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CHINA AEROSPACE STUDIES INSTITUTE

CHINESE AIRBORNE C4ISR

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November 2020

Printed in the United States of America
by the China Aerospace Studies Institute

ISBN 9798583085569

To request additional copies, please direct inquiries to
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Air University, 55 Lemay Plaza, Montgomery, AL 36112

Cover art is Shaanxi KJ-200" (mod flight).jpg, Alert 5, 2 April 2018.
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China Aerospace Studies Institute

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Preface

As we move further into the era of 21st century great power competition, it is important to understand the many facets of that competition. This report is the next in a series of studies by the China Aerospace Studies Institute (CASI) that seeks to lay the foundation for better understanding the Aerospace Sector of the People's Republic of China (PRC).

An effective modern military requires timely information on the location and disposition of friendly and enemy forces, precise timing and positioning data, and communication links between physically separated forces. As a result, accompanying the rapid modernization of China's military has been the fielding of a wide range of airborne sensors and command and control aircraft along with constellations of satellites. These include early warning aircraft, specialized electronic intelligence (ELINT) aircraft, and maritime patrol aircraft, both manned and unmanned, as well as communications, radar, optical, and signals-collecting satellites. These platforms are essential enablers of the new combat aircraft and precision weapons that China's aerospace forces have been acquiring and are vital to China's ability to conduct long-range precision fires as well as pre-strike reconnaissance and post-strike damage assessment.

This report examines China's aerospace Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities. These include early warning, command and control, and electronic and optical reconnaissance aircraft, a burgeoning number of unmanned aerial vehicles (UAVs), and aerostats, which have seen a rising level of investment due to their ability to stay aloft for long periods of time and carry capable sensor packages. It also includes China's rapidly expanding constellations of reconnaissance, communications, and positioning, navigation, and timing (PNT) satellites. While each of these topics is worthy of separate study, Chinese writings make it clear that they are intended to operate in conjunction with each other and as part of a networked system of systems that will allow the PLA to operate globally and at higher levels of inter-branch and inter-service coordination.

Drawing on Chinese-language government publications, news articles, authoritative writings on strategy and tactics, and academic studies, this report lays out the historical background and some key drivers, then examines China's current Airborne C4ISR platforms and outlines observable trends in training for their operational use. Finally, it examines recent developments in Chinese satellites, and concludes with an examination of potential future developments. Taken together, these provide a clear snapshot of China's Airborne C4ISR.

We hope you find this volume useful, and look forward to bringing you further details on the foundations of Chinese aerospace in this series.

Dr. Brendan S. Mulvaney
Director, China Aerospace Studies Institute

ABBREVIATIONS

AECC	Aero Engine Corporation of China
AESA	Active Electronically Scanned Array (radar)
AEW&C	Airborne Early Warning & Control
AAM	Air-to-Air Missile
ASW	Anti-Submarine Warfare
AVIC	Aviation Industry Corporation of China
BUAA	Beijing University of Aeronautics and Astronautics
BVR	Beyond Visual Range
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAAA	China Academy of Aerospace Aerodynamics
CASC	China Aerospace Science and Technology
CASS	Chinese Academy of Social Sciences
CAST	China Academy of Space Technology
CATIC	China National Aero-Technology Import & Export Corporation
CCP	Chinese Communist Party
CETC	China Electronics Technology Company
CMC	Central Military Commission
CNSA	China National Space Administration
ECM	Electronic Countermeasures
EDD	Equipment Development Department
ELINT	Electronic Intelligence
GAD	General Armaments Department
HALE	High Altitude Long-Endurance
HMD	Helmet-Mounted Display
IFF	Identification Friend or Foe
IRST	Infrared Search and Tracking System
ISR	Intelligence, Surveillance, and Reconnaissance
MAD	Magnetic Anomaly Detector
MAWS	Missile Approach Warning System
MCF	Military-Civilian Fusion
MIIT	Ministry of Industry and Information Technology
MOST	Ministry of Science and Technology
NDU	National Defense University
NDRC	National Development and Reform Commission
NRT	Near Real-Time
NUAA	Nanjing University of Aeronautics and Astronautics
NUDT	National University of Defense Technology
NWPU	Northwestern Polytechnical University
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PNT	Positioning, Navigation, and Timing
PRC	People's Republic of China
RMB	Renminbi
SAR	Synthetic Aperture Radar
UCAV	Unmanned Combat Aerial Vehicle

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Introduction

Chinese platforms are not developed in a vacuum. China's unmanned aerial vehicles (UAV) programs owe a major debt to technology recovered from crashed drones in China and Vietnam. For much of the history of the People's Republic of China (PRC), it was subject to surveillance by other countries, and at the same time, lacked the capability to consistently monitor areas of strategic interest to it. During the period of U.S. involvement in the Vietnam conflict, U.S. aircraft frequently intruded, intentionally or otherwise, into Chinese airspace. Chinese sources reportedly claim 383 U.S. violations of Chinese airspace between 1964 and 1968.[1] Of particular note, between 1964 and 1969 the Chinese detected at least 97 American UAV overflights.[2] In addition, Taiwanese U-2 pilots reportedly flew roughly 102 missions over mainland China between 1962 and 1974.[3] This experience was a major driver of China's surface-to-air missile and interceptor aircraft programs. It also prompted the People's Liberation Army (PLA) to attempt to develop its first airborne early warning aircraft, the KJ-1, beginning in 1969, though the combination of a shifting strategic environment and technological hurdles realigned priorities toward ground-based early warning.

Although the United States and Taiwanese aircraft are not known to deliberately enter China's airspace anymore, Chinese officials regularly complain about U.S. reconnaissance flights along China's coast over China's exclusive economic zone, but still over international waters.[4] More recently, according to reporting by *Aviation Week and Space Technology*, the U.S. Air Force has been regularly deploying its RQ-180 stealthy, high-altitude long-endurance (HALE) reconnaissance UAV around China's periphery.[5] Aside from the desire to monitor foreign surveillance flights over or near Chinese territory, Chinese observers of U.S. involvement in the First Gulf War and Kosovo conflict concluded that the PLA needed C4ISR aircraft to be able to effectively coordinate air and naval forces. The performance of U.S. cruise missiles further highlighted the need to be able to field airborne early warning radars capable of detecting these threats.

According to China's 2019 Defense White Paper, China's National Defense in the New Era, "War is evolving in form towards informationized warfare [信息化战争], and intelligent warfare [智能化战争] is on the horizon." As a result, China's short-term goals (by 2020) include "significantly enhanced informationization." The proliferation of sensors and linkages between them and users will define these two stages.[6]

Section 1: Airborne Intelligence, Surviellance & Reconnaissance Capabilities

China began developing its first airborne reconnaissance aircraft in 1960, when the PLA decided to build a dedicated artillery spotter aircraft using the JJ-5 jet trainer, which was based on the MiG-17 jet fighter.[7] The resulting JZ-5 remained in service until 1986. A longer-range medium-altitude reconnaissance aircraft, the HZ-5, was developed on the basis of the H-5 (Ilyushin Il-28) light bomber beginning in 1965. The design was finalized in 1977.[8] The aircraft carried two medium/high altitude cameras and had a range of 3,000 km. However, the primary utility of these aircraft was for tactical reconnaissance. As noted in the previous section, China faced frequent intrusions by Taiwanese and U.S. aircraft, and its ground-based air defense radar network was unable to adequately monitor China's airspace, despite occasional successes in shooting down intruding aircraft.[9] As a result, the PLA sought to acquire airborne radar platforms. Airborne radars are less limited by the curvature of the earth, which restrict surface radars to an effective detection range of about 30 kilometers. Chinese sources state that airborne radars can increase the area covered by a factor of 15-30 and the probability of successful interception by 35-150%.[10]

While China has invested heavily in space-based ISR (see the section that follows), airborne surveillance and reconnaissance offers capabilities that satellites cannot provide. Satellites have limited ability to be tasked to fly over a specific area sooner than their regular orbits would take them, as it requires the use of limited onboard fuel stores.[11] As a result, an individual imagery satellite can generally only observe a given area once every two or three days. Satellite sensors, operating at an altitude of 300 miles or more, also have lower resolution than airborne sensors, which operate at an altitude of less than 15 miles. Similarly, for Electronic Intelligence (ELINT) missions, aircraft offer superior localization capabilities over satellites.

1.1 Reconnaissance Aircraft

JZ-8

The JZ-5 and HZ-5 reconnaissance aircraft mentioned above, China's first purpose-built ISR aircraft, are no longer in operation. The PLA still operates reconnaissance versions of the J-8 fighter aircraft, however, under the designator JZ-8. The most recent versions feature a conformal camera compartment behind the nosewheel compartment (see photograph).

