

Chapter 3

Development of China's Major Aviation Equipment

Jui-Min Hung*

I. Introduction

The 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China (the 14th Five-Year Plan) published in March 2021 classified the aerospace and aviation industry as one of the strategic and emerging sectors and the new pillar of China's industrial system.¹ This shows that aviation equipment is currently on the top of China's national agenda.² The technology in use or under development for such equipment underpins whether the PLA Air Force is able to smoothly migrate from the defensive position for its national territories to airland battles, both in offensive and defensive operations. In addition, as the PLA planes have significantly stepped up their harassment of Taiwan, it is also necessary to keep a close eye on their newest development in order to establish an effective response strategy. This chapter analyzes some of China's main aircraft, engines, and airborne weapon systems and assesses their development, influence, and outlook.

* Assistant Research Fellow, Division of Defense Strategy and Resources, Institute for National Defense and Security Research.

¹ "Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China," *Central People's Government of the People's Republic of China*, March 13, 2021, http://big5.www.gov.cn/gate/big5/www.gov.cn/xinwen/2021-03/13/content_5592681.htm.

² China refers to the People's Republic of China herein.

II. Development of Key Equipment

1. Main Aircraft Force

(1) J-20

The J-20 fighter was defined as the fifth generation of military aircraft during its debut in 2011, entered formal service in 2017, and is still under constant improvement by the Beijing government. In the adoption of the Electro-Optical Targeting System and the nose cone design with technology and design similar to those of the U.S. Air Force, F-22 and F-35, the J-20 fighter also came up with some unique technology, including an excellent capacity for its built-in fuel tank. In recent years, the main progress with the J-20 fighter has been the surface finish, including Low Observable (LO) technology and overall manufacturing quality, such as (pneumatic) actuators and intakes.³ However, the lag in the engine R&D makes it impossible for the J-20 fighter to perform super-cruise, and its radar cross-section (RCS) is also too high. While its rectangular faceted nozzle achieves stealth by reducing radar returns from the engine,⁴ it will be hard-pressed to achieve the Very Low Observable (VLO) standard before the completion of its own engine, WS-15.

There have been a small number of J-20 fighters produced. The 15 J-20 fighters at the 100th anniversary of the founding of the Communist Party on July 1, 2021 were the largest public parade to date.⁵ According to various data sources, there is no definite conclusion regarding its total numbers.⁶ It is generally believed to

³ Justin Bronk, “Russian and Chinese Combat Air Trends,” *Royal United Services Institute*, October 30, 2020, https://static.rusi.org/russian_and_chinese_combat_air_trends_whr_final_web_version.pdf p. 41.

⁴ “The Shorter the Engine, the More Powerful J-20? Breakthrough in Rectangular Faceted Nozzle to Reduce Infrared Radiation by 80%,” *Tencent*, November 18, 2020, <https://new.qq.com/omn/20201118/20201118A0I52I00.html>.

⁵ Ning-che Liu, “Celebrating the 100th Anniversary of the Founding of the Communist Party of China: 15 J-20 Fighters Debut in Large Numbers at Tiananmen Square,” *Ta Kung Pao*, July 1, 2021, <http://www.takungpao.com/news/232108/2021/0701/604195.html>.

⁶ Examples are relevant discussions: Hsi-fu Ou, “Chinese Communist Party Exaggerates Strengths of J-20,” *National Defense Security Real-time Assessment*, July 8, 2021, <https://ppt.cc/fvpGTx>; Lu Bo-Hua, “At Least 150 J-20 Fighters in Service, PLA Air Force Announces It Attains the Threshold as Strategic Aircrafts,” *China Times*, August 31, 2021, <https://www.chinatimes.com/realtimenews/20210831005816-260409?chdtv>.

be in the range of 24 to 150 fighters. There is not much public information on the J-20 fighters in live-fire exercises. Meanwhile, the question remains whether its technology is mature enough to engage in battles—perhaps why there have been only a small number of J-20 fighters produced to date.

