EYES IN THE SKY

By Andrew S. Erickson

With 15 new satellites launched in 2008 alone and an ambitious program to produce more space-based surveillance technology, China is increasing its ability to monitor its near seas with deadly precision.

China is developing increasingly capable naval platforms, aircraft, and missiles that could hold U.S. Navy vessels and their supporting assets at risk in the Western Pacific. To employ these systems well, China will need effective information, surveillance, and reconnaissance (ISR). One element of ISR, an emerging network of space-based sensors, could improve the targeting capabilities of China's People's Liberation Army Navy (PLAN) and Second Artillery. This network promises to give the Chinese military unprecedented ability to monitor surface ships on China's maritime periphery. It might permit China to precisely target such ships with both cruise and ballistic missiles. Thus, this network could facilitate the devastating multi-axis saturation attacks envisioned widely by Chinese analysts.

Prioritization and Progress

China is expanding its military exploitation of space. According to the U.S. Department of Defense, "China has accorded building a modern ISR architecture a high priority in its comprehensive military modernization, in particular the development of advanced space-based C^4 [Command, Control, Communications, Computers] ISR and targeting capabilities."[1] Satellites, long prioritized for development by Chinese planners, are regarded increasingly as critical providers of real-time long-range maritime targeting. Maritime surveillance has been prioritized at the national level under China's 863 State High-Technology Development Plan. Its presence in this national-level planning guidance suggests that related technological developments are receiving significant funding and human capital.

Beijing's satellite capabilities, while far from cutting-edge, are improving rapidly. China today has only a fraction of the overall space capability of the United States, still has major gaps in coverage in every satellite application, and relies to a considerable extent on technology acquired through non-military programs with foreign companies, research institutes, and governments (e.g., Russia's). It will likely purchase commercial imagery products to supplement its current reconnaissance capabilities until it is able to deploy a more advanced set of surveillance satellites in the coming decade.[2]

But Beijing is combining foreign knowledge with increasingly strong indigenous capabilities to produce significant advances of its own. China launched 15 satellites in 2008 alone. Its satellite developers are experimenting with a new workplace culture that emphasizes modern management, standardization, quality control (including management initiatives based on international standards), and emerging high-volume production ability—part of a larger trend in its dual-use military/technological projects. China is developing at least five variants of three major small satellite buses. These mission-optimized, standardized platforms around which mass-production units are built will constitute the backbone of China's future small satellites, thereby reducing costs and enhancing reliability. Small satellites can be replenished rapidly and potentially deployed in constellations.

An Emerging Surveillance Satellite Network

China has developed military, civilian, and dual-use satellites. Among currently operational satellites, remote-sensing satellites include the *Fengyun*-1D and -3A weather satellites, capable of visible, infrared, and microwave imaging. Advanced imagery satellites include eight *Yaogan/Jianbing* high-resolution synthetic aperture radar (SAR) and electro-optical military satellites. China-Brazil Earth Resources Satellites (CBERS)-2 and -2B near real-time electro-optical satellites, with 2.7-meter resolution, are also used for military observation. According to Chinese media, the military now uses such satellites as *Beidou*-4 and *Tianlian*-1 for, respectively, positioning and data relay (near-real-time transmission of imagery data from a satellite passing over a target, but not within line of sight of a ground station).[3]

Given its overall emphasis on signals intelligence (SIGINT), China also may have communications satellites, or even dedicated versions, with electronic intelligence (ELINT) and SIGINT capabilities. There is no clear evidence in this regard, but that might be expected as nations guard such capabilities carefully. China apparently had a program in the 1970s to develop ELINT satellites, but its present status is unclear.

Roughly 40 Chinese small satellites (weighing 500 kg or less) have been launched to date. These include three *Shiyan*

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The remote-sensing satellite *Yaogan*-9 blasts off from the Jiuquan Satellite Launch Center in China's Inner Mongolia Autonomous Region, 5 March 2010. China has launched a number of these highly advanced satellites in rapid succession.

satellites with electro-optical sensors reportedly capable of 10m resolution. *Chuangxin*-1-02 is also electro-optical, and *Beijing*-1 offers panchromatic images with 4m resolution.