These aircraft are reportedly also capable of carrying ELINT, signals intelligence (SIGINT), and synthetic aperture radar (SAR) pods.[12]

Tu-154M Surveillance Aircraft

Tu-154M

China has modified several civilian Tu-154M airliners for surveillance, adding pods to the bottom centerline which are believed to carry cameras and SAR. They have a crew of five and roughly 25 technical operators.[13]

These aircraft were previously identified as part of the 102nd Air Regiment of the 34th Division and were directly subordinate to PLAAF HQ, though it is unclear if this has changed as part of the PLA's broader reorganization in recent years. The aircraft are based at Beijing's Nanyuan Airport [北京南苑机场].

These aircraft have accompanied multiple H-6K flights through the East China Sea and into the Sea of Japan.[14] Others have been observed operating on their own in what appears to be a maritime surveillance role in the East China Sea, potentially in support of submarine tracking operations.

1.2 Early Warning Aircraft

KJ-1

Following a 1969 Chinese Military Commission (CMC) directive ordering the development of airborne early warning aircraft, the People's Liberation Army Air Force (PLAAF) decided to modify a Tupolev Tu-4 propeller-driven bomber into an airborne early warning aircraft, called the KJ-1 [空警 1], by adding a seven-meter radome. The KJ-1's first flight was on 10 June 1971.[15] The KJ-1's 843 radar had a detection radius of 220 km but used vacuum tubes and had very weak data processing power.[16] During testing in August 1970, the radar proved unable to distinguish targets from ground clutter except in flat areas or aircraft flying at high altitudes.[17]

A combination of factors, including a decreased threat of bombing and reconnaissance flights from Taiwan and improvements to China's ground-based early warning radar network, contributed to a decision to stop developing the KJ-1. The program was finally canceled in 1979 on the grounds that it was unable to meet mission requirements.[18]

In the early 1990s, China sought to purchase the Beriev A-50 airborne early warning and control (AEW&C) aircraft from Russia. Negotiations began in 1992 but were terminated in 1995 due to the high cost of the platform, estimated at U.S.$270 million per aircraft, not including training and maintenance.[19]

China then attempted to acquire the Israeli Phalcon AEW&C system. Integrated onto a commercial aircraft body, the Phalcon featured a much more capable radar than the A-50. Despite signing a contract in 1998 to sell three of the systems to China, Israel canceled the deal in 2001 due to pressure from the U.S. government.[20] As a result, China chose to develop its own early warning aircraft.

Phalcon System Integrated on a Boeing 707 for the Chilean Air Force

Y-8J

Yz8J

The Y-8J was China's first operational airborne early warning aircraft. Built on the airframe of the Y-8 (Antonov An-12) medium transport, the Y-8J was first spotted near Shanghai in 2000. It is equipped with a Skymaster surveillance radar, 6-8 sets of which were purchased in 1996 from the United Kingdom's Racal. The radar has a maximum detection range of 400 km and can simultaneously track a total of 1z0 aerial targets, and the control center can direct up to six aircraft to intercept enemy aircraft. The Y-8J can also provide target information to surface ships and submarines via datalink. This aircraft is believed to be less capable than the KJ-200, but four Y-8Js remain in service with the PLA Navy.[21]

KJ-200


KJ-200

Development of the KJ-200 began in 2002, shortly after the deal to purchase the Phalcon fell through. The aircraft saw its first flight in January 2005, but the program was almost derailed in 2006 following the worst accident in the PLAAF's history. Icing on the wings of the second aircraft caused a crash in eastern Anhui Province, killing the 35 experts and five crew aboard.

The long "balance beam"-shaped housing above the fuselage has a JY-06 Active Electronically Scanned Array (AESA) radar. Perhaps due to its ungainly appearance, the KJ-200 is sometimes referred to as the "Zhuying" (猪鹰, lit. "pig eagle").[22] Unlike the KJ-500 and KJ-2000 (see below), the KJ-200 is only equipped with traditional line-of-sight radio communications capabilities; it lacks satellite communications equipment. An improved "B" variant equipped with additional radar arrays built into the side and offering greater coverage is believed to be under development. Chinese media regularly cite a detection range of 330 km for the KJ-200 and a flight range of 5,600 km.[23]

In July 2015, KJ-200s began participating with other aircraft in long-distance flights transiting international airspace above the Miyako Strait, likely acting as an airborne command post allowing the flight commander to coordinate the aircraft involved.[24] Descriptions of training indicate that units equipped with the KJ-200 have practiced directing attacks by JH-7 fighter-bombers under a unit belonging to the North Sea Fleet.[25] The aircraft have also participated in domestic Red Sword [红剑] joint command exercises and in the Shaheen [雄鹰] series of exercises with Pakistan.[26]

KJ-500

Officially unveiled during the 2015 military parade marking the 70th anniversary of the end of World War II, the KJ-500 is a major improvement on the KJ-200.[27]

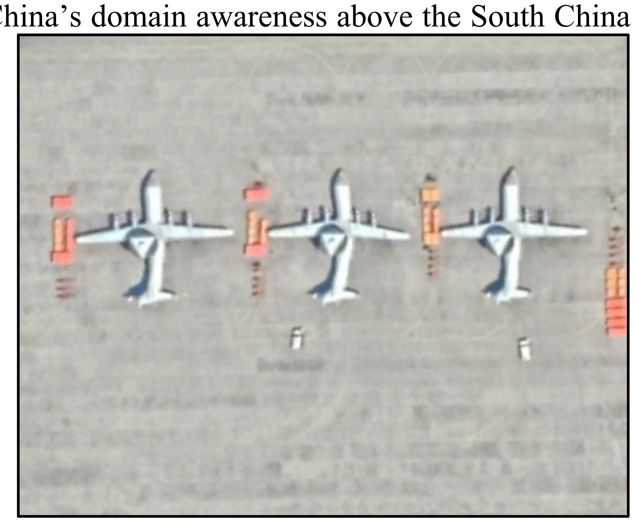
KJ-500

It uses the Y-9 design (a modernized version of the Y-8) as its airframe and has a patrol range of 5,700 km. Like the KJ-2000 (see below), it has a stationary radome equipped with three AESA radars, giving it 360-degree coverage, as compared to the KJ-200's two-sided "balance beam" radar, which presumably cannot detect targets directly ahead or behind the aircraft. Other improvements include satellite communications systems, which previously only the KJ-2000 incorporated.[28] The KJ-500 is believed to have a detection radius of 470 km.

Examples produced after May 2018 are equipped with an aerial refueling probe, making the KJ-500 the first Chinese AEW&C platform to do so.

China is also offering a similar early warning aircraft, the ZDK-03, for export, though it is said to use a different radar than the KJ-500. China signed a contract with Pakistan in 2008 to sell four ZDK-03 aircraft.

The KJ-500 appears to be in use by PLAAF and PLA Naval Aviation units. Several are believed to be stationed in Hainan to improve China's domain awareness above the South China Sea. Commercial satellite imagery has also shown KJ-500 aircraft on the ground at Lhasa Gonggar Airport [贡嘎机场] in Tibet.[29]



From Google Earth

KJ-2000

KJ-2000

The KJ-2000, currently China's primary "strategic early warning aircraft" [战略预警机], resembles the Soviet/Russian A-50. After deciding to purchase the Israeli Phalcon instead of Russian A-50 system, China intended to use the same Il-76 airframes as the A-50, but equip them with Israeli radars. When the Phalcon deal fell through, China began to develop its own airborne radar for the platform.[30]

The KJ-2000's first flight occurred in November 2003. In 2007, the KJ-2000's design was approved, and the first aircraft were delivered to the PLA.[31]

The KJ-2000 has a non-rotating radome with a three-sided AESA radar developed by the 14th Institute of China Electronics Technology Group Corporation (CETC). Each array covers 120° and operates in the 1200-1400 MHz range.[32] It is believed to have a detection range of 470 km, and to be capable of tracking up to 100 airborne targets (including low-flying aircraft) at a time, and to have a flight range of 5,500 km.

The KJ-2000 is equipped with a suite of ultra-high frequency (UHF) and shortwave radio communication systems and a K-band satellite link to allow it to communicate with airborne fighters and ground-based forces.

Looking ahead, Russian reluctance to sell more IL-76 aircraft, combined with significant production line problems that delayed sales to China, will likely further encourage China to adapt the domestic Y-20 transport aircraft as the basis for future KJ-2000 or follow-on production.

