航空 航天

CHINA AEROSPACE STUDIES INSTITUTE

Sino-Russian Defense Cooperation's Impact on Chinese Aerospace Research, Development and Acquisition (RD&A) Enterprise

China Partner Country Pavilion at the Moscow Air Show--MAKS 2019

ANDREW W. HULL AND DAVID R. MARKOV

Printed in the United States of America
by the China Aerospace Studies Institute
ISBN 9798782516550

To request additional copies, please direct inquiries to
Director, China Aerospace Studies Institute,
Air University, 55 Lemay Plaza, Montgomery, AL 36112

E-mail: Director@CASI-Research.ORG
Web: http://www.airuniversity.af.mil/CASI
https://twitter.com/CASI_Research @CASI_Research
https://www.facebook.com/CASI.Research.Org
https://www.linkedin.com/company/11049011

China Aerospace Studies Institute

CASI's mission is to advance the understanding of the strategy, doctrine, operating concepts, capabilities, personnel, training, organization, of China's aerospace forces and the civilian and commercial infrastructure that supports them.

CASI supports the Secretary, Chief of Staff of the Air Force, the Chief of Space Operations, and other senior Air and Space leaders. CASI provides expert research and analysis supporting decision and policy makers in the Department of Defense and across the U.S. government. CASI can support the full range of units and organizations across the USAF, USSF, and the DoD. CASI accomplishes its mission through conducting the following activities:

- CASI primarily conducts open-source native-language research supporting its five main topic areas.
- CASI conducts conferences, workshops, roundtables, subject matter expert panels, and senior leader discussions to further its mission. CASI personnel attend such events, government, academic, and public, in support of its research and outreach efforts.
- CASI publishes research findings and papers, journal articles, monographs, and edited volumes for both public and government-only distribution as appropriate.
- 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.
- CASI maintains the ability to support senior leaders and policy decision makers across the full spectrum of topics and projects at all levels, related to Chinese aerospace.

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

We should not forget that in the "Era of Great Power Competition," the United States has two peer "Strategic Competitors" and several others with whom we compete. When our two largest competitors, namely the People's Republic of China and the Russian Federation, cooperate toward their common strategic goals, the United States, our allies, and partners, should pay close attention. Although there is no great deep-seated trust between them, when their interests align, China and Russia are more than happy to cooperate, particularly when it means presenting a greater challenge to the U.S. and our allies and partners.

China and Russia are prioritizing joint technological cooperation in their respective aerospace sectors, and they see bilateral technical cooperation as a path to accelerate progress, overcome technological limitations, and find workarounds for Western sanctions on exporting defense and dual-use technologies.

This study examines the nature of Sino-Russian technical cooperation in defense and dual-use aerospace sectors, including arms sales, joint research, and development of weapons systems, technology transfers, and sharing of technical knowledge. In doing so, it identifies prominent organizations on both sides involved in technical cooperation, and it discusses the potential impacts of Sino-Russia cooperation for the United States.

Dr. Brendan S. Mulvaney

Director, China Aerospace Studies Institute

Table of Contents

Introduction, Approach, Sources, and Observations on the Impact of COVID-19 4

Approach 4

Sources 4

Observations on the Impact of COVID-19 on Sino-Russian Defense RD&A Cooperation 5

History Of Sino-Russian Defense Cooperation 8

Legacy of Cooperation: 1949-1991 8

Reborn Cooperation: 1992-2010 9

Continuing Cooperation and Emerging Competition: 2011-2021 14

Scale of Military-Related Acquisition (Hardware and Components) 42

Russian exports of military and dual-use equipment to China 42

Organizations and Types of Cooperative Activities 44

Research, Development, and Testing 44

Conferences, Forums, Dialogs, and Seminars 55

Production and Manufacturing 60

Organizations Seeking Sales and Acquisition Opportunities 61

Impacts of the Defense and Dual-Use Cooperative Relationship 89

Impacts on China, Russia, and the United States 89

APPENDIX A: Russian Aerospace Weapon Systems and Components Delivered to The Chinese PLAAF: 1991 to 2020 96

APPENDIX B: Chinese Organizations Involved in Cooperative R&D Activities with Russia .. 99

APPENDIX C: Russian Organizations Involved in Cooperative R&D Activities with China . 101

ENDNOTES 102

Introduction, Approach, Sources, and Observations on the Impact of COVID-19

Approach

The paper has four main topics: The first is a narrative overview of the history of Sino-Russian military-technical cooperation divided into three periods: (1) 1949 to 1991, (2) 1992 to 2010, and (3) 2011 to present. Each period has a distinctive character and unifying underlying theme. These broad-brush historical narratives describe the evolution of relations and critical events that shaped the course and character of the period. Within the first topic is a deeper look from 2011 to present, which provides illustrative vignettes or mini-case studies of specific instances of defense-technical cooperation (e.g., sale of Su-35 multi-role fighters, national missile early warning system) and Chinese and Russian presence at each other's international aerospace exhibitions. The next topic presents the defense trade volume representative of the acquisition of military-related systems and dual-use equipment from Russia to China and vice versa. The third topic identifies and describes individual Chinese and Russian organizations engaged in the following types of cooperative defense-oriented activities: (1) research, development, and testing, (2) forums, dialogs, and seminar, (3) production and manufacturing, (4) sales and acquisition, and (5) education and training. The final topic discusses the implications of the Sino-Russia defense cooperation for the United States and the near-, medium-, and long-term trends for Sino-Russia defense cooperation.

Finally, three appendices are included that provide listings of Chinese and Russian R&D companies as well as tables of all Russian weapon systems sold to China from 1991 to 2021:

- Appendix A: Russian Aerospace Weapon Systems and Components Delivered to the Chinese PLAAF: 1991 to 2020
- Appendix B: Chinese Organizations Involved in Cooperative R&D Activities with Russia
- Appendix C: Russian Organizations Involved in Cooperative R&D Activities with China

Sources

Research for this paper drew from three main sources. First was the personal experience of the authors. They have attended international arms exhibitions in Russia since 1992 and in China since 2004. At these exhibitions, the authors could see equipment being marketed by the Russians to the Chinese and vice versa, and where we also acquired technical data from marketing brochures and hardware/component displays provided by Russian and Chinese defense industries. The second drew insights from Chinese and Russian language open-source materials. Such sources included official Russian and Chinese manufacturers' websites, Chinese and Russian-language media and professional publications, and Internet military forums and blog sites. The authors also used Russian, Chinese, and English-language publications written by seasoned military observers and defense specialists. The final source was Western analysts with an established track record of

studying the interrelationships of China and Russia, with a particular focus on those interactions taking place between research, development, and acquisition (RD&A) enterprises.

Observations on the Impact of COVID-19 on Sino-Russian Defense RD&A Cooperation

This paper provides a framework to look at the various efforts and defense cooperation that have taken place between Chinese and Russian RD&A enterprises from 1991 to 2021. Since the outbreak of the worldwide COVID-19 outbreak, like all other economic activities worldwide, Sino-Russian defense RD&A cooperation has significantly slowed since the health crisis began roughly in January 2019 and continued in some fashion through May 2021.

The National Interest details numerous impacts of COVID-19 on China in 2021 that provide insights on the disruptive nature of the pandemic on the Chinese defense industry: [1]

- *"The disruption that COVID-2019 coronavirus has inflicted on China's industry is well documented. Wuhan, a major industrial center, was still in lockdown as of early March 2020. Many factories have gone to a standstill, with major effects on the supply of goods around the world. However, less talked about is the effect the coronavirus has had on the Chinese military industry. While this is understandable, given how China has restricted information about the coronavirus's effects and the general opacity of the Chinese military industry, some information has come out."* [2]

- *"Evidently the effect on the military industry is waning, as announcements of resumption of production of certain items have come out. On February 21[2021], Shenyang Aircraft Corporation announced that it was resuming production of J-15 fighters after a short pause due to coronavirus fears. This follows announcements earlier that other aviation industry firms had resumed full production. Measures against further coronavirus infections were also included in speeches in which productions were resumed, including regular temperature checks among the workforce. In other sectors, such as shipbuilding, major efforts have taken place to resume full pace production, including the use of reserve manpower to replace those who are sick.* "[3]

- *"The implications of the minimal impact, if true, are interesting. It suggests that China's military industry's supply chain is relatively insulated from that used to supply the factories that produce goods for export. Articles discussing the start of Wuhan's civilian industry are not optimistic, saying materials may run out as other sectors of the Chinese economy remain disrupted. Chinese authorities appear to be aware of this, and have initiated pushes to restart production from the bottom up in military industries. A quote provided to the South China Morning Post reinforces this: "Other state-owned enterprises like steel plants have also resumed production, and it's impossible for the aircraft and naval industry to slow up production once the heat-treating furnaces are turned on."* [4]

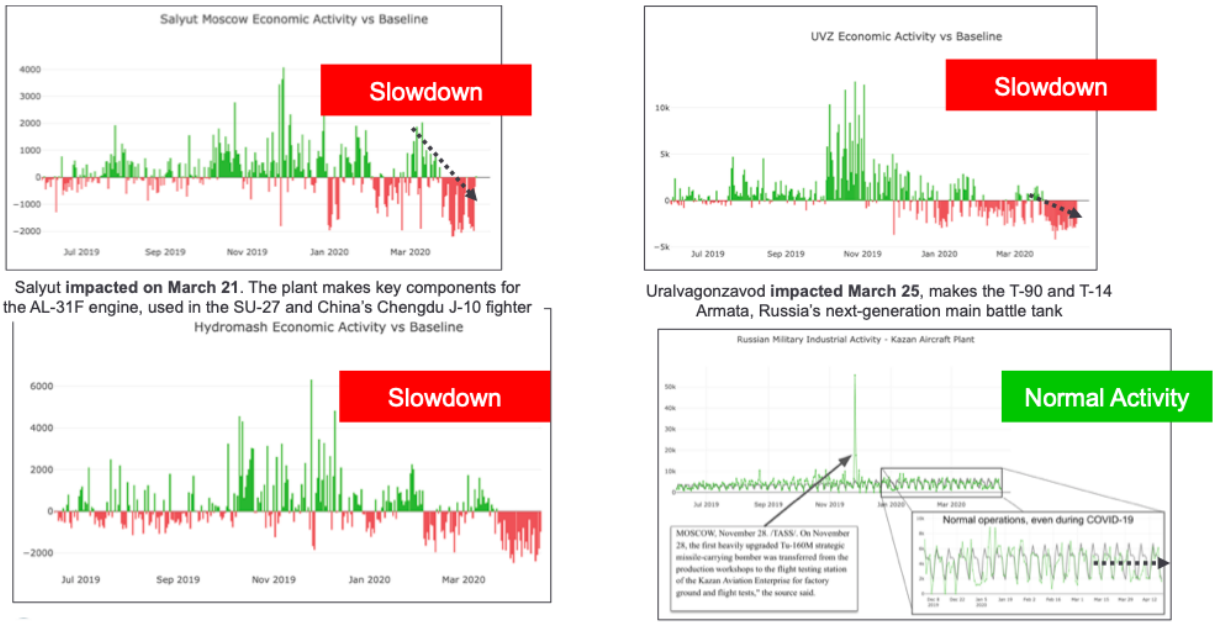
- *"… the outbreak of COVID-19 is slowing the progress of the CR929 project. A two-week quarantine shut the Shanghai headquarters of CRAIC. Also, travel between the two countries [China and Russia] has been restricted to prevent the transmission of the virus. According to Valery Okulov, general director of United Aircraft Corporation (UAC), work has resumed with direct communications between engineers being replaced by remote conference formats."*[5]

In contrast to China's apparent limited success in adapting to this new normal, according to *Defense One* in 2020, it reported impacts have been more dramatic and appear to be more long-term for the Russian defense industry.[6] COVID-19 has directly impacted human capital needed in Russian aerospace and ground force vehicle defense industries:

- *"Salyut, which makes parts for Russia's Su-27 and China's Chengdu J-10 fighter jets, has 2,000 fewer people in the factory, as indicated by cell phone pings."*[7]

- *Hydromash, which makes landing gear parts, hydraulics, and cylinders for the Su-30MK and Su-34 fighters, has more than 2,000 fewer people."* [8]

- *Uralvagonzavod, which makes parts for the T-90 and the T-14 Armata tanks, had 3,500 fewer people."* [9]



Salyut **impacted on March 21**. The plant makes key components for the AL-31F engine, used in the SU-27 and China's Chengdu J-10 fighter

Uralvagonzavod **impacted March 25**, makes the T-90 and T-14 Armata, Russia's next-generation main battle tank

Hydromash **slowdown starts March 21**, for development of landing gear / hydraulic units / cylinders for SU-30MK and SU-34

No significant drop-off of activity from COVID-19 at Kazan Aircraft Plant (makes supersonic strategic bombers)

Key Russian Defense Manufacturing Economic Activity Slowdowns: Salyut Moscow (upper left) and Uralvagonzavod--UVZ (upper right); Hydromash (lower left) and Kazan Aircraft Plant (lower right) (Orbital Insight) [10]

COVID-19 has undoubtedly had impacts, and those mentioned above may have impacted defense programs, including Sino-Russian defense and dual-use collaborations. The bottom line is that China is staying in business while COVID-19 has more severely impacted Russia's defense industry, particularly regarding human capital.[11] Because Russia has been affected more deeply than China, one can expect some delays in defense programs for both countries, including those where both countries are cooperating.

However, it now appears with the rollout of many vaccines globally that an attempt is being made to resume regular international commerce and bi-lateral ties between China and Russia. Two significant events scheduled for 2021 will portend the current relationship between these two partner countries. The first is the Moscow Air Show, also known as MAKS 2021, which will take place from July 14-19, 2021, in Moscow, Russia, and the second being Airshow China 2021, being held from September 28 to October 3, 2021, in Zhuhai, China. These two events will reveal much about the current state of Sino-Russian defense cooperative programs and what delays imposed by the COVID-19 pandemic will have on their timeframes to research, develop, produce, and field these joint efforts.

History Of Sino-Russian Defense Cooperation

Legacy of Cooperation: 1949-1991

Sino-Soviet military-technical cooperation began shortly after the two countries entered a treaty of alliance in 1950. The pace of military-technical cooperation accelerated once the Korean War began with the Soviet Union sending weapons to China. By the mid-1950s, the Soviet Union was delivering significant amounts of weapons, military technology, and even technical assistance to construct newly established Chinese defense enterprises. Relations declined, however, in the late 1950s, virtually collapsing in the early 1960s. Armed Chinese-Russian clashes near Damansky (Zhenbao) Island on the Ussuri (Wusuli) river in March 1969 marked the low point in relations and led to a prolonged freeze in Sino-Soviet relations, including military-technical cooperation and arms sales. A Sino-Soviet Border Agreement was signed in 1991 after several years of negotiations and ratified in 1992. After this agreement, military cooperation resumed between the two countries.[12]

Suspension of Sino-Soviet military-technical cooperation had minimal impact on Chinese military R&D and production because of the Great Proletarian Cultural Revolution, which ran from May 1966 to October 1976. During that time, Chinese defense R&D programs, except for the nuclear program, were decimated as tens of thousands of scientists and engineers were sent for political reeducation and proletarian class consciousness-raising through manual labor. The Cultural Revolution led to widespread and often violent disruption of defense production as millions of young workers were mobilized to join the Red Guards to conduct political campaigns in factories to exchange revolutionary experiences and discuss grievances. The education system was disrupted and led to the loss of an entire generation of scientists and engineers.

In the late 1980s, the Central Military Commission (CMC) and its Vice-Chairman Liu Huaqing considered the possibility of importing Russian military equipment to modernize the PLA, especially the Air Force, and initiated discussions about doing so with the Soviet Union. These discussions did not bear fruit. The Chinese concluded the Russian asking price for military equipment was too high and that the Russians were trying to sell "obviously out of date" weapons and military equipment.[13]

However, Chinese interest in military-technical cooperation with Russia revived after the West imposed sanctions and embargos on transferring military and dual-use technologies to China following the Tiananmen Square Incident in 1989. The Aviation and Aerospace Industry Electronic Products Division of the PLA Air Force held a meeting that concluded that military-technical cooperation with the Russian aviation industry was a priority and encouraged sending a delegation to the Soviet Union. Shortly afterward, the Chinese minister responsible for the aviation industry led a delegation to the Soviet Union. Upon his return, the delegation reported the level of Soviet technology was very high (comparable to American technology), and talks with the Russians were "constructive, friendly and open." The delegation then proposed "using the opportunity to obtain the necessary advanced technology from the Soviet Union."[14]

A delegation from the Chinese Commission of Science, Technology, and Industry next visited the Soviet Union in March 1990 to investigate the feasibility of purchasing Russian weapons and military equipment. A high-ranking Chinese governmental delegation returned to the Soviet Union in May 1990 and proposed creating bilateral cooperation in the aviation sector. One of the May meeting outcomes was a recommendation to establish a joint working group on military-technical cooperation. Subsequently, the proposed working group was created, and one of its first actions was to consider the possibility of China purchasing Su-27s or MiG-29s and related production technologies.[15]

The Chinese CMC deliberated the possibility of military-technical cooperation and then sent another delegation to the Soviet Union later in 1990 to learn more about the tactical and technical performance of the Su-27. Two years of negotiations took place by China to purchase Su-27 fighters and the rights to produce those aircraft in China. Even after the agreement was signed, however, the Chinese worried the deal would not be implemented because of "dramatic political changes in the Soviet Union." The Chinese sought assurances from "the highest levels" of the Soviet Government that all transactions would be realized.[16]

Overall, the Chinese and Russian relationship in this period was driven by Russia's desperation to keep its defense industrial base alive in the collapsing Soviet Union and China's desperation to close the wide gap between its military capabilities and those of the United States. Indeed, the performance of United States forces in Operation Desert Storm in 1991 quickly and decisively defeating Iraqi forces (which had more battle experience and somewhat greater technical sophistication than the Chinese People's Liberation Army) shocked the leaders of the Chinese Communist Party and PLA into a realization of the width of military-technical gap vis-a-vis the United States.[17] The other decisive factor fueling the relationship was the growing ability of the Chinese economy to finance massive defense spending on equipment upgrades and force modernization. Some Russian sources characterize Chinese behavior in this period as "introduction, digestion, and copying" of acquired Russian military technology.[18]

Reborn Cooperation: 1992-2010

China took advantage of better Sino-Russian relations and the collapse of the Soviet Union in 1992 to resume wide-ranging and large-scale military-technical cooperation. China also took advantage of the Russian defense industry's eagerness to export even the most advanced military technologies to stay viable after the drastic decline in domestic orders. For many Russian defense enterprises, it was either export or die. Exports to China were also crucial for the Russian military because they kept industrial production lines open to supplying Russian defense minimal production needs during the early 1990s (see Appendix A: Russian Aerospace Weapon Systems and Components Delivered to the Chinese PLAAF: 1991 to 2020).

Three primary considerations drove Chinese interest in acquiring Russian military systems at the beginning of the 1990s:[19]

- Russia was one of the few countries willing to sell arms to China after the embargo was lifted;

- New Russian weapons were compatible with the PLA technology of the Soviet era; and

- The relative cheapness of weapons in comparison with Western models.

The period began with China and Russia signing in 1992 the Military-Technical Cooperation Agreement that established a legal framework and institutionalized underpinning for across-the-board military-technical cooperation.[20] The two countries then created the Mixed Intergovernmental Commission on Military-Technical Cooperation which became the centerpiece for bilateral cooperation efforts. The Intergovernmental Commission's annual meeting was co-chaired by the Vice-Chairman of China's CMC and Russia's Defense Minister.[21] The signing of the Intergovernmental Commission also marked the beginning of a period of massive Russian arms imports, license production, and intellectual property transfers to China that lasted until 2006.

The China Aviation Research Institute claims it served as "the external window" of China's aviation science and technology community to Russia from the late 1980s through the early 1990s. In that role, the China Aviation Research Institute organized and coordinated Sino-Soviet personnel exchanges and technical cooperation matters in the aviation science and technology circles. The Institute's activities included introducing and dispatching experts, organizing academic and technical exchange seminars, and promoting cooperation in scientific and technological research projects.[22]

A representative of the Russian Kamov Design [helicopter] Bureau told the *Canva Air Defense* magazine that Bureau made a significant contribution to developing the Chinese W-10 / WZ-10 attack helicopter based on Kamov Project 941, explicitly designed to meet Chinese requirements. "Kamov Design Bureau and the Chinese side created a joint design group and worked on Project 941 for about 2.5 years beginning in 1995. A drawing catalog has been created. The main technical requirements - weight and dimensions - were put forward by the Chinese side. KB Kamov carried out design work under these parameters," according to a representative of Kamov.[23]

In a 2013 interview with *Flight International* at the Heli-EXPO in 2013, Sergei Mikheyev, General Designer of the Kamov [helicopter] Design Bureau, claimed, "They gave us the weight we wanted, we discussed the preliminary specifications, then we signed a contract and fulfilled it." Kamov also conducted wind tunnel tests of a model of the design. The project was not publicly acknowledged at the time for "obvious reasons," according to Mikheyev. He then admitted subsequent work on the helicopter took place without the participation of the Russian side."[24] China denied the Russian claim and insisted the design was wholly indigenous. This claim led to a dispute between Kamov and China over intellectual property rights to the helicopter.

Comparison of Russian Project 941 and Chinese Z-10 Helicopter Designs[25]

The watershed event of the period was Russia agreeing to transfer of Su-27 technology, selling assembly lines, and issuing a license for Su-27 to assemble in China. Russians familiar with the deal have told the authors that Sukhoi offered to sell more than a license to manufacture. Sukhoi also wanted to provide technical know-how on setting put the production line and provide Russian-made tooling. China declined, saying they had considerable experience producing fighter aircraft believing that manufacturing Su-27s could not be much more difficult. The Chinese also declined to purchase Russian tooling, saying they already had state-of-the-art tooling, much of it of Western origin.

The Chinese aircraft industry quickly ran into difficulties trying to produce Su-27s and turned to Sukhoi for assistance. Sukhoi responded by showing the Chinese how to organize the production process and providing Russian-made tooling. The authors were also told that the Chinese were disappointed in the initial Su-27 performance from Russia. Sukhoi representatives investigated Chinese claims and found that the problems were not technical deficiencies of the aircraft. Instead, the People's Liberation Army Air Force (PLAAF) assigned the first pilots based on political criteria rather than posting the most technically proficient pilots. ***These two stories offer important lessons. Transferring Russian defense technology to China can be more complicated than it first appears to be. Sometimes the Chinese have trouble translating transferred technology into production capabilities. Also, it is not always easy to transition newly produced systems into the force. Therefore, Western observers need to be somewhat careful in assessing the possible impact on the U.S-Chinese military balance offered to the Chinese by Russian technology transfers.***

The relationship, however, then cooled significantly. There were no significant sales of complete systems between 2006 and 2010. Another sign of the times was the failure of the 2006 and 2007 annual meetings of the Mixed Intergovernmental Commission on Military-Technical Cooperation.[26] The precipitating event was probably when Shenyang Aircraft Corporation started producing and marketing an unauthorized, reverse-engineered version of the Su-27 in 2007 called the J-11. Chinese production and marketing of the J-11 as an indigenous aircraft sparked

considerable wrangling with the Russians about the theft of intellectual property and Russian concern for minimizing intellectual property losses in the future.

The Russians also worried that the Chinese would begin to undercut Russian aircraft exports based on price. Russian detractors of arms exports to China raised other objections, including: (1) China was dictating financial terms often forcing firms to sell at reduced prices, (2) insisting on paying with barter rather than cash, (3) income from sales often did not flow back into the industry because of managerial and government corruption, and (4) defense firms had far too much influence in deciding what systems were to be exported emphasizing economic considerations rather than strategic political factors.[27] Some members of the Russian State Duma, academia, and the media also expressed concern about the security threat posed by a more assertive Chinese military.[28]

Chinese Shenyang J-11 Fighter Developed from the Russian Su-27 Flanker[29]

The Chinese side, too, was upset by Russian pricing policies for military equipment and the inadequate maintenance record of equipment already purchased.[30] Each country viewed the issue of price from its point of advantage. The Chinese thought the Russians were charging too much, whereas some Russians thought China was depressing the prices of military exports.

Relations began improving in 2008 with Russia and China signing the Agreement of Intellectual Property in Military-Technical Cooperation which somewhat relieved Russian concerns about Chinese intellectual property theft. (Russian concern over theft of intellectual property and unlicensed copying of Russian equipment would remain a factor for a long-time afterward and is still a significant consideration when Russia evaluates military technology transfers to China.) One sign of improving relations was the renewal of annual meetings of the Mixed Intergovernmental Commission on Military-Technical Cooperation in 2008.[31]

The Russians were right to remain concerned. Rostec's head of projects on intellectual property complained to the *TASS* state news agency in December 2019 about massive unauthorized copying by China. According to Rostec's Yevgeny Livadny: "The difficult situation with unauthorized copying of our equipment abroad: over the past 17 years [recorded] more than 500 cases of such copying. Only in China: aircraft engines, Sukhoi aircraft, carrier-based fighters, air defense systems, MANPADS, Pantsir analogs – all of it's copied."[32] Rosoboronexport announced in October 2020 that it was creating a consulting group for the protection of rights to the results of intellectual activity in the framework of military-technical cooperation.

Starting in 2009 and running through 2019, the Chinese Academy of Aeronautics and the Russian Central Academy of Aerodynamics (TsAGI) jointly organized six Chinese-Russian aviation science and technology academic exchanges discussing topics such as aerodynamics, structure strength, aeroacoustics, flight mechanics and safety, test methods, materials, and other fundamental issues in aviation science. In total, more than 227 Chinese and Russian papers were presented, and more than 500 Chinese and Russian experts participated in exchanges over that time.[33]

TsAGI and Chinese Academy of Aerospace Aerodynamics (CAAA) Hold Meeting During MAKS 2019[34]

Even though military-technical cooperation resumed, massive sales of Russian weapons to China no longer took place for the final years of the period (see Appendix A). Russian analyst Andrey Yurievich Pavlov asserts that China's share in Russian defense exports declined from about 70% in 1997 (the peak of Russian exports) to 40% in 2006 and further to only 17 to 19% afterward.[35] The character of Russian exports to China also changed from major systems to "aggregates" such as aircraft engines and into supporting systems.[36] Although the majority of advanced Soviet arms and military equipment became available for China following the disintegration of the Soviet Union, Chinese imports for the entire period concentrated on missile, aviation, and naval systems.[37] The

Chinese were sufficiently confident in their domestic research, development, and production capabilities to forego important ground forces equipment.

Declining purchases of weapons were also due to changing Chinese priorities. Increasingly the Chinese preferred to import technology so it could produce weapons rather than purchase them. Further, the Chinese strategy for acquiring technology and know-how centered on people-to-people interaction. Large numbers of Russian scientists and engineers worked in Chinese design bureaus and defense plants. Large numbers of Chinese scientists and military officers trained in Russian facilities and military academies, reminiscent of the early years of Sino-Soviet cooperation.[38]

Continuing Cooperation and Emerging Competition: 2011-2021

Sino-Russian military-technical cooperation changed considerably during this period becoming a more reciprocal and interdependent relationship (see Appendix B and C). Several factors brought about changes. One of the most important was Western sanctions following Russia's annexation of Crimea, which cut off Russian access to many defense industrial tools and dual-use components. Russia also conducted a strategic assessment of the threat posed by transferring advanced military technologies to China. A Russian strategic policy review in 2014 concluded that "the military-strategic threat that China posed to Russia was severely overblown."[39] Despite this conclusion, concern about licensed Chinese copying continued to be a significant issue in many deals.

The Russian strategic review also partially ameliorated Russia's concerns over Chinese intellectual property theft and illegal reverse-engineering of advanced Russian military technologies because many of the military technologies allegedly stolen from Moscow in the 1990s were actually developed by cash-strapped Russian companies contracts with China's defense firms.[40] The assessment also concluded that "China's military industry sector was far more advanced than previously hoped" and would reach a point within a decade where China could develop the same weapons systems Moscow hoped to sell to Beijing, thereby reducing the risks to Russia's defense industry posed by Chinese reverse-engineering of Russian weapons systems.[41] These factors resulted in a renewed willingness to sell advanced technology military systems to China.

Kommersant, a Russian national daily newspaper devoted to politics and business issues, offered an even harsher rationale for the increasing willingness for Russia to supply high-tech weapons to China during this period:[42]

> ***The number of technologies that are of interest to China is diminishing every year. Most likely, the PRC's scientific and technical backwardness will be overcome within the next decade.*** *Apparently, this is precisely the reason for the lifting of restrictions on cooperation with Beijing in recent years: Moscow understands that this is the last chance to capitalize on the remnants of the Soviet legacy. After its potential is exhausted, cooperation will finally move from the field of arms sales to the sphere of scientific and technical cooperation, space, cyber*

security, and educational projects. On all these issues, Moscow and Beijing defend similar positions on the world stage.

- **Su-35 Multi-Role Fighter (2011 to 2019)**

Russia first displayed the Su-35 in China at the Zhuhai Air Show, also called AirShow China 2008, where Chinese generals (including General Xu Qiliang, then commander of the Chinese Air Force) asked Sukhoi company representatives' details about the aircraft. "In 2011, China expressed its intention to purchase a certain number of the aforementioned aircraft and made corresponding suggestions to us." according to Fu Ming, deputy director of the Russian Federal Military-Technical Cooperation Agency.[43] China and Russia signed a preliminary agreement and negotiated the technical and financial terms of the transaction over the following three years. Negotiations stretch out because there were many contentious points of disagreement between the two sides.[44] The final contract was signed in November 2015.

Chinese Su-35 Multi-Role Fighter[45]

"A heated debate" broke out among local Chinese military experts regarding the desirability of China buying Su-35s shortly after the purchase was announced.[46] The debate resurfaced in 2019 when the news of a possible second purchase became public. Some Chinese commentators argued domestic Chinese fighters were more capable than Russian Su-35s. Some Chinese military experts said China "does not need to learn anything more from Russia technically" and because the Su-35 "cannot compare with the most advanced fight generation stealth aircraft such as China's J-20."[47] Military commentator Xi Yazhou of the *Observer Network* wrote an article in 2018 that argues the relative superiority of the Chinese J-10C to the Russian Su-35. Xi Yazhou claimed that domestically produced J-10C fighter jets could suppress the imported Su-35 to death. He

justified this position by claiming that recent exercises demonstrated that J-10C avionics fire control and ammunition performance was better and that the passive phased array radar of Su-35 is completely suppressed by the active phased array radar of J-10C. He further asserted the J-10C equipped with the Chinese PL-10 short-range, infrared-homing air-to-air missile was not inferior to the Su-35s armament, a contention affirmed in many air-to-air joint training exercises.[48] Other articles dismissed the idea that China was needing to purchase Su-35s to acquire Russian advanced aircraft engines saying, "China's aviation power is already very good, reaching the world's advanced level."[49]

One central sticking point centered on Russian concerns about China's "super counterfeiting capabilities" and the possibility of the Chinse producing unauthorized copies of the Su-35.[50] According to the Russian newspaper *Kommersant*, during the deal to purchase 48 Su-35 aircraft, "an unexpected obstacle" arose. The Russians demanded legal guarantees that Beijing would not copy the aircraft to protect itself from a potential competitor in other countries' markets depressing prices. Despite the existence of an existing framework agreement to protect intellectual property in the field of military-technical cooperation, the Russians insisted on concluding a separate agreement for additional guarantees because the earlier framework was not legally binding.[51] A source close to the Russian Federal Service for Military-Technical Cooperation (FSMTC) insisted to *Kommersant:* "This is, indeed, an important condition."[52] But "China is in no hurry to give such guarantees."[53]

Another major point of disagreement was the size of the order. Russia originally proposed selling 48 fighters to China. The authors of this paper were told by Westerners with contacts in the Russian aviation industry that the Russians thought the risk of unauthorized Chinese copying was only worthwhile with a large buy, whereas the Chinese were only interested in purchasing 12 Su-35s. Ultimately, the two sides compromised on 24 aircraft after much wrangling.

