航空航天

CHINA AEROSPACE STUDIES INSTITUTE

China's Aviation Industry: Lumbering Forward

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A CASI Monograph

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China Aerospace Studies Institute

CASI's mission is to advance understanding of the capabilities, development, operating concepts, strategy, doctrine, personnel, organization, and limitations of China's aerospace forces, which include: the PLA Air Force (PLAAF); PLA Naval Aviation (PLAN Aviation); PLA Rocket Force (PLARF); PLA Army Aviation (PLAA), the Strategic Support Force (PLASSF), primarily space and cyber; and the civilian and commercial infrastructure that supports the above.

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- CASI establishes and maintains institutional relationships with organizations and institutions in the PLA, the PRC writ large, and with partners and allies involved in the region.
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CASI supports the U.S. Defense Department and the China research community writ large by providing high quality, unclassified research on Chinese aerospace developments in the context of U.S. strategic imperatives in the Asia-Pacific region. Primarily focused on China's Military Air, Space, and Missile Forces, CASI capitalizes on publicly available native language resources to gain insights as to how the Chinese speak to and among one another on these topics.

Preface

As we move further into the era of 21st century great power competition, it is important to understand with whom we are competing. This study is the first in a series of studies by the China Aerospace Studies Institute that seeks to lay the foundation for better understanding the Aerospace Sector of the People's Republic of China (PRC). This study focuses on the major actors and institutions in the aviation portion of the PRC's aerospace sector. Further case studies will examine specific programs within the sector, as well as the role of so-called 'private' or 'commercial' companies. This foundational study looks at the national-level, and the state-owned enterprises (SOE) that make up the bulk of PRC aviation.

It goes without saying that the PRC's system of research, development, and acquisition (RD&A) is very different from that of the United States. As such, it is important to understand just how different it is, in order to really understand the nature of the competition. Whereas the United States largely relies on competition between commercial companies, typically large publicly traded multinationals, for R&D and production, the PRC uses all levers of Party and State power to pursue its goals. This study maps those relations, policy bodies, and centers of specialization.

While this report focuses mainly on the military aspects of the aviation sector, largely because that has been the nearly exclusive focus for the PRC for decades, it is useful to remember that as the PRC attempts to build it own commercial aviation sector, that the bulk of the knowledge, funding, support, manpower, etc. will still come from these SOEs, and the many subsidiaries that they hold or manage. Indeed, it is likely that the next series of major break throughs in technology and systems integration that the PRC achieves, will be transfers of intellectual property and technical expertise from the commercial-civil sector back to the military applications, under the PRC's Military-Civil Fusion (军民融合) state policy dictate.

CASI would like to thank the team at TextOre for their investigative hard work in dissecting the often opaque details of the Chinese system. We hope you find this volume useful, and look forward to bringing you further details on the foundations of Chinese aerospace in this series.

Brendan S. Mulvaney
Director, China Aerospace Studies Institute

Sections

Sections (continued)

Abbreviations

AESA	Active Electronically Scanned Array (radar)
A2/AD	Anti-Access, Area Denial
AEW&C	Airborne Early Warning & Control
AAM	Air-to-Air Missile
AM	Additive Manufacturing
AMS	Academy of Military Sciences
ASW	Anti-Submarine Warfare
AVIC	Aviation Industry Corporation of China
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAAC	Civil Aviation Administration of China
CAD	Computer Aided Design
CAE	Chinese Aeronautical Establishment
CASC	China Aerospace Science and Technology
CASS	Chinese Academy of Social Sciences
CCDI	Central Commission for Discipline Inspection
CCP	Chinese Communist Party
CFD	Computational Fluid Dynamics
CIMS	Computer Integrated Manufacturing Systems
COMAC	Commercial Aircraft Corporation of China
CMC	Central Military Commission
CMI	Civil-Military Integration
CNC	Computer Numerical Control
CNSA	China National Space Administration
COSTIND	Commission for Science, Technology and Industry for National Defense
DWP	Defense White Paper
ECM	Electronic Countermeasures
EDD	Equipment Development Department
EW	Early Warning
GAD	General Armament Department
GSD	General Staff Department
HALE	High Altitude Long-Endurance
ISR	Intelligence, Surveillance, and Reconnaissance
JASDF	Japanese Air Self Defense Force

Abbreviations (continued)

JSD	Joint Staff Department
LAM	Laser Additive Manufacturing
LRIP	Low-rate Initial Production
MCF	Military-Civilian Fusion
MIIT	Ministry of Industry and Information Technology
MOST	Ministry of Science and Technology
NBS	National Bureau of Statistics
NDU	National Defense University
NRDC	National Development and Reform Commission
NUDT	National University of Defense Technology
PAP	People's Armed Police
PBSC	Politburo Standing Committee
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PLARF	People's Liberation Army Rocket Force
PLASSF	People's Liberation Army Strategic Support Force
PRC	People's Republic of China
RDA	Research, Development, and Acquisition (Also RD&A)
RMB	Renminbi
ROC	Republic of China
SCIO	State Council Information Office
TCAF	Theater Command Air Force
SASAC	State-owned Assets Supervision and Administration Commission
SASTIND	State Administration for Science, Technology and Industry for National Defense
UCAV	Unmanned Combat Aerial Vehicle

Introduction

China's[a] aviation industry dates its formal founding to 1951. In the almost 70 years since then, it has undergone a massive technological transformation. While China's leaders always envisioned an active civilian aviation industry, circumstance has dictated that, for much of its history, the aviation industry was dominated by the requirements of the People's Liberation Army (PLA). Thrown into the Korean War shortly after the founding of the People's Republic of China (PRC), the nascent aerospace industry, partnered with—and became largely reliant on—Soviet expertise, and quickly began production of fighters, bombers, and helicopters, all based on Soviet designs. Organizationally, this laid the foundations for a scientific and industrial enterprise by establishing factories and training engineers and scientists.

Aviation innovation was largely put on hold during the Cultural Revolution (1966-1976). Once the Cultural Revolution ended, a return of official support for conventional weapons development occurred in 1977, and China began to rapidly purchase or co-develop a wide range of new aircraft types, typically with Western partners. Even the United States began four foreign military sales (FMS) programs to China, which provided an injection of U.S.-built capabilities and technology. All of which, however, were put on hold due to U.S.-China tensions after the Tiananmen Square Incident in June 1989. China was able to get relief, in some part, due to a new influx of Soviet and later, Russian aviation expertise in the early 1990s. Reinvigorated by top-level concern about the new, technologically-driven way of war on display in the early 1990s, as evidenced by the United States military in Iraq, the PLA reformed, reorganized and reduced in size, dragging bloated aerospace companies along the path to reform with it. In the early 2000s, charged with safeguarding Chinese interests abroad and enforcing territorial claims closer to home, strategic power projection became a driving force for aerospace projects.

Further emboldened by a booming economy, a more assertive and confident government embarked on an ambitious program of military modernization that would have been impossible even a few years earlier. The civilian aviation industry has also seen tremendous growth, with China's expanding middle class driving demand for domestic and international travel. The civilian aviation industry, working in tandem with the central government, is attempting to meet domestic demand with indigenously-produced aircraft. However, the Chinese aviation industry today remains reliant on foreign technology but has demonstrated an ability to innovate and improve on foreign designs. This trend suggests truly indigenous, and potentially revolutionary innovation is on the horizon.

a For the purposes of this paper, we use the term "China" to mean the People's Republic of China, unless specifically noted otherwise.

Key Findings

Broadly speaking, there are several important trends in organization, development, and utilization within the Chinese aviation industry.

Organization

China's leaders have long recognized that the organization of its aviation industry is an important element in its effectiveness and ability to innovate. Dispersed throughout the country during the 1960s as part of the Third Line strategy to prevent them from being overwhelmed by a Soviet attack, Chinese aerospace conglomerates developed as disconnected pockets of excellence, stretching from Harbin to Chengdu, often building redundant systems or retreading similar research. Today, however, given greater oversight, through the creation of state-owned enterprise (SOE) supervisory bodies such as the State-owned Assets Supervision and Administration Commission (SASAC), which was created in 2003, and with many of the redundant factories spun off into private industry, what remains has gone through a series of reforms. These factories, at various times, have competed against or been vertically integrated with each other. At present, they are largely consolidated under the banner of the Aviation Industry Corporation of China (AVIC). Due to new government regulations, AVIC and the remaining conglomerates have greater access to funds from capital markets. Chinese Communist Party (CCP) General Secretary Xi Jinping's anti-corruption campaign appears to have largely avoided taking on these industries directly, though the results of official investigations suggest that there have been issues with procurement and they are under greater scrutiny to improve their processes.

Organizational innovations have not been limited to SOEs. The establishment of the General Armament Department (GAD) in the PLA in 1998 and the Commission for Science, Technology, and Industry for National Defense (COSTIND) in 1982 and its successor, the State Administration for Science, Technology, and Industry for National Defense (SASTIND) in 2008, helped streamline and better control weapons development. Repeated restructuring of State Council bodies, including the March 2018 Plan to Deepen Reform of Party and State Institutions [《深化党和国家机构改革方案》], is aimed at improving oversight of China's state-owned industries. Most important, however, are the reforms to the PLA itself, which started in earnest in 2016. These reforms sought to institute a joint structure for the military, and so far, have resulted in an organization that, in theory at least, should better represent the Research, Development, and Acquisition (RDA) needs of China's services more equally. The reforms are also intended to give greater voice to important guiding bodies such as the Central Military Commission's (CMC) Science and Technology Commission [中央军委科学技术委员会]. To date, however, progress toward functional jointness is slow, with many of the new bodies continuing to be dominated by PLA Army personnel.[b]

b For example, the former GAD was reorganized and renamed as the CMC Equipment Development Department (EDD) in 2016; however, it was downgraded in grade and the director was removed from the CMC during the 19th Party Congress in October 2017.

Development

For both the military and civilian sectors, continuous innovation will be key in building aircraft that are market-competitive or survivable in a conflict. China has made tremendous strides in improving its Research and Development (R&D) systems. While many improvements can be attributed to the aforementioned organizational reforms, additional improvements deserve independent attention. In particular, the acceleration of the use of Computer Integrated Manufacturing Systems (CIMS) [电脑综合制造], which include a full range of processes and tools such as Computer-Aided Design (CAD), Modelling, Quality Control, 3D Printing, and Computer Numerical Control (CNC) milling and lathing, have dramatically sped up the R&D process. As a result, since 2000, projects appear to be completing their conception-to-test-flight phases more rapidly than before. New materials, such as composites, carbon fiber, and titanium, which reduce radar cross-sections, save weight, and allow faster speeds, are frequently cited in the construction of new airframes. However, according to official assessments and statistics put out by Chinese government bodies, China is overwhelmingly reliant on imports of foreign technologies. For example, Xin Guobin [辛国斌], who is a Deputy Director of the Ministry of Industry and Information Technology (MIIT)[c], recently noted that 52 percent of core materials are imported. When certain types of processors and other technology necessary for "intelligentized" [智能化] manufacturing and other industries are taken into account, this number rises to between 70 and 95 percent.[1] While addressing this reliance is a major priority for Xi Jinping and other Party leaders, the aerospace industry has a mixed track record of building capabilities indigenously and developing replacements will take time, particularly in the middle of a trade war.

Despite these vulnerabilities, both civilian and defense aviation firms are benefiting from foreign technology. The government is also emphasizing "spinning on" civilian-developed technologies for military use [民转军], a reversal from the 1980s and 90s when military industrial capacity and know-how was used to build the civilian economy. Xi Jinping has made these types of synergies and increased cooperation between the civilian and military sectors (Military-Civil Fusion [军民融合]) a centerpiece of his administration.

Utilization

Shifts in civilian market and military requirements and utilization are having a major impact on the Chinese aviation industry. The industry will play a major role in the PLA's modernization more broadly, but specifically with its strategic transformation [战略转型]. Both the PLA Navy's aviation branch and the PLA Air Force (PLAAF) are the recipients of major upgrades over the past decade. The PLAAF has a specific strategy for air operations "Integrated Air and Space Operations, Simultaneous Offensive and Defensive Operations" [空天一体, 攻防兼备], which it adopted in 2004. In 2014, Xi Jinping tasked the PLAAF with becoming a "Strategic Air Force."[2] In 2015, China's Military Strategy [中国的军事战略], the latest defense white paper, said that the PLAAF will "shift its focus from territorial air defense to both defense and offense, and build an air-space defense force structure that can meet the requirements of informationized operations." The PLAAF is also regularly framed as a "Strategic Service" [战略性军种], meant to be capable of precision long-range strike and transport, including airborne, operations.[3] In an interview with People's Daily, Air Force Command College [空军指挥学院] Professor Wang Mingliang [王明亮] described a "Strategic Air Force" as necessarily possessing three capabilities: Strategic Defense Capability [战略防御能力] across all domains; Strategic Attack Capability, including deep strikes against enemy positions regardless of terrain; and Strategic Power Projection [战略投送能力]. This last capability is particularly important and includes logistical support to be able to gather resources needed for operations, as well as the ability to deliver them over long distances in a short time.[4] Additionally, according to the 2018 DOD Report to Congress on China's Military, the "PLAAF has been newly re-assigned a nuclear mission."[5]

These requirements, and similar shifts in operational use of aviation by the Naval Aviation and Army Aviation branches, create a significant shift in the direction of aviation R&D. Purchases of advanced Russian fighter jets (Su-35), indigenous production of the Y-20 heavy-lift transport aircraft, the introduction of advanced variants

c MIIT was created in 2008

of the H-6 bomber, and ongoing development of an "H-20" bomber can all be understood as responses to this strategic guidance. Similarly, in the commercial market, government plans such as the Large Aircraft Project [大型飞机项目] are responsive both to commercial market demand and the central government's intention to move China's economy up the value chain through promoting advanced manufacturing.

Structure of the Report

This report is divided into six sections. The first section consists of a literature review, introducing the materials reviewed to make this report and discussing where future research could be conducted. The second section lays out the key players, scientists, and programs of China's aviation industry. After a review of the important historical context, the report addresses current bottlenecks and breakthroughs, setting the stage for the rest of the report. An overview of the major aviation corporations and design institutes follows, broken down by their primary sector and giving examples of top designers and scientists. Due to the large size of China's aerospace industry and to provide greater detail on specific areas involving the space and rocket industry, including military and civilian launch platforms, ballistic missiles, and air-to-air missiles, these subjects will be covered in separate reports by CASI.

Section 1: Sources and Materials

Chinese-language Sources

Major Strategic Planning Documents:

An important part of this study involves a detailed review of important strategic planning and policy documents.

Significant details about the direction and success of policy goals can be gleaned from China's five-year plans. These wide-sweeping documents set out economic priorities for China. While reference is made to several early plans for historical context, particular focus has been given to the 10th, 11th, 12th and 13th five-year plans, covering the period 2001-2020. Additional revisions and "notices" [通知] issued on specific topics are also referenced. An attempt is made to predict priorities for the next plan (2021–2026) using ongoing discussions in authoritative op-eds, conferences, and major meetings.

Party Work Meetings

Another common category of reporting is "Work Meetings" [工作会议]. Major meetings by large organizations, including the CCP, PLA bodies such as the CMC, civilian agencies and companies, all of which typically have at least annual work meetings. These events help set high-level priorities and signal to subordinate bodies what direction leadership is going.

In August 2018, the State Council set up a State National Science and Technology Leading Group [国家科技领导小组] to consolidate priority setting and planning for science and technology (S&T).[6] This body replaces the former National Technology and Education Leadership Group.[d]

Defense White Papers [国防白皮书]

The Chinese government periodically issues white papers on the state of its national defense with important insights into its priorities. While these were previously published on a semi-regular basis, no new document has been released since 2015. This study makes use of the three previous white papers.

- *China's National Defense in 2010* 《2010 年中国的国防》
- *The Diversified Employment of China's Armed Forces* (2013) 《中国武装力量的多样化运用》
- *China's Military Strategy* (2015) 《中国的军事战略》

d Leading Small Groups [领导小组] are used throughout the Chinese government from the senior echelons of the central government to local municipalities to carry out policy making, typically on a specific issue or group of issues. A standard reference is: Alice Miller, "The CCP Central Committee's Leading Small Groups," China Leadership Monitor, No. 26, 2 September, 2008. http://media.hoover.org/sites/default/files/documents/CLM26AM.pdf

Books:

Official and semi-official sources come from China's Academy of Military Sciences Press [军事科学出版社], the PLA Press [解放军出版社], the Aviation Industry Press [航空工业出版社], and Blue Sky Press [蓝天出版社]. Blue Sky Press publishes books under the imprimatur of the PLA Air Force's Political Work Department and the Central Party Press.

National Defense University Press [国防大学出版社]:

Scholars at China's NDU have published a series of books to train military talent [培养人才] under the nationwide 2110 Program [2110 工程].[e] One book in particular, Military Equipment Theory and Reform Implementation 《军事装备前沿理论与改革实践》, is a 2010 textbook that, among other topics, details how aviation-related research, development and procurement function. While several of the organizations in the process described have changed, important insights can still be drawn about the drivers behind the development of new equipment.

Academy of Military Sciences Press [军事科学出版社]:

- *The Science of Campaigns* (2006) 《战役学》
- *The Science of Military Strategy* (2013) 《中国战略学》
- *Lectures on Joint Campaign Command* (2013) 《联合战役指挥教程》
- *Lectures on Joint Battle Command* (2013) 《联合战斗教程》
- *Lectures on the Science of Joint Tactics* (2013) 《联合战术学》

These volumes, written as study materials for PLA officers at the Academy of Military Science (AMS), provide the basis of many insights into the PLA's understanding of strategy and the basic outlines of how it intends to conduct warfare. In understanding China's military industry, a key component of our research is to understand how China itself understands its security environment and how it plans to fight wars. The R&D efforts it prioritizes and the equipment it buys, while subject to other factors, are focused on meeting these strategic requirements and tactical capabilities.

On the Strategic Air Force 《战略空军论》

Published in 2009 by Blue Sky Press, this collection of essays by a number of retired PLAAF officers and professors represents an interesting moment in the PLAAF's development. After the adoption of the Air Force's first strategic guidelines "Integrated Air and Space Operations, Simultaneous Offensive and Defensive Operations," in 2004, strategists were working through the implications of the new strategy and what types of aircraft were needed. These essays represent an argument by those who said that China needed to acquire longer-distance capabilities and move beyond the close-range air defense thinking that had dominated since 1956. The chief editor of the book, Zhu Hui [朱晖], teaches at the Air Force's Command College in Beijing. Another of the major contributors, Dong Wenxian [董文先], is an experienced PLAAF reconnaissance unit commander and teacher who has published several books on the PLAAF's modernization. Taken together with the other contributors, these essays represent an attempt to raise awareness of the importance of a strategic air force. Individually the essays are rather shallow in terms of content. But if understood as posing an argument within the bureaucratic system of the PLAAF and the broader PLA, their essays take on greater significance. Of note, this book is a series of individual papers and is not considered an "authoritative" PLAAF publication, because it was not part of a funded plan nor did it have a forward by a senior PLAAF leader.

A common phrase in Chinese could be used to summarize our assessment of these essays' value: "You have to make an issue legitimate in order to address it authoritatively; if not, nothing can be accomplished [名不正, 则言不顺; 言不顺, 则事不成]". While the author's advocacy has likely had some effect, the issues they raise are largely

e Specifically, these books are labeled "装备指挥技术学院" 2110 工程"教材"

well understood. There is certainly some reason to believe that there have been major debates within the PLA regarding the direction of its strategy, but our conclusion is that the larger budgets, rather than a fundamental shift in thinking, have had the greatest effect in putting the PLAAF on the path to a strategic air force.

The Chronicle of the Chinese Aerospace Industry (1951-2011) [中国航空工业大事记 (1951-2011)] is a day-by-day account of the aviation industry, published in 2011 to commemorate the 60th anniversary of its founding in 1951. This book proved to be a vital resource in establishing timelines, finding the names of key designers and important data points like the growth of the industry. However, review of other books from this publisher reveals that most are actually textbooks on specific engineering subjects at a level of detail beyond the scope of this work, or else translations of similar works into Chinese.

Popular histories, such as *Chronicle of the Chinese Air Force* [中国空军纪事] tend to have limited use beyond greater detail about certain periods of time. This book, for example, which covers China's early aviation history and the birth of the PLAAF from 1921-1965, has useful details about the Korean War, the First and Second Taiwan Straits Crises, and the PLAAF's interceptions of Republic of China Air Force (ROCAF) and U.S. reconnaissance planes.

Biographies of senior officials provide useful insights into key processes and strategic thinking. *The Biography of Peng Dehuai*,[7] which follows the life of one of China's senior military leaders from the revolution through the late 1950s for example, provides a clear narrative of China's strategic thinking after the Korean War and the debates about the direction of domestic economic spending and military modernization. A review of similar biographies of later military leaders and aerospace engineers would doubtless provide insights about similar, more contemporary issues.

Journals:

This study used a wide range of military, academic, and technical journals to examine the strategic direction of the aviation industry, persistent problems in organization, funding, and research, as well as specific technological hurdles.

Strategic Direction:

The PLA's primary theoretical journal featured discussions of multiple aspects of these problems. *Chinese Military Science* [中国军事科学] is produced by the Chinese Academy of Military Science. Articles used in this study argue for the importance of near-space surveillance assets and similar adjustments to China's "Integrated Air and Space Operations" aerospace theory.

Other military-affiliated journals consulted include the *Journal of National Defense Technology* [国防科技学报], and *National Defense Science & Technology* [国防科技]. The former is the official journal of the PLA's National University of Defense Technology (NUDT) [国防科学技术大学]. The latter is also associated with NUDT and featured articles by professors from the National Defense Science and Technology University. *National Defense* [国防] is a joint publication of AMS and the CMC National Defense Mobilization Department [中央军委国防动员部]. Other Chinese military institutions provide regular coverage of the aviation industry in their affiliated journals. Examples consulted include the *Journal of Military Transportation University* [军事交通学院学报] and the *Journal of the Academy of Armored Force Engineering* [装甲兵工程学院学报].

Organizational Problems:

More general publications on financial issues and other topics periodically yielded useful information. Several financial publications had scholarly articles about issues within the defense industry. *Finance Think Tank* [金融智库] and *Industrial Economy Review* [工业经济论坛], for example, had articles by Chinese Academy of Social Sciences [中国社会科学院] (CASS) scholars and Beijing Institute of Technology [北京理工大学] professors addressing how the flow of money through the defense economy could be improved.

Non-military topics enjoy a much broader range of academic and technical discussions. Journals such as *Aviation Industry Economic Research* [航空工业经济研究] offer valuable insights into military and civilian aspects of technological innovation and Chinese funding systems.

Newspapers and Magazines:

Air Force News [空军报]: As the PLA Air Force's official newspaper, published five times a week by the PLAAF's Political Work Department, *Air Force News* provides important insights into the PLAAF's missions and training. If think-pieces and Academy of Military Sciences (AMS) textbooks can be viewed as providing the strategic picture, articles in *Air Force News* provide the low-level tactical and practical viewpoints. Issues such as pilots' difficulty in adjusting to new airframes, the outlines of training, or new developments in maintenance are important to understanding the "demand"-side of the military aerospace industry.

Two newspapers are published by China's dominant aerospace SOEs: *China Aviation News* [中国航空报], published by AVIC and *China Space News* [中国航天报], published by China Aerospace Science and Technology (CASC) and China Aerospace Science and Industry Corporation (CASIC).

PLA Pictorial [解放军画报], this bimonthly publication of the PLA Press provides coverage of all services, with occasional detailed discussions of unit training or references to major modernization programs.

China Air Force [中国空军], the PLAAF's official monthly magazine, provides more detailed discussions of equipment, training, and operational improvements. Profiles of pilots, maintenance crews, radar and SAM units, though written in an uplifting and propagandistic tone, can provide useful insights into the state of training or challenges these units are facing.

Defense Science and Technology Industry [国防科技工业], a monthly trade magazine, is published by SASTIND's News and Propaganda Center [新闻宣传中心] and features news, coverage of conferences, profiles of technicians and scientists as well as insightful comments by authoritative academics and technical members of the field.

Trade magazines such as *International Aviation* [国际航空], which is produced by a subsidiary of AVIC, tend to rely on translations of foreign news but can provide useful short reports on domestic developments, particularly in regard to civil aviation.[f]

Xinhua News Agency [新华社] is the official news agency in China and is run by the Chinese Communist Party's Central Committee.

People's Daily [人民日报] is an official propaganda newspaper run by the Chinese Communist Party's Central Committee. *People's Daily* is one of the most authoritative and largest newspapers in circulation in China. *People's Daily* content reflects the official position of the Chinese Communist Party and has both a domestic and overseas edition. Its website has been translated into several languages, including English, Russian, Japanese, French, Spanish, Korean, and Arabic.

Science and Technology (S&T) *Daily* [科技日报] is an official newspaper run by the PRC's Ministry of Science and Technology. *S&T Daily* and its associated website S&Tdaily.com provide officially-sanctioned reporting on technology news in China. Content is meant to popularize science news and provide official coverage of Chinese breakthroughs in the field of science and technology.

People's Liberation Army Daily [解放军报], the official daily newspaper of the Chinese military, *PLA Daily* is an essential source of information regarding all aspects of defense-focused aviation. Published under the imprimatur of the Central Military Commission (CMC), through the Central Political Department, its articles and op-eds are viewed as having greater authority than other publications.

China National Defense News [中国国防报] is published by the CMC's Political Work Department (former General Political Department). Published five times a week, *China National Defense News* follows domestic and international military news.

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f AVIC Culture Co. [中航文化有限责任公司]

Television:

Chinese television news, talk shows, and documentaries offer a largely-untapped source of information for language-enabled researchers.

China's state television network, CCTV [中国战法], is a basic source of news information. Several daily news shows, such as *Focus Today* [今日关注] or *Military Report* [军事报道] are easily accessible and provide digestible coverage of aviation and military news. Television programs such as *Technologies in The Military* [军事科技] offer basic discussions of platforms, but often include overviews of important aerospace and military export-focused conferences as well as useful imagery or brief discussions by military experts. In addition to regular news reports, CCTV also produces historical documentaries. *Memories of the Military Industry* [军工记忆], is a joint production of the State Administration for Science, Technology, and Industry for National Defense (SASTIND) and CCTV. Its episodes discuss the development of China's important weapons programs ranging from the JL-1 SLBM to the J-10 and KJ-2000. Popular talk shows, such as *Voice* [开讲啦] offer very informal but candid discussions with aerospace engineers such as Wu Ximing [吴希明], chief designer of the Z-10 attack helicopter.

Chinese language media based in Hong Kong also provides some useful coverage of military and aerospace developments. *The Tactics* [中國戰法] is a program on the Phoenix News Network based in Hong Kong. Although the network has ties with the PLA via its founder, programming on the network is not considered to be official state media. While the show covers a wide range of topics, programs on aviation issues frequently bring together former test pilots, designers, and consultants for the PLA to discuss China's progress, issues with current programs, and compare domestically-produced platforms with international ones.

In sum, television news programs, documentaries, and talk shows offer a very different format and level of detail than that of traditional news media. While requiring high-level Chinese-listening skills and being time-intensive to sift through, there are worthwhile bits of information included that are difficult to replicate elsewhere.

Websites:

The PLA's official website, 81.cn, is, like *PLA Daily*, a major source of authoritative information regarding Chinese military developments. Though related to the *PLA Daily*, it is distinguished from the newspaper through its use of articles from other publications. Attention to the original source of information is important and articles frequently include caveats indicating whether something is an official source or not. The website includes multiple sub-domains for each of China's theater commands, services and important CMC organizations, each with a particular mix of news.

Aviation company websites have proven to be useful sources of recent news and history about the companies, though due to sensitivities many lacked significant detail about current or older weapons—even when they are well known or out of production.

The State Council Information Office (SCIO [国务院新闻办公室]) and National Development and Reform Commission (NRDC; [国家发展和改革委员会]) websites, (www.ndrc.gov.cn and www.scio.gov.cn) are important sources of official state plans [计划] and Defense White Papers [国防白皮书].

Social Media:

All aforementioned media have official social media accounts, as do each of China's military services. Some commentators and military enthusiasts occasionally post useful discussions or photos to Weibo.

Databases and Statistics:

Two major Chinese sources of statistics have been consulted for this report: The National Bureau of Statistics (NBS) and the Civil Aviation Administration of China. Statistics from the NBS provide insight into research budgets and industrial production.[8] Due to the NSB's track record of providing overly rosy statistics, however, these are regarded only as a rough guide. Statistics produced by the Civil Aviation Administration of China showing the

Examples of Social Media Sources	
Source	Web Address
Aviation Companies	
AVIC	https://www.weibo.com/u/3061210763
AVIC International	https://www.weibo.com/u/2786981943
COMAC	https://www.weibo.com/comac
Military News	
Ministry of Defense	https://www.weibo.com/u/5611549371
PLA Daily	https://www.weibo.com/u/2280198017
PLA Air Force	https://www.weibo.com/u/5707057078
PLA Navy	http://t.people.com.cn/planavy

total number of flights and airports built offer a benchmark for understanding the growth and expansion of civilian demand for and ability to provide sufficient infrastructure for China's growing civil aviation industry.[9]

English-language Sources

Books:

Histories

While there is a huge body of work on modern Chinese history, very little of it touches directly upon Chinese military industrial matters directly. Even fewer of these sources focus on the aviation industry specifically. However, piecing together information from various sources actually provides a more useful guide to the development of the Chinese aerospace industry, which has been directly impacted by broader trends in politics and economics. U.S. Air Force Historian Zhang Xiaoming's classic history *Red Wings Over the Yalu: China, the Soviet Union, and the Air War in Korea* is a foundational work for understanding the context in which China's aerospace industry was born. The vast amounts of material and training provided by the Soviet Union to aid in China's effort in the Korean war provides the basis for much of its later growth. Designs produced during this time remained in active service through even the early 2010s among the PLA Naval Aviation. The study also points to important political events that would shape the industry, such as Marshall Peng Dehuai's advocacy for a professional PLA, air power in general, and a bomber force due to his experiences as the commander of Chinese forces in Korea. Peng's subsequent marginalization after the Lushan Conference [庐山会议] can be understood as a watershed for the Chinese aviation industry just as it could be for PLA modernization in general. The limitations of Zhang's book are mostly related to its scope: it focuses on a particular time. Examination of more modern history must be found elsewhere.

Li Xiaobing's *A History of the Modern Chinese Army* includes some useful details about the early development of China's scientific and technological development and is a great overview of the PLA's history though it does not have a particular focus on the aviation industry.

Despite significant organizational changes since its publication in 2012, Dennis Blasko's book *The Chinese Army Today: Tradition and Transformation for the 21st Century* (Second Edition) remains a standard reference on the PLA's history, missions, and publications. A keen observer of the PLA, his work on Chinese military doctrine in the STI series of publications, and studies of China's helicopter force provide valuable insights into various aspects of the PLA and the Aerospace industry.