(2) Y-20

Over the recent years, there have been attempts to remodel Y-20 transport aircraft into an aerial tanker Y-20U as the PLA's main force in order to provide air refueling by three aircraft to accommodate six to eight J-11 Series or J-20 fighters.⁷ The fuel volume each Y-20U can carry is three times larger than HY-6 aerial tankers. On the other hand, while the Il-78 has a similar fuel carrying capacity with Y-20U, the Y-20U's glide ratio is larger, given its supercritical wings which provide a better climb performance and greater fuel efficiency.⁸

Furthermore, the Y-20U's development is approaching its final stage, with the completion of the prototype's first flight in 2018. The aerial pictures at Xi'an Yanliang Airport on December 30, 2020 showed the parking of four Y-20U aircraft completely remodeled, which means that its remodeling plan has been completed or the quality is sufficient to achieve serial production.⁹ On September 3, 2021, pictures of Y-20U aircraft's training with J-16 fighters were taken.¹⁰ All these signs suggest that Y-20U has been gradually entering the PLA Air Force's military power.

⁷ Xiao Shan, "Successful Remodeling by China to Greatly Y-20 Aerial Tankers," *Groupe Radio France Internationale*, April 28, 2019, <https://ppt.cc/fQIMMx>.

⁸ "HY-6 Y-20U enlisted, enhancing PLA Air Force's remote warfare capability," *MP Headlines*, September 13, 2021, <https://min.news/zh-tw/military/b37960ae2e05a807c86bee45188539a9.html>.

⁹ Mike Yeo, "Satellite Images Suggest China's New Tanker Aircraft is Under Production," *Defense News*, February 18, 2021, <https://www.defensenews.com/global/asia-pacific/2021/02/18/satellite-images-suggest-chinas-new-tanker-aircraft-is-under-production/>.

¹⁰ Greg Waldron, "China's Y-20U Tanker Spotted Flying with Fighter," *Flight Global*, September 3, 2021, <https://www.flightglobal.com/defence/chinas-y-20u-tanker-spotted-flying-with-fighter/145332.article>.

2. Engines

(1) *WS-15*

The first batch of J-20 fighters produced in 2016 was equipped with AL-31FN Series 3—the modified version of Russia’s AL-31F engines—at a thrust of 137 kN. Despite China’s intention to push for the replacement of AL-31FN with 160-180 kN WS-15 engines for J-20 fighters as early as possible, the final test remains a hurdle. Hence, the J-20 fighter had to use the WS-10C engine as a transition.¹¹ As the improvement model of WS-10B, WS-10C has the thrust vector control capability and a thrust of 145 kN.¹² At the Zhuhai Airshow from September 28 to October 3, 2021, the J-20 fighter with “a Chinese heart” made its debut.¹³ While the Beijing officials did not specify which domestic engine is this Chinese heart, it is likely an indication of the near completion of the re-equipment of J-20 fighters with WS-10C.¹⁴ That said, WS-10C’s thrust is still behind the 156 kN F-119 engines for F-22 fighters and 190 kN F-135 engines for F-35 fighters. The requirement for WS-15 is rather urgent.

Furthermore, we can see China’s constant progress in the key technologies of engine production in recent years. For instance, while an engine’s turbine blades must resist strong heat and high temperatures, the turbine inlet temperature in the new generation engines, such as F-135, reaches 1,980 degrees Celsius. Special alloys must be used to withstand the working temperature above 1,000 degrees Celsius. After the rare metal rhenium was discovered in Shaanxi in 2010 for high-temperature alloys, the single crystal blades made with rhenium alloys reached

¹¹ Minnie Chan, “China Wants to Modify the Engines on its J-20 Stealth Fighter to Match the US’s F-22,” *Business Insider*, January 11, 2021, <https://www.businessinsider.com/china-modifies-j20-stealth-fighter-engine-to-match-us-f22-2021-1?r=US&IR=T>.