China received its first batch of Su-35s from Russia in 2016. Delivery of all 24 Su-35s was completed in 2018. The *TASS* state news agency reported that the Russian FSMTC proposed an additional sale of Su-35s to China at the ARMY 2019 exhibition in Moscow.[54] The Chinese announced in 2019 that "in the next two years, it will consider the prospects for continuing the procurement of Russian Su-35 fighters and their assembly in China, as well as the possibility of purchasing Russian Su-57 fighters."[55]

Why did China purchase Su-35 multi-role fighters? Russian and Chinese commentators have put forward several theories.

- **Technical Problems with the J-20**: Vasily Kashin, an expert at the Russian *Center for Strategic and Technical Analysis*, suggested two possibilities: (1) the Chinese wanted to obtain the latest Russian technology, and (2) "The preparation to purchase such a large number of fighter jets proves that the Chinese have encountered serious technical problems in the development of their own Su-27-based aircraft. Through the purchase, they can conduct research on new Russian fighter jets."[56]

- **Insufficient production capacity for J-20**: The author of an article in the *Sino Military* opined: "Although the Chinese Air Force is now constantly emerging new fighters, our Air Force retains a lot of second-generation fighters. The successive retirement of these second-generation fighters will result in a large equipment gap. The production capacity of new domestic fighters is limited, which is not enough to meet the needs of the PLAAF. Su-35 is a mature shelf product. In addition, the Chinese Air Force has been using the Flanker series for a long time and is more familiar with the use of Sukhoi fighters. Purchasing the Su-35 can fill a certain gap in combat effectiveness."[57] Likewise, media covering AirShow China 2014 reported: "China may purchase a batch of Su-35 due to insufficient production capacity of domestically produced heavy fighters to maintain the air force's combat power."[58] The Chinese newspaper *Sohu* argued: "When analyzing the situation, it turned out that at the disposal of the PRC there are now more than 3,000 military aircraft, including 1,700 fighters, of which only 600 belong to the machines of the 4th and 5th generations. As a result, the rest of the equipment turns out to be unsuitable for participation in modern hostilities. It will take from 8 to 10 years to correct this situation with China's own military-industrial complex. Buying a Su-35 at a reasonable price - in case of a shortage of its own production capacity - is a pretty reasonable decision."[59]

- **Surrogate for Confrontation Training**: A cover story in the Chinese publication *Epoch Weekly* suggested that the Su-35 could serve as a "training partner" for J-20 and a surrogate for the U.S. F-35 fighter.[60]

- **Desire to acquire advanced Russian engines:** According to military expert Liu Linchuan speaking at a *Global Talk Forum* on Su-35, China was "very interested" in obtaining Russian 117C engines, but Russian was unwilling to do so except in the context of the sale of Su-35s. "Russia generally refuses to sell an aviation component (or sub-system) separately. He likes to package important aviation components (or sub-systems) in the whole machine export contract and sell them together. Especially for the new aviation subsystem, this is a consistent tradition in Russia. If we do not buy a part of the Su-35, Russia will probably not export the 117S engine to us separately."[61] Commentators from the Chinese newspaper *Sohu* have written that Chinese engineers were interested in other technologies embedded in Su-35, including radar with a passive phased antenna array and an air-to-air missile with a flight range of over 200 kilometers.[62]

- **Cost:** Experts from the Chinese newspaper *Sohu* have written that one of the reasons for the purchase of Russian fighters is the high cost of serial production of Chinese J-20s. Chinese writers also cite lower maintenance costs of the Su-35 as a powerful inducement to purchase them.[63] "It is very rational not only because of the experience of working with the Russian "Sukhoi" but also because of the economic benefits of their use since they do not require large maintenance costs." As a result, the Chinese edition of the newspaper *Sohu* came to the following conclusion: "It is unlikely that it will be possible to replace all 1,700 aircraft of the Chinese Air Force with fifth-generation aircraft in a short time, so the

introduction of the Su-35 without increasing the complexity and cost of maintenance is an economically viable solution.".[64]

- **Deterring Neighboring Countries**: According to Chinse military expert Liu Linchaun, "As a well-known fighter with a reputation, the Su-35 is a deterrent to some small neighboring countries that despise China but are superstitious of Russian weapons."[65]

- **Russian Import Substitution for Western Microelectronics (2014-Present)**

Russia was heavily dependent on dual-use Western microelectronics (microcircuits, semiconductors, transistors, resistors, diodes, etc.) for military and space systems before annexing Crimea. The European Union and the United States responded by limiting the export of such products to Russia in 2014. Sanctions led to production interruptions in some sectors. As a result, the Russian "state spends huge amounts of money on import substitution in electronics."[66]

China was quick to respond to this emerging market opportunity. In August 2014, representatives of specialized Chinese institutes held technical seminars on military microelectronics for Russian manufacturers. The Chinese used the opportunities to acquaint potential Russian customers with the characteristics of Chinese defense and space microelectronics products, make contacts, discuss quality, and provide pricing data.[67]

Zhao Chunchao, a vice president of the Great Wall Industry Corporation, told a seminar organized by OJSC Reshetnev Information Satellite Systems in 2014 that China would lift export sanctions on electronic equipment for space applications by Russia. He went on to say that Chinese enterprises were working on a list of microelectronics products of possible interest to the Russian space industry. Chunchao noted that requests of some Russian manufacturers in some areas were different from those produced in China but assured the Russians that "We believe that we could organize the development and production of the microelectronics that we are not doing yet, but which Russian manufacturers need." Other Chinese companies attending the seminar were the China Aerospace Corporation (CASC), the 9th Academy (CASC structure, which develops EEE for use in space), Beijing Institute of Microelectronic Engineering (BMTI), Xi'an Institute of Microelectronic Engineering (XMTI).[68] Chinese analysts also say that the China Electronics Technology Corporation (CETC) supplied electronics and components for Russian military equipment, mainly for radars and software.[69]

Dmitry Shugaev, head of the FSMTC of Russia, said in January 2019 that Russia had orders from China for more than $7 billion. He stated that China accounted at the time for more than 15% of Russian export orders in the field of military-technical cooperation.[70] However, the United States and Europe sanctions in the wake of Russia's seizure of Ukraine closed those sources of supply for defense and dual-use goods. According to Deputy Prime Minister Rogozin, dual-use products, particularly microelectronics, were widely used in the Russian defense sector; e.g., "all chipsets and receiver modules for GLONASS [navigation satellites] are manufactured outside Russia."[71] An October 2015 NATO report estimated that the Russian defense electronics industry

imported 20-30% of its components.[72] In some areas, dependence on electronics imports was even higher. Sixty-five to seventy electronic components for Russian space launch vehicles and satellites were imported before the imposition of Western sanctions.[73] Sergey Chemezov, CEO of Rostec, noted in the spring of 2015 that 90% of IT solutions for Russian defense companies came from foreign sources.[74] *RBC,* Russia's 24-hour business news TV channel, reported Western technology restrictions forced defense and civil aircraft producers in 2018 "to adjust to other suppliers, to revise previously approved projects, which causes delays and production declines because it's impossible to directly replace [production] in some cases."[75]

Imports from friendly foreign partners (mostly China, India, and Belarus) are currently being substituted for Western products when Russian-made analogs prove unsatisfactory or cannot be manufactured in sufficient quantities to meet demand. In cases such as microelectronics (an area of traditional Russian weakness), Russia substituted suppliers. A source from Roscosmos told *Izvestia* in 2014 that China Aerospace Science and Technology Company (CASIC) had "already provided us with several dozens of items that are either a direct alternative or have slight alterations, of those elements that we cannot buy due sanctions imposed by the U.S."[76] Russian space, rocket and defense enterprises were expected to purchase $1 billion of Chinese microelectronics products in 2015.[77] Russia's United Rocket and Space Corporation expressed interest in working with the Chinese as well as with "all manufacturers of electronic components who can make competitive offers in terms of quality, supply time and price."[78] ***At the ARMY 2018 exhibition, a Russian vendor distributed an entire catalog of Chinese microelectronics products his firm sells in Russia.***

Unfortunately, import substitution means replacing foreign dependence on one country for another. In some cases, the new suppliers are unable to meet the quality of previous sources. A Russian analyst writing in *Voyenno-Promyshlenny Kurier* (*Military-Industrial Courier*) in March 2016 complained that sample import substitutes from China were lower quality than what they were replacing from the West.[79] This assertion is consistent with reviews from Russian enterprises that conclude Chinese-made components are not qualitatively competitive with Western counterparts.[80] Perhaps even worse, the Russians paid a premium to procure replacements, as illustrated by remarks from Ivan Moiseyev, head of the *Space Policy Institute*:[81]

> *The United States refused, in the spring of 2014, to supply components for satellites to Russia, as they were dual-use technology. A replacement had to be found in China. At that time, the 'China Aerospace Science and Industry Corporation' provided several dozen electronics products to Russia.* ***At the same time, China raised the prices***. (Emphasis added)

Import substitution also imposed technical difficulties. "European and Asian components can vary significantly. The transition from one to another requires a complete redesign of the device, building cooperation with suppliers, and this takes time," according to Nikolay Orlov, regional vice president of the satellite company Eutelsat.[82] They were switching to other components

sometimes meant utterly redesigning the unit or system and again carrying out the entire range of necessary tests that cost time and money when the budget is usually limited.

- **Advanced Heavy Lift (AHL) Helicopter Project (2015 to Present)**

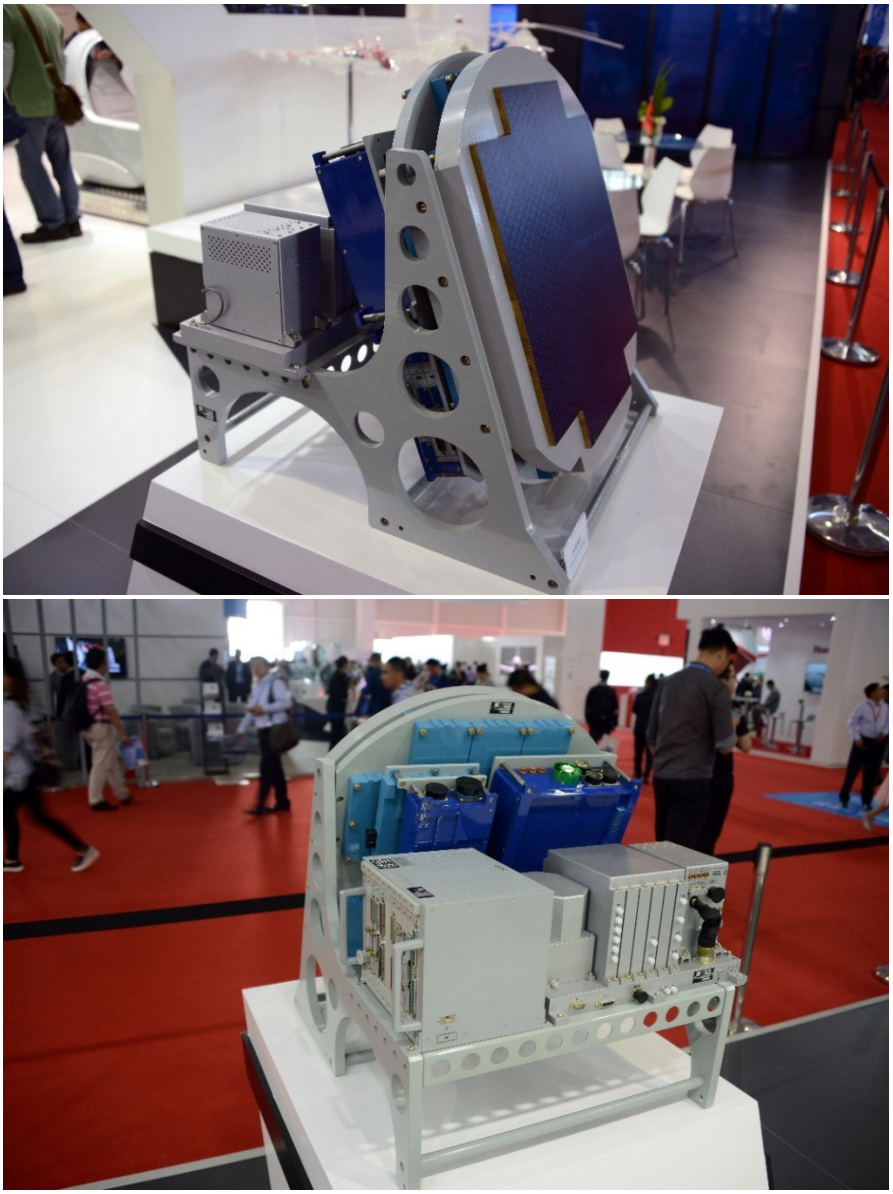
The Aviation Industry Corporation of China (AVIC) and the "Russian Helicopters" corporation signed an agreement in 2015 to develop the preliminary specifications and gain a consensus on the basic design of what became known as the Advanced Heavy Lift (AHL). The original clean-sheet design envisioned a helicopter with a maximum take-off weight of 38.2 tons.[83] AVIC has primary responsibility for developing and manufacturing the AHL but will receive assistance from Rostec State Corporation's "Russian Helicopters" corporation. Russia's technical assistance is likely since the design of the AHL will be heavily influenced by technology transferred from the Mil Helicopters' Mi-26 large helicopter program.[84]

A scale model of the AHL was displayed for the first time at the AVIC booth at AirShow China 2018. According to *AINonline*, "Interestingly, the model had a somewhat different appearance than the three-view drawings published on leaflets. In particular, it had smaller sponsons affixed to the fuselage sides for the main landing gears. Additionally, the model featured a sleeker design of the air intake area, with what looks like an aerodynamic fairing ahead of the rounded air inlets for the engines."[85]

Scale Model of AHL & Associated Data Placard at AirShow China 2018[86]

- **Russian Presence at AirShow China 2016**

A total of 49 Russian companies participated in AirShow China 2016. Twenty-seven of those companies exhibited over 220 pieces of military hardware. The Deputy Director of FSMTC made a special point of noting, "The scale of the participation of Russian companies in the AirShow China 2016 annually increases.[87] Thus, the Russian display area compared to 2014 increased by 2.5 times and is more than 1,500 square meters." One of the highlights from Russia was the unveiling of the new Zhuk-AME multi-functional, multi-mode new active electronically-scanned array (AESA) radar developed by the Concern Radio-Electronic Technologies (KRET) part of the Rostec group for the Russian MiG-35 fighter.[88]



KRET Zhuk-AME (FGA50) AESA Radar for the MiG-35 Fighter Aircraft on Display at AirShow China 2016[89]

United Aircraft Corporation Booth at AirShow China 2016[90]

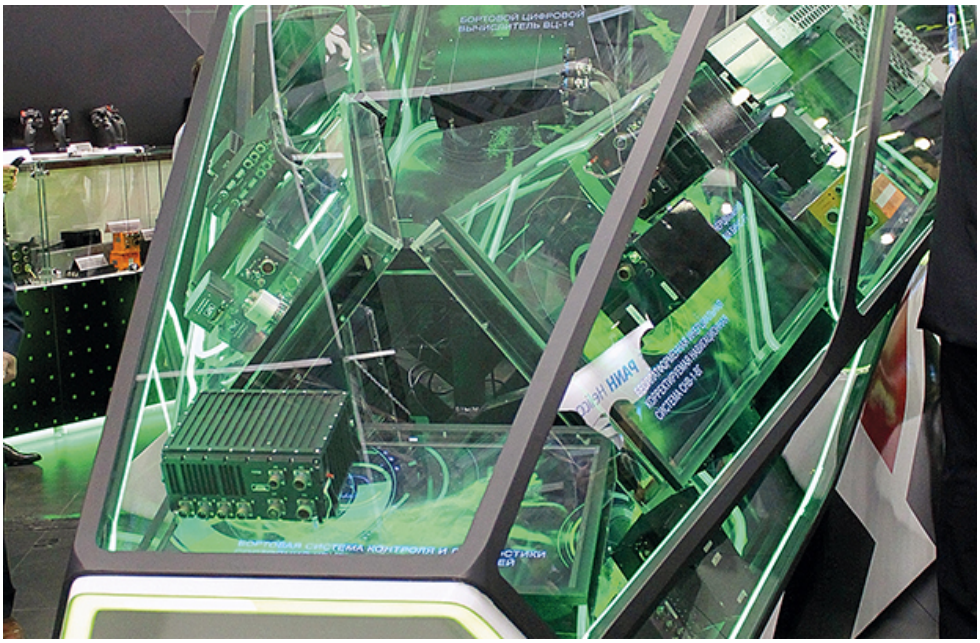
KRET also ***showcased more than 40 military and civilian products "based on breakthrough innovative technologies"*** at AirShow China 2016 to include:[91]

- Displaying an advanced full-scale helicopter avionics demonstrator that emulated real-life operations of a new flight and navigation system. "The system presents the crew with information via electronic displays, and also supports radio communications with other aircraft and air traffic control centers in keeping with the modern requirements."

- Featuring on a placard and a brochure was an export version of the President-S airborne MANPADS countermeasure defense system designed to protect all types of aircraft and helicopters. This system uses a DIRCM (Directed InfraRed Countermeasure) system that utilizes a laser-based counter-MANPADS complex.

- Highlighting export versions of the Sukhoi Su-35 fighter's avionics which are "new generation radio-electronic solutions are based on an information management system designed to help the pilot control onboard equipment." These solutions included an RSUO weapon management system, the MZBN compact, protected airborne recorder, a family of small-sized X- and Ka-band airborne radars, and an integrated IBKO-152 system.

- Offering mass-produced strap-down inertial navigation systems for use on a wide variety of civilian and military aircraft types.



Advanced Helicopter Avionics Demonstrator Displaced by KRET at AirShow China 2016[92]

Although the Russians did not manage to sell any military equipment at AirShow China 2016, Wuhan Rand Aviation Technology Service company purchased two "medical" Ansat helicopters, two Mi-171s, and one Ka-32 helicopter with an option for further purchases. Jiangsu Baoli Aviation Equipment company agreed to purchase one each of the Russian Ka-32, Mi-171, and Ansat helicopters in 2017.[93] Before opening AirShow China 2016, however, the Russians signed a $1 billion contract with the Chinese to supply AL-31 and D-30 aircraft engines over three years.[94]

Russian AL-31 (upper) and Chinese WS-10 Turbofan Engines (lower)[95]

Chinese J-20 Fighter Engine Testbed with
Russian AL-31 (left) and Chinese WS-15 Turbofan Engine (right)[96]

Russian D-30KP-2 Turbofan Engine[97]

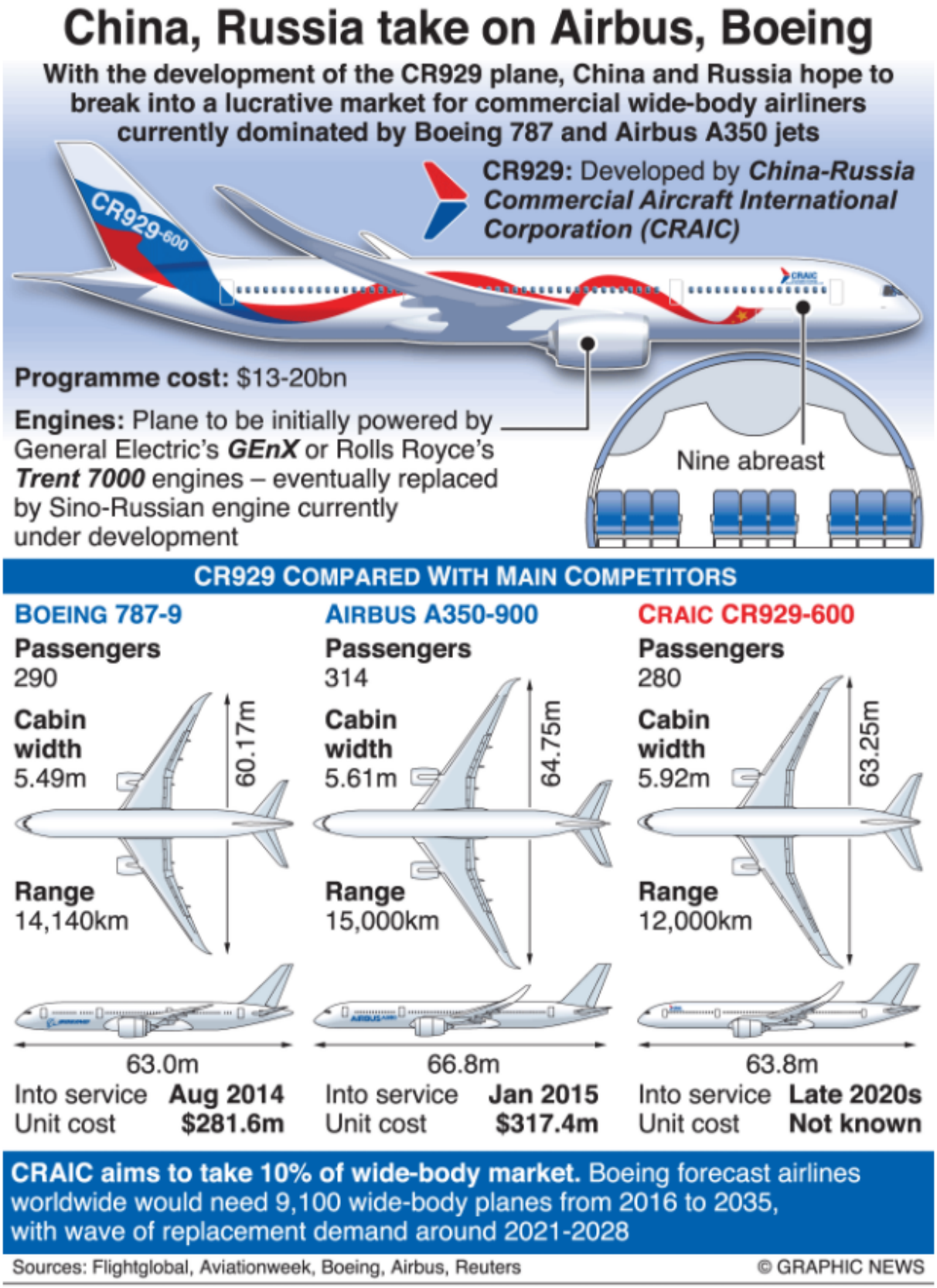
The Russians and Chinese also discussed several dual-use cooperative projects at AirShow China 2016. Among the discussions was the possibility of creating a joint global low-orbit satellite system called the "Star of Happiness." The proposed project envisioned a constellation of 100 satellites for broadband Internet access. The project, if implemented, would provide Internet access to both Chinese users and third countries.[98] The Taganrog Aviation Scientific and Technical Complex (TANTK) imeni G.M. Beriev also signed a memorandum of understanding to supply two Be-200 amphibious aircraft. The memorandum also arranged for the Leader Energy Aircraft Manufacturing Co., Ltd. of China to license produce the Russian Be-103 amphibious aircraft in China.[99]

Poster Displayed by United Aircraft Corporation of the Be-200 at AirShow China 2016[100]

According to Russian media reports, the VSMPO-Avisma stand at AirShow China 2016 "become the center of attraction for visitors." Russian media also claimed that they had to put up protective racks around the VSMPO-Avisma stand to contain the influx of visitors. VSMPO-Avisma's displays of blanks for engine parts with rough machining, aluminum, and titanium semi-finished products "aroused great interest from potential buyers." VSMPO-Avisma was already supplying such parts to China but engaged in talks to expand the supply volumes.[101]

- **China-Russia Commercial Aircraft International Corporation Limited (CRAIC) Joint Venture (2017 to Present)**

On May 22, 2017, CRAIC was launched as a 50-50 joint venture between China and Russia to develop and produce the CR929 wide-body passenger aircraft. CRAIC describes the effort as a "major strategic cooperation program between both countries."[102] The CR929 is scheduled to enter service by 2027 to challenge the Airbus and Boeing products currently dominating both the Russian and Chinese civil aviation markets. The primary CRAIC engineering center is located in Russia. A satellite office in Shanghai will be the future location for the aircraft's final assembly line.

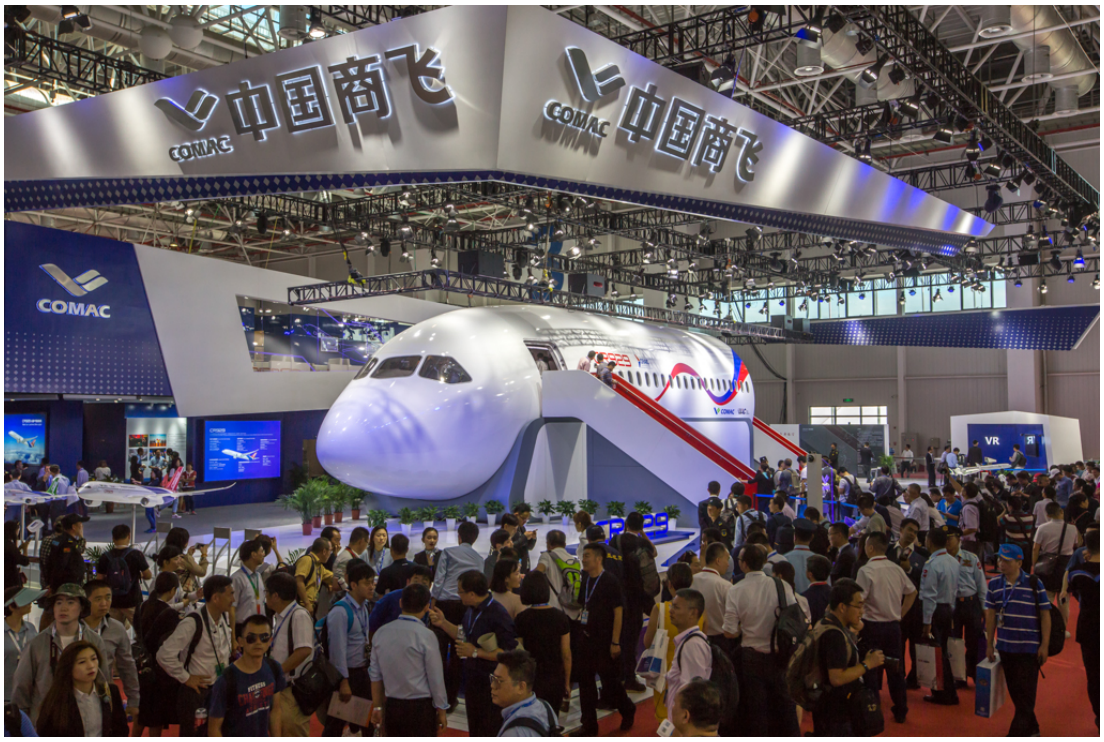


CRAIC's Sino-Russian Widebody CR929 Passenger Aircraft Details[103]

Cooperative activities include technological development, marketing, manufacturing, and sales of products – long-range wide-body commercial aircraft; after-sales service and consulting; project management of long-range wide-body commercial aircraft and related products; investment and financial activities in connection with the project as well as activities in the field of foreign trade, international cooperation, international technical cooperation, and other activities.[104] As part of the project, Rostec built a 40,000 m^2 testing complex at UEC-Perm Engine.

The conceptual design stage and lining-up of first-tier suppliers for the program were scheduled for completion in 2020. But CRAIC developers still have not built a prototype and don't even have a flying proof of concept that raises doubts about their ability to meet the scheduled first flight between 2025 and 2027. However, the outbreak of COVID-19 is slowing the progress of the CR929 project. A two-week quarantine shut the Shanghai headquarters of CRAIC. Also, travel between the two countries has been restricted to prevent the transmission of the virus. According to Valery Okulov, general director of United Aircraft Corporation (UAC), work has resumed with direct communications between engineers being replaced by remote conference formats.[105]

Although the announced purpose is cooperation in civil aviation technology, it is important to note that the work has dual-use implications for transferring wide-body aircraft technology and production know-how into Chinese military programs such as its heavy transport aircraft, airborne refueling aircraft, and airborne early warning and surveillance aircraft. Transferring such technology to military programs is likely since the Chinese emphasizing "spinning on" civilian technology into military systems and promoting "civil-military fusion."



CR929 Widebody Passenger Aircraft at MAKS 2019[106]

- **Russian Presence at AirShow China 2018**

Russian defense industry had a significant presence at AirShow China 2018. The Russian display at the exhibition covered an area of about 1,500 m^2. This space was taken up by fourteen of the largest Russian developers and manufacturers to display their products for the air force, air, and space defense forces. Among them are Russian Helicopters, Almaz-Antey Group, United Engine Corporation, United Aircraft Corporation, Concern Radio-Electronic Technologies (KRET), Tactical Missiles Corporation (KTRV), and Roscosmos State Corporation.

In total, the Russian companies showcased more than 200 pieces of armaments and military equipment. Over 100 military products, mainly for the Air Force and Air Defense Force, which are particularly popular in the Asia-Pacific Region, were exhibited on the Rosoboronexport booth, including the Su-35 multipurpose super-maneuverable fighter, the MiG-29M/M2 multifunctional fighter, the Su-32 fighter-bomber, as well novelties from Rosoboronexport's catalog, the Ilyushin Il-78MK-90A tanker and the Ilyushin Il-76MD-90A military transport aircraft which were considered to be the most promising Russian Air Force weapon systems in the region. Much attention at the Russian exhibition also focused on air defense systems, including the S-400 Triumph long-range air defense missile system, the Tor-M2E SAM system, and the Verba MANPADS. In addition, the Buk-M3 Viking SAM system, the newest addition to the line of the famous Buk SAM systems developed by the Almaz-Antey Group, was showcased at the AirShow China 2018 for the first time in the framework of international exhibitions. Rosoboronexport's Director General Alexander Rosoboronexport's Director General Alexander Mikheev noted, "…China has become the first foreign customer of the world's best S-400 air defense missile system and advanced Su-35 aircraft."[107]

The Director-General of Russian Helicopters noted in 2018 that China was the most promising and fastest-growing market for helicopters globally. Russia had already supplied over 400 Mil and Kamov helicopters to China. He went on to say that he was confident that new models being shown at AirShow China 2018 would find demand in the Chinese market. He also announced that Russian Helicopters was seeking to open a service center in China and seek potential Chinese partners at the air show.[108] Russia's helicopters, in particular, the Ka-52 scout/attack, the Mi-171Sh military transport, and the Mi-35M transport/attack helicopters, generated keen interest in the region.

