaging in negotiations over space security and demonstrating leadership with such measures will help characterize the United States as a responsible actor and render it with the authority to respond with force when an attack is made on its or allied space assets. The latest *National Security Space Strategy* has indicated that the United States would use force in response to offensive operations against it in a manner consistent with long-standing principles of international law, treaties to which the United States is a party, and the inherent right of self-defense.[53] The international community should be convinced of the justice to punish a space aggressor and to support the United States in its use of lethal force to do so. Engaging in discussions to establish ground rules during times of peace will help to provide such support.[54]

Unfortunately, there has been a lot of opposition within the United States to engage in any type of formal negotiations with China. China, along with Russia, has been demanding a space arms control agreement with the United States. In April 2002, China's vice foreign minister Qiao Zonghuai summarized the official Chinese view in the United Nations Conference on Disarmament (UNCD) by stating, "Due to the development in technology, considerable progress has been made in outer space–related weapons research and military technology. It will not take long before drawings of space weapons and weapon systems are turned into lethal combat instruments in outer space." Meanwhile, military doctrines and concepts such as "control of space" and "ensuring space superiority" have been unveiled successively, and space operation command headquarters and combatant troops are in the making. If we remain indifferent to the above-mentioned developments, an arms race would very likely emerge in outer space in the foreseeable future. Outer space would eventually become the fourth battlefield besides land, sea, and air. To avoid repeating the mistakes that have been made on the issue of nuclear weapons, it is imperative for the international community to take effective measures to forestall any possible mishaps. The international community has concluded a number of legal instruments to regulate the activities carried out in outer space by all states. However, after a careful reading of these legal instruments, we find they are not adequate to effectively prevent an arms race in or the weaponization of outer space. Given the situation, it is imperative to conclude an international legal instrument devoted to preventing the weaponization of and an arms race in space."[55] The US government has, however, consistently rejected all space arms control talks sponsored by Russia and China at the United Nations, seeing these as a covert attempt to limit US military space operations. The 2006 *National Space Policy* explicitly states that "the United States will oppose the development of new legal regimes and other restrictions that seek to prohibit or limit US access to or use of space."[56] Even in the aftermath of the 2007 Chinese ASAT test, a State Department official said,

> The test is not cause to open negotiations on a new treaty that would place limits on what countries can do in space. We do not think there is an arms race in space. The United States believes that the existing body of existing international agreements—including the Outer Space Treaty, as well as the liability and respective compensation conventions—provide the appropriate legal regime for space. The [US] space policy clearly states that the United States will oppose the development of new legal regimes or other restrictions that seek to prohibit or limit US access to, or use of, space and that no change in that policy is warranted. Arms control is not a viable solution for space. For example, there is no agreement on how to define space weapon. Without a definition you are left with loopholes and meaningless limitations that endanger national security. No arms control is better than bad arms control.[57]

Recently though, the United States has indicated a willingness to participate in a nonbinding, voluntary space code of conduct. Although not directly addressing the issues undergirding ASAT concerns, this is a useful attempt to open the grounds for discussion and negotiation. In January 2012, the US State Department announced its interest in participating in a European Union–sponsored space code of conduct. In a written statement announcing the decision, Secretary of State Hillary Clinton said, "the long-term sustainability of our space environment is at serious risk from space debris and irresponsible actors. Unless the international community addresses these challenges, the environment around our planet will become increasingly hazardous to human spaceflight and satellite systems, which would create damaging consequences for all of us."[58] Others have also come out in defense of this initiative. Writing in the *Strategic Studies Quarterly*, Amb. Gregory L. Schulte, deputy assistant secretary of defense for space policy, and Audrey M. Schaffer, space policy advisor to the office of the undersecretary of defense for policy, argued,

> A code of conduct in space operations such as the EU's draft proposal would enhance US national security by building international political consensus around precepts such as debris mitigation, collision avoidance, hazards notifications, and general practices of spaceflight safety. The precepts in the EU's proposal are largely consistent with current US practices and, because the draft focuses

on behaviors, not capabilities, it would not constrain the development of, for example, missile defense.[59]

The Pentagon has given some reserved support for the code of conduct. Gen William Shelton has said that the US military will gain from an international "code of conduct" on space activities.[60]

Opponents to space arms control negotiations have, however, come out against even this very limited engagement. Amb. John R. Bolton, former US ambassador to the United Nations, has argued that "the last thing the United States needs is a space code of conduct. The ideology of arms control has already failed in the Russian 'reset' policy, and it is sure to fail here as well. The European Union code would interfere with our ability to develop antiballistic missile systems in space, test antisatellite weapons and gather intelligence."[61] Others have argued that the code of conduct for space will restrict how space forces are used by the US military.[62] Members of the Senate Armed Services Committee have expressed reservations in the code, claiming it would limit US actions in space and thereby harm national security, even after assurances by the administration that the code is voluntary and nonbinding.[63] In fact, it explicitly avoids addressing any issues of space security and deals only with civilian spaceflight operations safety.