¹² Ning-che Liu, “Domestic Aviation Development Finally Takes Off, WS-10 Enters the 14-Ton Era, Remodeling of Multiple Aircrafts at the Same Time,” *HK01*, November 21, 2020, <https://www.gushiciku.cn/dl/0ln53/zh-tw>.

¹³ “How Big the Challenges to Overcome for Statement about “Chinese Heart” of J-20 Fighter?,” *Sina Military Section*, September 29, 2021, <https://mil.news.sina.com.cn/china/2021-09-29/doc-iktzscyx7084139.shtml>.

¹⁴ “As Closing Remarks for Zhuhai Airshow, Experts Comment on China’s New Weapons and UAVs under Development,” *Voice of America*, October 5, 2021, <https://www.voachinese.com/a/booming-Chinese-drone-industry-is-aiming-at-practical-military-defense-and-offense-20211005/6257705.html>.

the first-flight standard in 2017.¹⁵ In 2020, the Chinese media revealed that China is able to mass produce single-crystal blades,¹⁶ which indicates sufficient stability in quality—a big boost to the service life of WS-15. Furthermore, Cheng Ronghui, Chief Designer of WS-15, was listed at the top of the list of candidates for 2020 Military People of the Year¹⁷—an indirect validation of the meaningful development of WS-15 to date.

(2) *WS-20*

The PLA Air Force hopes to replace the Russia-made D-3 and its improved version, the WS-18 engine, with WS-20. Compared to D-30's bypass ratio of 1:2.24 and WS-18's bypass ratio of 3, WS-20's bypass ratio reaches 1:5. Currently, the development with WS-20 is smooth. On November 23, 2020, the Y-20 equipped with WS-20 completed its first flight.¹⁸ There has been subsequent increasing news flows about relevant tests.¹⁹ On July 14, 2021, the Aviation Industry Corporation of China's official Weibo posted a Y-20 carrying four big alcohol barrels, implying the start of the retrofit with WS-20.²⁰ At the 2021 Zhuhai Airshow, the Y-20 Chief Designer Tang Chang-Hong said that "Y-20 is equipped with a Chinese heart and has been going well",²¹ which is also a statement on the satisfaction of the WS-20 development.

¹⁵ "Superb New Materials for Chinese Aircraft Engines, Able to Hold Shape under 117 Tons of Weight," *Sina Military Section*, September 5, 2017, <http://mil.news.sina.com.cn/jssd/2017-09-05/doc-ifykqmrsv9836273.shtml>.

¹⁶ "Congratulations! China's First Volume Production of Single Crystal Blades for Aircrafts," *kknew.cc*, May 11, 2020, <https://kknews.cc/zh-sg/n/9vmgm4b.html>.

¹⁷ "WS-15 Chief Engineer at Top of Military Engineering Awards. Testimony of Great Success of WS-15," *Zhihu*, December 15, 2020, <https://zhuatlan.zhihu.com/p/337112609>.

¹⁸ Wen Chu, "Major Breakthrough: China's Y-20 with Domestic WS-20 Engines Takes First Flight," *MdEditor*, June 13, 2021, <https://ppt.cc/fbdShx>.

¹⁹ "Newest Photo of Y-20B Equipped with Four WS-20 Engines in Test Flight. Aviation "Heart Disease May Have Healed," *MdEditor*, July 19, 2021, <https://www.gushiciku.cn/dl/0zZ9G/zh-tw>.

²⁰ "Y-20B Likely to Be Officially Confirmed for Newly Changed Aircraft Engines of High Bypass Ratio Meeting Expectations," *Sina Military Section*, July 17, 2021, <https://mil.news.sina.com.cn/china/2021-07-17/doc-ikqciyzk6037298.shtml>.