- **China Given "Partner Country" Status at Moscow Air Show or MAKS 2019**

The Russian-Chinese relationship has grown closer in recent years (see Appendix B: Chinese Organizations Involved in Cooperative R&D Activities with Russia and Appendix C: Russian Organizations Involved in Cooperative R&D Activities with China). The Chinese, for example, were invited to become a "partner country" at the Moscow International Aviation and Space Salon, also known as the Moscow Air Show or MAKS 2019. This event was the first time MAKS organizers invited a foreign nation to be a country partner. China had a stand-alone exhibition hall

with 3,000 m^2 space for 20 exhibiting Chinese companies at MAKS and an outdoor exhibition space of roughly 400 m^2.[109]

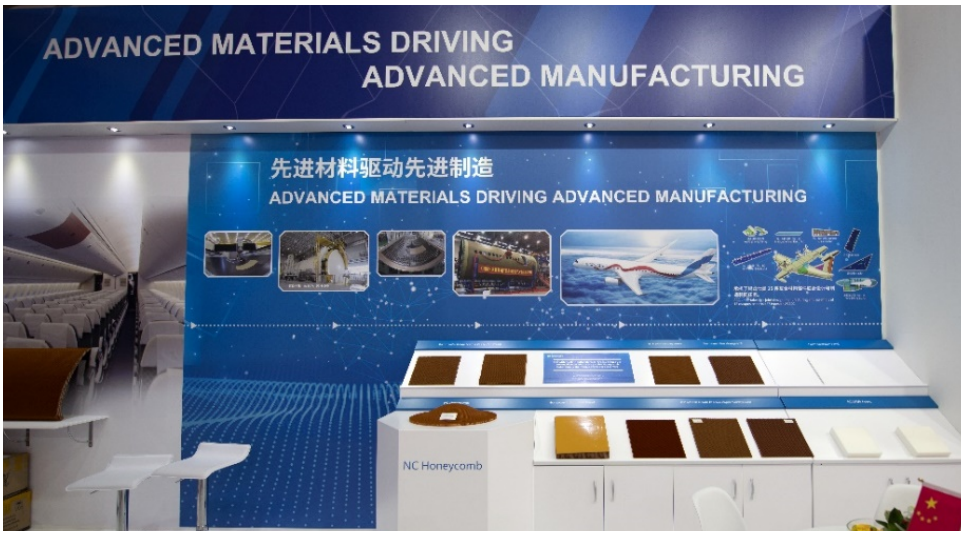
Dedicated Chinese Hall[110] and Wing Long I/II UAVs on Outdoor Space[111] at MAKS 2019

Chinese companies exhibiting at MAKS 2019 included the following:[112]

- **AVIC Composites Co., Ltd.**

AVIC Composites is a member of the China Aviation Industry Corporation (AVIC) and is affiliated with AVIC Foundation Institute. It has advanced national defense technology key laboratory, structural carbon fiber national engineering laboratory, and green composite material Beijing engineering laboratory. In regards to human capital, this firm has:

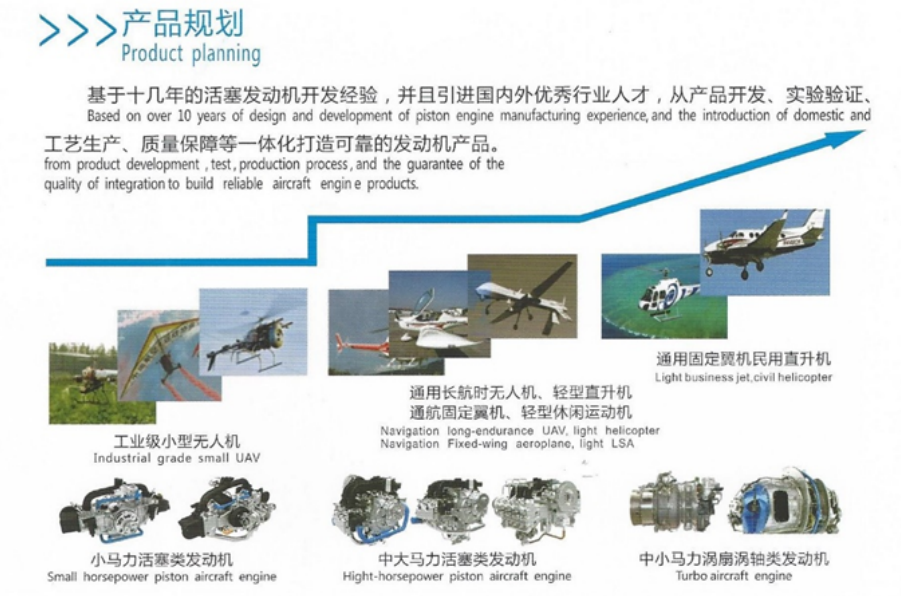
- 450 scientific research and management personnel with one Academician of the Chinese Academy of Engineering
- 34 researchers
- 126 senior engineers
- More than 210 Master's degree and above



AVIC Composites Co., Ltd. Booth at MAKS 2019[113]

- **Anhui Haery Aviation Power Co. Ltd.**

This firm marketed engines for light aircraft, UAVs, helicopters, and hang gliders.



Brochure Distributed by Anhui Haery Aviation Power at MAKS 2019[114]

- **Blue Arrow Space Technology Co. Ltd. (LandSpace)**

This firm marketed five models of "Suzaku" series launch vehicles and a full-scale model of "Tianque" 80-ton liquid oxygen methane engine at MAKS 2019.[115]

- **China Aviation Industry Group Co., Ltd. (AVIC)**

AVIC emphasized four major categories of 15 key aviation products and professional equipment systems: military aircraft, civil aircraft, avionics systems, and aerospace composite materials. Featured at the booth were models and placards on the AG600 Kunlong seaplane.

Large-Scale Model of AG600 Kunlong Seaplane on Displayed at AVIC Booth at MAKS 2019[116]

- **Commercial Aircraft Corporation of China (COMAC)**

COMAC showcased the ARJ21 new regional aircraft, the C919 large passenger aircraft, and the CR929 twin-aisle long-range passenger aircraft model jointly developed by China and Russia, as well as two future passenger demonstration prototypes.

ARJ21 Regional Aircraft (left), C919 Large Aircraft (center), and CR929 Twin-Aisle Aircraft on Display at MAKS 2019[117]

Two Future Passenger Demonstration Projects on Display at MAKS 2019[118]

- **China Aero Engine Group Co., Ltd.**

AECC demonstrated the AEF3500 wide-body passenger aircraft engine verification machine, CJ1000 civil large bypass ratio turbofan engine, AES100 turbine engine, AEP80 turboprop engine, and the QD70 light gas turbine engine.

AECC AEF3500 Wide-Body Passenger Aircraft Engine on Display at MAKS 2019[119]

- **China Aerospace Science and Industry Corporation Group Ltd. (CASC)**

CASC exhibits included the "Long March 2D, Long March 3B, Long March 7, Long March 11 and other carrier rockets and commercial microwave remote sensing satellites, Dongfanghong 5 communication satellites, and Mars probes at MAKS 2019. At the same time, the products and applications of communication satellites and remote sensing satellites, as well as China's development in various fields such as manned spaceflight, lunar exploration, Mars exploration, Beidou navigation, and low-orbit constellations…"[120] CASC also marketed the KZ series of commercial space launchers.

Display of KZ Series of Space Launchers by China Aerospace Science and Industry Corporation at MAKS 2019[121]

- **China Electronics Technology Group Co., Ltd. (CETC)**

CETC focused on constructing a network information system and displayed the supply chain capacity and key applications of the industry chain in basic electronics, public safety, drones, and new energy. CETC's 38th Institute offered a wide array of microchip manufacturing technology.

Examples of Products Offered by CETC's 38th Institute at MAKS 2019[122]

IC Photomasking Platform

CETC 58

Controllable and Unique 0.13μm Photomasking in China

Provide Service for All Industries and Safeguard Security of Data Information

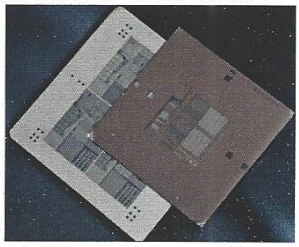
◆Capability: Domestic advanced 0.13 μ m photomasking technique

◆Application: Mainly applied to 8–inch wafer lines as well as 5/6–inch ones

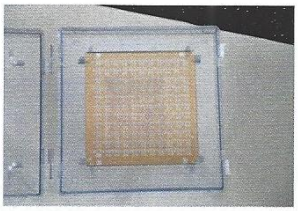
◆Product Presentation:

- 130nm BIM photomasking
- 130nmPSM photomasking
- Customized optical device manufacture
- Customized grating product manufacture
- Customized glass Photomasking
- Capacity of 10,000 pieces per year
- Product Type–Product Type

5009, 6012, 6025 BIM & PSM

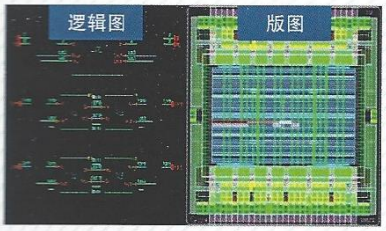


The picture of BIM product

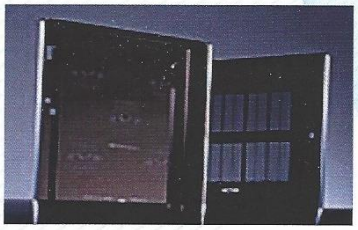


The picture of PSM product

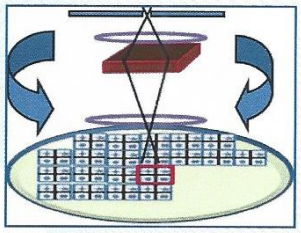
The Position of Photomasking in IC Production Chain



Design



Photomasking



Chip Manufacturing

Examples of Products Offered by CETC's 38th Institute at MAKS 2019[123]

IC Manufacturing Platform

5/6-inch

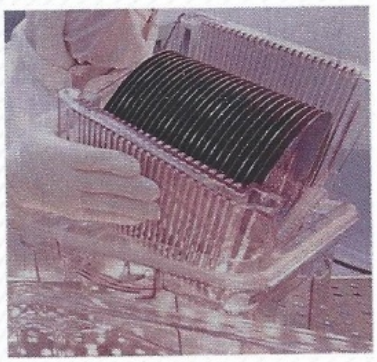
CETC Radiation-hardened SOI Technology R&D Center
5/6-inch 0.35~3.0μm CMOS Mil-spec Wire

- 0.35~1.5um multi-generation CMOS flexible research production line compatible with multiple technologies
- Platform: 0.35~1.5 μ m standard CMOS technology; 0.35~0.8 m radiation-hardened SOI technology
- Technology: 30 kinds of technology such as high pressure, low pressure, EEPROM, SPIC, BiCMOS and SOI
- Capability: Integrated scale at 400~500 K-gate and working frequency at 40~80 MHz
- Capacity: 10000 pieces of wafer per month

8-inch

Autonomous and Controllable 8-inch Processing Platform for Military Use Undertaking Multiple National Key Development Tasks

- Platform: 0.13~0.18 μ m standard CMOS technology; 0.18um radiation-hardened technology; 0.18 μ m anti-fuse technology
- Technology: More than 20 kinds of technology such as mixed-signal, radiation-hardened SOI and anti-fuse technology
- Capability: Integrated scale at 6 M-gate and working frequency at 500 MHz
- Capacity: 3,000 pieces of wafer per month



Examples of Products Offered by CETC's 38th Institute at MAKS 2019[124]

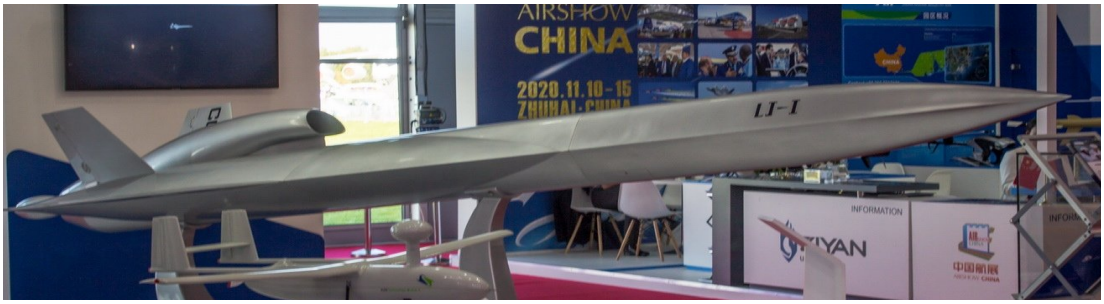
- **China Great Wall Industry Corporation**

In addition to displaying several products, Liu Qiang, chairman of China Great Wall Industry Corporation, told the *Xinhua News Agency* that China and Russia could develop various cooperation modes such as joint design, joint research and development, and joint plant construction in addition to single aircraft procurement.[125]

China Great Wall Industry Corporation Display at MAKS 2019[126]

- **Northwestern Polytechnical University**

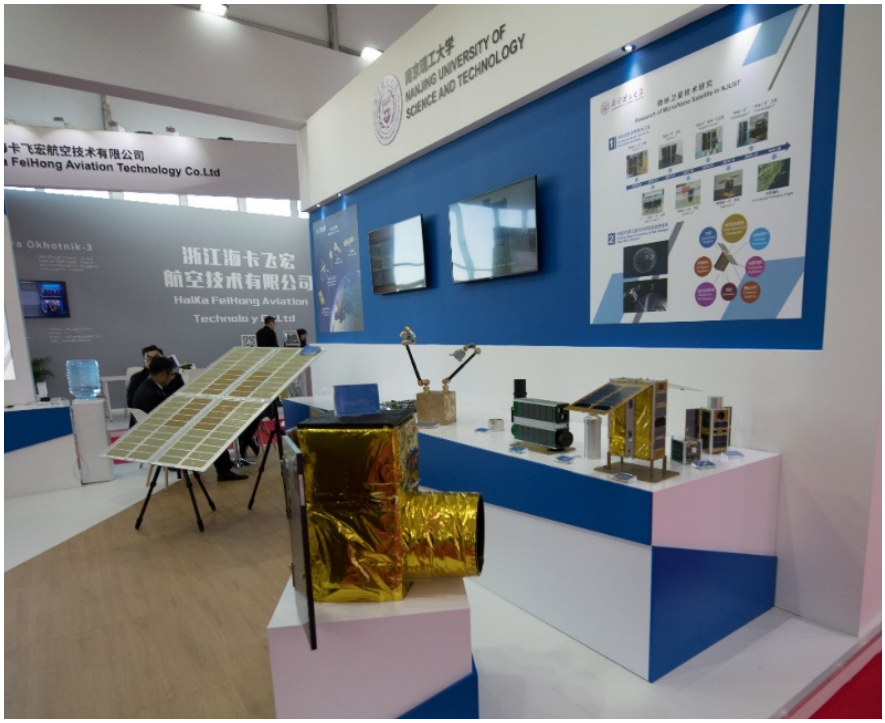
NPU demonstrated the achievements in the development of UAVs and microsatellite satellite research. Among items displayed was a model of the LJ-I ("砺剑-1"/ "Sword-1") stealthy target drone developed together with Xian Technology Group Ltd. The drone is intended to simulate fourth-generation fighters for anti-aircraft defenders.



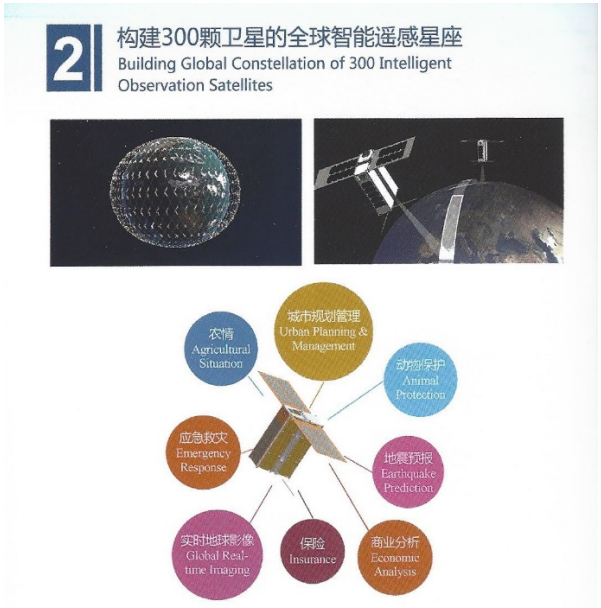
LJ-I ("砺剑-1"/ "Sword-1") Stealthy Target Drone Displayed at MAKS 2019[127]

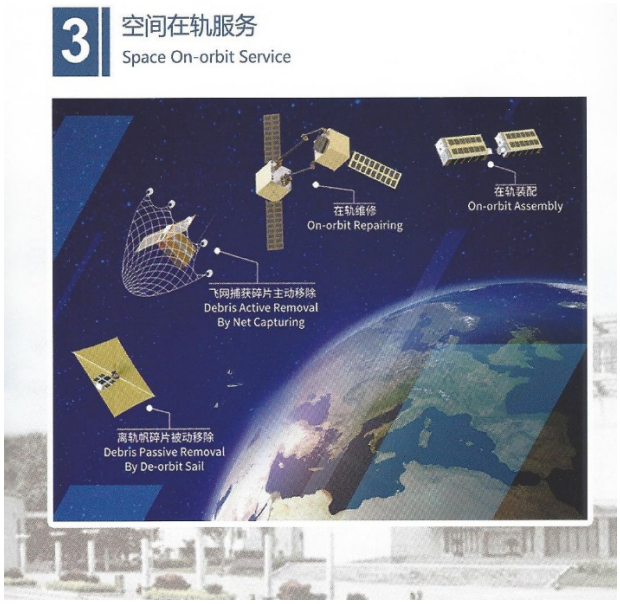
- **Nanjing University of Science and Technology**

Nanjing University of Science and Technology also demonstrated achievements in the development of UAVs and microsatellite satellite research. Also advertised at MAKS 2019 was a "Space On-Orbit Service" for removing space debris and making on-orbit repairs to space vehicles.



Nanjing University of Science and Technology Booth at MAKS 2019"[128]





Brochure Distributed by Nanjing University of Science and Technology at MAKS 2019"[129]

- **Phoenix Electronics LLC (Joint Chinese-Russian Company)**

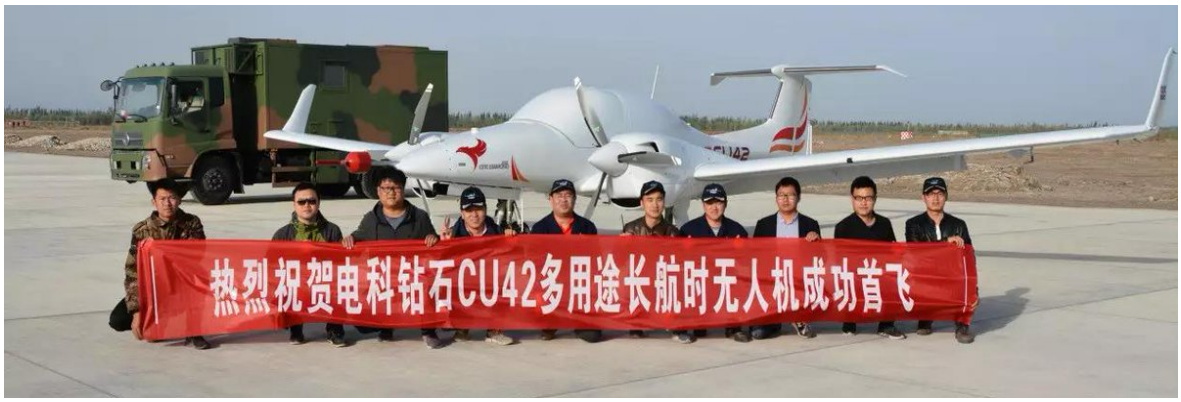
Supplier of electronic components from the largest manufacturers of China. Exclusive representatives of the China Aerospace Components Engineering Center to Russia. Specializes in supplying electronic components of various quality levels, including electronic components for military and space applications, including analog and digital ICs, transistors, DC/DC converters, microprocessors, microcontrollers, analog multiplexers, FPGAs, ADCs, DACs, and diodes.

The goal is to provide Russian manufacturers of electronic equipment with high-quality electronic components. The company has delivered more than 1,000 items to Russia. The provided packages of documents for flight models include reports on all types of tests, including tests for resistance to radiation (accumulated dose, exposure to heavy charged particles). It also includes prototypes for flight models with a complete package of supporting documentation.

China Aerospace Components Centre CAST CACEC, a Quality Assurance Center that Completes 90% of Chinese Spacecraft: Flow of Electronic Components from China to Russia in Brochure Distributed by Phoenix Electronics LCC at MAKS 2019"[130]

- **Wuhu Diamond Aircraft Manufacturing Co., Ltd.**

Wuhu Diamond, part of China Electronics Technology Group Corporation (CETC), marketed the CU42, a large, twin-engine long-endurance drone at the MAKS 2019. CU42's missions include: counter-terrorism, border patrol, rescue, and geographical surveying. The CU42 drone is based on Austrian Diamond DA42 Twin Star aircraft as part of the Chinese Austrian joint-venture.



CU42 Long-Endurance Drone Produced by Wuhu Diamond Aircraft Manufacturing Co., Ltd. Placard at MAKS 2019"[131]

- **Ziyan Unmanned Aerial Vehicle Co., Ltd.**

This firm marketed and displayed the Blowfish A2 and A3 dual-use drones at MAKS 2019. Military models of Blowfish A2 can carry various types of small radar, interference equipment, detection equipment, large firearms equipment, launching weapons, etc., and joining the front optoelectronic pods and related fire control systems. By adding a front-mounted photoelectric pod and connected fire control system, one can realize diversified tactical functions such as target finding and tracking and integration of inspection and fighting.

The civil model of Blowfish A2 carries various types of laser radar, technical detection equipment, communication relay, large-scale photoelectric load, geophysical equipment, life-saving equipment, and other large-scale size-related materials and equipment. Blowfish A3 can be equipped with 40mm rockets, bombing load bins, multi-purpose tactical bombs (five types), LG6 grenade guns, and laser mapping modules.

Blowfish 2A (left) and Blowfish A3 Models Displayed at MAKS 2019[132]

- **Other firms that exhibited at the Chinese pavilion at MAKS 2019:**
  - Dajiang Innovation
  - Taiyuan Iron and Steel (Group) Co., Ltd.
  - Jiangsu Hengshan Co., Ltd.
  - Zhejiang Haika Feihong Aviation Technology Co., Ltd.
- **National Missile Early Warning System Proposed at MAKS 2019**

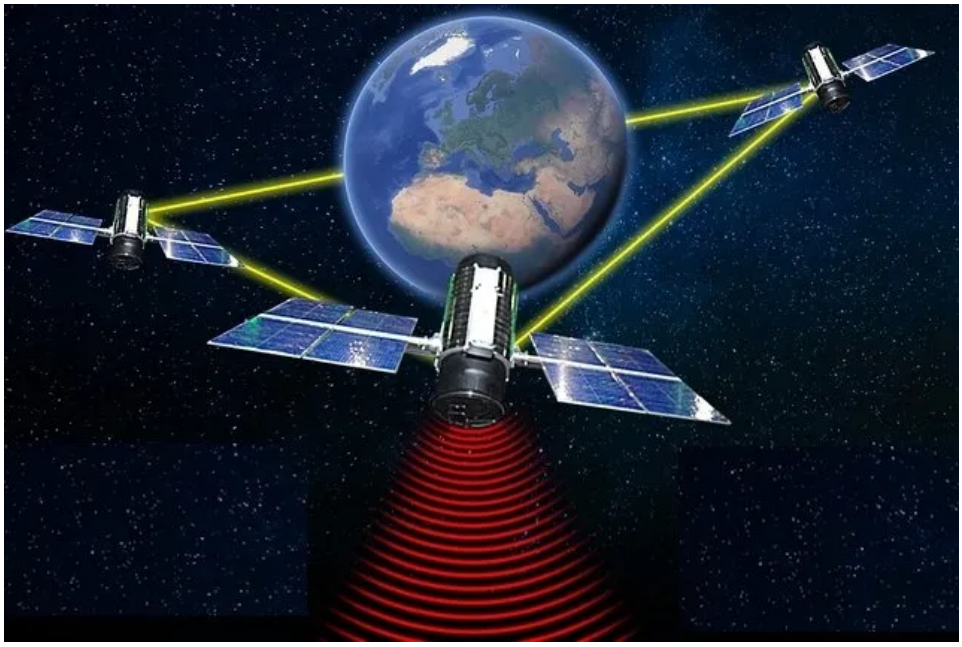
The Chinese and Russians discussed a proposal at MAKS 2019 for joint Russian-Chinese cooperation in designing, developing, producing, and fielding a nationwide missile early warning system. According to Viktor Murakhovsky, Editor-in-Chief of the *Arsenal of the Fatherland* journal: "For several years now, China has been studying our missile attack early warning system, the algorithms of its operation and technical capabilities and, finally, it has decided that it needs a similar system. We are providing both consultative and technology transfer support to it and are delivering some equipment." Examples being offered by Russia, according to Murakhovsky, included the Voronezh-M and Voronezh-DM meter- and decimeter-range missile early warning radars developed by RTI Systems Group. Similarly, Igor Korotchenko. Editor-in-Chief of the journal *National Defense* claims Russia is offering China over-the-horizon radars capable of detecting the launches of ground- and sea-based intercontinental ballistic missiles.[133]

Russian President Vladimir Putin announced on October 3, 2019, that Russia would assist China "to create a missile-warning system, a missile-attack warning system."[134] The missile attack warning system is designed to record the launch of ballistic missiles (mainly ICBMs and ballistic missiles of enemy submarines) and track their trajectory. This early warning system will consist of a network of radar stations capable of detecting targets at a distance of several thousand kilometers, satellites equipped with IR sensors to detect ballistic missile launches, and ground control and data processing systems. The early warning system then transmits information about imminent attacks (including the aggressor state, the scale of the missile strike, the attacked areas, and the time of arrival of the warheads from the aggressor state) to Chinese military command posts and then onto Chinese national leaders. The full extent of Russian assistance is unknown. Russian media, however, reported the signing of a $60 million contract for Russian firms (including PJCS MAC Vimpel-Communications and Central Scientific Research Institute Kometa) to develop software for the Chinese systems.[135]

The presence of Russian technologies in the Chinese early warning system may have strategic implications, according to Viktor Murakhovsky of the magazine *Arsenal of the Fatherland*. According to Murakhovsky use of Russian technologies in the Chinese early warning system will create conditions for the compatibility of Russian and Chinese systems. This, in turn, will facilitate the exchange of information between Russian and Chinese military forces. The creation of a single information and control field is not envisioned, and the early warning systems of the two countries will be under national command.[136]

According to a *Defense World Net* article: "A Chinese missile early warning system –based on the Russian Tundra satellites and Voronezh ground-based radar stations may be closer to completion going by recent events and statements." [137] Further, this article noted that "The Kupol missile attack early warning system consists of the space segment that currently comprises four Tundra satellites and the ground-based component that consists of Voronezh radar stations." [138]

Russian Missile Detection Control Display: An Example of Kind of Technology Under Discussion for Technology Transferred from Russia to China[139]

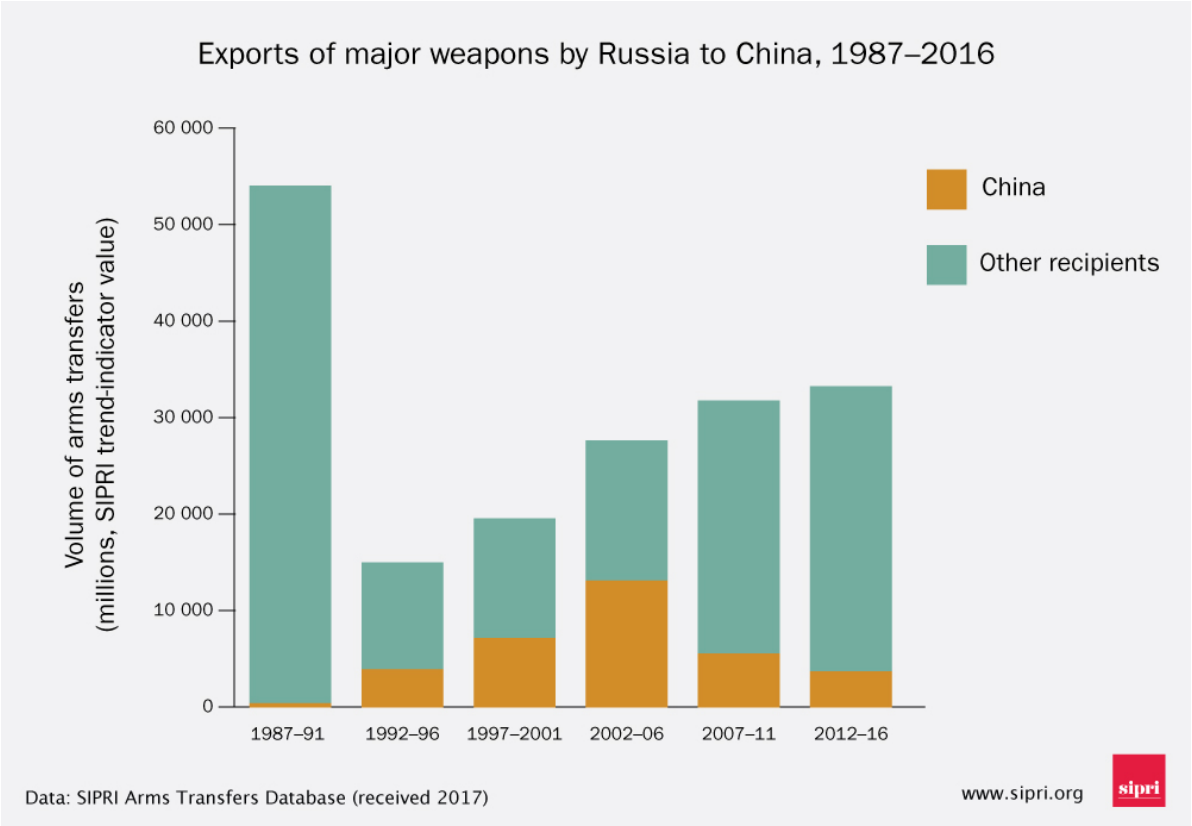


Russian 'Tundra' Satellite Constellation to Track American Missiles: Technology Under Discussion for Technology Transferred from Russia to China[140]

Scale of Military-Related Acquisition (Hardware and Components)

Russian exports of military and dual-use equipment to China

Historically, Russian arms have poured over the border to China, but this trend is shifting. Russian arms sales to China averaged $2.6 billion through the 2000s, reaching a peak of $3.2 billion in 2005. This figure dropped significantly, averaging $816 million between 2010 and 2018. As a result, China's share of Russian arms exports has declined from 47.7 percent of total sales in 2006 to 13.7 percent in 2018.[141]



Chinese exports of dual-use equipment to Russia[142]

A deeper dive on Russian arms exported to China shows that they have accounted for a low of nearly 22 to a high of 89 percent of total imported arms to China from 1991 to 2020. China has dramatically reduced the number of arms imports from a high of 3,123 SIPR TIVs or 87.77 percent of the total imported arms for 2005 from Russia (see a full explanation of TIVs under the table on the following page) to its declining trend of 600 SPIRI TIVs or 73.98 percent of the total imported arms from Russia for 2020. [143] From 1991 to 2020, Russia's arms exports have accounted for 77.91 percent or 37,028 SIPR TIVs of China's arms imports. 144 Russia has and remains the largest single country with which China imports defense goods, products, and services. China remains important, if albeit declining customer, for Russia's defense trade and cooperative activities.

Arms Exports to China from Russia: 1991-2020 (SIPRI TIV: Trend Indicator Values)

Year	1991	1992	1993	1994	1995	
Russia	n/a	1,023.00	1,011.00	72.00	498.00	
Total	482.00	1,228.00	1,239.00	327.00	739.00	
Russia %	**n/a**	**83.31**	**81.60**	**22.02**	**67.39**	
Year	**1996**	**1997**	**1998**	**1999**	**2000**	
Russia	1,241.00	732.00	174.00	1,462.00	2,231.00	
Total	1,528.00	952.00	403.00	1,752.00	2,522.00	
Russia %	**81.22**	**76.89**	**43.18**	**83.45**	**88.46**	
Year	**2001**	**2002**	**2003**	**2004**	**2005**	
Russia	2,495.00	2,536.00	2,066.00	2,872.00	3,123.00	
Total	2,816.00	2,871.00	2,333.00	3,287.00	3,558.00	
Russia %	**88.60**	**88.33**	**88.56**	**87.37**	**87.77**	
Year	**2006**	**2007**	**2008**	**2009**	**2010**	
Russia	2,450.00	1,301.00	1,459.00	1,075.00	685.00	
Total	2,847.00	1,639.00	1,809.00	1,368.00	981.00	
Russia %	**86.06**	**79.38**	**80.65**	**78.58**	**69.83**	
Year	**2011**	**2012**	**2013**	**2014**	**2015**	
Russia	746.00	598.00	694.00	602.00	780.00	
Total	1,055.00	1,571.00	1,289.00	1,077.00	1,262.00	
Russia %	**70.71**	**38.06**	**53.84**	**55.90**	**61.81**	
Year	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Russia	691.00	1,011.00	1,696.00	1,108.00	600.00	37,028.00
Total	1,139.00	1,338.00	1,962.00	1,347.00	811.00	47,529.00
Russia %	**60.67**	**75.56**	**86.44**	**82.26**	**73.98**	**77.91**

SOURCE: Table generated on May 31, 2021, from *SIPRI* website at https://armstrade.sipri.org/armstrade/page/values.php.

