



Geneva Institute of International Relations

# THE FUTURE OF AERIAL WARFARE: THE EVOLUTION OF SIXTH- GENERATION FIGHTER PROGRAMS

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## INTRODUCTION

The aviation world has seen five generations of jet fighters. Numerous militaries around the world are currently working to develop sixth-generation fighters, which would represent a significant leap forward from the capabilities of the current fifth-generation fighters. The goal is to ensure their military forces remain at the cutting edge of aerial combat technology. Sixth-generation fighters will be the most advanced fighters in the world and will be designed to ensure air superiority and meet evolving defense needs. The race to develop sixth-generation fighters underscores the strategic importance of air superiority and technological advancement in modern warfare. These programs promise to deliver unprecedented capabilities, setting new standards for future combat aircraft. With these new fighters, the landscape of military aviation will transform dramatically. Sixth-generation fighters will integrate new technologies that will differentiate them from their predecessors, such as artificial intelligence, manned-unmanned teaming, enhanced stealth, and directed-energy weapons. Stealth coatings will decrease the radar signature, making them difficult to detect and enabling them to evade enemy air defenses and remain safe even in most environments. Advanced propulsion systems will likely be more fuel-efficient, extending flight times and operational range. A mix of traditional gas turbine engines and hybrid electric engines might power these jets. The use of newer materials, such as carbon fiber, might also make these planes lighter and more robust. Future cockpits will also likely incorporate new technologies such as artificial intelligence, helmet-mounted displays, eye tracking, direct retinal projection, data sharing, and advanced combat systems. These developments will help pilots have better situational awareness and enhance performance. Sixth-generation jet fighters will also likely be equipped with hypersonic missiles or directed-energy weapons.

Several countries are at the forefront of developing these next-generation fighters through independent national programs or collaborative international projects with a current goal to have these planes enter service in the 2030s. The **United States (U.S.)** is spearheading two major sixth-generation fighter programs addressing the unique requirements of the **Air Force (Next Generation Air Dominance (NGAD)** program) and the **Navy (the F/A-XX Program)**. The **Future Combat Air System (FCAS)** program is a joint effort by **France, Germany, and Spain**. The **Global Combat Air Programme (GCAP)** is a joint program initially led by the **United Kingdom (U.K.)**, which now also includes **Italy, Sweden, and Japan**. These programs are part of a broader technological arms race to maintain aerial superiority.

## I. THE GLOBAL COMBAT AIR PROGRAMME (GCAP)

The **Global Combat Air Programme (GCAP)** is an international collaborative project between the **United Kingdom (U.K.)**, **Italy**, and **Japan** to develop a six-generation fighter aircraft by 2035. The **U.K.** and **Italy** will merge their **Tempest** fighter program with **Japan's Mitsubishi F-X** project.

### 1. The U.K: The Tempest program

On July 16<sup>th</sup>, 2018, the **U.K.** publicly unveiled the **Tempest**<sup>1</sup>, a cutting-edge, sixth-generation fighter aircraft, at the Farnborough Airshow. The goal was to have this plane replace the **Royal Air Force's (RAF) Eurofighter Typhoon** by 2035. This program was spearheaded by an industrial consortium composed of **BAE Systems**, **Rolls-Royce**, and **MBDA**. Team Tempest was working with the **U.K.** Ministry of Defence (MoD) and the **RAF** to develop the future fighter jet. The British government pledged \$2.5 billion to fund the early stages of the program. Nonetheless, significant contributions from international partners were considered essential to bring money, technology, and markets to the table.

The **Tempest** was to incorporate several advanced technologies such as an AI-driven Intelligent Virtual Assistant (IVA), an augmented reality cockpit with minimal physical controls, directed-energy weapons, hypersonic weapons, manned-unmanned teaming, and the ability to operate autonomously with a human pilot onboard. Additionally, the **Tempest** will be able to share battlefield data and coordinate maneuvers with other units. Most of the aircraft's physical controls

In July 2019, the **U.K.** and **Sweden** signed a Memorandum of Understanding (MOU) under which both governments agreed to work on a joint combat air development and acquisition program.<sup>2</sup> In September 2019, **Italy** officially joined the **Tempest** program, becoming the third nation to do so. **Italy's** Secretary General of Defense, Gen. **Nicolò Falsaperna**, and Sir **Simon Bollom**, CEO of Defense Equipment & Support, signed a Declaration of Intent. The Italian involvement in the **Tempest** program was logical, as **Leonardo** was already taking part in the program. Both countries also need to find a replacement for the **Eurofighter Typhoon**, have the **F-35** as their first 5th generation fighter, and participate in manufacturing some of the critical systems of the **F-35**.<sup>3</sup>

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<sup>1</sup> Robert Valencia, "What Is The Tempest? Jet Carrying Hypersonic Missiles, Lasers Could Change Stealth Fight", Newsweek, 21 July 2018, <https://www.newsweek.com/what-tempest-aircraft-carrying-hypersonic-missiles-and-lasers-could-change-1036057>

<sup>2</sup> Andrew Chuter "Sweden to join British 'Tempest' next-gen fighter push", Defense News, 07 July 2019, <https://www.defensenews.com/global/europe/2019/07/07/sweden-to-join-british-tempest-next-gen-fighter-push/>

<sup>3</sup> David Cenciotti, "Italy Joins Tempest Becoming Third Nation To Partner On The Program To Develop A 6th Generation Fighter", The Aviationist, 10 September 2019, <https://theaviationist.com/2019/09/10/italy-joins-tempest-becoming-third-nation-to-partner-on-the-program-to-develop-a-6th-generation-fighter/>

In July 2020, new suppliers were recruited to join the development of the **Tempest**. These included **Bombardier** in Northern Ireland, **GKN**, **Martin Baker**, and **Qinetiq**, alongside **Collins Aerospace**, **GE Aviation**, and **Thales**. The Swedish company **Saab** revealed it was setting up a hub in the **U.K** to potentially participate in future combat air systems work between the two nations.<sup>4</sup>

In December 2020, Italian Minister of Defense **Lorenzo Guerini**, British Secretary of State for Defence **Ben Wallace**, and Swedish Minister for Defence **Peter Hultkvist** signed a trilateral Future Combat Air System Cooperation Memorandum covering cooperation for research, development and joint conception of the **Tempest**. Under this MoU, all signatory countries will have equal participation in the development activities related to **Tempest**.<sup>5</sup>

**Leonardo**'s role was to develop a new radar technology called the Multi-Function Radar Frequency System. **BAE Systems**' role was to work on the "wearable cockpit" concept in which Augmented and Virtual Reality (VR) systems replace physical controls. The cockpit controls would be projected inside the pilot's helmet and completely customizable according to the pilot's preference and mission's needs. **MBDA UK** was charged with integrating information about weapons systems and operations in the wearable cockpit concept. **Rolls-Royce** was to develop the advanced combustion system technology that would power the **Tempest**.