James Mulvenon's 2001 study of the PLA and private industries in the 1990s is a useful snapshot of the tumult of that era. At the end of the national crisis of the Tiananmen Massacre and the PLA's nationwide crackdown on student and labor demonstrations nationwide, China underwent leadership changes, purged thousands of recalcitrant PLA officers and enlisted personnel. Partly in exchange for its continued loyalty, the PLA was allowed to maintain its business interests.[g] However, the accompanying corruption and distraction from training left the PLA hollow and ill equipped for war. The Third Taiwan Straits Crisis in the late 1990s helped spur a return to focus on operational matters. Xi Jinping's anti-corruption campaign and focus on "actual combat" [实战] can be seen as a continuation of the central leadership's attempts to change the culture in the PLA. In terms of understanding the aerospace industry, this is an important period because it helped set the tone for greater independence of the private sector and a push for a less commercially-focused PLA.

Studies of China's Military Industrial Complex:

In the 1990s, landmark studies of China's strategic weapons programs by John Lewis and Xue Litai set the tone for an entire body of academic work on Chinese defense issues. Drawing on biographies and materials published during a relatively open period in Chinese history, as well as taking advantage of China's desire to trumpet domestic S&T breakthroughs, these books remain the golden standard of English-language scholarship on their respective topics. In particular, Tai Ming Cheung's works *Fortifying China: The Struggle to Build a Modern Defense Economy* (2013) and *Forging China's Military Might – A New Framework for Assessing Innovation*, an edited volume published in 2014 are of importance.

Additional references that draw heavily from the Chinese internet include Yefim Gordon and Dmitriy Komissarov, *Chinese Aircraft: China's Aviation Industry Since 1951* and a series of books by Andreas Rupprecht, *Modern Chinese Warplanes: Combat Aircraft and Units of the Chinese Air Force and Naval Aviation*. These two books in particular focus heavily on equipment and organizations of the aviation industry specifically.

In 2016, the Jamestown Foundation published an edited volume, *China's Evolving Military Strategy*, that analyzed the Chinese military textbook "Science of Military Strategy 2013" mentioned in a previous section. Well-regarded scholars examined sections of the book relevant to their expertise and provide useful context by drawing from other Chinese authoritative sources. Sections on the Air and Space domains were valuable to this study as references.

Reports and Studies:

On specific topics such as innovation, other mainstream think tanks such as the Center for Strategic and International Studies (CSIS) had both useful short discussions and comprehensive reviews of certain topics. In particular, China Scholar Scott Kennedy's study of innovation in China was a useful overview of that topic.[10]

Federally-funded research institutions such as RAND and the National Defense University have also produced numerous relevant studies.[h]

In the private sector, American companies such as Boeing, and consultancies such as Deloitte and the Teal Group, track the trajectory of aerospace trends in China. Boeing's reports, in particular, provided useful insights into the broad trajectory of the civil aviation industry and aggregate demand. While publicly available assessments by Deloitte and the Teal Group touch on defense issues, their primary focus is related to investment and generally do not address the strategic implications for the United States or internal Chinese considerations.

Conference Papers:

The China Maritime Studies Institute (CMSI) based at the U.S. Naval War College in Newport, Rhode Island holds bi-annual conferences on Chinese military issues. A 2010 conference produced a study on China's aerospace capabilities with a focus on implications for the maritime domain. An annual conference held at the Carlisle Barracks and co-hosted by the National Bureau of Asian Research (NBR) has produced many relevant papers, among them "The PLA Air Force: 1949-2002 – Overview and Lessons Learned" published in 2003. Other studies

g Other considerations include a decision made by the CMC in 1985 that allowed the military to go into business to help fund the PLA.

h Relevant studies by RAND include "Ready for Takeoff: China's Advancing Aerospace Industry," by Roger Cliff, Chad Ohlandt, David Yang, 2011. and Allen, Kenneth W. Krumel, Glenn; Pollack, Jonathan D. "China's Air Force Enters the 21st Century," RAND, 1995, among others. Phillip C. Saunders and Joshua K. Wiseman's study of the Chinese aviation industry, "Buy, Build, or Steal: China's Quest for Advanced Military Aviation Technologies," published in 2011 retains its relevance nine years later.

have provided useful insight into Chinese military priorities and more general industrial capabilities.

Studies for Congressional Commissions:

Testimony given by experts for the U.S.-China Economic and Security Review Commission (USCC) provides a periodic snapshot into U.S. academic, private and government views of China's aerospace industry. This report primarily drew on hearings and research published since 2010. Additional hearings on China's manufacturing industry were also held. However, given the limited time allotted to hearings and space limitations on associated testimony means that while the provided information is succinct, it can lack in terms of depth. The need to repeatedly use the same scholars or scholars that have other China-specialties is also indicative of the narrow base of government, academics and private citizens working in the public sphere on this important issue.

Newspapers & Magazines:

This study makes limited use of English-language newspapers published outside of China. Some few exceptions include investigative reports and discussions of materials appearing in Chinese-language forums by CASI-partners Jeffrey Lin and P.W. Singer in their *Popular Mechanics* column, *Eastern Arsenal*. These articles frequently use photos and discussions that are hard to find elsewhere, but which also prove difficult to vet. Veteran National Security Reporter Bill Gertz frequently publishes analysis of Chinese weapons tests for the Washington Free Beacon. However, the lack of Chinese-language references and frequent use of unnamed U.S. intelligence community sources typically mean some care is needed when using these as indicative of broader trends. *Aviation Week and Space Technology* offered expert analysis of publicized Chinese developments but often rely on secondary sources such as the South China Morning Post or analysis of amateur photographs. *Defense News*, *Air Force Times*, and similar coverage of U.S. procurement priorities and next-generation aircraft offered a useful source of information on those topics in support of official statements from DOD, DARPA, and other government bodies. The Jamestown Foundation's *China Brief* publication, while not strictly a journal, provides regular coverage of Chinese military developments including relevant organizational changes, Air Force strategy, and aerospace industrial capabilities by top scholars.

Databases:

The Stockholm International Peace Research Institute (SIPRI)
Website: https://www.sipri.org/

The Stockholm International Peace Research Institute maintains a comprehensive database of international arms sales, including equipment sold, associated dates and estimated costs. This database provides valuable insights into the extent of Chinese international cooperation, the volume of its imports and the direction of its aerospace industry.

The International Institute for Strategic Studies (IISS)
Website: https://www.iiss.org/

IISS is a British think-tank based in London that publishes an annual snapshot of global military capabilities. *The Military Balance* is regarded as authoritative and contains a detailed breakdown of total manpower and numbers of individual equipment and weapon systems by variant. This database proved very useful when evaluating the proportion of aircraft and helicopters by military service and primary mission.

Other non-English language sources

Russia-24 (Russian: Россия-24) formerly called Vesti, is a state-owned Russian-language news channel administered by the All-Russia State Television and Radio Broadcasting Company (VGTRK). It covers major national and international events as well as focuses on domestic issues.

Russian News Agency TASS (Russian: Информационное агентство России ТАСС) is a major news agency in Russia. Founded in 1902, TASS is the largest Russian news agency and one of the largest news agencies worldwide. TASS is registered as a Federal State Unitary Enterprise, owned by the Government of Russia. Headquartered in Moscow, TASS has 70 offices in Russia and in the Commonwealth of Independent States (CIS), as well as 68 bureaus around the world.

Summary of Source Material

The quality of publicly available information on China's aerospace industry is quite varied. Where it is most useful, it is most fragmented. While many aerospace firms now maintain active English-language websites, Chinese language skills remain a core competency needed to access most information in any meaningful way.

For Chinese language sources *Chinese Aviation News*, published by AVIC is probably the most valuable source of information. For defense-related aspects, however, it tends to have a more propagandistic slant. More meaningful data is found in academic journals but tends to be buried in technical discussions.

A decade ago a leading expert on China's defense industries joked that the number of people studying Chinese technology was so small they could easily fit into a minivan. Fortunately, that has changed. A larger number of scholars with Chinese language skills are highlighting important information, giving congressional testimony and generally raising the visibility of important trends.

Overall, we assess that a hybrid approach pulling together Chinese-language authoritative books, biographies and official media, supplemented by English-language scholarly works and, when possible, drawing on imagery analysis remains the most valuable method of study.

Section 2:
China's Aerospace & Defense Industrial Base

History

While the focus of this study is the development of China's aviation industry between 2004-2018, a brief overview of the history of the Chinese aviation industry is necessary to understand how it has arrived at its present position. China's drive for technological superiority, self-reliance, and sometimes byzantine organizational structures all derive from its experience in wars, political infighting, and economic development.

1950s

Birth and Development of China's Aviation Industry

China's early history as a modern state was shaped in part by the need for effective airpower. Emerging threats and missions during the early 1950s helped drive the early stages of China's aviation industry. The PLA Air Force, founded in November 1949 with Chinese Nationalist (KMT) defectors and their planes, quickly found a new mission defending PRC airspace from KMT air attacks coming out of Taiwan.[11] KMT B-29 bombers, for example, attacked Shanghai 26 times between May 1949 and February 1950.[12]

The newly-founded People's Republic of China received an early and unpleasant introduction to the new era of mechanized, industrial warfare. In the nine months between China's entry to the Korean war and June 1951, it suffered 577,000 casualties.[13] The PLAAF's numbers swelled due to Soviet support. Zhang Xiaoming's research suggests that China received enough aircraft between 1951 and mid-1954 to outfit twenty-two air divisions.[14] While this direct injection of large amounts of equipment helped quickly modernize the PLA, the underlying expertise in their use and production would take longer to acquire.

The effect of UN airpower, primarily provided by the U.S., helped galvanize senior Chinese leaders, particularly Marshall Peng Dehuai [彭德怀], commander of Chinese forces during the Korean War, and Marshall He Long [贺龙] to become advocates for extensive modernization of Chinese forces. At the end of the war, faced with shrinking budgets, the central leadership decided to significantly reduce the size of the PLA, which by that time had swelled to 5.5 million. Peng Dehuai emerged as a major advocate for reducing the proportion of regular infantry and focusing on air force, artillery, and armored forces.[15] Evan Feigenbaum argues that China's military-industrial development was largely defined by its experiences in the Korean War, and the interest groups and push factors, such as fear of reliance on foreign expertise, are direct consequences of that war.[16]

The 1950s also helped establish the pattern that politics, not strategic requirements, would be a driving force for Chinese defense industry and equipment procurement. Peng was a major advocate for China's budding bomber program, but his purge from the Communist Party in the wake of the 1959 Lushan Conference helped sideline conventional modernization as a priority, and aviation in particular.[17]

The PLA Army's domination of Chinese military power that has continued until today was baked into the post-Korean War PLA. The development of airpower as a distinct service with its own doctrine independent of the Army was stifled because airpower was conceptualized as subordinate to, and in service of, ground forces.[18] Ironically, Chinese airpower saw one of its historic successes during this period. The emerging aerospace industry and the PLAAF's military strength were used as proof of the effectiveness of the Party's leadership.[19] In 1955 the PLAAF participated in its first, and so far only, joint air campaign against the ROC-held Yijiangshan islands.[20] Continuing U.S. and ROC electronic and photographic reconnaissance activity also acted as a driver for Chinese fighter jet, and later surface-to-air missile, development.[21] Despite success using airpower locally, the PLA's broader strategy would circumscribe the PLAAF's missions. In March 1956, an expanded meeting of the Central Military Commission decided to make "Active Defense" [积极防御] the PLA's strategic guideline [战略方针], focusing the PLAAF on territorial defense missions.[i]

China's aerospace industry saw rapid expansion during its first decade. In 1951, the year typically used as the beginning of the Chinese aviation industry, the first generation of aircraft designers such as Tu Jida [屠基达] (who would later play a crucial role in the development of the J-7 and other aircraft), created special aviation programs to train a cadre of engineers and designers for "New China."[22] In April 1951 the State Council passed the "Resolution on Building an Aviation Industry" 《关于航空工业建设的决定》, which established the Bureau of Aviation Industry. National Factory 112 [国营112厂], which later became Shenyang Aircraft Corporation, was also founded in 1951, and was China's first aviation production line. The precursors of other key players such as Harbin Aircraft and Chengdu Aircraft Companies were also founded during this period.

To staff these factories and their associated design institutes, two educational institutions that would train generations of designers were founded in 1952: Beijing Institute of Aeronautics (now Beihang [北航]) and Nanjing College of Aviation Industry (now Nanhang [南航]). An influx of returnees from abroad, particularly after negotiations with the U.S. to allow Chinese students to leave the U.S. in 1954, resulted in important scientists joining China's nascent aerospace industries. Foremost among them was Qian Xuesen [钱学森], the father of China's rocket and nuclear programs, and others such as Tu Shou'e [屠守锷], Ren Xinmin [任新民], and Wang Xiji [王希季] who would play vital roles in the rocket and space programs.[23] The first Five-Year Plan (1953-1957) also laid the foundation for Chinese civil aviation, with ambitious goals for domestic air routes for passengers and cargo.[24]

Other important elements of China's military procurement system would last until today, such as the military representative system [军事代表] established in 1951, which pairs military officers with aircraft factories and research institutes.[25] To help China's domestic industry grow and guide research and development, on 16 October 1958, the National Defense Science and Technology Commission (NDSTC) [国防科委] and the National Defense Industrial Commission [国防工委] NDIC were established.[26] However, new regulations issued in 1958 limited the budgets of the military and the police to no more than a combined 30 percent of the national budget.[27]

While much effort was made to set up a domestic industry and lay foundations for future indigenous development, China's early reliance on foreign assistance is striking. Tai Ming Cheung notes that "Of the 134 medium- and large-sized defense industrial enterprises that were in operation by the end of the 1950s, forty-one were built using Soviet assistance."[28] China's first fixed-wing and rotary-wing aircraft, including the J-6 fighter, Tu-16 bomber and Z-5 helicopter were produced from kits purchased from the Soviet Union. The opportunity to expand on these designs soon ran into serious obstacles, as a decade that had begun with great expansion of Chinese aerospace ended with the nation-wide humanitarian and environmental disaster of the Great Leap Forward.

In 1956, Qian wrote "Some Thoughts on Building China's National Defense Aerospace Industry" [建立中国国防航空工业的意见] which included a number of suggestions that laid the foundations for China's aerospace industry.[29] The aviation industry made important milestones, with successful test flights of indigenously built: trainers (1954), multi-use civilian aircraft (1957), helicopters (1958), and the first tests of indigenously-designed jet engines (1958).

i The decision is called 《关于保卫祖国的战略方针和国防建设问题》

1960s

Innovating in Spite of Chaos

Much like the rest of the country, China's aerospace industry was hard hit by the ideological extremism and political chaos of the 1960s. The speed of the PLA's race to modernize and build a professional force was sapped by the purging of key leaders such as Peng Dehuai, the withdrawal of Soviet support in 1960, and through sustained political and economic chaos from the Great Leap Forward and political infighting. The Cultural Revolution "cost the PLAAF almost two decades of development and sharply diminished its political influence."[30]

Unsurprisingly, Chinese long-term defense planning suffered. According to a declassified National Intelligence Assessment of Chinese military capabilities in 1970, "The Military Affairs Committee,[j] the highest official body responsible for military planning, lost almost half of its standing members and was reorganized."[31]

However, Peng's successors assumed the role as keepers of the flame of PLA modernization by building organizations, client, and family networks around key programs to protect them. Marshal Nie Rongzhen [聂荣臻] is viewed as a key figure in this regard and helped push China to achieve strategic goals such as the "Two Bombs, One Satellite" [两弹一星] initiative.

Momentum from the 1950s also carried over in other areas. The Chinese Aeronautical Establishment [航空研究院] was established in 1960 and acts like an umbrella organization for Chinese Aerospace research centers [研究中心] and Institutes [研究所] and Test Facilities [试验设施]. The National Defense Industries Office (NDIO) [国防工办] followed in 1961. In 1962, as a result of a brief thaw in Sino-Soviet relations, Soviet engineers shared plans for the MiG-21 fighter jet with China, and the Chinese-built J-7, a copy of the Mig-21, surfaced in 1966. The Chinese Aeronautical Establishment achieved other milestones, including the first test flight of the indigenously-designed Q-5 ground attack jet.

In 1964, China's leadership embarked on the Third Line [三线] strategy, which had the dual goals of improving the economies of China's interior while concurrently making its core industries, particularly defense-related ones, less vulnerable to Soviet or U.S. attack.[32] Factories were relocated and new ones set up. Shaanxi Aircraft, producer of the Y-8 and Y-9, was established in 1964 as part of this program, as was Guizhou Aviation Corporation. This distribution of aviation companies across China, a strategic decision at the time, would end up being one of the defining, and limiting factors of Chinese aviation development.[33]

1970s

Radical Change

The 1970s profoundly changed China and with it the direction of its aviation industry. While the cultural revolution still raged for much of the first half of the 1970s, China still saw important political and scientific milestones. On April 24, 1970, China launched its first satellite, the Dong Fang Hong 1 [东方红一号]. The following year, Henry Kissinger feigned illness during a visit to Pakistan to fly to China, laying the groundwork for the warming of relations and President Nixon's visit in 1972. However, political chaos did not recede until Mao's death in 1976, which opened the door to real political change. Throughout this time, China's strategic focus remained locked on the Soviet Union.

Fear of a Russian invasion from China's northeast kept the majority of Chinese forces focused on that threat. A National Intelligence Estimate, in 1978, for example, calculated that 44.8 percent of PLA troops (1,400,000 of 3,200,000) were concentrated in the four provinces of Northeastern China [东北], as well as 41 percent of its combat aircraft (1,400 of 3,900).[34] Reflecting the focus on "active defense" [积极防御] and Territorial Defense [国土防御] thinking, Chinese airpower during this time overwhelmingly consisted of short-range, borderline-obsolescent fighters [see inset]. R&D programs during the 1970s were also characterized by unrealistic expectations, and poor-quality control. This would change after 1978 with the emergence of Deng Xiaoping as China's top leader.

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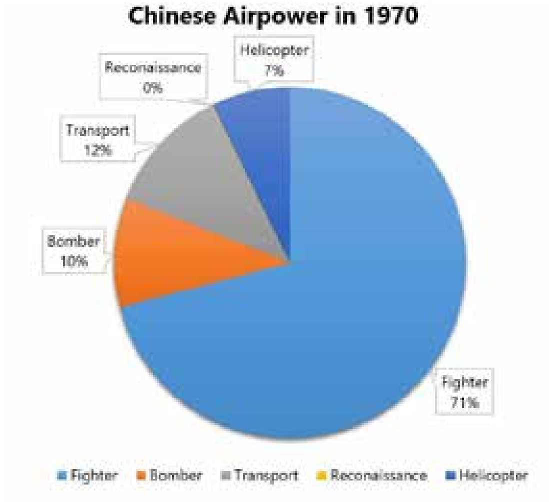
j Which, since 1982, has been identified in English as the CMC, even though the Chinese name did not change



Estimated Numbers of Military Aircraft in Operational Units (1970-1972)				
July 1, 1970				July 1, 1972
	PLA Air Force	PLA Naval Aviation	Total	Total
Fighters				
Mig-15/17	1,700	300	2,000	1,700-1,900
Mig-19	800	200	1,000	1,300-1,500
Mig-21	25	0	25	N/A
			3,025	3,000-3,400
Bombers				
Tu-2	90	20	110	40-60
Il-28	170	125	295	250-300
Tu-4	12	0	12	8-12
Tu-16	12	0	12	60-100
			429	358-472
Transport				
Medium	26	0	26	30-40
Light	420	50	470	475-500
			496	505-540
Reconnaissance				
Be-6	0	5	5	4-5
Helicopters				
Mi-4	275	25	300	375-400
Alouette III	10	0	10	8-12
			310	383-412
Source: CREST – National Intelligence Estimate: Communist China's General Purpose and Air Defense Forces, June 11, 1970 Some terms have been updated or simplified from the original for clarity				

During the latter half of the 1970s, having consolidated his power from Hua Guofeng, Mao's designated successor, Deng Xiaoping, began pushing modernization of China's institutions and especially the PLA. Perhaps the most important policy for the aerospace industry during this period was the decision to reprioritize conventional military capabilities, a reversal of decades where China focused on building a limited strategic arsenal of nuclear weapons and planned to rely on "People's War" [人民战争] to defend against invasion.[35]

In late 1977, under the guidance of Deng, the Central Military Commission shifted its emphasis back to conventional weapons modernization. The Air Force was tasked with developing a high-speed, medium altitude fighter, eventually choosing to pursue the J-7, two J-8 variants, and the Q-5.[36] Organizational changes reflected the shift, with the Commission for Defense Science and Technology Equipment (CDSTE) created to handle new procurement requirements. Dual-use technology was embraced, with the idea that a strong, vibrant economy would better serve as a platform for scientific development and overall defense capabilities rather than singular investment in a few strategic areas. This new emphasis was embodied in the official slogan "[repurpose] military technology for the civilian world, use domestic production for foreign markets [军转民, 内转外]." A decision was also made in 1979 to begin selling military aircraft to help build the civilian industry which had hitherto been free transfers.[37]

China's poor performance during its brief border war with Vietnam in 1979, which did not involve any PLAAF aircraft flying over the border into Vietnam or engaging any Vietnamese aircraft along the border, helped catalyze deeper changes in the PLA. The PLAAF and PLA Naval Aviation's inventory of aircraft were obsolescent by this time and played little role in the conflict. Following this conflict, the PLA's manpower was cut by 40 percent (from 5 million to 3 million).[38] The PLA's budget shrank and morale plummeted. Units began supplementing their reduced budgets by engaging in commercial activity.[39]

1980s

Laying the Foundations for Innovation

The 1980s were a crucial period for China's aerospace industry. Drawing on lessons from its experience with Vietnam in 1979, and the warming of relations with the Soviet Union, in 1985 China changed its official strategic guidance for its armed forces to preparation for "local limited wars around China's borders, including its maritime territories and claims."[40]

The 1980s were also characterized by attempts to move beyond the paradigm of large numbers of early supersonic jets, such as the J-7s that had dominated China's inventories of jets and instead acquire a truly indigenous fighter jet equipped with advanced radars and air-to-air missiles.[k] The first half of the decade saw unprecedented levels of international cooperation on defense projects, including the expansion of China's cooperation with France on helicopter production, and the $550-million dollar "Peace Pearl" Program that partnered Northrop Grumman with Shenyang Aircraft to modernize the J-8II's fire control system.[41]

Over the course of the decade, the seeds planted by the Reform and Opening would begin to bear fruit in the form of more efficient aircraft design augmented by modern computers and digital design programs.

Perhaps the most important development during this period was the March 1986 proposal to invest in strategically important technologies. Embraced by Deng Xiaoping, the "State High Technology Research and Development Plan" [国家高技术研究发展计划], commonly known as the 863 plan [863计划], targeted automation, energy, biotech, IT, lasers, space technology, and new materials.[42] Much like the "Two Bombs, One Satellite" program of the 1960s, the plan sought to give China a strategic edge in the emerging areas of technological competition through state-backed investments in R&D.

Accompanying these new programs was a major shift in the PLA's involvement in production. The PLA went into business, transitioning obsolete aircraft factories into producing cars, motorcycles, and light consumer goods. According to James Mulvenon's research, the PLA's profits grew by 700 percent between 1985-1990. This legacy remains in the form of numerous AVIC subsidiaries that still produce these goods today.[43]

By the end of the decade, however, China would be largely isolated, as a consequence of the Tiananmen massacre. U.S. cooperation with China on electronic upgrades for the J-8II, and plans for an upgrade of the J-7 were scrapped.

1990s

Recalibration

The 1990s saw tremendous change to the aviation industry and the PLA. China was able to overcome major bottlenecks after the cutoff of defense cooperation with the West in the late 1980s, in part due to expanded cooperation with the Soviet Union. Rapprochement in the late 1980s opened the possibility of renewed purchases of military equipment. In 1990, Admiral Liu Huaqing [刘华清], a long-time weapons modernization advocate and CMC member, visited Moscow to negotiate the purchase of Su-27 long-range fighter jets. The jets were delivered in 1991 and were quickly copied to produce the J-11, thus beginning the ongoing and complicated stage of China-Russia arms sales characterized by mistrust despite continued sales.

Meanwhile, several international developments had a major impact on Chinese strategic thinking and aviation. French and U.S. agreements in 1992 to sell 60 Mirage 2000-5 fighters and 150 F-16 jets to Taiwan threatened to alter the cross-strait military balance.[44] Tensions with Taiwan further escalated during the Third Taiwan Straits Crisis (21 July 1995 to 23 March 1996), ending without conflict, but not before the PLA launched missiles into the waters north and south of Taiwan, and after the U.S. dispatched two carrier groups to the Philippine Sea. U.S. demonstrations of air power with land- and carrier-based air operations over Iraq (1991), Bosnia and Herzegovina (1994–1995), and Yugoslavia (1999), further convinced PLA leaders that the PLA needed to comprehensively modernize to compete on the international stage.

To modernize, China needed more effective and agile defense industries. A more market-oriented China began a new round of SOE restructuring. In 1993, the Ministry of Aerospace Industry was disbanded, and replaced with the Aviation Industries of China (AVIC), a super-SOE tasked with making the industry more competitive in a market economy. This move reflected Jiang Zemin's macroeconomic strategy which formally embraced a "hybrid"

k China classifies these aircraft as 1st- and 2nd Generation fighter jets, using a different system than standard use in Western publications.

socialist economy. Accompanying this broader shift in attitudes came concern about the PLA's involvement in business. After watching the success of the United States' tech-enabled campaign against Iraq in 1991, in 1993 Jiang Zemin issued a new strategic guideline: "Local Wars Under Modern High-Tech Conditions." Modernization, however, is expensive and the PLA's commercial activity effectively doubled the PLA's defense budget at times.[45] A leaner PLA, undistracted by commercial interests, was needed to fight the wars of the future. This resulted in a series of personnel drawdowns and divestitures. According to James Mulvenon, between 1993 and 1995, the total number of PLA enterprises [军队企业] was reduced by half, from 20,000 to 10,000.[46] And then, in 1997, the PLA was ordered to cut half a million troops.[47]

Further restructuring of Chinese defense industries [军工] followed these reductions. COSTIND had proven incapable of streamlining procurement or helping match development with requirements [需求]. A General Armament Department (GAD) was created out of COSTIND, and also combined existing elements of the GSD and General Logistics Department (GLD).[l] An additional element was the consolidation of China's major defense industries under a new policy, broadly called The Four Mechanisms [四个机制]. This policy created several giants such as Norinco [北方工业] and Nanfang [南方工业], splitting these companies along geographic lines.[m]

With the defense industrial base falling behind civilian industry, the focus shifted from spinning off military tech into civilian applications, to spinning on innovations from the civilian for the military. AVIC split into two companies in 1999. The resulting companies, AVIC I and AVIC II, were each composed of a mix of military and civilian production and research facilities. These companies were given approval to be listed on Chinese stock exchanges for the first time, giving them access to non-state sources of funding. However, these companies continued the trend of focusing on non-military production, or industries only tangentially related to their core business, such as real estate or car manufacturing. Frustrated by the PLA's corruption through its involvement in business and eager to reassert more direct authority, Jiang Zemin gave a speech in 1998 calling for the PLA to divest from its involvement in business.[48]

2000s

Charting a new path for the PLA

In the early 2000s, the PLAAF's inventory of aircraft was still largely dominated by J-6 fighters, which were only marginally better than those used during the Korean War. Continuing sales of advanced fighter jets by the U.S. to Taiwan, meant that the PLA had only limited deterrent capability, which was supposed to be its core task. Rapid modernization to bring the PLA up to par with the United States was needed. In 2004, the PLA issued new strategic guidance [战略方针]: Winning Local Wars Under Conditions of Informationization [打赢信息化条件下的局部战争].

After just shy of a decade as separate companies, AVIC I and II were merged again into a single company in November 2008. AVIC announced a "Two Merges, Three News, Five Changes, and One Trillion" [两融 三新 五化 万亿] plan driving consolidation, integration of new technology, increasing competitiveness, market reforms, and the goal of raising revenue to a trillion RMB.[49] The failure as independent companies to foster competition was a clear indication that, despite the organizational battles of the 1990s, China's defense industries still had far to go in escaping their pasts as bloated, inefficient enterprises.

In March 2008, COSTIND was renamed and downgraded to the State Administration for Science, Technology, and Industry for National Defense (SASTIND), and was staffed solely by civilians.[50]

In the mid-2000s, policy began to emphasize using the civilian industrial base to benefit the military. "Integrate Military with Civilian Purposes and Combine Military Efforts with Civilian Support [军民结合, 寓军于民]," was made official policy during the 3rd Plenum of the 16th Party Congress, laying the groundwork for dual-use technologies.[51]

l In reality, GAD, which never had a non-Army director or deputy director, managed all Army equipment RD&A but oversaw Navy, Air Force, and Second Artillery Force projects that were managed directly by each of those entities.

m China State Shipbuilding Corporation (CSSC) and its sister ship-building company China Shipbuilding Industry Corporation (CSIC) were created this way.

During the 2000s, China's growing national wealth began to have a marked impact on Chinese defense spending. Greater resources at the Chinese government's disposal, particularly after 2000 and the rapid expansion of its economy, allowed China to invest in weapons development programs.

2010-Present

Building a Joint Force

The past eight years have seen some of the most important reforms in the PLA since the end of the Cultural Revolution in 1976. Not only have the services been restructured, but the bureaucratic connections between the PLA and the defense industries have been changed in deeply important ways.

In the summer of 2015, China issued its latest Defense White Paper, titled "China's Military Strategy" [中国的军事战略], clearly laying out a mission for the PLA with more prominent roles for the Navy and Air Force, and with special emphasis on cyber and space domains.[52]

Prior to the 2016 reforms, the four General Departments, i.e. General Staff, General Political, General Logistics, and General Armament, served first as the Army Headquarters and second as the Joint Headquarters. The December 2015 creation of a CMC Joint Staff Department to replace the General Staff Department, and the replacement of the General Armament Department with the CMC Equipment Development Department, formalized the push to give the PLA's other services greater autonomy. Freed from what was essentially a PLA Army superstructure managing the Army's research, development and acquisition (RD&A) as well as overseeing the other services' weapons development, each service now has an independent channel to communicate its equipment requirements to the CMC.

Perhaps equally important is the elevation in status of the former Science and Technology Committee [科学技术委员会] to the CMC Science and Technology Commission, independent of the EDD. This committee, detailed below, plays an important coordinating role between the CMC, scientific organizations, SASTIND, SOEs, and private industry.

The former Army Equipment Scientific Research and Procurement Department has also been transformed into the Scientific Research and Procurement Bureau under the EDD. This new organization dropped its Army-specific role as the Army created a new PLA Army (PLAA) Headquarters with its own Staff, Political Work, Logistics, and Equipment Departments and gained, for the first time, its own Equipment department on par with the other services. The Army, Navy, and Air Force all appear to have Aviation Equipment Bureaus or equivalent offices under their Equipment Departments.