NOTE: SIPRI statistical data on arms transfers relates to actual deliveries of major conventional weapons. To permit comparison between the data on such deliveries of different weapons and to identify general trends, SIPRI has developed a unique system to measure the volume of international transfers of major conventional weapons using a common unit, the trend-indicator value (TIV). The TIV is based on the known unit production costs of a core set of weapons and is intended to represent the transfer of military resources rather than the financial value of the transfer. SIPRI TIV figures do not represent sales prices for arms transfers. They should therefore not be directly compared with gross domestic product (GDP), military expenditure, sales values or the financial value of export licenses in an attempt to measure the economic burden of arms imports or the economic benefits of exports. They are best used as the raw data for calculating trends in international arms transfers over periods of time, global percentages for suppliers and recipients, and percentages for the volume of transfers to or from particular states. (Above explanation taken in whole from https://www.sipri.org/databases/armstransfers/sources-and-methods)

Figures are SIPRI Trend Indicator Values (TIVs) expressed in millions, and figures may not add up due to the conventions of rounding.

Organizations and Types of Cooperative Activities

This section identifies and describes individual Chinese and Russian organizations engaged in the following types of cooperative defense-oriented activities: (1) research, development, and testing, (2) forums, dialogs, and seminars, (3) production and manufacturing, (4) sales and acquisition, and (5) education and training.

Research, Development, and Testing

Anhui Institute of Optics and Fine Mechanics & Hefei Institute of Material Science & Russian Institute of Atmospheric Optics
[安徽省光学精密机械研究所 / 合肥材料科学研究所 / Институт оптики атмосферы]
Websites:
Anhui Institute of Optics and Fine Mechanics: http://www.aiofm.cas.cn/
Hefei Institute of Material Science: http://www.hfcas.ac.cn/
Locations:
Anhui Institute of Optics and Fine Mechanics: 350 Shushanhu Road, Hefei, Anhui
安徽省合肥市蜀山湖路350号
Hefei Institute of Material Science: Hefei
合肥

"The Anhui Institute of Optics and Fine Mechanics, Hefei Institute of Material Science, Chinese Academy of Sciences, and the Institute of Atmospheric Optics of the Russian Academy of Sciences signed a contract to promote the establishment of the Sino-Russian Joint Research Center for Atmospheric Optics in Hefei. The joint research center intends to establish the world's largest aperture full-elevation lidar atmospheric detection platform and an international coordinated super observatory to promote the development and application of weather forecasting, climate change research, lidar technology, and at the same time to be the atmosphere to be constructed by the Hefei Comprehensive National Science Center Environmental three-dimensional detection experimental facilities provide technical support."[145]

Beijing Institute of Aeronautical Materials
[北京航空材料研究所]
Chinese Website: http://www.biam.com.cn
Location in China: No. 8, Huanshan Village, Wenquan Town, Haidian District, Beijing
北京市海淀区温泉镇环山村8号

The Beijing Institute of Aeronautical Materials (BIAM) cooperates with the following Russian organizations according to the Institute's official website:[146]

- All-Russia Research Institute of Light Alloys
- Aviation and Technology Research Institute

- Institute of Aviation Materials
- Institute of High Current Electronics
  (Siberian branch of the Academy of Sciences)
- Institute of Strength Physics and Materials Science
- Institute of Theoretical and Applied Mechanics
  (Siberian branch of the Academy of Sciences)
- Lavrentyev Institute of Hydrodynamics
  (Siberian Branch of the Russian Academy of Sciences)
- Lebedev State Scientific Research Institute of Synthetic Rubber
- ORPE Technologiya
- Scientific Research Institute of Elastomeric Materials and Articles
  (Siberian Branch of Russian Academy of Science)
- Tomsk Polytechnic University
- VSMPO-AVISMA Corporation

Beijing Aeronautical Science and Technology Research Institute (BASTRI)

中国商飞北京航空科学与技术研究院（BASTRI）

Chinese Website: http://english.comac.cc/
Location for COMAC: Shanghai, Shibo Avenue 1919, 200126
上海世博大道1919号200126

BASTRI is the research branch of Chinese aircraft manufacturer COMAC (Commercial Aircraft Corporation of China).

Beijing Greiner Electronics Co. Ltd. and Russian XJ Technologies Company Ltd.

[北京格瑞纳电子有限公司 /

Chinese Website: http://www.carila.cn/
Location in China: 401, 4th Floor, Gate 1, Building 3, 3rd Street, Shangdi Information Industry Base, Haidian District, Beijing
北京市海淀区上地信息产业基地3街3号楼1号门4楼401室

Beijing Greiner Electronics Co. Ltd and Russian XJ Technologies Company Ltd. collaborated to develop Anylogic simulation software purchased by the Chinese Academy of Aeronautics and Astronautics.[147]

China Academy of Aerospace Aerodynamics and Russian Central Aerohydrodynamic Institute (TsAGI)

[中国航天航空动力学研究院 / Центральный аэрогидродинамический институт]

Chinese Website: http://www.caaa-spacechina.com/
Location in China: P.O. Box 7215, 17 Yungang West Road, Fengtai District, Beijing

邮局 北京市丰台区云岗西路17号7215信箱

The Russian Central Aerohydrodynamic Institute (TsAGI) signed an agreement on scientific and technical cooperation with the China Academy of Aerospace Aerodynamics at AirShow China 2018. The agreement covers cooperation in studying spacecraft for landing on Mars.[148]

China Aerodynamics Research and Development Center (CARDC) and Russian Central Aerohydrodynamic Institute (TsAGI)

[中国空气动力学研究开发中心 / Центральный аэрогидродинамический институт]

Chinese Website: www.cardc.cn
Location in China: No.6, South Section, Second Ring Road, Mianyang City, Sichuan Province
四川省绵阳市二环路南段6号

Specialists from the CARDC and TsAGI conducted acoustic tests of full-size chassis models of a joint project from November 14-30, 2019. The testing was done at CARDC's FL-17 wind tunnel. "TsAGI specialists conducted multi-channel measurements of flow noise for 70 variants of full-size chassis models at various flow rates. In the course of the work, several important results were obtained: the noise sources of the chassis were localized, the influence of the geometric parameters of the chassis on the noise was studied, and information was obtained to determine the effect of the scale model on its noise by comparing new information with the results obtained in TsAGI on a muffled AK installation-2."[149]

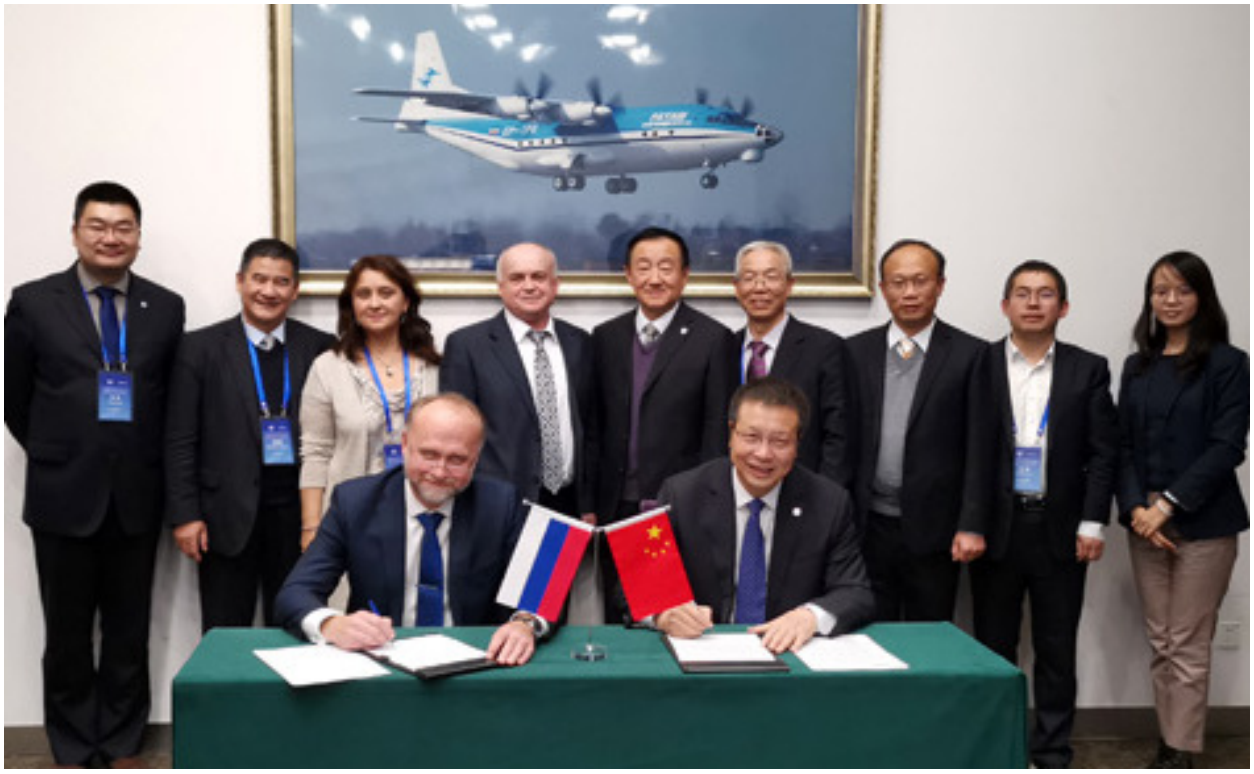
TsAGI also created design documentation for a transonic wind tunnel with the know-how to reduce distortion of the aerodynamic characteristics of a model during an experiment for CARDC in July 2016.[150]

TsAGI also examined the preliminary designs of some structural elements for a large continuous flow transonic wind tunnel for CARDC in 2019. "Under the contract, TsAGI will carry out an examination and preliminary design of some structural elements of the pipe. The parties also discussed the status of ongoing joint research projects. In particular, one of the issues on the agenda was the holding of bilateral symposia on fundamental and applied aerodynamics. Representatives of the institute got acquainted with the experimental base of the center - wind tunnels in the speed range from subsonic to hypersonic, aero-refrigeration unit, and a new acoustic pipe."[151]

China Aviation Academy and Russian Central Aerohydrodynamic Institute (TsAGI)
[中国航空科学院 / Центральный аэрогидродинамический институт]

The China Aviation Academy and Russia's TsAGI signed a five-year contract at the *XVI Russian-Chinese Conference on the Fundamental Problems of Aircraft Aerodynamics, Flight Dynamics, Strength and Safety* in November 2019. The contract identified forms of interaction

between the two organizations, such as carrying out research activities in fundamental and applied aviation research in the framework of mutually agreed contracts and agreements. The contract also planned joint participation in scientific and technical seminars, symposia, conferences, and data exchanges on the status and development of cooperation regularly through consultations and annual meetings of the leadership of TsAGI and the China Aviation Academy.[152]



China Aviation Academy and Russia's TsAGI Representatives at a Signing Ceremony[153]

China Aviation Manufacturing Technology Research Institute (aka Aeronautical Industry Manufacturing Institute and 625th Research Institute of China Aviation Industry Corporation) and Russian Aeronautical Materials Research Institute (VIAM)

[中国航空制造技术研究院 / aka 航空工业制造研究所 / Научно-исследовательский институт авиационных материалов]

Chinese Website: http://www.avicmti.avic.com/

Location in China: Chaoyang Road, Chaoyang District, Beijing

[北京市朝阳区朝阳路]

The China Aviation Manufacturing Technology Research Institute concluded a strategic cooperation agreement with the Russian VIAM in November 2018 to conduct R&D on high-strength and high-toughness titanium alloys, high-strength aluminum alloys, corrosion protection, testing, and inspection technologies in key areas such as aerospace materials technology, advanced manufacturing technology, and aviation special equipment technology. The agreement was also intended to promote Sino-Russian aviation material technology and advanced manufacturing

technology by strengthening mutual visits and exchanges, holding academic conferences and forums, and jointly applying for scientific and technological projects.[154]

China Aviation Research Institute and Russian Central Institute of Aviation Motors (CIAM)

[中国航空科学研究院 / Российский центральный институт авиационного моторостроения]

The China Aviation Research Institute (also known as the Chinese Aeronautical Establishment) is a subsidiary of the Aviation Industry Corporation of China (AVIC). This institute signed a memorandum of understanding with the Russian Central Institute of Aviation Motors (CIAM) to support potential collaboration in aero-engine technology development in January 2017.[155]

China Research Institute for Automatic Flight Control (FACRI) and Russian Central Aerohydrodynamic Institute (TsAGI)

[中国自动飞行控制研究所 / Центральный аэрогидродинамический институт]

http://www.facri.com/

Location in China: No. 129, Jinye Road, Yanta District, Xi'an City, Shaanxi Province

陕西省西安市雁塔区金业路129号

TsAGI signed a contract with the China Research Institute for Automatic Flight Control (FACRI) focused on conducting design and experimental assessments of the stability and controllability of the Chinese single-rotor helicopter. FACRI and TsAGI conducted additional talks in 2019 about forming a joint research program focused on aerobatic displays.[156]

Meeting of TsAGI to Report Results of 2018 Contract to FARCI[157]

China-Russia Commercial Aircraft International Corporation Co., Ltd. (CRAIC)
[中俄商用飞机国际有限公司]
Chinese Website: n/a
Location in China: Zhang Yang Road 25, Pudong, Shanghai
上海市浦东张杨路25号

On May 22, 2017, CRAIC launched a 50-50 joint venture between China and Russia in Shanghai, China, to develop the CR929 wide-body passenger aircraft. Joint activities include technological development, marketing, manufacturing, and sales of products – long-range wide-body commercial aircraft as well as after-sales service and consulting; project management of long-range wide-body commercial aircraft and related products; investment and financial activities in connection with the project; activities in the field of foreign trade, international cooperation, international technical cooperation, and other activities.[158]

Commercial Aircraft Corporation of China (COMAC)
[中国商用飞机公司]
Chinese Website: http://english.comac.cc/aboutus/introduction/
Location in China: Shibo Avenue 1919, Shanghai
上海市世博大道1919号

COMAC, as noted by their website, is the: [159]

> *Commercial Aircraft Corporation of China, Ltd. (COMAC) functions as the main vehicle in implementing large passenger aircraft programs in China. It is also mandated with the overall planning of developing trunk liner and regional jet programs and realizing the industrialization of civil aircraft in China. COMAC is engaged in the research, manufacture and flight tests of civil aircraft and related products, as well as marketing, servicing, leasing and operations of civil aircraft.*
>
> *COMAC, headquartered in Shanghai, was founded on May 11th, 2008. It is jointly invested by State-Owned Assets Supervision and Administration Commission (SASAC) of the State Council, Shanghai Guo Sheng (Group) Co., Ltd., Aviation Industry Corporation of China (AVIC), Aluminum Corporation of China Limited (CHALCO), China Baowu Steel Group Corporation Limited, and Sinochem Corporation. At the end of 2018, new shareholder units including China National Building Materials Group Co., Ltd. (CNBM), China Electronics Technology Group Corporation (CETC), and China Reform Holdings Corporation Ltd. joined in. The present Secretary of the Party Committee and Chairman of the Company is Mr. He Dongfeng, and the present Deputy Secretary of the Party Committee and President of the Company is Mr. Zhao Yuerang.*

COMAC owns the following member organizations: Design and Research Center (Shanghai Aircraft Design and Research Institute), Assembly Manufacturing Center (Shanghai Aircraft Manufacturing Co., Ltd.), Customer Service Center (Shanghai Aircraft Customer Service Co., Ltd.), Beijing Research Center (Beijing Aeronautical Science & Technology Research Institute), COMAC Flight Test Center, Capability & Supporting Center (Shanghai Aviation Industrial (Group) Co., Ltd.), Press Center (Shanghai Commercial Aircraft Magazine Co., Ltd.), COMAC University (Party School of COMAC Committee of CPC), COMAC Sichuan, American Corporation, COMAC Capital Co., Ltd., and COMAC Finance Limited Liability Company. The company also has its American Office and European Office in Los Angeles and Paris respectively. COMAC is a shareholder of China-Russia Commercial Aircraft International Co., Ltd., Chengdu Airlines Co., Ltd. and SPDBank Financial Leasing Co., Ltd.

Commercial Aircraft Corporation of China (COMAC) and Russian United Aircraft Corporation (UAC)

[中国商用飞机公司 / Объединенная авиастроительная корпорация]

TsAGI conducted week-long tests in its transonic T-128 wind tunnel under the program of the Russian-Chinese wide-body long-range CR929 aircraft of the COMAC and Russian UAC in December 2019. TsAGI used the standard high-speed model to test a 1:39 scale model of the configuration of the fuselage plus wing. The model was co-designed by Russian and Chinese aerodynamics experts.[160]

High-speed Standard 1:39 Scale Model Tested by TsAGI for COMAC and UAC[161]

Institute of the Chinese Academy of Aerospace Aerodynamics and Russian Central Aerohydrodynamic Institute (TsAGI)

[中国宇航科学院空气动力学研究所 / Центральный аэрогидродинамический институт]

As part of its business program, TsAGI held talks with a delegation from the Institute of the Chinese Academy of Aerospace Aerodynamics at the MAKS 2019. The discussion centered on possible cooperation in experimental research, particularly developing multi-component scales for testing models in wind tunnels. The parties discussed the status of the project and further steps for its implementation. Chinese scientists also took the opportunity to familiarize themselves with TsAGI experimental facilities, including its supersonic wind tunnel, a vacuum wind tunnel, and an acoustic reverberation chamber.[162]

Meeting of Russian and Chinese Delegations at International Aviation and Space Salon MAKS 2019 in Moscow[163]

Institute of Aeronautical Industry Manufacturing (aka AVIC Manufacturing Technology Institute and Beijing Institute of Aeronautical Manufacturing Engineering)

[航空工业制造研究所]

Chinese Website: http://www.avicmti.avic.com/
Location in China: No.1 Chaoyang Rd., Chaoyang District, Beijing
北京市朝阳区朝阳路1号

According to the institute's website: "After the establishment of the institute, it has established good cooperative relations with Russian institutes and universities in many fields. Especially since 1990, it has carried out a wide range of technologies with the Russian Aeronautical Technology Research Institute (NIAT), the Institute of Laser Physics (ILPH), the All-Russian Institute of Aeronautical Materials (VIAM), and the Volga Basin Aeronautical Technology Research Institute

(AviTI). Cooperation. The areas of cooperation involve high-speed blade processing technology, laser processing technology, high-frequency microscopic detection technology, ion implantation technology, etc."[164]

Institute of Aeronautical Industry Manufacturing (aka AVIC Manufacturing Technology Institute and Beijing Institute of Aeronautical Manufacturing Engineering) and Russian Scientific Research Institute of Aviation Materials (VIAM)

[航空工业制造研究所 / Научно-исследовательский институт авиационных материалов]

Chinese Website: http://www.avicmti.avic.com/
Location in China: No.1 Chaoyang Rd., Chaoyang District, Beijing
北京市朝阳区朝阳路1号

The Chinese Institute of Aeronautical Industry Manufacturing and Russian VIAM has a strategic cooperation agreement in the areas of high-strength and high-toughness titanium alloys, high-strength aluminum alloys, corrosion protection, testing, and inspection technologies in key areas such as aerospace materials technology, advanced manufacturing technology, aviation special equipment technology. The two institutes agreed to joint R&D to promote Sino-Russian aviation material technology and advanced manufacturing technology by strengthening mutual visits and exchanges, holding academic conferences and forums, and jointly applying for scientific and technological projects.[165]

Institute of Engineering Thermophysics (Qingdao Branch) and Russian Central Institute of Aviation Motors (CIAM)

[工程热物理研究所（青岛分院) / Российский центральный институт авиационного моторостроения]

Chinese Website: http://www.iet.cas.cn/gjjl/jldt/201807/t20180711_5041209.html
Location in China: No. 11 North Fourth Ring West Road, Beijing
北京市北四环西路11号

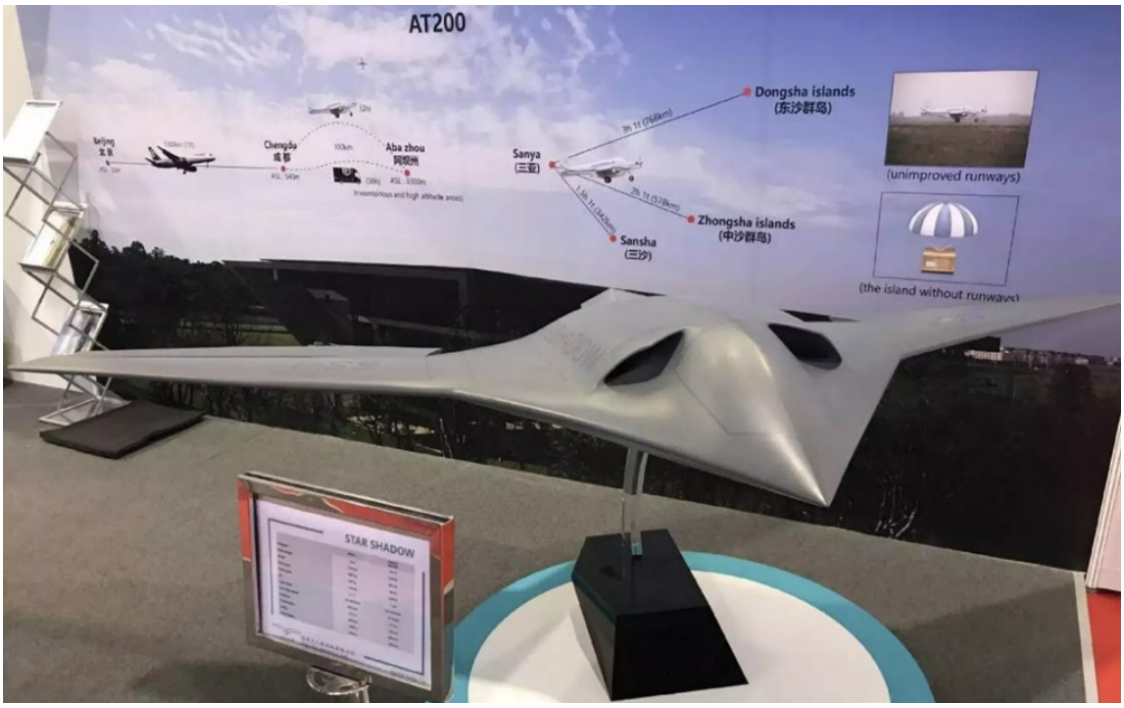
The Institute of Engineering Thermophysics (part of the Chinese Academy of Sciences) and the Russian CIAM conducted in-depth exchanges on cooperation regarding the high-altitude station and the engine airworthiness and signed the minutes of intent regarding technical cooperation in July 2018. The two sides agreed to conduct "extensive cooperation" on engine airworthiness procedures and tests. This exchange and cooperation laid the technical foundation for the next phase of the flight test of the engine and promoted the development of aero-engines.[166]

Institute of Engineering Thermophysics of the Chinese Academy of Sciences, Chengdu Zhongke Aero Engine Co., Ltd. and Russian Central Institute of Aviation Motors (CIAM)

[工程热物理研究所，成都中科航空发动机有限公司 / Российский центральный институт авиационного моторостроения]

Locations in China: Chengdu Zhongke Aero Engine Co., Ltd:
成都中科航空发动机有限公司

Institute of Engineering Thermophysics of the Chinese Academy of Sciences and the company's shareholding company, Chengdu Zhongke Aero Engine Co., Ltd., performed a 60-hour endurance test in 2017 on a 750 kg thrust grade medium bypass ratio turbofan developed by China Aviation Engineering Corporation. The testing was done at the high-altitude platform at the Russian CIAM. The performance test work covered the typical operating conditions in the flight range of 10,000 to 15,000 meters and the speed range of Mach 0.4 to 0.8 and carried out the 18,000 meter altitude engine performance test. The engine tested was the TWS-800 turbofan engine that powers the "Star Shadow" stealth UAV developed by Chengdu Zhongke Aero Engine Co., Ltd., and Institute of Engineering Thermophysics and displayed at the Singapore 2018 Air Show.[167]



"Star Shadow" Stealth UAV[168]

Joint Stock Company UEC-Perm Engine of Russia
[Пермский моторный завод]
Russian Website: http://www.pmz.ru/eng/
Location in Russia: Outside Perm

Rostec State Corporation announced in September 2018: "United Engine Corporation (UEC), a part of Rostec, will build a test complex for the prospective PD-35 aircraft engine, which is proposed to be used in the Chinese-Russian CR929 aircraft. The testing facilities will be created at JSC UEC-Perm Engine. "There will be about 40,000 square meters of production, administration and accommodation, and engineering areas with state-of-the-art

equipment on the premises of the out-of-town test facility in Russia's Perm Krai. The project's cost is about $300 million, and the first test stands will be built in 2021."[169] Victor Kladov, Director for International Cooperation and Regional Policy Department of Rostec, noted in the announcement that "The most important objectives during the implementation of the prospective PD-35 project include exhaustive tests of both separate subassemblies and full-size engines. To achieve this, we are creating infrastructure that meets the latest requirements." Additionally, the complex will include a logistics center, a final assembly building for engines and test preparations, and a whole range of test benches. There will also be an outdoor stand on which acoustic tests of engines, tests for casting ice, birds, and breaking a blade will occur.[170] The complex will be completed by the end of 2025.

Moscow Aviation Institute (MAI)
[Московский авиационный институт]
Russian Website: https://mai.ru/
Location in Russia: Volokolamskoe highway, 4, Moscow

MAI is involved in several cooperative projects with the Chinese. These include multi-year participation in the Russian-Chinese conferences on the *"Fundamental Problems of Aircraft Aerodynamics, Flight Dynamics, Strength and Flight Safety"* and involvement in the CR929 wide-body aircraft project.[171]

Russian Technology Group (RTG)
[Русская Технологическая Группа]
Russian Website: http://www.rustechgroup.ru/eng/about_firm.htm
Location in China: Beijing
北京

The Russian Technology Group or RTG consists of more than 700 companies with interests covering aviation, aircraft engines, electronics, medicine, and other fields. Victor Kradov, director of the International Cooperation and Regional Policy Department of the Russian Technology Group, told Chinese journalists at the ARMY 2019 that RTG has a representative office in Beijing, and its staff is the largest among the group's overseas representative offices. The Russian Technology Group has signed cooperation agreements with many Chinese companies in recent years, including the China Electronics Technology Group (CETC), China Commercial Aircraft Corporation (COMAC), and the Aviation Industry Corporation of China (AVIC). Among the projects being supported by the RTG are CR929 long-range wide-body passenger aircraft and heavy-lift civilian helicopters.[172]

School of Aeronautics of Northwestern Polytechnic University and Russian Institute of Control Sciences (ICS)
[西北工业大学航空学院] / Институт проблем управления РАН]
Chinese Website: https://en.nwpu.edu.cn/

Location in China: Xi'an, Shaanxi Province
陕西省西安市

The School of Aeronautics of Northwestern Polytechnic University and the Institute of Control Sciences of the Russian Academy of Sciences signed an agreement in November 2017 to establish the International Joint Unmanned Aerial Vehicle System and Design Laboratory.[173]

Shenyang Aircraft Design Research Institute (SADRI) and Russian Central Aerohydrodynamic Institute (TsAGI)
[Центральный аэрогидродинамический институт]
Location in China: 5 Yjin Road, Longhua Airport, Xuhui District, Shenyang
沉阳市徐汇区龙华机场益进路5号

The Shenyang Aircraft Design Research Institute (SADRI) and Russia's TsAGI discussed implementing a project to study the non-stationary aerodynamic characteristics of a passenger aircraft model in the experimental facilities of TsAGI. The discussion took place at the XIV Russian-Chinese conference on "*Fundamental Problems of Aircraft Aerodynamics, Flight Dynamics, Strength, and Flight Safety*" held in 2015.[174]

Conferences, Forums, Dialogs, and Seminars

Russian-Chinese Conference on the "Fundamental Problems of Aerodynamics, Fight Dynamics, Aircraft Strength, and Acoustics"

"The Russian-Chinese conference is held every two years alternately in two countries. The purpose of the meeting is a comprehensive exchange of research results and the development of business contacts between scientists. The event is included in the general plan of cooperation between Russian and Chinese enterprises in the field of science and technology…***The exchange of scientific achievements often becomes a solid foundation for launching joint projects.***"[175]

XI Russian-Chinese Conference on the "Fundamental Problems of Aerodynamics, Fight Dynamics, Aircraft Strength and Acoustics" (2011)

"The conference was divided into two sections: 'Aerodynamics, flight dynamics, aeroacoustics' and 'Aircraft structural strength'. The event was attended by 22 foreign experts from 14 organizations of the PRC (including representatives of the China Flight Testing Institute, the First Aviation Institute, the Aviation Research Institute of Strength, Shenyang Aerodynamic Institute, Northwest Polytechnic University). From the Russian side, Russian experts from 5 domestic organizations made speeches – TsAGI [Central Aerohydrodynamic Institute], MAI [Moscow Aviation Institute], LII [Gromov Flight Research Institute], SibNIA [Siberian Aeronautical Research Institute], VIAM [Scientific Research Institute of Aviation Materials] 40 reports from the Russian and Chinese sides were heard."[176]

XIV Russian-Chinese Conference on the "Fundamental Problems of Aerodynamics, Fight Dynamics, Aircraft Strength and Acoustics" (2015)

"The conference is part of the general plan of cooperation between Russian and Chinese enterprises in the field of science and technology. It implies the implementation of promising joint projects, such as creating a wide-body passenger airliner and a heavy transport aircraft," according to the acting First Deputy General Director of FSUE TsAGI Valery Sukhanov. Participants presented 11 reports covering aircraft aerodynamics, the aerodynamics of power plants, static and thermal strength, measuring equipment and metrology, dynamics and control systems, resource structures.[177]

XV Russian-Chinese Conference on the "Fundamental Problems of Aircraft Aerodynamics, Flight Dynamics, Strength and Safety" (2017)

"The TsAGI plenary report highlighted the priority issues of aerodynamics research on civilian aircraft, some of which could potentially be studied jointly with Chinese partners. In turn, colleagues from ASRI presented an overview of current changes and new opportunities for cooperation between scientists of the two countries in the field of strength and aeroacoustics of aircraft. TsAGI specialists prepared more than 20 reports covering the entire spectrum of thematic areas of the conference. In addition to the presentation of their scientific results, the results of studies conducted in collaboration with partners were presented." Russian attendees included Central Aerohydrodynamic Institute (TsAGI), Siberian Aeronautical Research Institute (SibNIA), Moscow Aviation Institute (MAI), Central Institute of Aviation Motors (CIAM), and Gromov Flight Research Institute (GFRI or LII). Chinese attendees came from Beijing Aeronautical Science and Technology Research Institute (BASTRI), Flight Automatic Control Research Institute (FACRI), Shanghai Aircraft Design and Research Institute (SADRI), China Helicopter Research and Design Institute (CHRDI), Hongdu Aviation Industry Group Ltd, Aviation Industry Corporation of China (AVIC), and Tsinghua University.[178]

First Russian-Chinese Conference on Innovative Development of Aircraft Engines (2017)

The event was organized and hosted by the Russian Central Institute of Aviation Motors (CIAM) in conjunction with the Aero-Engine Corporation of China (AECC) and its affiliates Aero Engine Academy of China. The Chinese delegation included representatives from AECC, Shenyang Engine Research Institute, Shenyang Liming Aero-Engine Co., Ltd., and the Hunan Aviation Powerplant Research Institute. Russian specialists came from the Central Aerohydrodynamic Institute (TsAGI) and CIAM. "In total, the conference participants presented 14 reports, prepared by CIAM specialists. The main topics are related to the discussion of opportunities and the necessary basis for ensuring technological progress in civilian engine building. The participants of the event on the part of the PRC drew attention to the fact that Russia today has a powerful technological base and unique scientific competencies for further developing the aviation industry."[179]

Presentation to Chinese and Russian Participants
at First Russian-Chinese Conference on Innovative Development of Aircraft Engines[180]

II Sino-Russian Forum "Investments in Innovation" (2017)

This forum was intended to foster direct and open dialogue between technological investors of Russia and China and promote expansion and diversification of cooperation in the field of innovations and high technologies. Topics covered have included discussing:[181]

- Main trends in the development of the venture capital and innovation ecosystems market of Russian and China

- Getting access to the current analyses revealing the specifics of the development of Russian and Chinese markets for direct and venture investment, learning about examples of successful joint transactions

- Exploring possibilities for creating joint ventures

15th China-Russia Aviation Science and Technology Academic Exchange Conference (2017)

The conference was jointly organized by the China Aviation Research Institute and Russia's Central Aerohydrodynamic Institute (TsAGI). The conference had representatives for 11 Chinese aviation research institutes, enterprises, universities, and more than 60 representatives from five Russian aviation research institutes and universities. The conference featured exchange reports

covering aircraft and aerodynamic technology, structural strength technology, fight mechanics, and flight safety technology.[182]

Symposium on China-Russia Aviation Technical Cooperation (2017)

The China Aviation Research Institute hosted a seven-person delegation from the Russian Zhukovsky National Research Center in January 2017. The Russian delegation consisted of members from the Central Aeroengine Research Institute (CIAM), the Central Aerohydrodynamic Institute (TsAGI), and the national aviation expert representative of the Institute of Systems Science (GosNIlAS). Representatives from TsAGI and CIAM also visited the COMAC North Research Center and the China Aviation Development Aeroengine Research Institute.