## 2. Japan: The Mitsubishi F-X program

After the **United States (U.S.)** banned exports of the **Lockheed Martin F-22 Raptor** with the 1997 Obey Amendment over concerns that its advanced systems could eventually wind up in the hands of potential adversaries, **Japan** started looking into domestically developing a fighter. With the increase of advanced fighter deployments from **China** and **Russia**, **Japan** needed to develop a high-performance fighter to maintain its defensive edge. Between 2009 and 2010, **Japan**'s Ministry of Defense started conducting studies on developing a new fighter jet that would be a generation ahead of contemporary fifth-generation fighters to replace the **Mitsubishi F-2**.

In 2009, **Japan** started developing the **ATD-X** prototype, which then led to the development of the **Mitsubishi X-2 Shinshin**<sup>6</sup> experimental aircraft. This plane was to test advanced stealth fighter aircraft and sixth-generation technologies. The test phase took place between 2016 and 2018. By 2018, **Japan** had successfully achieved its primary objectives and gathered sufficient data from flight tests to evaluate the maturity of the demonstrated technologies. This program was a significant milestone in **Japan**'s defense strategy as it helped

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<sup>4</sup> "Andrew Chuter, *British next-generation fighter program taps new suppliers*", Defense News, 20 July 2020, <https://www.defensenews.com/global/europe/2020/07/20/british-next-generation-fighter-program-taps-new-suppliers/>

<sup>5</sup> Stefano D'Urso, "Italy, United Kingdom And Sweden Sign Tempest FCAS Cooperation Memorandum Of Understanding", The Aviationist, 05 January 2021, <https://theaviationist.com/2021/01/05/italy-united-kingdom-and-sweden-sign-tempest-fcas-cooperation-memorandum-of-understanding/>

<sup>6</sup> "Mitsubishi X-2 Shinshin", Wikipedia, [https://en.wikipedia.org/wiki/Mitsubishi\\_X-2\\_Shinshin](https://en.wikipedia.org/wiki/Mitsubishi_X-2_Shinshin)

the country gain valuable technological advancements. It, therefore, laid the foundation for the development of **Japan's** next-generation fighter aircraft.

In 2018, the Japanese government was still deciding whether to develop its future Fighter domestically or based on an existing fighter design. It sought offers from **Boeing**, **Northrop Grumman**, **Lockheed Martin**, and **BAE Systems** about possible cooperation in its stealth fighter project.<sup>7</sup> The country was seeking to share development costs and access advanced technology while ensuring key components, such as avionics and engines, are developed domestically by Japanese companies. **Lockheed Martin** proposed a hybrid design based on its **F-22** and **F-35** jets.<sup>8</sup> **Northrop Grumman** responded to **Japan's** request for information and held preliminary talks but did not make specific proposals.

In 2010, **Japan's** Ministry of Defense also launched a conceptual next-generation jet fighter program to replace the **Mitsubishi F-2**. The **i3 Fighter**<sup>9</sup> (Informed, Intelligent, Instantaneous) was envisioned to be a generation ahead of the existing fifth-generation fighters. It would have been equipped with advanced stealth capabilities, a high-power radar system to counter enemy stealth capabilities, the ability to receive targeting data from other platforms like drones and AWACS, fly-by-optics for faster data processing, and directed energy weapons like lasers and high-power microwaves for missile defense. By 2018, a prototype of the High-Power Slim Engine (IHI XF9-1) was developed, and by 2019, the Ministry of Defense had included budget allocations. The **i3 Fighter** remained a conceptual project, but it significantly influenced the development of the **F-X** program.

In April 2020, the next-generation fighter program was officially launched as the **F-X** program. **Japan's** Defense Ministry selected **Mitsubishi Heavy Industries (MHI)** as the main contractor for its sixth-generation stealth fighter set to replace the **Mitsubishi F-2** by the mid-2030s. This long-range Fighter was to be **Japan's** first domestically developed jet design in nearly a half-century, following the **Mitsubishi F-1** fighter, which first flew in 1975.

The twin-engine **F-X** was designed for air superiority and was to integrate advanced technologies. These would have included remote drone control capabilities, a VR-style helmet-mounted display, advanced sensors like Active Electronically Scanned Array (AESA) radar, passive radio frequency sensors, integrated self-defense systems against missiles and other aerial threats, and microwave weapons for missile disruption.<sup>10</sup> It would have had stealth

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<sup>7</sup> Tim Kelly and Nobuhiro Kubo, "Exclusive: Northrop Grumman angles for role in Japanese stealth fighter programme – sources", Reuters, 06 July 2018, <https://www.reuters.com/article/us-japan-defence-northrop-grumman-exclus/exclusive-northrop-grumman-angles-for-role-in-japanese-stealth-fighter-program-sources-idUSKBN1JW0YU/>

<sup>8</sup> Tim Kelly and Nobuhiro Kubo, "Exclusive: Lockheed Martin to propose stealthy hybrid of F-22 and F-35 for Japan – sources", Reuters, 20 April 2018, <https://www.reuters.com/article/us-japan-defence-lockheed-exclusive/exclusive-lockheed-martin-to-propose-stealthy-hybrid-of-f-22-and-f-35-for-japan-sources-idUSKBN1HR0MM/>

<sup>9</sup> i3 fighter, Wikipedia, [https://en.wikipedia.org/wiki/I3\\_fighter](https://en.wikipedia.org/wiki/I3_fighter)

<sup>10</sup> "Japan selects Mitsubishi Heavy Industries as main contractor to develop new stealth fighter", Defense Here, 31 October 2020, <https://www.defensehere.com/en/japan-selects-mitsubishi-heavy-industries-as-main-contractor-to-develop-new-stealth-fighter>

elements such as serpentine air ducts, carbon-based radar absorbers, and network capabilities. Its internally stowed weapons would have included six air-to-ground and anti-ship missiles.<sup>11</sup>

The timeline was to finalize the core design by March 2021, produce a prototype by 2024, and start serial production by 2031, with deliveries to the **Japan Air Self-Defense Force (JASDF)** expected around 2035. The **JASDF** goal was to procure around 90 **F-X** fighters.

In December 2020, **Japan's** Ministry of Defense announced that American defense company **Lockheed Martin**, which has extensive experience with fifth-generation fighters like the **F-22** and **F-35**, would be assisting **MHI** in the **F-X** fighter aircraft. The company has expertise in mission systems integration, performance, stealth capabilities, and detailed design through computer simulation.<sup>12</sup>

The program had an estimated cost of \$48 billion, and **Japan** was willing to pay the over a half billion dollars for each of its 90 **F-Xs** jets rather than purchasing two or three times as many **F-35s**. For fiscal year 2021, **Japan** has allocated ¥57.6 billion (approximately over \$550 million) for the **F-X** program. This program would have the ability to transform **Japan** into a first-rate military aerospace power that is no longer as dependent on **U.S.** companies and export policy. The **F-X** would have been a generation ahead of the **F-35** and rival Chinese and Russian stealth fighters.