It is important to note that, despite these reforms, the organizations themselves remain dominated by the Army. As of this writing, only one senior member of the EDD is from another service. The EDD's Political Commissar, Lieutenant General An Zhaoqing [安兆庆], has spent most of his career with Air Force units.[53]

Anti-Corruption Campaign

On January 22, 2013, at the second plenum of the Central Disciplinary Inspection Department Committee of the 18th Party Congress, newly-elected CCP General Secretary Xi Jinping announced a sweeping anti-corruption campaign targeting "tigers" (senior, powerful figures) and flies (lower-level officials) throughout the Chinese government and industry [老虎, 苍蝇一起打]. By the end of 2015, for example, the central inspection team had completed inspections of 55-state-owned enterprises. SASAC, the supervisory body for Chinese state-owned enterprises, had also carried out more than 50 such inspections.[54] Given the tremendous amount of money flowing through the defense industries and their civilian subsidiaries and their traditional problems with corruption, it was expected that several tigers would be caught. In 2014, Wu Hao, Deputy General Manager of AVIC Heavy Machinery Co, which is in the casting, forging and hydraulics business, was investigated as part of the anti-corruption campaign due to irregularities in his income.[55] Other industries faced more intense scrutiny. The Deputy Party Secretary and CEO of China Shipbuilding Industry Corporation [中船重工, CSIC], for example, faced disciplinary and supervisory inspections.[56]

During the most recent round of anti-corruption campaigns in the PLA, after November 2013, over 70 senior officers from the PLA and PAP have been removed. Close to 80 percent of the officers were removed between early 2014 and late 2015, which is consistent with the purge of officers prior to the most recent round of PLA reforms, after 31 December 2015. Over 65 percent of the officers were in the operational career track, i.e. commanders of units and military districts, or directors of departments, and over 25 percent were in the political career track, i.e. political commissars or directors of Political Departments. The top three organizations that officers were purged from were logistics related, i.e. General Logistics Department over 20 percent; Military Districts over 20 percent; and the People's Armed Police over 15 percent. Within the research, development, and acquisition apparatus, including the former General Armament Department or the Equipment Development Department, only three high-ranking officers were swept up in the campaign. The highest ranking, Major General Huang Xing [黄星], Director of the Science and Research Guidance Department [科学研究指导部] was relieved from his position due to severe breach of discipline [严重违纪].[57] It is unclear what, if any, impact this had on the defense industries' broader research, development, and acquisition process.

The aviation industry and defense companies more broadly appear to have largely escaped Xi Jinping's anti-corruption campaign. In 2015, the Central Inspection Committee under Wang Qishan did carry out an inspection of AVIC, but their report largely gave the company a passing grade. AVIC leadership was reprimanded for laxity and wasteful spending on official receptions and for irregularities in procurement, but were not individually singled out.[58] Instead, Lin Zuoming, the CEO, was allowed to take a leave of absence and was then replaced by Tan Ruisong.

It is widely acknowledged that anti-corruption campaigns such as this, typically have political goals; in this case, consolidating the political position of Xi Jinping while improving his populist credentials. However, previous campaigns such as Jiang Zemin's in the late 1990s resulted in major changes to China's defense industries in an attempt to reduce corruption and improve their effectiveness. An article that appeared in the Party's Red Banner journal argued that State-Owned Enterprises' future competitiveness and success was in part predicated on their ability to fight corruption.[59] If corruption becomes too egregious and Xi Jinping is unsatisfied with AVIC and other corporations' production, it is possible that they could be targeted again.

Stocks and Investments:

Chinese aerospace firms access to private capital since the 1990s has had a significant impact on their ability to acquire or develop new technologies and improve manufacturing capabilities. AVIC senior leaders have repeatedly discussed how public offerings of their companies' subsidiaries has allowed them greater funds to invest in R&D and acquire new technology through cooperative agreements with foreign firms.[60]

The late 2010s have seen important moves toward consolidation of research, design, and manufacturing organizations. In 2017, for example, AVIC's First Aircraft Institute [航空工业一飞院] in Xi'an Yanliang, Shaanxi Province, was approved as a National-Level Industrial Design Center [国家级工业设计中心] as part of a plan under the 13th Five Year Plan.[61]

Major Trends:

Two recent forces deserve special attention: Centralization [集权化] and Marketization [市场化]. Many Chinese analysts comment on the problems arising from the aviation industry's, and defense industries in general, lack of centralization. In some ways, this dates back to the Third Line [三线] strategy of the 1960s which moved strategically important Chinese industries to central and southern hinterlands, away from the line of a likely Soviet advance. While this made China's military industries more survivable during a nuclear war or invasion, it had the effect of scattering resources and expertise. The trend since the 1970s has been slow and often painful consolidation, a pattern that has accelerated since 2008 with the reintegration of AVIC I and II, and the 2016 creation of Aero

Engine Corporation of China (AECC). This consolidation pulled nearly all of China's engine-building expertise into a single company. Chinese analysts hope that initiative will streamline research and make better use of available resources. Centralization, particularly the shift from State Owned Enterprises [国有企业] to Wholly-State Owned Enterprises [国有独资公司], is aligned with Xi Jinping's political goals of consolidating political power and giving the central government greater direct authority over massive state-run companies. Centralization also allows the CCP to exercise more effective control over finances and resources and harmonize priorities.

The countering force, marketization, represents the forces pushing large aviation SOEs toward greater engagement with private industry. Chinese defense analysts argue that greater access to private capital would represent an important step and provide the defense industry with needed funds outside of government contracts. Lin Zuoming's replacement as AVIC CEO appears to have been motivated, in part, due to his highly public support for marketization and resistance toward greater government involvement in the defense industry.

Making the Leap to Innovation

> *"..Our independent innovation ability, especially in the area of original creativity, is not strong. We still have to depend on others for core technology in key fields. Only by holding key technology in our own hands can we really take the initiative in competition and development, and ensure our economic security, national security and security in other areas. We cannot always decorate our tomorrows with others' yesterdays. We cannot always rely on others' scientific and technological achievements for our own progress. Moreover, we cannot always trail behind others. We have no choice but to innovate independently."* – Xi Jinping[62]

Xi Jinping has made becoming a technological and scientific superpower a priority. In particular, he has focused on making China an innovative country. This is not merely lofty rhetoric. China has identified technological innovation as a major priority and is making an all-out push for parity with western nations' R&D capabilities by 2050.

According to Li Keqiang's Work Report at the 13th National People's Congress, the contribution of technological advances to economic growth has risen from 52.2 to 57.5 percent.[63] The 13th Five Year Plan for National Science and Technology Talent Development (2016-2020) set a per-capita goal for spending on R&D of 500,000 yuan by 2020. The rate in 2014 was 370,000 yuan per capita.[64]

In the aerospace industry, innovation takes on an additional strategic dimension. According to assessments by Chinese economists and defense industry experts, China remains overwhelmingly reliant on key technologies [关键技术]. China's C919 narrow-body passenger aircraft, widely hailed as proof of China's independence in aviation, relies on imported hydraulics, avionics, special construction materials, and engines. Chinese helicopters, despite decades of effort in research and acquisition, require imports of basic technologies, making only minor breakthroughs that allow import-substitution with domestically produced products, such as antennas, worthy of significant official praise.[65]

China faces a major roadblock to becoming truly innovative in the form of a culture of systematic fraud in its scientific laboratories. In response, the State Council issued new regulations in May 2018 that will hold researchers accountable for fraudulent research by leaving a permanent mark on their "social credit" report.[66]

In his work report at the 19th Party Congress CCP General Secretary Xi Jinping said:

> *We should aim for the frontiers of science and technology, strengthen basic research, and make major breakthroughs in pioneering basic research and groundbreaking and original innovations. We will strengthen basic research in applied sciences, launch major national science and technology projects, and prioritize innovation in key generic technologies, cutting-edge frontier technologies, modern engineering technologies, and disruptive technologies.*[67]

China could potentially fall further behind because of its lack of investment in basic research [基本研究]. Over-emphasis on certain research priorities that are viewed as politically more important can move resources away from areas where China needs to improve. As a result, Chinese government organizations and companies have set up numerous "Innovation Centers" [创新中心] throughout the Chinese aerospace industry to propel innovation.[68]

In his 2014 speech to the Chinese Academy of Science (CAS) and the Chinese Academy of Engineers (CAE), Xi highlighted "institutional bottlenecks" that prevented China from capitalizing on innovations.[69] Tellingly, ambitious goals have been downshifted as the reality of the difficulty involved begins to set in. For example, Made in China 2025, a long list of technological milestones China is striving for by 2025, for example, has been rebranded under a less ambitious plan to "strengthen innovative power, develop new 'kinetic power'," and abandon short-term gains for longer-term benefit [增强创新力 发展新动能].[70]

Additionally, in response to official papering-over of barriers to innovation, senior leaders in the field have started to take a stand and point out problems with China's innovation culture. In June 2018, Liu Yadong [刘亚东], Chief Editor of Science and Technology Daily [科技日报], China's main official source of science news run by the Ministry of Science and Technology (MOST), criticized the state of scientific inquiry during remarks in Beijing at the 2018 World Science and Technology Innovation Forum [2018世界科技创新论坛] in Beijing. Liu said:

> *Take the scientific and technological community for example, our original innovation ability is low, basic research is weak, major theoretical breakthroughs and original leading results are lacking. You can find a thousand reasons, but the most important and fundamental is the lack of scientific spirit. Along with the lack of scientific spirit, there are many ugly phenomena such as academic corruption, fraud, exaggeration and impetuousness.*[71]

Looking ahead on the short- (5 year) and medium-term (10 year) horizon takes us through the end of the current National and National Defense Science Industrial Medium-and Long-Term Science and Technology Development Plans [中长期科学和技术发展规划]. Organizations tasked with drafting those plans, such as the National Leading Group of Science, Technology, and Education [国家科教领导小组], are likely already at work on the next plan.

Bottlenecks

Since the 1950s, China's aviation industry has encountered bottlenecks that have limited growth or proven to be difficult scientific or manufacturing problems. In other areas, development of capabilities that the Chinese military needs for deterrence, mobility, or operations have proven harder than expected to overcome. Broadly speaking, these break down into two major areas: Institutional bottlenecks, where the underlying structure of the R&D organization or procurement system is at fault; and technological bottlenecks, where a manufacturing technique or platform has proven difficult to perfect, build, or purchase from abroad.

Institutional Bottlenecks:

Importantly, China, and particularly the PLAAF, sees its personnel lacking in technological capability. Technicians are unfamiliar with proper operation of new equipment, and pilots, trained on older-generation aircraft struggle to adapt to the modern, data-driven cockpits.[72]

Procurement Process

Lack of Common Procurement

The Chinese aviation industry suffers from a lack of coordination and cooperation in research programs. Military-civilian fusion is frequently suggested as a partial solution involving co-development by both civilian and military companies to achieve faster development. The same argument can be made for development within the PLA itself.

There is currently no evidence that PLA Naval Aviation and PLAAF systems are acquired through a coordinated process. Although the PLAN Aviation and PLAAF, and to a lesser extent, PLA Army, operate numerous common aircraft types, their procurement systems are separate, resulting in redundancy and waste.

Given the PLA's broader aspirations for building a joint force, commonality of systems should make coordination of operations and logistics support much easier. While there will always be differences in requirements due to different operating environments, shared development would save significant time and effort. The reorganized Equipment Development Department and the subordinate changes it forced, namely, greater power for service-level equipment departments [军种装备部], may help resolve this problem.

Technological Bottlenecks:

Despite gaining a massive leg-up from Russian technicians during the early years of China's aviation industry, strong official support for basic research programs, and strategic partnerships with other countries, China continues to face a number of important technological bottlenecks.

Engines

Writing in New Economy Weekly in 2017, Jiang Jiang [姜疆], an experienced civil-aviation executive wrote that "Even until today, all of Chinese civil-aviation aircraft engines rely on imports. Military engines primarily follow the model of "imitation + imports," with the number of independently developed models relatively low." According to Jiang, despite significant progress, China's domestically-produced engines still lag 30 years behind U.S.-produced engines. In this he presents a significantly more negative view than international experts who typically estimate that China needs roughly 5–10 years to catch up.[73]

Other experts are similarly pragmatic. Writing a technical assessment of heavy helicopter engines, Cai Jianbing [蔡建兵] and Hu Pai'an [胡柏安], both affiliated with the AVIC Powerplant Research Institute [中国航空动力机械研究所], note that domestically-produced engines currently being used are insufficiently powerful to meet the requirements for heavy-lift helicopters.[74]

Despite major efforts at indigenous innovation, the history of China's aviation engines can be characterized as largely one of duplication and a quest for import-substitution. In 1958 a team led by Wu Daguan [吴大观], generally called the "father of China's Aviation engine," held China's first successful jet engine test at the Shenyang 410 Factory; it, however, was a copy of a Soviet jet engine.[75] Nevertheless, it played an important role in China's aviation development, as the subsequent decline in relations between the two countries made China's drive for self-reliance a major priority. Other important milestones in the 1960s included successful tests of the WP-7A [涡喷-7甲] and WP-8 [涡喷-8] jet engines. In both cases, the designs were based on Soviet engines. The WP-7 was a copy of the R-11 engine, provided to China during a brief thaw in relations in 1962. The WP-8 was important in particular because it was a copy of a Soviet design used on the Tu-16, which is the basis of the Chinese H-6 bomber.

Chinese helicopters have seen a similar mix of importation, duplication, and incremental innovation. China's larger transport helicopter, the Z-8, for example, relies on three Canadian PT6B-67A turboshaft engines built by Pratt and Whitney. China has been successful in producing less powerful engines. The helicopter industry passed an important milestone in November 1992 when the WZ-8A [涡轴8A], a development of a licensed-produced French engine, successfully passed certification.[76] Improved variants of this engine continue to power Chinese Z-9, Z-10, and Z-19 helicopters.

China's reliance on foreign-built engines and designs continues to be a major issue. The inability to innovate around this issue and produce a high-performance engine has severely limited the capabilities of several types of aircraft, or ensured that for the time being, Russian and other countries' engines form a vulnerable supply line.

Maintenance contracts emerging from offset agreements are also important. China has become a hub for maintenance of various airlines including the entire United Airlines B-777 fleet. This leads to one of the most important areas of focus for the Chinese Aerospace Industry, the ability of China to independently design and manufacture its own engines and parts independently of technical support from western firms.

China's knowledge and capabilities in developing aircraft engines is largely based on western technology through partnerships or technology transfer agreements with western manufacturers, or through the direct acquisition of foreign assets. Analysis of China's WS-10 [涡扇-10] Turbofan engine (meant to reduce China's reliance on imports of Russian engines like the AL-31F) reveals that even its domestically-produced engines are in fact copies of foreign imports.

In 1974 GE and Safran created a joint venture called CFM International (CFMI). CFMI used GE's F101 engine, used to power the USAF B-1 Lancer, to design the CFM56, which would go on to power McDonnell Douglas, Boeing, Airbus, and the KC aerial refueling aircraft.[77] A 1982 article in Aviation Week and Space Technology claimed that China was seeking to procure two CFM56-2 turbofan engines to replace their Trident airliners. In 1985, Chinese airlines China Southwest Airlines and China Eastern Yunnan purchased two Boeing 737s, which were powered by CFM56-3s, the 3rd- generation of that engine.[78] These procurements allowed Shenyang Liming-Aero Engine to examine the CFM56 turbofan technology, which heavily influenced the WS-10A turbofan's core.[79] A key challenge the WS-10 project faced was material sciences, as it was difficult to replicate fan blade material that was heat resistant, flexible, and precise enough for turbofan technology. Images taken by Chinese military enthusiasts and posted on forums appear to show the WS-10 being tested on a J-20 prototype. Used on J-20, the WS-10 was meant for J-10, but was not ready at the time of production, thus they used the Russian AL-31F. A follow-on engine meant for the J-20, the WS-15, has continued to have problems with production. According to the South China Morning Post, issues with the WS-15's single-crystal turbine blades prevented J-20s equipped with the new powerplant from appearing at the 2018 Zhuhai Air Expo.[80]

China has achieved significant engineering breakthroughs in its development of aircraft engines, particularly in the area of turbine blades. This has been facilitated using new and more efficient manufacturing processes such as additive manufacturing (AM) and the use of new composite materials such as ceramics. Additive manufacturing is a relatively new set of techniques that include creation of parts through heating of plastics and metal powders to create an object, rather than fastening materials together or carving them out. Some techniques extrude heated material while others sinter powders with lasers. Creating objects this way requires detailed computer modeling and precision machinery, but can result in greater strength and lighter weight.A type of additive manufacturing known as LMD or "laser metal deposition" has been recently used in the construction of titanium alloy structures for the Chinese aerospace industry and this is an important development in China's ability to compete with the U.S. and Europe. [81]The material science of fan blades and other engine components continues to be the major limiting factor.

The J-20 is China's first fifth-generation fighter (by its counting) and it exhibits some of the recent breakthroughs by China to develop its own engines. This advancement allowed China the independence to move away from reliance on foreign models and blueprints, although it is largely speculated that the designs for the J-31 are based on stolen blueprints for the U.S. F-35.

Direct acquisition of technologies and processes has also proven to be a successful model. The German aerospace industry has contributed to Chinese engine development through the Chinese acquisition of Thielert Aircraft Engines which enabled China to acquire a fully operational manufacturing facility. The German aerospace parts suppliers to Airbus, Cotesa, was also recently acquired by China's Advanced Technology & Materials (AT&M) following a review by Germany's Federal Ministry of Economic Affairs and Energy.[82]

In addition to continuing acceleration of partnerships with, and purchases of, foreign companies, China is also attempting to streamline its domestic engine production capability. The creation of AECC in 2016, which consolidated various state-owned enterprises and research institutes in the fields of material science and engine design, was meant to speed research and help China break through this key bottleneck. During a visit to China Aeroengines Materials Research Institute [中国航发航材院], Xin Guobin [辛国斌], a deputy director of the

Minister of Industry and Information Technology said that China must use cloud computing and intelligent manufacturing to make major progress in improving high strength, high-temperature resistant fan blades for a new generation of advanced engines.[83]

Capabilities Bottlenecks:

A core goal of the defense aviation industry is to address the strategic and tactical needs of China's military. Examining a few areas where a need has driven investment, research, and production provide important insights regarding the industries' capabilities. Three areas stand out as aviation capabilities that China needs: Aerial refueling [空中加油], Airborne Early-warning [空中预瞀], and aerial Anti-Submarine Warfare.

Aerial Refueling

A characteristic of Chinese aircraft acquisition has been a push for longer-range aircraft capable of patrolling China's long, complicated borders, and enforcing claims over vast distances, as in the South China Sea. In the early 1980s, in response to continuing tensions with Vietnam and the first island-building operations by Malaysia in the South China Sea, China sent bombers on flights to the southernmost parts of its claims. Due to their short range, Chinese fighter-jets, however, were only able to accompany the bombers part way. In 1986, China signed a MoU with a British company to acquire a hose-and-drogue refueling system. Later military clashes in 1988 further pushed Chinese leadership to begin developing a solution to the tyranny of distance.[84] On 23 December 1991 China's aerial refueling project saw its first successful test of refueling operations.[85]

The purchase of aerial refueling-capable Su-30MKK jets in 1996, and development of refueling capable variants of the J-8, J-10, and J-11 throughout the late 90s and early 2000s, further built China's aerial refueling capabilities.

The continued emphasis on "far seas training" [远海训练], which requires aerial refueling for some aircraft, is placing increasing demands on China's small aerial-refueling fleet.[86] In recent exercises through the Miyako Strait and in the South China Sea, PLAAF J-10s and Su-30s have used aerial refueling.[87] Due to the limited number of aerial refueling aircraft, the Chinese Air Force's sole aerial refueling unit, the 23rd Air Regiment of the 8th Air Division based in the Southern TCAF, has to send sub-units [分队] to various locations across China to carry out training exercises. Between 10–20 of these missions were carried out in 2016.

Due to problems with Russian production, the Chinese military has few heavy IL-78 tankers. As such, both the PLAN and PLAAF are largely reliant on tankers based on the antiquated Tu-16-derived H-6, which has limited fuel capacity. The PLAAF has received modernized versions of this airframe, sometimes designated the HY-6 (轰油-6), while the PLAN currently uses a tanker based on the older "D" variant.

In addition to upgrading the H-6U, there are other indications that China is making greater progress in overcoming its aerial refueling bottleneck. Chinese carrier-borne J-15s have been observed "buddy tanking," using a Russian hose and drogue system to transfer fuel from one jet to another, an important part of modern carrier operations. Presumably a larger, carrier-capable tanker will need to be developed to make Chinese carrier aviation truly "blue-water" viable.[88] Additionally, as newer, more capable airframes come online, such as the Y-20 or potentially the C919, these will likely be adapted for tanking missions. Leaked images from an AVIC demonstration show a "U.S.-style" refueling boom operator's station, suggesting that the company is investigating the technology.[89] A refueling boom, which directly connects to another aircraft, has the advantage of delivering fuel much more quickly.

As new aircraft are rolled out, aerial refueling probes have become a standard feature. The newer "B" variant of the JH-7 fighter-bomber for example, includes this capability.[90]

Anti-Submarine Warfare Aircraft

China 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

Y-8Q[91]

a potent force of advanced Soryu- and Oyashio-class submarines. From Chinese discussions, it is clear that U.S. nuclear attack submarines are present in Chinese waters or areas claimed by China.

China currently has limited numbers of fixed-wing Anti-Submarine Warfare aircraft. Y-8Q aircraft with a Magnetic Anomaly Detector (MAD) boom tail have been observed deploying to bases in the Southern Theater Command as part of the 9th Naval Division. China's only other fixed-wing ASW aircraft, the SH-5 [水轰-5], is an obsolete sea-plane design. The Y-8Q now appears to be in low-rate initial production, though analysts note that the Y-8Q has limitations as a platform due to its slow speed and limited range.[92]

The C919 domestically-produced narrow-body commercial aircraft is widely discussed as the base of a future Maritime Patrol/ASW aircraft in the same way that the U.S. P-8 is based on the Boeing 737. Images at an aviation exhibit showing the C919 carrying a YJ-83K anti-ship missile further suggest that the idea is under consideration.[93] Improvements in rotary-wing ASW are likely contingent on the success of China's Z-20 medium-lift helicopter program and the development of a navalized variant. As of this writing, no reports of a Z-20 practicing shipborne operations appear to be available.

Breakthroughs

Despite continuing bottlenecks, there are a number of notable areas where the aerospace industry has made technological and organizational breakthroughs that are streamlining and improving the aviation industry's research, development, and procurement processes.

Digital Platforms for Procurement and Research

A recent area of major investment for Chinese defense industries is online platforms to help researchers communicate, and help companies to better streamline their research, design and procurement systems.

Patents and Research Databases:

Particularly since the early 2000s, Chinese defense development and acquisition has emphasized dual-use [双用/ 两用] and both "spin-on" [民转军] and "spin-off" [军转民] technologies, i.e. finding ways to use existing civilian products and platforms for military purposes, and adapting technologies from the civilian R&D world for military use.[n] The CMC's Equipment Development Department's National Defense Intellectual Property Bureau [国防知识产权局] actively works with TC and provincial government Intellectual Property Bureaus to promote this type of patent sharing. In March 2018, PLA Daily reported that the CMC EDD National Defense Intellectual Property Bureau declassified over 3,000 national defense patents for civilian use.[94] The State Council is also getting involved, creating new regulations that make state-sponsored research publicly available to further improve its national scientific development capability.[95] These types of systems are being rolled out across the entire PLA. In March 2018, CMC Vice Chairman Zhang Youxia [张又侠] announced the launch of an "information, innovation, and service platform" for PLA personnel to help share ideas and provide better education.[96]

A repeated theme mentioned by Chinese scholars discussing defense industries is that Chinese firms are performing duplicative research and are siloed in such a way that they are unaware of parallel or complementary efforts. The military is also reluctant to share technical information with civilian sectors, citing national security reasons and a desire to guard it as its own interest not to be shared with a third party.[97] Patent sharing and making more research publicly available is meant to help address this problem.

n The terms used here are "transforming the military into the civilian" [军转民] and "transforming the civilian into the military" [民转军].

Procurement systems:

There is recognition that lack of competitive bidding processes and stove-piped procurement is inefficient and hurts the military.[98] In 2017, MIIT issued a plan called the "Three-year Action Plan for Industrial E-Commerce" [工业电子商务发展三年行动计划], meant to fundamentally improve the supply-side of Chinese industries, help drive innovation and improve R&D and procurement. The plan sets a goal for 60 percent of key industries, including aviation, to use the platform by 2020.[99]

AVIC's platform for online procurement, AVIC B2B Online Trading Platform [航空工业电子采购平台], has been repeatedly praised by the MIIT and other state bodies for its contributions to improving supply chain management, which view it as a model for military-civil fusion.[100] Other AVIC subsidiaries such as AECC have set up their own online marketplaces, in this case, called AECC Online Mall [航发网上商城].[101] Many of these companies, as more traditional military enterprises, have struggled to adopt the new technology. Transparency is also a goal, with the implicit hope that this will help reduce corruption.

Another recent area of emphasis is the creation of electronic procurement platforms [采购平台]. In late 2017, China North Industries Group Corporation (Norinco) [北方工业], a major producer of armaments for the PLA, launched an electronic bidding platform, introducing greater competitiveness and helping it bring in bids from the private sector. The platform logged more than 2.5 billion RMB in transactions for over 1,000 contracts in its first year.[102] Other major SOEs, such as AECC, are following its example. AECC has launched an online portal to replace its supply chain and procurement management system [供应链采购管理].[103] The CMC has identified Military-Civil Fusion as being a way to make significant breakthroughs in procurement, using civilian-developed platforms and drawing on local suppliers to reduce costs.[104] In 2015, the PLAAF held a Military-Civilian Fusion Forum for PLAAF Procurement that involved over 80 leaders and staff members from the military representative offices [军事代表局] of 39 companies.[105] According to the CMC Logistic Support Department's Procurement Management Bureau [采购管理局], the new online procurement website was able to cut costs across 23 contracts by 20 percent, from 200 million RMB to 160 million.[106]

Overall, measuring the effectiveness of online R&D databases and procurement sites is difficult. However, given frequent complaints about redundancy of research and inefficient procurement, it is fair to assess the widespread implementation of these systems as representing important progress for Chinese defense industries.

Digitally-aided Design and Production

Chinese aerospace firms' widespread adoption of Computer-Assisted Design (CAD), Computational Fluid Dynamics (CFD), Computer Numerical Control (CNC), and Additive Manufacturing processes (including 3D Printing/Laser Sintering) represent an area of major breakthroughs for the aerospace industry.

Computer-Assisted Design (CAD)

Foreign firms have contributed to the Chinese aerospace industry through the transfer of specific processes, such as CAD or Computer-Assisted Design, and design-making capabilities. This has bolstered Chinese domestic production of aerospace components. For China greater use of CAD has been a major breakthrough. The J-10 multi-role fighter-jet, which was conceived in the mid-1980s and had its design finalized in 2004, was able to complete its design phase in the 1990s due to CAD, despite Chengdu Aircraft only having a limited number of computers with the software.[107] Certain foreign-manufactured technologies and industry secrets are not shared and this would include the design of turbines and fans for example, not to mention the production of jet engines. Other technologies or other types of products that are easier to design and develop are being produced in China with precision and success and this contributes to an improvement in quality and the ability of China to compete against global competitors.[108]

Several large U.S. and European firms have transferred software for aircraft design to China. Chief among them is Honeywell Technology Solutions Lab–China (HTSL-China), which provides software and engineering support and "avionics development support" to Chinese customers.[109] Honeywell has since expanded its business in China, signing a Memorandum of Understanding (MOU) in 2016 with the Civil Aviation University of China [中国民航大学] expanding S&T cooperation.[110]

Chinese aerospace companies saw massive increases in the speed in which they were able to design and prototype aircraft designs after widespread introduction of digital design software. Chengdu Aircraft Corporation (CAC), for example, reported that it was able to speed up development by 50 percent for certain portions of the process.[111] Several of China's notable aerospace designers, such as Wu Ximing [吴希明], profiled later in this report, were lauded for their use of digital design software.

Computational Fluid Dynamics (CFD) [计算流体力学]

Another important way in which computer modeling is being used in aircraft design is Computational Fluid Dynamics (CFD), which allows the flow of air around an aircraft to be mathematically modeled before a prototype is even built.[112] Gu Songfen [顾诵芬], one of the pioneers of China's aviation industry and generally referred to as the Father of the J-8II, played a major role in incorporating CFD into design during its introduction to China.[113] China continues to make investments in the technology. In 2014, CAE held China's first Computational Fluid Dynamics/Wind Tunnel Testing International Research Forum in Beijing, bringing together scholars from Germany, the Netherlands, Russia, and four other countries.[114]

Li Keming [李克明], a deputy general manager and chief engineer at Shenyang Aircraft and a member of the Chinese People's Political Consultative Conference [人民政协] noted that most software used by the aviation industry, from engineering and design to management, is foreign. As a result, he argued that China must independently research and develop software used in digital design, manufacturing and management software, particularly CAD.[115]

Computer Numerical Control (CNC)

Advanced computer numerical control machine tools, or CNCs, have boosted China's key manufacturing sectors and added over 70.6 billion RMB ($10.3 billion) to industrial output over the past eight years according to the Chinese government.[116] CNC machining uses computers to control machine tools such as drills, lathes, grinders, and various types of mills. China's CNC machine tools occupied about 30 percent of its machine tools market in 2015 which lags behind developed countries such as Japan, the United States, and Germany whose CNC rates exceed 70 percent.[117]

In the 13th Five-Year Plan (2016-2020), the goal of the CNC project was to improve domestic R&D capabilities and catch up with advanced countries. Deputy Director of MIIT's Equipment Industry Department, Luo Junjie [罗俊杰] said that by 2020, the domestic CNC sector should be able to meet 80 percent of manufacturing demand from key areas like aviation, aerospace and automobiles.[118] Given available information about current levels of utilization, this forecast seems optimistic.

Additive Manufacturing – 3D Printing/Laser Sintering

China uses Additive Manufacturing (AM) to produce parts for the J-15, J-16, J-20, and J-31 fighter aircraft. On the commercial side, AM is used in the production of the Y-20 transport and the C919 commercial airliner.[119]

The Chinese Government views 3D printing as both a threat and an opportunity. It is a threat because it could radically streamline the use of labor in factories and therefore reduce foreign outsourcing to Chinese foundries and factories, disrupting the Chinese established manufacturing base. It is an opportunity because it could lead to a new area of technological advancement over western countries and allow China to overcome any gaps in manufacturing processes. The aerospace industry is a prime candidate for the use of 3D printing and China has now applied this process with success.