The Chinese were represented by more than 40 experts from 12 organizations affiliated with the Aviation Industry Corporation of China (AVIC), China Aviation Research Institute, and COMAC. The symposium had seminars devoted to aviation noise, composite materials, engine control and management, avionics integration, and man-machine efficiency. The symposium was carried out in accordance with the signed bilateral strategic cooperation agreement between CAE Dean Zhang Xinguo and Director NRC Dutov at the 2016 Zhuhai Air Show and was considered by the Chinese to be "an important step in exploring innovative cooperation models."[183]

Symposium on China-Russia Aviation Technical Cooperation Held in 2017[184]

6th Sino-Russian Engineering and Technical Forum for Cooperation in the Field of Aviation and Cosmonautics (2019)

More than 400 representatives from Russian and Chinese aerospace-related enterprises, research institutes, and universities of the two countries attended the meeting. Topics discussed included enthalpy test equipment, space debris mitigation technology, airship transportation system, lunar exploration program, solar test station, drone technology application, commercial aerospace, etc. The Russian Federation of Science and Industry signed a letter with the Municipal Development and Reform Commission and the Chinese Aeronautics and Astronautics Society for cooperation in the planning and cultivation of the aerospace industry, talent cultivation, scientific and technological exchanges, and international cooperation in Guangzhou. Also, during the event, Deyang Aviation, Quanzhou Deyuan Bearing Industry Co., Ltd., Xiamen Aviation Industry Co., Ltd., and Xiamen Oestuo Co., Ltd., and other companies issued employment certificates to six Russian experts.[185]

Signing Ceremony between the Guangzhou Academician Station and the Russian Federation of Science and Industry[186]

China-Russia Civil Aviation Cooperation Working Conference (2019)

The conference was held in Beijing to "discuss the joint development of the CR929 project of the long-range wide-body passenger aircraft and the guest of honor at the MAKS 2019. In-depth exchanges and consultations were held on topics such as preparations for national activities and the 2019 Civil Aviation Working Group of the Industrial Cooperation Sub-Committee of the China-Russia Prime Ministers Regular Meeting Committee and the next work plan was determined."[187]

Fourth Russian-Chinese Industry Cooperation Sub-Commission (2019)

The fourth Russian-Chinese Industry Cooperation Sub-Commission Session was held at MAKS 2019. Chinese and Russian session members discussed the key projects and issues of industrial cooperation between the two countries and summed up the working group's civil aviation and civil aircraft construction, equipment, raw materials, and electronics.[188]

Symposium and Site Visit Hosted by School of Aeronautics and Astronautics of Shanghai Jiaotong University for Delegation of Russian Academicians (2019)

The School of Aeronautics and Astronautics of Shanghai Jiaotong University hosted Russian Academicians Academician Cheslav Leznicenko, Academician Lagunov Alexander Vyacheslavovich, Academician Genanov Valery Garifianovich Cherkasov, Academicians Sergey Vladimirovic, and Academician Alexei Petrov for a site visit and to participate in a symposium. During the visit, the Russians were shown: (1) on-going experimental projects (including satellite technology) in the information control department, (2) propulsion department where Chinese Academician Lu Shaopeng discussed the thermal protection of turbine blades and other topics, and (3) the Department of Aircraft Design. At the symposium, the Russian

Academicians elaborated on the current research content of an engine project and ***discussed the future direction of cooperation***. "The academicians proposed that the forthcoming book '*The Superalloys*' on high-temperature resistant alloys can provide relevant theoretical support for the institute, and look forward to further discussing the publication plan in China with the institute and carrying out extensive cooperation and exchanges."[189]

Russian Academicians Visiting Aero-Engine Department[190]

China-Russia Innovation Cooperation Week (2019)

The School of Materials Science and Engineering of Beijing University of Aeronautics and Astronautics hosted Professor Lagunov, Academician of the Russian Academy of Engineering, and Professor Reznikchenko, Academician of the Russian Academy Natural Science, as part of the China-Russia Innovation Cooperation Week. Deputy Dean Guo Hongbo welcomed the two Russian academicians on behalf of the college and ***suggested several ways for Sino-Russian cooperation***. Dean Guo Hongbo hoped that the two sides could further cooperate through these channels in the future. After touring the school, Academician Lagunov gave an academic report entitled "*High-Temperature Resistant Alloys on Turbine Disks and Blades*," and Academician Leznikchenko did a presentation titled "*ACAP (Advanced Composite Body Design) — The Feasibility and Results of Using Polymer Composite Materials for Helicopter Fuselages*."[191]

Production and Manufacturing

Harbin Guanghan Gas Turbine Co., Ltd. and Russian United Engine Group
[哈尔滨广汉燃气轮机有限公司 / Объединенная двигателестроительная корпорация]

Website: http://www.ghturbine.com
Location: 31 Honghu Road, Daoli District, Harbin

哈尔滨市道里区洪湖路31号

The two companies signed a strategic cooperation agreement at the 2014 National Defense Exhibition in Russia. "The two parties will cooperate in the field of the aero-engine ***military to civilian***" (emphasis added).[192]

Russian Taganrog Aviation Scientific and Technical Complex (TANTK) imeni G.M. Beriev and Chinese Leader Energy Aircraft Manufacturing Co., Ltd.
[Российский Таганрогский Авиационный Научно-Технический Комплекс (ТАНТК) имени Г.М. Бериева / 利德能源飞机制造有限公司]

The two companies signed a memorandum of understanding at AirShow China 2016 to permit licensed production of Russia Be-103 amphibious aircraft by the Chinese Leader Energy Aircraft Manufacturing.

Organizations Seeking Sales and Acquisition Opportunities

- **Chinese Companies**

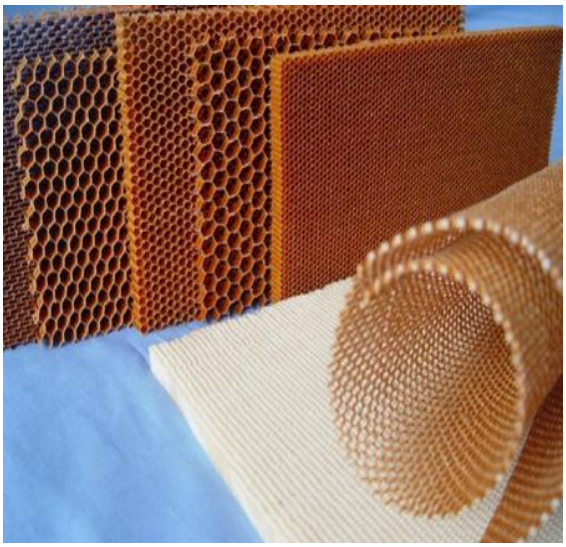
Anhui Haery Aviation Power
[安徽海利航空动力]
Website: http://www.haerypower.com/en/
Location: Technical Innovation Center 7F, WanDong Road, Xinwu Economic Development Zone, WuHu AnHu
芜湖市安湖区新武经济开发区万东路7楼技术创新中心

Anhui Haery Aviation Power is an integrated enterprise for aircraft engine research and development, production, sales, and after-sales service business. Haery mainly provides power equipment to aviation aircraft of rotor-wing, fixed-wing aircraft, and UVAs.[193] Anhui Haery Aviation Power participated as an exhibitor at MAKS 2019

AVIC Composite Materials Co., Ltd.
[中航复合材料有限公司]
Website: http://www.avicht.cn/zh-cn/industry.fhcl
Location: No. 25, Shun Road, Shunyi District, Beijing
北京市顺义区顺路25号

Member of the China Aviation Industry Corporation (AVIC) and is affiliated to AVIC Foundation Institute. AVIC Composite Materials Corp., Ltd. conducts development and applied research on resin matrix wave transmitting composites, ceramic matrix wave transmitting composites, core materials, and other material systems. AVIC is an advanced national defense technology key laboratory and is a structural carbon fiber national engineering laboratory and

green composite material Beijing engineering laboratory.[194] AVIC Composite Materials participated as an exhibitor at MAKS 2019.



Products of AVIC Composite Materials Co., Ltd.[195]

Beijing Institute of Microelectronic Engineering (BMTI)

[北京微电子工程学院]

Website: https://www.ime.pku.edu.cn/english/index.htm
Location: Micro/Nanoelectronics Building, Institute of microelectronics, Peking University
北京大学微电子研究所微/纳电子大楼

Attended an August 2014 seminar organized by OJSC Reshetnev Information Satellite Systems, which broached the subject of exporting Chinese microelectronics components for use in Russian space systems.[196]

Blue Arrow Space Technology Co., Ltd. (LandSpace)

[北京蓝箭航天科技有限公司]

Website: www.landspace.com/
Location: H1, Zhonghang International Plaza, No. 13 Ronghua South Road, Yizhuang Economic and Technology Development Zone, Beijing
北京亦庄经济技术开发区荣华南路13号中航国际广场H1

Founded by Tsinghua University in 2015, the company focuses on the design, manufacturing, and operations of small and medium commercial space launch vehicles. LandSpace is devoted to developing Liquid-fuel (LOX+LCH4) Rocket Engines (LREs) and low-cost commercial launch vehicles with independent intellectual property rights. LandSpace could complete the system and unit design, manufacture, test, and delivery with highly integrated design and innovation capability by a first-class technical team to provide economical and reliable high-quality launch services for commercial satellites and special-purpose spacecraft, as well as the development of new

technologies and systems for space applications. The Long March 11 rocket is the basis of the company's family of Zhuque (ZQ) family of rockets. LandSpace marketed five models of "Suzaku" series launch vehicles and displayed a full-scale model of "Tianque" 80-ton liquid oxygen methane engine at MAKS 2019.[197]

ZQ-2 Private Commercial Space Launch Firm's Design Concept at MAKS 2019[198]

Zhuque (ZQ) Family of Rockets (left) on Display and Tianque 80-ton Liquid Oxygen Methane Rocket Engine (right) on Display and from Brochure at MAKS 2019[199]

China Aero Engine Group Co., Ltd. (AECC)

[中国航空发动机集团有限公司]

Website: www.aecc.cn

Location: 5 Landianchang South Road, Haidian District, Beijing

北京市海淀区兰甸场南路5号

AECC was formed in August 2016 through the merger of 24 AVIC subsidiaries involved in aircraft engine development and production. AECC marketed the AEF3500 wide-body passenger aircraft engine verification machine, the CJ1000 civil large bypass ratio turbofan engine, the

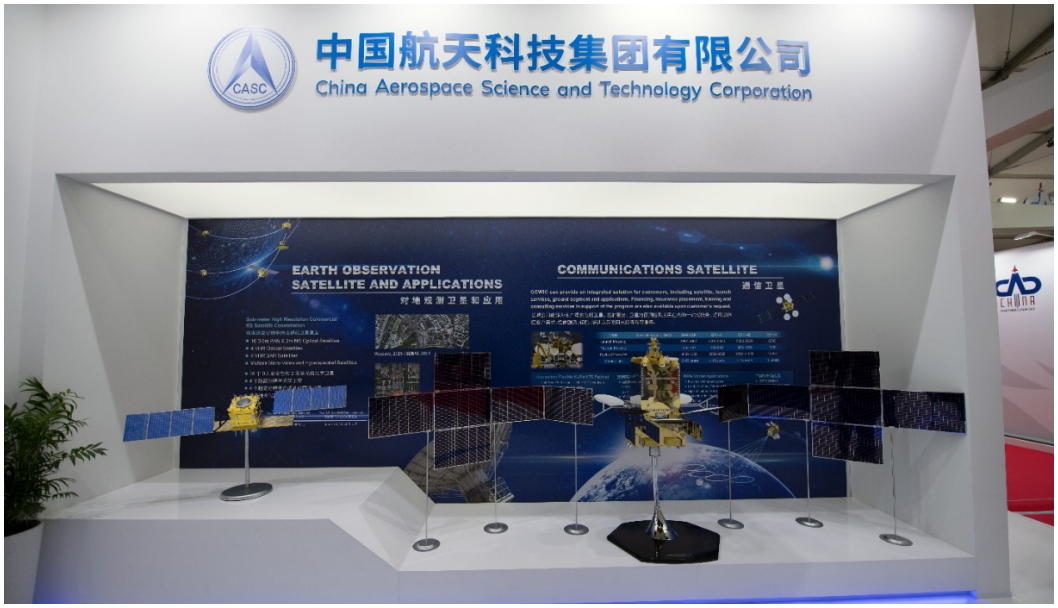
AES100 turbine engine, the AEP80 turboprop engine, and the QD70 light gas turbine engine at MAKS 2019.

China Aerospace Science and Technology Corporation (CASC)

[中国航天科技集团公司]

Website: http://english.spacechina.com
Location: 16 Fucheng Road, Haidian District, Beijing
北京市海淀区阜成路16号

"CASC is dedicating itself to building China into a space power, continuously carrying out the national major scientific and technical programs such as Manned Spaceflight, Lunar Exploration, Beidou Navigation, and High-Resolution Earth Observation System; initiating several new major programs and projects such as heavy launch vehicle, Mars exploration, asteroid exploration, space vehicle in-orbit service and maintenance, and space-ground integrated information network; and actively conducting international exchanges and cooperation…"[200] CASC showcased the Long March 7 and 11 carrier rockets and Mars probes and exhibited the LW-30 laser defense system at the MAKS 2019.[201]



Earth Observation and Communication Satellites as CASC Booth at MAKS 2019[202]

LW-30 Laser Defense System at AirShow China 2018 (left) and Model at MAKS 2019 (right)[203]

China Aviation Industry Corporation Co., Ltd. (AVIC)

[中国航空工业股份有限公司]

Website: http://www.avic.com/en/
Location: AVIC Plaza, No.128 Jianguo Road, Chaoyang District, Beijing
北京市朝阳区建国路128号中航广场

AVIC concentrates on aviation products and services to customers in many sectors - from research and development to operation, manufacturing, and financing. AVIC's business units cover defense, transport aircraft, helicopters, avionics and systems, general aviation, research and development, flight testing, trade and logistics, assets management, finance services, engineering and construction, and automobiles. AVIC has over 100 subsidiaries, nearly 27 listed companies, and more than 450,000 employees.[204] AVIC was a featured exhibitor at MAKS 2019.

Commercial Passenger Aircraft at the AVIC Booth at MAKS 2019[205]

China Electronics Technology Group Co., Ltd. (CETC)

[中国电子科技集团有限公司]

Website: http://en.cetc.com.cn/
Location: No.27 Wanshou Road, Haidian District, Beijing
北京市海淀区万寿路27号

"CETC has become the only large-scale technology corporation in China covering all fields in electronic information. It is the most powerful national central corporation in defense electronics, security electronics, and informatization, with the market covering more than 110 countries and regions in the world. The defense electronics has formed seven main product systems: airbase early warning, integrated electronic information system, radar, communication and navigation, electronic warfare, UAV electronic equipment, and integrated IFF. The field of security electronics and information mainly includes public security, e-government, intelligent transportation, new energy, components, and other products and businesses."[206] CETC exhibited the CU42, China's first large, twin-engine long-endurance drone, and displayed a collection of semiconductor radio frequency components to show China's capability of mastering related materials, techniques, designs, and production at MAKS 2019.[207]

CETC Booth at MAKS 2019[208]

China Great Wall Industry Corporation (CGWIC)

[中国长城实业总公司]

Website: http://www.cgwic.com/
Location: No. 88 Nan Cai Yuan Street Xi Cheng District, Beijing
北京市西城区南蔡园街88号

"China Great Wall Industry Corporation (CGWIC) is the only commercial organization authorized by the Chinese government to provide commercial launch services, satellite systems and to carry out space technology cooperation. It is a subsidiary of China Aerospace Science and Technology Corporation (CASC)."[209] CGWIC had a working meeting with NPO Energomash about possible cooperation in developing liquid propellant rocket engines at the International

Aviation and Space Salon Aviation Expo China – 2017 held in the China National Convention Center in Beijing.[210] CGWIC also participated in the MAKS 2017 and 2019.[211]

China Great Wall Industry Booth at MAKS 2019[212]

Commercial Aircraft Corporation of China (COMAC)

[中国商用飞机公司]

Website: http://english.comac.cc/aboutus/introduction/
Location: Shibo Avenue 1919, Shanghai
上海市世博大道1919号

"Commercial Aircraft Corporation of China, Ltd. (COMAC) functions as the main vehicle in implementing large passenger aircraft programs in China. It is also mandated to develop trunk liner and regional jet programs and realize the industrialization of civil aircraft in China. COMAC is engaged in the research, manufacture, and flight tests of civil aircraft and related products, as well as marketing, servicing, leasing, and operations of civil aircraft."[213] COMAC participated as an exhibitor at MAKS 2019.[214]

COMAC and Sukhoi Show Mockup of CR929 Passenger Aircraft at MAKS 2019[215]

Dajiang Innovation (DJI)
Website: https://www.dji.com/
Location: 14th Floor, West Wing, Skyworth Semiconductor Design Building, No.18 Gaoxin South 4th Ave, Nanshan District, Shenzhen
深圳市南山区高新南四路18号创维半导体设计大厦西翼14楼

DJI exhibited for the first time at MAKS 2019, attempting to penetrate the Russian and near-abroad markets with their extensive line of commercial and military UAVs. DJI is one of the world's largest producers of commercial drones in the world.

Nanjing University of Science and Technology
[南京科技大学]
Website: http://www.njust.edu.cn/
Location: 200 Xiaolingwei Street, Xuanwu District, Nanjing
南京市宣武区小灵卫街200号

The Nanjing University of Science and Technology demonstrated achievements in the development of UAVs and microsatellite satellite research. They also advertised "Space On-Orbit Service" for removing space debris and making on-orbit repairs to space vehicles at MAKS 2019.

Nanjing University of Science and Technology Brochure at MAKS 2019[216]

Nanjing University of Science and Technology Brochure at MAKS 2019[217]

9th Research Institute of Chinese Aerospace Science and Technology Corporation (CASC) [第九研究所航空航天科技公司]

Website: http://english.spacechina.com/n16421/index.html

Attended an August 2014 seminar organized by OJSC Reshetnev Information Satellite Systems, which broached the subject of exporting Chinese microelectronics components for use in Russian space systems.[218]

Northwestern Polytechnical University
[西北工业大学]
Website: https://www.nwpu.edu.cn/
Location in China: Chang'an Campus Address: No. 1, Dongxiang Road, Chang'an District, Xi'an
长安校区地址：西安市长安区东乡路1号

Marketed the LJ-1 target drone featuring sustained-G, long-endurance, stealth, and recoverability. It can simulate third- and fourth-generation fighter jets and, depending on another commonly used classification, fifth-generation fighter jets at MAKS 2019.[219]

Phoenix Electronics LLC (Joint Chinese-Russian Company)
Website: http://www.phoenix-electronics.ru/about.html
Location: 426035 Izhevsk, St. Russia, Tel./fax: 7 (3412) 50-00-84

Phoenix Electronics is a reliable supplier of electronic components from China's largest manufacturers. This company specializes in supplying ECB with different levels of quality, including electronic components of military and space applications. The firm's goal is to provide Russian manufacturers with high-quality electronic components. They offer customers a wide range of electronic components, including analog and digital IMS, transistors, DC/DC converters, microprocessors, microcontrollers, analog multiplexers, PLIS, ADC, CAP, diodes, etc. This firm participated as an exhibitor at MAKS 2019.

Types of Chinese Electronic Products Offered by Phoenix Electronics LLC Brochure at MAKS 2019[220]

Trading Partners of Phoenix Electronics LLC Brochure at MAKS 2019[221]

Wuhu Diamond Aircraft Manufacturing Co., Ltd.

[芜湖钻石飞机制造有限公司]

Website: https://www.cetcd.com/diamondsplane_en/web/index.php/about
Location: No. B2, Wanjiang Fortune Plaza, Jiujiang District, Wuhu City, and the Aviation Industrial Park of Wuhu city
芜湖市九江区万江财富广场B2号及芜湖市航空工业园

Wuhu Diamond is a joint venture between China Electronics Technology Group Corporation (CETC) and Wuhu city. The Company produces the Diamond DA42 and 2-seat DV20E multi-purpose light aircraft as well as the CU42 drone.[222] The CU42 drone was displayed, and this firm participated as an exhibitor at MAKS 2019.

Wuhu Diamond DA42 Drone on Display at MAKS 2019[223]

Xi'an Institute of Microelectronic Engineering (XMTI)

[西安微电子工程学院}

Website: n/a
Location: Xi'an
西安

Attended an August 2014 seminar organized by OJSC Reshetnev Information Satellite Systems, which broached the subject of exporting Chinese microelectronics components for use in Russian space systems.[224] Showcased the LJ-1 a tactical target featuring sustained-G, long-endurance, stealth, recoverability and can simulate third- and fourth-generation fighter jets at MAKS 2019.

LJ-I ("砺剑-1/Sword-1) Stealthy Target Drone on Display at MAKS 2019[225]

Youqing (Shanghai) Software Technology Co., Ltd.

Youqing (Shanghai) Software Technology Co., Ltd. is a Chinese branch of UNIGINE Corporation, a Russian real-time 3D modeling engine company (also known as UNISOL Technologies). This firm's main business is real-time 3D engine sales and original technical support, and also performs the design, optimization, and execution of one-stop project support solutions in professional fields such as virtual reality, simulation, training, scientific research, and visualization. Clients include AVIC, CETC, CAST, PLA, PLA Navy, PLA Air Force, PLA military academies and research institutes, and People's Armed Police (PAP).

Youqing (Shanghai) Software Technology Co., Ltd. is a Chinese branch of UNIGINE Corporation, a Russian Real-time 3D Engine Provider (UNISOL Technologies) [226]

Ziyan Unmanned Aerial Vehicle Co., Ltd.
[紫岩无人机有限公司]
Website: http://ziyanuav.com/aboutus.html
Location: 广东省珠海市香洲区唐家湾镇科技七路中电高新区2栋101

Ziyan develops and manufactures intelligent electric unmanned helicopter platforms. The main product is an unmanned electric helicopter that can be used for high-speed inspections, rescue, border patrol, anti-terrorism, special operations, air security, training target drones, and small and medium-sized fast logistics platforms. A future air intelligent unmanned cargo platform can be used in the civilian and military markets, relying on advanced unmanned helicopter technology.[227] This firm participated as an exhibitor at MAKS 2019

- **Russian Companies**

Almaz-Antey Air and Space Defense Corporation"
[Алмаз-Антей Групп]
Website: http://www.almaz-antey.ru
Location: 41 Vereyskaya Street, Moscow

Almaz-Antey Corp. consolidates more than 60 high-technology companies specialized in developing and producing air defense and anti-missile systems, radars, and control systems, providing operation, modernization, and repair of products supplied to the customers. Its advertising emphasizes products manufactured by Almaz-Antey to ensure protection against air and space attack means and air and ground surveillance and control. Almaz-Antey is one of the leading companies in the world arms market for defense supplies.[228]

Concern Radio-Electronic Technologies (KRET)
Website: www.kret.com
Location: Goncharnaya st., 20/1, building 1, Moscow

KRET currently manufactures a broad range of products designed for the following industries: (1) radio-electronics, (2) aerospace, (3) industrial manufacturing, and (4) healthcare, but its business is the manufacturing of onboard radio-electronic equipment for military and civilian aircraft.[229] KRET is Russia's leading designer and manufacturer of onboard radio-electronic equipment for all aircraft types (over 80% of the market) and state identification systems (over 90% of the market). KRET also designed the electronics for some of Russia's most advanced military aircraft, including Su-57, Su-35S, Ka-52 Alligator, Mi-171A2, Yak-130, MiG-29K/KUB, IL-476, and Tu-204SM, as well as for the Soyuz TMA manned spacecraft. KRET includes over 90 scientific research institutions, development laboratories, and production facilities.[230] KRET ***showcased more than 40 military and civilian products "based on breakthrough innovative technologies" at AirShow China 2016.***[231]

Central Scientific Research Institute Kometa (TsNII Kometa)
[ЦНИИ Комета]
Website: http://istc.kz/en/institute/10323
Location: 5, Velozavodskaya street, Moscokom

The main technical areas are: (1) high-performance computing and networking/information and communications, (2) fluid mechanics and gas dynamics/physics, and (3) radiofrequency waves/physics.[232] TsNII Kometa is developing software for the Chinese early missile warning system.[233]

JSC Electrostal Metallurgical Plant
[Электросталь, металлургический завод]
Website: https://www.elsteel.ru/en/
Address: Zheleznodorozhnaya Ulitsa, 1, Elektrostal, Moscow

JSC Electrostal Metallurgical Plant is one of Russia's leading enterprises for producing steels and special heat resistant alloys for high-tech products, including aircraft engines.[234] This firm exhibited at AirShow China 2012 and 18th Aviation Expo/China 2019.[235]

JSC Electrostal Metallurgical Plant Advertisement at HELIRUSSIA 2010[236]

NPO Energomash
[НПО Энергомаш]
Website: http://www.npoenergomash.ru/eng
Location: 1 Burdenko street, Khimky, Moscow

NPO Energomash has a working meeting with the China Great Wall Industry Corporation about possible cooperation in developing liquid propellant rocket engines at the International Aviation and Space Salon Aviation Expo China – 2017 held in the China National Convention Center in Beijing. NPO Energomash, Deputy General Director for Strategic Development Dmitry Pakhomov, told the media that "The Chinese side is showing great and stable interest in propulsion, this is especially important now when the State Duma of the Russian Federation is ratifying the intergovernmental agreement on cooperation between Russia and China in the field of space technology. Our task is to find out what areas in the part of liquid-propellant rocket engines are of interest to the Chinese side to inform ROSCOSMOS State Corporation and be ready to start cooperation."[237]

PJSC MAC Vimpel
[ПАО МАК Вымпел]
Website: http://macvympel.ru/

PJSC MAC Vimpel is developing software for the Chinese early missile warning system.[238] The general designer of the Russian missile warning system, head of the Russian defense corporation PJSC MAK Vympel, told *Interfax* that his company is helping China model a missile early warning system: "Interaction along the line of modeling the early warning missile system is being carried out. We cannot speak in more detail since this is associated with confidential agreements."[239]

Roscosmos
[Роскосмос]
Website: https://www.roscosmos.ru/
Location in Russia: 42 Shchepkina Street, Moscow

Dmitry Rogozin, director general of Roscosmos, told the Russian state news agency Sputnik at the MAKS 2019 that Russia was to supply rocket technology to Chinese space launch vehicles. "Cooperation in the field of space transport services could involve the launches of Chinese spacecraft onboard Russian carrier rockets to deploy China's multi-satellite constellation, as well as possible deliveries of rocket engines." Rogozin went on to say Russia and China would discuss "cooperation in near-space infrastructure" when a Chinese delegation visits Roscosmos in late 2019 or early 2020.[240]

Russian Helicopters
[Российские вертолеты]
Website: https://www.rhc.aero/
Location: Bolshaya Pionerskaya Street, 1, Moscow

"Russian Helicopters is a leading player in the global helicopter industry, the sole Russian rotorcraft designer and manufacturer and one of the few companies worldwide with the capability to design, manufacture, service, and test modern civilian and military helicopters. Russian Helicopters is part of State Corporation Rostec. Russian Helicopter facilities span the entire country. The Company includes design bureaus, helicopter assembly plants, components production, maintenance and repair enterprises, aircraft repair plants, and helicopter service companies providing after-sales support in Russia and abroad. Russian Helicopters is headquartered in Moscow."[241]

According to the website *The National Interest:* [242]

- *"In 2016, Moscow and Beijing signed an agreement to cooperate on the development of advanced civilian helicopters for the Chinese market. The JSC Russian Helicopter Company, which is part of the Rostec state corporation, provided Chinese partners in developing the rotary aircraft. China has become the largest operator of Russian helicopters in the Asia-Pacific region, and this has come about after years of cooperation between companies in the two nations."*

- *"… China has now placed a new order with the Russian firm to supply an additional 121 aircraft. According to Rostec's annual report, the contract from the government in Beijing as well as private enterprises is for sixty-eight Mi-171 helicopters including the upgrade Mi-171E; eighteen Mi-171Sh military transport helicopters; and fourteen Mi-171 helicopters with VK-2500 engines. An additional twenty-one Ansat helicopters are also part of the deal."*

Salyut Machine-Building Production Association
[Салютское машиностроительное производственное объединение и Китай]
Website: http://www.salut.ru
Location: Pr-t Budyonny, 16, Moscow

Salyut Machine-Building Production Association (part of the United Engine Corporation) is Russia's leading commercial and military aircraft engine production association. Aircraft engine repairs and diagnostic services are also provided. Under conversion programs, Salyut produces a variety of commercial machinery and small engines. The Salyut Machine-Building Production Association supplies AL-31FN military turbofan engines for all Chinese J-10 fighter series variants (also see Appendix A for a listing of engines sold to the PRC).[243] Salyut will also develop

and later produce the PDI-35 engine for the CR929 wide-body passenger aircraft with a joint Chinese-Russian venture.[244]

