TextOre

China's Development of Advanced Fighter Technology

By Roger Cliff, Ph.D.

5-21-2021

China's first domestically-designed fourth-generation fighter aircraft, the J-10, did not become operational until 2006, 27 years after the F-16, to which it is comparable, entered service. In 2017, however, China's first fifth-generation fighter, the J-20, became operational, just 12 years after the comparable U.S. F-22 entered service. The J-20 has features similar to those of the F-22 and F-35 Joint Strike Fighter, the only other fifth-generation fighters currently in operation. The most obvious of these features is its "stealth" – a very small radar cross-section (RCS) from a combination of external shaping, diverterless supersonic inlets, radar-absorbent material coatings, and internal weapon carriage. These result in an estimated front aspect RCS of less than 0.05 m^2. Another feature that the J-20 shares with other fifth-generation aircraft is a wide-band, active electronically scanned array (AESA) radar regarded as comparable to the APG-77 installed on the F-22. The J-20 is also assessed to use advanced datalinks to provide secure networking with other J-20s as well as airborne early warning and control (AEW&C) aircraft. The one area in which the J-20 appears to be inferior to its U.S. (and Russian) counterparts is its powerplant. Prototype and low-rate initial production (LRIP) versions appear to be powered by twin Saturn AL-31F turbofans, but recently produced examples may be equipped with the comparable Chinese-made WC-10C. Either engine, however, probably provides insufficient power given that the J-20's maximum takeoff weight is estimated to be 56,000 lb. Thus, it is believed that later models will be fitted with the developmental WS-15 turbofan, which is projected to enter service around 2025. The WS-15 is assessed to have thrust-vectoring capability and an estimated power output in the 32,000-40,000 lb. range, which would potentially enable supercruise for the J-20.[1]

The J-20 will present a formidable challenge to air forces of the United States and its allies. China's aerospace industry, moreover, will likely produce even more capable aircraft in coming years. Indeed, Chinese research institutes are believed to already be developing the technologies that will enable China's next-generation fighter, expected to enter service by 2035.[2] To understand the future trajectory of China's aerospace industry, TextOre has analyzed a range of Chinese-language primary sources and identified several key trends and lines of effort.

Chinese analysts assess that certain capabilities will likely be present across all next-generation manned and unmanned aircraft designs. These include stealth, omnidirectional broadband radar, greater flight altitude, and highly agile tactical performance. According to these observers, operating at high speeds, including supercruising, will require an entire new generation of engines, systems, and advanced materials. Fixed-wing and rotary-wing unmanned aerial vehicles (UAVs) will also see widespread application, improving the number of sensors and linkages on the battlefield and operating in a wide range of intelligence, surveillance, and reconnaissance (ISR) and strike roles.[3] Chinese researchers further estimate that the key characteristics of U.S. sixth-generation fighters will be hypersonic and directed-energy capabilities, while Russia's military is expected to focus on extreme stealth, high maneuverability, and combined formations of manned and unmanned systems.[4]

The Chinese air force's strategy of Integrated Air and Space Operations implies a greater emphasis on space-based platforms in the future as well as operating in "near-space," the portion of the earth's atmosphere above the maximum altitude at which normal air-breathing aircraft can operate, but below the so-called Kármán line (i.e., between roughly 100,000 feet and 100 km) that defines the transition between the atmosphere and space. Analysts affiliated with the Chinese air force's Air Defense and Antimissile College and its Equipment Academy argue that near-space will be critical to the Chinese air force's strategy in the future.[5]

Chinese aerospace researchers are focused on developing a number of crucial technologies in support of these requirements, with a particular emphasis on improving China's capabilities in the area of aeroengines. One such technology is light, high-temperature-resistant materials used in the manufacture of turbine blades. The high temperatures and pressures involved in modern aeroengines make the use of advanced materials a necessity. Chinese scientists and engineers have slowly begun to overcome the immense technological hurdles involved in their manufacture. A 2016 overview of progress toward developing high temperature alloys by researchers from the Aviation Key Laboratory of Science and Technology on Advanced Titanium Alloys at the Beijing Institute of Aeronautical Materials, however, made clear that, while Chinese labs understood the technical steps required to make titanium alloys heat resistant, they were still in the theoretical investigation, research, and laboratory test phase. The Key Laboratory researchers acknowledged that more tests and experimentation were needed to build a sufficient data pool to move forward.[6]