### 3. Timeline to the merger

In March 2017, the **U.K.** and **Japan** agreed to jointly explore the feasibility of potentially co-developing an advanced new fighter jet and sharing aviation technologies. At the time, **Japan** decided to keep the right to continue discussions with other countries regarding future fighter jet co-development projects. Both countries also decided to continue working together to develop a new ramjet-powered, beyond-visual-range air-to-air missile.<sup>13</sup>

In December 2021, **Japan** decided to collaborate with the **U.K.** to jointly develop a jet engine demonstrator for both the **Tempest** and **F-X** programs. This project was to be led by **MHI** and **IHI** from **Japan**, as well as **Rolls-Royce** and **BAE Systems** from the **U.K.**<sup>14</sup>

In July 2022, it was revealed that the **U.K.** and **Japan** were nearing an agreement to merge their **Tempest** and **F-X** programs into a joint project. In December 2022, the heads of

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<sup>11</sup> Sebastien Roblin, "Japan Plans To Spend \$48 Billion To Field F-X Stealth Fighters By 2035 That Would Outperform F-35 And Chinese Fighters", Forbes, 15 December 2020, <https://www.forbes.com/sites/sebastienroblin/2020/12/15/japans-mitsubishi-to-deploy-48-billion-f-x-stealth-fighters-by-2035-with-boost-from-lockheed/>

<sup>12</sup> "Japan selects Lockheed Martin to support MHI in developing next-generation fighter aircraft", Janes, 18 December 2020, <https://www.janes.com/osint-insights/defence-news/japan-selects-lockheed-martin-to-support-mhi-in-developing-next-generation-fighter-aircraft>

<sup>13</sup> Franz-Stefan Gady, "Japan and UK to Collaborate on Advanced Stealth Fighter Jet", The Diplomat, 28 March 2017, <https://thediplomat.com/2017/03/japan-and-uk-to-collaborate-on-advanced-stealth-fighter-jet/>

<sup>14</sup> "UK and Japan to work together on future fighter jet engine demonstrator", Leonardo, 22 December 2021, <https://uk.leonardo.com/en/news-and-stories-detail/-/detail/uk-japan-future-fighter-jet-engine-demonstrator>

government of the **U.K.**, **Italy**, and **Japan** (**Rishi Sunak**, **Giorgia Meloni**, and **Fumio Kishida**) formally announced a groundbreaking partnership to jointly develop a next-generation fighter jet under the **Global Combat Air Programme (GCAP)**. The **GCAP** project will merge **Japan's F-X** and the **U.K.'s Tempest** programs. The six-generation stealth fighter is intended to replace **Japan's aging F-2** fleet and the **Eurofighter Typhoon** fleets in the **U.K.** and **Italy**.<sup>15</sup> The start of the development phase was scheduled for 2024, the flight of the first demonstrator for 2027, and the deployment by 2035. The jet is envisioned to be a multi-role fighter designed to surpass the capabilities of current models like the **F-35** and the **Eurofighter**. It will feature advanced sensors and networking capabilities for coordinated operations with drones and various other cutting-edge technologies. This common platform will have minor variations to meet each country's specific needs.

Under this new partnership, **MHI** will collaborate with **BAE Systems** and **Leonardo** to develop the fighter jet. The engine will be jointly developed by **IHI**, **Rolls-Royce**, and **Italy's Avio Aero**, while avionics will be a cooperative effort between **Mitsubishi Electric**, **Leonardo U.K.**, and **Leonardo Italy**. This collaboration aims to reduce production costs by increasing volumes, making the project more economically viable.

This trilateral collaboration marks a significant shift in **Japan's** defense strategy as it expands its defense cooperation beyond its traditional ally, the **United States**. This is driven by regional security challenges and the need to counter **China** and **North Korea**. Japan is expanding its defense spending and military partnerships across Southeast Asia, the Indo-Pacific, and Europe. It also marks the first time that **Japan** has participated in a multinational organization that jointly develops new military equipment. This historic merger is also a strategic effort to share development costs and deepen defense ties between the two nations. It has the potential to significantly reshape the defense landscape in Europe and Asia.

In September 2023, the **U.K.**, **Italy**, and **Japan** signed a trilateral collaboration agreement to support the long-term arrangements and requirements of the **GCAP**. The countries agreed to create a joint body called the **GCAP International Government Organization (GIGO)**, which will manage the private-sector joint venture and oversee the aircraft's development. It will centralize the management of development and production plans, improving efficiency and consolidating work among the individual countries involved. This organization is to be headquartered in the **U.K.**, headed by a Japanese official, and the joint venture was to be led by an Italian representative.<sup>16</sup>

This trilateral collaboration was dependent on **Japan** easing its postwar ban on exporting jointly developed lethal weapons to third countries. Under the postwar pacifist

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<sup>15</sup> Mari Yamguchi, "Japan to jointly develop new fighter jet with UK, Italy", Associated Press, 09 December 2022 <https://apnews.com/article/business-japan-united-kingdom-government-states-219e0adadd5f14b115766141cd0c5f6f>

<sup>16</sup> Mari Yamguchi, "Japan, UK and Italy formally establish a joint body to develop a new advanced fighter jet", Associated Press, 14 December 2023, <https://apnews.com/article/japan-uk-italy-fighter-jet-signing-military-52b2f50ba62e0b6580c3fbc78108fd66>



Constitution, the country cannot sell a jointly developed fighter jet. The Japanese government discussed the possibility of easing military sales and relaxing restrictions on transferring licensed technology and equipment. In March 2024, the Japanese government agreed to relax the rules concerning defense export, allowing the export of jointly developed fighter jets to other countries.

In June 2024, **Japan's House of Councilors**, the upper chamber of the Diet, approved the international treaty to establish the **GIGO**. The ruling **Liberal Democratic Party**, its coalition partner **Komeito**, and the main opposition **Constitutional Democratic Party of Japan** all backed the treaty. The **House of Representatives** had approved the treaty the previous month.

Discussions on the distribution of the workshare and financial investment are also still ongoing. The proposals suggest either an equal distribution of costs or a 40/40/20 split among the **U.K.**, **Japan**, and **Italy**. Negotiations have been delayed due to the ongoing discussions around intellectual property ownership and workshare distribution. In September 2023, **Italy** had committed to funding its share of the **GCAP** for 15 years. The **U.K.** Ministry of Defence had also emphasized a flexible approach to budgeting that would evolve depending on each country's industrial capabilities rather than rigid early-stage divisions.<sup>17</sup>

The program remains open to the possibility of accommodating new partners to share the costs of development. Nonetheless, the possible expansion would need to be managed carefully to avoid delays in the program's ambitious timeline. In March 2023, **Andrew Howard**, **Leonardo U.K.**'s Director of **GCAP**, acknowledged that **Sweden** had partnered with the **U.K.** to develop the **Tempest** but was no longer considered a central part of the **GCAP** program. It emerged that **Sweden**'s vision did not quite line up with what the other countries wanted. It seems, therefore, increasingly unlikely that **Sweden** will join the **GCAP** program.<sup>18</sup>

In March 2024, **Leonardo's** CEO, **Roberto Cingolani**, criticized the **U.K.** for the lack of transparency regarding the **GCAP's** broader system procurement and each company's responsibilities. In July 2024, The CEO of **Leonardo** also expressed interest in **Saudi Arabia** joining the **GCAP** in case the new **Labour** government in the **U.K.** reduces its commitment following its defense spending review<sup>19</sup>. **Rolls-Royce's** CEO, **Tufan Erginbilgic**, emphasized the strategic importance of **GCAP** amid the ongoing defense review.