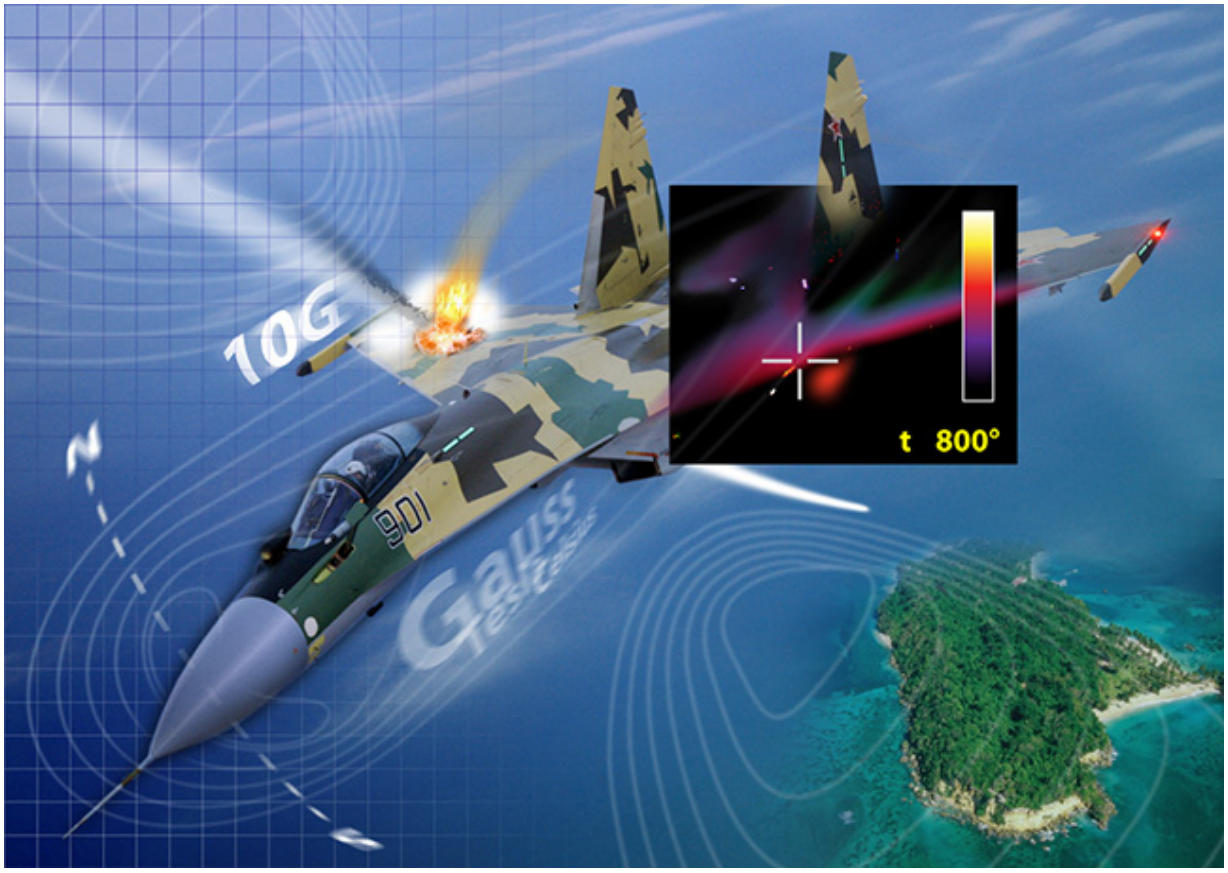
Name	Description	Builder	Year	Thrust	Thrust vectoring	Aircraft	Status
AL-31F	Basic engine developed to power the Su-27 fighter	Salyut UMPO	1981	27,600 lbf (122.6 kN)	No	Sukhoi Su-27 **Shenyang J-11** Sukhoi Su-30MKK Sukhoi Su-30 (Salyut)	In-service/ production
AL-31F3	Improved variant for the naval version Su-33	Saturn Lyul'ka		28,200 lbf (125.57 kN)	No	Sukhoi Su-33	In-service/ production
AL-31FP	Improved variant for the Indian Su-30MKI with thrust vectoring	Salyut	2000	27,600 lbf (122.6 kN)	Yes	Sukhoi Su-30 MKI Sukhoi Su-30MKM	In-service/ production
AL-31FN	Improved variant for the Chengdu J-10	Salyut	2002	28,000 lbf (124.5 kN)	No	**Chengdu J-10**	In-service/ production
AL-31FN Series 3	Improved variant for the Chengdu J-10B	Salyut	2013	30,200 lbf (134.3 kN)	No	**Chengdu J-10**	In-service/ production
AL-31F M1	Improved version for the Russian Air Force	Salyut	2007	30,300 lbf (135 kN)	Yes	Sukhoi Su-27SM, Sukhoi Su-30 Sukhoi Su-34	In-service/ production
AL-31F M2	Improved version for the Su-34 and Chengdu J-20	Salyut	2012	32,600 lbf (145 kN)	No	Sukhoi Su-34 **Chengdu J-20**	In-service/ production
AL-41F-1S (117S)	Advanced derivative for the Su-35	UMPO	2010	31,900 lbf (142 kN)	Yes	**Sukhoi Su-35**	In-service/ production
AL-41F1 (117)	Advanced derivative for the Sukhoi Su-57	UMPO	2010	33,000 lbf (147 kN)	Yes	Sukhoi Su-57 prototype	In-service/ production

Wikipedia Listing of Russian AL-31/-41 Fighter Aircraft Engines with Some Models and Versions Sold to the PRC (RED highlights models used by PRC)[245]

Scientific Research Institute of Aviation Systems (GosNIIAS)
[Научно-исследовательский институт авиационных систем или ГосНИИАС]
Website: https://www.gosniias.ru/
Location: 7 Viktorenko Street, Moscow

GosNIIAS is a Russian scientific center for systemic research of military and civil aviation, development of algorithms, information, and software for the operation of aviation complexes, and analysis of the effectiveness of aviation systems. A delegation from GosNIIAS had negotiations

with the management of AVIC CARERI, AVIC SAE, AVIC TAICO, and AVIAGE Systems at AirShow China 2016. "An understanding was reached of the need for further cooperation and an agreement on the exchange of proposals in the selected areas of joint activity."[246]



Combat Life, Resistance of Weapons and On-Board Equipment to External Factors[247]

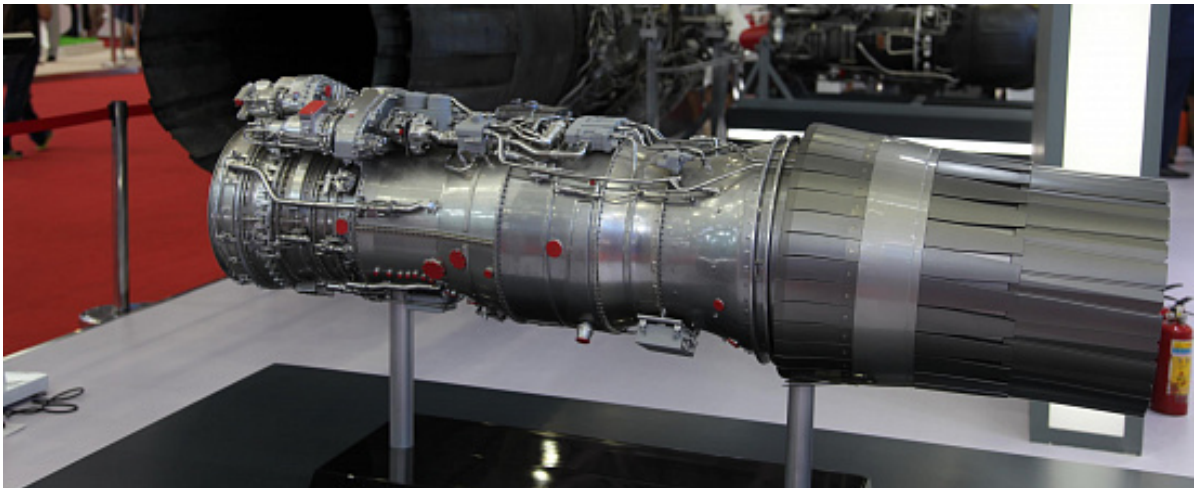
Tactical Missiles Corporation (KTRV)
[Тактическая ракетная корпорация]
Website: http://eng.ktrv.ru/
Location: 7 Korolev, Ilyicha Street, Moscow

Tactical Missile Corporation develops and produces guided missiles, tactical missile systems for air, ground, and naval platforms, precision-guided munitions fifth-generation aircraft. The Corporation contains design bureaus and experimental and batch plants, which provide product life support, including development, production, testing, after-sales service, upgrading, and product disposal.[248] KTRV and Almaz-Antey combined have sold nearly 8,287 different types and kinds of air-to-air, air-to-ground, and air defense missiles to China (for a listing of missiles sold to the PRC, see Appendix A).

Cruise Missiles Produced by Tactical Missile Corporation[249]

Ufa Engine-Building Production Association (UMPO)
[Уфимское моторостроительное производственное объединение]
Website: http://www.umpo.ru/
Location: Bashkortostan, Ufa, street. Ferina, 2

The Ufa Engine-Building Production Association (part of the United Engines Corporation) is a developer and the largest aircraft engine manufacturer in Russia. It has supplied RD-93 engines for Chinese-Pakistani JF-17 fighters and AL-31FN engines for Chinese J-10 fighters.[250] UMPO attended AirShow China 2018, where the company exhibited the AL-41F-1S product - a 4 ++ generation turbojet engine with an afterburner and a controlled thrust vector which is a deep modernization of the AL-31F engine. UMPO's booth at AirShow China 2018 also promoted the PD-14 engine for the MS-21 airliner, the RD-93 engine for fighter aircraft, and the VK-2500PS civil helicopter engine.[251]



AL-41F-1S Engine Displayed by UMPO at AirShow China 2018[252]

United Aircraft Corporation
[Объединенная авиастроительная корпорация]
Website: https://www.uacrussia.ru/en/corporation/
Location: Ulansky side-street, 22, bldn.1, Moscow

The United Aircraft Corporation (UAC) manages all of Russia's main aviation plants, which produce aircraft of such brands as Sukhoi, MiG, Ilyushin, Tupolev, Beriev, Superjet100, and MC-21 passenger aircraft. It is responsible for developing and producing military and civilian aircraft.[253] UAC licensed Su-27 fighter production to China from 1992 to 1996 and more recently sold Su-35 fighters to China.

United Engines Corporation (UEC)
[Объединенная Корпорация Двигателей]
Website: https://www.uecrus.com/rus/
Location in Russia: 105118, Moscow, pr. T Budennogo, d.16

United Engines Corporation (UEC) signed a memorandum of understanding in 2017 with the Aero-Engine Corporation of China (AECC) to develop and produce an engine to power the new joint CR929 passenger wide-body aircraft. Salyut Machine-Building Production Association will participate in developing and producing the new PD-35 engine for the CR929.[254]

VSMPO-Avisma Corporation
[ВСМПО-Ависма]
Website: http://www.vsmpo.ru/en/
Location: Parkovaya St. 1, Verkhnaya Salda, Sverdlovsk region

VSMPO-Avisma sells metal blanks for aircraft engine parts with rough machining, aluminum, and titanium semi-finished products to China.[255]

- **Education and Training**

Aviation Technology Joint Research Center: Zhejiang University (ZJU) and Moscow Aviation Institute (MAI)
[航空技术联合研究中心]
Website: https://www.zju.edu.cn/ and https://mai.ru/
Location in China: Zhiquan Rd, Xihu, Hangzhou, Zhejiang
浙江省杭州市西湖区志权路

According to Zhejiang University (ZJU), "On September 16 [2018, President WU Zhaohui met with a delegation of Moscow Aviation Institute (National Research University) headed by Rector Mikhail Pogosyan, in Shanghai. They signed a ZJU-MAI cooperation agreement and unveiled the plaque for the ZJU-MAI-Haika Aviation Technology Joint Research Center.

"With the strategic guidance of Chinese and Russian leaders, the China-Russia comprehensive strategic partnership of coordination has taken on a more positive look since 2018. The partnership in the domains of science, technology, and education between the two countries is vital for the attainment of win-win cooperation and peaceful development. MAI is superbly outstanding in aerospace technology globally. In recent years, our university has achieved tremendous progress in the fields of aeronautics and astronautics. I hope that with joint efforts, the ZJU-MAI-Haika Aviation Technology Joint Research Center will become a paradigm for cooperation in talent cultivation and scientific innovation," said WU Zhaohui. [256]

"We have harvested some fruits in the past year. MAI and other universities in China have carried out collaborative research in commercial aircraft engines and wide-body passenger jets. I look forward to substantial cooperation and exchange with ZJU in general aviation. I hope that the signing of the cooperation agreement, the unveiling of the joint research center and the launch of the student program will lay a solid foundation for comprehensive cooperation in talent cultivation and scientific research," said Mikhail Pogosyan. [257]

President WU Zhaohui met with a delegation of Moscow Aviation Institute (National Research University) headed by Mikhail Pogosyan in Shanghai on September 16, 2018[258]

China-Russia Joint Aviation Academy: Shanghai Jiaotong University (SJTU) and the Moscow Aviation Institute (MAI)

[中俄联合航空学院]

Location in China: Shanghai

上海

The China News Agency announced the creation of the China-Russia Joint Aviation Academy in April 2017 between SJTU and MAI. A news release from the Shanghai Jiaotong University News Center emphasized that China-Russia Joint Aviation Academy initially concentrated on aerospace composite structure, aero-engine, and aerospace product lifecycle management. Initially, research and training will focus on the jointly developed CR929 long-range wide-body passenger aircraft project. The program will accommodate 60 students (30 each from China and

Russia) who will work towards a Master's degree and clarify their research area of specialization. Students will study public and professional basic courses the first year. The second-year is devoted to professional courses and scientific research practices. Third-year students complete and defend their Master's thesis. Additionally, Chinese and Russian students regularly have exchange visits. Training also includes university and enterprise tutors.[259]

"Moscow Aviation Institute and Shanghai Jiao Tong University (SJTU) will admit the 5th group of students [April 23, 2021]. The international target corporate master's program is aimed at training the personnel reserve for the Russian-Chinese wide-body long-range aircraft project CR929. To date, more than 100 students have completed the program and received a master's degree. "[260]

College of Aeronautics and Astronautics of Zhejiang University

[浙江大学航空航天学院]

Website: http://saa.zgy.edu.cn

Location in China: Zhiquan Rd, Xihu, Hangzhou, Zhejiang

浙江省杭州市西湖区志权路

The College of Aeronautics and Astronautics of Zhejiang University organized 40 undergraduates to participate in the 2019 Summer Aviation School of Moscow Aviation Academy. The exchange focuses on drones. According to an announcement from the College of Aeronautics and Astronautics: "During the one-week study, the instructors of the Moscow Aeronautical Academy introduced the concepts of 3D printing, the advantages and disadvantages and their development, the application of 3D printing software and other 3D printing knowledge, and the classification of drones for the teachers and students participating in the activity, components and their functions, drone design, assembly and other knowledge of the drone, and organized the actual operation and parameter adjustment of 3D printing, demonstration, and teaching of the actual operation of the drone and other activities, so that every one of the students can combine theory and practice, and have a deeper and more specific understanding of the knowledge they have learned."[261]

Nanjing University of Aeronautics and Astronautics (NUAA) and Moscow Aviation Institute (MAI)
[南京航空大学 / Московский авиационный институт]
Website: http://iao.nuaa.edu.cn/ and https://en.mai.ru/
Location in China: 29 Yudao St, Qinhuai District, Nanjing
京市秦淮区玉道街29号

NUAA and MAI announced a dual degree program in aircraft and engine design in April 2019. The joint training is conducted by "international advanced aviation professionals with international vision, proficiency in the relevant professional theoretical basic knowledge and strong research and application capabilities." Training lasts five semesters: (1) first and second semesters focus on basic theoretical courses and professional courses and related scientific research, (2) third and fourth semesters deal with professional courses (in English and writing and defense of a thesis in English at the Moscow Aviation Institute), and (3) fifth-semester students return to China to defend their thesis in the Chinese language at Nanjing University of Aeronautics and Astronautics.[262]

Northwestern Polytechnical University and Multiple Russian Institutes and Universities
[西北工业大学]
Website: https://www.nwpu.edu.cn/
Location in China: Chang'an Campus Address: No. 1, Dongxiang Road, Chang'an District, Xi'an
长安校区地址：西安市长安区东乡路1号

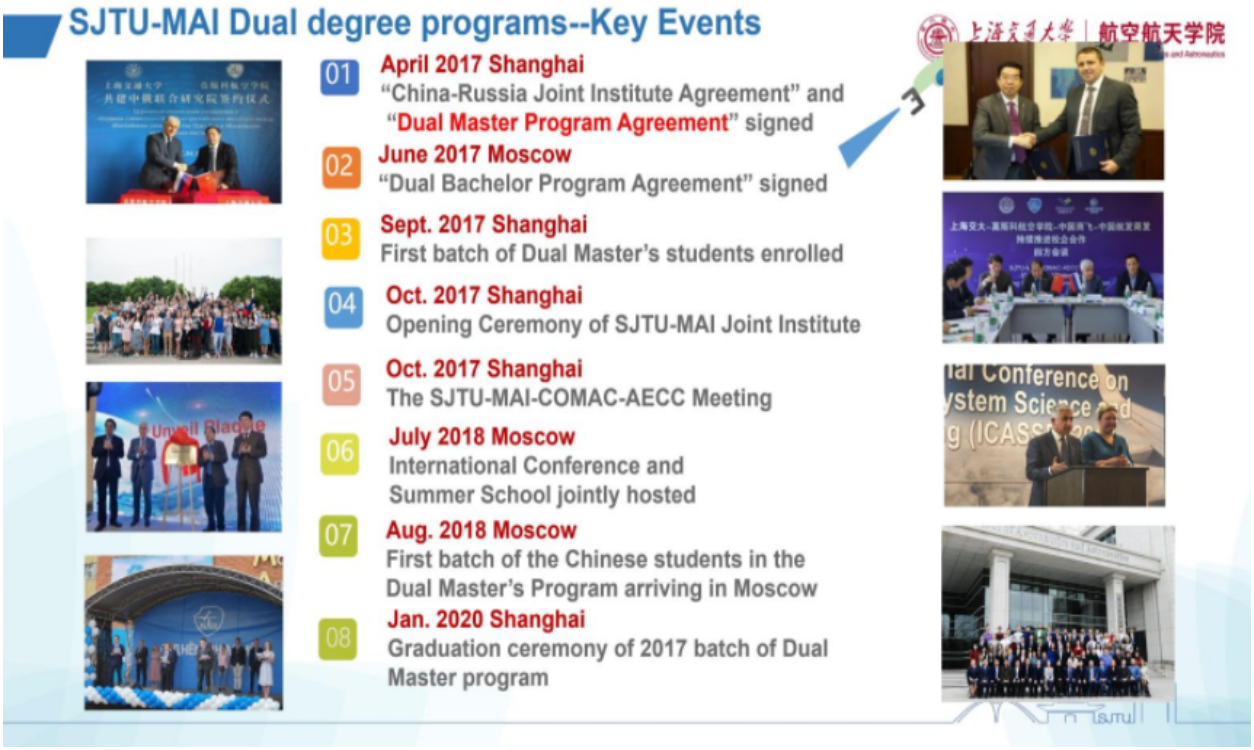
Northwestern Polytechnical University signed agreements in 2019 with Kazan State Technical University, Moscow Aviation Institute, Samara University, and "many other famous Russian universities" on joint training of students, joint research centers, and Russian language centers. Northwestern Polytechnical also signed an agreement with Moscow Bauman State Technical University signed a school-level cooperation agreement on joint training of undergraduate, master, and doctoral level students.[263]

Sino-Russian Joint Research Institute: Shanghai Jiaotong University (SJTU) and Moscow Aviation Institute (MAI)
[中俄联合研究院]
Website: http://www.aero.sjtu.edu.cn/En/Data/View/3938

SJTU and MAI signed a cooperation agreement to build the Sino-Russian Joint Research Institute on April 20, 2017. "The two sides will jointly recruit full-time double masters students, cultivate aspiring aerospace careers, have a solid theoretical foundation and professional knowledge, have practical capabilities, innovative spirit and international vision of complex aerospace science and technology talents, promote the development of economic and cultural exchanges between the two countries, and then serve based on national strategies and industry needs, it helps the development of global air and space undertakings."

Placard for the Shanghai Jiaotong University and Moscow Institute of Aeronautics Joint Educational Programs[264]

Briefing on the SJTU and MAI Dual Degree Programs Background[265]



Briefing on the SJTU and MAI Dual Degree Programs Key Events[266]

SJTU-MAI Dual degree programs—Features and Data

上海交通大学 | 航空航天学院

Chinese and Russian students share:

- One joint syllabus
- One teaching team
- One Chinese-Russian combined class

Till Sept. 2020, 312 Chinese and Russian students in total enrolled in China-Russia Joint Institute.

Grade	# of Students in Dual master program	# of Students in Dual bachelor program
2017 batch	Chinese: 23 Russian: 29 (Graduated in Mar. 2020)	Preparation stage
2018 batch	Chinese: 28 Russian: 24 (Graduate in Mar. 2021)	Chinese: 30 Russian: 16
2019 batch	Chinese : 29 Russian: 26	Chinese: 21 Russian: 12
2020 batch	Chinese: 29 Russian: 23	Chinese: 22 Russian: in the process of enrollment

Briefing on the SJTU and MAI Dual Degree Programs Features and Data[267]

Briefing on the SJTU and MAI Dual Degree Programs
International Conference and Seminar Participation[268]

Impacts of the Defense and Dual-Use Cooperative Relationship

Impacts on China, Russia, and the United States

Long-term Sino-Russian aerospace technical cooperation has had significant impacts on China, Russia, and the United States. The effects on China have been positive and massive, with just a few areas of disappointment where technical cooperation (e.g., aircraft engines) where Russia was not as cooperative as China wished. Impacts on Russia have been significant over the years, some positive and some negative. Impacts on the United States also have been significant, but virtually all negative in terms of America's defense posture vis-à-vis both China and Russia.

In summary, the Sino-Russian defense and dual-use cooperative relationship have resulted in:

- Collaboration enabling Russia and China to continue technology development, notwithstanding the United States and other attempts at sanctions;
- Cooperation with Russia enables China to overcome the "lost generation" of technical talent caused by the Great Proletarian Cultural Revolution;
- For China, the collaborative relationship providing access to developing and producing better versions of common defense consumable goods and sub-systems; and
- China is advancing rapidly down a path with Russian assistance to having its first credible strategic missile early warning system – a qualitatively new capability.

- **Impact on China**

Sino-Russian technical cooperation in defense and dual-use projects has led to a massive technological upgrade of PLAAF equipment and China's research, development, and production capabilities. Cooperation over the years has allowed China's acquisition strategy to move through several stages:

- The first and most basic stage focused exclusively on purchasing Russian military end items.
- Next, China moved to a "made in China" phase where the Chinese defense industry acquired licenses to produce Russian end-items domestically and began modifying Russian systems with Chinese developed components and sub-systems to create hybrid products like the Chinese J-11 fighter evolving from the license-manufactured Su-27.

- The transfer of technical know-how, joint research projects, technical exchanges, and joint education has allowed China to move on to the most advanced stage – "developed in China" – which has resulted in the appearance of next-generation weapons such as the J-20 and J-31 fighters.

- The transition to stage three has not, however, been completed. China is still dependent on some key Russian components (military aircraft engines and sensors) because of continuing shortfalls in domestic development capabilities. These are areas where Russia is unwilling to extend full military-technical cooperation despite repeated Chinese requests to do so.

Perhaps one of the most profound (but not always recognized impacts) of Sino-Russian military-technical cooperation has been on the human capital of China's defense research, development, and production enterprise. As discussed earlier, the Chinese defense development and production sectors lost an entire generation because of the Cultural Revolution. That meant that many of today's scientists, engineers, designers, and production managers are very young compared to their Russian and Western counterparts.

The average age of the design team for the AG600 amphibious aircraft, for example, was only 28 years old, and more than 80% were young people.[269] The average age of the eleven employees of the Engineering Department of Liaoning Ruixiang General Aircraft Manufacturing Co., Ltd., which does aircraft tooling, is 30 years old or less.[270] As already noted, Chinese professionals lacked the opportunity to learn from the Cultural Revolution era generation, which is missing.

It is probably impossible to underestimate the amount of influence the transfer of Russian technical know-how and experience had on expanding the knowledge base and hastening the maturation process of this generation of Chinese scientists, engineers, and production managers. The venues for passing knowledge and experience varied widely. They included: (1) joint research projects, (2) joint technical conferences and symposiums, (3) joint educational programs for Chinese students at Russian research institutes, technical universities, and military-technical academies, (4) joint projects, (5) the presence of contracted Russian specialists in Chinese facilities, (6) S&T parks, and (7) dialogues and exchanges.[271]

As noted earlier, six Chinese-Russian aviation science and technology academic exchanges discussing topics such as aerodynamics, strength, aeroacoustics, flight mechanics and safety, test methods, materials, and fundamental issues in aviation science resulted in the interaction of over 500 Russian and Chinese scientists and the presentation of more than 227 scientific papers.

Shanghai Jiaotong University and the Moscow Aviation Institute created a joint Aviation Academy where joint classes of 30 Chinese and 30 Russian students studied introductory professional courses and more specialized topics such as aerospace composite structure, aero-engine, and aerospace product lifecycle management.[272] Such activities created an intellectual base to support the development of current and future military technologies and systems.

Before the Tiananmen Square Incident in 1989, China reached out to the West and Russia in search of military and dual-use technologies in support of Chinese defense modernization efforts. Subsequent embargos forced China to turn increasingly (and in some cases solely) to Russia. Concentration on Russian technology, weapons, and dual-use components had unintended consequences. Chinese defense industries were already familiar with Russian technical approaches to developing new equipment. Chinese engineers shared a common intellectual heritage with Russia making it easier and quicker to absorb and improve Russian military technology. Concentrating on military technologies and systems of Russian origin also made absorbing military technology for the PLAAF easier since the Air Force was already familiar with Russian maintenance practices, operating characteristics, and training approaches.

Decades of military modernization aided and accelerated by Sino-Russian military-technical cooperation allowed China to transition from a large arms importer to a net exporter with the potential to become one of the world's leading arms exporters.[273] Indeed, China becomes a major player in the global arms trade to a point where China ranked 5th on the net arms exporter list based on dollar volume in 2018.[274]

"Russian-Chinese military-technical cooperation has become the basis for the modernization of China's armed forces. It is directly related to the increase in the overall power of the Chinese armed forces" (assertion in Chinese doctoral thesis).[275] Military-technical cooperation with Russia accelerated the pace of narrowing the military-technical gap between the United States and Russia. Military-technical cooperation has allowed the PLAAF to acquire advanced foreign military equipment and develop such equipment domestically.

The PLAAF's inventory now includes many "modern" aircraft including, 4++ generation J-20 and Su-35 fighters, other 4th generation J-10 series of fighters, bombers, airborne early warning aircraft, heavy-lift transports, and aerial refueling aircraft. The PLA Air Force also received much improved air-to-air and air-to-ground munitions.[276] Some capabilities (e.g., early warning aircraft) are entirely new functional capabilities.[277] The Russians also supplied major aircraft subsystems and components to fill shortfalls in Chinese domestic development capabilities. Russia, for example, delivered more than four thousand engines for helicopters, combat, and military transport aircraft to China between 1992 and 2019, according to Alexander Grachev, deputy general director of the United Engine Corporation for sales and service.[278] Russian weapons and technology transfers have also strengthened China's air defenses and enhanced China's capability to defend against the threat of air forces near its territory.[279]

- **Impact on Russia**

Military technical cooperation with China proved a good news/bad news proposition for Russia. The plus/minus ratio of military-technical cooperation was lopsidedly in favor of Russia in the early years. After 2010, the negative aspects of the relationship grew for Russia, and the relationship became more symbiotic.

One of the main positive impacts of Sino-Russian military-technical cooperation before 2010 was the financial impact for Russian defense industries. *TASS* estimated arms exports to China accounted for 30% of Russian exports between 1994-1997 and grew to a high of 64.4% in 2005 and then fell off sharply.[280] As noted earlier in this paper, other Russian sources estimated China counted for as much as 70% of all Russian exports in 1997 and declined to 40% in 2006. The authors were unable to verify which estimates were correct. It probably does not matter for our assessment since regardless of the precise amount, the point remains that China was a "cash cow" for the Russian defense industry at a time of its greatest need. Many of these exports were in the aerospace sector. Chinese money kept many Russian defense enterprises alive at a time of few orders from the Russian Ministry of Defense and helped finance the refurbishment of aging Russian defense production capacity. Consequently, the Russian defense industrial base was ready to support major Russian rearmament programs after 2010.

Another benefit from the relationship was that China proved to be a reliable partner when Russia needed to replace Western products following European and American sanctions. The Russian paper *Gazeta* asserted: "Experts said the results of arms sales not only increased confidence in the military industry and spurred the country's economic growth, but also demonstrated Russia's influence as a military force."[281]

The Russian military-technical cooperation relationship with China is paradoxical:

> *"The more advanced the Chinese military is, the less providing it with military technology poses a meaningful added military risk to Russia. Moscow is operating in a "sell or lose" scenario, with the expectation that Beijing's own defense sector will be able to develop indigenous analogues with or without access to Russian military technology. China's growing industrial potential in the defense sector is likely to change the nature of defense cooperation from transactional arms sales to more joint development, defense services, and transfer of technology."*[282]

One of the significant downsides to the relationship for Russia is the rampant theft of intellectual property and unauthorized copies of Russian military equipment. China then sold some of these unauthorized copies to third-world customers in competition with Russia. Additionally, the increasing quality of domestic Chinese defense goods and more competent defense industry is allowing China to challenge (and, in some cases) undercut Russia in the arms export market.

For example, the Russian *Council for International Affairs* published the following assessment Russian-Chinese competition in Africa by a "leading specialist" in the Marketing Department and Foreign Activity of JSC Technodinamika. According to that "leading specialist":[283]

> *Recently, Russia, which has traditionally occupied a leading position in the African arms market, has been facing competition from China, which is rapidly increasing its military-industrial potential…At the moment, China's active policy in the region [Africa] creates a real*

threat of ousting Russia from its traditional markets in developing countries. Over the past two decades, Russia has strengthened its position in the African arms markets, nevertheless, the pace of the PRC's increase in its presence in the African arms markets is significantly ahead of Russia's.

In general, arms deliveries from China to the African continent are growing at the highest rates: in the period from 2012 to 2016. the volume of exports from China increased by 122% compared to the period 2007 to 2011.

Another Russian, Vladimir Gutenev, believes competition is heating up in Southeast Asia as well. Gutenev writes, "China is increasingly implementing military-technical cooperation in the Southeast direction, which is traditional for Russia. Every year, China is ready to present more and more competitive proposals to the arms market, and in this situation, Russia, remaining the undisputed leader, must take these trends into account."[284]

China is also developing military-technical cooperation links with Russia's traditional partners in Central Asia. China now engages in military-technical cooperation with the defense industrial complexes of Kazakhstan, Turkmenistan, and Uzbekistan.[285] Local media reported in 2012 that Kazakhstan considered China to be one of the priority partners in the field of defense and was also building up ties with the largest defense enterprises of China.[286]

- **Impact on the United States**

For the United States, the impacts of Sino-Russian military-technical cooperation are entirely negative. "China is now gradually replacing Russia as an indicator for the United States to set standards for its armed forces, especially in China's pursuit of modernized air force and navy." According to the International Institute of Strategic Studies, the globalization of China's Military Power is beginning to challenge the United States.[287] China also poses the greatest challenge to the Defense Department, according to John C. Rood, a former Undersecretary of Defense for Policy.[288] This concern is also reflected by the "US Army thinks China will be a bigger threat than Russia by 2028" – "Instead of focusing on fielding a fully modernized force to [U.S. European Command], an alternative may deter Russia with minimal current conventional forces and permit the Army to shift strategic focus for modernization efforts to [U.S. Indo-Pacific Command] according to a report by the Army Transition Team for the new Chief of Staff, Gen. James McConville."[289]

According to the *China Military Power 2019* assessment by U.S. Defense Intelligence Agency (DIA), "China is building a robust, lethal force with capabilities spanning the air, maritime, space, and information domains which will enable China to impose its will in the region. As it continues to grow in strength and confidence, our nation's leaders will face a China insistent on having a greater voice in global interactions, which at times may be antithetical to U.S. interests."[290] "Examples of incremental improvements to PLA power projection in the region are readily found in annual military exercises and operations. For instance, in 2015, the PLAAF carried out four

exercise training missions past the first island chain through the Bashi Channel, the northernmost passage of the Luzon Strait, and through the Miyako Strait closer to Japan."[291] Accelerated Chinese military modernization brought about through infusions of Russian military equipment, technology, and know-how have increased China's ability to challenge potential military intervention launched by the United States in Taiwan and disputed access and control of the South China Sea.[292] Russian weapons and technology transfers notably strengthened China's air defenses and enhanced China's capability to defend against the threat of air forces near its territory.[293]

Other adverse consequences of Sino-Russian military-technical cooperation for the United States include:

- Russia's willingness to sell Su-35 multi-role fighters overcomes limited production rates for Chinese J-20 fighters by the Chinese defense industry. This has meant China has acquired more 4++ generation fighters for the PLA than if the PLAAF had had to depend solely on domestic enterprises alone.

- The symbiotic nature of Sino-Russian military-technical cooperation defeated the impact of American and European sanctions on the two countries. Sanctions did not prevent military modernization because of ongoing military technology exchanges between Russia and China. Other complexities, such as the need to qualify new parts and adopt new devices, also impacted the pace of modernization.

- China's large-scale purchases of Russian military equipment (especially aircraft) in the decade after the collapse of the Soviet Union preserved the Russian aerospace defense industrial base, which now supports Russian military modernization programs.

- The debut of the J-20 next-generation fighter caused "a sea change in the way the PLA watching community evaluated subsequent PLA developments that would emerge in the rest of the 2010s, where rumors that would have seemed outlandish before J-20 were instead considered with more deliberation"[294] Western assessments of the pace and quality of developing Chinese military systems continue to be more optimistic than before the J-20 emerged.

