Chapter 4

What Explains China's Comprehensive but Uneven Aerospace Development?*

Andrew S. Erickson†

Abstract

With respect to aerospace development capabilities, China is changing from a developing country whose leaders prioritized some specific sub-sectors at the expense of others to a great power capable of developing simultaneously all types of high-level aerospace products. World-class levels have already been reached with missiles/rockets and satellites; aircraft, particularly civilian, remain the most critical lagging area, but show potential for rapid improvement. This chapter explores China's Cold War aerospace trajectory and prospects for future development.

Conceptual Context

In order to place China's aerospace development—its achievements in the areas of aviation and spaceflight—in its larger context, it is necessary to develop a theory, or at least an analytical framework, for understanding aerospace development and its larger geopolitical implications. The realist school of thought in

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† U.S. Naval War College, Newport, Rhode Island, U.S.A.

political science, which is based on the idea that nations naturally compete for security and scarce resources in an international system that lacks centralized governance, offers a useful theoretical basis for explaining state behavior with respect to aerospace development.

Viewed from this perspective, states engage in what I term "geotechnological" competition, including such behaviors as balancing. This also involves cooperation, such as the development of formal and informal mechanisms and partnerships with respect to technology and finished product development, and transfer to meet needs that states are unable to fulfill on their own. States do so to prevent competitors from denying them access to critical items, and occasionally even to distract competitors with geostrategic challenges.[2]

While economic and cooperative factors are clearly a major force in the international system, and should not be ignored, observation of nations' behaviors with regard to critical aerospace technologies nevertheless reveals precisely this sort of prioritization, contention, and maneuvering, even among nations who otherwise enjoy exceptionally positive relations. Examples include disputes about technology transfer among the United States and European Union (EU) member nations and between the United States and Japan.

Since China's reform and opening up to the world in 1978, the efforts of China's leaders in the aerospace realm have been informed by at least three widely held perceptions: (1) realist assumptions about the nature of the international system; (2) of techno-nationalism (技术民族主义), the idea that technological strength is an effective determinant of national power in a harshly competitive world; and (3) of the need to learn from history, a primary lesson of which is that the Soviet Union overextended itself by overemphasizing military development at the expense of economic development. In this, the Chinese leaders were unusually effective in both their assessment of aerospace opportunities and challenges and their pursuit of them but hardly unique in their aspirations in this regard.

Historical Background

Since the end of World War II, when technological advances for the first time enabled the combination of precision delivery with the destructive power of nuclear weapons, full-spectrum aerospace development has been an indicator of relative comprehensive national power. National leaders wish both to demonstrate strong state capacity and to realize aerospace development's manifold benefits. They therefore strive to maximize overall aerospace development and to minimize (within country) differential aerospace development, which I define as disparities in the technological level of different sub-sectors of aerospace technology.

Aerospace development is an important component of state capacity and great power status. The correlation between aerospace development and state capacity and also great power status leads many national leaders to believe that such development can be manipulated to extend national capabilities significantly. While not all national leaders make achieving full spectrum aerospace development their first priority, one cannot help but notice the attraction that it holds for so many of them. The most significant victims of this revisionist illusion are typically leaders of autocratic polities with significant leeway to allocate rapidly vast amounts of national resources, and hence to dictate such a course. This is precisely what happened during World War II in Nazi Germany and during the Cold War in the Soviet Union.[3]

This salience of aerospace development as an indicator of relative national capacity increases whenever the international system's order is challenged significantly, as it was during World War II and the Cold War. Berlin's maximalist efforts during the former competition and Moscow's during the latter triggered an all-out response in which Washington (and its allies, in many respects) brought the full measure of its capabilities to bear, and they proved to be significantly greater. Currently there is no such dramatic effort at geopolitical revisionism by any rising power, and hence aerospace development may not be as visible an indicator. In any case, the international system is not witnessing dramatic short-term efforts by any power, particularly by such status quo powers as the United States—though achievements by such developing powers as China and India may be significant over time, and, as such, may yet trigger compensatory aerospace efforts by the United States and other developed powers.

As these historical cases have demonstrated clearly, then, while aerospace development may be a somewhat loose indicator (whose significance may vary), it is nevertheless an objective, exogenous indicator of being a great power, that is, a proxy for state capacity or relative power. In other words, it cannot be used to manipulate a nation's relative comprehensive national power. The major industrialized great powers today (the United States; the European Union, which is composed of individual Member States, but increasingly operates as a largely unitary entity when engaging in large-scale strategic aerospace projects, for example, Airbus, the European Space Agency, and Galileo; and Russia, with its significant Soviet inheritance) have all achieved full-spectrum aerospace development. Japan is a partial exception, as it lacks indigenous aircraft production. This may be explained by its unique security circumstances whereby it lacks sufficient military spending to effectively subsidize civilian aircraft production, a course that Washington, Brussels, and Moscow have all taken.