Titanium laser additive manufacturing (LAM) in the Chinese aerospace industry began in 1995 and an important area of research focus.[120] LAM involves the deposit of layer-upon-layer of powdered metal onto a pool of metal to create a new structure. In this way, little scrap is produced, saving more than 90 percent of the raw material used in the manufacturing process. The weight of LAM-produced components is dramatically reduced, and production is streamlined through the elimination of extra metal in soldered seams.[121] LAM is particularly helpful in the repair of damaged parts by fusing powdered metal directly onto damaged areas and thus strengthening or repairing the damaged component or part.

China claims to have manufactured the largest ever titanium component using LAM, which would be significant for U.S. companies, for example, especially the use of AM to produce parts for the F-35 program. However, the production of customized components for the aviation industry using AM is generally on a smaller scale, not as a means to mass produce components.

The most significant application of AM in the aerospace industry in China involves the design and production of the C919. Multiple component parts such as the windshield frame and certain parts of the wing structure, (e.g. the central wing rib), were produced for the C919 at a fraction of the cost and with significant time and materials savings compared with the normal process of forging metals. It is reported that other aircraft designs including the J-15, J-16, and the Y-20 are also using additive manufacturing processes.[122]

In 2012, Su Bo [苏波], the Chinese Vice-Minister of Industry and Information Technology, proposed a three-step plan for the use of Additive Manufacturing in China to include: (1) creating a medium- and long-term development strategy for AM, (2) building a set of codes and standards, and (3) providing more support to the AM industry in China including technology development and commercialization to be funded through customized fiscal and taxation policies.[123]

In 2016 the State Council and National Development and Reform Commission (NDRC), Finance Ministry and MIIT set up a 20 billion RMB ($3 Billion USD) Advanced Manufacturing Fund [国家先进制造产业投资基金] to modernize industry and promote advanced manufacturing.[124] This is part of the broader effort to automate manufacturing and reduce labor costs. Research by the Berlin-based Mercator Institute for China Studies, for example, suggests that local governments are investing very heavily in industrial robotics to the tune of 40 billion RMB, double the amount set aside by the fund.[125]

The use of AM in aerospace manufacturing has allowed the Chinese to be more competitive globally and insource much of its parts production to domestic sources at lower cost and without reliance on foreign producers.

Private Industry

Accompanying the broader trends in the Chinese economy, private companies are increasingly entering the defense industry alongside state-owned enterprises. In 2010, the State Council released Several Opinions of the State Council on Encouraging and Guiding the Healthy Development of Private Investment [国务院关于鼓励和引导民间投资健康发展的若干意见], explicitly encouraging greater private investment in the defense sector.[126] Chinese analysts note that due to restrictions on capital, unclear profit mechanisms and lack of transparency, the defense industry has not yet become an attractive sector for investment.

Wang Ning [王宁], who was affiliated with the Graduate School of the Chinese Academy of Social Sciences [中国社会科学院研究生院], has noted that despite China's shift from a planned economy to market economy, there has been "essentially no change" in the way that funds are distributed to the defense industry.[127] Investment channels are subject to severe restrictions, meaning that defense companies are largely reliant on government funding or state-owned banks. Only a small number of defense industry enterprises have access to funding through stocks and bonds. The lack of transparency, unclear profit mechanisms, and restrictions all contribute to making these companies unattractive investments. Moving in the direction of greater market access [市场化], is likely unpalatable to the central government.

Major Programs

The research contributing to China's S&T progress, including aviation, can be broken out into three core areas. State plans and programs have been set up to promote research in each of these areas.

The Three Major Components of Aviation Scientific Development in China	
Testing and Development Research [试验发展]	Flight testing, weapons testing, weather testing
Applied Research [应用研究]	Wind tunnel testing, Avionics testing Computational Fluid Dynamic Modeling (CFD)
Basic Research [基础研究]	Material Sciences, aerodynamics, electronics

National Key Research and Development Plan [国家重点研发计划]

Start Date	Program	
1986	863 Program [863 计划]	State High-Tech Development Plan [国家高技术研究发展计划]
1995	Project 211 [211 工程]	
1997	973 Program [973 计划]	National Basic Research Program [国家重点基础研究发展计划]
1998	985 Program [985 计划]	
	995 Program [995 计划]	New High-Tech Weapons Plans [新型高科技武器计划]
2000	Project 2110 [2110 工程]	
2015	National Key Research and Development Plan [国家重点研发计划]	

Almost immediately after the first official decision to build an aerospace industry, Chinese leaders laid the foundations for aerospace-focused universities. Beihang, Nanhang, and Northwest Polytechnical Universities (profiled below) became the source of most major design and engineering talent. Paired with an emphasis on education, these institutions have been a high-level recognition of the necessity of investment in basic research.

In 1986, a group of scientists approached Deng Xiaoping with a proposal for expanding basic scientific research in strategic areas. The 863 Program, named for the date when it was proposed, has formed a cornerstone of scientific and technological development in China ever since.[128] Additional programs such as the 2110 Project and 985 Plans gave Chinese universities funds to expand their S&T programs. In 2000, the PLA set up the 2110 Program to specifically help equip its personnel with the knowledge to fight modern wars.[129]

The investments in the 1990s paid off with accelerated innovations in the 2000s.[130] The aviation industry specifically benefited from the programs' focus on space, IT, automation, manufacturing, and advanced materials. China has also undertaken a major overhaul of its Research and Development plans. In 2015, the Ministry of S&T announced the National Key Research and Development Plan [国家重点研发计划] which will combine over 100 programs, including the 973, 863, and national S&T support plan, to minimize duplication, reduce waste, and streamline projects.[131]

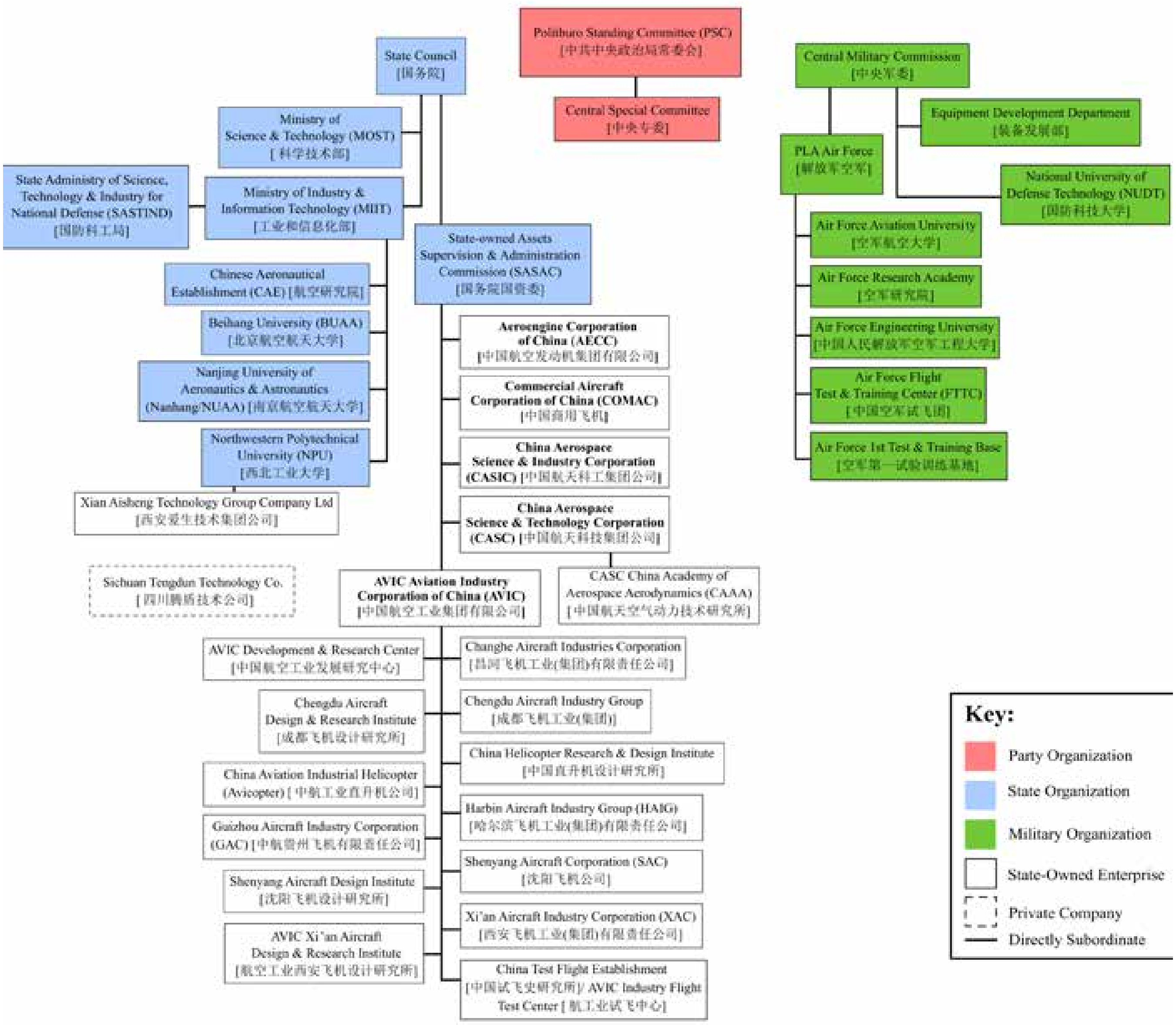
Foreign Talent

The aviation industry has also benefited from government programs meant to draw on expertise abroad. In December 2008, the Chinese central government introduced the "Thousand Talents" [lit. thousand people plan; 千人计划].[132] The program helps provide visas and stipends for people who are recognized experts in their fields and whose knowledge can help Chinese S&T research. The Large Passenger Aircraft Engine Project, for example, has already attracted 73 foreign experts to work at the AVIC Commercial Aviation Engine Research Center.[133] Since 2008, 13 groups of foreign experts representing over 6,000 individuals have come to China to participate in programs meant to advance China's strategic goals.

Overview by Sector

Breakdown of Aircraft by Type by Company							
Primary Contractor		**Aircraft Types**					
AVIC	*Shaanxi* *Xi'an*	Y-8 H-6	Y-9 Y-20	KJ-200 JH-7	KJ-500† H-20	KJ-2000 Y-7	 MA-60
CAIGA		AG600					
CASC		CH-1*	CH-2*	CH-3*	CH-4*	CH-5*	
Changhe		Z-8	Z-10	Z-11	Z-18		
CAC/CADI		J-7	J-10	J-20	FC-1	GJ-I	Sky Wing*†
COMAC		C919	ARJ21		CR929†		
GAIC		JL-9	WZ-200*	YY-I*	BZK-007*	WZ-2000*	
HAIG		SH-5	Z-9		Z-19	BZK-005*	Y-12
Hongdu (Nanchang)		JL-8	JL-10	Q-5			
NPU		ASN-206					
Shenyang/SADI		J-8	J-11	J-15	J-16	J-31†	AVIC-601*
Imported							
Russian Helicopters		Mi-171	Ka-31				
United Aircraft Corporation	*Ilyushin*	IL-76/78					
	Sukhoi	Su-27	Su-30MKK	Su-35			
	Tupolev	Tu-154					
Key: *: UAV | †: In Development | In Chinese terminology, J=Fighter (Jian; 歼), H=Bomber (Hong; 轰), Q=Attack (Qiang; 强) Y=Transport (Yun; 运), Z=Helicopter (Zhi; 直), GJ=Attack Drone (Gongji; 攻击), NPU=Northwestern Polytechnical University, NUAA=Nanjing University of Aeronautics and Astronautics. Su = Sukhoi, IL = Ilyushin, Mil = Mil Moscow Helicopter Plant							

China's Aviation Industry



Fixed Wing

Overview

Despite continuing reliance on critical foreign components, Chinese aerospace companies have successfully produced a series of increasingly advanced and capable fighters, transports, missiles, and drones for domestic use and export.

Chinese Fixed-Wing Aircraft Generations			
Years	Generations	Characteristics	Examples
1950s-1960s	First Generation [一代]	Swept wing, limited service life	J-5, J-6, Q-5, H-5
1970s-1980s	Second Generation [二代]	Delta wing, higher performance engines, more powerful radars, air-to-air missiles	J-7, J-8, H-6
1990s-2000s	Third Generation [三代]	Multi-role, beyond visual range combat capability, multiple target tracking	J-10, J-11
2010s-Present	Fourth Generation [四代]	High thrust engines, AESA radars, composite materials	J-15, J-16,
Future	Fifth Generation [五代]	Low radar cross-section, supersonic cruise	J-20, J-31
Note: This classification is different from those used by Western nations. Typically, aircraft are listed as being one generation older even if the aircraft are roughly similar. Confusingly, while official histories use this convention, mainstream media sometimes uses the western version.			

As with the aerospace industry itself, fixed-wing aircraft development in China owes a major debt to the Soviet Union, both in directly transferred plans and in aircraft designs derived from ones given to China. For more than twenty years the MiG-15, transferred to China in massive numbers during and after the Korean War dominated the PLAAF's inventory. Later more advanced designs including the MiG-19, for example, were produced in China as the J-6 and remained in service as a manned aircraft through 2011.[o] In the second half of the 1960s, China acquired plans for the supersonic MiG-21 from the Soviet Union. Given only partial blueprints, Chinese aerospace engineers were forced to begin working on an indigenous version, the J-7. The new, and by some metrics, improved, fighter represented China's entrance to Second Generation Aircraft.

The late 1990s saw China make the leap from indigenous production of Second-Generation Aircraft to Third-Generation with its introduction of the J-10.[p] For China, Third Generation aircraft design and production represented a major advancement due to the significant differences in performance, testing, and even hydraulics needed compared to 2nd Generation aircraft. As a result, the J-10 directly benefited from digital design, modeling, and testing technologies that would help lay the foundations for future aircraft.

After the J-10, CAC's most prominent aircraft is the J-20 stealth fighter.

Yang Wei [杨伟] – Chief Designer of the J-20

Yang Wei [136]

Born in Beijing in May 1963, Yang graduated from Northwestern Polytechnical University in Xi'an in 1982 with a degree in Aerodynamics. He later received a master's degree in Flight Dynamics, also from NPU. In 1985, he joined the Chengdu Aircraft Design and Research Institute. At a time when most of China's military aircraft were obsolescent 2nd-generation, (e.g. J-6.). Yang was part of a major effort to create a new generation of advanced digitally controlled, (fly-by-wire), aircraft.[134] He is representative of what might be termed the "second generation" of Chinese aircraft designers after the first generation that included the likes of Tu Jida [屠基达] and Gu Songfen [顾诵芬].

In his career Yang has been the lead designer on seven different types of aircraft, including the J-10 and its variants, the FC-1 Xiaolong, and China's first

o Some appear to be reequipped as drones assigned to an UAV air brigade in Liancheng, Fujian province. Reference: Google Earth, 1 December, 2017. Coordinates: 25° 40.178'N 116° 44.769'E

p See Graphic "Chinese Fixed-Wing Aircraft Generations"

4th generation J-20 stealth fighter. Yang Wei was a key part of the J-10 and J-10S development teams, giving him the experience to work on the J-20.[136] According to Yang, the J-20 has already entered service and is fully operational.[137]

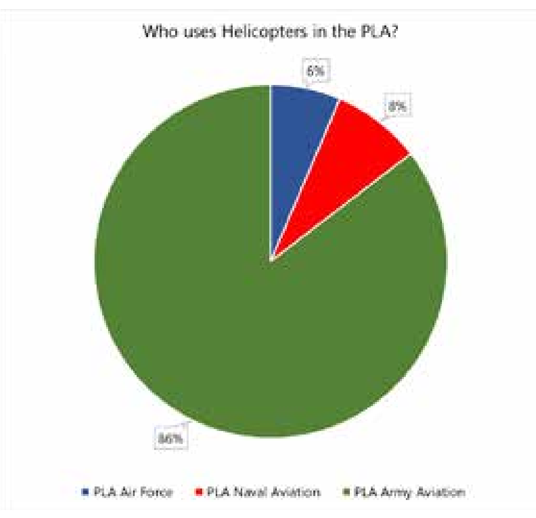
He has received multiple awards for his work, including the National S&T Progress Awards special commendation, the Ho Leung Ho Lee Foundation award, National Model Vanguard Worker, National May First Worker and the Sitara-i-Imtiaz award from Pakistan. Selected to be an academician at China's Academy of Science in 2017, On August 20, Yang was selected to be a member of AVIC's Party committee and a deputy general manager [副总经理].[138] Yang previously served as Deputy Director of the Science Committee at AVIC.[139]

Rotary Wing

Overview

China is well suited for helicopters. Its mountainous terrain and complex urban environments mean that from Xinjiang to Shanghai, rotary wing aircraft's flexibility is an important strategic and tactical capability for China's military. In 2008, the search and rescue effort after the Wenchuan [汶川], earthquake in the southwestern province of Sichuan highlighted the importance of helicopters in navigating China's complex terrain. Altogether 69 military helicopters and 30 civilian helicopters played an enormous role in responding to the deadliest earthquake in modern Chinese history.[140] Going forward, helicopters will play an even larger role in China's military capabilities.

Since the 1970s, and particularly since 1986, armed helicopters provided not only tactical movement and resupply, but also specialized attack roles against ground, sea, and underwater targets. Increasingly capable helicopters are now able to operate at high altitudes where China fights and perform SAR missions on remote islands in the south China Sea. Continuing innovations from China's aviation industry, though in many cases informed by stolen or purchased technology, have made this once backward sector of the industry into one of its most dynamic.[141]



China began producing MI-4 (Z-5) helicopters beginning in the late 1950s.[142] For almost three decades after that, all military helicopters belonged to the PLAAF. As with many aspects of Chinese conventional military development, the 1970s marked a watershed. First, China began focusing on conventional armaments after almost two decades focused on strategic armaments and fighting "People's War". Secondly, warmer relations with the Soviet Union and the West opened the door to military and civilian aviation technologies. In the early 1970s, China began purchasing MI-6 and MI-8 helicopters from the Soviet Union.[143] In 1977, China purchased at least two Alouette IIIs (YC-II) scout helicopters from France, beginning an important relationship that later led to its acquisition of Dauphin and Super Frelon helicopters.[144] Domestically produced versions of these helicopters (the Z-9 and Z-8) form the mainstay of China's rotary wing force.[145] Successful production of the Z-8, beginning in 1985 gave China its first indigenous heavy military helicopter transport. Development of the WZ-9 turboshaft engine helped China overcome a dangerous reliance on imported engines and set up the production of Z-10 and Z-19 attack helicopters in the 2000s, both of which use the domestically produced engine.

China's helicopter force appears to have had three major drivers: tactical mobility for soldiers, direct-attack capability, and shipborne requirements.

The biggest customer for helicopters in the Chinese military is, by far the PLA Ground Forces (Army). In 2018, 85 percent of Chinese military helicopters in China's inventory were used by PLA Ground Force units.[146]

Within the PLA Ground Forces, available information indicates that the helicopters are split roughly equivalently between transport and attack units, pointing toward the two major roles the PLA envisions for them.

Ground Attack

China's desire for airborne ground attack and specifically anti-tank capability has had two major drivers. First, during the Cold War, China faced the threat of invasion by the Soviet Union led by armored divisions it had no real ability to combat. Chinese anti-tank weapons at the time were incapable of penetrating the armor of most Soviet tanks.[q] Second, as with many other areas, Chinese observations of U.S. military performance during the first Gulf War had a major impact. The effectiveness of Apache and Cobra helicopters against Soviet-built Iraqi tanks further brought home the importance of an airborne anti-tank and close-air support helicopter.[147] The first of these domestically produced armed Z-9s were delivered to the PLA in June 1986.

Army Aviation Attack helicopters under the Eastern Theater Command frequently practice flying low-altitude missions over water. Images of these missions show them carrying large fuel tanks and stopping and refueling on small islands off China's coast, suggesting that they will have a role in operations against Taiwan or the small islands it controls near the mainland coast.[148] As China's navy has expanded, so too have the roles and importance of its ship-borne aviation.

Shipborne Helicopters:

The Z-9C is the workhorse of Chinese naval aviation. But it wasn't until the 2010s that China began to fully explore the utility of these helicopters, their first pilot to land on a ship deck at night only did so in 2012. However, they have played an important role in logistical resupply, ASW, and emergency transport since then. With the expansion of the Chinese navy's mission to become a global force, these responsibilities have only further expanded.

Z-10 attack helicopter practices landing on a ship[152]

The Army Aviation branch has also experimented with landing other helicopters, such as the Z-10 attack helicopter, on ships.[149] In 2014, the PLA released photos of a Z-10 landing on a Type 072 Lanking Tank Ship. A CCTV7 report in 2018 showed another Z-10 landing on the Yimengshan [沂蒙山], No. 988, a Type 072 Amphibious Dock Transport as part of joint training.[150] While available information makes it impossible to assess the extent of their training, such a capability could allow the helicopters to refuel and rearm while providing close air fire support for landing amphibious forces.

Civilian Market

Over the last decade, the domestic civilian market for helicopters has grown significantly. According to reporting by Chinese Aviation News journalists, the number of privately registered helicopters has now reached 1,017, a year-on-year increase of 23.3 percent.[152] This number still falls short of the 1139 helicopters estimated to be operated by the PLA.[153] In the United States, by comparison, private demand far outstrips military demand, lowering costs and helping drive innovation that the military can in turn leverage. With the rapidly rising number of privately-owned helicopters however, private ownership may finally outstrip the PLA's total inventory for the first time in Chinese history.

q According to a declassified National Intelligence Estimate written at the time, "Beijing considers the fielding of newer antiarmor weapons an extremely high priority because it faces over 29,000 Soviet tanks and armored personnel carriers in the Far East." CREST "China Opening Doors," p. 10

Wu Ximing[155]

Wu Ximing [吴希明]

Chief Designer of the Z-10 and Z-19 Attack Helicopters

The career of one of China's most prominent helicopter designers sheds some useful light on the progress of China's development in this area. Born in Shaowu [邵武市] in Fujian province in 1964, Wu was obsessed with helicopters since childhood. Wu attended the Nanjing College of Aviation Industry, now Nanjing University of Aeronautics and Astronautics. After graduating, Wu began work as a designer at the AVIC Helicopter Institute Laboratory [中航工业直升机所总体研究室] in Jingdezhen, Jiangxi province.[155]

During his career, Wu made several important contributions to his field, particularly regarding the use of Computer-Aided Design and Manufacturing (CAD/CAM). In the 1980s and 90s he was involved in the design of the Z-8, Z-9, and Z-11 helicopter designs. In 2001, at the age of 37, Wu became China's youngest-ever chief helicopter designer. He has a reputation for commitment to his work, even riding along during early live-fire tests of the Z-10 attack helicopter to reassure the pilots that the helicopter is safe.[156]

Wu has been nominated to the Chinese Academy of Engineering, and has received several awards for his work, including National Model Worker in 2010.[157] Wu regularly appears as a commentator on China's helicopter industry. In the past he has argued that China has independent development capacity for core technologies and that "The technology spillover of China's fast-paced military helicopter industry will surely boost the development of more civilian helicopters to meet commercial demand."[158]

Unnamed Aerial Vehicles (UAVs)

Overview

Chinese drones are quickly becoming one of its prominent parts of its aviation industry.[159] Despite a relatively slow beginning, with mostly university-led military projects copying Soviet drones or rigging traditional aircraft with remote controls, since the 1980s China has created an ecosystem of commercial, industrial, and military drones. China's domination of electronics and light manufacturing have helped make UAVs a top export item for China since consumer electronics made commercial drones cheap enough for widespread use. For the Chinese military, every combatant arm of the PLA employs drones for tactical reconnaissance, strike, and communications roles.

China's first drone, the CK-1 [长空一号] was a target drone copied from the Soviet-supplied La-17. China also experimented with unmanned An-2 biplanes and Il-28 bombers.[160]

Milestones in China's Drone Development	
1958	NUAA builds first drone
1958-1959	BUAA conduct drone test flights
November, 1964	China successfully shoots down U.S. reconnaissance drone
December, 1966	CK-1 [长空一号] drone's first flight
1967-68	NUAA produces version of Soviet La-17 target drone
November, 1972	China's first reconnaissance UAV launched in 1972 (CH-1)
1976	BUAA establishes the Drone Design Institute
May, 1978	CH-1 [长虹一号] completes flight testing[223]
1980	Finalized version of CH-1 enters service
December, 1980	R&D of "New Type High Altitude reconnaissance WZ-5 drone" completed
1994	NPU Aisheng completes R&D on the ASN-206
April, 1995	China successfully tests an unmanned supersonic aircraft, a modified J-7.[224]
1996	ASN-206 is present at the Zhuhai Airshow; has entered mass production
1998	China purchases HARPY loitering anti-radiation missile from Israel
2000	CH-1 begins development
2006	BZK-005 HALE UAV appears at Zhuhai Airshow
2007	CH-3 first flight
October, 2007	Yilong-1 first flight
October, 2009	Drones make their first appearance in a Chinese military parade
2010	PLA purchases 100 S-100 drones from Austria
2013	Harrier Hawk Yaoying [鹞鹰] I first flight
September 2013	Japanese Maritime Self Defense Force releases images of BZK-005 drones flying in the East China Sea
2015	CH-5 first successful test flight
2016	Yunying/Cloud Shadow UAV first public appearance at Zhuhai Airshow
July, 2017	40 UAVs of three different models participate in Zhurihe military parade
July, 2018	Harrier Hawk Yaoying [鹞鹰] II GAIC first flight
November, 2018	CAS unveils the CH-7 UCASS at the Zhuhai Airshow[225]

Perhaps in contrast to available evidence for traditional aviation, unmanned aviation has experienced massive growth in the civilian [民用] sector. Driven by a combination of hobbyist interest, commercial use, and military demand, the market for UAVs is expected to rise to 75 billion RMB ($10.6 billion USD) in 2025.[164] Civil registrations of UAVs (required by the Civil Aviation Administration of China CAAC [民航局]) have taken off, exceeding 180,000 total as of May 2018, with agricultural-use and recreational aerial photography the leading sectors.[165] In April, the CAAC issued the first provisional license for UAV package delivery to SF-Express [顺丰速

运], with the goal of augmenting its existing logistics network by allowing delivery of a package weighing greater than 10kg going more than 100 km.[166]

Highlighting private companies' participation in UAV design and production, in September 2018 roughly 40 Chinese drone makers displayed more than 70 drones at the Unmanned Aviation Week held in Chengdu, Sichuan.[167] And there was an entire pavilion dedicated to UAVs at the 2018 Zhuhai airshow.

Major Areas of Investment and Research

In addition to traditional military roles such as reconnaissance, strike, and communications, several emerging trends in UAV research are worth highlighting.

Swarming [集群]:

Notable Chinese Drone Swarm Demonstrations		
Date	**Institution/Company**	**Swarm Size**[u]
November 2016	Tsinghua University and Posong Technology	67 Fixed-wing UAVs
February 2017	Ehang[v]	1000 Quad-copter UAVs
June 2017	China Electronics Technology Group Corporation (CETC)	119 Fixed-wing UAVs
December 2017	National University of Defense Technology	21+ Fixed-wing UAVs[230]
December 2017	Ehang	1180 Quad-copter UAVs
May 2018	Ehang	1374 Quad-copter UAVs
May 2018[231]	China Electronics Technology Group Corporation (CETC)	200 Fixed-wing UAVs

The PLA is betting heavily on intelligent, unmanned systems. A 2005 RAND report offered the following definition: "Swarming occurs when several units conduct a convergent attack on a target from multiple axes."[170] Commenting on the June 2017 test of a drone swarm, Chen Lincheng [沈林成], Commandant of the College of Intelligence Science, stated that China must concentrate on accelerating the intelligentization [智能化] of the military and comprehensively build a world-class military force.[171]

Given China's domination of the cheap, light consumer drone industry, there is strong potential for military use of drone swarms, particularly for short-range applications. A number of demonstrations by both government-backed and private companies highlight the scales at which these swarms could be used. Elsa Kania notes that the PLA envisions the swarms being used to overwhelm high-priority targets.[172] Understandably, there is an ongoing debate about the actual utility of these swarms.[173]

r For context, in the United States, Intel's Drone Light Show Team used 958 drones flying together to make a cover for Time Magazine in May 2018. The Defense Advanced Research Projects Agency has held tests of aircraft-deployed swarms of over 100 drones.

s Ehang [亿航智能] is a private manufacturer of hobbyist and professional drones based in Guangzhou. "关于我们," Ehang Website, [accessed January 2019], http://www.ehang.com/cn//about.html.

High-Altitude, Long Endurance (HALE) Persistence:

High-altitude drones offer the capability of operating beyond the engagement envelopes of most Surface-to-Air Missiles and all Anti-Aircraft Artillery (AAA). Additionally, operating at over 60,000 feet puts these drones beyond the typical service ceilings, i.e. maximum altitudes, of most combat aircraft. Additionally, their long endurance, typically over 10 hours, means that they have a sustained ability to monitor areas superior to satellites, which typically do not have sustained coverage of an area short of being placed in a geosynchronous orbit. Examples of tests of these types of equipment include the June 2017 test of the Caihong solar-powered drone. [彩虹太阳能无人机].[174] The drone operated at an altitude of over 65,000 feet, over 20,000 meters, for 15 hours. The drone can carry a 20-kilogram payload, meaning that it is likely capable of carrying photographic and transmission gear. Described as a high-altitude, high speed, stealthy and long range drone, the CH-7's missions include persistent surveillance, early warning, SEAD, and attack.[175] Additionally, the Chinese government has explicitly encouraged partnerships between civilian and military companies.

Classification[t]	Altitude	Endurance
Tactical	<10,000ft (~3,000m)	30min–10 hrs
Low-Altitude	<25,000ft (7,600m)	10–20 hrs
Medium-Altitude Long Endurance (MALE)	25,000–50,000ft (7,620–15,240m)	~24 hrs
High-Altitude Long Endurance (HALE)	>60,000ft (18,288 m)	24+ hrs
Near-Space	65,617–328,084ft (20,000-100,000m)	

China's UAV industry has experienced explosive growth. The Shenzhen-based private firm Dajiang Innovations Science and Technology Co., Ltd. [大疆创新科技有限公司], commonly known as DJI, currently dominates the civilian hobbyist market.[176] This has created PR headaches for companies like DJI, which has been banned from use by the U.S. Army due to fears of hacking and intelligence gathering.[177]

One article examining the past and future of civilian and military drone development in China noted that the drone industry has not consolidated, with many companies pursuing similar projects, wasting resources.[178] Regulations' inability to catch up with the development of the drone industry is further hampering progress through limiting market access and creating dangerous situations by not regulating civilian drone use.