²¹ "J-20 Fighter and Y-20 Installed with Chinese Hearts! Closeup at Aviation Exhibitions: Big Country, Heavy Weapons, Power of China," *CCTV International*, September 30, 2021, https://www.youtube.com/watch?v=75M9wdqKzEA&ab_channel=CCTV%E4%B8%AD%E6%96%87%E5%9B%BD%E9%99%85.

3. Airborne Weapon Systems

(1) *Anti-Radiation Missile (ARM)*

The two missiles hanging on the J-11BS’s side wing shown in the video released by the PLA Air Force in November 2020 are believed to be China’s most recently developed Anti-Radiation Missiles (ARMs), with the same features as China’s CM-102 ARM for exports and India’s Rudram-1 ARM.²² This suggests that the new ARM may be developed on the technological basis of the former. In addition, it adopts a Double-Pulse Solid Rocket Motor that matured on the PL-15 and has a range further than CM-102’s 100 km.²³

(2) *Air-to-air Missiles*

The PL-21 showcased in 2016 is the ultra-long-range air-to-air missile (AAM) at the forefront of R&D efforts. Similar to the PL-15, it is equipped with a Double-Pulse Solid Rocket Motor, whose combustion chamber has a diaphragm that divides incendiary agents into two independent ignition systems. Ignition timing for different systems is controlled by the airborne computer on the rocket. After the completion of the first pulse, the ignition for the second pulse can be determined according to actual requirements, which enables effective management of rocket fuels and increases flight distance. Meanwhile, the PL-21’s Active Radar Homing achieves independent guiding by emitting and receiving radar waves. It is said that the PL-21’s range already reaches 300 km or even 400 km,²⁴ which is a great improvement from the PL-15’s range of 200 km.

However, as the Chinese authority has never published information related to PL-21, how it achieved technological breakthroughs is closely watched. While a Double-Pulse Solid Rocket Motor increases the range, the solid propellant rocket

²² Thomas Newdick, “This May Be Our First Glimpse of China’s New Air-Launched Anti-Radiation Missile,” *The Warzone*, November 9, 2020, <https://www.thedrive.com/the-war-zone/37513/we-may-just-have-got-the-first-glimpse-of-chinas-new-air-launched-anti-radiation-missile>.

²³ “New Weapon for J-16D to Suppress S400 and Standard 6 System (Picture),” *Sina Military Section*, November 12, 2020, <https://www.cna.com.tw/news/firstnews/202103310114.aspx>.

²⁴ “With a Missile Length of Six Meters, Larger than J-20 Fighter’s Internal Weapon Bay, Can PL-21 Attain a Range of 400km?,” *Military Comments Online*, April 29, 2021, <https://club.6parkbbs.com/military/index.php?app=forum&act=threadview&tid=16369457>.

engine requires its own oxidant and fuels. The longer the range, the heavier the weight and the larger the size. This attribute is accompanied by greater complexity and higher costs.²⁵ In addition, the solid propellant rocket engine also affects the detection and strike of targets. Therefore, whether the PL-21 development is as reported by the Chinese media remains observed.

III. Battlefield Values and Impacts

1. Major Aircrafts

(1) *J-20*

Considering the limited number of the manufactured fifth generation, the PLA Air Force will rely on the fourth generation of fighters as its main force over the next few years. According to the report, “Military and Security Developments Involving the People’s Republic of China 2020”, submitted by the U.S. Department of Defense in September 2020 to the Congress, the PLA’s major fighters are J-10, J-11, and J-16, at a total number of over 800.²⁶

However, the small number of J-20 fighters are already playing a role in air defense by accompanying the four generations of fighters in the event of the enemy’s invasion of China’s airspace. The P-15-equipped J-20 poses a grave threat to the opponent’s intelligence, surveillance, and reconnaissance (ISR) capability. In addition, a better-performing built-in fuel tank strengthens its role as a long-range interceptor, allowing it to strike the approaching energy aircraft far from the homeland. This is a thorny problem for the U.S. Armed Forces, which rely on aerial tankers overseas air combats.²⁷

²⁵ “PL-20/PL-21,” *Global Security.org*, January 5, 2021, <https://www.globalsecurity.org/military/world/china/pl-21.htm>.

