CHAPTER SEVEN

Chinese Air- and Space-Based ISR

Integrating Aerospace Combat Capabilities over the Near Seas

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China's progressively more potent naval platforms, aircraft, and missiles are increasingly capable of holding U.S. Navy platforms and their supporting assets at risk in the near seas and their approaches. Central to maximizing Chinese ability to employ these systems—and hence to consolidating China's aerospace combat capabilities over the near seas—are its emerging command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities. These systems will enable the Chinese military to strengthen coordination, cueing, reconnaissance, communications, and data relay for maritime monitoring and targeting, as well as to coordinate Chinese platforms, systems, and personnel engaged in these roles. Particularly important will be effective utilization of ISR, the collection and processing of information concerning potential military targets. Many platforms and systems can support such operations; this chapter focuses on those dedicated to such purposes, with the exception of unmanned aerial vehicles (UAVs) and helicopters, both of which are growing in importance but on which data are more difficult to verify at this time.

The successful achievement of high-quality real-time satellite imagery and target-locating data and fusion, as well as of reliable indigenous satellite positioning, navigation, and timing (PNT), would facilitate holding enemy vessels at risk via devastating multiaxis strikes involving precision-guided ballistic and cruise missiles launched from a variety of land-, sea-, undersea-, and air-based platforms in coordinated sequence. Emerging space-based C4ISR capabilities could thus greatly increase China's capacity to assert its interests militarily in, over, and beneath the near seas. Beijing has a clear strategic rationale and corresponding set of programs to master the relevant components, particularly for "counterintervention" operations in and around its near seas. Doing so could finally enable the People's Liberation Army (PLA) to translate its traditional approach of achieving military superiority in specific times and areas, even in a context of overall inferiority (以劣胜优), into the maritime dimension.

China has many ways to mitigate its limitations in C4ISR and target deconfliction for kinetic operations within the near seas and their immediate approaches, and potentially also for nonkinetic peacetime operations farther afield. Conducting high-intensity wartime operations in contested environments beyond the near seas, by contrast, would require major qualitative and quantitative improvements, particularly in aerospace, and impose corresponding vulnerabilities.

This chapter reviews dedicated Chinese air- and space-based ISR systems, examines one relevant operational scenario (tracking hostile surface ships in and around the near seas), considers China's remaining limitations, and concludes by assessing strategic implications for China's military and the U.S. Navy.

China's C4ISR Foundation and Emphasis

The PLA decided that it was necessary to develop "an integrated C4ISR system" in the early 1990s.[1] This was motivated by observations of U.S. prowess in Operation DESERT STORM, the U.S. role in the 1995–96 Taiwan Strait crisis, and the 7 May 1999 Belgrade embassy bombing. The subsequent development of network-centric warfare added further impetus. In addition to the cumulative impact of these events, it was perhaps physical destruction and damage to sovereignty by the Belgrade bombing that most strongly reinforced Jiang Zemin's visionary thinking concerning the future of warfare and catalyzed the support of other top leaders for decisive investment to realize this goal. Accordingly, in May 1999, China initiated the 995 Program (995 工程) to support megaprojects for the development of "assassin's mace" weapons, which promised disproportionate effectiveness vis-à-vis a top military power, such as the United States, despite China's overall technological inferiority.[2]

Essential to the integration and employment of the assassin's mace weapons thus developed since the late 1990s, Chinese C4ISR capabilities have improved markedly in parallel. This has occurred as part of a larger effort at "informatization," facilitated in part by development in civilian information technology and the telecommunications industry. As of China's 2008 defense white paper, the PLA aspired to establish a foundation for informatization by 2010, achieve major progress by 2020, and realize informatization by 2050.[3] In 2000, the PLA issued a manual, or outline (纲要), detailing the construction of "command automation systems," or "military information systems that possess command and control, intelligence and reconnaissance, early warning and surveillance, communications, electronic countermeasures, and other operational and information support capabilities with computers as the core."[4]

Over the next decade, "the PLA began to develop and field airborne and space-based ISR technologies, and it was during this time that Chinese military analysts began to consider the requirements and applications of C4ISR systems to be used by the PLA."[5] Today, in Larry Wortzel's assessment, "China's military reconnaissance capability is probably similar to the capabilities of Western sensor systems of the 1990s, a location to about ten meters in accuracy, clock geosynchronous signals to within 50 nanoseconds, and velocity to within 0.2 meters per second."[6] The Central Military Commission (CMC) and the General Staff Department (GSD) command center are linked redundantly with alternate command posts, military region headquarters, and subordinate units operating up to, and in some cases beyond, the "First Island Chain."[7] While the PLA has not achieved the level of situational awareness of its American counterpart, which can extend data-sharing to the individuals in many respects, all the PLA Navy's (PLAN's) "major combat ships are networked and can share data. In the PLA Air Force, a majority of newer fighter aircraft are able to share data and be part of an information system managed by the PLA's own airborne early-warning aircraft. For the ground forces, it looks like automation and information age systems have penetrated down to the regimental level."[8]

According to the U.S. Department of Defense, as of 2012 "the PLA [was] focused on developing C4ISR systems that will allow the military to share information and intelligence data, enhance battlefield awareness, and integrate and command military forces across the strategic, campaign, and tactical levels. A fully integrated C4ISR system, as envisioned by PLA leaders, would enable the PLA to respond to complex battlefield conditions with a high level of agility and synchronization."[9]

More broadly, developing a "high-resolution earth observation system," to include an "airborne remote sensing system" and a "national satellite remote sensing (ground) network system," is among sixteen national megaprojects prioritized in China's Eleventh Five-Year Plan (2006–10) and the "Outline of National Medium- and Long-Term Science and Technology Development" (2006–20).[10] This priority guarantees top leadership support and tremendous institutional, financial, and human resources.

Near-real/real-time C4ISR is facilitated increasingly by China's integrated Qu Dian (区电) military C4ISR system, which enables civilian and military leaders to communicate with forces in-theater using secure fiber-optic cables and both high-frequency and very-high-frequency communications and microwave systems, as well as related wireless networks and data links. These latter include airborne radio and communications relay and secure PLA voice/data communications provided by Fenghuo/Zhongxing/Shentong communications satellites. According to China's 2010 defense white paper, "The total length of the national defense optical fiber communication network has increased by a large margin, forming a new generation information transmission network with optical fiber communication as the mainstay and satellite and short-wave communications as assistance."[11] This system may be the equivalent of the U.S. Joint Tactical Information Distribution

System; China has developed, and possibly deployed, a related Triservice Tactical Information Distributed Network (三军战术数据分发系统).[12] These capabilities are currently structured to support near-seas operations. Extending high-intensity coverage much beyond the near seas, however, would be far more difficult in many respects.

Airborne ISR

Aircraft play an essential role in maritime reconnaissance because they are typically easier and cheaper to acquire than satellites and also because they can be rapidly redirected to new areas of priority in a fluid tactical environment. China's fixed- and rotary-wing aircraft and UAVs contribute to peacetime signals intelligence (SIGINT) and communications intelligence (COMINT); in wartime they would support air defense and antisubmarine warfare (ASW). Breakthroughs in the Beidou/Compass satellite system (discussed later) and high-speed data links, as demonstrated by China's airborne early-warning aircraft systems, are enabling rapid Chinese UAV progress.[13] Table 1 details major dedicated, manned, aerial C4ISR platforms. Sources for details on UAVs may be found in endnote 14 below.[14]

China employs a growing variety of aircraft as dedicated ISR platforms. If developed successfully, they could give China important aerial battle-management capacity. While the role of rotary-wing aircraft is limited, fixed-wing ISR aircraft, as indicated in table 1, are numerous and diverse; hence they are covered in detail below.

To support the effective use of the PLA Air Force (PLAAF) and PLAN aviation, China is attempting to improve its airborne ISR capabilities, in part by developing several variants of airborne early-warning (空中早期, AEW) aircraft. These include two major indigenous platforms meant to build on previous efforts.