Another important aeroengine technology is integrally bladed rotors, in which the turbine blades and the rotors they attach to are fused together into a single "bladed-disk" or "blisk." Blisks can have a major impact in reducing the weight and number of compression stages and thus an engine's overall weight. Chinese research institutes are actively developing technologies in this area. The Beijing Iron and Steel Research Institute and Beihang University, for example, have reported successfully producing a two-layer titanium alloy blisk using laser additive manufacturing.[7]

Full authority digital engine control (FADEC) systems improve engine performance, safety, and lifespan. They represent a major improvement over the hydraulic systems of previous generations. In the West, FADEC systems first came into use in the 1980s. In China, however, the first domestically-designed FADEC system is reported to have been accepted for use by the PLA Air Force Equipment Department only in 2003.[8] More recently, China's aerospace industry has been seeking to move from "transitional" distributed structure FADECs to fully distributed FADECs by improving the temperature resistance of sensors, which must withstand temperatures in excess of 1,800 degrees Celsius while continuing to function.[9]

Thrust vector control is another key technology that China's aerospace industry is seeking to master. It is used primarily on advanced fighter jets to provide greater control and maneuverability by manipulating the direction of thrust itself, rather than relying solely on flight control surfaces. China's progress in this area was displayed at Airshow China 2018 in Zhuhai, when a J-10B thrust vector demonstrator successfully performed "post-stall" maneuvers.[10]

In addition to pursuing technologies to improve the performance of China's fighters, China's aerospace industry is also upgrading the capabilities of the weapons they carry. Currently, Chinese enterprises are developing and deploying two advanced air-to-air missiles. One has the designator PL-15. Its existence was first confirmed by Chinese media in 2015, although the missile might have been tested as early as 2011.[11] Chinese reports identify the missile's developer as the China Airborne Missile Academy, based in Luoyang, Henan province. Image-analysis of published photos of the PL-15 suggests that the missile is about four meters long and 200 mm in diameter. The range and speed of the PL-15 are enhanced through the use of a dual-pulse solid rocket motor, possibly in conjunction with ramjet engines. Based on these parameters, it is estimated to have a range of 150-200 km.[12]

The PL-15 is also believed to be equipped with an advanced AESA radar seeker and jam-resistant datalinks. It is assumed to employ a composite guidance system that features both mid-course and terminal guidance. Its mid-course guidance capability enables the missile to receive course correction information in flight from a standoff AEW&C aircraft such as a KJ-2000, without requiring the missile's launch platform to turn on its own radar and risk giving away its position.[13]

The second new air-to-air missile known to be in development is believed to have the designator PL-21. It is said to be a ramjet-powered, active radar homing, very long-range air-to-air missile with performance characteristics roughly comparable to those of the American AIM-120 AMRAAM, Europe's MBDA Meteor, and the Russian Vympel R-77. According to Chinese media reports, the missile is capable of hypersonic speeds (i.e., greater than Mach 5), implying that the missile engine is a scramjet. The engine is said to be able to more than triple the range of existing Chinese BVRAAMs, to more than 300 km.[14] A display graphic at the 2014 Zhuhai Airshow appeared to show a J-31 fighter carrying four unidentified missiles fitted with ramjet engines. The missiles were significantly larger than any known Chinese air-to-air missiles and may have been examples or mockups of the PL-21.[15]

The areas of research in which China's aerospace industry is engaged have two principal implications. First, China is clearly determined to bring the performance of its aeroengines up to the standards of the United States and Russia. When this is accomplished, China's fighter aircraft will essentially be comparable in performance to other fifth-generation fighters. Second, China is clearly focused on equipping its fighters with high-performance, long-range air-to-air missiles. The principal intended targets of these missiles, however, are probably not fighters. Rather, these missiles are likely designed to be used primarily against large, high-value aircraft such as AEW&C, aerial refueling, and electronic intelligence aircraft. With these aircraft neutralized or forced to operate from greater distances, the effectiveness of frontline fighters will be significantly reduced, providing China with not just parity in air-to-air combat against any opponent, but potentially even the advantage. In developing future air dominance systems, the United States and its partners need to consider these and other capabilities being developed by China's evolving aerospace industry.