Near-, Medium- and Long-Term Trends in Sino-Russian Military-Technical Cooperation

- Sino-Russian technical cooperation will remain resilient, but its character will change over time. It will become more asymmetrical, with Russia slipping more and more into the role of junior partner.[295]

- China will continue pursuing its goal of increasing its "absorptive capacity" to recognize, assimilate, and utilize in developing military technology.[296]

- Both countries will expand the relationship beyond military technology with a new emphasis on dual-use technologies such as civil aircraft engines, wide-body passenger aircraft, artificial intelligence, big data, space optics, and cloud computing.[297] There is also growing cooperation on 5G next-generation telecommunications networks.[298] Other priority areas with implications for military aerospace technology include mathematics, physics, and new materials.[299] Other areas of emerging cooperation include quantum-based computing, communication (China and Russia are building a quantum secure communication channel to each other to be completed in the five years), and sensing. [300]

- China will become an increasingly competitive exporter of conventional arms because of increasing product quality, low price, willingness to accept barter payments in resources, and ***no end-use restrictions***. ***China's goal will be to capture a significant portion of the Russian arms export markets*** with a primary focus on Central, South, and Southeast Asia as well as in Africa. Success in doing so will gradually allow China to shape the direction and character of regional arms competitions through weapons exports.[301]

- Expansion of academy cooperation in the form of joint university programs, joint work-study programs, and paid internships at research institutes and bilateral seminars is another form of military-technical cooperation.[302] Some of these activities have resulted in cooperative R&D projects between Russian institutes and their Chinese counterparts.

APPENDIX A:
Russian Aerospace Weapon Systems and Components Delivered to The Chinese PLAAF: 1991 to 2020

Russian Aerospace Weapon Systems and Components Delivered to the Chinese PLAAF: 1991 to 2020

Weapon		Year		Number Delivered	Comments
Designation	Description	Order	Delivered		
76N6/Clam Shell	Air search radar	1992	1993	1	For use with S-300PMU (SA-10) SAM
ST-68/Tin Shield	Air search radar	1992	1993	1	For use with S-300PMU (SA-10) SAM
Zhuk	Combat aircraft radar	2001	2001-2005	100	Zhuk-8 version; for modernization of J-8B (J-8-II) combat aircraft to J-8IIM
Sub-total of various air defense and aircraft radars				**102**	
R-73/AA-11	SRAMM	1991	1992	300	For Su-27 combat aircraft; ordered from the Soviet Union and delivered from Russia after the break-up of the Soviet Union
5V55U/SA-10	SAM	1992	1993-1997	150	For S-300 (SA-10) SAM system
R-73/AA-11	SRAAM	1995	1996-2004	3000	For Su-27 and Su-30 combat aircraft
Kh-31A1/AS-17	ASHM/ARM	1997	2001-2016	1000	Kh-31A and Kh-31P or Kh-31AMK and Kh-31PMK version; for Su-30, J-8M, and/or JH-7 combat aircraft; including production of Kh-31P in China as KR-1, YJ-9 or YJ-91
9M338/SA-15	SAM	1997	1999	400	For Tor-M1 SAM systems
9M338/SA-15	SAM	1998	2000	500	For Tor-M1 SAM systems; payment for debt
Kh-29/AS-14 Kedge	SAM	1999	2001-2002	100	Included for Su-27SK and Su-30MKK combat aircraft
Kh-59ME Ovod/AS-18	SAM	1999	2004-2006	150	Included for Su-30 combat aircraft
RVV-AE/AA-12 Adder	BVRAAM	2000	2002-2009	750	For Su-27SK and Su-30MKK combat aircraft
48N6/SA-10	SAM	2001	2002	150	For S-300 (SA-10) SAM system
48N6/SA-10	SAM	2004	2007-2008	297	For S-300 (SA-10) SAM system
Kh-59MK/AS-18MK	ASHM/ARM	2004	2008-2015	200	For Su-30 combat aircraft; probably Kh-59MK2 version developed for and funded by China
48N6/SA-10	SAM	2006	2008-2009	750	For S-300PMU-2 (SA-20B) SAM system
48N6/SA-10	SAM	2015	2018-2019	300	Part of $3 billon deal for 8 S-400 SAM systems
R-77/AA-12 Adder	BVRAAM	2015	2017-2019	240	Designation unclear (reported as 'missiles'); probably for Su-35 combat aircraft
Sub-total of various types of missiles				**8,287**	
S-300PMU1/SA-20A	SAM	1992	1993-1997	4	Number could be 6
Tor-M1/SA-15	Mobile SAM	1997	1999	15	
Tor-M1/SA-15	Mobile SAM	1998	2000	20	Payment of debt
S-300PMU1/SA-20A	SAM	2001	2003-2004	4	$400 million deal (partly payment for debt)
S-300PMU2/SA-20B	SAM	2004	2007-2008	8	$980 million deal
S-300PMU2/SA-20B	SAM	2006	2008-2009	8	
S-400/SA-21	SAM	2015	2018-2019	8	$3 billion deal
Sub-total of various types of air defense systems				**67**	

Russian Aerospace Weapon Systems and Components Delivered to the Chinese PLAAF: 1991 to 2020

Weapon		Year		Number Delivered	Comments
Designation	Description	Order	Delivered		
Su-27S/ Flanker-B	FGA Aircraft	1991	1992	21	Part of 24 (included 4 Su-27UBK versions) ordered in $700 million deal (offsets 40%) from the Soviet Union had 3 delivered Soviet Union before the break-up of the Soviet Union and 21 from Russia
Su-27S/ Flanker-B	FGA Aircraft	1992	1992	2	Su-27UBK version; original order for 12 Su-27SK reduced to 2 Su-27UBK
Su-27S/ Flanker-B	FGA Aircraft	1995	1996-1997	24	$2.2 billion deal; included 2 to 10 Su-27UBK
Su-27S/ Flanker-B	FGA Aircraft	1996	1998-2007	105	Part of $1.5 to $2.5 billion deal for 200 but about 95 canceled; assembled from kits; Chinese designation J-11
Su-27S /Flanker-B	FGA Aircraft	1999	2000-2002	28	$1 billon deal (payment for debt); Su-27UBK version
Su-30MK	FGA Aircraft	1999	2000-2001	38	$1.5-$2 billon deal; Su-30MKK version
Su-30MK	FGA Aircraft	2001	2002-2003	38	$2 billon deal; Su-30MKK version
Su-30MK	FGA Aircraft	2003	2004	24	$1 billon deal; Su-30MKK2 naval attack version
Su-35S	FGA Aircraft	2015	2016-2018	24	$2 billon deal; Su-35S version
Sub-total of various types of fighter/ground attack aircraft				**304**	
Il-76M	Transport Aircraft	1992	1993	10	$200 million deal (offsets 60% as barter); included 3 for military-owned airline
Il-76M	Transport Aircraft	2000	2002	1	Sold via Russia; originally to be modified to A-50I AEW&C aircraft in Israel but AEW order canceled and aircraft delivered to China without AEW systems
Il-76M	Transport Aircraft	2011	2013-2015	5	Second-hand
Il-76M	Transport Aircraft	2015	2015-2016	7	Second-hand but probably modernized before delivery
Sub-total of various types of transport aircraft				**23**	
Mi-8MT/Mi-17	Transport Helicopter	1995	1996-1997	60	Mi-171 and possibly Mi-17V-5 and/or Mi-17V-7 version
Ka-32	Helicopter	1998	1999	3	Ka-28PS SAR version
Mi-8MT/Mi-17	Transport Helicopter	1998	1999-2000	15	Mi-171 version
Mi-8MT/Mi-17	Transport Helicopter	2001	2002-2003	35	Mi-17-V5 version
Mi-8MT/Mi-17	Transport Helicopter	2002	2003-2004	25	Probably Mi-171 and/or Mi-17V-5 and/or Mi-17V-7 version
Mi-8MT/Mi-17	Transport Helicopter	2005	2007-2012	54	Mi-171 or Mi-171E version; possibly assembled in China from kits
Mi-8MT/Mi-17	Transport Helicopter	2006	2006-2007	24	$200 million deal; probably Mi-171 and/or Mi-17V-5 and/or Mi-17V-7 version
Mi-8MT/Mi-17	Transport Helicopter	2009	2010-2011	32	Mi-171E version; possibly for police or other non-military government agency
Mi-8MT/Mi-17	Transport Helicopter	2012	2012-2014	52	Mi-171E version; possibly for police or other non-military government agency
Mi-8MT/Mi-17	Transport Helicopter	2019	2019	18	Armed Mi17Sh version
Mi-8MT/Mi-17	Transport Helicopter	2019	2019-2020	68	Mi-171 and Mi-171E versions
Mi-8MT/Mi-17	Transport Helicopter	2019	2019-2020	14	Mi-17V-7 version
Sub-total of various types of military helicopters				**400**	
Grand total of various types of military aircraft and helicopters				**727**	

Russian Aerospace Weapon Systems and Components Delivered to the Chinese PLAAF: 1991 to 2020

Weapon		Year		Number Delivered	Comments
Designation	**Description**	**Order**	**Delivered**		
D-30	Turbofan	2009	2009-2012	55	For H-6K bomber aircraft produced in China and possibly for modernization of Il-76 transport aircraft
D-30	Turbofan	2011	2012-2017	184	For H-6K bomber aircraft and Y-20 transport aircraft produced in China and modernization of Il-76 transport aircraft
D-30	Turbofan	2015	2018-2020	425	For H-6K bomber aircraft and Y-20 transport aircraft produced in China
Sub-total of D-30 aero-engines				**664**	
AL-31	Turbofan	2000	2001-2005	54	AL-31FN version for J-10 combat aircraft produced in China; incl spare engines
AL-31	Turbofan	2005	2006-2009	100	AL-31FN version for J-10 combat aircraft produced in China; probably included spare engines
AL-31	Turbofan	2009	2009-2012	122	AL-31FN version for J-10 combat aircraft produced in China; probably included spare engines
AL-31	Turbofan	2011	2013-2016	--	$500 million deal; AL-31FN version for J-10 combat aircraft produced in China; probably included spare engines
AL-31	Turbofan	2011	2013-2017	125	AL-31F version for J-15 combat aircraft produced in China
AL-41F	Turbofan	2015	2016-2018	10	AL-41F-1S version; spares for Su-35 combat aircraft
AL-31	Turbofan	2014	2017-2020	80	AL-31F-M2 version for J-20 combat aircraft produced in China
AL-31	Turbofan	2016	2016-2020	125	AL-31FN version for J-10 combat aircraft produced in China; probably included spare engines
Sub-total of AL-31 aero-engines				**616**	
Total of various types of aero-engines				**1,280**	

SOURCE: SIPRI Arms Transfers Database and information generated as of May 30, 2021; https://www.sipri.org/ databases /armstransfers (information as of May 30, 2021).

NOTE: The 'Number delivered' and the 'Year delivered' columns refer to all deliveries since the beginning of the contract. The 'Comments' column includes publicly reported information on the value of the deal. Information on the sources and methods used in collecting the data and explanations of the conventions, abbreviations, and acronyms can be found at http://www.sipri.org/contents/armstrad/sources-and-methods.

Abbreviations

ASHM	Anti-ship missile (ASHM)
ARM	Anti-radiation missile (ARM)
BVRAAM	Beyond Visual Range Air-to-Air Missile (BVRAAM)
SRAAM	Short-range Air-to-Air Missile (SRAAM)
SAM	Surface-to-Air Missile (SAM)
FGA	Fighter/Ground Attack (FGA) aircraft

APPENDIX B:
Chinese Organizations Involved in Cooperative R&D Activities with Russia

- **Aero-Engine Corporation of China**
- **Anhui Institute of Optics and Fine Mechanics**
- **Aviation Industry Corporation of China**
- **Aviation Research Institute of Strength**
- **Beijing Aeronautical Science and Technology Research Institute**
- **Beijing Greiner Electronics Co. Ltd.**
- **Beijing Institute of Aeronautical Materials**
- **Chengdu Zhongke Aero Engine Co., Ltd.**
- **China Academy of Aerospace Aerodynamics**
- **China Aerodynamics Research and Development Center**
- **China Aviation Academy**
- **China Aviation Manufacturing Technology Research Institute (aka Aeronautical Industry Manufacturing Institute and 625th Research Institute of China Aviation Industry Corporation)**
- **China Aviation Research Institute**
- **China Helicopter Research and Design Institute**
- **China Research Institute for Automatic Flight Control**
- **China Electronics Technology Group**
- **China-Russia Commercial Aircraft International Corporation Co., Ltd**
- **Commercial Aircraft Corporation of China**
- **Deyang Aviation**
- **Flight Automatic Control Research Institute**
- **Hefei Institute of Material Science**
- **Hongdu Aviation Industry Group Ltd**
- **Hunan Aviation Powerplant Research Institute**
- **Institute of Aeronautical Industry Manufacturing (aka AVIC Manufacturing Technology Institute and Beijing Institute of Aeronautical Manufacturing Engineering)**
- **Institute of the Chinese Academy of Aerospace**
- **Institute of Engineering Thermophysics (Qingdao Branch)**
- **International Joint Unmanned Aerial Vehicle System and Design Laboratory (Joint Chinese and Russian)**
- **Northwest Polytechnic University**
- **Quanzhou Deyuan Bearing Industry Co., Ltd.**
- **School of Aeronautics of Northwest Polytechnic University**
- **Shenyang Aerodynamic Institute**

- **Shanghai Aircraft Design and Research Institute**
- **Shenyang Aircraft Design Research Institute**
- **Shenyang Engine Research Institute Shenyang Engine Research Institute**
- **Shenyang Liming Aero Engine Co., Ltd.**
- **Tsinghua University**
- **Xiamen Aviation Industry Co., Ltd.,**
- **Xiamen Oestuo Co., Ltd**

APPENDIX C:
Russian Organizations Involved in Cooperative R&D Activities with China

- **Aeronautical Materials Research Institute**
- **Aeronautical Technology Research Institute (NIAT)**
- **All-Russia Research Institute of Light Alloys**
- **Central Aerohydrodynamic Institute**
- **Central Institute of Aviation Motors**
- **China-Russia Commercial Aircraft International Corporation Co., Ltd (Joint Venture)**
- **Gromov Flight Research Institute**
- **International Joint Unmanned Aerial Vehicle System and Design Laboratory (Joint Chinese and Russian)**
- **Institute of Atmospheric Optics**
- **Institute of Control Sciences of the Russian Academy of Sciences**
- **Institute of High Current Electronics (Siberian branch of the Academy of Sciences)**
- **Institute of Laser Physics**
- **Institute of Strength Physics and Materials Science**
- **Institute of Theoretical and Applied Mechanics (Siberian branch of the Academy of Sciences)**
- **Joint Stock Company UEC-PERM ENGINE**
- **Lavrentyev Institute of Hydrodynamics (Siberian Branch of the Russian Academy of Sciences)**
- **Lebedev State Scientific Research Institute of Synthetic Rubber**
- **Moscow Aviation Institute**
- **ORPE Technologiya**
- **Scientific Research Institute of Aviation Materials**
- **Scientific Research Institute of Elastomeric Materials and Articles (Siberian Branch of Russian Academy of Science)**
- **Siberian Aeronautical Research Institute**
- **State Research Institute of Aviation Systems (GosNIIAS)**
- **Tomsk Polytechnic University**
- **United Aircraft Corporation**
- **United Engine Corporation**
- **Volga Basin Aeronautical Technology Research Institute**
- **VSMPO-AVISMA Corporation**
- **XJ Technologies Company Ltd.**

ENDNOTES

1 Charlie Gao, "The Chinese Military is Busy Fighting a Serious Foe: Coronavirus," *The National Interest,* April 2, 2021, https://nationalinterest.org/blog/reboot/chinese-military-busy-fighting-serious-foe-coronavirus-181699.

2 "The Chinese Military is Busy Fighting a Serious Foe: Coronavirus," op.cit..

3 "The Chinese Military is Busy Fighting a Serious Foe: Coronavirus," op.cit..

4 "The Chinese Military is Busy Fighting a Serious Foe: Coronavirus," op.cit..

5 "Russian and Chinese engineers collaborate remotely on CR299 due to coronavirus threat," *Russian Aviation Insider*, March 15th, 2020, http://www.rusaviainsider.com/russian-and-chinese-engineers-collaborate-remotely-on-the-cr929-due-to-coronavirus-threat/.

6 Scott N. Romaniuk and Tobias Burgers, "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," *China Institute*, February 26, 2020, https://www.ualberta.ca/china-institute/news-events/the-latest/2020/02/scott-covid19.html and Patrick Tucker, "Russian Arms Production Slowed by Coronavirus, Analysts Find," *DefenseOne*, May 1, 2020, https://www.defenseone.com/technology/2020/05/russian-arms-production-slowed-coronavirus-analysts-find/165071/.

7 "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," and "Russian Arms Production Slowed by Coronavirus, Analysts Find," op.cit..

8 "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," and "Russian Arms Production Slowed by Coronavirus, Analysts Find," op.cit..

9 "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," and "Russian Arms Production Slowed by Coronavirus, Analysts Find," op.cit..

10 "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," and "Russian Arms Production Slowed by Coronavirus, Analysts Find," op.cit..

11 "The Impact of COVID-19 on China's Arms Industry: Commentary on COVID-19 and China's arms industry," and "Russian Arms Production Slowed by Coronavirus, Analysts Find," op.cit..

12 "Military Cooperation Between Russia and China: The Military Alliance Without an Agreement," *International Center for Defense and Security*, July 1, 2020, https://icds.ee/military-cooperation-between-russia-and-china-the-military-alliance-without-an-agreement/.

13 Sergei Nikolayovich Goncharov, "Su-27 the Beginning of Sino-Russian Military Cooperation (part 1)," *Lehman Military Network*, no date, http://www.rimnds.com/art/show.htm?id=1585.

14 Sergei Nikolayovich Goncharov, "Su-27 the Beginning of Sino-Russian Military Cooperation (part 1)," *Lehman Military Network*, op. cit..

15 "Su-27 the Beginning of Sino-Russian Military Cooperation (part 1)," op. cit..

16 "Su-27 the Beginning of Sino-Russian Military Cooperation (part 1)," op. cit..

17 Robert Farley, "What Scares China's Military: The 1991 Gulf War," *The National Interest*, November 24, 2014, https://nationalinterest.org/feature/what-scares-chinas-military-the-1991-gulf-war-11724.

18 "A Number of Sino-Russian Military Industrial Cooperation Starts at the Same Time," *canjaixuaixi.com*, no date, http://www.cankaoxiaoxi.com/s/military/zhongehezuo/.

19 Dmitry Belyakov, "How the military-political union of the Russian Federation and the Celestial Empire is being formed," *Sonar2050*, June 11, 2018, https://www.sonar2050.org/publications/na-puti-k-alyansu-rossiya-kitay/.

20 Lei Yu and Sophia Sue, "China-Russia military cooperation in the context of Sino-Russian strategic partnership," *Asia Europe Journal*, July 18, 2019, https://link.springer.com/article/10.1007/s10308-019-00559-x.

21 Alec Blivas, "Sino-Russian Military-Technical Cooperation: A Primer," *Defense360*, March 2020, http://defense360.csis.org/wp-content/uploads/2020/03/Blivas_Russia-China-MTC_Brief.pdf.

22 "10 Years of CAE Cooperation and Exchanges with Russia," *CANnews*, August 27, 2019, http://www.cannews.com.cn/2019/0827/200996.shtml.

23 "Combat Helicopter Changhe Z-10 (China)," *NEVSKII-BASTION*, May 6, 2014, http://nevskii-bastion.ru/z-10-china/.

24 "Kamov was the origins of the Chinese combat helicopter WZ-10," *Live Journal*, no date, https://bmpd.livejournal. com/474579.html.

[25] "Changhe Z-10 Combat Helicopter," *NEVSKII-BASTION*, November 10, 2018, http://nevskii-bastion.ru/z-10-china/.
[26] "Sino-Russian Military-Technical Cooperation: A Primer," op. cit..
[27] Paradorn Rangsimaporn, "Russia's Debate on Military-Technical Cooperation with China: From Yeltsin to Putin," *Asian Survey* Vol. 46, No. 3, May/June 2006, https://www.jstor.org/stable/10.1525/as.2006.46.3.477?seq=3#metadata_info_tab_contents.
[28] "Russia's Debate on Military-Technical Cooperation with China: From Yeltsin to Putin," op. cit..
[29] "Shenyang J-11: Air Superiority," *Military Today*, January 20, 2021, http://www.military-today.com/aircraft/j11.htm.
[30] Dmitry Gorenburg, "An Emerging Strategic Partnership: Trends in Russia-China Military Cooperation," *George C. Marshal European Center for Security Studies*, April 2020, https://www.marshallcenter.org/en/ publications/security-insights/emerging-strategic-partnership-trends-russia-china-military-cooperation-0.
[31] "Sino-Russian Military-Technical Cooperation: A Primer," op. cit..
[32] "Military Cooperation Between Russia and China: The Military Alliance Without an Agreement," op. cit..
[33] "10 Years of CAE Cooperation and Exchanges with Russia," op. cit..
[34] "TsAGI holds a meeting with the Chinese Academy of Aerospace Aerodynamics (CAAA)," *Central Aerohydrodynamic Institute*, January 20, 2021, http://www.tsagi.ru/en/pressroom/news/4491/.
[35] Zheng Qi, "The Main Trends in Military-Technical Cooperation Between Russia and China at the Present Stage," *Bulletin of the Russian State Pedagogical University*, *Bulletin of the Russian State Pedagogical University*, 2008, https://cyberleninka.ru/article/n/osnovnye-tendentsii-voenno-tehnicheskogo-sotrudnichestva-mezhdu-rossiey-i-kitaem-na-sovremennom-etape.
[36] "The Main Trends in Military-Technical Cooperation Between Russia and China at the Present Stage," op. cit..
[37] "China-Russia military cooperation in the context of Sino-Russian strategic partnership," op. cit..
[38] "Russia's Debate on Military-Technical Cooperation with China: From Yeltsin to Putin," *Asian Survey*, op. cit..
[39] "Sino-Russian Military-Technical Cooperation: A Primer," op. cit..
[40] "Sino-Russian Military-Technical Cooperation: A Primer," op. cit..
[41] Chen Hanshi, "What are the reasons for Russia and China to strengthen security relations?" *Carnegie Endowment for International Peace*, September 24, 2018, https://carnegieendowment.org/2018/09/24/zh-pub-77659.
[42] "Friendship at arm's length: How Moscow and Beijing defined the boundaries of what is acceptable," *Kommersant*, May 31, 2019, https://www.kommersant.ru/doc/3984186.
[43] "Foreign media: China may purchase 48 Russian-made Sui-35 fighter jets," *Global Times*, March 7, 2012, http://www.chinanews.com/gn/2012/03-07/3725329.shtml.
[44] "President Sukhoi went to Zhuhai to promote the Su-35, but it is difficult to enter PLA's legal eye," *Latitude 40 degrees north*, October 10, 2014, http://www.bw40.net/880.html.
[45] "Russia Offers China Second Batch of Elite Su-35 Fighters – But Does the Air Force Need Them?", *Military Watch Magazine*, June 28, 2019, https://militarywatchmagazine.com/article/russia-offers-china-second-batch-of-elite-su-35-fighters-but-does-the-air-force-need-them.
[46] Max Boserman, "Should China Buy Russian Su-35s," *Nauka Tehnika,* July 23, 2019, https://naukatehnika.com/sohu-nuzhno-li-kitayu-pokupat-su-35.html.
[47] "China did not need Russian Su-35 fighters," *AVIA PRO,* July 2, 2019, https://avia.pro/news/kitay-zachem-pokupat-su-35-esli-j-20-ego-prevoshodit.
[48] "Will China buy another batch of Su-35? Very likely and few purchases," op. cit..
[49] "Why Is the Su-35 A Chinese Expert for China?" *Military News*, July 23, 2013, http://mil.news.sina.com.cn/2013-07-23/0929732367.html.
[50] Wang Dongdong, "Sino-Russian fighters contest: J-20 and Su57 can't match F-35," *Epoch Weekly*, June 18, 2019, https://www.epochweekly.com/b5/618/19204.htm.
[51] "Russia demands from China legal guarantees of refusal to copy S-35 fighter," *Wars on Line*, March 6, 2010, http://warsonline.info/aviatsiya/rossiya-trebuet-ot-kitaya-iuridicheskich-garantiy-otkaza-ot-kopirovaniya-istrebitelya-su-35.html.

[52] "Su-35 protected from Chinese counterfeiting," *Kommersant*, June 3, 2012, https://www.kommersant.ru/doc/1887462.
[53] "Su-35 protected from Chinese counterfeiting," op. cit..
[54] "Russian offers China to buy a new batch of Su-35 fighters," *TASS*, June 26, 2019, https://tass.ru/armiya-i-opk/6598313.
[55] "China thought about buying a new batch of Russian Su-35," *EKD*, July 1, 2019, https://ekd.me/2019/07/kitaj-zadumalsya-nad-pokupkoj-novoj-partii-rossijskix-su-35/.
[56] "Foreign media: China may purchase 48 Russian-made Sui-35 fighter jets," op. cit..
[57] "Will China buy another batch of Su-35? Very likely and few purchases," op. cit..
[58] "President Sukhoi went to Zhuhai to promote the Su-35, but it is difficult to enter PLA's legal eye," op. cit..
[59] "Should China Buy Russian Su-35s," op. cit..
[60] "Sino-Russian fighters contest: J-20 and Su57 can't match F-35," op. cit..
[61] "Why Is the Su-35 A Chinese Expert for China?" op. cit..
[62] "Explained the reason for China's purchase of Russia Su-35," op. cit..
[63] "Explained the reason for China's purchase of Russia Su-35," op. cit..
[64] "Should China Buy Russian Su-35s," op. cit..
[65] Why Is the Su-35 A Chinese Expert for China?" *Military News*, op. cit..
[66] Fyodor Petunin, "Why microelectronics has become a 'black hole' for the Russian budget," *Комсомольская правда*, June 25, 2019, https://www.kp.ru/daily/26994/4054881/.
[67] Sergey Gololobov, "Bought in China: Russia has found an alternative go American microelectronics," *Radiovesti*, August 6, 2014, https://radiovesti.ru/brand/61178/episode/1417491/.
[68] Ivan Cheberko, "China will lift any restrictions on the export of electronics to Russia, *Izvestia*, August 24, 2014, https://iz.ru/news/575498.
[69] Rafael Fakhrutdinov, "Sanctions helped: China spoke about the development of the Russian military-industrial complex," *Gazeta,* April 6, 2020, https://www.gazeta.ru/army/2020/04/06/13038607.shtml.
[70] "Moscow has announced no plans to create a military alliance with China," *Interfax*, December 19, 2019, https://www.interfax.ru/world/688638.
[71] Dmitry Rogozin quoted by Anna Borshchevskaya in "Case for Keeping Sanctions against Russia's Defense Sector" *Forbes*, August 12, 2016, https://www.forbes.com/sites/annaborshchevskaya/2016/08/12/the-case-for-keeping-sanctions-against-russias-defense-sector/#3b347ff4e226.
[72] "Case for Keeping Sanctions against Russia's Defense Sector" op. cit..
[73] Victor Dyatlikovich, "How will Russia survive under Western Sanctions?" *expert.ru*, 2014, http://expert.ru/russian _reporter/2014/24/za-kamennoj-stenoj/.
[74] Remarks by Sergey Chemezov cited in "Russian IT market for defense industry," *TADVISER*, December 25, 2015, http://www.tadviser.ru/index.php/Статья:ИТ_для_оборонно-промышленного_комплекса_(рынок_России).
[75] "Russian Plane Production Plummeted in 2018, Official Data Shows," *The Moscow Times*, April 8, 2019, https://www.themoscowtimes.com/2019/04/08/russian-plane-production-plummeted-in-2018-official-data-shows-a65138.
[76] "Chinese microelectronics will replace U.S. microelectronics in Russian space, defense industries – newspaper," *Russia Beyond*, August 6, 2014, https://www.rbth.com/news/2014/08/06/chinese_microelectronics_will_replace_us_microelectronics_in_russian_spa_38790.html.
[77] "Chinese microelectronics will replace U.S. microelectronics in Russian space, defense industries – newspaper," op. cit..
[78] "Chinese microelectronics will replace U.S. microelectronics in Russian space, defense industries – newspaper," op. cit..
[79] "Case for Keeping Sanctions against Russia's Defense Sector" op. cit..
[80] "Russian satellites need technological breakthrough," *Vzglyad*, April 24, 2018, https://news.rambler.ru/ scitech/ 39695308-rossiyskim-sputnikam-neobhodim-tehnologicheskiy-proryv/.

[81] "Crisis or rebirth of microelectronics in Russia," *Russia Beyond*, August 16, 2016, https://www.rbth.com/economics/business/2016/08/16/microelectronics-in-russia-crisis-or-rebirth_621409.
[82] "Three Asian countries turned out to be the main suppliers of microelectronics to Russia," *RBC,* July 10, 2019, https://www.rbc.ru/economics/10/07/2019/5d2478bc9a7947fb4f267654.
[83] Grigory Omelchenko and Mike Hirschberg "Russia and China Show Latest Aircraft," *VERTIFLITE*, November/December 2015, https://vtol.org/files/dmfile/RussiaChinaOmelchenko1.pdf.
[84] Aljosa Milenkovic, "China-Russia heavy helicopter cooperation: Making the rotorcraft of the future," *CGNT*, April 10, 2019, https://news.cgtn.com/news/3d3d674e7a4d544f33457a6333566d54/index.html.
[85] Vladimir Karnozov*, "*AVIC Provides First Glimpse of Sino-Russian Heavy-lifter," *AINonline*, November 17, 2018, https://www.ainonline.com/aviation-news/defense/2018-11-17/avic-provides-first-glimpse-sino-russian-heavy-lifter.
[86] Photos taken by authors at AirShow China 2018.
[87] "Russia will present more than 220 weapons at Airshow China 2016," *RIA Novosti*, October 25, 2016, https://ria.ru/20161025/1479946288.html.
[88] "Airshow China 2016 Russia unveils new ASEA radar for MiG35 fighter," *Military Review Update*, June 24, 2017, https://www.youtube.com/watch?v=-OCDTEOicvo.
[89] Photos taken by authors at AirShow China 2016.
[90] "ODK at Airshow China is the latest Russian aircraft engines," *posted by Newsmaker,* November 1, 2016, https://chelorg.com/2016/11/01/odk-at-airshow-china-is-the-latest-russian-aircraft-engines/.
[91] "Innovative electronic technologies from Russia," *Russian Aviation Insider*, November 2, 2016, http://www.rusaviainsider.com/innovative-electronic-technologies-from-russia/.
[92] "Innovative electronic technologies from Russia," op. cit..
[93] Nikolai Litovkin, "AirShow China 2016: What did – or didn't—Russia manage to sell?" *Russia Beyond*, November 8, 2016, https://www.rbth.com/defence/2016/11/08/airshow-china-2016-what-did-or-didnt-russia-manage-to-sell_646001.
[94] "Airshow China – 2016 opens in Zhuhai, China", *RIA Novosti***,** November 1, 2016, https://ria.ru/20161101/1480408932.html.
[95] "'Copying Failed': the causes of Chine's problem with aircraft engines," *Defense View,* February 18, 2021, https://defenceview.in/copying-failed-the-causes-of-chinas-problems-with-aircraft-engines/.
[96] "'Copying Failed': the causes of Chine's problem with aircraft engines," op. cit..
[97] "China buys 463 D30 engines for Y-20 and H-6K, WS-20 to come," *China Arms,* January 6, 2020, https://www.china-arms.com/ 2020/01/d30-engines-for-y20-and-h6k/.
[98] "Airshow China – 2016 opens in Zhuhai, China, op. cit..
[99] Sergey Akhrameev, "TANTK Named After G.M. Berieva and Chinese Leader Energy Aircraft Manufacturing Co. Ltd. Signed a Memorandum of Understanding on Supply of Two Be-200," *AviaPort.ru*, November 7, 2016, https://www.aviaport.ru/news/2016/11/07/404373.html.
[100] "TANTK Named After G.M. Berieva and Chinese Leader Energy Aircraft Manufacturing Co. Ltd. Signed a Memorandum of Understanding on Supply of Two Be-200," op. cit..
[101] "VSMPO-Avisma Strengthens Business Contacts with China," *Aviaport.ru*, November 24, 2016, https://www.aviaport.ru/digest/2016/11/24/400882.html.
[102] "China-Russia Commercial Aircraft International Co., Ltd. established,' *COMAC News Center*, May 22, 2017, http://english.comac.cc/news/latest/201705/24/t20170524_5262164.shtml.
[103] "China-Russia Commercial Aircraft International Corporation Co., Ltd., *United Aircraft Corporation*, no date, https://www.graphicnews.com/en/pages/38507/aviation-new-sino-russian-cr929-jet.
[104] "Sino-Russian widebody aircraft takes on Airbus and Boeing", *GraphicNews*, November 6, 2018, https://www.uacrussia.ru/en/corporation/company/china-russia-commercial-aircraft-international-corporation-co-ltd/.
[105] "Russian and Chinese engineers collaborate remotely on CR299 due to coronavirus threat," op.cit..
[106] "Ten new Rostec products at MAKS-2019," *New Defence Order Strategy*, no date, https://dfnc.ru/aviazcia/desyat-novinok- predpriyatij-rosteha-na-aviasalone-maks-2019.