Following cancellation of Israel's Phalcon sale amid mounting American pressure in 2000, China purchased A-50 AWACS (airborne warning and control system) aircraft, a modified Ilyushin Il-76, from Russia. China has been developing the KJ-2000 indigenous AWACS-type aircraft, based on the Russian A-50 airframe, to conduct surveillance, perform long-range air patrol, and thereby coordinate naval air operations. The KJ-2000 has phased-array radar, data processing, Identification Friend-or-Foe (distinguishing friendly, hostile, and unknown tracks), C3I (command, control, communications, and intelligence systems), and data-link capability—all Chinese developed.[15] According to Carlo Kopp, "this system employs radar technology two generations ahead of that used by the US Air Force's E-3C AWACS."[16] A mid-November 2007 exercise held jointly by the South Sea Fleet and the East Sea Fleet in the South China Sea reportedly included employment of one or more KJ-2000s.[17] Four or more KJ-2000s are reportedly operational with the PLAAF's 26th Air Division.[18]

Table 1. *Selected Chinese Manned Airborne ISR Platforms*

		Type	Manufacturer	Role	Number in Service	Location	First Delivery
fixed wing	PLAAF	Y8T / Gaoxin 4	Sha'anxi Aircraft Corporation (SAC [Sha'anxi])	command post (C3I)	3	Nanjing Military Region (MR), 76th Air Regiment, 26th Air Division, Wuxi-Shuofang?	2007
		B-4052/737-300	Boeing, U.S. / Xi'an Aircraft Company Limited (XAC) modified	command post (C3I)	2		?
		KJ-2000 (A-50 Mainstay / Il-76MD)	Beriev, Russia / XAC-modified	airborne early warning and control (AEW&C)	4–5	Nanjing MR, 76th Air Regiment, 26th Air Division, Wuxi-Shuofang?	2004
		Y-8W/KJ-200	SAC (Sha'anxi)	AEW&C	4–5	Nanjing MR, 76th Air Regiment, 26th Air Division, Wuxi-Shuofang?	2007
		H-6B/HZ-6	XAC	reconnaissance/ELINT	1+	?	1979
		H-5/HZ-5	Harbin Aircraft Manufacturing Corporation (HAMC)	ISR	7	?	1966–82
		Su-30MKK Flanker	Sukhoi, Russia	reconnaissance/ surveillance (SAR capability on one airframe demonstrated 2003)	73*	?	2000
		JH-7A	XAC	strike fighter / bomber (configuration variant, e.g., with BM/KZ-900 SIGINT pod)	83*	?	2004
		Y-8H	XAC	reconnaissance/ surveillance	2?	?	
		Y-8CB / Gaoxin 1 Karakoram Eagle	SAC (Sha'anxi)	reconnaissance/ surveillance, COMINT	6	Nanjing MR, EW Flight Regiment, 10th Air Division, Nanjing-Dajianchang?	2005–2009

Table 1. *(continued)*

	Type	Manufacturer	Role	Number in Service	Location	First Delivery
	J-8F/JZ-8FR	Shenyang Aircraft Corporation (SAC [Shenyang])	tactical reconnaissance/ surveillance	24	Shenyang MR, 3rd/4th Independent Fighter Reconnaissance Regiment, 30th Fighter Division, Shenyang Yuhuntun; and/or 78th Reconnaissance Regiment, Suzhou; and/or Jinan MR, 1st Independent Fighter Reconnaissance Regiment, 31st Fighter Division, Wendeng?	?
	J-8I/JZ-8	SAC (Shenyang)	reconnaissance/ surveillance	24		?
	J-8/JZ-6	SAC (Shenyang)	reconnaissance/ surveillance	48	Guangzhou MR, 2nd Independent Fighter Reconnaissance Regiment, 42nd Fighter Division, Taihe; and Nanjing MR, 3rd Independent Fighter Reconnaissance Regiment, 29th Fighter Division, Suzhou?	1976
	Y-8G / Gaoxin 3	SAC (Sha'anxi)	SIGINT and/or communications relay	10	Shenyang MR, 3rd/4th Independent Fighter Reconnaissance Regiment, 30th Fighter Division, Shenyang Yuhuntun; and/or Nanjing MR, 30th Air Regiment, 10th Air Division, Anqing North?	before 2011

Table 1. *(continued)*

	Type	Manufacturer	Role	Number in Service	Location	First Delivery
	Y-8EW / Gaoxin 8	SAC (Sha'anxi)	dorsal satellite communications dome + antennas; ELINT?	N/A		At China Flight Test Establishment, April 2011
	Tu-154M/D Careless	Tupolev, Russia	EW/ELINT/SIGINT	4	102nd Air Regiment, 34th Transportation Division, Beijing-Nanyuan?	1998
	HD-6	XAC	EW	1+	?	
	Y-8XZ/ECM, Gaoxin 7	SAC (Sha'anxi)	EW	2	Nanjing MR, 30th Air Regiment, 10th Air Division, Anqing North; and/or Shenyang MR, 4th Independent Electronic Warfare Regiment, Shenyang Yuhuntun; and/or Nanjing MR, 30th Electronic Warfare Regiment, 10th Bomber Division, Nanjing Dajiaocang?	2007
PLAN	Y-8J/W/WH, KJ-200, Gaoxin 5	SAC (Sha'anxi)	AEW&C	4–6	North Sea Fleet (NSF), 1st Independent Air Regiment, 5th Fighter Aviation Division, Liaoyang?	1998
	H-5/HZ-5 (Il-28 Beagle)	HAMC	ISR	7–24	NSF, 5th Bomber Aviation Regiment, 2nd Bomber Aviation Division?	1966–82
	JH-7A	XAC	strike fighter / bomber (configuration variant, e.g., with BM/KZ-900 SIGINT pod)	75*	?	2004

Table 1. *(continued)*

		Type	Manufacturer	Role	Number in Service	Location	First Delivery
		JH-7	XAC	strike fighter / bomber (configuration variant, e.g., with BM/KZ-900 SIGINT pod)	50–65*	?	1998
		Y-8JB/DZ, Gaoxin 2	SAC (Sha'anxi)	SIGINT, reconnaissance/ surveillance, and/or ELINT	5	NSF, 1st/3rd Independent Air Regiment, 5th Fighter Aviation Division, Liaoyang; 1 in South Sea Fleet, 7th Independent Air Regiment, Sanya/ Yaxian?	2004
		Sh-5	HAMC	maritime patrol / surveillance	4	NSF, 3rd Independent Air Regiment, 5th Fighter Aviation Division, Tuandao?	1986
		Y-8X	SAC (Sha'anxi)	maritime patrol / ASW	5	NSF, 1st Independent Air Regiment, 5th Fighter Aviation Division, Liaoyang?	1985
		Y-8Q / Gaoxin 6	SAC (Sha'anxi)	ASW	1–5	NSF, 1st Independent Air Regiment, 5th Fighter Aviation Division, Liaoyang?	
rotary wing	PLAN	Ka-31B	Kamov, Russia	AEW	8	?	?
		Zhi (Z)-8YJ/SA-321 Super Frelon	Changhe Aircraft Industries Group; French technology, license production	AEW	2	?	?

Notes:
Question marks indicate information not available in reliable open sources.

Owing to the profusion of constantly evolving Y-8/Gaoxin variants—many of which overlap in function—as well as extreme difficulty in determining where a given aircraft is deployed at a given time, data in this table must be interpreted with particular caution.

* Many of these may not be ISR-focused/equipped.

Sources: "Chinese SIGnals INTelligence (SIGINT) Air Vehicles," Command Information Systems, China, *IHS Jane's,* 23 December 2013, www.janes.com; Institute for International Strategic Studies, *The Military Balance 2013* (London: Routledge, 2013), pp. 286–95; "China: Air Force," *Jane's World Air Forces,* 4 June 2013, www.janes.com/; "Air Force, China," *Jane's Sentinel Security Assessment: China and Northeast Asia,* 17 September 2013, www.janes.com/; "World Navies: China," *Jane's World Navies,* 4 October 2013, www.janes.com/; "XAC KJ-2000," *Jane's All the World's Aircraft,* 8 July 2013, www.janes.com/; "SAC Y-8 (Special Mission Versions)," *Jane's All the World's Aircraft,* 7 July 2013, www.janes.com/; "XAC H-6," *Jane's All the World's Aircraft,* 8 July 2013, www.janes.com/; "Kamov Ka-31 Helix B," *Jane's Fighting Ships,* 11 February 2013, www.janes.com/; Andreas Rupprecht and Tom Cooper, *Modern Chinese Warplanes: Combat Aircraft and Units of the Chinese Air Force and Naval Aviation* (Houston, Tex.: Harpia, 2012), pp. 83–87, 110–12, 219. And see Erickson, "China's Modernization of Its Naval and Air Power Capabilities," pp. 114–15, 117, 120.