In July 2024, at the Farnborough Airshow, representatives from **BAE Systems**, **Leonardo**, and **MHI** unveiled the stealth fighter concept for the **GCAP**. The updated design features a large triangular wingspan for enhanced aerodynamics, speed, and payload capacity. The goal is to create a versatile fighter jet capable of both air-to-air and surface-attack missions.

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<sup>17</sup> Paul Sandle, "Italy committed to fund fighter jet programme with UK, Japan", Reuters, 13 September 2023, <https://www.reuters.com/world/italy-committed-fund-fighter-jet-programme-with-uk-japan-2023-09-13/>

<sup>18</sup> Andrew White, "Sweden Joining UK-Japan-Italy Fighter Effort Seen as Unlikely by Industry Partners", Breaking Defense, 22 March 2023, <https://breakingdefense.com/2023/03/sweden-joining-uk-japan-italy-fighter-effort-seen-as-unlikely-by-industry-partners/>

<sup>19</sup> "Leonardo chief 'open to' Saudi role in fighter jet project if UK cuts support", Financial Times, 25 July 2024, <https://www.ft.com/content/237c8be9-7c29-4977-aa77-d287a7929d16>

Nonetheless, the design suggests a focus on long-range missions, stealth, and advanced weaponry rather than close-range dogfighting. The Fighter will integrate domestically produced weapons, adaptive cycle engines, Artificial Intelligence, and sophisticated datalinks. A flying demonstrator is set to debut in 2027, with testing supported by a converted **Boeing 757-200**.

## II. RUSSIA: THE PAK DP / MiG-41 PROGRAM

**Russia** also has an ambitious project to develop a sixth-generation fighter jet that promises to revolutionize aerial combat by the early 2030s. **Russia's** vast airspace demands advanced defense capabilities, and the **MiG-31 Foxhound** has been the cornerstone of the country's air interception efforts since the Cold War. This fourth-generation plane capable of reaching Mach 2.83 was introduced in 1975 and has not been in production since 1994. Despite continuous upgrades to extend its service life into the 2030s, the fleet is aging. The **MiG-41**, also known as the **PAK DP**, is envisioned as a replacement for the **MiG-31 Foxhound**. It is still conceptual but promises to outperform today's most advanced warplanes, including the American **F-22 Raptor** and the Russian **Su-57**.<sup>20</sup> PAK stands for "Perspektivny aviatsionny kompleks" or Prospective air complex, and D.P. stands for "Perspektivny aviatsionny kompleks dal'nego perekhvata" or Prospective air complex for long-range interception.<sup>21</sup>

The primary role of the **MiG-41** would be as an interceptor and to counter threats, such as hypersonic missiles and advanced reconnaissance aircraft. It would be one of the most advanced aircraft due to its revolutionary features. According to **Ilya Tarasenko**, General Director of **MiG Corporation**, it would have the ability to exceed Mach 4 speeds, making it potentially the fastest military aircraft in the world. The **MiG-41** is also expected to operate at near-space altitudes, allowing it to intercept various aerial threats, including bombers, cruise missiles, and drones. It will also be capable of performing combat missions in the Arctic. According to **Viktor Bondarev**, former commanders-in-chief of the Russian Aerospace Forces, the **MiG-41** will have a range of 700 to 1,500 km. It would also be equipped with an anti-missile laser and advanced features like internal weapons bays for improved stealth. It might be equipped with **R-37M** missiles and anti-satellite weaponry. The **MiG-41** might also be equipped with an electromagnetic pulse (EMP) gun, which could drastically expand the range and effectiveness of its targeting capabilities. It is expected to use the **Saturn AL-51** engine currently in development for improved variants of the **Sukhoi Su-57** and the **Sukhoi Su-75 Checkmate** fifth-generation fighter. The new engine will offer a 19% higher thrust-to-weight ratio than its predecessor and a reduced radar signature.

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<sup>20</sup> David Anderson, "Russia's MiG-41 PAK-DP: A Game Changer in Aviation Technology", Military News, 01 April 2024, <https://military.news/russia-s-mig-41-pak-dp-a-game-changer-in-aviation-technology/>

<sup>21</sup> Joseph P Chacko "What We Know About Russian PAK-DP MiG-41 Sixth Generation Fighter", Frontier India, 01 September 2022, <https://frontierindia.com/what-we-know-about-russian-pak-dp-mig-41-sixth-generation-fighter/>

The **MiG-41 PAK DP** program started in early 2014, with an expected service introduction by 2028. The aircraft design bureau, **Mikoyan Gurevich**, is in charge of the development. It has built many famous military aircraft since the 1940s, such as the **MiG-15**, **MiG-21**, **MiG-29**, **MiG-25**, and **MiG-31**. In 2018, **Russia's United Aircraft Building Corporation (UAC)** transferred documents to the Ministry of Defense on the PAK DP project, and by 2019, the **MiG-41 PAK DP** design was finalized.

The **MiG-41's** proposed capabilities seem impressive and ambitious as they could redefine air combat. Nonetheless, they present significant technical challenges.<sup>22</sup> There is skepticism about the possibility of **Russia** bringing this ambitious vision to life. Sustaining supersonic flight at Mach 4 requires enormous amounts of fuel, and extreme heat is generated at such high speeds. It would necessitate developing new materials that can withstand the temperature while maintaining stealth capabilities. Some proposed technologies, such as the pulse-detonation engine and the EMP gun, are also still largely theoretical. The development of these innovations remains experimental and unproven. **Russia** has economic difficulties on top of such technical difficulties. The country faces economic sanctions and is also engaged in an armed conflict in **Ukraine**. There is doubt about **Russia** being able to allocate sufficient resources to bring the **MiG-41** to completion. **Russia** also has a history of setting ambitious timelines that are not respected. It has struggled with mass production for military projects like the **MiG-35**, the fifth-generation **Su-57** jet fighter. The claims of a test flight in 2025 and full operational status by the 2030s remain highly optimistic due to the current state of **Russia's** defense industry. As **Russia** progresses with its development, the world will be watching to see if the **MiG-41** can meet its ambitious timelines and emerge as a game-changer in global military aviation by the early 2030s or if it will remain an unrealized dream in the history of military technology.