China is currently believed to have four KJ-2000s based at the 77th Airborne Command and Control Regiment of the 26th Specialized Division and the Wuxi-Shuofang Air Base [无锡硕放机场] in Jiangsu Province.[33]

Y-8T

The PLA Air Force Y-8T appears to function as an airborne command post intended to provide better coordination for air operations. Based on the Y-8 airframe, it has a redesigned rear fuselage section. A dorsal fairing aft of the wing section might house a SATCOM antenna, and there are multiple communication antenna arrays along the top and bottom of the fuselage and on the vertical tailfin. Three Y-8Ts are believed to be in service with the PLA Air Force.[34]

Y-8T

Training

The introduction of KJ-200 and KJ-2000 aircraft gave Chinese forces their first real airborne AEW&C capability; production of the KJ-500 as well as of airborne electronic warfare and ELINT aircraft have added new capabilities. The PLAAF previously employed its early warning and airborne C2 aircraft in an ad hoc, supplementary manner, but it has more recently begun to employ them as a "core operational element" as they have evolved from being simply "airborne radar stations" to being "airborne command centers."[35] Descriptions of North Sea Fleet Naval Aviation opposition-force drills [对抗演练] from 2017 indicate that PLA Naval Aviation has been teaming early warning aircraft with fighters during offensive operations to detect and cue them against defending aircraft.[36] PLAAF and Naval Aviation bombers, for example, now undertake "comprehensive sensing and tracking" [综合探测跟踪] and "networked early warning and control" [组网预警指挥] training missions together with early warning aircraft.[37] These aircraft also train in conditions and for missions that would have been relatively rare in previous decades, such as flying in poor weather conditions and at very low altitudes [超低空飞行] below 100 meters.[38]

1.3 Maritime Patrol Aircraft

SH-5

China claims an 18,000 km coastline and 3,000,000 km^2 of territorial waters, including disputed areas. Maintaining domain awareness above, and below, this area and enforcing China's claims is an enormous task. China also faces a complex undersea threat environment. To the northeast, Russia maintains a significant number of conventional and nuclear attack and ballistic missile submarines in Vladivostok and Petropavlovsk. Japan has a potent force of advanced Soryu- and Oyashio-class submarines. Chinese discussions also state that U.S. nuclear attack submarines are present in waters claimed by China. As a result, maritime surveillance has been a top priority for China's aircraft and UAV development.

Notably, PLA aircraft are relatively new to maritime operations, with the PLAAF excluded from flights over water until the 1990s, and PLA Naval Aviation fielding relatively small numbers of aircraft.

China currently has limited numbers of fixed-wing maritime patrol aircraft. China's first fixed-wing maritime patrol aircraft, the SH-5 [水轰-5], was a seaplane. It was domestically designed, although it apparently mimicked features of the Soviet Beriev Be-12 and the Japanese Shin Meiwa US-1A. It was equipped with a Doppler search radar in its nose and a magnetic anomaly detector (MAD) in its tail, and was capable of dispensing sonobuoys. Some may also have been fitted with ELINT equipment. Development of the aircraft began in 1968, but it did not enter service until 1986. Apparently, only four operational examples were produced, and they do not appear to be in service any longer.[39]

The Y-8X (pictured) was the PLA Navy's first long-range maritime patrol aircraft. Built on the Y-8 airframe, it was originally equipped with an American Litton AN/APS-504(V)3 surface search radar and two large film cameras. More recently these aircraft may have been upgraded with forward-looking infrared (FLIR) turrets, jamming antennas, and possibly a SAR.[40]

Y-8X

The Y-8Q (also known as the KQ-200 or GX-6) is a maritime patrol aircraft based on the Y-8 airframe. It is reportedly equipped with a surface search radar under the nose, an electro-optical payload under the fuselage and a MAD in its tail. It is capable of launching sonobuoys, as well as anti-submarine mines and torpedoes.[41] Y-8Qs now appear to be in service with all three theater commands that have naval components (Northern, Eastern, and Southern).[42] Chinese analysts note that the Y-8Q has limitations as a platform due to its slow speed and limited range (reportedly 5,000 km, with a patrol endurance of 10 hours).[43]

Y-8Q

In addition to land-based maritime patrol aircraft, China currently fields a limited rotary wing airborne early warning capability aboard its aircraft carrier *Liaoning* and some larger surface combatants. Descriptions of training with the *Liaoning* involve land-based early warning aircraft coordinating with the carrier to establish a command network, part of a larger integrated reconnaissance and early warning system, for the carrier battle group.[44]

Training for PLA Naval Aviation units appears to have improved significantly, though low numbers of maritime patrol aircraft in the past required these units to travel between fleets frequently to support training.

1.4 Electronic Intelligence Aircraft

The Y-8CB and Y-8JB are ELINT aircraft built on the Y-8 airframe. They are believed to be fitted with a BM/KZ800 ELINT system (frequency 1-18GHz, range 300 km). There is speculation that some technologies of this system may have come from the American EP-3 ELINT aircraft that emergency-landed on Hainan Island in April 2001. At least four Y-CBs are in service with the PLA Air Force, and four Y-8JBs are in service with the PLA Navy.[45]

Y-8JB

Y-8CB

The Y-9JZ is a newer ELINT aircraft based on the Y-9 airframe. It is equipped with numerous antennas believed to be part of an advanced integrated ELINT system along with a turret containing a FLIR/TV camera. The first Y-9JZ entered the service with PLAN in early 2013, and six are now believed to be in service.[46]

China’s ELINT collection aircraft have become much more active since 2013. According to the Japanese Ministry of Defense Joint Staff's Twitter account, a Chinese Y-9 (GX-8) electronic intelligence-gathering aircraft was detected and intercepted by Japanese Maritime Self-Defense Force aircraft flying between the East China Sea and the Sea of Japan in October 2019.[47]

In October 2019 the PLAAF announced a fifth “training brand”, *Qingdian* [擎电]. This joined the four existing “training brands”: Red Sword[i], Golden Helmet, Golden Dart, and Blue Shield. According to Xinhua, the new series is designed to improve the PLAAF’s electronic warfare capability, as a part of the effort to enhance the PLAAF’s overall operational capabilities.[48]

Y-9JZ

[i] The 2017 Red Sword exercise focused on reliance on airborne early warning and command, acknowledging the rising role airborne platforms will play and the dwindling role of ground-based early warning and command.

1.5 Major C4ISR Aircraft Companies, Research Institutes, and Academic Institutions

Shaanxi Aircraft Corporation
[中航工业陕西飞机工业]
Location: Hanzhong, Shaanxi [汉中市，陕西省]

Y-8J

Shaanxi Aircraft Corporation (SAC), part of Aviation Industry Corporation of China (AVIC), is the producer of the Y-8 and Y-9 medium transports on which many of China's C4ISR aircraft are based.

SAC was established in 1964 as part of the Third Line [三线] strategy, whose goal was to build a more secure defense industry in the interior of China, away from vulnerable areas near the borders. Design work on the Y-8 began in 1969 at Xi'an Aircraft Design and Research Institute [西安飞机设计研究所]. Test flights of the first airframe began in December 1974. It has been in continuous production since then.[49] By 2006, SAC had produced nearly 30 variants of the multi-role Y-8, which is employed by the PLA Army, Navy, and Air Force.

Though typically described as indigenously developed [自主研制], the Y-8 and Y-9 are based on the Soviet/Ukrainian An-12, and many improvements in recent years have benefited from partnership with Russia's Antonov, the original designer of the aircraft. In 2002, SAC signed a joint development agreement with Antonov.[50] After 40 crew members and scientists were killed in the crash of a KJ-200 early warning aircraft on 3 June 2006, this relationship was apparently expanded; Shaanxi partnered with Anotov to significantly improve the design of the aircraft.[51]

Xi'an Aircraft Industry Corporation (XAC) ［西安飞机工业（集团）有限责任公司］
Location: Xi'an, Shaanxi［西安市，陕西省］

Xi'an Aircraft Industrial Corporation (XAC) is one of China's key aviation research and development (R&D) facilities and manufacturers. It was founded in 1958 and produces a variety of large and medium-sized military and civilian aircraft. XAC was the first Chinese company to establish international cooperative agreements.[52] XAC has partnered and built parts for Boeing and Airbus since 1980 and 1997, respectively.[53] The company produces the Y-7 and MA-series turboprop transport aircraft (based on the Antonov An-24), the JH-7 fighter-bomber, H-6K bomber (based on the Tupolev Tu-16), and aircraft parts for both domestic and international airliners. Most recently it has been producing the Y-20 strategic transport jet (a truly indigenous design roughly comparable to the U.S. C-17), on which future KJ-2000 or follow-on aircraft might be based.