China's Y-8 medium-range transport airframe, derived from Russia's Antonov An-12 Cub transport and produced under license by the Sha'anxi Aircraft Industry (Group) Corporation, is the basis for eight Gaoxin ISR variants.[19] They perform such missions as electronic intelligence (or ELINT—variant one; and possibly an eighth variant), SIGINT (variant two), SIGINT and/or communications relay (variant three), electronic warfare / electronic countermeasures / C3I (variants four and seven), airborne early warning (variant five), and ASW (variant six).[20] Tupolev Tu-154 variants perform similar roles.

China's smaller KJ-200/Y-8 Balance Beam maritime patrol, electronic warfare, airborne-early-warning and control aircraft, with its electronically steered, active, phased-array radar (similar in appearance to, but larger than, Sweden's Ericsson Erieye active phased-array radar), complements the KJ-2000 by performing tactical AEW and ELINT more economically.[21] Various sources report that a KJ-200 aircraft crashed on 4 June 2006, killing forty people and possibly setting back the program.[22] But the program appears to be back on track, and Carlo Kopp believes that the KJ-200's technology is "two generations ahead of the mechanically steered technology used by the US."[23] On 12 March 2010, a PLAAF KJ-200 may have been spotted by the Japan Maritime Self-Defense Force near the Miyako Strait.[24] Like the KJ-2000, the KJ-200 is reported to be in service with the PLAAF's 26th Air Division;[25] the PLAN has apparently taken delivery of its first KJ-200s as well.[26]

In addition to its two dedicated AWACS platforms, and the numerous and diverse Y-8 Gaoxin variants detailed above, the PLAAF and PLAN have reconnaissance regiments with a wide range of other specialized aircraft. Relevant fixed-wing types include a number of H-6s, derivatives of Russia's Tu-16 Badger, which also conduct reconnaissance and ELINT.[27] As part of a late-2003 exercise, an Su-30MKK fighter used a new synthetic aperture radar (SAR) to surveil the length of Taiwan.[28] A portion of the PLAN and PLAAF's JH-7A strike fighter / bombers, together with the older JH-7 variant still employed by the PLAN, are apparently outfitted with BM/KZ-900 SIGINT pods.[29]

Beyond the strictly military dimension, as China strengthens its maritime law-enforcement forces and consolidates the majority of them under the State Oceanic Administration, their airborne surveillance capabilities may grow apace. On 5 March 2009, a Y-12 maritime surveillance aircraft conducted twelve fly-bys of USNS *Victorious* (T-AGOS 19), operating in international waters in the Yellow Sea, at an altitude of four hundred feet, range five hundred yards; the following day, a Y-12 conducted eleven fly-bys of USNS *Impeccable* (T-AGOS 23), operating in international waters in the South China Sea, at an altitude of six hundred feet and a range of between a hundred and three hundred feet.[30]

Space-Based ISR

Space capabilities underpin China's current naval and other military capabilities for the near seas. The successful achievement of reliable indigenous satellite navigation and high-quality real-time satellite imagery and target-locating data will greatly strengthen PLA capabilities. While still purchasing supplementary imagery, Beijing is combining foreign knowledge with increasingly robust indigenous capabilities to produce significant advances in maritime C4ISR.

China has developed a full range of military, civilian, and dual-use satellites of various mission areas and sizes. While they still face difficulties involving reliability and life span, these systems are improving rapidly.[31] China uses a variety of satellites to link sensors to shooters and to support related network functions. China's second data-relay satellite, *Tianlian-1-02/B,* provides "near real-time transfer of data to ground stations from manned space capsules or orbiting satellites";[32] *Tianlian-1-03,* launched on 25 July 2012, further extends and strengthens this capacity.[33] China's ground stations and Yuanwang-class space-event support ships add important telemetry, tracking, and command capacity. China is moving cautiously with respect to establishing overseas ground stations but plans by 2030 to have established "network nodes" at the North Pole, at the South Pole, and in Brazil as part of a "Digital Earth Scientific Platform."[34] The *Fenghuo-1* communications satellite and its identically named follow-on reportedly support military operations.[35] China has made great progress in small-satellite development; its satellites under five hundred kilograms now boast high performance, in addition to low weight. The 9.3 kg *Tiantuo-1* nano-satellite, launched on 10 May 2012, receives signals from China's shipborne Automatic Identification System.[36] The Shijian series of experimental satellites is testing new technologies. Satellite surveying and mapping are being exploited by a variety of services, including the PLAN. One South Sea Fleet unit developed a reportedly combat-relevant "Stipulated Technical Procedure for Maritime Terrain Digitized Satellite Surveying and Mapping."[37]

Maritime Surveillance Satellites

China's reconnaissance-capable satellites include electro-optical (EO), multi- and hyperspectral, and radar, especially SAR. Maritime-relevant variants include Fengyun (FY), the China-Brazil Earth Resources Satellite (CBERS), Ziyuan (ZY), the Disaster Monitoring Constellation (DMC), Haiyang (HY), Huanjing (HJ), and Yaogan (YG) satellites. Chinese sources categorize the Shenzhou (SZ) manned spacecraft, which remain as orbital modules after their crews return to earth, and the *Tiangong* (TG) space-station module launched in 2011, as relevant to reconnaissance.[38] Fengyun weather satellites provide visible, IR, and microwave imaging. Possible future launches include FY-2G and -2H in 2014, FY-3D/PM1 and FY-4 M in 2015, FY-3E/AM1 in 2017, FY-3F/PM2 in 2019, FY-3G/AM3 in 2021, FY-3H/PM3 in 2023, and FY-4 O at an unspecified date. FY-2H and FY-4 O and M will be geostationary; all others have polar orbits. Three satellite series are particularly relevant to maritime monitoring. The CBERS polar near-real-time electro-optical satellites, with 2.7-meter resolution, are used for military observation. CBERS-3 and -4 follow-ons, with resolution halved to ten meters through PAN-MUX optical sensors, may be launched as early as 2013. Yaogan satellites are already so numerous that they must be addressed separately (in the next section).

Ocean surveillance, a significant focus of Chinese satellite development, has been prioritized at the national level as one of eight pillars of the 863 State High-Technology Development Plan.[39] China launched its first three Haiyang polar maritime observation satellites in 2002 (no longer operational), 2007, and 2011. Roughly a dozen further Haiyang ocean-monitoring satellites are planned, in three sets over the next decade, with HY-1E/F possibly set for launch at this writing in 2013, HY-2C in 2015, HY-1G/H in 2016, HY-3B in 2017, HY-2D in 2018, and HY-1C/D, HY-2B, and HY-3A at unspecified dates.[40] Initial follow-ons will have three-meter resolution. China's Huanjing visible-, IR-, multispectral-, and SAR-imaging constellation is designed, once eight additional satellites join the three already in polar orbits beginning in 2013 or later, to form a complete image of China every twelve hours.[41] Table 2 surveys maritime-relevant remote-sensing satellites currently in orbit.