Ocean surveillance is a significant focus of Chinese satellite development. China launched its first maritime observation satellite, *Haiyang*-1A (HY-1A), on 15 May 2002. This satellite, which monitored ocean water color and temperature, had military applications; an official publication states that 12 percent of HY-1A's 2003 "satellite data distribution" was "military."[4] HY-1A stored data using a solid-state memory and downloaded it to receiving stations located near Beijing and in Sanya on Hainan Island. The satellite transmitted detailed data concerning the Taiwan Strait's aerosol silt distribution, ocean currents, coastal and ocean water interface, temperature distribution, and sea dynamics. A follow-on satellite, HY-1B, with double its predecessor's data capacity, was launched in April 2007 to survey the Yellow, East, and South China seas.

A total of 15 further *Haiyang* satellites are planned, in three sets over the next decade. The HY-1 series will monitor ocean color with an optical radiometer and sea-surface temperature with a medium spatial-resolution optical sensor. Eight satellites, designated HY-1C –J, will be launched in pairs every three years between 2010 and 2019.

The HY-2 series will employ a Ku/C dual-frequency radar altimeter, tri-frequency radiometer, Ku-band scan radar scatterometer, and a microwave imager to monitor sea surface wave field, height, and temperature. Four satellites, HY-2A –D, will be launched every three years over the same period.

The HY-3 series will use SAR sensors with 1-10m resolution and X-band radar to monitor maritime resources, pollution, and coastal zones. Three satellites will be launched in 2012, 2017, and 2022 respectively.[5] According to an analysis published by Taiwan's Navy, the *Haiyang* satellites are part of an "ocean monitoring system that has strengthened the PRC military's knowledge of . . . a potential Pacific Ocean battlefield."[6]

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Models of Chinese Long March rockets were displayed at the International Astronautical Congress in Daejeon, South Korea, in October 2009. With its emphasis on small satellites and low-cost launchers such as the ones pictured here, China is gaining the ability to rapidly increase the number of satellites in orbit if needed.

Likewise relevant to maritime surveillance will be China's eight-satellite *Huanjing* disaster/environmental-monitoring constellation, envisioned to contain satellites capable of visible, infrared, multi-spectral, and SAR imaging. Two initial satellites in the series, *Huanjing*-1A and -1B, provide real-time multi- and hyperspectral imaging, respectively, to a resolution of 30m.

Detecting and Tracking Maritime Targets

Satellite-based ISR will improve the ability of Chinese ballistic and cruise missiles to strike moving maritime targets. A DF-21D antiship ballistic missile (ASBM), for instance, might be launched on a modified ballistic trajectory—based in part on satellite data—aimed roughly at the position of a carrier strike group. Satellites might also be used to track and target the strike group, in part by supplying position updates. This could be a difficult process, as the ships likely would be moving unpredictably over a broad area and could employ a variety of countermeasures.

If engaged in air operations, the carrier strike group would have a large electromagnetic signature. Any ELINT-capable satellites that China develops could detect such radiation. Other initial detection systems include China's existing land-based sky-wave and surface-wave over-the-horizon (OTH) radars, which could detect aircraft Doppler. Arrays vary in capability, but surface-wave OTH radars might be expected to have a range of 200 to 300 kilometers. Such near-space vehicles as airships eventually might play a similar role as China develops persistent regional surveillance architecture.[7]

Inputs from these systems, in turn, could be used to task imaging satellites to search small areas to confirm identification of the carrier strike group. In descending level of utility for maritime target detection, imaging capabilities can be derived from radar, e.g., SAR; and multi- and hyperspectral, infrared, and electro-optical imaging. China has satellites with all such sensors; SAR in particular offers wide coverage at sufficient resolution (less than 1m in the case of China's *Yaogan*-6 satellite) to detect a carrier with its large deck—as much as four acres in area—or its wakes (which suggest its speed and direction) under a wide range of conditions. An ASBM could rely on SAR images for cueing, then on SAR for terminal guidance by employing on-board automated target recognition (ATR) software.