Because a nation's overall power defines the outer limit of its aerospace development potential, emerging great powers (for example, China, India, and Brazil), which by definition still face significant limitations in national capacity, have achieved increasing, but uneven, aerospace development. Lacking the means to achieve full-spectrum development, they must make difficult choices about the relative prioritization of various aerospace sub-sectors, either consciously or by default. The key for scholars and analysts is to understand this unevenness in each case.

The reasons for this differential aerospace development stem less from the relative technical difficulty of the products involved than from individual limitations specific to the countries themselves. Examining China, India, and Brazil in detail reveals the differing domestic priorities and political factors that influence their courses and levels of development. Of the three, China has both the most uncertain political future and the greatest potential to influence the international order. China already has the world's second largest economy and defense budget. According to U.S. National Intelligence Council projections, China's economy will become the world's largest by GDP in 2022 as measured by purchasing power parity, and "sometime near 2030" by market exchange rates.[4] China is thus a particularly important topic of research and will now be considered in detail.

China: A Case of Differential Aerospace Development

China's post-1949 evolution suggests that political decisions best explain its successful development of rockets and satellites and also its failure until now to mass produce viable commercial aircraft. These political decisions have taken the form of great national financial and human capital commitments since the 1950s. They did not occur in a vacuum, but were rather shaped by such idiosyncratic factors as leadership preferences and geopolitics. It is thus necessary to examine closely the history of China's aerospace development and its larger context to understand the reason for its trajectory.

Initially China devoted much of its limited technical resources to producing nuclear weapons and the long-range missiles necessary to demonstrate capability to deliver them to the capitals that Beijing sought most to deter on a grand scale: Moscow and Washington. Under Mao Zedong's official endorsement of a "nuclear bomb, missile, and satellite" (两弹一星) policy, satellites were also prioritized for military reasons and because they could not be purchased from abroad following the 1960 Sino–Soviet split. This policy, further strengthened by Mao's endorsement of the brilliant Massachusetts Institute of Technology (MIT)- and Caltech-trained engineer Qian Xuesen's position as the progenitor of much of China's emerging aerospace infrastructure, ensured that the nation's scarce financial, technical, and human resources were allocated disproportionately in these areas.[5]

Beijing's relative prioritization of rockets, satellites, and aircraft was revealed in even starker relief during the "Great Leap Forward" and the "Cultural Revolution," which harmed development and exacerbated resource competition. Premier Zhou Enlai intervened personally to protect China's nuclear, missile, and even satellite programs from the predations and chaos of the radically destructive elements that Mao's policies unleashed, but even he had finite political capital, and failed to extend similar protection to aircraft programs. The military importance of aircraft was recognized in theory, but the miniscule resources available and unrealistic goals that further dispersed them—both organizationally and geographically—devastated actual production. Consequently, the aircraft industry's organization, and the quality of its products, remained poor.

As one of China's defense industry's few early "pockets of adequacy," by contrast, China's missile production became relatively well organized and capable. Satellite launch capabilities, a spin-off from Chinese intercontinental ballistic missile (ICBM) development, have since captured 10 percent of global market share. China has developed and deployed some of the world's most advanced ballistic and cruise missiles. With well over 1,000 short-range ballistic missiles deployed opposite the Taiwan Strait, Beijing has the world's greatest sub-strategic missile force.[6] China's road-mobile DF-31A ICBMs can access the entire United States, may be extremely difficult to detect and target, and as such have likely at last provided Beijing with a secure nuclear second strike capacity.[7] China has even developed the world's first ballistic missile capable of striking (conventionally) moving targets at sea, for example, aircraft carriers.[8] China is likewise developing the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) architecture necessary to support this and other systems. This is a complex and difficult challenge, and progress here is slower than many aspects of hardware development.

China has developed and deployed all major types of military and civilian satellites. There have been some challenges, with Beijing's first maritime surveillance satellite, *Haiyang-1*, suffering from problems with dynamic motor coupling,[9] but this and other series have been improved and continue with success.[10] China is currently working to transform its regional *Beidou-1* Satellite Navigation and Positioning System (北斗卫星导航定位系统) into a 35-satellite *Beidou-2*, or Compass, system with global commercial and military capabilities. China has launched twenty *Beidou* satellites to date, with sixteen remaining fully operational.

The Aircraft Paradox—Poised for Resolution at Last?