High-Resolution Reconnaissance, Possible ELINT Satellites: Yaogan

China's Yaogan series of twenty-three advanced, paired SAR and EO remote-sensing satellites, operating in near-polar, sun-synchronous orbits, "may provide multiwavelength, overlapping, continuous medium resolution, global imagery of military targets."[42] The series was reportedly "implemented" (实施) by China National Space Administration, though this nominally civilian organization lacks the institutional autonomy of the U.S. National Aeronautics and Space Administration.[43] With its high-resolution (five-meter) L-band SAR, *Yaogan-1* was China's first synthetic-aperture-radar satellite. SAR Yaogans are optimized for monitoring "ocean dynamics, sea surface characteristics, and coastal zones" (海洋动力, 海表特征, 海岸带), as well as "observing sea-surface targets and shallow-water bathymetry" (海面目标, 浅海地形等观测).[44] EO Yaogans, which appear to be based on the China Academy of Space Technology (CAST)–2000 small-satellite "bus" (that is, standardized "backbone" platform on which the satellite is built), monitor land and sea areas, including "coastal zones" (海岸带), with resolution as fine as a half-meter.[45] Sometimes using orbit maneuver capability, Yaogans have attained a variety of orbits, some lower than five hundred kilometers to increase resolution.[46] A major Chinese study on the nation's remote-sensing satellites states that Yaogan satellites are "very

Table 2. *China's Currently Operational Earth Observation Satellites*

Satellite	NORAD ID	International Code	Contractor	Launch Date/ Time (UTC)	Launch Site
FY-2D	29640	2006-053A	Shanghai Institute of Satellite Engineering, Shanghai Academy of Spaceflight Technology (SAST)	2006.02.18 16:53:00	Xichang
FY-2E	33463	2008-066A	SAST	2008.12.23 00:54:00	Xichang
FY-2F	38049	2012-002A	SAST	2012.01.13 00:56	Xichang
FY-3A/ AM	32958	2008-026A	SAST	2008.05.27 03:02	Taiyuan
FY-3B/PM	37214	2010-059A	SAST	2010.11.04 18:37:00	Taiyuan
CBERS-2	28057	2003-049A	CAST	2003.10.21 00:00:00	Taiyuan
CBERS-2B	32062	2007-042A	CAST	2007.09.19 03:26:00	Taiyuan
ZY-2B	?	?	?	2002.10.27	Taiyuan?
ZY-2C	28470	2004-044A	?	2004.11.06 03:10:00	Taiyuan
ZY-3	?	?	?	2012.01.09 03:17:00	Taiyuan
DMC/ BJ1/ *Tsinghua*	28890	2005-043A	?	2005.10.27 06:52:00	Plesetsk (Russia)
HY-1B	31113	2007-010A	?	2007.04.11 03:27	Taiyuan

Launch Vehicle	Orbit; Perigee × Apogee (km); Inclination (°); Period (min.); Semimajor Axis (km)[a]	Mass (kg)	Primary Sensors	Resolution (m)	Ocean Applications
CZ-3A	geostationary; 35,784.7 × 35,805.4; 1.6°; 1,436.2; 42,166	1,380	VISSR-2	?	sea temperature, color, meteorology; images every 30 min.
CZ-3A	geostationary; 35,784.7 × 35,807.4; 1.2°; 1,436.2; 42,167	1,390	VISSR-2; visible and infrared high-resolution cloud imagery	?	sea temperature, meteorology; images every 15 min.
CZ-3A	geostationary; 35,774.1 × 35,806.5; 1.3°; 1,435.9; 42,161	1,369.0	Stretched Visible and Infrared Spin Scan Radiometer	?	sea temperature, meteorology; images every 15 min.
CZ-4C	polar; 828.1 × 841.2; 98.6°; 101.5; 7,205	2,295	MERSI ocean color, VIRR IR sensors; MWRI microwave radiometer	?	sea color, temperature, wind speed, coastal zones, meteorology
CZ-4C	polar; 833.2 × 836.2; 98.8°; 101.5; 7,205	2,299	VIRR, MERSI, MWRI; 11 instruments capable of global, all-weather, multispectral, 3-dimensional, quantitative Earth observations	?	sea color, temperature, wind speed, coastal zones, meteorology
CZ-4B	polar; 781.4 × 782.6; 98.2°; 100.3; 7,152	1,600	CCD, infrared multispectral scanner (IRMSS), WFI	20	coastal zones
CZ-4B	polar; 746.6 × 791.5; 98.3°; 100.1; 7,140	1,500	CCD, WFI, HR	20 (CCD), 2 (HR)	coastal zones
?	polar	?	HR, PAN-MS	2 (HR), 5 (PAN-MS)	land, coastal zones
CZ-4B	polar	?	HR, PAN-MS	2 (HR), 5 (PAN-MS)	coastal zones
?	polar	2,630	HR, PAN-MS, CC DX2; 3 high-resolution panchromatic cameras, IRMSS	2 cameras (front/rear-facing): 3.5 m (spectral). Ground-facing camera: 2.1 m (spectral). IRMSS: 6.0 m (spectral).	coastal zones, high-resolution remote sensing, stereo mapping
Cosmos (Russian)	polar	?	PAN-MS	32/4	coastal zones
CZ-2C	polar; 787.4 × 811.2; 98.4°; 100.7; 7,170	?	COCTS, CZI; ocean color, IR, temperature sensors	?	sea color, sea temperature, coastal zones

Table 2. *(continued)*

Satellite	NORAD ID	International Code	Contractor	Launch Date/ Time (UTC)	Launch Site
HY-2A	37781	2011-043A	?	2011.08.15	?
HJ-1A	33320	2008-041A	?	2008.09.06 03:25:00	Taiyuan
HJ-1B	?	?	?	2008.09.06 03:25:00	Taiyuan
HJ-1C	38997	2012-064A	?	2012.11.18 22:53:00	Taiyuan
SZ-1	25956	1999-061A	?	1999.11.19 22:30:00	Jiuquan
SZ-2	26664	2001-001A	?	2001.01.09 01:00:00	Jiuquan
SZ-3	27397	2002-014A	?	2002.03.25 14:00:00	Jiuquan
SZ-4	27630	2002-061A	?	2002.12.29 16:40:00	Jiuquan
SZ-5	28043	2003-045A	?	2003.10.15 01:00:00	Jiuquan
SZ-6	28879	2005-040A	?	2005.10.12 01:00:00	Jiuquan
SZ-7	33386	2008-047A	?	2008.09.25 13:10:00	Jiuquan
SZ-8	37859	2011-063A	?	2011.10.31 21:58:00	Jiuquan
SZ-9	38461	2012-032A	?	2012.06.16 10:37:00	Jiuquan
SZ-10	39179	2013-029A 2013-029H (orbital module)	?	2013.06.11 09:38:00	Jiuquan

Launch Vehicle	Orbit; Perigee × Apogee (km); Inclination (°); Period (min.); Semimajor Axis (km)[a]	Mass (kg)	Primary Sensors	Resolution (m)	Ocean Applications
?	polar; 973.3 × 973.7; 99.4°; 104.4; 7,344	?	microwave radiometer, altimeter, scatterometer	?	ocean surveillance: sea surface winds, wave height, and water temperatures
CZ-2C	polar; 632.8 × 672.9; 97.8°; 97.6; 7,023	?	CCD; optical, infrared cameras; SAR; hyperspectral imager	30	sea color, red tide, vegetation, oil spills, coastal zones, sea temperature
CZ-2C	polar	?	CCD; optical, infrared cameras; SAR	30	sea color, coastal zones, sea temperature
CZ-2C	polar	890	?	?	1st radar satellite in China's environment & disaster monitor constellation, operating w/ *HJ-1A/1B* optical satellites
CZ-2F	195 × 315; 89.6; 42.6°; 0.00905	7,600.0	?	?	?
CZ-2F	330 × 346; 91.3; 42.6°; 0.00119	?	?	?	orbital module conducted zero-gravity experiments
CZ-2F	332 × 337; 91.2; 42.4°; 0.00037	?	?	?	orbital module
CZ-2F	196 × 329; 89.8; 42.4°; 0.01001	?	?	?	?
CZ-2F	?	?	?	?	?
CZ-2F	342 × 350; 91.46; 42.4°; 0.00059	?	?	?	orbital module conducted scientific research
CZ-2F	329 × 336; 91.2; 42.4°; 0	?	?	?	?
CZ-2F	?	8,080.0	?	?	?
CZ-2F	?	?	?	?	?
CZ-2F	?	7,800.0	?	?	left orbital module

Table 2. *(continued)*

Satellite	NORAD ID	International Code	Contractor	Launch Date/ Time (UTC)	Launch Site
TG-1	37820	2011-053A	?	2011.09.29 13:16:00	Jiuquan

useful for monitoring dynamics of the ocean environment and maritime monitoring” (对于海洋动力环境和海洋监视监测十分有用).[47]