Li Feng [李锋]
CASC 11th Research Institute Director, Chief Designer of the CH-TI

Li Feng[180]

Li was born in Beijing in April 1961. In 1983, he graduated from Northwestern Polytechnical University with a Ph.D. in engineering and is the Dean, and Deputy Party Secretary, of CASC's China Academy of Aerospace Aerodynamics (CAAA) [中国航天空气动力技术研究所], also called the 11th Research Academy [十一院].

In this role he has significant oversight of the Caihong [彩虹] series of drones. According to Li, the program has faced some severe challenges in quality control, requiring added measures to address the problem.[180]

Li specializes in unstable aircraft aerodynamics, improving aircraft aerodynamics, jet technology, CFD algorithms, micro-aircraft design, and MEMS technology. He has published over 30 articles in both Chinese and international journals, won awards from the National Commission for Science, Technology and Industry for National Defense, and the China Spaceflight Award.[181]

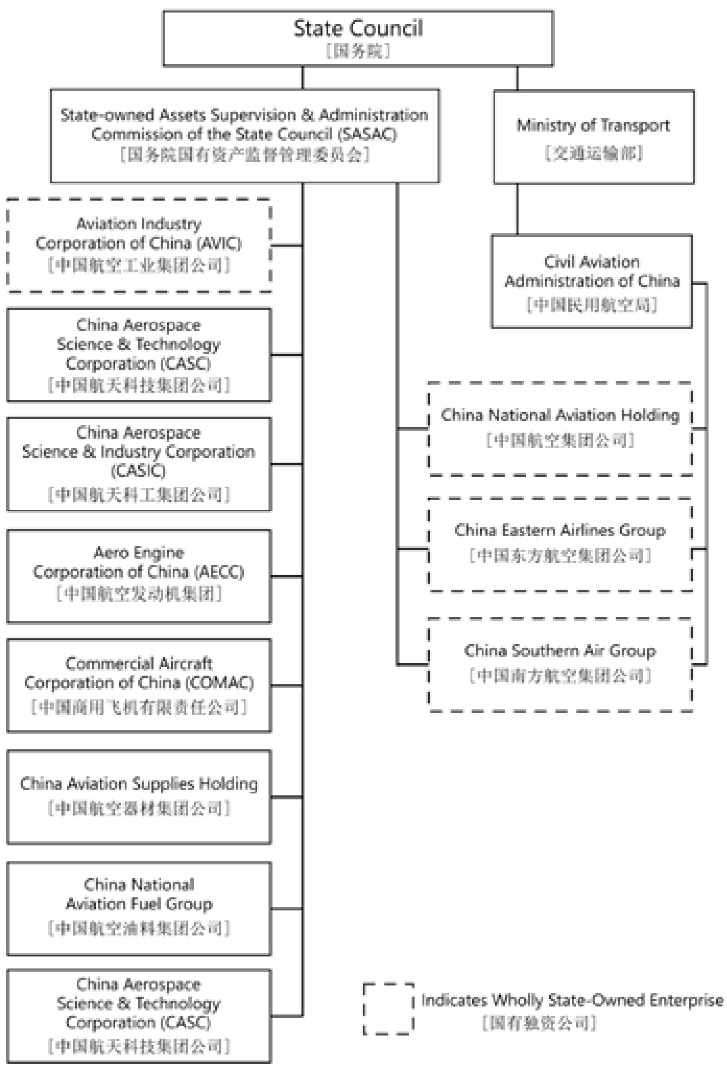
t Definitions vary – this is intended only give a rough parameter of these aircraft's operating parameters.

Section 3:
Defense-Related Aerospace Industrial Policy

Policy-Making Organizations

Planning for Chinese aerospace research and development is done by a large number of Party, State, Military bodies. This section highlights important organizations and their role in determining what to build and in what quantity to achieve which mission.

State Administration of the Aerospace Industry in China



CCP Central Special Committee [中央专委/ 中央专门委员会]

This committee is part of the central standing committee of the Politburo. Little information is available about this committee, but it is clear that it has played an important coordinating role during major R&D efforts. This organization, whose organizational forebearer was set up by Nie Rongzhen in the 1960s to give the scientific community a direct line to the CMC plays an important role in directing budgets and setting priorities.[182]

Nie Wenting [聂文婷], a Ph.D. student at the Chinese Academy of Social Sciences, for example, has described it as "the highest decision-making body and organization and coordination mechanism of the Central Committee of the Communist Party of China in leading the defense industry."[183] However, the current exact status of this body is unclear.

Leading Small Groups [领导小组]

These organizations exist throughout the Party, State, and Military structure, and assist leaders in developing and implementing policy. In many cases they act as an important forum to allow leaders to interact with experts on specific topics and learn information to enhance their decision making.[184] These groups are worth noting due to their likely role in the aviation industry's connection with Party, state, and military bodies.

National Science and Technology Leading Small Group [国家科技领导小组]

As mentioned earlier, Chinese national plans [计划] play an important role in setting research priorities for laboratories and corporations. These plans are decided upon by top-level Leading Small Groups. In August 2018 the State Council set up a State National Science and Technology Leading Group [国家科技领导小组] to consolidate priority-setting and planning for S&T.[185] This body replaces the former National Technology and Education Leadership Group. The body pulls together leaders of the Ministry of Education, Ministry of Science and Technology (MOST), MIIT, Finance, Ministry of Human Resources and Social Security, Agriculture, People's Bank of China, SASAC, Chinese Academy of Sciences, Chinese Academy of Engineering (CAE), Party leaders from the China Association for Science and Technology, and State Council organs, along with the chief of the CMC Science and Technology Commission [科学技术委员会]. Notably, the new leading Small Group, unlike its predecessor, includes members from CMC organizations.[186]

CMC Equipment Development Department [装备发展部]

Within the PLA, the most important organization for China's defense aviation is the EDD, which is responsible for planning, research, development, testing and procurement for the entire military. The transformation of the General Armament Department (GAD) into the CMC Equipment Development Department will have wide-ranging consequences. As noted earlier, however, during the 19th Party Congress in October 2017, the EDD was downgraded from CMC member grade to Theater Command leader grade and the director was removed from the CMC. As a result, the EDD does not have as much clout as it did before the Party Congress.

The General Armament Department, had primary responsibility within the PLA for developing weapons, conducting testing, and developing relevant regulations.[187] However, it was primarily focused on developing equipment for the Army. The GAD was responsible for Ground Force RD&A and administered China's space program but did not have direct control over the Air Force, Navy, or Second Artillery's equipment development.[188] Under the new system, the Army Equipment Scientific Research and Procurement Department is now simply the Scientific Research and Procurement Bureau [装备科研订购局], which falls under the EDD General Office. By contrast, the former Science and Technology Commission [科学技术委员会] under the GAD has been upgraded to Theater Command Deputy Leader grade and given independence from the EDD under the CMC. With the replacement and downgrading of the Army Equipment Scientific Research & Procurement Department, the formerly subordinate Military Representative Bureau is now an independent body.

While some responsibilities for space launch, testing and telemetry, and control appear to have been transferred to the Strategic Support Force, the Manned Space Engineering office [载人航天工程办公室] and the official leadership (the commander-in-chief [总指挥] position) remain with the EDD, meaning that ultimate control and direction of China's space program remains under the PLA in the CMC EDD. As of early 2019, Zhang Youxia [张又侠] is the commander-in-chief of the Manned Space Program Office [载人航天工程总指挥].

CMC Science and Technology Commission [中央军委科学技术委员会]

The CMC S&T Commission, formerly under the GAD, is an independent, Theater Command deputy-leader grade organization under the CMC, established on 11 January, 2016.[189] China's Ministry of Defense website describes the body as "aimed [at] strengthening the strategic management of national defense science and technology, promoting independent innovation in that area, and pushing for the integrated development of military and science technology."[190] Its leader is Liu Guozhi [刘国治], a Lieutenant General who is an expert in high-power microwaves [高功率微波] who previously served as deputy director of the GAD.[191] He holds a Ph.D. in Engineering Physics from Qinghua University.[192] In June 2018, Liu visited "Dalian Sida," a company focused on "large aircraft digitized intelligent equipment manufacturing" and the first private company to provide this capability for aerospace in China.[193] Dalian Sida has also "helped China overcome the technological 'blockade'" imposed by foreign countries. Liu also visited Harbin Institute of Technology [哈尔滨工业大学], due to its "important contributions" to National Defense Space modernization.[194]

In 2017, the Ministry of Science and Technology along with the CMC Science and Technology Commission issued the *13th Five-year Plan Science and Technology Military-Civil Fusion Development Special Plan* ["十三五"科技军民融合发展专项规划].[195] The plan is meant to coordinate research, identify and implement important projects, promote sharing of resources, and collaboration platforms. According to Xin Yi [辛毅], deputy director of the CMC Science and Technology Commission, the plan provides basic direction and guidance for relevant policies.[196]

Ministry of Science and Technology (MOST) [科学技术部]

As the leading State Council organization in charge of drafting S&T Plans, this organization oversees the implementation of the National Basic Research Program [国家基础研究专项规划] and National High-Tech R&D Program.

This latter role involves coordination among national laboratories, universities, and other parts of the national research system, and the supervision of R&D budgets. MOST also issues the National S&T Awards [国家科学技术奖励]. Wang Zhigang [王志刚] serves as Party Secretary and Minister of MOST. Many of MOST's investments, such as funding for research into meta-materials, a key component of next-generation stealth technology, will be crucial for the aviation industry.[197]

Ministry of Industry and Information Technology (MIIT) [工业和信息化部]

Established in 2008, MIIT is in charge of administering and planning China's traditional and IT industries. It also plays an important part in information security. The Party Secretary and Minister of MIIT is Miao Wei [苗圩], he is a former engineer with a background in the automotive industry.[198]

If a major theme of the aviation industry's goals can be understood as import substitution, Made in China 2025 and its successor plans can be viewed as part of the national-level planning to help achieve those goals across a wide range of industries. Most important for China's aviation industry, MIIT is the administering organization for SASTIND, and SASTIND's director serves as a Vice Director of MIIT. MIIT directly administers several numbered research institutes, including the Fifth Electronics Research Institute [工业和信息化部电子第五研究所].[199]

State Administration for Science, Technology, and Industry for National Defense (SASTIND) [国防科工局]

SASTIND's predecessor, COSTIND, was created in 1958 to give the CMC and Politburo direct control over China's strategic weapons programs.[200] SASTIND works to support Chinese aviation companies through coordination with state and military bodies and through setting priorities.

In May of 2018, Zhang Kejian [张克俭] became the head of SASTIND, replacing Tang Dengjie [唐登杰].[201] Zhang previously served as the deputy Party Secretary and as a deputy director of the agency. His academic background includes degrees from NUDT in applied physics and high energy physics. He also received a master's degree in Mechanics of Explosions [爆炸力学] from the University of Science and Technology of China.[202] The current director of SASTIND, Zhang Kejian, also serves as a deputy director of MIIT.

SASTIND appears to have Deputy Directors [副局长] with portfolios focused on nuclear, materials [材料], ordnance (equipment), space, and aviation. For the aerospace industry, two deputies are the primary points of contact. Xu Zhanbin [徐占斌], who has experience working at Harbin Aviation Industry Group (HAIG) appears to oversee aviation-related work at SASTIND and makes regular visits to AECC and other Chinese aviation companies.[203]

Tian Yulong [田玉龙], who is in charge of the space portfolio, has a background in aerospace engineering, including serving in various roles at CASC and China's national space agency.[204] SASTIND's annual meeting on national defense science, technology, and industry (STI) [国防科技工业工作会议] bring together members of the military and state organizations including the heads of the CMC EDD and MIIT.[205]

Key Leaders

Zhang Youxia[207]

GEN Zhang Youxia [张又侠]

Vice-chairman of the Central Military Commission

General Zhang Youxia currently serves as one of the two vice-chairmen of the Central Military Commission (CMC) and is a member of the Political Bureau, 19th Central Committee of the Communist Party of China. Zhang was born in July 1950 in Weinan, Shaanxi Province. Zhang joined the PLA in December 1968 and became a Party member in May 1969. Zhang spent much of his early career in Yunnan, under the 14th Corps near Kunming. During tensions with Vietnam after the 1979 border war, Zhang's unit was rotated to the border and his regiment saw significant combat. The 119th Regiment was involved in the Battle of Laoshan, in which over 3,000 Vietnamese soldiers were killed.

After several leadership positions in the southwest, he became deputy commander and then commander of the Shenyang Military Region in China's Northeast. In 2012 he was appointed Director of the PLA's General Armament Department, which later became the CMC Equipment Development Department. In October 2017 he was named one of the two CMC Vice Chairman. As Director of the Equipment Development Department he was also the commander-in-chief of China's manned space program and frequently oversees space launches.[207]

Zhang appears to have been involved in the PLA's push to improve its information systems, launching the "Strong Army" [强军网] information hub for soldiers during his tenure.[208] The EDD Director also serves as a high-level contact when establishing relationships with other nation's defense industries. In this role Zhang met with his counterparts in Belarus, Hungary and Italy.[209]

Li Shangfu[211]

LGEN Li Shangfu [李尚福]
Director of the Equipment Development Department

Li Shangfu is the current Director of the CMC's Equipment Development Department, replacing Zhang Youxia before the 19th Party Congress.[211] Born in Sichuan in 1958, Li has had a long career focused on civilian and military space programs. A career officer, Li enlisted in the PLA in 1978 and was admitted to PLA National University of Defense Technology, graduating in 1982. Upon graduating, Li was assigned to Sichuan province's Xichang Satellite Launch Center (AKA 27th "Test and Training Base") [第二十七试验训练基地] Li first entered Xichang as a technician in 1982 and over his 31-year career at the Test Base rose to Commander in 2003.[212]

While at Xichang, Li was involved in several key developments in China's space and rocketry tests, for example: the 1990 Long March-2E carrier test, the 2000 Beidou navigation satellite, the 2007 anti-satellite missile test and Chang'e 1 lunar exploration program, and the 2008 Long March-3C carrier rocket test.[213] Xichang also accounts for 40 percent of China's space launches. In 2013, he replaced General Shang Long [尚宏少将] as commander of the Jiuquan Satellite Launch Center [酒泉卫星发射中心], AKA the 20th "Test and Training Base" [试验训练基地].

In 2013, he replaced Major General Shang Hong [尚宏] as the General Armaments Department chief of staff and was promoted to Deputy Director the following year.[214] Shortly after the PLASSF was established in late 2015, Li was appointed as deputy commander for one year.[215] Given Li's career, his current position in the Equipment Development Department is one of the clearest indicators of the emphasis China is giving to space as a "new security domain" [新型安全领域].

Section 4: China's Civil-Military Aerospace Industrial Capacity

Major Concepts

Origins:

China, more than most countries, has had a blurry distinction between civilian and military roles in its economy. An important part of the PLA's DNA has always been its mission as a "productive force" in society.[216] This has developed partly due to ideology and partly as a result of political and economic realities, such as the results of the Chinese revolution, which ended with the PLA in charge of large swathes of the country due to conquest, and later during political turmoil in the 1960s and 1970s when it intervened and took control of industries and local governmental tasks. While the basic concept has remained the same, the terminology used and some of the goals have evolved over time.

"Combine the Military and Civilian Sectors" [军民结合]

In 1978, Deng Xiaoping first put forward what would later become the basis of Military-Civil Fusion (MCF): "Combine the Military and Civilian Sectors" [军民结合].[217] In 1982, Deng issued a 16-character slogan that would set the tone for military-civil cooperation in industry: integrate military and civilian purposes, combine peacetime and wartime preparations, give priority to military products, and sustain the military with the civilian [军民结合, 平战结合, 军品优先, 以民养军].[218]

Together, this 16-character formulation dominated Chinese thinking until the 1990s, pushing military industries to be adapted to civilian use. Many civilian industries, from airlines to automotive producers, began their lives as military industries in the 1980s.

The emphasis remained on pushing military industries expertise into the civilian economy, with the reasoning that to be strong, militarily or otherwise, China must first be strong economically. As China's economic power grew, the military could increasingly learn more from or adapt from the civilian world, reversing the emphasis of the 1970s and 80s. The government ensured that as China's economy grew the military had access to and benefited from that growth.

In 2007, Hu Jintao's Party Work Report at the 17th Party Congress included language about MCF for the first time:

> *We will adjust and reform the systems of defense-related science, technology and industry and of weapons and equipment procurement, and enhance our capacity for independent innovation in R&D of weapons and equipment with better quality and cost-effectiveness. We will establish sound systems of weapons and equipment research and manufacturing, military personnel training and logistics that integrate military with civilian purposes and*

combine military efforts with civilian support, build the armed forces through diligence and thrift, and blaze a path of development with Chinese characteristics featuring military and civilian integration.[219]

In 2008, the same State Council reforms that established SASTIND created the Ministry of Industry and Information Technology's Civil-Military Integration Promotion Department, to give MIIT greater authority to promote MCF through its oversight of the defense industry and other large SOEs.

Under Xi Jinping, emphasis on MCF has increased dramatically. The 2015 Defense White Paper laid out explicit goals for MCF:[220]

- Establishing uniform standards for infrastructure
- Training military personnel in civilian educational institutions
- Developing weaponry and equipment by national defense industries
- Outsourcing logistics support to civilian support systems

Xi's work report at the 19th National Congress of the Communist Party of China in October 2017 further emphasized MCF as a component of "[Ensuring] that efforts to make our country prosperous and efforts to make our military strong go hand in hand."[221] China is rapidly expanding the legal framework promoting civil-military cooperation throughout China's economy. On 4 December 2017, China's State Council issued opinions on the promotion of MCF in the defense S&T industry [国务院办公厅关于推动国防科技工业].[222] A legislative agenda put out for the 13th National People's Congress includes deliberation of a Military Civil Fusion Development Law [军民融合发展法].[223]

Policy-Making Organizations:

Party, State and Military Organizations Leading Military Civil Fusion Initiatives

	Organization
Party	Central Military-Civilian Fusion Development Commission [中央军民融合发展委员会]
Central Military Commission	CMC Equipment Development Department [中央军委装备发展部]
	CMC Science and Technology Commission [中央军委科学技术委员会]
State Council	Ministry of Science and Technology (MOST)
	SASTIND [国防科工局]
	Department of Civil-Military Integration Promotion
	Ministry of Science and Technology (MOST)
	National Development and Reform Commission
	Provincial Governments
	Prefectural/ Municipal Governments

To implement MCF, China created several Party, Military, and State organizations down to the prefectural level.

Centralization, particularly through the creation of the Central MCF Commission in 2017, is meant to improve coordination and avoid "low level redundant [projects] [避免低水平重复建设]."[224]

Fundamentally, the goals of Military-Civil Fusion can be described as improved capacity, capabilities, and cost.

Capacity:

Arthur Herman noted in his study of U.S. war materiel production during WWII that the key to U.S. success was not a ramping up of capacity during the war but putting the necessary levers in place to bring this capacity into play once the war started. A crucial period of deliberate industrial growth occurred between mid-1940 through the end of 1941, i.e. before Pearl Harbor and prior to U.S. entrance into the war.[225]

Bill Knudsen, largely responsible for this effort, said "I know if we get into war, the winning of it will be purely a question of material and production. If we know how to get out twice as much material as everyone else, know how to get it, how to get our hands on it, and use it, we are going to come out on top, and win."[226]

MCF will help increase the variety and sophistication of what the PLA can build, and in turn, lead to breakthroughs and technologies that will benefit the private sector. The potential for spinoff technologies is obviously very high. Gao Hongwei [高红卫], the Chairman and party secretary of CASIC, said that more than 2,000 aerospace spin-off technologies have been used throughout China's economy.[227] As an example, aluminum alloys developed for the military by a NORINCO subsidiary in Baotou, Inner Mongolia have been used in Chinese high-speed trains and the aviation industry.[228]

The PLA also has a significant lead in certain technologies that the private sector wants. MCF does not just extend to State Owned Enterprises. Increasingly, private companies are joining MCF-related ventures, mirroring their concurrent rising level of involvement in defense production. In April 2018, some 40 participated in Civil-military discussions with AECC and the Air Force Equipment Department.[229] The EDD has also created a catalog of specifications for military equipment as part of an effort to set universal standards. Doing so will allow civilian companies to provide appropriate products.[230]

Capability:

The ability to draw on civilian assets during an emergency or wartime can dramatically improve the PLA's warfighting capabilities. Although the PLA controls Chinese airspace, military-civil coordination offices are being set up at airports to streamline communication during peacetime. In the event of war, these offices will give the PLA access to a much wider range of runways, making the PLAAF much more flexible.

Civilian transport companies are also being tapped to assist the PLA with movement. In June 2018, a reserve Anti-Aircraft Artillery (AAA) Division in Shaan'xi held an exercise with West Dragon [西部飞龙通用航空有限公司], a helicopter transport company. In 2012 the company signed a strategic cooperation agreement with the PLAAF.[231]

Cost:

Another goal is to use MCF to cut costs by sharing resources and reducing redundant research. AVIC, for example, signed agreements with Dongfeng Motor Company [风汽车公司] to make use of high-end equipment, technologies, or services for both the civilian and military markets, including lithium-ion batteries and smart equipment.[232] AVIC has also drawn on innovations from the private sector to develop the Yilong [翼龙] series of drones.[233]

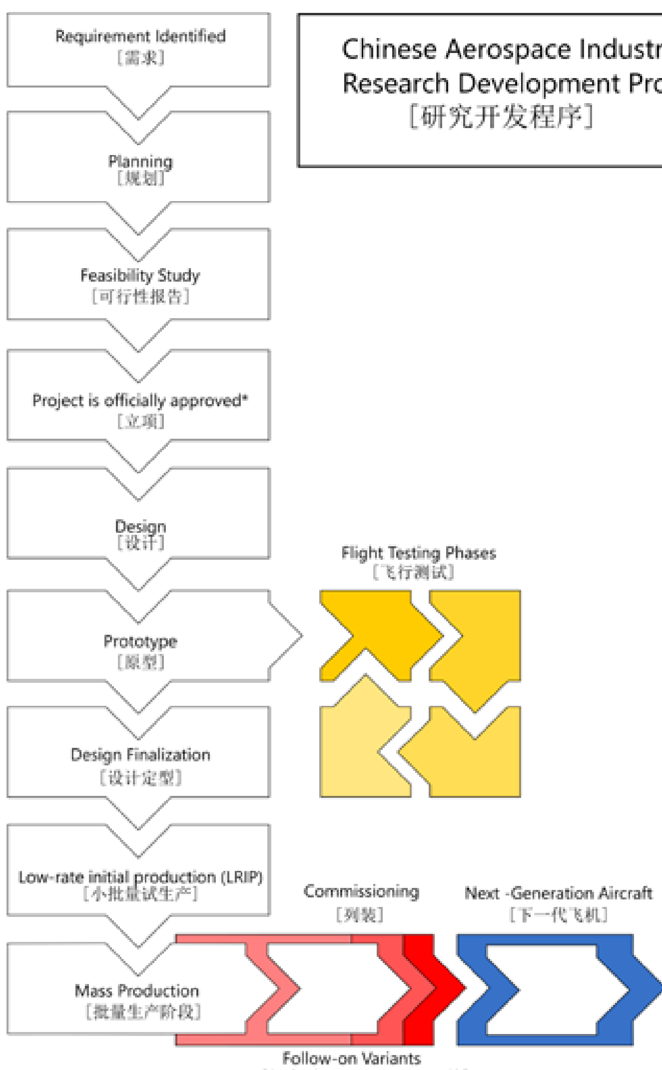
Other examples include agreements signed between Guizhou Aircraft Industry Corporation (GAIC) and the private sector to open its manufacturing, service repair and material sciences divisions to greater cooperation.[234]

Significant cost savings have also been achieved through MCF-type agreements. Harbin Aircraft Industry Group began contracting out portions of its workload in 2017, and currently estimates that by 2020, the contracted business will be worth more than 800 million RMB ($118,338,000 USD) in value.[235]

Section 5:
The Research, Development, and Acquisition (RDA) Process

Overview

While it is hard to generalize across the full range of Chinese aviation platforms, there appears to be a regular set of stages that almost all aircraft go through.



* Usually given a code name at this time ［代号XXX工程］
** Other common words used to describe this include: ［服役/交付部队/入列］

Setting Priorities

The initial stages of aircraft R&D in China appear to have two major origins. First, senior officials assess China's national, strategic, operational, and tactical requirements [需求] and task a research institute with carrying out initial R&D to determine whether a suitable platform can be developed. In the second case, R&D institutes, carrying out their own independent research, hit upon a design idea and present it to their superiors. Related to the latter process, some aircraft are designed purely for foreign markets, or with both domestic and foreign customers in mind. An example of these priorities can be seen in the Large Aircraft program [大型飞机项目].

The authors of *Military Equipment Theory and Reform Implementation* note that a persistent problem is that there are too many people in charge [多头], and that the industry is dispersed [分散] and segmented [分段].[236]

Restricted by cost, technology, industrial base, and management levels.

The Party, through the Central Special Committee [中央专委/ 中央专门委员会], exerts control over the R&D process, consulting with top scientists and making final decisions on what to approve.[237] State Council organizations, such as the National Science and Technology Leading Small Group [国家科技领导小组], help set priorities that may be referenced during other work. The PLA sets priorities through the CMC Equipment Development Department [装备发展部] and the Equipment Departments [装备部], which exist for each of China's military services.

Phases of Testing		
Initial Testing [初步设计]	Digital modeling begins	数字化原型
	Computational Fluid Dynamic Testing	计算流体力学
	Scale Prototype	尺寸样机
	Wind Tunnel Testing	风洞试验
	Full-scale prototype	全尺寸样机
	Simulation testing	模拟试飞
Flight Testing [飞行测试]	Scientific research test flight	科研试飞
	Avionics tests	航电系统试验
	Air Worthiness test flights (includes both handling tests and environmental tests like performance in cold weather, crosswinds, etc.)[239]	适航取证试飞
	Weapons, radar, Fire control system tests	机载武器/雷达/火控系统 试验
Design Finalization		设计定型
Individual Unit Testing	The aircraft is incorporated into existing or new units and begins training in various environments and situations to further hone tactics and identify problems.[240]	

The Army and Navy each additionally have Aviation Equipment Bureaus [航空装备局], likely tasked with overseeing the helicopters belonging to those services. The Navy has a special Aircraft Office [飞机办公室] dedicated to its carrier-borne aircraft.

Each of the theater commands also appears to have set up a Military Requirements Bureau [军事需求局] under their Joint Staff departments [联合参谋部] to better refine the operational "real combat" needs of each Theater Command [战区].[240] This is likely a refinement of the pre-reform system, which had Operations Departments. After requirements are decided upon, the next stage then is planning [规划] how to achieve those requirements.

Research and Development

FTC-2000G Undergoing Testing[242]

After the general design parameters have been decided upon, designers and engineers develop aircraft design concepts [设计理念]. A feasibility study [可行性报告] determines if further research is worthwhile. If so, the State Council and CMC will approve the project, research funds are allocated, and the project is officially registered[u] [立项]. This process is not always efficient. Chinese commentators have cited the lack of pre-research [预先研究] to determine feasibility before proceeding to the modeling phase as a continuing problem that wastes resources.[242] From more recent media reports, it appears that this continues to be

u This is an important point, that while some strategy and theory may be secretive, the PRC typically plans and publishes long term projects and programs.

an issue and more resources are being allocated to this type of research.[243] After the design is finalized, the aircraft begins low-rate initial production [小批量试生产].

A vital stage is the flight testing carried out by both military pilots and aircraft companies' own flight test units.[244] Each major aircraft factory appears to have associated testing stations [试飞站], each with groups [大队] of test pilots.[245] These test pilots are responsible for the first round of refinements, identifying issues and working with the factory to improve subsequent batches. Some aircraft are dispatched to specialized testing facilities for weather testing, (e.g. high wind, or ice resistance), or in the case of helicopters, high-altitude flying capability. Flight test groups [试飞大队] are assigned to China's major aircraft factories in Shenyang (SAC), Harbin (HAC), Chengdu (CAIG), Hongdu (HAIG), Anshun (GAC) and Chenggu County [城固县] /Hanzhong (Shaanxi Aircraft).

The Air Force maintains two Test and Training units:

Air Force No. 1 Test and Training Base "Dingxin Test and Training Base" [空军第一试验训练基地]

Location: Jiuquan, Gansu Province
[酒泉市,甘肃省]

The Dingxin base is the regular venue for several important PLAAF events: China's Golden Helmet fighter pilot competition; Golden Dart, its strike aircraft and bomber competition; Blueshield/Golden Shield, focused on air defense and suppression of enemy air defense missions; and Red Sword, focused on dealing with realistic confrontation scenarios.[246]

Air Force Flight Test and Training Center (FTTC) [中国空军试飞团]

Location: Cangzhou, Hebei Province
[沧州市, 河北省]

In 1987, the PLAAF established a Flight Test and Training Center at near Tianjin at Cangzhou. The FTTC conducts OPFOR training for PLAAF units and is home to a specially-equipped unit of J-10 pilots that train to fly as likely adversaries.[247]

AVIC itself runs an additional flight test center:

China Test Flight Establishment/AVIC Industry Flight Test Center [中国试飞史研究所]/[航工业试飞中心]

Location: Yanliang/Xi'an, Shaanxi
[阎良, 陕西]

The Test Center is China's primary scientific test unit for aircraft, aeroengines, helicopters, and other equipment. It also conducts testing of civil-aviation aircraft, for the CAAC. A key area where its research has made significant contributions is in engine testing and design.[248]

Chinese Aeronautical Establishment (CAE) [航空研究院]

Established in 1960, CAE is the Chinese government-authorized organization for international cooperation and engagement in international aerospace cooperation.[249] CAE acts like an umbrella organization for Chinese Aerospace research centers, institutes and facilities. It also serves an educational role, teaching graduate students in the field of aviation. In 2014 CAE held China's first Computational Fluid Dynamics/Wind Tunnel Testing International Research Forum in Beijing, bringing together scholars from Germany, the Netherlands, Russia and four other countries.[250]

AVIC Development and Research Center [中国航空工业发展研究中心]

The AVIC Development and Research Center plays an important role in advising AVIC and SASTIND on trends in aviation, science, and technology. The research center uses advanced information technology, including simulation technologies, to test technologies and tactics.[251] As China's sole research institute devoted to comprehensive study of aviation technology and industrial development, it is a core part of China's Military-Civil Fusion plan under MIIT.