Xi’an Aircraft Design and Research Institute
[西安飞机设计研究所]
Location: Yanliang District, Xi’an, Shaanxi [阎良区，西安市，陕西省]

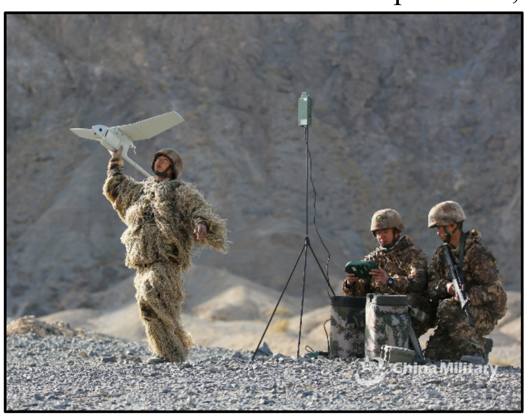
Also called AVIC No. 1 Aircraft Design and Research Institute, the Xi’an Aircraft Design and Research Institute is currently the only enterprise in China capable of designing fighter-bomber, bomber, civilian, transport and special-mission aircraft under one roof. As of 2018, it employed 2,600 people, including over 210 researchers. [54]

SECTION 2: UNMANNED AERIAL VEHICLES (UAVS)

The PLA is said to be undergoing a process of "unmanification" [无人化] with the adoption of multiple types of UAVs at every level, from strategic UAVs such as the Soar Dragon ("Xianglong" [翔龙]) to hand-launched UAVs operated by grassroots militia units.[55]

China's first UAV, the Chang Kong 1 (CK-1), was reverse-engineered in the late 1960s from Lavotchkin aerial targets transferred from the Soviet Union. Beginning in the 1970s, China developed a series of surveillance UAVs based in part on U.S. Firebee drones that had crashed or been shot down on Chinese territory. The resulting aircraft, designated WZ-5 or Chang Hong, was developed by Beihang University (then Beijing Aviation Academy) [北京航空学院], with the Zhuzhou Aeroengine Factory [株洲航空发动机厂] producing the engine. An upgraded version, the Z-5II, was designed to carry out real-time observation [实时监视] 30-50 km behind enemy lines.[56] The Z-5II's design was approved in November 1990, and its first successful test flight was in December of that year.

Since the 1990s China has fielded a number of increasingly capable medium and high-altitude UAVs. The Wing Loong (Yilong [翼龙], "Pterodactyl") series, designed by Li Yidong [李屹东] (profiled in a later section), in particular, has found success in overseas markets. While these UAVs have offensive capabilities, their primary intended use appears to be ISR.



Tactical UAV

The PLA Army has enthusiastically embraced UAVs, likely as part of a shift toward combined arms battalions, which sometimes feature organic reconnaissance units, and each Group Army appears to now include battalion-sized UAV units.[57] At the battalion level, some positions appear to have been added to staffs to help battalion commanders improve their control over the new assets.[58] At the tactical level, reconnaissance units, sometimes described as "instrument reconnaissance companies" [仪器侦察连], are being equipped with UAVs for tactical reconnaissance.[59] PLA Army brigades, for example, have been mentioned in Chinese media as having multiple subordinate UAV fendui [分队].[60] PLA Ground Forces appear to be fielding greater numbers of UAVs.[61] In 2015, PLA units in what are now the Southern and Western Theater Commands were described as having adapted civilian UAVs for military use [民转军装备].[62]

UAVs also appear to be an area of major investment by the PLA to improve its maritime domain awareness. In 2010, China purchased 100 Schiebel Camcopter S-100 rotary-wing maritime ISR UAVs from Austria to operate off its ships, and carrier-capable fixed-wing UAVs appear to be under development. In addition, commercial satellite imagery from DigitalGlobe captured a BZK-005 UAV (see below) at China's carrier catapult test facility on 17 November 2016.[63]

Described below are UAVs that are believed to be in service with the PLA or that have been exhibited by the PLA at official events, organized roughly by operating altitude. Not included are the large number of UAVs that have been seen in model form at trade shows or that have been seen undergoing testing in China, as it is unclear which, if any, of these models and demonstrator aircraft will prove successful and be adopted for use by the PLA.

2.1 Tactical and Low-Altitude UAVs

ASN-206 and ASN-207

The ASN-206 and an upgraded version, the ASN-207, also known as the BZK-006 and BZK-006A or WZ-6 and WZ-6A, are tactical reconnaissance UAVs roughly comparable to the U.S. Army's AAI Corporation RQ-7 Shadow. They were developed in the mid-1990s by Northwest Polytechnic University, are powered by 4-cylinder piston engines, use rocket-assisted takeoff, and land with the aid of a parachute. The ASN-207 (pictured) is said to have an endurance of 12 hours, is equipped with retractable chin turrets housing FLIR/CCD cameras, and can also carry a small ground surveillance radar. It maintains a digital datalink with its ground station via a communications antenna mounted on top of its head section. The ASN-206 and/or ASN-207 are believed to be in service with the PLA Army.[64]

ASN-206/ASN-207

CH-91

The CH-91, also known as the BZK-008, is a small UAV developed by China Aerospace Science and Technology Corporation (CASC) that is roughly comparable to the U.S. Army's RQ-7 Shadow. It is equipped with a chin-mounted, retractable turret containing FLIR and CCD cameras. It entered service with the PLA Army in 2011 and is said to be used for artillery directing, tactical reconnaissance, and communications jamming.[65]

CH-91

2.2 Medium-Altitude Long-Endurance UAVs

BZK-007

The BZK-007 was developed by Guizhou Aircraft Industry Corporation and Beihang University based on their Harrier Hawk (Yaoying [鹞鹰]), a civilian remote sensing UAV. It has a mission payload of 60-100 kg and can carry a variety of sensors including FLIR and CCD TV cameras. It is said to have a maximum level speed of 230 km/hr (145 mph), a ceiling of 7,500 m (25,000 ft), an endurance of 16 hours, and to be in service with the PLA Army and PLA Navy.[66]

BZK-007

Wing Loong I

The Wing Loong (Yilong [翼龙]) I, also known as the GJ-1, is a medium-altitude long-endurance UAV roughly comparable to the U.S. MQ-1 Predator. It was developed by the Chengdu Aircraft Design Institute and the Guizhou Aircraft Industry Corporation with the first flight occurring in 2007. The Wing Loong I is said to have a maximum speed of 280 km/hr (175 mph), a range of 4,000 km (2,500 mi), an endurance of 20 hours, a service ceiling of 5,000 m (16,000 ft), and to be able to carry 200 kg (440 lb) of weapons (e.g., two laser-guided anti-tank guided missiles or two 100 kg cluster bombs). A chin-mounted turret houses a FLIR, TV camera, and laser range finder/laser designator, and the head bulge contains a satellite communications antenna. An improved version, the Wing Loong 1D, is said to have an endurance of 35 hours, a service ceiling of 7,500 m (25,000 ft), and to be able to carry 400 kg (880 lb) of weapons. The Wing Loong I is believed to be in service with the PLA Air Force and to have been sold to a number of countries including United Arab Emirates, Saudi Arabia, Kazakhstan, Pakistan, Egypt, Indonesia, Uzbekistan, and Serbia.[67]

According to its designer, Li Yidong (see appendix), Wing Loong I UAVs have performed in multiple conflicts at a level “exceeding expectations.” In one of the conflicts, three Wing

Loong I UAVs were used for 24/7 surveillance and made a significant impact on the outcome of the conflict.[68]

Wing Loong I

Wing Loong II

The Wing Loong II, also known as the GJ-2, is a larger and more capable version of the Wing Loong I, roughly comparable to the General Atomics MQ-9 Reaper. It is said to have a maximum speed of 370 km/hr (230 mph), a service ceiling of 9,000 m (29,500 ft), an endurance of 20 hours, and to be capable of carrying 480 kg (1,050 lb) of external stores. In addition to its chin-mounted electrooptical/infrared turret, the Wing Loong II is said to house a SAR in its nose. An ELINT version is also believed to exist. The Wing Loong II's first flight was reportedly in 2017, and it is believed to be in service with the PLA Air Force and to have been sold to several foreign countries.[69] According to Li Yidong, Wing Loong II won the trust of overseas customers when it reportedly hit an unmanned SUV in a target practice demonstration.[70]