Yaogan-9; *Yaogan-16A, B,* and *C;* and *Yaogan-17A, B,* and *C* constellations may constitute a vital part of a larger long-range ship-tracking and targeting ISR network. Flying in triangular formation in similar orbits at identical inclinations, each constellation apparently contains

> an electro-optical surveillance satellite, a Synthetic Aperture Radar (SAR) satellite, and possibly an electronic/signal intelligence satellite. Designed for location and tracking of foreign warships, the satellites collect optical and radio electronic signatures of naval vessels that are used in conjunction with other information by the Chinese Navy. . . . They are thought to be able to find and track large Western warships, providing accurate positioning data for targeting by land-based antiship ballistic missile systems.[48]

This is similar to the first and second generations of the U.S. Navy’s WHITE CLOUD Naval Ocean Surveillance System, which reportedly detected surface vessels by sensing their electronic emissions, identifying them on the basis of their operating frequencies and transmission patterns, and locating them using triangulation and time distance of arrival.[49] In a trio of Yaogan satellites, then, one satellite would monitor a wide expanse of ocean but could not locate emitting ships precisely; two satellites together would locate emitting ships, albeit still imperfectly; and the inputs of a third satellite would locate emitting ships precisely. The ships’ locations would then be transmitted to the relevant parts of the PLA reconnaissance-strike complex.[50] The Yaogan-9 system has apparently been superseded by the -16 and -17 systems, as *Yaogan-9B* has apparently fragmented into two pieces.[51] See table 3.

China possesses dedicated ELINT and SIGINT satellites.[52] China reportedly launched an ELINT satellite program, the 701 Program, in the late 1960s. Following a lengthy hiatus, during which its primary ELINT capabilities were land-based and airborne, China has redeveloped interest in dedicated satellite-based ELINT applications, and Chinese experts have conducted considerable research in this area.[53] As Mark Stokes and Ian Easton point out, China may have long launched “unidentified ELINT sensors attached to other satellite payloads, and recent launches simply represent an increase in dedicated systems.”[54] China’s Shijian satellites, particularly the -6 series, launched in four pairs from 2004 to 2010, are believed by some Western sources to perform SIGINT missions.[55]

Launch Vehicle	Orbit; Perigee × Apogee (km); Inclination (°); Period (min.); Semimajor Axis (km)[a]	Mass (kg)	Primary Sensors	Resolution (m)	Ocean Applications
CZ-2F	?	8,506.0	?	?	?

Notes:
Question marks indicate information not available in reliable open sources.

a. Data from "Real Time Satellite Tracking and Predictions," *ITPROSTAR,* which are typically more detailed, are used by default, except in the case of Shenzhou spacecraft, which *ITPROSTAR* does not include. For Shenzhou spacecraft, data are from "National Space Science Data Center Master Catalog," *NASA,* nssdc.gsfc.nasa.gov/. Contrary to the general column heading, orbit values from NASA for Shenzhou spacecraft are for periapsis, apoapsis, period, inclination, and eccentricity.

Sources: He Mingxia et al.,"Chinese Spaceborne Ocean Observing Systems and Onboard Sensors (1988–2025)," pp. 91–103; "Real Time Satellite Tracking and Predictions," *ITPROSTAR,* www.n2yo.com/; "National Space Science Data Center Master Catalog," *NASA,* nssdc.gsfc.nasa.gov/; "Fengyun Series," *Jane's Space Systems and Industry,* 2 July 2012.

These might include time distance of arrival and frequency distance of arrival of electronic signals received, as well as other geo-location techniques, to triangulate the position of U.S. carrier strike groups (CSGs) and other ships at sea for near-real-time tracking and targeting.[56]

Supporting PNT: Beidou/Compass Satellites

By offering reliable location signals, PNT facilitates command and control and also monitoring of friendly forces and targeting of enemy ones. The PLA regards autonomous reliability in this area as vital. A retired senior PLA official alleges that PLA analysis has concluded that unexpected Global Positioning System (GPS) disruption likely caused the PLA to lose track of the second and third missiles of a three-missile salvo fired into the East China Sea 18.5 kilometers from Taiwan's Keelung naval port in March 1996, as part of a larger effort to deter what Beijing perceived to be pro–Taiwan independence moves. "It was a great shame for the PLA . . . an unforgettable humiliation. That's how we made up our mind to develop our own global [satellite] navigation and positioning system, no matter how huge the cost. Beidou is a must for us. We learned it the hard way." Retired PLA general Xu Guangyu adds that China's Beidou and Yuanwang systems guarantee that "there is no chance now for the U.S. to use its GPS to interfere in our operations at all."[57]

Fearing that it might lose access to PNT provided by U.S. GPS and Russian GLONASS (Global Navigation Satellite System) systems in the future, and having been denied access to the military mode of Europe's nascent Galileo system, China is developing its own—Beidou/Compass (北斗卫星导航定位系统).[58] The director of the China Satellite Navigation and Locating Applications Management Center, Yang Baofeng, terms it "the

Table 3. *Yaogan Satellites Currently Operational: Notional Specifications*

Yaogan #	Military Designation	NORAD ID	International Code	Contractor	Launch Date/ Time (UTC)
2	JB-6-1	31490	2007-019A	DFH / CAST 508 Institute	2007.05.25 07:12:00
3	JB-5-2	32289	2007-055A	SAST	2007.11.11 22:48:00
4	JB-6-2	33446	2008-061A	DFH / CAST 508 Institute	2008.12.01 04:42:00
5	JB-8-1	33456	2008-064A	DFH / CAST 508 Institute / Xi'an Institute of Optics and Precision Mechanics	2008.12.15 03:22:00
6	JB-7-1	34839	2009-021A	SAST	2009.04.22 02:55:00
7	JB-6-3	36110	2009-069A	DFH / CAST 508 Institute	2009.12.09 08:42:00
8	JB-7-2?	36121	2009-072A	SAST / Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP)	2009.12.15 02:31:00
9A/B/C	?	36413, 36414/38303, 36415	2010-009A, 2010-009B/G, 2010-009C	DFH / CAST 508 Institute	2010.03.05 04:55:00
10	JB-5-3	36834	2010-038A	SAST	2010.08.09 22:49:00
11	JB-6-4	37165	2010-047A	DFH / CAST 508 Institute	2010.09.22 02:42:00
12	JB-8-2	37875	2011-066B	DFH / CAST 508 Institute / Xi'an Institute of Optics and Precision Mechanics	2011.11.09 03:21:00
13	JB-7-2	37941	2011-072A	SAST	2011.11.29 18:50:00
14	?	38257	2012-021A	CAST 508 Institute / CIOMP	2012.05.10 07:06:00
15	?	38354	2012-029A	CAST 508 Institute / CIOMP	2012.05.29 07:31:00
16A/B/C	?	39011, 39012, 39013	2012-066A, 2012-066B, 2012-066C	DFH / CAST 508 Institute	2012.11.25 04:06:00

Launch Site	Launch Vehicle	Orbit: Perigee × Apogee (km), Inclination (°), SSO Time on Descending Node	Transmission Frequency (MHz)	Mass (kg)	Type
Jiuquan	CZ-2D	631 × 655, 97.8, 13:30	2,216.527	800?	EO; HR, PAN-MS
Taiyuan	CZ-4C	627 × 629, 97.9, 06:00	2,212.809	2,700	L-band SAR
Jiuquan	CZ-2D	640 × 660, 97.9, 11:00	2,216.525	800?	EO; HR, PAN-MS
Taiyuan	CZ-4B	488 × 495, 97.4, 10:30	2,220.5	2,700	L-band SAR
Taiyuan	CZ-2C	511 × 513, 97.6, 10:00	?	2,000?	L-band SAR
Jiuquan	CZ-2D	630 × 666, 97.8, 15:00	2,216.527	800?	EO; HR, PAN-MS
Taiyuan	CZ-4C	1,200 × 1,211, 100.5, 09:30	2,266.3	1,040	L-band SAR
Jiuquan	CZ-4C	(9A) 1,089 × 1,106, 63.4; (9B) 1,060 × 1,076, 63.4; (9C) 1,089 × 1,107, 63.4	2,218 (9B)	1,000? (9A)	EO; HR, PAN-MS/ SAR/ELINT?
Taiyuan	CZ-4C	615 × 629, 97.8, 06:00	?	2,700	L-band SAR
Jiuquan	CZ-2D	627.3 × 657.4, 98.01, 09:00	2,216.527	800?	EO; HR, PAN-MS
Taiyuan	CZ-2D	488 × 498, 97.41, 10:29	?	2,700	EO
Taiyuan	CZ-2C	504 × 511, 97.11, 01:56	?	2,000?	SAR
Taiyuan	CZ-4B	472 × 479, 97.2, 14:14	?	2,700?	EO
Taiyuan	CZ-4C	1,201 × 1,206, 100.1, 14:30	?	1,040	EO
Jiuquan	CZ-4C	(16A) 1,080 × 1,089, 63.38, 106.93 min.; (16B) 1,078 × 1,090, 63.38, 106.93 min.; (16C) 1,032 × 1,081, 63.38, 106.33 min.	?	1,000? (16A)	EO/SAR/ELINT?