In 2014, Li Bo [厉博] and Zhang Yang [张洋], who both are affiliated with AVIC's Development and Research Center [中国航空工业发展研究中心] wrote that "currently China's aviation research and development capability are dispersed and technologies severed, making scientific and technological innovation difficult."[252] According to Li and Zhang, each "link" in Chinese S&T, such as scientific disciplines, programs, laboratories, and research area, all stand by themselves. They noted that despite there being more than ten Chinese carbon fiber companies with more than ten independent companies, none have mastered the core technology [核心技术] or made their own breakthroughs, and thus remain reliant on imports.[253]

Other subsidiaries take on specific phases of testing. AVIC Wuyi [中国航空武仪], for example, has carried out special research to help Chinese helicopters resolve the issue of ice buildup on their rotors.[254]

Funding and Procurement

Sources of Defense Industry Funds	
Government Expenditures	国家财政支出
Enterprise Reserve Funds	企业的预留资金
Government-related banks	政策性银行
Stocks and bonds (restricted)	股票与债卷

Data from the Stockholm International Peace Research Institute's Military Expenditures Database estimates Chinese military spending in 2017 at $228 billion USD, more than double the level in 2008.[255] For the aviation industry, funding primarily comes from four sources, as listed in the chart.

A consistent complaint among analysts of China's military industrial complex [军工] is the inefficiencies involved in the funding mechanisms. Government Expenditures [国家财政支出] remain the largest, and growing, source of funds.[256] Restrictions on which banks aviation companies can take loans from, and other restrictions on their ability to issue stocks and bonds have also limited these companies' ability to raise capital using the global financial system.

Military Representative System

Purpose and Organization

The Military Representative System [军事代表制度] is a unique characteristic of the Chinese defense industry that has existed since 1951. At the highest levels, the Central Military Commission's Equipment Development Department exerts control through the Military Representative Bureau [军事代表局]. Individual factories have

Military Representative Offices (MRO) [军代表室] with members of relevant services, for example, AVIC enterprises producing fixed wing aircraft will have Air Force and Navy representatives, while those producing attack helicopters will have representatives from the Army. These offices are administered by municipality and province-level bureaus [局]. MROs are themselves subordinate to their services' respective equipment department [装备部].[v]

Military representative offices play an important role in managing the bidding process, overseeing contractual compliance, and ensuring quality control.[257] They also identify ways to improve the capabilities of the equipment being produced. In this way, they act as a bridge between market demands placed on the companies producing aircraft and the necessary capabilities for the aircraft to be combat-ready. At AECC subsidiary Xi'an Aero-Engine [中国航发西航], Navy and Air Force military representatives hold monthly meetings with factory leaders to resolve quality issues and ensure timelines are kept.[258]

The PLA's 67-year-old military representative system faces a number of major challenges. The rapid adoption of new technology and equipment into the PLA, which has posed a problem for soldiers unused to informationized weaponry and tactics, poses a challenge for military representatives charged with overseeing ever-more complex design and manufacturing processes. Representatives are now expected to have a higher level of education and professional technical knowledge than previously required.[259] If representatives are stationed at a factory for too long, it is likely that they will lose touch with operational requirements. If moved between posts too frequently they likely have difficulty maintaining currency with relevant manufacturing techniques.

Susan M. Puska, Joe McReynolds, and Debra Geary have noted that these representatives "often remain indefinitely within their narrow system, transferring from one job to another without ever being assigned to an operational unit."[260]

An incident that has received significant attention from official press highlights the importance of the Military Representative system to ensuring standards. In 2013 AVIC Wuyi [中国航空武仪], saw a massive increase in quality control problems, with 232 issues.[261] As a result, company, military, and local government coordinated to increase training to resolve the issues. The MRO invited air force experts to train military representatives, company management, and other employees to improve understanding of standards.[262]

v The PLA Army [陆军] has an Aviation Equipment Bureau [航空装备局] subordinate to its Equipment Department. It is unclear if MROs are subordinate to the lower organization. Similarly, the PLA Navy has an Aviation Equipment Bureau, though it also has an Aircraft Office [飞机办公室] with a subordinate Carrier-borne Aircraft Support Division [舰载机保障处].

J-10 [歼-10] Multi-role Fighter

J-10 Timeline[364]	
1982	Deng Xiaoping states that China must build a "new type" fighter aircraft.
February, 1984	The "canard style" [鸭式] layout for the J-10 is approved
May, 1984	COSTIND [国防科工委] approves Chengdu Design Research Institute (611 Academy) to carry out research and development and Chengdu Fighter Factory (132 Factory) to carry out manufacturing of the new fighter
January, 1986	State Council and CMC approve establishment of the program to build a new fighter, code name "No. 10 Project" assigned
August, 1991	First full-scale prototype completed
June, 1994	Assembly Instructions [生产图] are completed
December 1994	Detailed Design complete
August 1995	Spare parts for J-10 No. 01 begin assembly
March 1996	First simulated test with the flight control system installed
June, 1997	First J-10 is assembled
March, 1998	First Successful flight
2003	Setting a precedent, the J-10 is the first military aircraft that is delivered to the military while still in testing
Fall 2003	First successful firing test of a guided missile from J-10
December 2003	First successful flight of the J-10S [双座] two-seater trainer
2004	Final design passes inspection and is approved
2005	J-10S design is finalized and passes inspection
2006	The J-10 becomes operational
2009	"8.1" flying team adopts the J-10
December, 2016	J-10B participates in the 11th Chinese International Aviation and Aerospace Exhibition (Zhuhai Airshow)
July, 2017	J-10C participates in the military parade commemorating the 90th anniversary of the founding of the PLA in Zhurihe, Inner Mongolia

Mission: The J-10 is an important bridge between the pre-2004 emphasis on National Territorial Air Defense [国土防御] and the PLAAF's mission of Combining "Integrated Air and Space Operations, Simultaneous Offensive and Defensive Operations" [空天一体, 攻防兼备].

As a multi-role fighter, the J-10 typically is pictured carrying a mix of short-range and beyond visual range (BVR) air-to-air missiles (AAMs) in an air defense role but is capable of carrying out close air support and other ground attack roles. The J-10 has been adopted by both the PLAAF and PLA Naval Aviation. Most appear to be equipped with aerial refueling probes, and Chinese media frequently shows them training and conducting long-distance flights.

Available information appears to indicate that it will largely serve as a replacement for China's inventory of obsolete air superiority fighters, supplementing smaller numbers of longer-range aircraft being produced that would be used in strike roles.

Background:

Although the design was finalized more than a decade ago, the J-10 offers some useful insight into the RDA process, in part because the process has been explained in greater detail than other Chinese aircraft.

The J-10 is a good example of how requirements have changed in response to shifts in China's strategic environment. For example, in 1978 all work on the J-9, a prototype next-generation fighter jet, ceased work after 14 years of development due to a recognition that a clean-sheet design was needed to better respond to other nations' capabilities.[264] While the Chinese aviation industry during the 1980s essentially started from scratch, it successfully developed the JH-7A supersonic fighter-bomber (first successful flight on 14 January 1988), and began work on an improved J-8, the J-8II.

In the mid-80s China's leadership realized that the capabilities of its inventory of fighters, of which the MiG-21 and J-8 were the most advanced, was falling behind other countries. The U.S. and China laid the groundwork to upgrade the J-8II through improved avionics and advanced air-to-air missiles. However, an indigenous design was also needed to reduce Chinese reliance on foreign imports and expertise.

Song Wencong [宋文骢], who had been involved in the J-9 effort, which also used a canard-layout, proposed a new, more capable multi-role 3rd-generation fighter to a group of senior Party and State Council Officials. In January 1986 the CMC, state council, and presumably, leading Party organizations, gave approval for the establishment of the project , and assigned it the code name "Project No. 10".[265]

Key Figures in the J-10 Program	
Chief Designer [总设计师]	Song Wencong [宋文骢]
Chief Engineer [总工程师]	Xue Chishou [薛炽寿]
Chief Program Director [总指挥]	Liu Gaozhuo [刘高倬]
J-10 lead test pilot [首席试飞员]	Lei Qiang [雷强]

Song Wencong[267]

Like the experiences of Xi'an-based designers that were then working on the JH-7, Song's team of engineers in Chengdu faced significant technical difficulties due to the much higher level of complexity involved in nimbler, fly-by-wire 3rd generation fighter aircraft. Part of the technical difficulty associated with the J-10 was due to the need for a large proportion of entirely new technology and parts.

According to Chengdu Aircraft engineers and designers, new aircraft normally require 30 percent of the technology and features to be wholly newly designed. For the J-10, due to China's technological level and the design parameters, roughly 60 percent was entirely new. Due to these requirements, the J-10 was the first Chinese aircraft to incorporate widespread use of CAD for its structural design.

Computational Fluid Dynamic (CFD) testing also played a key role throughout the refinement of the design. The development of the J-10 also saw improvements in China's wind tunnel technological development, with AVIC Aerodynamics Research Institute [航空工业气动院] FL-1, FL-2, and FL-8 wind tunnels providing research support for the project.[267] According to Song, more than 10,000 wind tunnel tests were carried out over the course of a year for the J-10.[268] China's limited digital modeling capabilities at the time meant that the hydraulics system, which was much more complicated than 2nd Generation fighters, had to be tested via physical models.[269]

Demonstrating the importance of the project, while inspecting the project in 1994, then General Party Secretary Jiang Zemin said the J-10 was "more useful than the atom bomb."[270] In 1998, Chinese Deputy Chairman and CMC member Liu Huaqing [刘华清] went to Chengdu for the J-10's unveiling ceremony.[271]

In 1998, almost seven years after completion of the first prototype, Chengdu Aircraft conducted the first test flight of the J-10. Lei Qiang [雷强], the first to fly the J-10 prototype, was chosen for his familiarity with modern, western, 3rd generation aircraft capabilities. He was the only person in China with experience flying both the F-16, and the Soviet/Russian Su-27.[272]

Highlighting the difficulty of adapting to 3rd generation Aircraft, Lei has said:

> *Since I first got into an aircraft to learn how to fly, no matter which kind of aircraft, at the very least I could understand 70 or 60 percent of what everything was, such as this is the altimeter, airspeed gauge, I could figure this is speed this is altitude, this is my speed, this is my aircraft attitude…when I got into the J-10's cockpit, I basically didn't recognize anything because there were no dials.*[273]

Four more years of testing passed before the next major milestone. Flight-testing typically takes up half of the R&D funds and time needed to complete an aircraft. In a first for the PLA, CAD delivered the J-10 to training units in 2003, ahead of schedule.[274] This gave operational units greater input regarding their needs for the J-10s capabilities and to help Chengdu engineers to understand the sorts of stresses that would be put on the plane in combat.

J-10C with TVC[276]

The J-10 underwent weapons testing in the fall of 2003. The J-10A design was finalized in 2004. Subsequent variants such as the J-10S (dual seat trainer), J-10B (which began flight testing in 2009) and the J-10C variants further refined the design and incorporated several major improvements including Active Electronically Scanned Array (AESA) radar, what appears to be an electronic countermeasures (ECM) suite, and a superior air intake.[276]

Further Developments:

Radars and the Diverterless Supersonic Inlets (DSI) developed for J-10 were then integrated into the J-20.[277] Similarly, a J-10C has served as a testbed for the WS-10 "E'mei" [峨眉] engines with Thrust Vector Control (TVC) [推力矢量控制] technology, something it hopes to integrate into the J-20 and future platforms. Follow-on variants such as the J-10D are planned using a more powerful domestically produced WS-10B engine and TVC.[278]

According to an episode of Memories of the Military Industry [军工记忆], a SASTIND-produced documentary about China's defense industries, development of the J-10 involved 10 research and manufacturing institutes and several tens of thousands of people.[279] Overall the development of the J-10 took 22 years, from Deng's initial decision to pursue a "new type" fighter in 1982, to the J-10s' introduction into the PLA in 2004.

While this might seem slow for the development of a single-engine fighter, China faced a number of notable hurdles to move from 2nd Generation to 3rd Generation fighters. In doing so, it set the stage for the much more rapid RD&A of newer aircraft. Though many aircraft exhibit strong evidence of copying/imitation [仿制], or integrate innovations appropriated from abroad, the learning process from the J-10 certainly marks the beginning of a new era in China's aviation development. Most importantly for China, the J-10 is a domestically produced fighter aircraft can reliably replace the roughly 20 percent of its fighter inventory that are less-capable 2nd Generation fighters.

Y-20 [运-20] Heavy Transport Aircraft

Y-20[281]

Strategic airlift is key to countries that need to rapidly move a large amount of materiel long distances.

Mission: Strategic transport aircraft. Variants developed for aerial refueling.

Background: China has entered the large strategic airlift market which has been dominated by the U.S., Russia, and U.K., with the Xi'an Aircraft Industrial Corporation (XAC) Y-20 [运-20] or "Kunpeng" [鲲鹏]. The Y-20 is one of China's three "big plane projects," the other two being the C-919 airliner and the AG600 amphibious aircraft.[281] The Y-20 is the product of decades of Chinese aircraft R&D that started in the 1970s. Prior to the Y-20, the PLAAF deployed Soviet designed Ilyushin II-76s to serve as its strategic airlift transport. The Y-20 also has several key advantages over similar aircraft such as the IL-76, which for example requires a crew of seven to operate, while the Y-20's design only needs a crew of three.[282]

In the 21st century, renewed efforts to domestically produce strategic airlift transports began in 2003, culminating in a 2007 report that states that large aircraft development is a shared interest between the CCP, State Council, and the Chinese people.[283] Xia Simin [夏思敏], Cheng Wenming [程文明], He Mengliang [何孟良], Tang Zhun [唐准], and a group of graduate students and professors at the Air Force Engineering Academy in Xi'an, writing in the Journal of Military Transportation University [军事交通学院学报], note that the Y-8, the PLA's mainstay transport aircraft, can only carry 20 tons and has a flight radius of only 2,000km.[284]

This matches up with comments by Cao Gangchuan [曹刚川], the retired former CMC Vice Chairman (2002–2007) and former Director of the GAD, in a recent CCTV documentary on the Y-20, in which he noted that China's reliance on short-medium range transport aircraft derived from Soviet-Ukrainian An-24 and An-12 transports (Y-7 and Y-8, respectively) had a major influence on China's equipment development.[285]

Tang Zhanghong [唐长红] of the China Aeronautical Establishment [中国航空研究院] headed the Y-20 project.[286] The Y-20 has received R&D support from various research institutes, such as CASC 703 Institute, which developed the Y-20's flame retardant interior and used composite materials for construction.[287] Tang has said that its speed of development beat all his expectations due in large part not only because of the hard work put in by the teams working on it but also by the heavy use of digital design and 3D printing.[288] According to an interview with former deputy director of CAE, Hu Xitao [胡溪涛], China's large plane program needs to:

- Help create a large publicly traded civilian plane company
- Pursue Boeing as their standard
- Build safe, reliable aircraft that conforms to standards throughout its lifetime.[289]

Y-20 Timeline[388]	
2007	Y-20 project established
2008	Digital prototype completed
2010	Physical prototype complete
Mid-2012	Three prototypes (#01 – #03) finished, #02 static test
Late-2012	Roll out & first low-speed taxiing
Early 2013	First flight
July 6, 2016	Y-20 Officially is inducted into the PLA
Nov 2016	Debuts at the Zhuhai Airshow
July 30, 2017	Participates in military parade at Zhurihe
Spring 2018	Participates in airborne airdrop for the first time

In the following months, XAC, a subsidiary of Xi'an Aircraft International Corp, raised 6.6 billion RMB (approximately $960 million USD) by selling new shares on the Shenzhen stock exchange.[291] While its parent company maintained the majority of shares, this provided an opportunity for the private sector or other state-owned companies to invest into XAC's projects.[292]

On June 3, 2016, the Director of Chinese Aviation Group Large Aircraft Development Office [大飞机办公室], Zhu Qian [朱谦] said that China needs 1,000 Y-20s.[w] The figure is based on the number of heavy aircraft that the U.S. and Russia field. Zhu also stated that the plane's engines will initially be imported but will be replaced with domestic ones in the future. This should allow the Y-20 to fly nonstop from Harbin to Tibet with a full payload. The Y-20 is powered by 4x D-30 turbofan engines, a Soviet-era engine which powers the Ilyushin II-76 but is aiming to equip the Y-20 with domestic-made WS-20 engines. However, an October 2016 article reported that Russian turbofan company, Saturn, signed a $657 million contract to sell 224 additional D-30KP2s to China by 2020, suggesting that the WS-20 has not reached operational status yet.[293] The WS-20 is also being tested on the C-919 airliner, with the first airliner (no. 101) undergoing trial flights on May 5, 2017.[294] The second one, (no. 102) flew from Shanghai Pudong airport on December 17, 2017.[295]

As a platform, the Y-20 and future variants will play an important role in boosting the PLAAF's strategic early warning, airborne operations, and strategic projection capabilities, three capabilities that China's 2015 Defense White Paper, "China's National Military Strategy" identified as key priorities for the PLAAF.[296]

w Despite this estimate, is unclear where in the Chinese Air Force or other services these aircraft would go, even if many were converted to other roles. China does not currently have sufficiently large units (of all types) to accommodate this number.

Z-20 [直-20] Medium Transport Helicopter

Z-20[298]

The Z-20 is typically described as filling an important gap in Chinese military equipment and capabilities. The most common transport helicopters in the PLA, Mil-8, Z-9, and Z-8 lack sufficient payload capacity, particularly in high altitude environments like those encountered on the Tibetan plateau. When adopted, the multi-use Z-20 can be expected to fill a large range of roles from special forces insertion to ship-borne ASW. The latter role in particular, which is currently conducted by Kamov KA-28 and Z-9 helicopters, neither of which have sufficient lift or range to be effective.

Mission: Medium transport/utility helicopter with potentially search and rescue, ASW and attack roles.

Background: Until the late 1970s, China was reliant on outdated Soviet helicopter designs it purchased in the 1950s and 1970s. During the 1980s China made a concerted effort to acquire new helicopter technology to replace its Z-5 helicopter, a variant of the Soviet-designed Mi-4 Hound. In July 1980, China signed a deal with France to license the Dauphin helicopter, now produced as the Z-9 and the mainstay of China's light helicopter force. This partnership allowed the introduction of greatly improved designs but China still lacked important capabilities in medium-lift helicopters.

In 1984, China purchased 24 Sikorsky S-70Cs, a civilian version of the Blackhawk helicopter, from the United States for $165 million.[298] Purchase of the S-70s represented a major breakthrough for the PLA, which previously did not have any high-altitude-capable helicopters, severely limiting the PLA's tactical maneuverability and resupply on the Tibetan-Qinghai Plateau. After the cessation of U.S. arms sales to China and restriction on transfer of sensitive dual-use technologies in the wake of the Tian'anmen massacre in 1989, China was forced to look elsewhere for medium helicopters.

Z-20 Timeline	
2010	Project Begun
December, 2013	First Flight[300]
August, 2014	Design finalized
2017	Begin Service
2018 (?)[301]	Low Rate Initial Production

In 2010, under the direction of chief designer Deng Jinghui [邓景辉], the program was officially approved.[301]

While aesthetically similar to the Blackhawk, Chinese engineers have adopted a five-bladed rotor design in contrast to the Blackhawk's four. Of note, the Z-20 will use the indigenously produced WZ-10 [涡轴-10] 1600KW turboshaft engine, which Chinese analysts say has more power than the T700 used by the Blackhawk.[302] The Z-20 uses an advanced fly-by-wire avionics control system.

Despite speculation in the PLA Daily the Z-20 would be publicly unveiled at the 2018 Zhuhai Air Show in November, the new helicopter has yet to be officially unveiled.[303]

Advanced Heavy Lift Helicopter [AHL/ 重型直升机]

Advanced Heavy Lift Helicopter[307]

A paper in the journal of the Academy of Military Transportation on Russia's investments in strategic power projection capability and the lessons for China noted that China's insufficient numbers of heavy lift transport helicopters severely restricted the military's response during the Wenchuan earthquake in 2008.[304] In the past few years, China has sought to produce indigenous heavy lift helicopters. Previously a market dominated by only the United States and Russia, China signed a framework agreement on 8 May 2015 with Russia to begin negotiations on the development of the Advanced Heavy Lift helicopter.[305]

AHL Specifications (anticipated)[308]	
Weight:	38.2 tons
Maximum Take-Off Weight:	3,000 kilograms
Internal Cargo Capacity:	10 tons
External Sling Capacity:	15 tons[309]
Range:	630 kilometers[310]
Flight Range:	1.5 hours[311]
Maximum Cruising Speed:	300 kilometers per hour
Maximum Altitude:	5,700 kilometers

Mission: Search and Rescue/Tactical Transport

Background: A co-production between AVIC's Avicopter and Rostec's Russian Helicopters, the AHL is expected to use Russian-built engines, most likely designed based on the PD-14 which will be used by Russia's new MC-21 twin-engine passenger jet. Use of the PD-14 underscores China's continued reliance on foreign-made turbofan engines.[311] International and Regional Policy Director Victor Kradov said that China's market would demand roughly 200 AHLs.[312] During a talk at the 2017 China Helicopter Exposition in September 2017, Dr. Huang Chuanyue [黄传跃], Avicopter's deputy chief designer, indicated that the AHL would be designed with the ability to operate over China's western plateaus, central mountainous regions, and along the eastern coast.[313] Based on the AHL's specifications and mission sets, it is likely that the AHL will be deployed on future amphibious assault ships for both military and civilian operations.

Timeline: CEO of Russian Helicopters, Andrey Boginsky, indicated at the 2017 China Helicopter Exposition that the Russian side was willing to sign a contract by the year's end. China has also signaled that a contract could be signed by the end of the year; Gui Congyou [桂从友], the former Director-General of the Department of European-Central Affairs of the PRC Ministry of Foreign Affairs [中国外交部欧亚司司长] stated in April 2017 that the agreement between China and Russia to develop the AHL was "99 percent ready."[314] In March of 2018, Wu Ximing noted Chinese helicopter designer, revealed that progress was proceeding smoothly, and that the two sides will cooperate at each stage of design and production."[315]

CHT-T1 [彩虹-T1] Sea-Skimming UAV

CHT-T1[318]

Mission: Anti-capital ship/ "aircraft carrier assassin" [航母杀手].

Timeline: In April 2018, the CH-T1 began field testing with the PLA Navy.[316] It is unclear when it is planned to be put into operation.

Background: The CH-T1, also called an "Unmanned Ground Effect Test Vehicle [无人地面效应飞行器验证机] utilizes ground effect techniques to carry out long-range reconnaissance and strike missions. The prototype was spotted in May 2017 on Chinese internet discussion forums. It was developed by CASC's 11th Academy, also known as China Academy of Aerospace Aerodynamics.

Li Feng [李锋], President of the 11th Academy, was identified as the UAV's lead designer.[318] The CH-T1 is China's first sea-skimming high-speed high-payload drone. It features SATCOM datalink systems and its size and low-altitude operation in seaborne environments make it more challenging to detect than traditional ballistic missiles.[319] The CH-TI specifications also suggest that for longer-range attacks two light torpedoes could be carried, or in the case of shorter ranges it could also be armed with depth charges or heavy torpedoes.[320]

CH-T1 Ground Effect UAV Known Specifications	
Length:	5.8 meters
Maximum Take-Off Weight:	3,000 kilograms
Maximum Speed:	802 kilometers per hour (Mach 0.65)
Altitude Range:	Between 1 – 6 meters
Flight Range:	1.5 hours[322]

Its association with CASC suggests that the CH-T1 may be armed with CASC's existing C-6/7/800 or YJ missile series. Based on its flight range limitations and China's strategic interests, the CH-T1 will most likely be deployed along China's coast and on the artificial islands in the South China Sea.

International Cooperation

China has extensive research partnerships and joint ventures with almost a dozen countries. For the purposes of this report we chose to include Russia, due to the Soviet Union's pivotal role in creating China's aviation industry and Russia's robust export relationship with China.

France is also representative of current international agreements as a western nation that has shown willingness to partner extensively with China on civilian and military projects. In regard to U.S. companies' partnerships with civilian, or ostensibly civilian, Chinese firms there is a massive amount of literature that deserves research beyond the scope of this report.

Russia

Background

Sino-Russian aerospace cooperation spans several decades. Since its inception, Sino-Russian relations has been one of practicality, undergoing alternating periods of friendship and cooperation, to mistrust and outright confrontation. Russian willingness to sell defense equipment to China is influenced by historic geopolitical tensions, distrust due to Chinese reverse engineering, and the status of the Russian economy.

Sino-Russian defense relations began in earnest in the 1950s, when Soviet Russia sent technicians and specialists to China to assist in developing China's industrial capacity. An agreement signed in 1953, for example, committed the Soviet Union to assist with 141 major industrial projects.[322] However, domestic politics and ideological differences drove the two nations apart until their rapprochement in the 1980s. Western arms embargoes on China after the 1989 Tiananmen Massacre and the collapse of the Soviet Union in 1991, resulted in a period of practical defense relations between China and Russia, as China was seeking to modernize its military and Russia was trying to raise revenue by selling arms.

By the 1990s, Russian scientists, designers, and researchers were employed by Chinese aviation companies, and the Chinese secured Su-27s from the Russian government. Procurement of the Su-27 also demonstrates shortcomings within China's domestic aviation industry, as domestic industries were unable to produce an engine at the time for the J-10 fighter.[323] Aerospace ties between the two countries were stable during the late 1990s through the mid-2000s until the J-11, a reverse-engineered Su-27, was showcased in China. Arm sales were suspended until Russian willingness to sell its advanced equipment to China changed in the 2010s.

By the 2010s, China's aviation industry had rapidly modernized and began to compete with American and Russian products. Due in part to Western sanctions on Russia, and the increased desire to build relations with China, Russia chose to sell its advanced arms—as evidenced by sales of the S-400 and Su-35 fighter.[x] Despite China's advancement in aerospace technology and R&D emphasis on engine designs, they are still inferior to Russian technology, resulting in one of the few sustained areas of military dependence/cooperation between the two countries. Nevertheless, unlike the 1990s, China's aviation industry is no longer as reliant on Russian military technology. Their development trajectory suggests that recent Chinese purchases of Russian jet engines may be seen as a stop-gap measure to meet their current needs as they develop domestic replacements in parallel.

x Please note that negotiations regarding the sales of both of these weapons systems began well before Western sanctions were levied against Russia.

Chinese-Russian Military Cooperation

Concurrent with Chinese participation in Russian Vostok exercises in Russia's Far East in 2018, senior Chinese and Russian military officials committed to "strengthening strategic coordination" between the two militaries.[324] During a meeting in Vladivostok between Xi Jinping and Russian President Vladimir Putin, Xi vowed to "boost joint research and development of cutting-edge science and technology" with Russia.[325]

Chinese aerospace cooperation with Russia is in areas where it is unable to develop or unwilling to invest domestically. It is interesting to note how this relationship has evolved since its inception, as it highlights Russian willingness (or desperation) to cooperate with China's technological advancement, including bottlenecks in Chinese R&D. Presently, these trends can be observed in: helicopters, engine technology, and drones.

Helicopters

On 6 September 2017, Russian aviation giant Russian Helicopter held a signing ceremony for its Asia Pacific Operations Maintenance and Assembly HQ in Shuangliu, Chengdu. The company will invest 2.4 billion RMB (approximately $350 million USD) and use about 400 square kilometers to establish a headquarters, repair facility, assembly center, and flight test base for the Ansat, Mi-171, and Ka-32 helicopter.[326]

On 17 July 2017 at the MAKS Airshow, AVIC VP Chen Yuanxian [陈元先] led an AVIC delegation to Rostvertol and expressed interest in cooperating with Russian Helicopters in multiple areas.[327]

Engines

On 18 January 2017, a delegation from China Aero Engine Research Institute visited Russia's Central Institute of Aviation Motors to sign a memorandum of cooperation. The two sides agreed to advance technical research and aviation engine R&D, specifically, engine health management, distributed control systems, and engine thermal management.[328]

On November 25, 2017, Russian scientists, astronauts, and academics attended the Fourth China-Russia Aerospace Engineering Technology Conference, held in Zhejiang Province. Chinese representatives from the China Association for Science and Technology, CASC, CASIC, and other academic institutions and agencies attended. They discussed aerospace technology issues, breakthroughs in technology, platforms for information exchange, promoting civil-military fusion, cooperation in deep space and moon exploration, and lunar science and data cooperation.[329]

Drones

On 18 July 2017, at the MAKS Airshow, AVIC Vice President Zhang Xingguo expressed that as the One Belt, One Road initiative continues, there are great prospects for China-Central Asian cooperation for feeder aircraft, helicopters, and UAVs.[330]

China-Russia Civilian Cooperation

Commercial Airliners

Chinese-Russian cooperation in civilian aviation is also increasing. In addition to the C929 wide-body jet being co-developed by COMAC and Russia's United Aircraft Corporation, additional agreements are being drafted. On August 2, 2016, CAAC Chief Engineer Yin Shijun [殷时军] met with Russian Deputy Ministry of Transport Valery Okulov for the 20th China-Russian Transportation Subcommittee Meeting and the Civil Aviation Working Group Meeting. They agreed to revise draft bilateral agreements related to civil aviation security and in civil aircraft search and rescue.[331]

On 23 April 2017, Northwestern Polytechnical University held an inauguration ceremony for the Belt and Road Aerospace Innovation Alliance. The organization will incorporate 48 domestic and international academic institutions, research institutes, and enterprises to develop international exchanges and cooperation in the aviation industry. Several notable officials attended, including SASTIND Chief Engineer and China National Space Administration Tian Yulong [田玉龙].[332]

On 19 July 2017, at the 12th China-Russia Civil Aviation Cooperation Working Group Meeting, AVIC VP Li Benzheng [李本正], Vice Minister of Industry and Information Technology Xin Guobin [辛国斌], and Russian Deputy Minister of Industry and Trade Oleg Bocharv discussed work on fixed-wing aircraft, helicopters, aero-engines, S&T, airworthiness, and airborne equipment.[333]

France

Background:

Beginning in the late 1960s France began selling light utility helicopters to China, helping set a pattern for future arms sales.[334] In 1973 France signed a deal to sell China the SA-321 Super Frelon heavy utility helicopter, transferring 12 units between 1975-1977. The Super Frelon eventually became the basis of the Z-8, which today is used throughout China. China was quick to adapt the Super Frelon for shipborne use.

Pilots were trained in shipborne operations in Qingdao and used to support wreckage recovery operations during China's DF-5 missile test in May 1980 and its first submarine-launched ballistic missile test in 1982.[335] Perhaps most importantly, 1980 saw the beginning of the Sino-French Partnership involving co-production and eventual licensing of the AS565S Panther, which is now produced as the ubiquitous Z-9 helicopter. The Z-9 has also been the foundation of several follow-on projects including the Z-19 and Z-10 attack helicopters.

China-France Civilian Cooperation

A review of news from the last three years suggests that French companies are expanding their cooperation with Chinese firms. Airbus Group is a strategic partner of AviChina and holds 5 percent equity interests in AviChina.[336] AviChina, in turn, is a major holding company for a wide portfolio of AVIC subsidiaries, including the entirety of AviCopter.[337]

French aviation giant Safran has set up partnerships with Aero Engine Corporation of China (AECC) in the areas of helicopter engines, key components, and production supply chains.[338]

During French President Emmanuel Macron's January 2018 visit, he and Xi Jinping presided over the signing of a framework agreement between China Aerospace Science and Technology Corporation (CASC) [航天科技集团] and Dassault Systems.