China's high demand for all types of aircraft offers opportunities to begin indigenous production at a relatively low level of expertise. China boasts both the world's second largest commercial aircraft fleet and the second largest order backlog. By 2031, Boeing projects, Chinese civil airlines will possess 5,960 aircraft, which will require them to buy 5,260 new airplanes valued at $670 billion. By 2030, Civil Aviation Administration of China (CAAC) forecasts, China will represent the world's largest air transport market.[11]

Despite early indications of the importance of its aviation sector, normally self-reliant China failed in its first two attempts to enter its own domestic passenger aircraft market in the 1980s. This is in part because aircraft manufacturing had been subordinated to the higher priorities of missile and satellite development, and has thus received inadequate resources and organizational prioritization. Given increased funding, consolidation of inefficiently dispersed production facilities, and appropriate organizational reforms, however, Chinese aircraft development may yet succeed—indeed, several breakthroughs have recently occurred.

While China continues to purchase and produce, under license, advanced Russian aircraft, its recent deployment of the advanced J-10 multi-role combat aircraft, which is capable of all-weather day/night operation, suggests emerging world-class development capabilities in its military aviation sector. In some performance parameters, the J-10 may even approach the capabilities of the F-16 and Mirage 2000.[12] China has also deployed Su-27SK-derived J-11 fighter variants and Il-76MD-derived KJ-2000 airborne early warning and control aircraft; while flight-testing the Su-33-derived J-15 carrier-based fighter; and continuing to develop the Su-27/30-derived J-16 fighter-bomber and the J-20 and J-31 low-observable aircraft prototypes.

Commercial Aircraft Corporation of China (中国商用飞机有限责任公司, COMAC)'s ARJ21 Xiangfeng (翔凤) twin-engine regional airliner, China's first indigenously produced jetliner, is currently being flight-tested. It utilizes U.S. and European components, most notably General Electric Aircraft Engine (GEAE)'s CF34-10A high bypass ratio turbofan engines. Started in 2002 as part of China's 10th five-year plan, the project is envisioned to yield initial deliveries by the end of 2013. Four models are in development: the standard ARJ21-700, 70 to 95 passenger version;[13] the ARJ21-900 stretched fuselage, 95 to 105 passenger version;[14] the ARJ21F 10,150 kg capacity freighter version of the ARJ21-700;[15] and the ARJ21B business jet version.[16] While an impressive first for China, however, the ARJ21-700 as initially unveiled seems to lack the performance parameters to compete for major market share, and instead will likely fill niche capabilities for buyers who need small numbers of aircraft at relatively low prices, particularly to operate out of small, less-developed airfields.

Further in the future, China's "Large Aircraft Program" shows determination to produce marketable passenger aircraft of significant size. COMAC is engaged in a truly ambitious effort to compete with the Boeing 737 and Airbus A320 series with its 168–190 seat narrow-body C919. Deliveries are envisioned by 2016, although Chinese sources typically lack specifics and much uncertainty remains concerning the data that is available.[17] Whatever China's trajectory in this area at present, it should be expected that Chinese aircraft designers will learn quickly and make rapid progress, particularly given the strong commercial rationale for investment in this area.

Conclusion

China's emphasis on, and partial success in, aerospace development is in keeping with its substantial, rising comprehensive national power. By the end of the Cold War, China was the only developing country to have achieved full-spectrum, if still uneven, aerospace development. This is part of a larger science and technology revolution that is reducing, albeit not yet closing, the gap vis-à-vis Western industrialized nations.[18] A new era is dawning in Chinese aerospace development, one in which Beijing may truly be able to "do it all."

As China's aerospace capabilities become more evenly distributed across its sub-sectors, China itself is becoming a developed great power in terms of aggregate national capabilities. This, coupled with China's enormous population and still low per capita wealth and natural resources, is creating an unprecedented historical circumstance in which one of the world's great powers at the international level remains one of the world's poorer nations at the average individual level, a situation that some Chinese refer to as "rich country, poor people" (富国穷民).

Herein lies a challenge both for China and those seeking to project its future aerospace trajectory. Technological development in general, and aerospace development in particular, is shaped not only by the aggregate resources available to a country but also by the sociopolitical system in which the development occurs. While China's capabilities in this area already seem able to support aerospace achievement in keeping with its position in the great power hierarchy, its rate of future progress is uncertain. Some elements of China's sociopolitical system approach advanced world levels in their scope and quality, but others remain mired in problems stemming from low per capita income and organizational inefficiencies. In the military realm, for example, these challenges extend to the bureaucratic "data fusion" needed to coordinate the efforts of different sensors, platforms, and services, which remains a daunting task, particularly if China is to contemplate military missions of high operational intensity beyond its immediate maritime periphery.[19]