### III. EUROPE: THE FUTURE COMBAT AIR SYSTEM (FCAS) PROGRAM

The **FCAS** is an ambitious European defense initiative designed to secure and enhance autonomy and sovereignty in military capabilities in the air domain. It is a multinational effort involving **France**, **Germany**, and **Spain**, with major industrial players such as Dassault Aviation, Airbus, and Indra Sistemas leading its development. The **FACS** is expected to bolster Europe's technology and industry leader position.

The **FCAS** is a system of systems (SoS) aimed at revolutionizing air combat by 2040. It will integrate manned and unmanned airborne systems for offensive and defensive operations. The **FCAS** is centered around the **Next Generation Weapon System (NGWS)**, which will include the **New Generation Fighter (NGF)** and unmanned systems such as drones.

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<sup>22</sup> Air Marshal Anil Chopra, "Russia Pushes 'Aviation Boundaries' With MiG-41 PAK DP 6th-Gen Fighters; Can It Really Fly By Early 2030s?", Eurasian Times, 01 April 2024, <https://www.eurasiantimes.com/russia-pushes-aviation-boundaries-with-mig/>

These unmanned systems are expected to have a high degree of autonomy while remaining nonetheless under the control of human pilots. All these components will be interconnected through a comprehensive, collaborative data network known as the Combat Cloud. It will enable real-time communication and data sharing across all connected air, land, sea, and space platforms. The **FCAS** individual components are expected to be rolled out gradually. The first-generation loyal wingman (unmanned drones) are expected to be developed sooner and enter into service in the 2030s to complement existing fighter jet fleets.

The **NGF** will be a six-generation fighter that is set to replace the current fleets of combat aircraft in France, **Germany**, and **Spain**, which include the **Rafale (France)**, **Eurofighter Typhoon (Germany)**, and **F-18 Hornet (Spain)**. This transition will mark a significant leap in air combat capabilities for the air forces of these countries.

## 1. Launch of the program

The **FCAS** program was launched in July 2017 when French President **Emmanuel Macron** and then-German Chancellor **Angela Merkel** agreed to study the possibility of jointly developing a new fighter jet to replace the **Rafale** and the **Eurofighter Typhoon**.<sup>23</sup> Both countries agreed to come up with a roadmap by mid-2018 to develop this next-generation fighter.

In April 2018, **Dirk Hoke**, **Airbus Defence and Space** Chief Executive Officer (CEO), and **Eric Trappier**, Chairman and CEO of **Dassault Aviation**, signed a landmark partnership to develop and produce the **FCAS** jointly. Both companies were already cooperating on Europe's medium altitude long endurance new generation drone program. Both companies agreed to launch an initial joint study the same year and to work together on a joint roadmap that would include proposals to develop demonstrators for the **FCAS** program by 2025.<sup>24</sup>

In November 2018, **Dirk Hoke** noted that the company welcomed the agreed study if there were "*clearly defined responsibilities*" but also warned that France that demanding too big of a share of the program could prevent approval by the German parliament,

## 2. Spain joining

In December 2018, **Spain's** Minister of Defence, **Margarita Robles**, informed her French and German counterparts, **Florence Parly** and **Ursula von der Leyen**, by letter that her country was willing to take part in the **FCAS** program. She also requests that **Spain's** incorporation be made official by signing a tripartite Letter of Intent (LOI) or Memorandum of

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<sup>23</sup> Pierre Tran, "France and Germany Agree to Jointly Build New Generation Fighter Jet", Defense News, 14 July 2017, <https://www.defensenews.com/air/2017/07/14/france-and-germany-agree-to-jointly-build-new-generation-fighter-jet/>

<sup>24</sup> "Airbus and Dassault Aviation join forces on Future Combat Air System". 25 April 2018, <https://www.airbus.com/en/newsroom/press-releases/2018-04-airbus-and-dassault-aviation-join-forces-on-future-combat-air>

Understanding (MOU).<sup>25</sup> **Spain** joined the program in February 2019 with the signing of a letter of intent (LOI) between the Spanish Defence Minister, the French Defence Minister, and the German Defence Minister.<sup>26</sup> **Spain**'s initial contribution to the project was to be about €25 million over the first two years. In February 2019, **France** and **Germany** also awarded **Dassault Aviation** and **Airbus** a contract to conduct a Joint Concept Study (JCS) for the **FCAS**. The two-year study focused on identifying critical components for the **NGF**, the unmanned systems, and the overall **FCAS** architecture.

In June 2019, during the Paris Air Show at Le Bourget Airport, **Dassault Aviation** and **Airbus** delivered a joint industrial proposal to the governments of **France** and **Germany**.<sup>27</sup> It marked the beginning of the first Demonstrator Phase of the **FCAS** program that was to run until 2021. This phase aimed to develop, test, and refine the advanced technology and prototypes needed for the **NGF**. In this proposal, **Dassault Aviation** was the prime contractor for the **NGF**, and Airbus was to lead the development of the unmanned drones and Combat Cloud. The timeframe was for these systems to be operational by 2026. Other defense companies were also involved in this **FCAS** proposal. **MBDA Systems** and **Thales** were in charge of missile systems and electronic warfare, while **Safran** and **MTU Aero Engines** were responsible for developing a new engine for the **NGF**. The French and German governments are expected to invest an initial €4 billion in the combat jet by 2025.

During the Paris Air Show, mockups of the **NGF** and associated unmanned systems were revealed during a ceremony led by **Dassault Aviation** Chairman and CEO **Eric Trappier** and Airbus Defence and Space CEO **Dirk Hoke**. This ceremony was held in the presence of French President **Emmanuel Macron**, French Minister of the Armed Forces **Florence Parly**, German Federal Minister of Defence **Ursula Von Der Leyen**, and Spanish Minister of Defence **Margarita Robles**.<sup>28</sup> During this ceremony, **Spain** was officially welcomed in the **FCAS** development program.

In February 2020, Spanish Secretary of State for Defense, **Ángel Olivares**, and her French and German counterparts, **Joël Barre** and **Benedikt Zimmer**, signed an implementation agreement that would lay the roadmap for the full integration of **Spain** and its industry in the development of the Joint Concept Study of the **FCAS**.