²⁶ Office of the Secretary of Defense, “Military and Security Developments Involving the People’s Republic of China 2020,” *U.S. Department of Defense*, September 1, 2020, <https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/2020-DOD-CHINAMILITARY-POWER-REPORT-FINAL.PDF>, pp. 50-51.

²⁷ Justin Bronk, “Russian and Chinese Combat Air Trends,” *Royal United Services Institute*, October 30, 2020, https://static.rusi.org/russian_and_chinese_combat_air_trends_whr_final_web_version.pdf, p. 41.

(2) *Y-20*

The Y-20U’s service can effectively boost the range and the operating radius of the PLA Air Force.²⁸ According to the Hong Kong media, the completion of each air refueling increases by 25-30% of the operating radius of the H-6N bomber and by 30-40% of the operating radius of the J-8 and J-10 fighter aircraft,²⁹ which implies a significant enhancement of the J-20 fighter’s air superiority in the West Pacific. With the air supply from Y-20U, the J-20 fighter can continue to cruise without worrying about fuels. Its operating radius is expected to lengthen from 1,700 km to 2,500 km.³⁰ In the face of the U.S. Armed Forces fleeing from the First Island Chain and the Second Island Chain during conflicts at the Taiwan Strait, the J-20 fighter will be able to strike out by intercepting to ensure air dominance during the invasion of Taiwan.

2. Engines

(1) *WS-15*

The lag in the WS-15 development means the J-20 fighter has no adequate power. Under this circumstance, thrust vector control is a liability because it increases the fighter’s weight.³¹ While the retrofit with WS-10C improves the problem of insufficient thrust, the J-20 fighter still cannot achieve a super-cruise without an afterburner. Until the testing with WS-15 is completed, the J-20 remains unable to fully exercise its performance as a fifth-generation fighter.

(2) *WS-20*

The installation of WS-20 provides two benefits to Y-20. First, Y20 can

²⁸ Hsi-fu Ou, “China’s Aerial Tanker Fleet,” *National Defense Security Real-Time Assessment*, April 28, 2021, <https://ppt.cc/flwLWx>.

²⁹ “Strongest Protection- H-6U Refueling for All Air Space and Air Force’s Strengths up by Folds,” *Ta Kung Pao*, April 19, 2021, <http://www.takungpao.com.hk/news/232108/2021/0419/576130.html>.

³⁰ “First Picture of Air Refuelling of J-20 Fighter Released by Chinese Military, Implying Combats Extended to Guam,” *Radio France Internationale*, November 13, 2020, <https://ppt.cc/fwoYkx>.

³¹ Jamie Hunter, “China’s Enhanced J-20B Stealth Fighter May Arrive Soon, Here’s What It Could Include,” *The Warzone*, July 20, 2020, <https://www.thedrive.com/the-war-zone/34990/chinas-enhanced-j-20b-stealth-fighter-may-arrive-soon-heres-what-it-could-include>.

enter mass production without worrying about insufficient engines. Estimates from Chinese experts based on the requirements of battles and rescue missions demonstrate that the PLA currently needs to equip 400 Y-20 aircraft.³² As the delivery of D-30KP-2 engines from Russia is slow, there were embarrassing situations when no engine was available to Y-20.³³

The WS-20's quality reliability implies that Beijing can fully control the Y-20's supply chain. Further, it is possible to construct a strategic transport force based on Y-20 according to actual requirements. Moreover, Y-20 can fully perform its capabilities. A stronger thrust can increase the effective loading from 50 tons to 66 tons and make it possible to ship main equipment, such as Type 99 Main Battle Tanks previously not manageable by Il-76. The improvement in fuel consumption extends the range and the loiter time,³⁴ which empowers Y-20 to undertake strategic transport missions for further distances and achieve goals for the air force.