Note: Question marks indicate data unavailable in reliable open sources.

Sources: He Mingxia et al., "Chinese Spaceborne Ocean Observing Systems and Onboard Sensors (1988–2025)"; "Yaogan Series"; "Yaogan 9B," "Yaogan 9B DEB." Other data from "Real Time Satellite Tracking and Predictions," and "National Space Science Data Center Master Catalog"; data and format from *ITPROSTAR,* which are typically more detailed, are used by default.

largest scale, most complex, most technically demanding, and most widely applicable space-based system in Chinese aerospace history."[59] Beidou/Compass provides PNT to an accuracy of ten meters, 0.2 meters per second, and ten nanoseconds, respectively;[60] it also offers "differential" and "integrity" services.[61] Initially, unlike other PNT systems, which transmit signals directly, it transmitted signals indirectly, through a central ground station, although the PLA General Armament Department's newspaper recently reported that "after providing passive navigation and locating service, Beidou became more and more like the GPS system."[62] It also boasts a unique short-message communications system.[63] A Chinese aerospace expert contends that the system affords China numerous civil and military benefits and constitutes "an important measure to grab and retain favorable orbital position resources . . . for the purpose of 'carving up the domain before other competitors do'" [也是 "占位" 的需要].[64]

Twenty satellites have been launched thus far; sixteen remain operational. An initial two-satellite constellation was launched in 2000. Regional navigation and communications coverage, encompassing mainland China, neighboring countries (such as Pakistan, where it has been tested), and the near seas, was achieved in 2012;[65] service commenced in early 2013. Starting in 2014, a second series will be launched.[66] By 2020, a thirty-five-satellite constellation (five geostationary earth orbit, twenty-seven inclined medium earth orbit, and three inclined geostationary orbit [IGSO]) will provide global coverage.[67] IGSO satellites' high-inclination orbits improve coverage at high latitudes. Satellites launched thus far are manufactured by CAST. They weigh typically 2,300 kg at launch and 1,150 kg on station after maneuvering to initial orbit with a liquid apogee motor. They are three-axis stabilized and have twin solar arrays. The initial satellites were based on the DFH-3 bus; this changed to the -3A variant from *Beidou-G2* on and to the -3B variant from *-M3* on. All satellites have been launched from Xichang, from its Launch Complex 2 starting with *Beidou-2/Compass-M3*. See table 4.

The PLA is already using China's PNT system extensively. During long-distance exercises, Second Artillery units employ Beidou to track vehicles and communicate.[68] The North Sea Fleet headquarters information chief, Lei Xiwei, has stated that in February 2013 "Beidou provided positioning, security and protection" for the destroyer *Qingdao* and frigates *Yantai* and *Yancheng* in a South China exercise.[69]

Detecting and Tracking Maritime Targets

An emerging network of air- and space-based sensors promises to improve radically the targeting capabilities of the PLAN and other services with which it may operate, such as the Second Artillery. This critical linchpin, long limited by Beijing's lack of relevant sensor platforms, promises to give the PLA unprecedented ability to monitor surface vessels on China's maritime periphery and thereby facilitate their precise targeting with cruise

Table 4. *Beidou/Compass Satellites Currently Operational: Notional Specifications*

Satellite	NORAD ID	International Code	Launch Date/ Time (UTC)	Launch Vehicle	Orbit	Capabilities	Status
Beidou-1C	27813	2003-021A	2003.05.24 16:34:00	CZ-3A	geostationary (GEO): 110.5°E	20 m positioning accuracy	operational
Beidou-2A/ Compass-M1	31115	2007-011A	2007.04.13 20:11:00	CZ-3A	medium earth orbit (MEO) / experimental: perigee × apogee 21,519 × 21,545 km, inclination 55.3°, period 773.4 min.; by 2010.03: 21,524.7 × 21,553.5 km, 56.1°, period 773.4 min.	signal transmit carrier frequencies: 1,195.14–1,219.14 MHz, 1,256.52–1,280.52 MHz, 1,559.05–1,563.15 MHz, and 1,587.69–1,591.79 MHz; ground communications w/1 master control station, 2 upload stations, 30 monitor stations	experimental: 1st MEO satellite in series
Beidou-2C/ Compass-G1	36287	2010-001A	2010.01.16 16:12:00	CZ-3C	GEO: 140°E; initial transfer orbit: perigee × apogee 196 × 35,620 km, inclination 20.5°	?	operational
Beidou-2D/ Compass-G3	36590	2010-024A	2010.06.02 15:53:00	CZ-3C	GEO: 83.8°E; initial transfer orbit: perigee × apogee 205 × 35,647 km, inclination 20.5°	?	operational
Beidou-2/ Compass-IGSO-1	36828	2010-036A	2010.07.31 21:30:00	CZ-3A	geosynchronous (GSO): perigee × apogee 35,674.5 × 35,901.5 km, inclination 55.1°, period 1,435.8 min.; mean longitude of subsatellite ground point 118°E	?	operational
Beidou-2E/ Compass-G4	37210	2010-057A	2010.10.31 16:26:00	CZ-3C	GEO: 159.9°E	?	operational
Beidou-2/ Compass-IGSO-2	37256	2010-068A	2010.12.17 20:20:00	CZ-3A	GSO: perigee × apogee 35,714 × 35,856 km, inclination 55.24°, period 1,436 min.; mean longitude of subsatellite ground point 118°E	?	operational

Table 4. *(continued)*

Satellite	NORAD ID	International Code	Launch Date/ Time (UTC)	Launch Vehicle	Orbit	Capabilities	Status
Beidou-2/ Compass-IGSO-3	37384	2011-013A	2011.04.09 20:47:00	CZ-3A	GSO: perigee × apogee 35,721 × 35,880 km, inclination 55.3°, period 1,435.9 min.; "figure 8" ground track centered over 118°E	completed IGSO coverage with 3 satellites in equally spaced planes; marked establishment of basic navigation and positioning network	operational
Beidou-2/ Compass-IGSO-4	37763	2011-038A	2011.07.26 21:44:00	CZ-3A	GSO: perigee × apogee 35,706 × 35,878 km, inclination 55.2°, period 1,436.0 min.; "figure 8" ground track with intersection node over 95°E	?	operational
Beidou-2/ Compass-IGSO-5	37948	2011-073A	2011.12.01 21:07:00	CZ-3A	GSO: perigee × apogee 35,704 × 35,866 km, inclination 55.18°, period 1,436.02 min.; "figure 8" ground track	Beidou system's basic structure established; tests; trial service began 2011.12.27	operational
Beidou-2/ Compass-G5	38091	2012-008A	2012.02.24 16:12:00	CZ-3C	GEO: 58.68°E	?	operational
Beidou-2/ Compass-M3	38250	2012-018A	2012.04.29 20:50:00	CZ-3B	MEO: perigee × apogee 21,460 × 21,594 km, inclination 55.16°, period 773.2 min.	?	operational
Beidou-2/ Compass-M4	38251	2012-018B	2012.04.29 20:50:00	CZ-3B	MEO: perigee × apogee 21,456 × 21,601 km, inclination 55.11°, period 773.21 min.	?	operational
Beidou-2/ Compass-M5	38774	2012-050A	2012.09.18 19:50:00	CZ-3B/E	MEO: perigee × apogee 21,462 × 21,592 km, inclination 55°, period 773.2 min., revs/ day: 1.9	?	operational
Beidou-2/ Compass-M6	38775	2012-050B	2012.09.18 19:50:00	CZ-3B/E	MEO: perigee × apogee 21,476 × 21,573 km, inclination 55.1°, period 773.1 min., revs/ day: 1.9	?	operational
Beidou-2/ Compass-G6/G2R	38953	2012-059A	2012.10.25 15:33:00	CZ-3C	GEO: 80.1°E	completed regional network; service commenced	operational

Note: Question marks indicate information unavailable in reliable open sources.