Accuracy requirements would increase as the "kill chain" progressed from mid-course maneuvers to terminal homing, potentially increasing the importance of ground-, sea-, underwater-, and air-based ELINT sensors in relation to space-based sensors. Antiship cruise missiles, which can be launched from PLAN submarines, surface vessels, and aircraft but have relatively short ranges, are much less likely to rely on satellite surveillance capabilities given their alternative targeting methods. These include on-board inertial navigation systems and radar and electro-optical sensors. Land-attack cruise missiles (LACMs), currently ground-launched by the Second Artillery and air-launched by the People's Liberation Army Air Force (PLAAF), are long-range strategic strike weapons not currently deployed on PLAN surface ships, perhaps because they are redundant in regional scenarios and thus suggestive of extra-regional offensive strike capability. LACMs, typically used against fixed targets, may also rely on similar targeting methods to antiship cruise missiles as well as terrain-contour mapping and digital scene-matching area-correlation technology.

Imaging satellites, which must be based in low-earth orbit, remain in constant motion, and thus take snapshots of pre-designated areas at periodic and predictable revisit times. Shifting orbits could temporarily improve coverage slightly, but would consume precious fuel. Hence, one can estimate coverage by examining satellites' orbits, inclinations, and periods. China currently has approximately 22 imaging satellites with sufficient resolution to play a role in detecting and tracking a carrier strike group, but this is insufficient for continuous satellite coverage based on revisit times for specific ocean areas.[8] China, however, may launch sufficient satellites to achieve coverage regionally by 2015 and globally by 2020.[9] Even before then, China's emphasis on small satellites and small solid-fueled rockets may allow it to achieve a satellite surge capability. China's low-cost launchers may offer a combination of rapid turnaround and efficiency. Upgrading of Wenchang Satellite Launch Center, China's fourth, indicates a commitment to cutting-edge facilities. Its 19 degrees north latitude location and port access allow for efficient launches and barge delivery of large boosters.


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People's Liberation Army trucks carrying DH-10 land-attack cruise missiles drive past Tiananmen Square in Beijing during a parade marking China's 60th anniversary, 1 October 2009. China's estimated 150 to 350 DH-10s can use a variety of guidance systems and satellite inputs to achieve an accuracy of 10 meters.

Join the SATNAV Club

Satellite navigation facilitates monitoring friendly forces and targeting the enemy by providing reliable positioning. It supports command and control by providing basic communications functions. China uses the U.S. GPS and Russian GLONASS networks as well as its indigenous *Beidou* satellite navigation system. Beijing has had only limited access to receiver technology and was denied access to the military mode of Europe's nascent *Galileo* system; this has apparently intensified existing Chinese efforts to develop *Beidou* further.

China deployed its own four-satellite *Beidou*-1 navigation constellation in 2007, but the system is limited to providing service from 70 to 140 degrees east longitude and from 5 to 55 degrees north latitude (essentially a rectangle covering all China's territorial and maritime claims) and navigation coverage accurate to within about 20 meters. This allows *Beidou*-1 to support ship-positioning on China's immediate maritime periphery, but not further afield. It could not be used for short-range precision guidance because it is too slow, allowing for insufficient down- and uplinking of information during a missile's relatively short flight time.

In part to support broader operations, China is deploying a 35-satellite (five geostationary, 30 medium-earth orbit) constellation—called *Beidou*-2/*Compass*—that would provide much improved accuracy, with regional navigation and communications coverage anticipated by 2011 and global navigation coverage by 2015–20. Three satellites have been launched thus far.

Compass will be faster and passive, like GPS (not active as *Beidou*-1 is, and which severely constrains its military use since detection is relatively simple). As of 2006, *Compass*'s commercial Open Service was projected to offer "positioning accuracy within 10 meters, velocity accuracy within 0.2 meters per second and timing accuracy within 50 nanoseconds."[10] The following year, China's official media announced that *Beidou* offered a resolution of 0.5m.[11] An even more accurate signal, coupled with system-status updates, will reportedly be available to the People's Liberation Army (PLA). Such accuracy would significantly enhance guidance of missiles and munitions, and allow for detailed digital mapping. Radio frequencies used by *Compass* may overlay both *Galileo*'s Public Regulated Service and possibly GPS's M-Code (a more jam-resistant U.S. military-only signal), and combine laser tracking, automation, and data fusion, thereby greatly complicating any adversary's attempts to jam *Compass* during conflict.