In February 2020, **France** and **Germany** also launched the **FCAS** demonstrator phase by awarding an 18-month Phase 1A framework contract to **Dassault Aviation**, **Airbus**, **MTU Aero Engines**, **Safran**, **MBDA**, and **Thales**. This contract focused on developing

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<sup>25</sup> "España insta su participación como socio de pleno derecho en el futuro caza europeo", Spanish Ministry of Defence, 03 December 2018, <https://www-defensa-gob-es.translate.goog/gabinete/notasPrensa/2018/12/DGC-181203-caza-europeo-ngws.html? x tr sl=es& x tr tl=en& x tr hl=en-US>

<sup>26</sup> AFP, "Spain Joins France, Germany New Combat Fighter", France 24, 11 February 2019, <https://www.france24.com/en/20190211-spain-joins-france-germany-new-combat-fighter>

<sup>27</sup> "Industrial agreement, offers delivered to France and Germany: Dassault Aviation and Airbus achieve next decisive milestone for Future Combat Air System programme", Airbus, 17 June 2019, <https://www.airbus.com/sites/g/files/jlcbta136/files/9c80e4bb19abc011cb8b9ab6fcaee56e-EN-Press-Release-Airbus-Dassault-Aviation-FCAS-Industrial-Agreement.pdf>

<sup>28</sup> Jon Harper, "PARIS AIR SHOW NEWS: Europeans Move Forward with 'Sixth-Generation' Fighter", National Defense Magazine, 17 June 2019, <https://www.nationaldefensemagazine.org/articles/2019/6/17/europeans-moving-forward-with-development-of-sixthgeneration-fighter>

demonstrators and advancing key technologies, with flight tests scheduled for 2026. **Dassault** led the development of the **NGF** alongside **Airbus**. **Safran Aircraft Engines**, alongside **MTU Aero Engines**, focused on engine development. Airbus handled Remote Carrier and Combat Cloud technologies with **SATNUS** (a consortium of **GMV**, **SENER Aeroespacial**, and **TECNOBIT**), **Indra**, and **Thales** as partners. **Spain**'s defense industry, with **Indra Sistemas** as the national coordinator, was fully integrated into the project during this phase. **Indra Sistemas** focused on the development of the sensors with support from **Thales** and **FCMS**.<sup>29</sup>

In November 2020, **Indra Sistemas**, in partnership with **FCMS** from **Germany** and **Thales** from **France**, was charged with designing and developing advanced sensor systems for the **FCAS**. The sensors were to be integrated into the **FCAS** network and to be crucial in enhancing situational awareness, survivability, and information-gathering capabilities.

In December 2020, an initial framework contract was signed in order for **Spain** to become an equal partner alongside **France** and **Germany** across all activities relating to the **FCAS**. This was the completion of a 10-month-long process to “onboard” **Spain** into the program in both the ongoing Phase 1A demonstration and the joint concept study phases.<sup>30</sup>

On August 30th, 2021, French Defense Minister **Florence Parly**, German Defense Minister **Annegret Kramp-Karrenbauer**, and Spanish Defense Secretary **Esperanza Casteleiro Llamazares** met to sign the third implementation agreement of the **FCAS** program, which outlined the activities planned for the period from 2021 to 2027.

In December 2022, **Airbus** and **Dassault Aviation** reached an industrial agreement concerning the development of the **NGF**<sup>31</sup>. The agreement resolved intellectual property rights and the division of work responsibilities. **Dassault Aviation** sought guarantees for its intellectual property, and Airbus pushed for a more equal distribution of tasks. **Dassault Aviation**'s Chairman and CEO, **Eric Trappier**, expressed satisfaction that the long-standing impasse had been resolved and confirmed that the necessary guarantees had been secured. **Dassault Aviation** was confirmed as the prime contractor and architect of the **NGF**, securing protection for its industrial know-how and technologies. According to **Mike Schoellhorn**, CEO of **Airbus Defence and Space**, this deal was a major step forward for the **FCAS** program and would allow it to move forward into the next phase, which will involve preliminary studies and further development.

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<sup>29</sup> “*FCAS Phase 1A framework contract awarded*”, The Shephard News, 13 February 2020, <https://www.shephardmedia.com/news/air-warfare/fcas-phase-1a-framework-contract-awarded/>

<sup>30</sup> David Donald, “*Spain Now Fully Onboarded FCAS Program*”, AIN Online, 10 December 2020, <https://www.ainonline.com/aviation-news/defense/2020-12-10/spain-now-fully-onboarded-fcas-program>

<sup>31</sup> Tassilo Hummel and Christina Amann, “*Airbus, Dassault reach deal on FCAS jet programme*”, Reuters, 01 December 2022, <https://www.reuters.com/business/aerospace-defense/companies-have-reached-deal-fcas-jet-programme-says-dassault-aviation-head-2022-12-01/>

### 3. Phase 1B

Building on the success of Phase 1A, on December 20th, 2022, the governments of **France, Germany, and Spain** issued a contract for Phase 1B to **Dassault Aviation, Airbus, Indra Sistemas, Eumet**, and their industrial partners. This €3.2 billion contract was awarded by the French General Directorate for Armament (**DGA**), the French government's defense procurement and technology agency, on behalf of the governments of the three countries. It was to span three and a half years and focus on the continued development of the **FCAS** demonstrator and its components. This phase will run until 2028 with a budget of approximately €8 billion. Phase 1B will focus on conducting demonstrations of the various systems and technologies involved in the development of the **FCAS**. Under the new contract signed by the defense ministers, each country contributes 33% of the funding and receives an equivalent share of the work.

In **Spain, Indra Sistemas** received a €600 million contract to lead the Sensors pillar in collaboration with the French group **Thales** and the German **FCMS** consortium.<sup>32</sup> The development of the **NGF** was spearheaded by **Dassault Aviation** for **France**, with the collaboration of **Airbus** in **Germany** and **Spain**. The **NGF** engine's development was under the responsibility of the Eumet joint venture (comprised of **Safran Aircraft Engines** for **France** and **MTU Aero Engines** for **Germany**), which collaborated with **ITP Aero** in **Spain**. The Combat Cloud is overseen by **Airbus** for **Germany**, with **Thales** for **France** and **Indra Sistemas** for **Spain** as main partners. The Enhanced Low Observability part was under the responsibility of **Airbus** for **Spain**, with **Dassault Aviation** for **France** and **Airbus** for **Germany**. In April 2023, the defense ministers of **Spain, France, and Germany** gathered at the **Spanish Air and Space Force** headquarters in Madrid for the official launch of Phase 1B of the **FCAS**.<sup>33</sup>

In March 2023, in collaboration with **FCMS** and **Thales, Indra Sistemas** initiated the next design phase of the networked and distributed sensors suite for the **FCAS**. This innovative system, known as **NSDAS**, integrates advanced sensor technologies, defensive aids, and attack systems to enhance operational capabilities. The goal is to significantly improve sensor performance, situational awareness, firepower, and survivability of the **NGF** and Remote Carriers. Phase 1B will focus on ambitious technological advancements and the consolidation of the sensor suite's architecture.<sup>34</sup>

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<sup>32</sup> “*Indra firma un contrato de 600 millones en la nueva fase del FCAS y creará 1.000 empleos*”, Forbes, 15 December 2022, <https://forbes.es/ultima-hora/208702/indra-firma-un-contrato-de-600-millones-en-la-nueva-fase-del-fcas-y-creara-1-000-empleos/>