Since China's opening up and reform began in 1978, China's leaders have worked with great success to increase both national power and per capita income, in part by eschewing military entanglements in favor of domestic development. They have done so in part by prioritizing long-term investments and implementing large-scale infrastructure developments in ways that would be difficult if not impossible in a country with a different sociopolitical system. These efforts are driven by their assumption that concrete indicators of national power matter; as Thomas Christensen has stated, "China may well be the high church of realpolitik in the post-Cold War world."[20] Thus far, this has been a highly effective approach. But will China's leaders always be able to persuade their public, particularly its poorest members, to forego the short-term individual interests and passions that have frustrated such collective strategies in other societies, particularly developing ones where income disparities and social challenges are greater? Domestic factors such as these will play a major role in shaping China's potential for future aerospace technology development.

Endnotes

1 The views expressed in this paper are solely those of the author. They in no way reflect the policies or estimates of the U.S. Navy or any other organization of the U.S. government.

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[12] For further details, see http://www.sinodefence.com/airforce/fighter/j10.asp.

[13] See http://www.acac.com.cn/site_en/product01.asp.

[14] See http://www.acac.com.cn/site_en/product02.asp.

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[16] See http://www.acac.com.cn/site_en/product04.asp.

[17] See Xin Dingding and Chen Qide, "Jumbo Jet Project Boon to Suppliers," *China Daily* (27 August 2009); http://www.chinadaily.com.cn/bizchina/2009-08/27/content_8621974.htm; Mu Xuequan, "China Names First Jumbo Jet C919, to Take Off in 8 Years," *Xinhua* (6 March 2009); http://news.xinhuanet.com/english/2009-03/06/content_10959526.htm.

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Foreword

The 43rd History Symposium of the International Academy of Astronautics (IAA) occurred in conjunction with the 60th International Astronautical Federation Congress in Daejeon, South Korea, during October 2009. As in previous volumes of the symposium proceedings, the papers presented are published here as individual chapters. Although the editing team—volume, series, copy, and publisher—have sought to edit the individual papers lightly for the sake of stylistic and grammatical consistency, several of the 16 chapters in this current volume required more extensive alterations to make them intelligible to readers of American English. In every instance, however, the editing team has endeavored to remain faithful to each author's original intent. This pertains especially to those chapters authored by the late Vladimir Fedorovich Prisniakov. Hopefully, we have achieved our goal.

By now, anyone familiar with the IAA history series should expect to find a wide variety of material on the history of rocketry and spaceflight. This volume will meet expectations, with everything from biographies and technical studies to development of space policies. Since North Korea arguably launched its first satellite, *Kwangmyongsong-3*, in December 2012 and South Korea definitely succeeded in doing the same, with *Science and Technology Satellite 2C (STSAT-2C)*, in January 2013, this volume's fourth part offers a special, timely treat. It explores Korean rocketry from as early as the fourteenth century to the present and the historical evolution of both North and South Korea's spaceflight programs. Should anyone seek further intellectual stimulation, chapters on Chinese, Japanese, Israeli, Russian, Ukrainian, French, American, and international rocketry or spaceflight endeavors surely will whet the appetite.

With publication of this volume, the prospects brighten even more for bringing this series up to date. Once we achieve this, our aim is to publish the proceedings within 18–24 months of presentation of the papers at the IAA history symposium.

Dr. Rick W. Sturdevant
Series Editor
Air Force Space Command
Office of History

Preface

In this volume, the American Astronautical Society's history series presents 16 papers delivered at the 43rd History Symposium of the International Academy of Astronautics, held in Daejeon (South Korea) in early October 2009. This took place as part of the 60th International Astronautical Federation (IAF) Congress meeting at this time and place.

Following recent tradition, the papers do not appear in symposium order, but have been arranged, for the reader's convenience, by topic: Biographies and Memoirs, Space Policy, Corporate and Technical Histories, and Korean Space History.

These symposia continue to emphasize the shift in focus away from events before World War II and toward worldwide developments occurring after 1945; they also examine topics drawn from a wider range of subjects. Personal narratives are less numerous, and of particular interest to the reader will be the papers devoted to examining hitherto unknown aspects of IAF history. Taking profit of the congress location, this symposium offered a unique possibility in addressing the early Korean space history. This country's contribution to early rocketry finds here a fitting tribute.

The editor would like to dedicate this volume to our late colleague Vladimir Fedorovich Prisniakov. A space historian, specialized in the history of Ukrainian space pioneers and programs, he authored many papers on this topic, three of them being published in these proceedings. Sadly, he unexpectedly left us shortly after the Daejeon International Astronautical Congress. We will be missing him.

Christophe Rothmund
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