Sources: "Beidou/Compass." Other data from "Real Time Satellite Tracking,"and "National Space Science Data Center Master Catalog"; data and format from *ITPROSTAR,* which are typically more detailed, are used by default.

and ballistic missiles, potentially in combination—a devastating multiaxis, saturation approach envisioned widely by Chinese analysts but requiring mobility, speed, range, and precise coordination.

To achieve its near-seas operational objectives, the PLA must thus coordinate multiple sensors and weapons among multiple services to provide comprehensive communications and a common operational picture. Satellite-based ISR will improve the ability of Chinese ballistic and cruise missiles to strike moving maritime targets. For instance, a DF-21D antiship ballistic missile might be launched on a ballistic trajectory aimed roughly at the position of a CSG, as determined partly on the basis of satellite data. Satellites might also be used to track and target the CSG—by, for instance, supplying position updates.[70]

The Beidou/Compass navigation satellite system can be used to improve the precision of Chinese ballistic missiles. China's combination of land-based radars and satellites—perhaps augmented temporarily with deployment of UAVs and launches of satellites or microsatellites—might be sufficient to track and target CSGs within a certain zone off China's coastal waters from which it is believed essential to exclude them in combat.

Examination of the orbits, inclinations, and periods of imaging satellites offers a basic sense of their coverage.[71] By 2009, China had approximately twenty-two imaging satellites with sufficient resolution to play a role in detecting and tracking a CSG.[72] This number was insufficient for continuous satellite coverage, in terms of revisit times for specific ocean areas, but since then China has added significant numbers of Yaogan satellites of multiple types, and on 26 April 2013 launched the first in a new series of Gaofen satellites.[73] In 2009, civilian experts estimated that China would launch sufficient satellites to achieve coverage regionally (eight to twelve civilian satellites, plus additional military) by 2015 and globally (a further eight to twelve civilian, plus additional military) by 2020;[74] these estimates may require adjustment, given recent launch numbers. Even before 2020, 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 (e.g., the Kaituozhe) may offer a combination of rapid turnaround and efficiency. The development of the Wenchang Satellite Launch Center (China's fourth, scheduled to open in 2014) indicates a commitment to cutting-edge facilities.

The Challenge of Bureaucratic Coordination

Targeting enemy surface ships is a tremendously complex and difficult process. China would likely use its Qu Dian integrated C4ISR system for this purpose. Qu Dian would have to incorporate real-time sensor inputs into a multisensor data correlation and fusion process, then transmit the result to commanders and shooters. Even with complete coverage of relevant maritime zones, data transmission (i.e., from satellites to ground stations), imagery readouts by analysts (increasing in time consumption with size of area examined), and transmission of targeting data to the shooter will impose time delays. Software and data management requirements will be complex. Command and control will likely pose particular challenges: the PLA will have to coordinate both among the many service elements that "own" various ISR sensor and ground station architectures and that within the chain of command would authorize their prioritization and use, and with the release authority (CMC, supreme command, or campaign command) for the weapons systems that would employ their inputs.[75] Because of these ongoing challenges, the U.S. Department of Defense judges that "the PLA will need to overcome deficiencies in system integration and interservice coordination."[76]

Examples of related difficulties have already emerged, as well as of some progress toward surmounting them. In perhaps the best test of C4ISR and data-fusion capabilities to date, China's large-scale response to Sichuan's 12 May 2008 Wenchuan earthquake included the use of an AWACS aircraft to coordinate air traffic and of satellite imagery and ground-mapping radar and other remote-sensing aircraft, as well as a UAV, to survey damage.[77] Upon receiving these data, the National Earthquake Relief Headquarters "swiftly transmitted them to the frontline relief troops."[78] Chen Li, minister of water resources, said that "analyzing satellite and other aerial images" would allow officials to assess flooding risks stemming from "damaged reservoirs, hydropower plants, and dikes."[79] On 17 May the PLA, having reportedly detected "water rising to dangerous levels" in multiple Beichuan County lakes "using one of its most advanced satellites," ordered evacuation of the area.[80] China's massive resource deployment still left the PLA and other government organizations involved hampered in their efforts by Chinese satellite imagery that was deficient in quality and quantity, as well as by problems with data transfer, management, processing, and integration.[81]

Despite these apparently serious limitations in 2008, the PLA's response to the less-challenging 2010 Yushu earthquake seemed to reflect significant "lessons learned." For instance, the Chinese Academy of Sciences' State Key Laboratory of Remote Sensing Science used "Beijing-1 microsatellite data, with moderate spatial resolution and large sensor ground width . . . to analyze the environment background for the earthquake."[82] While China still uses imagery from foreign as well as domestic satellites, the large number of increasingly advanced satellites of many categories that China has launched since, together with its clear rationale to develop and integrate the relevant C4ISR architecture, suggests that its capabilities are now far greater. In January 2013, *China Daily* went so far as to claim that "China's first high-resolution, stereo mapping satellite Ziyuan III," launched on 9 January 2012, "meets international standards, ridding the country of its reliance on imports of satellite images."[83]

Despite this recent progress, China's ISR coordination challenge is illustrated by the present organization of its satellites as well as by the PLAAF's efforts to assume control over them. Peacetime ownership and operational control of some satellites and applications are divided among more than a dozen government, university, and civil organizations.[84] Seventy-five percent of satellites are normally run by nonmilitary organizations; wartime authority-transfer dynamics remain unclear.[85] Even granting the ability to transition smoothly to military control in wartime—a significant assumption—China's satellites and other space assets face uncertainty regarding service jurisdiction.[86] A new Space Force is rumored to be in development;[87] for now, the PLAAF appears to be best placed to assume authority over space assets.

Yet at present the PLAAF is not known to control any space assets. Indeed, the General Armaments Department (GAD), the GSD, and even the Second Artillery and the PLAN, to some extent, may be resistant to such a transfer of authority to the PLAAF, and institutional rivalry may complicate matters.[88] The GAD controls all orbital satellite operations yet lacks a combat role. The PLA already controls launch sites, the Second Artillery is heavily involved in missile programs, and various technical institutes are responsible for satellite development, so there will likely be extensive debate and negotiation within the PLA and civilian leadership concerning the ultimate control of various space assets (a process that took place earlier in the United States). Furthermore, there is not yet any clear evidence in open publications that the PLA has formally adopted space theory, doctrine, missions, or regulations, so what would govern the actions of whatever organization ultimately consolidates control is likewise unclear.

Air-breathing platforms face their own coordination challenges, given their distribution among the PLAAF, PLAN aviation, and even to some extent army aviation. Insufficient open-source information is available to determine how the PLAAF and PLAN aviation work together and divide responsibilities in various operational scenarios. As the PLAN assumes a robust deck-aviation mission, a critical question arises about the extent to which naval air assets (land- or sea-based) will receive direction from PLAAF assets like the KJ-2000. As long as the PLAN operates ski-jump carriers, it is unclear how much their air groups will contribute to the overall ISR picture, since ISR aircraft are typically underpowered relative to their weight and sophisticated versions would have difficulty launching via ski jump. This type of Chinese carrier will not be operating robust fixed-wing ISR assets like the American E-2 or S-3. Even with three carriers in the fleet, PLAN aviation would still be a primarily land-based air force. How, and to what extent, it will integrate with the PLAAF remains a key uncertainty.