<sup>33</sup> “*BOOSTING THE FCAS*”, Revista Española de Defensa, July 2023 <https://www.defensa.gob.es/Galerias/gabinete/red/2023/red-ingles/red-13/p-52-53-red-13-eng-fcas.pdf#:~:text=During%20the%20programme%20presentation%20event,%20the%20Spanish%20Minister%20of%20Defence,>

<sup>34</sup> “*Indra together with FCMS and Thales kick off next design phase of the networked suite of sensors contributing to superiority of next generation weapon system (NGWS)*”, Indra, 28 March 2023, <https://www.indracompany.com/en/noticia/indra-together-fcms-thales-kick-next-design-phase-networked-suite-sensors-contributing>

#### 4. Belgium joining the program

In June 2023, **Belgium** decided to become an observer country in the **FCAS** program alongside **France**, **Germany**, and **Spain**. In November 2023, Belgian Defense Minister **Ludivine Dedonder** revealed that by June 2025, the country would be joining as the fourth partner nation<sup>35</sup>. In April 2024, the Belgian government, acting on a recommendation from its Defense Minister, formally agreed to become an observer nation. This observer status allows **Belgium** to assess the program's impact on its defense industry while exploring opportunities for deeper involvement in the future. The country will also benefit from years of research and technological advancements with both military and civilian applications. Under the observer status, the country cannot yet take part in the decision-making process, but it will know enough about the program to prepare for further collaboration. **Belgium** has committed to contribute up to €60 million to the **FCAS** program. The program is expected to strengthen cooperation between the Belgian defense sector and **FCAS** partners, enhancing operational ties among the air forces of the participating countries.<sup>36</sup>

**Dassault** CEO **Eric Trappier** opposed Belgium entering the program as the country had acquired **F-35** fighters and not **Rafale** fighters when it was replacing its **F-16s**. He even said that he would fight against any future decision that would include giving Belgian companies jobs in the **FCAS** program.

## IV. THE U.S. NAVY THE F/A-XX PROGRAM

The **F/A-XX** program is the **U.S. Navy's** initiative to develop a sixth-generation fighter that will replace the **F/A-18E/F** Super Hornet and complement the **F-35C**. The **F/A-XX** is part of the **Navy's Next Generation Air Dominance (NGAD)** initiative (different from the **U.S. Air Force's**). It will incorporate advanced technologies such as supercruise, advanced stealth, directed energy weapons, networking with drones, and a range of multi-role functions such as air combat, ground attack, and electronic warfare. The **F/A-XX** aims to maintain the **U.S. Navy's** edge in future conflicts. Its primary missions could include air combat, air-to-air engagements, ground attack, surface warfare, and close air support.

The program began in 2012 when the **U.S. Navy** issued a Request for Information (RFI) for the **F/A-XX** to seek the defense industry's input on a six-generation fighter aircraft. The jet fighter was to operate from nuclear-powered aircraft carriers such as the **Nimitz** and **Ford** class and provide air supremacy with multi-role strike capabilities in anti-access/area denial environments. The primary missions would include air warfare, strike warfare, surface warfare, close air support, air-to-air refueling, reconnaissance, surveillance, target acquisition, and

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<sup>35</sup> Tim Martin, "Belgium to join Europe's FCAS next-gen fighter program in June 2025", *Breaking Defense*, 27 November 2023, <https://breakingdefense.com/2023/11/belgium-to-join-europes-fcas-program-in-june-2025/>

<sup>36</sup> The Brussels Times with Belga, "Belgium enters EU programme for 'next generation' fighter jets", *The Brussels Times*, 20 June 2023, <https://www.brusselstimes.com/562009/belgium-enters-eu-programme-for-next-generation-fighter-jets>



electronic warfare. At the time, the **Navy** was aiming for an operational capability around 2030 as the **F/A-18s** end their life span.<sup>37</sup>

In April 2013, **Boeing** unveiled a concept for the **F/A-XX** just before the **Navy League's Sea-Air-Space Exposition** in Washington. The artist's impression showed the **F/A-XX** as a tailless, twin-engine fighter with a design optimized for stealth. **Boeing**, which had received limited **U.S. Navy** funding, invested its personal resources into this **F/A-XX** concept design. The version of the **F/A-XX** was equipped with foreplanes similar to those on the **Eurofighter Typhoon**, **Dassault Rafale**, **Saab Gripen**, and **Chengdu J-20**. It also had engine nacelles on the top of the fuselage, and the engines were equipped with diverterless supersonic inlets.<sup>38</sup>

In February 2015, Chief of Naval Operations Adm. **Jonathan Greenert** discussed the potential design directions of the **F/A-XX**. He suggested that the fighter may prioritize capabilities other than stealth and speed. According to Adm. **Jonathan Greenert**, stealth may not be as crucial in future warfare as advanced aircraft will possibly be detectable by their heat and speed. He also emphasized that the **F/A-XX** might focus on overwhelming or suppressing enemy defenses with advanced payloads and new weapons systems.<sup>39</sup>

In April 2019, Rear Admiral **Scott D. Conn**, director of Air Warfare in the **Office of the Chief of Naval Operations**, announced that the Analysis of Alternatives (AoA) for the **F/A-XX** was to be completed by spring 2019 and a final report was to be published by the end of the year. The aim was to inform future budget cycles and decisions on the development of the **F/A-XX**.

In November 2021, the **U.S. Navy** released an unclassified version of the "*Navy Aviation Vision 2030-2035*,"<sup>40</sup> which outlines the future role of the **F/A-XX**. According to this document, the **F/A-XX** was expected to be a key component of the future Carrier Air Wing (CVW), which included the **F-35C** and unmanned systems like the **MQ-25 Stingray**. The **F/A-XX** was expected to feature advanced technologies such as passive and active sensor technologies and the ability to integrate with unmanned systems through Manned/Unmanned Teaming (MUM-T) to reduce risk to the manned aircraft and have increased range, speed, and survivability. The document also highlights the evolving nature of carrier-based aviation and

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<sup>37</sup> Dave Majumdar, "US Navy issues F/A-XX RfT", Flightglobal, 17 April 2012, <https://web.archive.org/web/20120427143214/http://www.flightglobal.com/blogs/the-dewline/2012/04/us-navy-issues-fa-xx-rfi.html>

<sup>38</sup> Robert F. Dorr., "Boeing Reveals Updated F/A-XX Concept", Defense Media Network, 09 April 2013, <https://www.defensemedianetwork.com/stories/boeing-reveals-updated-fa-xx-concept/>

<sup>39</sup> Sam LaGrone, "CNO Greenert: Navy's Next Fighter Might Not Need Stealth, High Speed", USNI News, 04 February 2015, <https://news.usni.org/2015/02/04/cno-greenert-navys-next-fighter-might-not-need-stealth-high-speed>

<sup>40</sup> "Navy Aviation Vision 2030-2035", Naval Air Systems Command, 2021, [https://s3.documentcloud.org/documents/21095460/navy-aviation-vision-2030-2035\\_fnl.pdf](https://s3.documentcloud.org/documents/21095460/navy-aviation-vision-2030-2035_fnl.pdf)

the fact that the **F/A-XX** is critical in maintaining the **Navy**'s edge in future conflicts. The specific design and capabilities of the **F/A-XX** were still under development at the time.<sup>41</sup>