3. Airborne Weapon Systems

(1) *Anti-Radiation Missile (ARM)*

China's progress in anti-radiation missiles (ARMs) will have tremendous benefits on the offshore battles for its air force. This is critical considering the enhanced air force capabilities in recent years among China's neighboring countries with strained ties. India's purchase of S-400 missile systems from Russia is one example, whose delivery is expected at the end of 2021. Meanwhile, the delivery and deployment of Pac-2 performance enhancements and Pac-3 missiles purchased were completed in Taiwan. The PAC-3 Missile Segment Enhancement

³² "Y-20 Becomes One of World's Top 10 Strategic Transport Aircrafts. Over 400 in Demand," *HK 01*, January 8, 2021, <https://ppt.cc/flqlix>.

³³ Chia-hsin Hsieh, "Chinese Military Magazine Says Only 40 Y-20 Aircrafts Can Be Produced with Engines Available. In Urgent Need of Domestically Developed Engines," *Sina Military Section*, July 26, 2014, <https://ppt.cc/flqlix>.

³⁴ "Newest Photo of Y-20B Equipped with Four WS-20 Engines in Test Flight. Aviation "Heart Disease May Have Healed," *MdEditor*, July 19, 2021, <https://www.gushiciku.cn/dl/0zZ9G/zh-tw>.

(MSE) is scheduled for completion in 2026.³⁵ By working with the J-16D electronic warfighter, it will be able to effectively destroy the aforesaid anti-aircraft missiles.

(2) *Air-to-air missile*

The PL-21’s length of nearly six meters makes it impossible to be hung on the J-20 fighter’s internal weapon bay, and it would expose the J-20 fighter if hung outside. It is generally believed that the PL-21 would be hung on the J-16 for long-range strikes. The PL-21’s ultra-long-range strike capability can play a pivotal role in the destruction of business intelligence and logistic supplies of the enemy’s air force system. Air Early Warning (AEW) airplanes and aerial tankers usually operate away from hot war zones, up to 300 km away. Therefore, the PL-21’s successful development with a range of 400 km can effectively attack high-value targets, such as Air Early Warning (AEW) airplanes and aerial tankers, and strongly enhance the PLA’s anti-access/ area denial (A2/ AD) capabilities.

IV. Conclusion

As far as the PLA Air Force’s overall development in aviation equipment is concerned, the shift from the defense of national territories to airland battles—both for offensive and defensive operations—indicates the intention of the new cohort of leaders in Beijing for the PLA Air Force to go out and go big in offshore attack and defense missions. The recent technological reforms and breakthroughs at different levels in fighters, transport aircraft, ARMs, and air-to-air missiles enable the PLA Air Force to fly from defense to offense. China’s stronger remote warfare capabilities are an increasing threat to the neighboring countries in the Indo-Pacific. The growing intensity of Chinese aircraft harassing Taiwan is a case in point. It is meant to intimidate Taiwan and demonstrate the rising strengths of the PLA Air

³⁵ “R.O.C. Armed Force Confirmed Purchase of PAC-3 Missile Segment Enhancement (MSE) from U.S. Armed Forces. Deployment to Be Completed in 2026,” *Central News Agency*, March 31, 2021, <https://www.cna.com.tw/news/firstnews/202103310114.aspx>.

Force.

That said, Beijing is still faced with many challenges, and engines have been the Achilles heel of the PLA Air Force. The slowness in the engine R&D prevents many aircraft under development from fulfilling the full capabilities and indirectly undermines the utilization benefits of airborne weapons. The Chinese government's strong emphasis on engines can be seen in many policies. However, China is still behind the U.S. and European countries in this regard. Whether it can overcome the long list of problems will determine the strategic development of China's air force over the next few years.