Doctrine and regulations flow downward and technology upward in PLA bureaucratic processes, but there is insufficient lateral movement. Technological incompatibility remains a challenge owing to decentralized development, and software problems are even more significant than hardware problems. Institutional stovepiping remains a major barrier to integration and joint operations, neither of which has been achieved fully. The PLA's joint organizational structure is still under development and still does not penetrate effectively to lower levels. Lingering ground-force dominance is a significant impediment; the gradual rise in funding and status of the nonground forces is helping to remedy this but is proceeding only slowly. Training is not yet sufficiently joint, and there is no permanent joint training structure. The lack of a permanent joint organization at the military region level exacerbates these problems.[89] Finally, PLA commanders are tempted—and PLA theoretical writings, at least, are succumbing to the temptation—to use technology and command automation to centralize operations further. Ironically, this is precisely contrary to the goal of efforts to empower lower-level officers to make decisions in real time, a reform regarded as essential by many militaries that have actually fought "local limited wars under informatized conditions"—an experience that China lacks entirely. These factors, not the technical parameters of satellites and other sensors, will likely constitute the primary limitations on the effectiveness of Chinese ISR system employment. The place to watch for institutional innovation may be the Jinan Military Region, which is a logical "joint reform test bed," because it has all services represented, as well as a fleet headquarters, but lacks the strategic urgency of the Nanjing and Guangzhou Military Regions, which are responsible for the East China Sea (including Taiwan) and the South China Sea, respectively.[90]

Geostrategic Implications

China's air- and space-based surveillance platforms—together with their supporting infrastructure, human and otherwise—are improving rapidly but remain incomplete and are experiencing growing pains. As Larry Wortzel emphasizes, "The duration on station of its AWACS aircraft is short, their range is limited, and not all of them are capable of aerial refueling. Most of the PLA's combat ships and aircraft can engage in networked operations but can handle only a limited number of targets. In addition, not all of the weapons they carry can receive the networked combat data."[91] As a result, "neither the PLAAF, nor the rest of the PLA, can field and operate a fully digitized force that can take advantage of an integrated picture of the battlefield and apply weapons in a fully coordinated manner."[92] Improvements in these areas will bring their own problems, increasingly subjecting PLA forces to some of the very same vulnerabilities that they are targeting so efficiently in U.S., allied, and friendly militaries that might operate close to China.

Institutional wrangling for control of China's space assets continues. The sprawling, stovepiped nature of the many military services and organizations that control the satellite/C4ISR architecture further complicates the horizontal and vertical interservice, interlevel, and military-civilian bureaucratic coordination necessary for real-time data fusion to support kinetic operations. While China may be able to employ a variety of strategies to conduct centralized non-space-based C4ISR operations near its territory, it may find it difficult to attain similar results farther afield, where information assurance is more elusive.

Despite these ongoing challenges, counterintervention affords China a strategic defensive posture along interior lines and a different and considerably easier C4ISR task than that of the United States. The PLA can mitigate ongoing limitations in jointness and challenges in command and control and in target deconfliction by employing landlines, high-power line-of-sight communications, advanced planning, and geographic and temporal segregation. China's emerging C4ISR capabilities are already undergirding growing counterintervention capabilities that are in turn changing the balance of military power on the nation's maritime periphery. In the near seas, at least, China's military awareness, coordination, and targeting capabilities must already be taken seriously.

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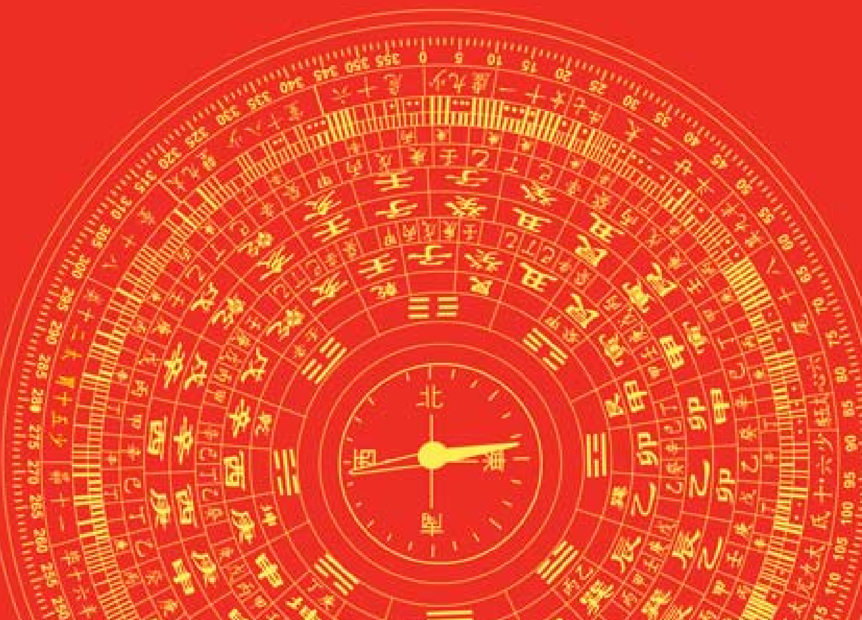

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Abbreviations and Definitions

A

A2/AD	antiaccess / area denial
AAD	area air defense
AAW	antiair warfare
AESA	active electronically scanned array
AEW	airborne early warning
AIP	air-independent propulsion
AIS	Automatic Identification System
ASBM	antiship ballistic missile
ASCM	antiship cruise missile
ASUW	antisurface warfare
ASW	antisubmarine warfare
AWACS	airborne warning and control system [or the U.S. Airborne Warning and Control System, in the E-3 Sentry]

C

C3I	command, control, communications, and intelligence systems
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CAST	China Academy of Space Technology
CATOBAR	catapult-assisted takeoff but arrested recovery
CBERS	China-Brazil Earth Resources Satellite
CDCM	coastal-defense cruise missile
CEP	circular error probable
CIWS	close-in weapon system
CMC	Central Military Commission

COMINT	communications intelligence
CSG	[aircraft] carrier strike group
CSIC	China Shipbuilding Industry Corporation

D

DDG	guided-missile destroyer
DMC	Disaster Monitoring Constellation
DoD	Department of Defense [U.S.]

E

EEZ	exclusive economic zone
ELINT	electronic intelligence
EO	electro-optical
ESM	electronic support measures
EW	electronic warfare

F

FAE	fuel-air explosive
FDO	flexible deterrent option
FFG	guided-missile frigate

G

GAD	General Armaments Department
GLONASS	Global Navigation Satellite System (Globalnaya navigatsionnaya sputnikovaya sistema)
GPS	Global Positioning System
GSD	General Staff Department

H

HALE	high-altitude, long-endurance
HE	high explosive
HFSWR	high-frequency surface-wave radar

I

IGSO	inclined geostationary orbit
IRST	infrared search and track
ISR	intelligence, surveillance, and reconnaissance

K	**kg/kN**	kilograms per kilonewton
	km	kilometers
	KMT	Kuomintang [Chinese Nationalist Party]
L	**LCS**	Littoral Combat Ship
	LO	low-observable
	LRPS	long-range precision strike
M	**MRBM**	medium-range ballistic missile
N	**nm**	nautical mile
O	**ONI**	Office of Naval Intelligence [U.S.]
	OTH	over-the-horizon
	OTHR	over-the-horizon radar
	OTHT	over-the-horizon targeting
P	**PLA**	People's Liberation Army
	PLAAF	People's Liberation Army Air Force
	PLAN	People's Liberation Army Navy
	PLANAF	People's Liberation Army Naval Air Force
	PNT	positioning, navigation, and timing
	PRC	People's Republic of China
S	**SAM**	surface-to-air missile
	SAR	synthetic aperture radar
	SIGINT	signals intelligence
	SLBM	submarine-launched ballistic missile
	SLOC	sea line of communication
	SS	diesel-electric submarine
	SSB	ballistic-missile submarine

	SSBN	nuclear-powered ballistic-missile submarine
	SSN	nuclear-powered attack submarine
	STOBAR	short takeoff but arrested recovery
	SWATH	Small Waterplane Area Twin Hull
T	**T-AGOS**	tactical auxiliary general ocean surveillance ship
	TEL	transporter-erector-launcher
U	**UAV**	unmanned aerial vehicle
	USN	U.S. Navy
V	**VHF**	very high frequency
	VLF	very low frequency
W	**w/t**	weight-to-thrust

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