CASC is eager to use Dassault's 3DEXPERIENCE business collaboration software to help speed development.[339] Frances' Centre National d'Etudes Spatiales (CNES), also signed an MOU on climate change and space exploration with Wu Yanhua [吴艳华], the Acting Administrator of the China National Space Administration (CNSA) [国家航天局].[340] In addition to conventional aerospace technologies, French and Chinese companies are also cooperating on cutting-edge technologies such as self-healing nano-materials.[341]

Section 6: Comprehensive Assessment

Chinese Views of Future Aviation Competition

To assess the Chinese ability to challenge U.S. superiority in aerospace, we examined the current state of Chinese design programs, investment in innovation, China's potential to cooperate and absorb technology from foreign countries, and macroeconomic trends that could affect China's defense-industrial capacity over a series of time horizons. To begin, however, it is important to look at how the Chinese themselves assess the state of their industry.

Chinese Assessments:

Chinese engineers and scholars, while positive about recent developments, are realistic about the uphill climb still facing China's aviation industry. Yang Wei [杨伟], designer of the J-20 for example, believes that the Chinese defense industry has made major gains but is still in the second rank and that while civil aviation still needs development, research is making good progress and the industry has good momentum.[342] An article in China Aviation News identified trends in the technologies and capabilities driving "5th Generation" fighter development, the resurgence in the importance of bombers, rotary wing aviation, and drones.[343]

The authors note that U.S. plans for the B-21 are for it to reach initial operating capability around 2025. They also cite then-Commander of Russian Aerospace Forces Colonel General Viktor Bondarev as saying that Russia's PAK DA bomber would likely begin service in 2023, though it appears that Russia is reconsidering further development.[y] Future helicopters will have advanced aerodynamic capabilities, including improved maneuverability. Particularly in light of known prototypes by Bell and Sikorsky, speed is a major emphasis, with much simplified aerodynamic bodies, and use of tilt-rotor, pusher-rotors and dual-rotor systems to maximize speed.[344] Electronic warfare will play a rising role, with helicopters' ability to evade or defeat radar and other detection systems increasingly important to their survivability as more advanced sensors proliferate.

New concepts that will likely be present across all sixth-generation manned and unmanned aircraft designs include stealth, omnidirectional broadband radar, greater flight altitude, and tactical performance. Operating at high speeds, including "super-cruise." sustained supersonic flight, will require an entire new generation of engines systems and advanced materials.

Crossing both fixed-wing and rotary-wing disciplines, UAVs will see widespread application, improving China's number of sensors and connectors on the battlefield and operating in a wide range of ISR and strike roles.

Yang Yujie [杨宇杰], Zhang Huijun [张慧军] and Liu Dan [刘丹], researchers at the Air Force Research Academy [空军研究院], wrote an assessment of future aviation, noting that competition in this field does not appear to be slowing down. They note that while the key characteristics of U.S. sixth-generation fighters are focused on hypersonic and directed-energy capabilities, Russia's military focuses on super stealth, high maneuverability, and

y More recent Russian planning documents suggest that Russia will instead invest in modernization of its existing bomber fleet.

combined formations of manned and unmanned systems.[345] Meanwhile, France and Germany are also cooperating on a twin-engine stealth fighter. China, therefore, cannot stand still and must continue to develop its aviation industry.

In the early 1980s, China faced a similar moment, where the arms race between the Soviet Union and the United States was driving rapid innovations and the creation of an entirely new type of next-generation fighter jet exemplified by the Su-27 and the F-15. These aircraft were fast, maneuverable and could carry a wide range of advanced weapons. Similarly, in the mid-to-long term, Russia and the U.S. are investing in truly-next generation weapons after the refinement of advanced technologies such as stealth that began to be introduced at the end of the Cold War.

Quantitative Analyses of Current Chinese Capabilities

A review of available numbers of Chinese fixed wing and rotary-wing inventory reveals several important facts to use as a baseline. First, roughly 20 percent of its current fighter inventory are what China would classify as second-generation aircraft, including Q-5s, J-7s, and J-8s. While many of these have been modernized far beyond the capabilities of their original 1960s and '70s-era variants, as a group they lag significantly behind more modern aircraft in air-to-air capabilities and lethality. This is the first group that China must phase out and replace with more capable fighters. Some will likely be retained in a transitional-trainer capacity until more modern JL-9s and JL-10s are produced.

With over 800 3rd and 4th Generation fighters and a rapidly increasing number of capable cruise missile and anti-ship missile launch platforms, broader than just bombers, China does have an impressive force when viewed in comparison to its neighbors. However, examination of the broader economic picture and some key trends provide important context to understand the momentum and staying power of this growth.

China is just as subject to "Augustine's Laws"[z] as the U.S., and the push for "informatization," more stealthy radar cross sections, and advanced weaponry are rapidly increasing the cost-per-copy of its aircraft. Unlike previous eras, China cannot disperse aircraft factories across the country and reasonably expect that they can produce modern aircraft, the technology involved in modern aircraft is too complex and requires a much more substantial support system.[aa]

Regional Competitors

Chinese-Russian Cooperation and Competition

Relations between China and Russia have continued to deepen over Xi Jinping's tenure as general secretary, as both he and President Putin of Russia see important advantages to cooperating with each other in order to balance the United States and use their respective strengths to advance economically and strategically. The Chinese and Russian militaries have made large-scale army, air force, navy, and joint military exercises a regular occurrence, particularly since 2014. Sales of Su-35 advanced fighter jets and S-400 surface to air missiles, previously off the table due to fear of Chinese copying, have recently been completed. However, it is worth noting that despite deep cooperation, competition with Russia has been one of the shaping forces of China's aviation industry. Evidence from Russian sources suggests that Russia's defense industry is down-shifting or de-prioritizing investment in clean-sheet design of advanced fighters and bombers in favor of upgrades of existing platforms. Yury Borisov, Russian Deputy Prime Minister for the Defense and Space Industry, has said that Russia will continue to focus on production of the Su-35, rather than next-generation aircraft due to the Su-35's performance in Syria.[346]

Russia's recent defense expenditures have seen major reinvestment in production of existing platforms, such as the Su-35 fighter and Su-34 fighter-bomber, as well as new purchases of helicopters. Russia's State Armament

z Augustine's laws are semi-serious precepts written by Norman Augustine about the aerospace industry. Specifically, he wrote "In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day." https://en.wikipedia.org/wiki/Augustine%27s_laws

aa Previously, China had many redundant factories all over the country producing the same aircraft. Consolidation and the need to have access to certain tech and material pipelines mean that this sort of dispersal is no longer realistic

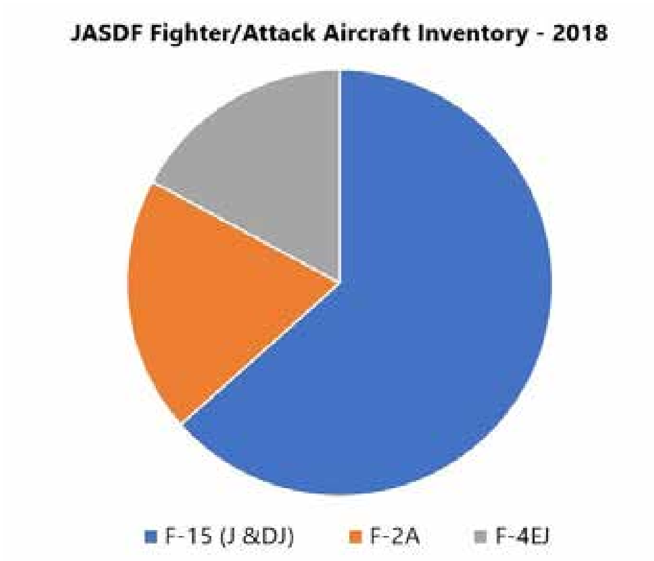
Program, its medium-term planning document that assesses priorities through 2027, apparently will include adoption of the Su-57 (T-50), MiG-35 (including a carrier-based variant) as well as upgrades to legacy bomber aircraft such as the Tu-22 and Tu-160. However, special emphasis will be placed on advanced SAMs and hypersonic missiles, suggesting that traditional fixed-wing and rotary aircraft development are not the highest priority for Russia.[347]

These priorities, along with general economic indicators for Russia likely mean that there is an opportunity for China to surpass its old partner and enemy, at least in production scale, and to take advantage of relative weakness to further gain from mutually beneficial programs such as the C929 wide-body passenger jet, which has significant potential utility as a military aircraft in ASW and refueling roles.

U.S. allies are also confronting aging inventories of aircraft.

Japan:

For the Japanese Air Self Defense Force (JASDF), out of its total of 298 combat aircraft, 17 percent are F-4Ejs, which are nearing obsolescence.[348] While these aircraft may benefit from a narrower mission set, e.g. territorial air defense, superior weaponry, pilot training, and more sophisticated Early Warning (EW), these numbers are concerning. Japan's latest defense white paper, The Defense of Japan-2018, highlights Chinese military aircraft transiting the Sea of Japan and through the Miyako Strait [宫古海峡].[349]



Enhanced Chinese strike capabilities in the form of stand-off land attack and anti-ship cruise missiles pose a significant threat both to Japanese and U.S. facilities on Okinawa and the main Japanese islands.[350] Emerging Chinese fixed-wing and vertical-lift ASW could undermine the deterrent effect of Japan's undersea deterrent: its potent complement of modern diesel submarines.

In response, Japan has begun acquiring advanced F-35 jets from the United States. An initial order of 42 aircraft has now been expanded by an additional 100 aircraft, including an unspecified number of the F-35B variant that is capable of short takeoff and vertical landing.[351]

In 2016, Japan showed off a demonstrator aircraft for its X-2 Shinshin indigenous stealth fighter program. However, rumors have swirled that the program was scrapped, and Japan may be looking elsewhere.[352]

The Japanese defense industry is well-placed to ramp up its production. Compared with China, Japan makes much greater use of CNC machines and other advanced manufacturing techniques, giving it an important advantage in terms of cost, manpower, and efficiency.[353]

MQ-25 Carrier-Based Tanker Drone[464]

Challenges to U.S. Superiority

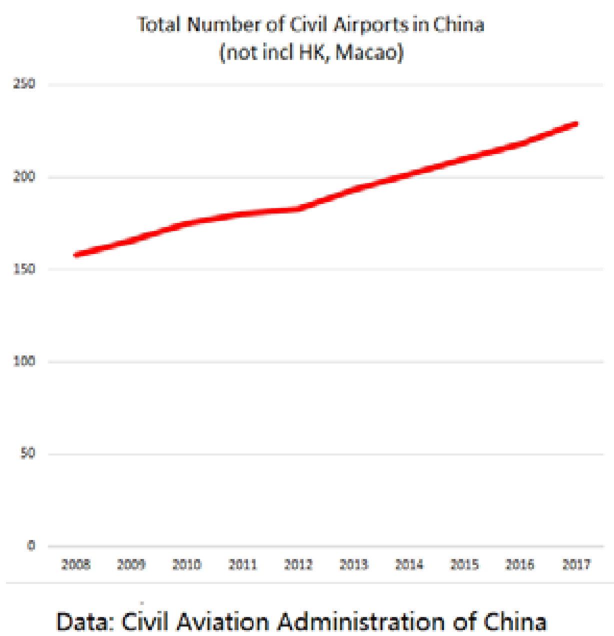
The U.S. is currently engaged in research for a new generation fighter. Medium-long term plans such as the Pentagon's "Air Superiority 2030" argue that the U.S. will need a "Penetrating Counter Air" superiority fighter.[354]

The U.S. navy is already working to mitigate vulnerabilities, such as aerial refueling aircraft, which China has specifically developed platforms to target. For example, Boeing's MQ-25 recently won a contract for a shipborne unmanned, stealthy refueling platform.[356]

The U.S. is investing in small helicopters with more potent electronic attack capabilities, as well as smaller physical profiles to hide in radar clutter.[357] Five other modernization priorities include long-range precision fires; a next-generation combat vehicle; a mobile and expeditionary network; air and missile defense capabilities; and soldier lethality.

Near-Term (Through 2023)

China can be expected to deploy a number of entirely new aircraft in the near term that fill important holes in its existing capabilities. These include the ASW aircraft detailed above, as well as some form of carrier-borne early warning aircraft [舰载预警机], an important part of the carrier's ability to detect and respond to threats.[358]



Total Number of Civil Airports in China (not incl. Hong Kong, Macao)

The growth of the civilian aviation industry to supplement and support military projects is an important trend here. Despite some recent decreases in private purchases of helicopters and jets, likely in response to the anti-corruption campaign, registrations of these aircraft are beginning to climb again. Deloitte, a consulting firm, estimated that deliveries of commercial aircraft are expected to rise to 7,210 by 2034, from 2,570 in 2014.[359] The Chinese government has made major investments in infrastructure to meet predicted demand, building 71 airports between 2008 and 2017 [see inset graphic].

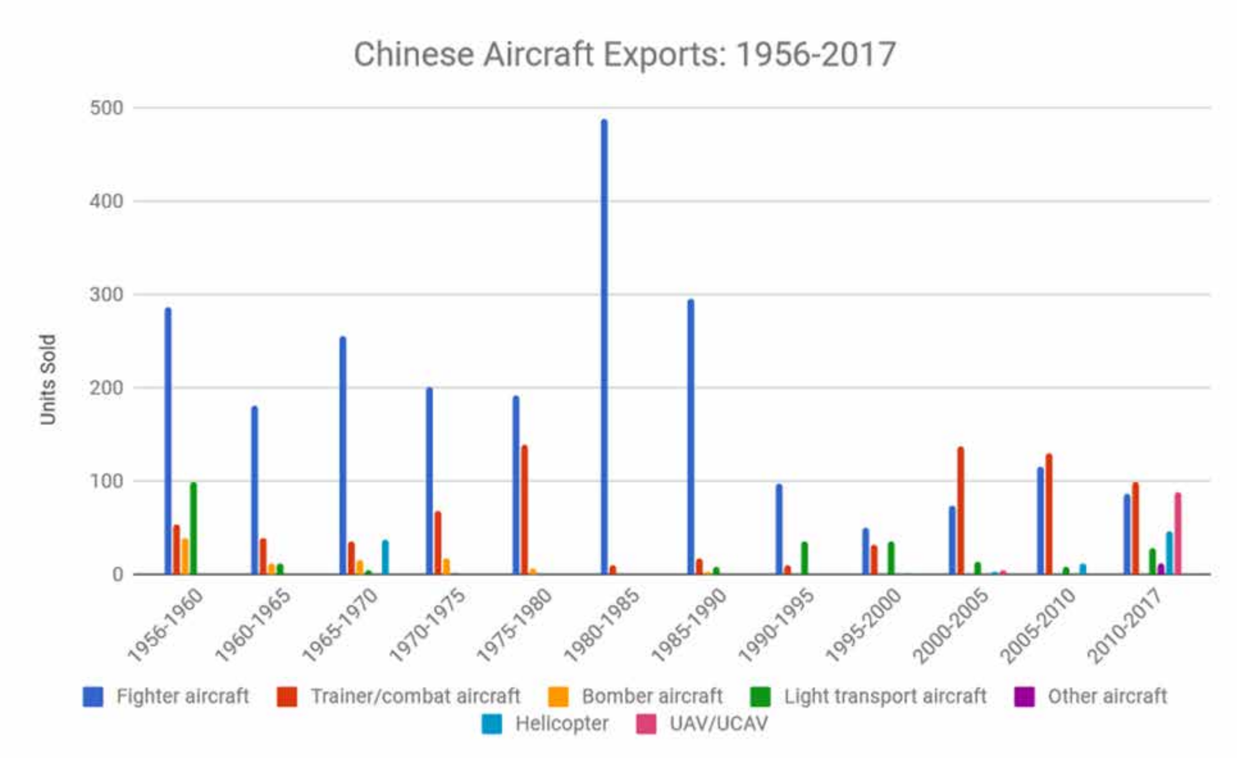
For China, its ability to successfully break its reliance on imported foreign passenger jets, particularly narrow-body jets that are estimated to account for 70+ percent of its market over the next decade, could make or break the civilian aviation industry.[ab] If the C919 is successful, the effect of this import-substitution could give Chinese firms the funds to expand R&D and become truly globally competitive.

Less lucrative, but still important, are Chinese military aviation exports. In 1996, China held its first aviation industry exhibition at Zhuhai in Guangdong Province. Since then, China has used the arms show to sign deals, highlight recent breakthroughs, and provide the first official showings of several types of aircraft. China has established itself as a major player in light transport, and cheap fighter jets. Particularly in Africa, countries are buying legacy Chinese jets to bolster their armed forces for regional and terrorist threats.[360]

UAVs have seen the largest growth in the last decade. China's UAVs are particularly attractive in the Gulf states. They see the low-flight hour costs of UAVs as desirable for long-running counter-terror campaigns that have taxed their traditional air power, and China's airframes are cheaper when compared to Western models.[361]

In contrast to the positive developments mentioned above, it is worth highlighting that China is lacking in some very basic technologies, such as high-quality steel.[ac] Chinese analysts have noted that for the "indigenously produced" C919 airliner, COMAC is reliant on imported aviation steel [航空钢材] due to imperfections in domestically produced materials.[362] According to Du Wansheng [杜挽生], Deputy Dean of the Chinese Iron and Steel Research Institute [中国钢铁研究总院], Chinese industry's ability to make high-pressure resistant monocrystalline, high-temperature alloys significantly lags behind developed countries. At least in the short-term, China's continuing inability to master the core technologies [关键技术] will remain meaningful barriers to achieving true independence in manufacturing, or more importantly, competitiveness for high value-added aviation products.

ab A forthcoming CASI study of Chinese Aero engines will address this question in greater depth.
ac Machining or sintering material does not necessarily impart characteristics like tensile strength, something that needs complicated forging processes.



Data via Stockholm International Peace Research Institute (SIPRI)

Medium-Term (Through 2028)

China's priorities for Air Power over the medium-term can be understood from three major trends.

First, comprehensive upgrading of the existing force to third-generation platforms and beyond. Over the next five to 10 years, China can be expected to replace its remaining first and second-generation aircraft, except in some sort of training roles, with third-generation aircraft, particularly advanced models of the J-10. Fourth generation jets, such as the Su-35, J-16, and J-20, are conducting cooperative training to test tactics and lay the foundations for the PLA's future force, which likely includes a mix of advanced interceptors, long-range fighters, strategic bombers, and increasingly, UAVs in various supporting roles.

Second, expansion of the "Integrated Air and Space Operations" strategy to place greater emphasis on space and the area between the two domains. Analysts affiliated with the Air Defense and Anti-missile College [空军工程大学防空反导学院] and the Equipment Academy [装备学院研究生院], for example, argue that near-space [临近空间] is an emerging area that will be foundational to the PLAAF's strategy of "Integrated Air and Space Operations."[363] Continuing investments in High-Altitude Long-Endurance (HALE) drones capable of operating at 60,000 feet or more and remaining on station for more than 10 hours is a good indication that this will be a major focus for ISR platforms for the PLA.

Third, China will continue building a "strategic air force" that can meet the requirements of informationized operations and effectively carry out strategic defense, attack, and power projection.

Innovation Capacity

As discussed earlier, despite 67 years of concerted effort, China remains significantly reliant on imports of foreign technologies. Andrea Gilli and Mauro Gilli have argued that modern technologies are difficult to replicate, and a technology typically fails because the techniques and even supply chains needed to build a finished aircraft or system are so complex.[364] An area that deserves greater attention is whether the large number of companies, research and design institutes, and test facilities are on track to give China the sufficient "Absorptive Capacity" to effectively imitate and innovate its way to a leading position in global aviation R&D. Many of the improvements that have been incorporated into its platforms have foreign origins. China is consolidating and streamlining its R&D institutes, as it recognizes that the current dispersed system of R&D institutes and funds is harming China's long-term competitiveness.

Long-Term (Through 2038)

China's primary strategic advantage in the aerospace industry is its industrial capacity. Over the long term, however, there are several economic and demographic trends that may threaten this and the development of China's aviation industry as a whole.

China's economy will almost certainly face significant long-term challenges. Despite the recent change to the One Child policy and new government plans encouraging couples to have more babies, China will likely experience a serious population decline in the 2020s-2030s. This will mean a decline in the labor market. Without significant progress in shifting manufacturing to higher-end automated systems, China's economy as a whole will suffer and the defense industry will be particularly hard hit. Other macroeconomic trends, such as the effects of insufficient investment in rural education and health care could also come into play, sapping industrial capacity by leaving rural populations, China's traditional source for factory workers, without the skills necessary to compete in a modern economy. The greying of this population, which pays little taxes, will further diminish government coffers.

The aviation industry, especially the military aspects of the industry, can be an enormous drain on state finances. It does appear that China has reached the point where private demand for aircraft can help supplement government orders in keeping its vast network of factories and laboratories afloat on their own. However, as many within the aviation industry have noted, the Chinese government still needs to make significant investments in supporting basic research, much less the broader network of companies and institutes involved in aviation R&D. If those investments fail to materialize, or if the aviation industry does not successfully transform to being more reliant on the civilian sector, it could face a major crisis if government funds falter. This risk is important to note as the Chinese government is facing a myriad of economic issues, including declining state revenues and increasing government costs.

Thus far, the Chinese government has prioritized investments in quick turn-around and immediate policy research for political purposes over areas with long-term importance. This harms China's long-term strength in R&D by diverting funds away from the basic research [基础研究] widely acknowledged as fundamental to it becoming a truly independent power in aviation.

Appendix A: Major Companies and Research Institutes

Fixed Wing

AVIC Aviation Industry Corporation of China (AVIC)
[中国航空工业集团有限公司]
Website: http://www.avic.com
Location: Chaoyang District, Beijing
[朝阳区, 北京市]

Aviation Industry Corporation of China (AVIC) is China's premier state-owned aerospace and defense enterprise. It is presently headed by Tan Ruisong [谭瑞松], who has a background in engine design and served in a variety of management roles in Harbin and within AVIC prior to his May 2018 appointment.[365] As of 2017, AVIC has 457,097 employees.[366] AVIC has undergone several organizational reforms. Notably, the company was split in 1999 into AVIC I and AVIC II to make it more competitive, however these organizations merged in 2008 as the separation yielded redundant projects and wasted resources. AVIC produces a variety of fighters, bombers, fighter-bombers, transports, helicopters, trainers, AEW&C, and UAV aircraft for both civilian and military roles. AVIC has several divisions, subsidiaries, and research institutes dedicated for specific R&D roles in its bureaucracy. Other subsidiaries are involved in non-aviation industries, and produce motorcycles, cars, trucks, and trailers.[367]

In late July 2017, the State Council announced a plan to implement structural changes to several important state-owned enterprises [国有企业], including AVIC. On January 3, 2018, this came into effect, changing AVIC into a State Solely-owned Enterprise [国有独资企业].[368] This has the effect of centralizing the state council's power in terms of funding and personnel decisions.[ad] Tan Ruisong's appointment can be understood as replacement of a voice that stood against centralization, as Lin Zuoming [林左鸣] was well-known for his opposition to excessive government interference, even describing government intervention that stifled the market and reduced competition as "giving up a major advantage" [自废武功].[369]

In 2015 the Central Commission for Discipline Inspection (CCDI) began an inspection [巡视] of AVIC as part of China's anti-corruption campaign.[370] While no senior leaders were punished, Lin Zuoming, then CEO, took leave of absence and was then replaced by Tan Ruisong, likely as a result of the investigation.

ad For example, the State Council may now name and remove key leadership, including Chairman of the Board and CEO.

AVIC Executive Vice President Chen Yuanxian [陈元先] has said that the aviation industry was the "main force" [主力军] of military-civilian fusion development in the defense industry.[371] AVIC holds annual meetings with members SASTIND, the EDD, the CMC Science and Technology Commission [军委科技委], relevant government leading small groups [领导小组], and the Air Force to plan military R&D priorities for the year.[372]

Y-8J[149]

Shaanxi Aircraft Corporation
[中航工业陕西飞机工业]
Website: http://www.saic.avic.com/
Location: Hanzhong, Shaanxi
[汉中市, 陕西省]

Shaanxi Aircraft (Shanfei; 陕飞), now incorporated into AVIC, is the primary producer of China's medium-size military cargo, Airborne Early Warning (AEW), and other types of special mission aircraft mostly derived from the Soviet/Ukrainian An-12, the Y-8 and Y-9, as well as derivative from the KJ-200 and KJ-500. The Y-9JB, China's primary electronic warfare/collection aircraft, gained prominence through their frequent transit of the airspace over the Miyako Strait, an action closely monitored by Japan.[374]

Shanfei 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 Institute [西安飞机设计所]. Test flights of the first airframe began in December 1974. It has been in continuous production since then.[375] Through 2006, Shanfei has produced nearly 30 variants of the multi-role Y-8, which is employed by the Army, Navy, and Air Force. The current form of the company was established in 1999.[376] Shanfei is led by Party Secretary and Chairman of the Board Han Yichu [韩一楚]. Han is an experienced engineer with degrees in aircraft manufacturing and management from Northwestern Poly University.[377]

Aero Engine Corporation of China (AECC)
[中国航空发动机集团]
Website: http://www.aecc.cn
Location: Haidian District, Beijing
[海淀区, 北京市]

AECC is China's primary producer of aircraft engines. Composed of more than twenty subsidiaries and employing more than 10,000 people, the company is based in Beijing but has research laboratories and test facilities all over the country. Originally Xi'an Aero Engine Corporation, its current form was created in 2016 as part of a consolidation meant to help China overcome issues with domestic engine production.

The Party Secretary and Chairman of the board of AECC is Cao Jianguo [曹建国]. While the company produces engines for both civil and military aviation, its slogan, "Power to Strengthen the Military, Science and Technology to Protect the Country" [动力强军, 科技报国] is explicitly military-focused. A key goal for the company is to harness the combined efforts of civilian and military sectors to rapidly help China overcome the technological bottlenecks it encountered in engine production. AECC has recently made advancements in electroplating graphene alloys, an important technique for the field.[378] AECC regularly coordinate with SASTIND, the Air Force Equipment Department and other elements of the Civilian and Military defense complex.[379]

JL-10[381]

Hongdu Aviation Industry Group (HAIG)
[中航工业洪都]

Website: http://www.hongdu.com.cn/
Location: Nanchang, Jiangxi Province
[南昌, 江西省]

Hongdu Aviation Industry Group is a subsidiary of AVIC and one of the PLA's aircraft manufacturers. Previously known as Nanchang Aircraft Manufacturing, HAIG produces China's trainer aircraft. Several projects, such as the joint-Chinese-Pakistani developed JL-8/K8 trainer have found markets abroad. The export variant K-8 has since been exported to many countries including Egypt, Myanmar, Bangladesh, and Bolivia.[381] AVIC Industrial Flight Test Center [航工业试飞中心] uses a modified variant of the K-8 to test new technologies.[382] HAIG is led by Song Chengzhi [宋承志].[383] HAIG has partnered with international companies such as Boeing, Airbus, Goodrich, and Eclipse.[384] In 1998, HAIG reorganized to conform with the 1998 "Four Mechanisms" [四个机制] policy by becoming the center of a larger enterprise with 24 member companies.[385] Notably, HAIG manufactures the L-15, JL-10 when it enters service, China's next-generation fighter trainer, which is used by the PLAAF, PLAN, and Pakistani Air Force, to prepare cadets for flying Su-27, Su-30, J-10, or J-11s. [386]HAIG is also working with Shenyang Aircraft Design Institute to manufacture the "Sharp Sword" (Lijian) [利剑] UCAV.[387] Over the past few years, HAIG has made significant investments to modernize its manufacturing and make improvements to its quality control systems, with the goal of transforming the company from one focused on production of 2nd Generation aircraft to 3rd Generation.[388]

JF-17[390]

Chengdu Aircraft Industry Group (CAC)
[成都飞机工业(集团)]

Website: http://cac.avic.com
Location: Qingyang District, Chengdu, Sichuan Province
[青羊区, 成都市, 四川省]

Founded in 1958, the Chengdu Aircraft Industry Group has been a major manufacturer of Chinese military aircraft, particularly fighter jets. It was involved in the production of the J-5, J-7, J-10, and J-20 stealth fighter. CAC also notably jointly produced the CAC FC-1 [枭龙] / PAK JF-17, a single-seat fighter with Pakistan.

In conjunction with its civil-aviation affiliate Chengdu Civil Aviation Company [成飞民机公司], Chengdu has participated in the design and production of the C919, ARJ21 airliners and AG600 amphibious aircraft.[390] One of the leaders of aviation technology, design, and manufacturing, CAC has won a national award for its use of Computer Integrated Manufacturing Systems (CIMS).[391]

Soar Dragon UAV[393]

Chengdu Aircraft Design and Research Institute (CADI)
[成都飞机设计研究所]

Website: N/A
Location: Wuhou District, Chengdu, Sichuan Province
[武侯区, 成都市, 四川省]

Chengdu Aircraft Design and Research Institute [成都飞机设计研究所] / No. 611 Design Institute began as a branch of the Shenyang 601 institute, sent to Chengdu, Sichuan province in

China's southwest to make Chinese aviation less vulnerable to Soviet or U.S. attack. This brought SAC's expertise in fighter aircraft to Chengdu, a legacy it has continued in its development of the J-7, J-10, and now J-20 series aircraft.[393] A key characteristic of CADI-designed aircraft is the use of canards [前翼/鸭翼], wing-like surfaces toward the front of an aircraft's fuselage, that can help provide additional maneuverability; it is a distinguishing aspect of the J-10 and J-20, and was a part of the J-9 fighter design, which was ultimately canceled in the late 1970s.