Wing Loong II

2.3 High-Altitude Long-Endurance UAVs

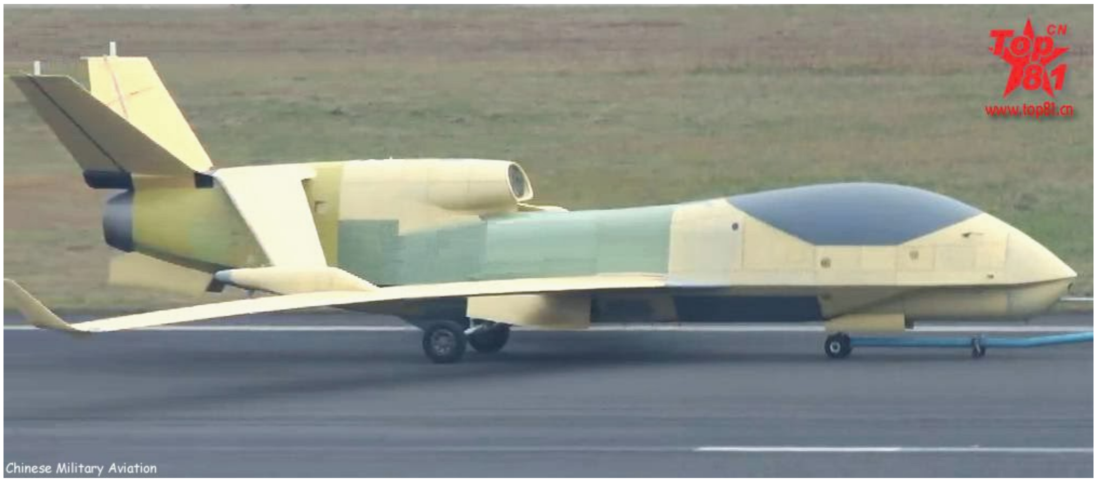
BZK-005

The BZK-005, or Chang Ying [长鹰], is a HALE UAV roughly comparable to the General Atomics MQ-1 Predator. It reportedly has a cruising speed of 150-180 km/hr (90-110 mph), maximum range of 1,800 km (1,100 mi) and a maximum endurance of 24 hours. It features a chin-mounted forward-looking infrared (FLIR) and/or charge-coupled device (CCD) camera, and the head bulge is assumed to contain a satellite communications antenna. Developed by Beihang University and the Harbin Aviation Industrial Group, the BZK-005 is described as ideal for ISR missions in a high-tech localized war (高技术局部战争中的情报侦察和监视任务). Versions of this UAV are believed to be in service with PLA Army, PLA Navy, PLA Air Force, and PLA Strategic Support Force.[71]

BZK-005 Chang Ying [长鹰] "Long Eagle"

Soar Dragon

The Soar Dragon (Xianglong [翔龙]), also known as the EA-03 or WZ-7 and, possibly, BZK-009, is a HALE UAV roughly comparable to the Northrup Grumman RQ-4 Global Hawk. Developed by the Chengdu Aircraft Design Institute and the Guizhou Aircraft Industry Corporation, it features a distinctive box-wing design in which the horizontal stabilizers are swept forward and connect to the tops of the wings. The Soar Dragon reportedly has a range of 7,000 km (4,400 mi), a cruising speed of 750 km/hr (470 mph), and a cruising altitude of 18,000 m (59,000 ft). Payloads are believed to include FLIR and TV cameras, as well as ELINT sensors. It is reportedly in service with the PLA Air Force.[72]



Soar Dragon

The Soar Dragon HALE UAV provides the PLA with strategic reconnaissance of important targets. Several can be seen on commercial satellite imagery to be based in Shuangliao, Jilin Province [双辽市, 吉林省] (see left).[73] These UAVs were believed to have been used to track U.S. ships transiting the Taiwan Strait in 2019.[74]

WZ-8

At the military parade celebrating China's 70th anniversary on October 1, 2019, a delta-winged UAV, reportedly designated WZ-8, was publicly displayed for the first time. Designed by the Chengdu Aircraft Design Institute and manufactured by the Guizhou Aircraft Industry Corporation, this vehicle is apparently carried under the belly of an H-6 bomber. Once released, it climbs into the stratosphere with the help of a solid rocket booster where it cruises at an altitude of more than 100,000ft and a speed greater than Mach 3. When its flight is complete, it glides to an airbase and lands.

WZ-8

GJ-11 Sharp Sword

Also displayed at the military parade on October 1, 2019, was a tailless, air-breathing flying wing UAV designated Sharp Sword (Lijian [利剑]). Said to be developed by the Shenyang Aircraft Design Institute and Hongdu Aviation Industry Group, the Sharp Sword is believed to be an unmanned combat aerial vehicle (UCAV) capable of carrying more than 2,000 kg (4,400 lb) of weapons in two internal bomb bays, but could perform ISR functions as well. It is believed to carry a chin-mounted infrared search and track system and may have conformal antennas embedded in the leading edges of its wings.[75]

GJ-11 Sharp Sword

2.4 Key UAV Developers

ASN-206

Xi'an Aisheng Technology Group Company Ltd [西安爱生技术集团公司]
Website: http://aisheng.nwpu.edu.cn/
Location: Yanta District, Xi'an, Shaanxi Province [雁塔区，西安市，陕西省]

Xi'an Aisheng has been a major pioneer of Chinese UAV technology. It is associated with Northwest Polytechnic University (NPU) and is also called NPU's 365th Research Institute [西北工业大学第 365 研究所]. Wang Junbiao [王俊彪] is the institute's Director; he is also Deputy Party Secretary and Deputy General Manager.[76]

Aisheng specializes in small, man-portable, or truck-launched surveillance UAVs. In the 1990s, the company developed the ASN-206 and ASN-207 reconnaissance UAVs described above. More recent efforts include the hand-launched ASN-217 Electric UAV, which can provide tactical ISR support somewhat similar to the RQ-11 UAV used by the U.S. armed forces.[77] Other small UAVs such as the 50 kg ASN-212 have more limited range and payload, but can perform battlefield surveillance, damage assessment, and border patrol missions.[78] More capable small UAVs include the ASN-215, which has a maximum take-off weight of 220 kg, a 60 kg payload, and a maximum altitude of 6000 m.[79]

NPU appears to be expanding its manufacturing capabilities. In 2016, it signed an agreement with Xixian New Area [西咸新区] in Shaanxi to build a civilian UAV manufacturing base [民用无人机产业化基地] in Fengxi New City [沣西新城] to help expand NPU and Aisheng's operations.[80]

CASC China Academy of Aerospace Aerodynamics (CAAA) [中国航天空气动力技术研究所]/ 11th Research Academy [十一院]
Website: http://www.caaa-spacechina.com
Location: Fengtai District, Beijing [丰台区，北京市]

Founded by Chinese aerospace pioneer Qian Xuesen [钱学森] in Beijing in 1956, the CASC China Academy of Aerospace Aerodynamics (CAAA) was China's first large-scale R&D center. The academy conducts R&D on space launch vehicles, aerodynamics, satellites, missiles, and other strategic weapons. [81] The institute is based in Beijing and has manufacturing facilities in Tianjin. It has partnerships with both Chinese and foreign universities as well as Chinese think tanks and has its own a doctoral program.[82] In addition to missiles, ground effect aircraft, and hovercraft, CAAA produces very-short to long-range UAVs. Most prominent of these is the CH or Caihong [彩虹] "Rainbow" series of UAVs designed by Song Wen [宋文], including the CH-91 described above. The CH series includes a range of hand-launched, rocket-launched, and full-sized UAVs that take off like traditional aircraft and perform a wide range of roles, including remote sensing, maritime inspection, artillery spotting, and data relay.[83]

Guizhou Aircraft Industry Corporation (GAIC) [中航贵州飞机有限责任公司]
Website: N/A
Location: Anshun, Guizhou Province [安顺，贵州省]

Guizhou Aircraft Industry Corporation (GAIC), also called Guizhou Aircraft Corporation (GAC) or 011 Base, is a subsidiary of AVIC founded in 1964.[84] The company has built parts for the J-6 and J-7 series fighter aircraft and builds the JL-9 jet trainer, an export version of which, the FTC-2000, is offered for international markets.[85]

Based in Anshun City [安顺市], Guizhou, although GAIC's background is in traditional aerospace, it has been making significant investments in unmanned systems in recent decades.[86] GAIC produces the BZK-007, Wing Loong I, and Wing Loong II medium-altitude surveillance UAVs, as well as the Soar Dragon HALE UAV.[87]

Section 3: Aerostats For Persistent ISR

An old technology that has seen a resurgence of interest in a persistent observation role is lighter-than-air aircraft. China is particularly interested in using aerostats and reconnaissance balloons for "near-space reconnaissance" [临近空间侦察] in the region of the atmosphere above 20,000 m and the 100,000 m "Karman line" typically used to denote the edge of space.[88] In an interview, PLAAF Early Warning College [空军预警学院][89] professor Xiong Jiajun [熊家军] stated that he believed that new weapons research and development was needed to deal with space and near-space [太空和临近空间] threats.[90]

Chinese research institutions see great potential for tethered lighter-than-air aerial vehicles (aerostats). These platforms can stay aloft at heights typically only achievable by large fixed-wing aircraft and can carry radar and optical sensors for surveillance or even act as electronic warfare platforms. Aerostats can also be used as communications hubs to improve signal transmission in mountainous terrain where laying cable is not practical.[91]

PLA news media and the military appear to have paid close attention to Russia, which has developed the AVK-05 tethered aerostat equipped with optoelectrical video surveillance cameras. Under optimal conditions, the AVK-05 can survey a radius of 10 km and operate between 300 and 1,000 m.