'Data Fusion' with 'Chinese Characteristics'

To target ships at sea, China will have to incorporate real-time sensor inputs into multi-sensor data correlation and fusion to be disseminated to commanders and shooters, perhaps through the *Qu Dian* integrated C4I system. Ground stations require improvements in manpower, downlinking speed, and bandwidth. Open sources offer no evidence that China has yet tested an ASBM at sea, to say nothing of running a series of tests to see if the re-entry vehicle seeker can pick an aircraft carrier out of the clutter of many other high-radar cross-section returns. The PLA can be expected to make progress in all these areas, but it will require significant effort.


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Construction began on the Wenchang Satellite Launch Center on Hainan Island in August 2009. Above: an artist's rendition of the center's launch pad. Scheduled to be completed by 2013, the launch site, China's fourth, demonstrates Beijing's commitment to leading-edge aerospace infrastructure.

Even with complete coverage of relevant maritime zones, data transmission, imagery readouts by analysts (increasing in time consumption with size of area examined), and sending targeting data to the shooter will impose time delays. Software and data requirements will be complex, and it remains unclear who will manage them and how. Command and control will likely pose a particular challenge. The PLA will have to coordinate (most likely through a joint theater command, which would probably fuse data) both among the many service elements that "own" various ISR sensor and ground-station architecture, and within the chain of command that would authorize their prioritization and use as well as the release authority (Central Military Commission, supreme command, or campaign command) for the weapons systems that would employ their inputs.

In addition to the PLAN (which controls sea, undersea, and some air assets) this will include the PLAAF (which controls most air assets, and likely at least some OTH and space tracking); the Second Artillery (which controls most ballistic missiles, and with its own operational/deployable intelligence regiment, takes imagery and other sensor data and inserts it into, e.g., the DH-10 LACM and presumably an ASBM); and the ground forces (which have apparently been given some ballistic missiles).

A new Chinese space force is rumored to be in development, but the PLAAF appears to be best placed to assume authority over space assets for now with its Central Military Commission–approved strategy, "integrated air and space, simultaneous offensive and defensive operations." The General Armaments Department and General Staff Department may be resistant to such a transfer of authority to the PLAAF, however, and the Second Artillery to relinquish its ambitions; institutional rivalry may complicate matters. The doctrine that would govern the actions of whatever organization consolidates control is likewise unclear. These factors, and not the technical parameters of satellites and other sensors themselves, will likely constitute the primary limitations on the effectiveness of Chinese satellite-based ISR employment.

We are thus likely to witness a larger pattern in which China rapidly deploys missile hardware that is formidable in technical parameters, but whose actual combat performance, while improving rapidly, remains unclear in important respects. China's mastery of detection, targeting, and particularly the computer-based and bureaucratic "data fusion" that support them will likely represent a moving target for U.S. analysts. They should thus employ a range of terminology, e.g., "initial threat availability," that evokes growing and relevant, but imperfect, capability. This disparity between technical parameters and integrated capability is somewhat analogous to naval warfare in World War I. There the range of the guns and the speed of the platforms were far more advanced than the targeting and command-and-control capabilities, which in some ways had not changed greatly since the Age of Sail.