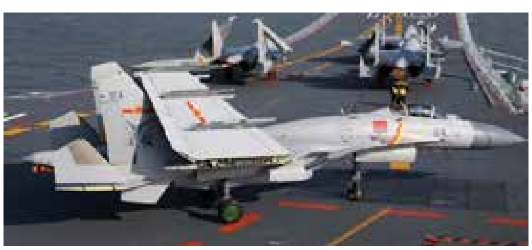
Chengdu Aircraft's design department is also involved in several of China's UAV programs, including the Soar Dragon (Xianglong; 翔龙) and Sky Wing (Tianyi; 天翼) High-Altitude Long Endurance (HALE) drones, Pterodactyl I (Yilong; 翼龙)[394] Medium-Altitude Long Endurance (MALE) and the stealth Dark Sword (Anjian; 暗剑) unmanned combat aerial vehicle (UCAV). Li Yidong [李屹东], Deputy Chief Designer CADI Chief Designer of the Yilong UAV series, has said Yilong-2's successful test flight showed that China had the ability to deliver a next-generation reconnaissance-combat UAV to overseas markets; he added that this was China's first domestically produced UAV with a turboprop engine.[395]

FTC-2000[397]

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 Aviation Corporation, also called the 011 Base, was founded in 1964.[397] The company has built parts for the J-6 and J-7 series aircraft, but most notably has produced the JL-9 jet trainer. An export version, the FTC-2000, is being offered for international markets.[398]

A subsidy of AVIC, AVIC Guizhou LLC [中航贵州飞机有限责任公司], appears to be in charge of GAC's Drone development arm. Based in Anshun, Guizhou, its Party Secretary Wang Wenfei [王文飞] has pointed out that while GAC's work on the JL-9 shows their strength in traditional aerospace, they are making important investments in unmanned systems.[399] GAIC has focused on long-endurance surveillance drones. In 2002, a model of the WZ-2000, a HALE drone produced by GAIC first appeared at the Zhuhai Airshow in 2002.[400] GAIC produces the "Harrier Hawk" Yaoying [鹞鹰] series of medium-high altitude surveillance drones.[401] The presence of High-Altitude Long-Endurance UAV/UCAVs at Anshun Huangguoshu airport from a number of developers is further confirmation of their new focus on becoming a major producer and tester of UAVs.[402]



J-15[404]

Shenyang Aircraft Corporation (SAC)
[沈阳飞机公司]
Website: N/A
Location: Shenyang, Liaoning Province
[沈阳, 辽宁省]

Founded in 1951, SAC is the oldest Chinese aircraft producer. Since its founding, SAC has primarily focused on producing advanced fighter jets, and it is frequently called the "cradle of Chinese fighters."[404] Building on that legacy, since the 1990s SAC has led the way for China's latest generations of advanced fighters including, the J-11, J-15 and J-16.

The Chairman of the Board and Party Secretary is Guo Dianman [郭殿满], an engineer who previously served as Party Secretary of Harbin Aircraft Industry Group (HAIG) and other roles at Avicopter. [405]According to their end-of-year report for 2017, SAC had revenues of over 19 billion RMB ($2.8 billion USD).[406] SAC's core business is defense-related aviation, although it manufactures spare parts for civilian aircraft. SAC was the first aviation company to apply additive manufacturing techniques to aircraft production and set up a dedicated research team studying the technology in 2014.[407] According to Aviation News, in 2017 SAC made important breakthroughs in advanced composite manufacturing that will allow it to make more use of the lighter and stronger materials in the C919 passenger jet.[408]

Shenyang Aircraft Design Institute (SADI)
[沈阳飞机设计研究所]

Website: N/A

Location: Huanggu District, Shenyang, Liaoning Province

[皇姑区, 沈阳市, 辽宁省]

Established in August 1961, The Shenyang Aircraft Design Institute [沈阳飞机设计研究所], (601 Institute), was China's earliest aircraft design academy. SADI has been a major driver of Chinese innovations in fighter aircraft, such as the J-11 and its derivatives, including the J-15 carrier fighter. In recent years, the institute has pioneered advances in UAVs, avionics, composites, stealth, thrust vectoring and other technologies. It also serves as an academic institution, training master's and Ph.D. students in advanced fields.

In 1991, China signed an agreement with Russian company Sukhoi to purchase Su-27 fighter jets. A subsequent agreement allowed SAC to build a licensed version of the jets.[409]

Li Tian [李天], an academician of the Chinese Academy of Engineering, long served as the design institute's chief expert, and made significant contributions to key technologies underpinning Chinese 4th generation fighters.[410] Li was also a key advocate for China's stealth program, serving as group leader of the Ministry of Aviation Industry's Stealth Technology research group [航空工业部隐身技术研究课题组] in the 1980s.

Xi'an Aircraft Industry Corporation (XAC)
[西安飞机工业(集团)有限责任公司]

Website: http://www.xac.com.cn

Location: Xi'an, Shaanxi Province

[西安市, 陕西省]

Xi'an Aircraft Industrial Corporation (XAC) is one of China's key aerospace R&D facilities and manufacturers. It was founded in 1958 and produces a variety of large and medium-sized military and civilian aircraft. XAC is headed by Liu Xuanmin [刘选民], who previously was AVIC's Chinese Flight Test Establishment's department chief. XAC was the first Chinese company to establish international cooperation.[411] XAC has partnered and built parts for Boeing and Airbus since 1980 and 1997, respectively.[412] XAC produces the MA-series turboprop airliners, JH-7 fighter-bomber, H-6 bomber, Y-series transports, and aircraft parts for both domestic and international airliners.

AVIC Xi'an Aircraft Design and Research Institute
[航空工业西安飞机设计研究所]
Website: N/A
Location: Xi'an, Yanliang District, Shaanxi Province
[阎良区, 西安市, 陕西省]

Also called AVIC No. 1 Aircraft Design and Research Institute, Xi'an Aircraft Design is currently the only institute capable of designing fighter-bomber, bomber, civilian, transport and special-use aircraft under one roof. As of 2018, it employs 2,600 people, including over 210 researchers.[413]

C919[415]

Commercial Aircraft Corporation of China (COMAC)
[中国商用飞机]
Website: http://www.comac.cc/
Location: Pudong, Shanghai
[浦东区, 上海市]

Commercial Aircraft Corporation of China (COMAC) is China's key civilian aircraft industry. It is headed by He Dongfeng [贺东风], who has been chairman since 2017. Founded in 2008, it has the support of China's State Council and has investments from the State-Owned Assets Supervision and Administration Commission (SASAC), Shanghai Guo Sheng Corporation, AVIC, Aluminum Corporation of China Limited, China Baowu Steel Group, and Sinochem Corporation.[415]

COMAC coordinates China's large civilian aircraft programs, and is engaged in civilian aircraft R&D, manufacturing and flight-testing, and marketing, servicing, and leasing of its aircraft. COMAC produces the ARJ21 and the C919. The C919 is one of three of China's "big plane projects," and took its maiden flight on 5 May 2017.[416] COMAC does not plan to mass produce the aircraft until they have been certified by the SASAC. According to reports, over 800 orders for the C919 have been placed by 28 countries.[417]

In 2008, COMAC acquired Shanghai Aviation Industries Group (SAIG) [上海航空工业公司], which had been responsible for the Y-10 passenger airliner and WS-8 series engines. In addition to work on the C919 and final assembly of the ARJ21 passenger jet, SAIG now assists COMAC with administration, management, logistics, auditing, incident investigation, and other related functions.[418] In 2011, SAIG signed a joint venture with Canadian manufacturer Eaton Corporation.[419] The joint venture, of which SAIG owns 51 percent, was formed to support the C919 program's development, design, manufacturing, and utilize Eaton's expertise in hydraulic and fuel conveyance systems.

COMAC and Russia's United Aircraft Corporation are partnering to build a wide-body aircraft, the C929.[ae] The joint design and production deal, announced in May 2014, is intended to be completed around 2022-2023.[420] The aircraft is envisioned as competing with Boeing's 787 and the Airbus 350.[421]

ae A model of which was on display at the 2018 Zhuhai airshow.

Rotary Wing

China Aviation Industrial Helicopter (Avicopter)
[中航工业直升机公司]

Website: http://avicopter.avic.com/index.shtml
Location: Airport Economic Zone, Tianjin
[空港经济区, 天津市]

Established in 2009, China Aviation Industrial Helicopter (Avicopter) is a joint venture between AVIC and the Tianjin municipal government. Avicopter, produces China's medium- and heavy-helicopters for both civilian and military purposes. It is headed by Yu Feng [余枫], who has been CEO since May 2017.[422] Yu has a graduate degree from the Central Party School in Beijing. He has received special awards from the State Council, SASTIND, and AVIC, and in 2010 was selected as a National "Model Worker."

The company coordinates, oversees, and manages AVIC's helicopter branches, including: Hafei, Changfei, Huiyang, China Helicopter Research and Development Institute (CHRDI), and Tianjin's helicopter branches.

In comparing Avicopter's 12th and 13th Five Year Plan objectives, the company has shifted from internal management reforms, R&D innovation, and breaking through technological bottlenecks to promoting civilian helicopter development, expanding service industries, improving operation quality, and becoming one of the world's top four helicopter manufacturers[af] by 2020.[423]

In 2016, Avicopter signed a joint-agreement with Rostec's Russian Helicopters to develop the Advanced Heavy Lift (AHL) helicopter. According to Russian Helicopters' website, the two entities will focus on the following:

- Russian Helicopters will contribute its technologies to the project, provide technical parameters, and develop individual AHL systems on a contractual base.
- Avicopter will manage the program's organization, implementation and engineering design, and design prototypes, conduct tests, certifications, serial production, and market promotion.[424]

In 2014, Avicopter and Airbus Helicopters signed an agreement to produce 1,000 new generation EC175/AC352 rotorcraft. The agreement stems from a 2005 contract between the two firms to jointly develop the helicopter. The two helicopters come from the same platform, with the AC352 being assembled by Avicopter for the Chinese market, and the EC175 assembled by Airbus for global markets.[425]

Changhe Aircraft Industries Corporation
[昌河飞机工业 (集团)有限责任公司]

Website: http://www.changhe.com/
Location: Jingdezhen, Jiangxi Province
[景德镇市, 江西省]

Established in 1969, Changhe is a helicopter-focused subsidiary of AVIC. It is one of China's premier helicopter R&D and production companies. Changhe is headed by Xu Depeng [徐德朋]. Changhe produces both military and civilian helicopters, including the Z-8, Z-10, Z-11, AC310, AC311, and AC313. Changhe also coordinated with several domestic and foreign companies, such as Sikorsky, Boeing, Leonardo, and COMAC to manufacture components and share technology.[426]

af Current top four: Airbus, Bell, AgustaWestland, and Sikorsky

AV500[428]

China Helicopter Research and Design Institute
[中国 直升机设计研究所]
Website: http://chrdi.avic.com/
Location: Jingdezhen, Jiangxi Province
[景德镇, 江西省]

The Chinese Helicopter Research and Development Institute (CHRDI), sometimes labeled the "cradle of Chinese helicopters," was founded in December 1969. Now a part of AVIC, it has participated in the design and production of more than 12 helicopter and UAV designs and over 50 variants since 2004.[428]

Over the course of 2017, CHRDI performed flight tests of the AV500, AV500W, and XM20 drones in Gansu and Qinghai provinces. The AV500W "War Wolf" ["战狼"] is an armed variant that can be equipped with small laser-guided missiles or machine guns and has a maximum speed of 170 kilometers per hour and an endurance of four hours.[429] This trial flight also helped to advance the AV500W's capabilities for future wars, execute counterterrorism tasks, and counter drug trafficking. The XM20 is a lighter quad-copter configuration meant to provide tactical ISR.[430]

A major priority for the research institute is developing substitutes for foreign technologies. In 2018, *S&T Daily* reported that CHRDI had developed a conformal aerial antenna that could be used on multiple military and civilian types, replacing a key technology that China had hitherto relied on foreign imports for.[431] Chinese reporting on the antenna regard the development as a major breakthrough, highlighting the degree to which China relies on foreign technology in this field.

Harbin Aircraft Industry Group (HAIG)
[哈尔滨飞机工业(集团)有限责任公司]
Website: http://www.hafei.com/
Location: Harbin, Heilongjiang Province
[哈尔滨市, 黑龙江省]

One of the earliest parts of China's aviation industry, HAIG was founded in 1952 as the No. 6 Main Aircraft Factory, Factory 122 [122厂]. In the first 5-year plan, it was tasked with producing heavy bombers. The first Chinese H-6 entered service in 1959. Helicopters produced from Soviet-made kits followed, and in 1958 it conducted the first flight of a Chinese helicopter, the Z-5. This was followed by the Z-6 in 1969. Throughout the 1970s, Harbin continued to build medium and large fixed-wing aircraft based on Soviet designs including the H-5 bomber and SH-5 maritime patrol aircraft.

With the acquisition of licensing rights to the French Dauphin helicopter in October 1980, China began building what was later designated as the Z-9 series helicopters, the current mainstay of its light helicopter force across the PLA, PAP, and civilian agencies. The Z-9 entered service in 1983. In 1992, Harbin again partnered with the French company Eurocopter to produce the EC120.[432] China has exported variants of the Z-9 to Bolivia, Cameroon, Ghana, Kenya, Laos, Mauritania, Namibia and Pakistan.[433]

In addition to helicopters, Harbin also produces the Y-12 turboprop aircraft currently used by the Chinese Coast Guard and Chinese Air Force Airborne Corps.[434] The light passenger aircraft is also being adopted by Chinese firms for domestic cargo and transport.[435] The Y-12 is also a popular export and was recently purchased by Nepal.[436]

Harbin Aviation Industrial Group and Beihang University (BUAA) have co-developed the BZK-005 "Giant Eagle" UAV. HAIG has also won awards for its "Wild Wolf" drones.[437]

UAVs

China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团有限公司]
Website: http://www.casic.cn/
Location: Haidian District, Beijing
[海淀区, 北京市]

China Aerospace Science and Industry Corporation (CASIC) is China's missile, aerospace electronics and equipment developer. It is headed by Gao Hongwei [高红卫], who became chairman and CEO in 2013. CASIC was part of China Aerospace Corporation (CAC) until its 1999 split, which also produced its sister organization, the China Aerospace and Technology Corporation (CASC). CASIC focuses on short- and medium-range ballistic missiles and cruise missiles.[438] CASIC also produces civilian satellites, communications, and electronic systems. CASIC is divided into specialized departments, academies, subsidiaries, and research institutes to conduct aerospace R&D.

China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团有限公司]
Website: http://www.spacechina.com/n25/index.html
Location: Haidian District, Beijing
[海淀区, 北京市]

CASC is China's primary R&D and manufacturer of Chinese space systems and ballistic missiles. A major subsidiary of CASC, China Academy of Launch Vehicle Technology (CALT) [中国运载火箭技术研究院] designs and manufactures most of China's rockets from the Jiuquan, Taiyuan, Xichang and Wenchang Space Launch Centers. Until 2018, CASC was headed by Lei Fanpei [雷凡培], who subsequently moved to CSSC, one of China's two largest shipbuilders, and was replaced as Chairman of the board and Party Secretary by Wu Yansheng [吴燕生].[439]

CASC was part of the CAC until its 1999 split, which also produced CASIC. In 2009, CASC expanded into satellite communications after acquiring China Satcom. CASC produces a variety of defense systems and weapons such as: ship-to-air, surface-to-air missiles, intercontinental ballistic missiles, space launch vehicles, UAVs, guided multiple-launch rocket systems, and precision-guided bombs.[440] CASC also has several subsidiaries, academies, and research institutes to conduct specialized R&D.

CAAA[442]

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 11th Research Academy 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.[442] The institute is based in Beijing and has manufacturing facilities in Tianjin. It has partnerships with both Chinese and foreign universities, Chinese think tanks, and has a doctoral program.[443] CAAA in particular produces a wide range of "special aircraft" including very-short to long-range drones, missiles, ground effect aircraft [地效飞行器], and hovercraft.

Most prominent of these is the Caihong (Rainbow) [彩虹] series of drones. Song Wen [宋文], is the chief designer of the CH series [彩虹] at (CAAA). The CH series includes a full range of hand-launched, rocket-launched and full-sized drones that take off like traditional aircraft performing a wide range of roles including remote sensing, maritime inspection, artillery spotting, and data relay.[444]

ASN-206[446]

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]

Associated with Northwestern Polytechnical University (NPU) and also going by the name Northwestern Polytechnical University 365 Research Institute [西北工业大学第365研究所], Aisheng has been a major pioneer of Chinese drone technology. Wang Junbiao [王俊彪] is the institute director, and Deputy Party Secretary, and Deputy General Manager.[446]

Aisheng specializes in small man-portable or truck-launched surveillance UAVs. In the 1990s they completed research on the ASN-206 reconnaissance drone. 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 US Armed Forces.[447] Other small UAVs such as the 50kg ASN-212 have more limited range and payload but can perform "battlefield surveillance, damage assessments and border patrol" missions.[448] More capable UAVs include the ASN-215 which has a max take-off weight of 220kg, 60kg payload and maximum altitude of 6000m.[449]

NPU appears to be expanding its manufacturing capabilities. In 2016 NPU signed an agreement with Luxi New City in Shaanxi to build a 605-acre UAV manufacturing "base" [无人机产业化基地] to help expand NPU and Aisheng's operations.[450]

TW328[452]

Sichuan Tengdun Technology Co.
[四川腾盾技术公司]
Location: Chengdu, Jinniu District
[金牛区, 成都市, 四川省]

A new company founded in 2016, Tengdun has quickly grabbed headlines for its ambitious high-end transport and military-use drones.

In December 2017, Tengdun announced that it was preparing to build the world's largest commercial UAV, the AT200. The AT200, essentially an unmanned turboprop plane, is envisioned as having a maximum range of 7,500km and cargo capacity of 3.4 tones.[452] A modified utility aircraft converted into a UAV is also envisioned as helping address logistical issues for China's far-flung military outposts in the South China Sea and mountainous western regions.[453]

Tengdun also displayed several aircraft at the Zhuhai Airshow in November 2018. Two of the largest on display were the TW328 and TW356, both linked twin boom tail design. The TW328 was portrayed as capable of carrying FT-9, C701K CM-502KG missile, and with a dorsal pod possibly for jamming and a targeting pod. Both variants are portrayed as modular and easily reconfigurable for multiple missions.[454]

Appendix B: Educational & Academic Institutions

China has a healthy interplay between its academic institutions, corporations, state and military organizations. The aviation industry and related government institutions are dominated by graduates of three institutions: Beihang, Nanhang, and Northwestern Polytechnical University. These universities are administered by the Ministry of Industry and Information Technology (MIIT).[455] Notably, each university is connected to the PLA's 2110 Program for cultivating expertise in defense-related fields.

Beihang University (BUAA)
[北京航空航天大学]
Website: www.buaa.edu.cn/
Location: Haidian District, Beijing
[海淀区, 北京市]

Beihang (Beijing University of Aeronautics and Astronautics) was established on October 25, 1952 as the Beijing Institute of Aeronautics, the result of the merger of aeronautics departments from several universities across China.

With the resumption of the national college entrance examination [高考] in 1978 at the end of the Cultural Revolution, the university was able to resume training students in advanced majors. It became a major source of scientists and engineers trained in missile and aircraft design, aerodynamics, materials science, and advanced electronics disciplines.[456] In 1988, the name was changed to Beijing University of Aeronautics and Astronautics (Beihang). AVIC's current Chairman of the Board and Party Secretary, Tan Ruisong [谭瑞松] completed his undergraduate degree at Beihang.[457]

Beihang has been a leader in China's UAV drone development, launching China's first reconnaissance drone in 1972 and, in January 2018, a team from BUAA won the National Science Progress award (first rank) for their Long Eagle [长鹰] High-altitude UAV.[458]

Nanjing University of Aeronautics and Astronautics (Nanhang/NUAA) [南京航空航天大学]

Website: www.nuaa.edu.cn
Location: Nanjing, Jiangsu Province
[南京市, 江苏省]

NUAA, also identified as Nanhang [南航], was founded in 1952, initially as the Nanjing college of Aviation Industry. The university has 29,000 students and hosts a National Key Laboratory and two National Defense Science Key Laboratories [国防科技重点实验室], among others.[459]

NUAA has an affiliated Helicopter Institute [直升机技术研究院] that has a National Key Laboratory focused on Helicopter Rotor Dynamics [直升机旋翼动力学].[460] NUAA has a long history of involvement in building drones, dating to 1958. In 1968, it became formally involved in UAV research, setting up the UAV Research Institute [无人机研究所] in 1979, initially called the Aviation Department's 362 Research Institute [航空部362研究所].[461]

Northwestern Polytechnical University (NPU) [西北工业大学]

Website: http://www.nwpu.edu.cn
Location: Xi'an, Shaanxi Province
[西安市, 陕西省]

While NPU's origins date to the 1930s, its modern form derives from the Northwest Institute of Engineering established in Xianyang, outside Xi'an in 1950. Departments from other universities and PLA engineering institutes were merged into the University and in 1957 it was renamed as Northwestern Polytechnical University.

The university has a student population of over 28,000 and is host to eight National Key Laboratories and two national engineering research centers. The university has seen major advances in the field of UAVs.[462]

PLA-Affiliated Universities

Three PLA-affiliated universities deserve special attention for their role in aerospace-related research. The first, NUDT, is subordinate to the CMC, while the remaining two are affiliated with the Air Force. While by no means an exhaustive list, these provide an example of the institutions that the PLA has working on the complicated engineering problems posed by aviation. These universities play an important role not only by training scientists, researchers and engineers for their respective fields, but also by popularizing new technologies and helping key organizations recognize trends and prioritize strategic areas of investment.

National University of Defense Technology (NUDT) [国防科技大学]

Website: www.nudt.edu.cn
Location: Changsha, Hunan Province
[长沙市, 湖南省]

NUDT is described as the apex of cultivating "high-quality, new-type talent" and "indigenous innovation in national defense technologies."[463] The university is regarded as helping the PLA achieve important breakthroughs necessary for military modernization.[464]

The origins of NUDT begin with the establishment of the PLA Military Engineering Academy [中国人民解放军军事工程学院], referred to as the Harbin Military Engineering Academy [哈尔滨军事工程学院], in 1952.

Throughout the 1950s and 1960s, specialized schools in artillery, armored vehicles, and nuclear chemistry were added. At the end of the 1960s, due to fears of Soviet invasion, many of the departments were split off and moved to the interior of the country. For example, the aviation component was folded into what became Northwestern Polytechnical University, the nuclear engineering department was moved to Sichuan, and the core of NUDT's current form was moved to Changsha.

The newly created "Changsha Engineering Academy" added specialties in guided missile design and electrical engineering. In 1978, the State Council and CMC officially established the National University of Defense Technology.[465] In 2017, the PLA reorganized its academic and research institutions, and this effort resulted in the NUDT incorporating smaller universities and colleges, including the Institute of International Relations [国际关系学院], National Defense Information Academy [国防信息学院, 湖北省武汉市], Xi'an Communications College [西安通信学院], Electronic Engineering College [电子工程学院], and the PLA University of Science and Technology's Meteorological Ocean Institute [解放军理工大学气象海洋学院].[466] Until 2018, NUDT was a Theater Command Deputy Leader grade (Grade 4) organization; however, in 2018, it was redesignated as a Corps Leader grade (Grade 5) organization.

In terms of technological achievements, NUDT has made valuable contributions to China's IT and artificial intelligence (AI) industries, helping build the CPU for the Tianhe-1 supercomputer.[467] The university has made notable advancements in UAV-related fields of Micro-UAVs and UAV swarms.[468] Notable alumni include important scientists such as Yang Xuejun [杨学军] who was the chief designer of Tianhe-1 and later served as Commandant of NUDT.[469] Notably, NUDT's new Commandant, Deng Xiaogang [邓小刚] is an expert in Computational Fluid Dynamics (CFD) [计算流体力学] modeling of hypersonic aircraft using the Tianhe supercomputer.[470]

Air Force Aviation University [空军航空大学]

Location: Changchun, Jilin Province

On 9 June 2004, the Air Force Aviation University (AFAU)[471] was established when the former Air Force Changchun Flight College [空军长春飞行学院], 7th Flight College [第七飞行学院], and Second Aviation College [第二航空学院] were combined.

The Air Force Aviation University's chief responsibility is to train pilots and aviation engineers, a fundamental source for the PLAAF's combat power. In total, the University has 12 campuses spread across seven cities in six provinces and its main campus is in Changchun, Jilin Province. The Air Force Aviation University has origins in March 1946 when the Northeast Aviation School [东北老航校] was founded. Over the subsequent 70 years, more than 140,000 personnel have attended the school, including 80,000 pilots and many famous Chinese generals, including former PLAAF Commander Wang Hai [王海] and the first Chinese person in space, Yang Liwei [杨利伟]. Air Force Aviation University is a Deputy Corps Leader grade (Grade 6) organization.[472]

The Air Force Aviation University offers academic majors in military sciences, engineering, aviation flight and command, aerial combat, aviation rescue, electronic confrontation technology and command, UAV application and command, equipment simulation technology, intelligence analysis, operational target support, and unit organization and training management.[473] In 2011, the PLAAF signed a strategic cooperation agreement with Tsinghua University, Peking University, and Beihang University to accelerate the cultivation of flight talent. As part of this agreement, students take a five-year course and, upon completion, earn a degree from one of the aforementioned civilian universities and the Air Force Aviation University. Under this program, students first take classes at civilian universities, including aerospace engineering, and then enroll in the Air Force Aviation University to carry out beginning and advanced training. In 2016, 25 of the 32 aviation students from the first Tsinghua class to participate in this program graduated.[474] The Air Force Aviation University is also connected to the PLA's 2110 program and has a Northeast regional military training information management center [东北地区军事训练信息管理中心], a parachuting training field, maritime rescue center, and an outdoor survival comprehensive training base.[475]

Air Force Engineering University
[中国人民解放军空军工程大学]

Location: Xi'an, Shaanxi

The Air Force Engineering University is in Xi'an, Shaanxi Province [陕西省西安市] and is the PLAAF's cradle for high-quality, new-type military personnel and an important base for innovation in military science and technology. The Air Force Engineering University has a historical legacy dating back to 1959 when the Air Force Engineering Academy [空军工程学院] was founded.

In 1999, the Air Force Engineering Academy merged with the Air Force Missile Academy [空军导弹学院] and the Air Force Telecommunication Engineering Academy [空军电讯工程学院][ag] to create the Air Force Engineering University.

Over the past two decades, the University has been reorganized another three times: in 2004, the College of Science [理学院] was added to the University; in 2012, a College Aeronautics and Astronautics Engineering [航空航天工程学院], College of Air and Missile Defense [防空反导学院], and College of Information and Navigation [信息与导航学院] replaced what was left of the organizations that had been consolidated in 1999; and in 2017, the PLAAF's First Aviation College [第一航空学院] was reorganized under the control of the Air Force Engineering University and renamed the Aviation Maintenance NCO School [航空机务士官学校].[ah] The Air Force Engineering University is believed to be a Corps Leader grade (Grade 5) organization.[476]

The Air Force Engineering University chief training missions are focused on training high-level engineering and technical officers and commanding officers to become aviators, surface air defense operators, and signalmen. The Air Force Engineering University currently has 8,000 students enrolled. Overall it has trained 70 percent of the Air Force's ground officers. Since its founding, it has trained 130,000 officers.

The University has one National Key Laboratory and three National Experimental Teaching Demonstration Centers [国家级实验教学示范中心]. The Air Force Engineering University has five campuses across China and is home to Northwest China's most advanced indoor comprehensive training center for colleges and universities. The University also has additional practice training grounds for combat aircraft, surface-to-air missiles, communication and navigation, and air traffic control. The Air Force Engineering University also trains personnel in the following fields: mechanical engineering, mechatronic engineering, electrical engineering and automation, electrical information

ag The Air Force Missile Academy was founded in 1958 and the Air Force Telecommunication Engineering Academy was founded in 1957.
ah The University also has the Air Traffic Control and Navigation College [空管领航学院] and the Equipment Management and Safety Engineering College [装备管理与安全工程学院].

engineering, flight vehicle propulsion engineering [飞行器动力工程], flight vehicle airworthiness technology [飞行器适航技术], weapons systems and engineering, weapons launch engineering, operations and mission planning, firepower command and control engineering [火力指挥与控制工程], aerospace defense command and control engineering [空天防御指挥与控制工程], air traffic control and navigation engineering, military installations engineering, station management engineering [场站管理工程], command information systems engineering, aviation equipment engineering, radar engineering, missile engineering, and unmanned equipment engineering.[477]

Towards the end of 2015, the Air Force Engineering University's College of Information and Navigation began taking corrective steps to enhance the capabilities of its graduate students. The effort was a result of the University's conclusion that some of its students demonstrated weak capabilities for carrying out practical tasks, especially in their first jobs after graduating.[478] In August 2018, it was reported that the Air Force Engineering University would begin providing technical support to the newly established Yulin Smart Unmanned Systems Military-Civilian Fusion Innovation Research Institute [榆林智能无人系统军民融合创新研究院].

Other organizations reported as providing support include the CMC Joint Staff Department's 55th Research Institute [军委联合参谋部55所], PLASSF, NWPU, the CMC Science and Technology Commission's Innovation Zone [军委科技委创新特区], the Academy of Military Science's Cutting-Edge Innovation Research Institute [前沿创新研究院], the Chinese Academy of Sciences, and NORINCO's Scientific Research Institute [兵器科学研究院].[479]

Air Force Research Academy
[空军研究院]

Location: Beijing

On 2 February 2004, PLAAF Headquarters held a ceremony to formally establish the new Air Force Equipment Research Academy [空军装备研究院], which is a corps leader-grade organization.[480] The research academy is responsible for consolidating the strengths of the PLAAF's scientific research, implementing S&T strategy for a strong military, and speeding up the informatization of the PLAAF's equipment and weapons. The new research academy consolidated more than 20 PLAAF division- and regiment-level scientific research organizations. Organically, the academy consists of several specialized institutes. As of 2005, about 1,500 officers were assigned to the academy. It has the following subordinate institutes:

- Equipment General Demonstration Research Institute [装备总体论证研究所]
- Aviation Equipment Research Institute [航空装备研究所]
- Air Force Ground Air Defense Equipment Research Institute [空军地面防空装备研究所]
- Air Force Radar and Electronic Countermeasures Research Institute [空军雷达与电子对抗研究所]
- Air Force Communications Navigation and Command Automation Research Institute [空军通信导航与指挥自动化研究所]
- Air Force Reconnaissance and Intelligence Equipment Research [空军侦察情报装备研究所]
- Air Force Weather and Chemical Defense Research Institute [空军气象防化研究所]
- SAM Technical/Technology Services Research Institute [导弹技术勤务研究所]
- Air Force Equipment Software Testing and Evaluation Center [空军装备软件测评中心].[481]

On 20 July 2017, the PLAAF held a ceremony to rename the Air Force Equipment Research Academy as the Air Force Research Academy [空军装备研究院], which is directly subordinate to PLAAF Headquarters and serves as the highest-level research organization within the PLAAF. At the start of November 2017, multiple Air Force specialized-research institutions [富有军种特色专业研究机构] were gradually established and integrated into the new academy-institute mechanism [院所体制] of the scientific research model [科研格局]. [482]The newly-reorganized Air Force Research Academy [空军研究院] is becoming the new main scientific research power house

[科研主体力量] of the PLAAF. The identified organizations are shown below:

- Building and Construction Research Institute Comprehensive General Office [建设发展研究所综合办公室]
- Meteorology affiliated research institute
- Communications and Missile Institute [通信与导弹所]
- Air and Missile Defense College [防空反导所]
- System Engineering Institute [系统工程所]

The Director of the academy is Major General Li Tieshi [李铁石]; Han Xianfeng [韩先锋] serves as the political commissar.[483] Li previously served as the Director of the Air Force Equipment Department's Factory Management Department and deputy chief engineer [副总工程师] of the Air Force Equipment Department.

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