China has been investigating balloons and aerostats for several decades with mixed results. In the late 1970s, Beihang began work on a series of lighter-than-air craft (pictured). These were used for aerial photography and other applications. China also appears to be deploying aerostats to its reclaimed islands in the South China Sea. In November 2019, for example, ImageSat International posted a satellite image, dated 18 November 2019, of an aerostat in use on Mischief Reef.[92] Other aerostats and associated facilities that are likely for military use have been identified outside Beijing, and in Shandong and Liaoning provinces.[93]

3.1 Developers of Aerostats

AVIC Special Vehicle Research Institute
[中国特种飞行器研究所]
Website: http://www.svri.avic.com/
Location: Jingmen City, Hubei Province
[湖北省荆门市]

A number of Chinese companies and research institutes appear to be developing aerostats for commercial and military applications. In 2018, for example, Zhang Mingwen [张明文], head of AVIC Special Vehicle Research Institute [中国特种飞行器研究院], said the company would invest heavily in the development of seaplanes and aerostats.[94] In July 2015, the Special Vehicle Research Institute signed a development agreement with Flying Whales, a French airship maker.[95]

In 2016, the Special Vehicle Research Institute and CETC both displayed aerostats at the Zhuhai Airshow. AVIC's exhibition included a display of a model "Airspace (Sea) Information Integration" aerostat system that incorporated high-resolution earth observation and communication relays. Staff at the event said that the systems could act as a replacement for satellites in low Earth orbit (LEO), staying aloft for months at a time at altitudes of 20,000 m.

China Electronics Technology Group Corporation
[中国电子科技集团有限公司]
Website: http://www.cetc.com.cn/
Location: Haidian District, Beijing [北京市, 海淀区]

CETC exhibited a 32-meter-long aerostat (above) capable of staying aloft for more than two weeks at an altitude of 1,000 m. It can act as a microwave and satellite communications relay and is said to carry high definition optical sensors.[96] At the World Radar Expo and 9th Military and Civilian Electronic Information Technology Exhibition in 2018, a model (right) indicated that CETC's 38th Institute is developing a system called the JY-400 series Tethered Balloon Reconnaissance & Monitoring System [系留气球侦察监视系统].[97]

Aerospace Information Research Institute, Chinese Academy of Sciences, [中国科学院空天信息研究院]
Website: http://www.aircas.cn
Location: Haidian District, Beijing [北京市, 海淀区]

In May 2019, the Aerospace Information Research Institute under the Chinese Academy of Sciences, [中国科学院空天信息研究院] launched an aerostat called the Jimu No.1 ([极目一号], lit. "as far as the eye can see No. 1") to an altitude of 7,003 m (22,976 ft) in western China.[98] The scientists are said to believe that the aerostat can eventually stay aloft at altitudes of 20,000 m for months at a time.

AVIC Aerospace Lifesaving Equipment Company
[中航工业航宇救生装备有限公司（中航工业航宇）]
Website: http://www.ali-jt.avic.com/
Location: Xiangyang, Hubei Province [湖北省襄阳市]

Another company involved in aerostat development is AVIC Aerospace Lifesaving Equipment, a major producer of parachutes and similar equipment for military and civilian applications. The company has been an important developer of hot air balloons and aerostats.

SECTION 4: SATELLITE C4ISR CAPABILITIES

Satellites are a key element of modern military operations. Imagery satellites use a wide range of sensors, including SAR and visible and infrared light to collect data. Other specialized satellites, such as those in ELINT or early warning roles, detect radio signals from enemy ships and aircraft or the heat given off by vapor trails from ballistic missile launches.

China's satellite program began after the Soviet Union successfully launched Sputnik in 1957. Rebuffed by the Soviet Union in 1958 when a visiting scientific delegation proposed cooperation, China embarked on a crash program to develop its own satellite. China's first rocket launch occurred in February 1960, followed by short- and medium-range ballistic missiles in June 1964. At the special meeting of the Central Special Committee [中央专门委员会] in August 1965, China's leaders established Project 651 [651 工程] to launch a satellite. On 24 April 1970, a Long March 1 [长征一号] missile lofted Dongfanghong 1 [东方红一号] to orbit.[99]

In recent years, China has rapidly expanded its number of satellites in orbit. China now operates more satellites than any country other than the United States.[100] According to the Union of Concerned Scientists, as of March 31, 2020, China had 363 operational satellites, as compared to 1,327 for the United States and 169 for Russia.[101] While China's government-owned satellites are notionally controlled by China National Space Administration (CNSA) [国家航天局], it is clear that the PLASSF plays a major role in managing them and maintains deep links with Chinese commercial providers of satellite imagery as well[ii].

Although the Chinese government and private launch companies rarely provide detailed about the satellites they launch, open source information suggests that many have military C4ISR roles. Provided below are descriptions of some of the principal types of satellite employed by China's military.

4.1 POSITIONING, NAVIGATION AND TIMING SATELLITES

The Beidou satellite navigation system provides positioning, navigation and timing (PNT) vital to coordinating precision military operations. The first satellite was launched in 2000, but the system has grown rapidly, with 30 satellites placed in orbit since 2017. As of November 2020, China had 44 Beidou satellites in orbit. It completed the populating of the constellation in June 2020.[102]

To provide global coverage the satellites are arranged in a combination of medium earth orbits (MEO) and geostationary earth orbits (GEO). Chinese media claim that the satellites are now capable of providing sub-meter-level positioning. The program is seen as having a significant economic impact domestically and through licensed applications abroad, especially in countries

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[ii] See Peter Wood, Alex Stone and Taylor A. Lee, *China's Ground Segment - Building the Pillars of a Great Space Power*, November 2020.

that are part of China's Belt and Road Initiative. Yu Xiancheng [于贤成], President of the China Satellite Navigation and Positioning Association [中国卫星导航定位协会], has estimated that by 2020 the scale of China's satellite navigation industry will exceed 400 billion RMB (U.S.$56.6 billion).[103]

4.2 Remote Sensing Satellites

The Gaofen constellation is a broad family of satellites that includes radar and multi-spectral satellites. It is administered in part under the "China High-Resolution Earth Observation System" (CHEOS) [高分专项], one of China's 16 "Major S&T Projects."

The Gaofen project was begun in 2010, and the first satellite was launched in 2013. Launches of the Gaofen-2 in August 2014, and Gaofen-4 gave China multi-spectral and high-definition optical imaging capabilities. At least 15 Gaofen satellites were believed to be in operation as of March 2020.[104]

According to reporting on the launch of Gaofen-7 in November 2019, its sensors are capable of sub-meter 3D mapping using optical cameras and high-precision laser altimetry.[105] Some 30 provincial centers have been set up to distribute CHEOS data. The program is said to be meant to provide assistance to local environmental management and protection and urban planning, as well as national priorities such as military-civil fusion and the Belt and Road Initiative.