Such opposition to exploring cooperative measures with China is short-sighted and flawed. To dissuade and deter China from employing an ASAT attack, the United States will need to employ all its assets, including diplomacy, to communicate to China the US ability to operate effectively in the face of an ASAT attack operation. Military-technical solutions might provide some relief; however, it is important to engage and address legitimate Chinese concerns about US weapons programs. Central to the threat of Chinese ASAT capabilities is China's perceived incongruence in capability between US and PLA forces. While it may not be politically possible to address all Chinese concerns, engaging and addressing some of them is the sensible way to build a stable and cooperative regime in space.

Conclusion

The argument that because the US armed forces are more dependent on satellites than potential adversaries, those satellites would be an obvious and valuable target, fails to hold up to critical examination. They are vital assets; yet, because of their resilience and redundancies, none of the individual components are critical. Adversaries like China will choose to attack those US assets that would result in tangible gains while controlling the consequent escalation. However, as argued above, attacking US ISR, GPS, or communication satellites seems to generate fleeting and limited benefits for China. The military functions performed by US military satellites are diffused among large constellations. These constellations possess redundancies that enable them to serve their utility even after some satellites are lost. Many of the functions performed by these satellite systems can also be performed by other terrestrial and airborne systems. Although the redundancies and alternatives will not completely compensate for many destroyed satellites, there is no indisputable evidence that the US armed forces would be crippled if some of its satellites are attacked.

An ASAT attack would also be very escalatory; more so, if neutral states' satellites are attacked directly or damaged as a secondary effect from the debris generated from a primary attack. The international reaction to China's 2007 ASAT test has already exposed it to the consequences of an ASAT mission that creates large debris fields in space.[64] Would the Chinese knowingly perform such an action again without an overwhelming tactical military benefit? The logical answer would be no.

Proponents of the view that China has an active ASAT program point to the surfeit of Chinese publications on this topic.[65] However, the majority of these publications seem to lack analytical evidence or military operational detail. They tend to portray conceptual capabilities in vague outlines. A substantial portion of these expositions, arguably, are recycled from US military documents or drawn from unreliable sources.[66] However, it is conceivable that some of these writings do represent actual Chinese ruminations, at least from the more hawkish elements, on the conduct of battle or as a means to signal the United States to disengage from an ongoing conflict in the Taiwan Straits. If indeed that is the case, then the United States must conceive a combination of systems development and policy initiatives—one that employs both its military-technical power and diplomatic leverage—to dissuade China. SSQ

Notes

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2. "US Sees China Missile Launch as Test of Muscle," Reuters, 16 May 2013, http://www.voanews.com/content/us-sees-china-launch-as-test-of-anti-satellite-muscle/1662191.html. There are other passive means like signal jamming, laser blinding, and cyber attacks that China would employ against US strategic satellites. However, these passive attacks can be countered. Gen William Shelton, commander of Air Force Space Command, has argued that the US military will have to find ways to fight through jamming. He has said that more resilient or resistant antenna designs can help. For details, see Kris Osborn, "Air Force Faces Increasing Space Threats: Shelton," *Defense Tech*, 18 September 2013, http://defensetech.org/2013/09/18/air-force-faces-increasing-space-threats-shelton/. An ASAT attack, on the other hand, aims to completely remove the attacked satellite from operation. ASAT attacks also generate debris that affects other satellites. Therefore, ASATs are a particularly dangerous and escalatory means of disabling US satellites. Given this, it can be argued that the threshold for nondestructive reversible ASAT attacks is lower than destructive reversible ASAT attacks.

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6. Brian Weeden, "Anti-Satellite Test in Space: The Case of China," Sound World Foundation, 29 August 2013, http://www.swfound.org/media/115643/china_asat_testing_fact_sheet_aug_2013.pdf.

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Review Commission, Washington, DC, 2008; Taylor Dinerman, "Hybrid Wars and Satellite Vulnerabilities,"*Space Review*, 13 March 2006; and Ashley Tellis, "China's Military Space Strategy," *Survival* 49, no. 3 (September 2007).

8. *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington: DoD, January 2001), http://www.dod.gov/pubs/space20010111.html.

9. Everett Carl Dolman, "New Frontiers, Old Realities," *Strategic Studies Quarterly* 6, no.1 (Spring 2012): 78–96.

10. In fact, China could more easily target the effects generated by these satellites rather than the hardware itself. The Chinese military, in all probability, possesses the technological maturity to use jammers and other electronic countermeasures along with active camouflage and deception techniques to passively disrupt US GPS, ISR, and communication systems. The United States, for example, operates the counter communications system that does this in the communications realm. See Col Don Wussler, "Space Superiority Systems Wing," PowerPoint presentation, 18 April 2007, http://www.smcindustrydays.org/2007/wussler.pdf. The effect of such actions is localized and temporary, without any escalatory consequences. Of course, the United States would respond to Chinese countermeasures with its own electronic counter countermeasure. This action-reaction is an integral part of warfare.