[107] "ROSOBORONEXPORT Organizes Russia's Largest Display in 2018 at AirShow China," *Rosoboronexport Press Release*, November 6, 2018, http://roe.ru/eng/press-service/press-releases/rosoboronexport-organizes-russia-s-largest-display-in-2018-at-airshow-china-/.

[108] "Russian sees more helicopter demand in China," *AviationWeek Show New*s, AirShow China 2018, November 8, 2018.

[109] Liu Xuanzun, "Chinese exhibitors display laser weapon, stealth target drone at Russian Expo," *Global Times*, August 27, 2019, http://www.globaltimes.cn/content/1162762.shtml.

[110] "Chinese exhibitors display laser weapon, stealth target drone at Russian Expo," op. cit..

[111] Photo taken by authors at MAKS 2019.

[112] "2019 Moscow Airline opens in China, China is invited to participate a guest country," *CCTV news*, August 28, 2019, https://www.hndnews.com/p/295916.html.

[113] Photo taken by authors at MAKS 2019.

[114] Photo taken by authors at MAKS 2019.

[115] "Chinese boutiques shine at Moscow Air Show, China and Russia look forward to deepening cooperation," op. cit..

[116] Zhao Lei, "China's aerospace capabilities on display at Russian Air Show," *China Daily*, September 9, 2019, https://www.chinadaily.com.cn/a/201909/09/WS5d75a861a310cf3e3556a67f.html.

[117] Photos taken by authors at MAKS 2019.

[118] Photo taken by authors at MAKS 2019.

[119] Photo taken by authors at MAKS 2019.

[120] "China Aerospace Science and Technology Products Debut in Moscow Air Show," *China Great Wall Industry Corporation*, August 27, 2019, http://cn.cgwic.com/news/2019/20190828.html.

[121] "China Aerospace Science and Technology Products Debut in Moscow Air Show," op. cit..

[122] Brochure distributed by CETC's 38th Institute at MAKS 2019.

[123] Brochure distributed by CETC's 38th Institute at MAKS 2019.

[124] Brochure distributed by CETC's 38th Institute at MAKS 2019.

[125] "Chinese boutiques shine at Moscow Air Show, China and Russia look forward to deepening cooperation," *Xinhua News Agency*, August 31, 2019, http://www.xinhuanet.com/2019-08/31/c_1124944836.htm.

[126] Photo taken by authors at MAKS 2019.

[127] Photo taken by authors at MAKS 2019.

[128] Brochure distributed by Nanjing University of Science and Technology at MAKS 2019.

[129] Brochure distributed by Nanjing University of Science and Technology at MAKS 2019.

[130] Brochure distributed by Phoenix Electronics LCC at MAKS 2019.

[131] Placard at Wuhu Diamond Aircraft Manufacturing Co., Booth at MAKS 2019.

[132] Photo taken by authors at MAKS 2019.

[133] "China's new missile warning system to reduce probability of big war say Russian experts," *TASS*, October 4, 2019, https://tass.com/defense/1081529.

[134] Masao Dahgren, "Russia Aiding China on Missile Warning System, *Missile Threat*, October 4, 2019, https://missilethreat.csis.org/russia-aiding-china-on-missile-early-warning-system/.

[135] Vasily Kashin, "How cooperation between Russia and China in the creation of an early warning system will affect the strategic balance in the world," *profile.ru*, October 15, 2019, https://profile.ru/military/kak-sotrudnichestvo-rossii-i-kitaya-v-sozdanii-sprn-povliyaet-na-strategicheskij-balans-v-mire-184537/.

[136] Alexey Nikolskylvan, Ivan Safronov and Varyara Podrugina, "Military alliance between Moscow and Beijing may turn from formal to real," *Vedomosti*, October 5, 2019, https://www.vedomosti.ru/politics/articles/2019/10/06/ 812956-soyuz-moskvi-pekina.

[137] "Chinese Missile Early Warning System-with Russian Help-May be Nearing Completion," *Defense World Net*, June 25, 2020, https://www.defenseworld.net/news/27280#.YLPPP4WSlZc.

[138] "Chinese Missile Early Warning System-with Russian Help-May be Nearing Completion," op. cit..

[139] "Chinese Missile Early Warning System-with Russian Help-May be Nearing Completion," op. cit..

[140] "Chinese Missile Early Warning System-with Russian Help-May be Nearing Completion," op. cit..

[141] Siemon T. Wezeman, "China, Russia and the shifting landscape of arms sales," *SIPRI*, July 5, 2017, https://www.sipri.org/commentary/topical-backgrounder/2017/china-russia-and-shifting-landscape-arms-sales.
[142] "China, Russia and the shifting landscape of arms sales," op. cit..
[143] "Importer/Exporter TIV Tables," op. cit..
[144] "Importer/Exporter TIV Tables," op. cit..
[145] "China-Russia Joint Research Center for Atmospheric Optics Unveiled," *Hefei Institute of Material Science*, June 26, 2019, http://www.cas.cn/yx/201906/t20190625_4696708.shtml.
[146] "Global Cooperation," *Beijing Institute of Aeronautical Materials*, no date, http://www.biam.com.cn/tabid/109/Default.aspx.
[147] "China Civil Aviation Research Institute of Science and Technology purchased Anylogic software and GeVop1.0 system graphics workstation from a single source for comments," *China Aerospace Science and Technology Corporation 2017*, http://www.castc.org.cn/cgxx/201708/t20170818_6476.html.
[148] "Zhukovchan – TsAGI experts, together with their Chinese colleagues, intend to conduct joint research of spacecraft for landing on Mars," *Muscovy*, 2018, https://www.nashamoskovia.ru/news-14687.html.
[149] "TsAGI and CADC investigate flow noise around full-size chassis models," *Aviation Explorer*, December 27, 2019, https://www.aex.ru/news/2019/12/27/206648/.
[150] "TsAGI Successfully Fulfilled the Contract of the Chinese Company AVIC ARI," *Press Service of the Russian Ministry of Industry and Trade*, July 29, 2016, https://ruchina.org/cfo-article/china/1151.html.
[151] "TsAGI scientists will help create a wind tunnel in China," *rcbc.ru*, April 16, 2019, https://rcbc.ru/12908.
[152] "TsAGI and CAE Sign Cooperation Agreement," *Aviation Explorer*, November 19, 2019, https://www.aex.ru/news/2019/11/12/204519/.
[153] "TsAGI and CAE Sign Cooperation Agreement," op. cit..
[154] "Aviation Industry Manufacturing Institute and Russian Aeronautical Materials Research Institute signed a strategic cooperation agreement," *kknews*, November 14, 2018, https://kknews.cc/zh-sg/other/5zkojv8.html.
[155] Lei Yu and Sophia Sui, "China-Russian military cooperation in the context of Sino-Russian strategic partnership, *Asia Europe Journal*, July 8, 2019, https://link.springer.com/article/10.1007/s10308-019-00559-x.
[156] "TsAGI visited the delegation of the Chinese Institute FARCI," *TsAGI website*, June 14, 2019, http://tsagi.ru/pressroom/news/4391/.
[157] "TsAGI visited the delegation of the Chinese Institute FARCI," op. cit..
[158] "China-Russia Commercial Aircraft International Corporation Co., Ltd.," *United Aircraft Corporation*, no date, https://www.uacrussia.ru/en/corporation/company/china-russia-commercial-aircraft-international-corporation-co-ltd/.
[159] COMAC, no date, http://english.comac.cc/aboutus/introduction/.
[160] "TsAGI Tested Under the Program of the Russian-Chinese Aircraft CR939," *Rostec*, December 12, 2019, https://rostec.ru/news/v-tsagi-proshli-ispytaniya-po-programme-rossiysko-kitayskogo-samoleta-cr929/.
[161] "TsAGI Tested Under the Program of the Russian-Chinese Aircraft CR939," op. cit..
[162] "TsAGI held a meeting with the leadership of the Chinese CAAA Academy," *TsAGI press release*, August 29, 2019, http://www.tsagi.ru/pressroom/news/4483/.
[163] "TsAGI held a meeting with the leadership of the Chinese CAAA Academy," op. cit..
[164] "Cooperation and Exchanges," *Institute of Aeronautical Industry Manufacturing*, no date, https://m.baike. com/>wiki> Beijing Aviation manufacturing.
[165] "Aviation Industry Manufacturing Institute and Russian Aeronautical Materials Research Institute signed a strategic cooperation agreement," *hotbak.net*, hotbak.net/key/.
[166] Ruan Changlong, "Experts from Russia Central Aero-Engine Research Institute visited Qiangdao Branch," *Institute of Engineering Thermophysics of Chinese Academy of Sciences*, July 29, 2018, http://www.iet.cas.cn/gjjl/jldt/201807/t20180711_5041209.html.
[167] "The 750kgf thrust turbofan engine of the Chinese Academy of Sciences completed the high-altitude performance test and will be used for high-altitude high-stealth long-range combat drones," *zhuanlan.zhihu*, 2017, https://zhuanlan.zhihu.com/p/109124782.

[168] "The 750kgf thrust turbofan engine of the Chinese Academy of Sciences completed the high-altitude performance test and will be used for high-altitude high-stealth long-range combat drones," op. cit..

[169] "Rostec creates test complex for PD-35 aircraft engine," *Rostec*, September 27, 2018, https://rostec.ru/en/news/rostec-creates-test-complex-for-pd-35-aircraft-engine-/.

[170] Eugene Kolyada, "Test complex for PD-35 will be built by the end of 2025," *ato.ru*, August 9, 2019, http://www.ato.ru/content/ispytatelnyy-kompleks-dlya-pd-35-postroyat-k-koncu-2025-goda.

[171] "CR929: Long-Range Perspectives," *Moscow Aviation Institute*, March 3, 2020, https://en.mai.ru/media/news/detail.php?ID=112832.

[172] "Interview: We work closely with China's scientific and technological research and development-Interview with Kradov, Director of the International Cooperation and Regional Policy Department of the Russian Technology Group," *Xinhuanet*, July 6, 2019, http://www.xinhuanet.com/world/2019-07/06/c_ 1124718335.htm.

[173] "School of Aeronautics and Institute of Control Science of the Russian Academy of Sciences sign an agreement to establish a joint laboratory," *Campus News*, November 6, 2018, https://news.nwpu.edu.cn/info/1003/59358.htm.

[174] "Scientists of FSUE TsAGI took part in the XIV Russian-Chinese Conference," *TsAGI Press Service*, October 8, 2015, http://www.tsagi.ru/pressroom/news/2315/.

[175] "In Zhukovsky, Russian and Chinese scientists discuss issues of aviation science," *zhuksgn.ru*, July 18, 2017, http://www.zhukgsn.ru/v-zhukovskom-rossiyskie-i-kitayskie-uchenyie-obsudili-voprosyi-aviatsionnoy-nauki/.

[176] "XI Russian-Chinese Conference 'Fundamental Problems of Aerodynamics, Fight Dynamics, Aircraft Strength and Acoustics' was held at TsAGI," *Aviation Explorer*, August 26, 2011, https://www.aex.ru/news/2011/8/26/87807/.

[177] "Scientists of FSUE TsAGI took part in the XIV Russian-Chinese Conference," op. cit..

[178] "In Zhukovsky, Russian and Chinese scientists discuss issues of aviation science," op. cit..

[179] "The first Russian-Chinese conference on innovative development of aircraft engines was held at CIAM," *CIAM Press Release*, July 21, 2017, https://www.ciam.ru/press-center/news/.

[180] "The first Russian-Chinese conference on innovative development of aircraft engines was held at CIAM," op. cit..

[181] "II Sino-Russian Forum 'Investments in Innovation'," *RVC*, June 2017, https://www.rvc.ru/en/calendar/detail.php?id=106194.

[182] "15th China-Russia Aviation Science and Technology Academic Exchange Conference was held in Russia," *CANnews*, July 20, 2017, http://www.cannews.com.cn/2017/0720/165512.shtml.

[183] "Symposium on China-Russia Aviation Technical Cooperation Held in Beijing," *China Aviation Research Institute*, January 18, 2017, http://www.cae.ac.cn/Cn/html/15023883.html.

[184] "Symposium on China-Russia Aviation Technical Cooperation Held in Beijing," op.cit..

[185] "Chinese and Russian scientists discuss cooperation in aerospace in Xiamen," *Xinhua News Agency*, November 26, 2019, http://www.gov.cn/xinwen/2019-11/26/content_5455873.htm.

[186] "The 6th China-Russia Engineering Technology Forum was held in Guangzhou," *Eddysun (Xiamen) Electronic Co., Ltd.,* November 29, 2019, http://www.dsn8088.com/index.php_m=content&c=index &a= show&catid=14&id=246.

[187] "Vice Minister Xin Goubin and Russian Deputy Minister of Industry and Trade Pochalov co-chaired the China-Russia Civil Aviation Working Conference in Beijing," *International Cooperation Department of the Chinese Ministry of Industry and Information Technology*, July 12, 2019, http://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057800/n3057810/c7032866/content.html.

[188] "MAKS 2019 – Results of the Second and Third Day of the Air Show," *Aviation Pulse*, August 31, 2019, https://50skyshades.com/news/events-festivals/MAKS 2019-results-of-the-second-and-third-day-of-the-air-show.

[189] "Russian Academic Delegation Visits Shanghi Jiaotong University Aerospace Academy," *College News*, October 12, 2019, http://www.aero.sjtu.edu.cn/Data/View/3626.

[190] "Russian Academic Delegation Visits Shanghi Jiaotong University Aerospace Academy," op. cit..

[191] "Russian academicians visit the School of Materials," *College News*, September 29, 2019, http://www.mse.buaa.edu.cn/info/1036/3988.htm.
[192] "Sino-Russian aero-engine military to civilian cooperation," *China Securities Network*, March 4, 2015, http://news.cnstock.com/industry,zxk-201503-3355365.htm.
[193] "About Us," *AnHui Haery Aviation Power Co., Ltd.,* no date, http://www.haerypower.com/en/info.asp?base_id=1&second_id=1001.
[194] "Overview," AVIC Composites Co., Ltd., *AVIC Composites* website, no date, http://www.avicht.cn/zh-cn/industry.fhcl.
[195] "Overview," AVIC Composites Co., Ltd., op. cit..
[196] Ivan Cheberko, "China will lift any restrictions on the export of electronics to Russia," op. cit..
[197] "Chinese boutiques shine at Moscow Air Show, China and Russia look forward to deepening cooperation," op. cit..
[198] Picture obtained from brochure at MAKS 2019.
[199] Picture obtained from brochure at MAKS 2019.
[200] "Company Profile," *CASC*, no date, http://english.spacechina.com/n16421/n17138/n17229/index.html.
[201] Liu Xuanzun, "Chinese aviation and space development commands attention in Russia," *Global Times*, August 28, 2019, https://www.globaltimes.cn/content/1162880.shtml.
[202] Picture obtained from brochure at MAKS 2019.
[203] Photo taken by authors at AirShow China 2018 and model at MAKS 2019.
[204] "About Us," *Aviation Industry Corporation of China*, no date, http://www.gaqfzxx.com/en/aboutus /index.shtml.
[205] Photo taken by authors at MAKS 2019.
[206] "Introduction," *CETC*, no date, http://en.cetc.com.cn/enzgdzkj/about_us/introduction29/index.html.
[207] "Chinese aviation and space development commands attention in Russia," op.cit..
[208] Photo taken by authors at MAKS 2019.
[209] "Company Profile," *China Great Wall Industry Corporation*, no date, http://www.cgwic.com/About/index.html.
[210] "NPO Energomash and Velikaya Stena Corporation held working meeting about possible cooperation," *Industry News*, September 9, 2017, http://www.russian.space/1144/.
[211] "China Great Wall Industry Group brings new products to Moscow Air Show. Sino-Russian space cooperation enters a new stage," *Public Service of GoGlobal Department of Guangdong Province Department of Commerce*, July 21, 2017, http://go.gdcom.gov.cn/article.php?typeid=10&contentId=7404.
[212] Photo taken by authors at MAKS 2019.
[213] "Introduction," *Commercial Aircraft Corporation of China* website, no date, http://english.comac.cc/aboutus/introduction/.
[214] "2019 Moscow Airline opens in China, China is invited to participate a guest country," op. cit..
[215] Yannick Genty-Boudry, "MAKS 2019: Sukhoi and Comac introduce a nose mockup of the CR929," *Air&Cosmos International*, August 3, 2019, https://aircosmosinternational.com/article/maks-2019-sukhoi-and-comac-introduce-a-nose-mockup-of-the-cr929-59.
[216] Brochure obtained at MAKS 2019.
[217] Brochure obtained at MAKS 2019.
[218] "China will lift any restrictions on the export of electronics to Russia," op. cit..
[219] "Chinese exhibitors display laser weapon, stealth target drone at Russian Expo," op. cit..
[220] Brochure obtained at MAKS 2019.
[221] Brochure obtained at MAKS 2019.
[222] "Wuhu-Made Diamond Aircraft to Take Off in 2016," *China Aviation Daily*, March 18, 2015, http://www.chinaaviationdaily. com/news/42/42441.html.
[223] Photo taken by authors at MAKS 2019.
[224] "China will lift any restrictions on the export of electronics to Russia," op. cit..
[225] Brochure obtained at MAKS 2019.
[226] Brochure and placard obtained at MAKS 2019.
[227] "About Us," Ziyan Unmanned Aerial Vehicle Co., Ltd., no date, http://ziyanuav.com/aboutus.html.

[228] "Exhibitor List: Catalog", *ARMY 2020 Expo*, https://www.rusarmyexpo.com/a-antei. "China-Russia Commercial Aircraft International Co., Ltd. established,' COMAC News Center, May 22, 2017, http://english.comac.cc/news/latest/201705/24/t20170524_5262164.shtml.

[229] "JCS Concern Radio-Electronic Technologies," *Rostec,* no date, https://rostec.ru/en/about/companies/346/.

[230] "Catalog, Moscow Air Show, 2019", *MAKS 2019*, no date, https://aviasalon.com/en/e-catalogue-of-participants?country =&keyword=kret.

[231] "Innovative electronic technologies from Russia," op. cit..

[232] "TsNII Kometa," *ISTC*, no date, http://www.istc.int/en/institute/10323.

[233] "How cooperation between Russia and China in the creation of an early warning system will affect the strategic balance in the world," op. cit..

[234] "Metallurgical plant 'Elektrostal' and GC 'Final': on the prospects for the development of aircraft engines," *Finval*, October 27, 2014, https://finval.ru/about/news/metallurgicheskiy_zavod_elektrostal_i_gk_finval_o_perspektivakh_razvitiya_aviatsionnykh_dvigateley/.

[235] "Exhibitors List," *Aviation Expo/China 2019,* no date, https://10times.com/beijing-aviation-expo/exhibitors.

[236] "Russian Machines," *HELIRUSSIA, 2011*, https://helicopter.su/assets/media_sources/zhurnal/%D0%96%D1%83%D1%80%D0%BD%D0%B0%D0%BB%D1%8B/2011/1102.pdf.

[237] "NPO Energomash and Velikaya Stena Corporation held working meeting about possible cooperation," op. cit..

[238] "How cooperation between Russia and China in the creation of an early warning system will affect the strategic balance in the world," op. cit..

[239] "Moscow has announced no plans to create a military alliance with China," op. cit..

[240] Liu Zhen, "Russia offers rocket engine tech as China's Long March 5 struggles to get off the ground," *South China Morning Post*, August 28, 2019, https://www.scmp.com/news/china/military/article/3024766/russia-offers-rocket-engine-tech-chinas-long-march-5-struggles.

[241] "Exhibitor List: Catalog", op. cit..

[242] Peter Suciu, "Russia's Rostec to Build Helicopters for China," *The National Interest*, October 27, 2020, https://nationalinterest.org/blog/buzz/russias-rostec-build-helicopters-china-171455.

[243] "Chengdu J-10B/C," *SinoDefence,* August 15, 2017, https://sinodefence.com/chengdu-j-10bc/.

[244] Aljosa Milenkovic, "Russia builds engine for CR929 aircraft," *CGNT*, December 6, 2017, https://news.cgtn.com/news/34417a4d30637a6333566d54/share_p.html.

[245] Table derived in part from Brian Wang, "China to get first 4 Su-35 Fighter Jets from Russia in 2016 and they will reverse engineer the AL-117s engine," *next BIG Future,* October 22, 2016, https://www.nextbigfuture.com/2016/10/china-to-get-first-4-su-35-fighter-jets.html and latest version taken from Wikipedia at https://en.wikipedia.org/wiki/Saturn_AL-31.

[246] "24 Nov FSUE 'GOSNIIAS at Airshow China-2016," Press release by the *Russian Scientific Research Institute of Aviation Systems*, 2016, https://niieap.com/2016/11/24/fgup-gosniias-na-airshow-china-2016/.

[247] "Combat Life, Resistance of Weapons and On-Board Equipment to External Factors," *Scientific Research Institute of Aviation Systems*, no date, http://tlib.gosniias.ru/.

[248] "Advanced Armament and Sophisticated Weapons," *Tactical Missile Corporation*, no date, http://eng.ktrv.ru/.

[249] "About Tactical Missile Corporation," *Tactical Missile Corporation*, no date, http://eng.ktrv.ru/.

[250] Melekhina Maria, "China intends to replace Ufa aircraft engines," *acexpert.ru*, August 30, 2016, http://www.acexpert.ru/news/kitay-nameren-zamestit-ufimskie-aviadvigateli.html.

[251] "Products of PJS 'UEC-UMPO' are presented at the International Aerospace Salon in Zhuhai (China)," *UMPO news release*, 2018, http://www.umpo.ru/press-tsentr/news/umpo/produktsiya-pao-odk-umpo-predstavlena-na-mezhdunarodnom-aerokosmicheskom-salone-v-g-chzhukhay-kitay/.

[252] "Products of PJS 'UEC-UMPO' are presented at the International Aerospace Salon in Zhuhai (China)," op, cit..

[253] "United Aircraft Corporation, PJCS, Catalog," *Moscow Air Show 2019*, https://aviasalon.com/en/e-catalogue-of-participants?country=&keyword=united+aircraft+corporation.

[254] "Russia builds engine for CR929 aircraft," op. cit..

[255] "VSMPO-Avisma Strengthens Business Contacts with China," op. cit..

[256] "China and Russia join hands to establish Aviation Technology Joint Research Center," *ZJU Newsroom*, September 17, 2018, https://www.zju.edu.cn/english/2018/0921/c19573a850496/page.htm.
[257] "China and Russia join hands to establish Aviation Technology Joint Research Center," *op. cit.*.
[258] "China and Russia join hands to establish Aviation Technology Joint Research Center," *op. cit.*.
[259] "Shanghia Jiaotong University and Moscow Aviation Institute jointly build Sino-Russian Joint Aviation Academy," *Observer Network Synthesis*, April 10, 2017, https://www.guancha.cn/Neighbors/2017_04_10_402951.shtml?web.
[260] "MAI-SJTU Institute: Heading up for the anniversary intake," *Moscow Aviation Institute (MAI)*, April 23, 2021, https://en.mai.ru/media/news/detail.php?ID=156698.
[261] "Our college organizes students to go to Russia to participate in the Moscow Aviation Academy Summer Aviation School," *Foreign Affairs Time,* September 26, 2019, http://saa.zju.edu.cn/redir.php? catalog_id=177&object_id=85024.
[262] Yan Shixuan, "Nanjing University of Aeronautics and Astronautics and Moscow Aviation Institute," *Aviation Institute*, April 16, 2019, http://aero.nuaa.edu.cn/2019/0416/c9643a154638/page.htm.
[263] "Overcome the difficulties and seek development together-the exchange and cooperation between Chinese and Russian universities during the epidemic continues," *Xinhuanet*, May 30, 2020, and Guo Shuang Chen, "The average age of the designer team was 28 when development of the amphibious aircraft AG600 started," *China News*, September 28, 2016, http://www.js7tv.cn/news/201609_62809.html.
[264] "Shanghai Jiao Tong University---Moscow Aviation Institute Dual Degree Program," Shanghai Jiao Tong University school website, no date, http://www.aero.sjtu.edu.cn/En/Data/View/3938.
[265] "Shanghai Jiao Tong University---Moscow Aviation Institute Dual Degree Program," Shanghai Jiao Tong University school website, no date, http://www.aero.sjtu.edu.cn/En/Data/View/3938.
[266] "Shanghai Jiao Tong University---Moscow Aviation Institute Dual Degree Program," op. cit..
[267] "Shanghai Jiao Tong University---Moscow Aviation Institute Dual Degree Program," op. cit..
[268] "Shanghai Jiao Tong University---Moscow Aviation Institute Dual Degree Program," op. cit..
[269] Guo Shuang Chen, "The average age of the designer team was 28 when development of the amphibious aircraft AG600 started," *China News*, September 28, 2016, http://www.js7tv.cn/news/201609_62809.html.
[270] "R&D Team," Liaoning Ruixiang General Aircraft Manufacturing Co., Ltd., no date, http://www.rgac.net.cn/Ruixiang/AboutUs/Team.php.
[271] Samuel Bendett and Elsa Kania, "A New Sino-Russian High-Tech Partnership," October 29, 2019, https://www.aspi.org.au/report/new-sino-russian-high-tech-partnership.
[272] "Shanghia Jiaotong University and Moscow Aviation Institute jointly build Sino-Russian Joint Aviation Academy," op. cit..
[273] "Strategic Contours of China's Arms Transfers," op. cit..
[274] "How Dominant is China in the Global Arms Trade," *ChinaPower*, 2018, https://chinapower.csis.org/china-global-arms-trade/.
[275] Zheng Qi, "The political role of military-technical cooperation in contemporary Russian-Chinese Relations," *disseCAT,* 2010, https://www.dissercat.com/content/politicheskaya-rol-voenno-tekhnicheskogo-sotrudnichestva-v-sovremennykh-rossiisko-kitaiskikh.
[276] "The JH-7 'Flying Leopard' Aircraft of the Chinese Air Force Received Missiles that Are Not Even on the J-20," *Eurasian Defense*, June 6, 2020, http://eurasian-defence.ru/node/46907.
[277] Lindsay Maizland, "China's Modernized Military," *Council on Foreign Relations*, February 5, 2020, https://www.cfr.org/backgrounder/chinas-modernizing-military.
[278] "History of the military-technical cooperation of Russia and China in photographs and documents," *Rosoboronexport*, June 2020, https://oborona.ru/includes/periodics/armstrade/2020/0331/ 184029023/detail.shtml.
[279] "Russia-China: a limited liability military balance," *The Warsaw Institute Review,* May 18, 2020, https://warsawinstitute. review/issue-2020/russia-china-a-limited-liability-military-alliance/.
[280] "Military-technical cooperation between Russia and China," *TASS*, September 2, 2015, https://tass.ru/info/2228966.

[281] "Sanctions helped: China spoke about the development of the Russian military-industrial complex," op. cit..
[282] Michael Kofman, "The Emperor League: Understanding Sino-Russian Defense Cooperation," *War on the Rocks*, August 6, 2020, https://warontherocks.com/2020/08/the-emperors-league-understanding-sino-russian-defense-cooperation/.
[283] Irina Bazikova, "Military-technical cooperation of the PRC with African countries and Russia's position on the African arms market," *Russian Council for International Affairs*, December 6, 2017, https://russiancouncil.ru/ analytics-and-comments/columns/sandbox/voenno-tekhnicheskoe-sotrudnichestvo-knr-so-stranami-afriki-i-pozitsii-rossii-na-afrikanskom-rynke-v/.
[284] "Vladimir Gutenev: China as a future competitor? China's military-technical cooperation with Southeast Asian countries expands," *Regions of Russia*, January 11, 2019, https://www.gosrf.ru/news/41952/.
[285] Diana Mikhailova, "Military-technical cooperation between China and the post-Soviet republics of Central Asia," *LiveJournal,* July 12, 2019, https://diana-mihailova.livejournal.com/3573615.html.
[286] "Military-technical cooperation between China and the post-Soviet republics of Central Asia," op. cit..
[287] "British think tank report: China's military modernization far exceeds expectations. This strategy worries the United States," *JF Daily*, February 14,2018, https://www.jfdaily.com/news/detail?id=80115.
[288] Terri Moon Cronk, "China Poses Largest Long-Term Threat to U.S., DOD Policy Chief Says," *U.S. Department of Defense*, September 23, 2019, https://www.defense.gov/Explore/News/Article/Article/1968704/china-poses-largest-long-term-threat-to-us-dod-policy-chief-says/.
[289] Harry Britsky, "US Army thinks China will be a bigger threat than Russia by 2028 – here's how the service plans to take them on," *Business Insider*, https://www.businessinsider.com/army-sees-china-as-bigger-threat-than-russia-by-2028-2019-10.
[290] "China Military Power: Modernizing a Force to Fight and Win," *Defense Intelligence Agency*, 2019, https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/China_Military_Power_FINAL_5MB_20190103.pdf.
[291] "China Military Power: Modernizing a Force to Fight and Win,"op. cit..
[292] "China-Russia military cooperation in the context of Sino-Russian strategic partnership," op. cit..
[293] "Russia-China: a limited liability military balance," op. cit..
[294] Rick Joe, "China's Military Advancements in the 2010s: Air and Ground," *The Diplomat*, February 5, 2020, https://thediplomat.com/2020/02/chinas-military-advancements-in-the-2010s-air-and-ground/.
[295] Marcin Kaczmarsk, "The Moscow-Beijing Relationship: Increasingly Asymmetrical and Resilient," *Australian Institute of International Affairs*, July 2, 2019, http://www.internationalaffairs.org.au/australianoutlook/the-moscow-beijing-relationship-increasingly-asymmetrical-and-resilient/.
[296] Samuel Bendett and Elsa Kania, "The Resilience of Sino-Russian High Tech Cooperation," *War on the Rocks*, August 12, 2020, https://warontherocks.com/2020/08/the-resilience-of-sino-russian-high-tech-cooperation/.
[297] "The Resilience of Sino-Russian High Tech Cooperation," op. cit..
[298] Adam Segal, "Peering into the Future of Sino-Russian Cyber Security Operations," *War on the Rocks*, August 10, 2020, https://warontherocks.com/2020/08/peering-into-the-future-of-sino-russian-cyber-security-cooperation/.
[299] Xiao Bin, "Development of sustainable scientific, technical and innovative cooperation between China, and Russia," *Russian Council for International Relations*, March 4, 2020, https://russiancouncil.ru/analytics-and-comments/columns/asian-kaleidoscope/razvitie-ustoychivogo-nauchno-tekhnicheskogo-i-innovatsionnogo-sotrudnichestva-kitaya-i-rossii/.
[300] "China and Russia work together to Build a Quantum Secure Channel for Communication with Each Other." *QuantumHermit*, June 27, 2020, http://quantumhermit.com/china-and-russia-work-together-to-build-a-quantum-secure-channel-for-communication-with-each-other/.
[301] "Strategic Contours of China's Arms Transfers," op. cit..
[302] "Strategic Contours of China's Arms Transfers," op. cit..