Yaogan ([遥感], "remote sensing") is the name for a series of what are widely believed to be Chinese military reconnaissance satellites. The first Yaogan satellite was launched in 2006 and, as of March 2020, more than 50 were believed to be operational.[106]

Observations of their orbits and launch patterns appear to indicate that the Yaogan satellites perform several types of missions including optical imaging, radar imaging, electronic intelligence, and perhaps ballistic missile early warning.[107]

The PLA's Strategic Support Force's Aerospace Reconnaissance Bureau [航天侦察局] is believed to have taken over responsibility for the Yaogan satellites under the new Space Systems Department.[108]

4.3 Communications Satellites

Communication satellites are important not only for long-distance military operations but also to relay to a ground station within China data from satellites in LEO whose line of sight to a ground station is blocked by the curvature of the earth. The Shentong 2 [神通 2] series of satellites, also known as ChinaSat 2, are believed to be Ku-band military communication satellites.[109] The Fenghuo 2 [风火 2] series, also known as ChinaSat 1, are believed to be data relay satellites.[110] Currently, three ShenTong 2 satellites and two Fenghuo 2 satellites are believed to be in operation.[111]

4.4 Signals Intelligence

China is believed to operate SIGINT/ELINT satellites under the Shijian ([实践], "Practice") designator also used for space science satellites and technology demonstrators. Eight SIGINT spacecraft in the Shijian 6 series and eight in the Shijian 11 series are believed to be operational.[112] A newer series, the Tongxin Jishu Shiyan [通信技术试验] or "Communications Technology Test") satellites, encompasses five objects (including a subsatellite) put into GEO orbits since September 2015. They are believed to serve optical earth observation, ELINT, and/or early-warning roles.[113] According to Xinhua, the most recently launched satellite in the series (TJS-4) will be used for "verification of multi-band and high-rate satellite communication technologies."[114]

Hyperspectral Sensors

An important area of development for China's remote sensing satellites is hyperspectral imaging. Sensors with this capability collect and analyze data across a wide range of the electromagnetic spectrum, fusing data collected from different bands to achieve to develop more detailed signatures for objects or traces of activity. Hyperspectral sensing has been an R&D priority for China since the mid-1980s and was part of the dual-use 863 Program. China began using Modular Airborne Imaging Spectrometers (MAIS) for geological mapping projects in the late 1980s. In 2002, it launched a hyperspectral sensor aboard the Shenzhou III [神舟三号].[115]

Since then, a series of earth-observing (EO) satellites--including the Fengyun-3 [风云三号] meteorological satellites and the "Huanjing-1a" [环境一号 A] earth observation satellite, members of the Gaofen constellation, and other satellites have included hyperspectral sensors.[116]

Commercial Earth Observation Satellites

The economic potential of earth observation satellites has encouraged private or semi-private businesses to launch their own satellites. China launched its first civilian earth observation satellite in 1999. In 2015, China launched the Jilin No. 1 [吉林一号], China's first "commercial" high-resolution remote sensing satellite.[117] Recognizing the utility of commercial imagery for military applications, constellations such as the Beijing Series using three optical satellites arranged so that they see the entire earth once per day, could augment those launched by the military. Other Chinese commercial satellite companies are also launching earth observation satellites. Zhuhai Orbita Aerospace Science and Technology Co., Ltd. [珠海欧比特宇航科技股份有限公司] is building its own constellation of video and hyperspectral satellites beginning in 2017. Chinese commercial launch companies are also investing in bigger rockets capable of taking larger payloads to higher orbits. [118]

CONCLUSION

The PLA is rapidly expanding its ability to carry out 24/7 surveillance of its own territory and beyond. While its aircraft currently lack the ability to fly much further than the second island chain or the basing and flight permissions needed to carry out missions further afield, its growing security cooperation with partners and neighbors such as Pakistan and its establishment of a base in Djibouti are likely heralds of what is to come.

Analysis of the PLA's known inventory of fighter aircraft between 2015-2019 indicates that China is phasing out older fighters (J-7s, J-8s, early J-10s) in favor of longer-ranged fighters equipped with advanced sensors and long-range weaponry (J-10C, J-15, J-16, J-20). When paired with larger numbers of early warning aircraft, particularly the more capable KJ-2000s (and its future Y-20-based version), China will have a much more robust air defense and be capable of more effectively intercepting enemy aircraft, particularly low-flying aircraft and cruise missiles.

Whereas in previous decades Chinese air defense systems and interceptor squadrons could realistically only protect a few strategic areas or point targets, a combination of airborne early warning systems and layered ground radars will offer a robust, nationwide air defense system. While Chinese claims of the utility of these systems against stealth platforms and cruise missiles should not be taken at face value, when integrated with passive sensors and low-frequency radar systems,[119] they could enable a significant improvement in China's capability to counter such threats.

Four future developments may be particularly significant: the acquisition of AEW&C capabilities that extend well beyond China's borders, the deployment of robust space-based C4ISR capabilities, the creation of redundant command and control networks, and the employment of artificial intelligence to process the data collected by China's new C4ISR capabilities.

Extensive AEW&C Coverage

China appears to be poised to field larger numbers of AEW&C aircraft. With the apparent success of the KJ-200, -500 and -2000, more are being built, and upgraded variants of the KJ-200 appear to be in development. Additionally, test models of a carrier-based early warning aircraft, the KJ-600, appear to indicate that China's growing carrier force, currently at two carriers but projected to grow to a total of six, will also field AEW&C aircraft, further pushing the airborne detection range out from China's shores.

Robust Space-Based C4ISR Capabilities

Greater numbers of satellites will improve the PLA's ability to carry out a full range of optical, radar and signals intelligence collection, more accurately monitor troop movements, and prepare for precision strikes or defensive operations.

An area that may see growth in the coming years is what is referred to as "responsive space reconnaissance" [应急空间侦察]: in urgent situations, rapid assembly and launch of space reconnaissance platforms or use of an existing platform after a change of orbit.[120] Rocket systems such as the Kuaizhou [快舟] (pictured) produced by China Aerospace Science and Industry Corporation [中国航天科工集团] provide a "space rapid-reaction" capability [空间快速响应能力] by offering the ability to quickly replace destroyed satellites. The Kuaizhou system was first tested in 2017, and subsequent launches have been used to put small satellites in LEO.[121] The Kuaizhou uses an adapted transporter erector launcher (TEL) similar to that used by ballistic missiles. These systems could give the PLA the ability to either conduct contingency reconnaissance ahead of conflict or replace satellite ISR and communication assets lost in conflict.

Furthermore, the development of reusable rocket launch vehicle technology, in which China is also investing, could drive down the cost of space launches. These vehicles, combined with ever-shrinking satellite sizes and development of effective sensors for small satellites, could allow China to field capable and redundant constellations of satellites for a variety of missions.

China's apparent development and testing of early warning satellites indicates the possibility of a deployment of a space-based network of infrared-sensing early warning satellites which, combined with its existing network of ground-based large phased array radars (LPARs), could provide China with a robust nuclear early warning capability. Similarly, space-based ELINT satellites, combined with China's ground-based over-the-horizon (OTH) radars, can be used to detect aircraft or ships operating outside of the coverage area of China's airborne AEW&C capabilities.

Redundant Command and Control Networks

The PLA has made significant investments in buried fiberoptic communication links, meant to make command and control nodes more resilient. Airborne networks combining manned aircraft, UAVs, and aerostats could offer another layer of redundancy and are clearly an area of research and development. CETC has displayed such a tactical datalink system, called the DT-03 [DTS-03 战术数据链系统], which is depicted as connecting KJ-500s to fighters, UAVs, and ground stations.[122] China has also developed a Joint Integrated Datalink System [全军综合数据链系统] similar to the U.S. Link-16 system. Chinese news in 2011 claimed that this system was rolled out across the PLA’s fleets and was capable of connecting to airborne early warning aircraft like the KJ-2000.[123]

Use of Artificial Intelligence

As China’s aerospace industry produces increasing numbers of C4ISR platforms, the PLA will seek to enhance its capability to exploit the vast amount of data they collect through use of artificial intelligence. Chinese government departments have even sponsored public competitions to improve satellite sensor identification and tracking.[124]

The deployments of the platforms laid out in the preceeding sections indicate that China has made significant progress in developing and fielding real C4ISR capabilities. Taken together, these latter four ongoing developments point toward a much more capable PLA, able to carry out modern informationized campaigns.