11. Folded within these assumptions is another belief that China will be able to execute an ASAT attack against a target satellite. Although the 2007 Chinese ASAT test demonstrated an intercept, there is no publicly available data on the conditions under which the test occurred. How long was the target satellite tracked? Was it transmitting telemetry data providing its orbital location information? These conditions matter. Unlike the United States, China has very limited low-Earth-orbit satellite tracking capability, most of which is based in its territory and possibly on a few ships. See Brian Weeden, Paul Cefola, and Jaganath Sankaran, "The Global Space Situational Awareness Sensors," Advanced Maui Optical and Space (AMOS) Surveillance Technologies Conference, 2010; and Ian Easton, *China's Evolving Reconnaissance-Strike Capabilities: Implications for the U.S.-Japan Alliance* (Arlington, VA: Project 2049 Institute and Japan Institute for International Affairs, February 2014), 12, http://www2.jiia.or.jp/pdf/fellow_report/140219_JIIA-Project2049_Ian_Easton_report.pdf. If the United States slightly changed the parameters of an orbit (e.g., its inclination) will China still be able to track, target, and intercept the satellite? The author has argued elsewhere that it is not feasible. See Jaganath Sankaran, "Debating Space Security: Capabilities and Vulnerabilities" (PhD diss., University of Maryland, August 2012), chap. 4, http://cissm.umd.edu/papers/display.php?id=599. However, for the purposes of this article, it is assumed that China would have the capability to target and intercept any satellite it chooses. The issue of contention is the capacity to simultaneously attack five or six satellites in higher orbits. It should be noted that China has made modest attempts to establish a globally spread optical satellite tracking network. In 2005, China led the formation of the Asia-Pacific Space Cooperation Organization (APSCO) with Bangladesh, Indonesia, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey as members. APSCO countries have planned a project, the Asia-Pacific Ground Based Optical Space Objects Observation System (APOSOS), to host Chinese-built observation sites in member state countries. Although still a plan on paper, if and when such a system materializes it would provide China with a far wider reach to track satellites. For now, however, China's satellite tracking capabilities are extremely limited. See James Clay Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press, 2012); and Jaganath Sankaran, "China-India Space Race: Rhetoric or Reality?," http://belfercenter.ksg.harvard.edu/files/chinaindiaspaceracterhetoricorrealitynotes.pdf.

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14. Sir Peter Anson and Dennis Cummings, "The First Space War," in *The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War,* ed. Alan D. Campen (Fairfax, VA: AFCEA International Press, 1992), 130.

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16. Anson and Cummings, "First Space War," 130.

17. "Space Launch Report," no date, http://www.spacelaunchreport.com/index.html.

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39. Lt Gen T. Michael Moseley, USAF, "Operation Iraqi Freedom—By the Numbers," USCENTAF Assessment and Analysis Division, April 2003, http://www.globalsecurity.org/military/library/report/2003/uscentaf_oif_report_30apr2003.pdf.

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45. Gen C. Robert Kehler, USAF, "Implementing the National Security Space Strategy," *Strategic Studies Quarterly* 6, no. 1 (Spring 2012): 18–26.

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65. Cheng, "China's Military Role in Space"; and Michael P. Pillsbury, "*An Assessment of China's Anti-Satellite and Space Warfare Programs, Policies, and Doctrines*," Report to the U.S.-China Economic and Security Review Commission, 19 January 2007.

66. The US Air Force space operations doctrine document, for example, defines *offensive space control* (OSC) as "operations that preclude adversaries from using space to their advantage by targeting their space systems, terrestrial systems, link or third party capability using a variety of permanent and/or reversible means." See "Annex 3-14: Space Operations," 19 June 2012, https://doctrine.af.mil/download.jsp?filename=3-14-D35-SPACE-OPS-OSC.pdf. This is very similar to how unofficial Chinese sources characterize their offensive space capability. For other sources examining Chinese space doctrine, see Joan Johnson-Freese, "A New US-Sino Space Relationship: Moving Toward Cooperation," *Astropolitics* 4, no. 2 (2006); Kevin Pollpeter, "The Chinese Vision of Military Space Operations," in *China's Revolution in Doctrinal Affairs,* eds. James Mulvenon and David Finkelstein (Washington: RAND, 2005); Zhang Hui, "Chinese Perspectives on Space Weapons," in *Russian and Chinese Responses to US Military Plans in Space*, eds. Pavel Podvig and Hui Zhang (Cambridge, MA: American Academy of Arts and Sciences, 2008); and Gregory Kulacki and Jeffery G. Lewis, "Understanding China's Antisatellite Test," *Nonproliferation Review* 15, no. 2, (2008).