****

About the Author: Dr. Roger Cliff has 20+ years of experience at policy institutes and with the U.S. Government conducting research and analysis on Asian economic, political, and security issues and implications for U.S. policy. He is also an author, coauthor, or editor of more than 40 published books, reports, journal articles, op-eds, and book chapters. Dr. Cliff received a B.S. in Physics from Harvey Mudd College, a M.A. in History (Chinese Studies) from the University of California, San Diego, and a Ph.D. in Public and International Affairs from Princeton University.

---

[1] "Fighters III," Chinese Military Aviation, http://chinese-military-aviation.blogspot.com/; "歼 10 首席试飞员不简单: 飞过美俄法战机总师都听他的," *Sina Military*, 31 October, 2017. http://mil.news.sina.com.cn/jssd/2018-02-25/doc-ifyrvspi1650919.shtml; "歼-20 真用了'峨眉'发动机?专家这样说," *S&T Daily*, http://www.stdaily.com/index/yaowen/2017-06/06/content_549456.shtml; Greg Waldron, "China's enigmatic J-20 powers up for its second decade," *FlightGlobal*, December 28, 2020 (https://www.flightglobal.com/defence/chinas-enigmatic-j-20-powers-up-for-its-second-decade/141698.article).

[2] "Fighters III," Chinese Military Aviation, http://chinese-military-aviation.blogspot.com/.

[3] "未来军用战机发展趋势," *China Aviation News*, 16 May 2016, http://www.cannews.com.cn/2016/0516/153912.shtml.

[4] "空天竞逐未有穷期," *PLA Daily*, 27 April 2018. http://kj.81.cn/content/2018-04/27/content_8017527.htm.

[5] "空天一体作战队临近空间侦察能力的体系需求分析" (Analysis of System Requirements of Air and Space Integrated Battle to Near Space Reconnaissance Capability), 许勇, 李大喜, 张强, 李小喜, *Journal of Academy of Armored Force Engineering* [装甲兵工程学院学报], Vol. 30, No.4., August 2016. pp. 14–15.

[6] "国产软件打破航空发动机单晶涡轮叶片研制国际垄断," *China Aviation News*, 30 March 2019. http://ep.cannews.com.cn/publish/zghkb7/html/1615/node_068795.html

[7] "航空发动机整体叶盘制造技术的变革创新!," *China Aviation News*, 18 October 2018. http://www.cannews.com.cn/2018/1018/183653.shtml

[8] "中国发动机全权限数字电子控制系统通过验收," Sina.com, 15 August 2003, http://mil.news.sina.com.cn/2003-08-15/143715.html; "姚华," *AVIC News*, 4 May 2010. http://www.cannews.com.cn/zghkb/html/2010-05/04/content_7066.htm

[9] "国外航空发动机分布式控制系统技术发展," *AVIC News*, 27 December 2011, http://www.cannews.com.cn/zghkb/html/2011-12/27/content_30087.htm

[10] "我国已掌握推力矢量关键技术" (China has Mastered Key Thrust Vector Technology), *S&T Daily* [科技日报], 7 November 2018, http://www.stdaily.com/kjrb/kjrbbm/2018-11/07/content_728406.shtml

[11] “外媒：中国霹雳-15 远程空空导弹试射成功,” 观察者, 24 September 2015, https://www.guancha.cn/military-affairs/2015_09_24_335481_s.shtml; “China successfully develops new-generation air-to-air missile,” *People's Daily Online*, 19 May 2011, http://en.people.cn/90001/90776/90786/7385767.html

[12] Jeffrey Lin and P.W. Singer, “PL-15 is China's best and baddest aerial weapon yet,” *Popular Science*, 22 September 2015, https://www.popsci.com/chinese-air-to-air-missile-hits-targets-spooks-usaf-general/

[13] “简氏：霹雳-15 导弹列装中国空军”, 观察者, 20 July 2017. https://www.guancha.cn/militaryaffairs/2017_07_20_419127.shtml

[14] "中国霹雳系列空空导弹发展历程," 兵器知识, 12 June 2010. http://mil.news.sina.com.cn/2010-06-12/1521596783.html

[15] Jeffrey Lin and P.W. Singer, “This new ramjet engine could triple the range of Chinese missiles”, *Popular Science*, 12 June 2017, https://www.popsci.com/chinas-new-ramjet-engine-triple-rangemissiles/#page-3