APPENDIX 1: MILESTONES IN CHINESE ISR DEVELOPMENT

1960	Work begins on the JZ-5 reconnaissance aircraft and artillery spotter
1965	Harbin Aircraft Plant begins design work on HZ-5 reconnaissance aircraft
26 June 1969	KJ-1 program established, design work completed in 18 months[125]
26 September 1969	CMC orders development of airborne early warning aircraft
25 November 1969	PLAAF Party Committee decides to use modified Tu-4 aircraft for KJ-1 program, assigns code name 926
24 April 1970	China launches its first satellite, the Dongfanghong 1 [东方红一号]
August 1970	Phase 2 of testing for the KJ-1 begins. The Type 843 radar proves unable to distinguish targets from ground clutter in any but optimal conditions[126]
December 1970	Development of HZ-5 reconnaissance aircraft begins[127]
10 June 1971	KJ-1, China's first early warning aircraft, successfully flies for the first time; flight test phase begins,[128] but problems with severe vibration plague subsequent tests
1979	KJ-1 ceases development due to inability to meet military requirements
31 December 1984	SH-5, China's first indigenous ASW aircraft, delivered to PLA Naval Aviation
1992	Negotiations begin for purchase of Russian A-50 AEW&C aircraft
April 1992	R&D of Z-9C ASW helicopter electronics and ASW systems begins.
26 December 1994	Z-9C ASW helicopter carries out first successful flight at Harbin Aircraft Manufacturing [哈尔滨飞机制造公司]
1995	A-50 negotiations break down, reportedly due to price of U.S.$270 million, not including training and equipment
1998	China and Israel ink agreement for sale of four Phalcon airborne early warning aircraft for U.S.$1 billion
18 February 2000	Design of Z-9C helicopter approved
March 2001	Israel cancels AEW&C aircraft sale to China due to pressure from Clinton Administration
2002	Development of KJ-200 begins
May 2003	KJ-200 early warning aircraft approved by the PLA General Armament Department
November 2003	KJ-2000 completes first flight
14 January 2005	First successful KJ-200 test flight carried out
3 June 2006	Prototype KJ-200 crashes in Anhui, an accident described as the PLA's worst air disaster
2007	KJ-2000 enters service with the PLA
2009	KJ-200 and KJ-2000 officially shown for the first time at military parade commemorating 60th anniversary of founding of PRC
2019	KJ-500 officially shown for the first time at military parade commemorating 70th anniversary of founding of PRC

Appendix 2: English-Chinese Glossary of Technical Terms

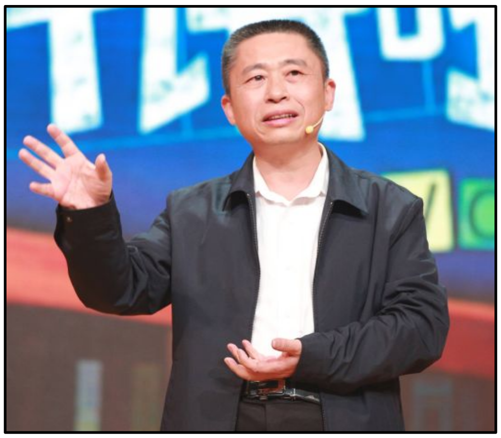
Due to the technical nature of the study and with the hope that other researchers will find this useful, we have included a list of some of the technical vocabulary we encountered in the writing of this report.

Aerostat	浮空器
Airborne Early Warning	航空预警
Airship	飞艇
Counter-Stealth	反隐身
Automatic Search and Interception	自动搜索和截获
Airship	飞艇
Beidou	北斗
Campaign Reconnaissance	战役侦察
Comprehensive Sensing and Tracking	综合探测跟踪
Datalink	数据链传
Jamming Aircraft	电子干扰机
Fengyun	风云
Gaofen	高分
Geostationary Earth Orbit (GEO)	静止轨道
Guided Attacks	引导攻击
High-Altitude Long Endurance Unmanned Aerial Vehicle	高空长航时无人机
Intelligentization	智能化
Joint Operations Capabilities	联合作战能力
Monitoring	监视
Networked Early Warning and Command	组网预警指挥
Reconnaissance	侦察
Reconnaissance Aircraft	侦察机
Responsive Space Reconnaissance	应急空间侦察
Semi-Active Radar Homing	半主动雷达制导
Shipborne UAV	舰载无人机
Space Rapid-Reaction Capability	空间快速响应能力
Space Reconnaissance Unit	航天侦察部队
Strategic Reconnaissance	战略侦察
Surveillance Early Warning Aircraft	诊察预警飞机
Surveying and Early Warning	探测预警
Synthetic Aperture Radar (SAR)	合成孔径雷达
Tactical Reconnaissance	战术侦察
Unmanned Aerial Vehicle Reconnaissance Unit	无人侦察机部队
Warning Aircraft	警戒机
Yaogan	遥感

APPENDIX 3: KEY RESEARCHERS

The following profiles are examples of highly-acclaimed aircraft designers and researchers operating in the field of early warning aircraft and HALE UAVs.

Lu Jun [陆军]



Lu Jun, Chief Scientist for CETC, was the chief designer of the KJ-2000 early warning aircraft. China views the KJ-2000 project as a particular point of pride due to its rapid speed after the United States prevented Israel from selling the Phalcon system to China.

Born in 1964, Lu entered the Radio Engineering Department of what is now Southeast University [东南大学] in Nanjing in 1981. After graduating in 1985 he studied at the University of Science and Technology of China [中国科学技术大学] in Anhui under the Director of CETC's 38th Institute.[129]

After receiving his masters he began working for CETC, initially on radars for artillery. In 2001 he was tapped to lead electronics design work on the KJ-2000. The KJ-2000's design was approved, and the first aircraft were delivered to the PLA in 2007.

Lu's many awards include the National May First Labor Medal (2006), the Gold Medal for the "High-Tech Weapons Equipment Development and Construction Project Major Contribution Award" [高技术武器装备发展建设工程重大贡献奖] awarded by the CCP Central Committee, State Council and CMC (2007), a State Science and Technology Progress Award Special Class Award [国家科技进步特等奖] (2010), and the National Defense Science and Technology Progress Special Class Award [国防科技进步一等奖] (2015). In November 2017, he was named an Academician [院士] of the Chinese Academy of Engineering [中国工程院].[130]

Li Yidong [李屹东]

Best known as the Chief Designer of the Wing Loong UAV series, Li Yidong serves as Deputy Chief Designer of the AVIC Chengdu Aircraft Design Institute (CADI) [中航工业成都飞机设计研究所]. Li graduated from Beijing University of Aeronautics and Astronautics (BUAA) in 1988 and appears to have spent the majority of his career at CADI. Prior to switching focus to work on UAVs, he won awards for his contribution to the single and tandem-seat variants of the J-10 fighter and for unspecified contributions during the 8th [1991-1995] and 9th [1996-2000] Five Year Plans. By 2008, he had risen to become the Deputy Chief Designer at CADI.[131]

Beginning in 2011, he has served as the Chief Designer of the Wing Loong series of UAVs. In 2013, he received a Ph.D. from BUAA.[132]

Li's greatest success appears to be the Wing Loong II UAV, a long-endurance integrated reconnaissance and strike UAV. Li said that his team developed three major systems for the Wing Loong II: the flight control system, the mission system, and the command and control system. Li assesses that the progress made in the Wing Loong II's development means that the UAV has "reached advanced international levels."

Appendix 4: Military Academic Institutions Involved in C4ISR

Two military academies appear to have primary responsibility for training mission crews for PLAAF and PLA Naval Aviation C4ISR aircraft.

Air Force Early Warning Academy [空军预警学院]
Website: N/A
Location: Wuhan, Hubei Province
[湖北省武汉市]

The Air Force Early Warning Academy was founded in 1952 as the PLA Air Defense School in Wuhan and Radar School in Nanjing. The two institutions were merged in 1958 and renamed the Air Force Radar Forces School. Formerly under the Guangzhou Military Region Air Force, it was upgraded to the status of a military academy in 1992 and in 2004 was put under the direct control of the PLAAF. It was renamed the Air Force Early Warning Academy in 2011. The academy acts as a mid-level professional education institution for command and engineering and technical officers as well as NCOs and technical personnel. It offers both professional training and degree programs, with the latter ranging from undergraduate to doctoral programs.[133] Although, as its history suggests, the Early Warning Academy is focused primarily on ground-based radar and air defense units, it is presumably also responsible for training the mission crews mission crews for PLAAF C4ISR aircraft

Naval Aviation University [海军航空大学]
Website: N/A
Location: Yantai, Shandong Province
[中国山东省烟台市]

The Naval Aviation University has primary responsibility for training mid-career naval officers, shore- and ship-based flight officers, and early warning and anti-submarine airborne combat officers.[134] It is a significant scientific research center for military aerospace development. The Naval Aviation University was created in 2017 via the consolidation of the Naval Aviation Academy [海军航空兵学院] (established 1 November 1950) and the Naval Aviation Engineering Academy [海军航空工程学院] (established 24 August 1950). [135]

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