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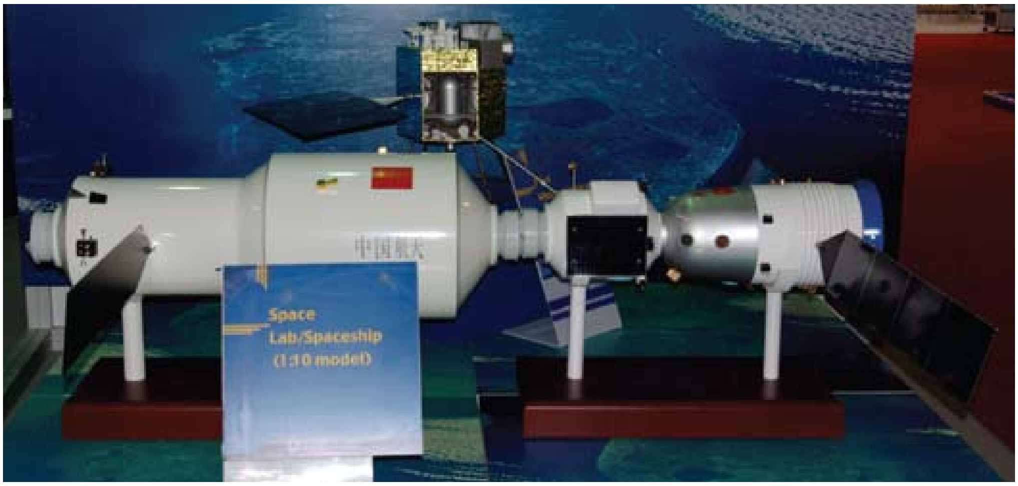

Models of China's planned *Fengyun*-4 satellite and *Tiangong* space station were on view at the 2009 Daejeon International Astronautical Congress. As part of its broad, multi-use satellite initiatives, China plans to launch six FY-4s beginning in 2013.

Future Outlook

The successful achievement of high-quality, real-time satellite target-locating data and reliable indigenous satellite navigation would be significant for the PLA. Given their potential for high resolution and accuracy, satellites will enhance Chinese ISR capabilities. Ongoing concerns about U.S. ability to intervene militarily, such as in a Taiwan Strait crisis, make Beijing likely to support relevant programs.

Satellites are only one component of a diverse, rapidly evolving, interactive architecture that, even as it increases in coverage and sophistication, remains different from that of the United States. The PLA has to be able to locate a carrier strike group on the ocean, limited to regions from which the group can strike China, and that is necessarily different from what the U.S. military has to do. With limited space and overseas ground assets and no formal overseas military bases on which it can rely, China has deployed the world's only major fleet of space-tracking ships. The increasingly sophisticated seekers on its missiles provide a variety of targeting options; it is possible that the DF-21D ASBM's seeker parameters are sufficient to cover the maximum radius in which a carrier strike group could move during the missile's flight time. And, given the PLAN's cultivation of a maritime militia and associated civilian vessels, and the PLA's apparent emphasis on cyber capabilities, it is not inconceivable that at least some rudimentary targeting data might be obtained via unconventional means. As one former PLA officer explained to the author, during the Vietnam War China was able to predict U.S. bombing runs with some precision by monitoring communications intercepts and commercial airline manifests. These factors suggest that U.S. analysts must not "mirror image" when assessing China's ISR targeting capabilities or assume that satellite capabilities are themselves definitive.

To the extent that the United States fails to deploy adequate countermeasures, China's growing space-based ISR capabilities will improve substantially the PLA's ability to hold at risk U.S. naval platforms in the Western Pacific. This would challenge U.S. interests in important areas and might be destabilizing initially. Threatening the core U.S. power-projection platform, the carrier strike group, could undermine U.S. ability to safeguard trade, maintain stability, and project influence in East Asia. Even the perception that China had gained such ability could have devastating effects, by convincing allied and friendly populations that America no longer had the wherewithal to advance their strategic interests in peacetime or protect them in the unfortunate event of conflict.

In a worst-case scenario, Chinese planners might even regard a conflict's expansion into space as favoring the PLA, which today could still function (albeit at a reduced level of capability) if denied access to space. As China's military becomes increasingly reliant on satellites, however, its own vulnerabilities increase, and as the United States further develops relevant countermeasures, China is likely to become more hesitant to use its growing ground-based anti-satellite capabilities (including lasers and kinetic direct ascent) to threaten U.S. satellites. A resulting increase in bilateral surveillance and early warning as well as strategic symmetry could thus ultimately enhance the substantial and growing chances that the two great powers avoid devastating conflict.

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