In December 2023, the **U.S. Navy** updated the requirements for the **F/A-XX** fighter. It should be a versatile, multi-role platform suited for contested airspaces and have a sleeker design, prioritizing functionality and survivability. The aircraft will fight alongside Collaborative Combat Aircraft. It will be the “quarterback” of these AI-enabled unmanned drones. It should also integrate advanced technologies such as directed energy weapons and feature adaptive engines for efficient cruising and high-speed bursts. It will have advanced interconnectivity and maximum connectivity through real-time battlefield updates and satellite links. The **F/A-XX** will have advanced interconnectivity with other platforms and sophisticated communications and sensor systems, enabling real-time battlefield updates via satellites and other aircraft. The aircraft will feature an open-architecture design that should allow interchangeable sensors, payloads, and weapons, providing greater versatility and adaptability. The **F/A-XX** will also require supercruise capabilities, advanced stealth, and possible features like air-to-air refueling, reconnaissance, surveillance, target acquisition (RSTA), and electronic warfare.

In August 2023, the **U.S. Navy** announced that the **F/A-XX** program had recently completed the concept refinement phase and was entering the design maturation phase. The **Navy** also confirmed that **Boeing**, **Lockheed Martin**, and **Northrop Grumman** were competing for the airframe development contract. **GE Aerospace** and **Pratt & Whitney** are competing to develop the engine.<sup>42&43</sup>

In 2023, the **House Armed Service Committee** decided to cut part of the funding for the **F/A-XX** program, citing “*unjustified requirements*”. This cut was made in a classified project called **Link Plumeria**, which ranked as the Pentagon's fourth-largest research and development program. It contained **Project 2937**, which supports the **U.S. Navy**'s **F/A-XX** program. The **Navy** had requested \$2.1 billion for **Link Plumeria** in its FY2024 budget, but the **House Armed Service Committee** decided to cut \$1.1 billion in its version of the budget. In response, the White House **Office of Management and Budget (OMB)** said the proposed cut for Link Plumeria would harm the development of the **F/A-XX** fighter. In December 2023, in a revised version of the FY2024 National Defense Authorization Act (NDAA), the budget for the **F/A-XX** fighter was nearly fully restored by **Congress**. The updated version of the bill did cut \$50 million from **Project 2937**. The restoration of funding for the **F/A-XX** program

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<sup>41</sup> Stefano D'Urso, “*The U.S. Navy Has Released New Details About The F/A-XX Next Generation Strike Fighter*”, The Aviationist, 01 November 2021, <https://theaviationist.com/2021/11/01/the-u-s-navy-has-released-new-details-about-the-f-a-xx-next-generation-strike-fighter/>

<sup>42</sup> Justin Katz and Michael Marrow, “*3 US aerospace primes actively facing off for Navy's next-gen strike fighter, F/A-XX*”, Breaking Defense, 29 August 2023, <https://breakingdefense.com/2023/08/3-us-aerospace-primes-actively-facing-off-for-navys-next-gen-strike-fighter-f-a-xx/>

<sup>43</sup> Jane Edwards, “*Navy Names Vendors Competing for Next-Gen F/A-XX Fighter Aircraft Program*”, GovConWire, 28 August 2023, <https://www.govconwire.com/2023/08/navy-names-vendors-competing-for-next-gen-f-a-xx-fighter-aircraft-program/>

indicated strong congressional support for the program.<sup>44&45</sup> The **Navy** will need to provide Congress with updates on its **F/A-XX** fighter and uncrewed Collaborative Combat Aircraft program through two semiannual reports. The first report will focus on the development and testing phases, and the second report will focus on cost estimates for air vehicles, propulsion, mission systems, and software.

In July 2024, a draft Senate defense bill for the 2025 Fiscal Year threatened the future of the **F/A-XX** program. The **Senate Armed Services Committee** proposed slashing nearly 90% of the requested \$453.828 million for the program. The program's budget was reduced to just under \$54 million. The program had already seen a reduction in funding from the previous year as the **U.S. Navy** initially asked for \$1.53 billion for Fiscal Year 2024. These severe budget reductions reflect financial constraints and shifting priorities within the Pentagon. The **Navy** will be prioritizing existing platforms like the **F-35C Lightning II**.<sup>46&47</sup> According to Navy Under Secretary **Erik Raven**, "*In terms of what comes at the top of the list, it is readiness. It is people. It is the today issues that we have to get on top of*".<sup>48</sup>

**Bill LaPlante**, the Pentagon's Undersecretary of Defense for Acquisition, reaffirmed that the **F/A-XX** program to develop the **Navy's** six-generation fighter will continue despite the current uncertainties. He indicated that it is essential to have continued assessments and adaptations based on threats and budget constraints and to make the right decisions before committing to engineering and manufacturing.<sup>49</sup> **Northrop Grumman** CEO **Kathy Warden** also confirmed that the **U.S. Navy** plans to select a builder for its **F/A-XX** by 2025 and that there had been no indication of any change despite the \$1 billion reduction in funding.<sup>50</sup>

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<sup>44</sup> "Congress Restores \$1 Billion for US Navy's F/A-XX", Homeland Security Today, 14 December 2023, <https://www.hstoday.us/subject-matter-areas/maritime-security/congress-restores-1-billion-for-us-navys-f-a-xx/>

<sup>45</sup> Steve Trimble, "White House Connects Secret Code Name To Next Navy Fighter", Aviation Week, 13 July 2023, <https://aviationweek.com/defense/budget-policy-operations/white-house-connects-secret-code-name-next-navy-fighter>

<sup>46</sup> Maya Carlin, "Navy's FA-XX 6th Generation Fighter Might Get 90% Cut in Funding", The National Interest, 18 July 2024, <https://nationalinterest.org/blog/buzz/navys-fa-xx-6th-generation-fighter-might-get-90-cut-funding-211926>

<sup>47</sup> Aaron Spray, "90% Budget Cut: US Senate Defense Bill Decimates Future US Navy F/A-XX Next-Gen Fighter", Simple Flying, 17 July 2024, <https://simpleflying.com/us-senate-defense-bill-90-percent-budget-cut-us-navy-fa-xx/>

<sup>48</sup> Justin Katz, "Navy delaying next-gen F/A-XX fighter spending for near-term investments", Breaking Defense, 11 March 2024, <https://breakingdefense.com/2024/03/navy-delaying-next-gen-f-a-xx-fighter-spending-for-near-term-investments/>

<sup>49</sup> Brian Everstine, "DOD Acquisitions Boss: NGAD, F/A-XX Will Continue", Aviation Week, 23 July 2024, <https://aviationweek.com/shownews/farnborough-airshow/dod-acquisitions-boss-ngad-fa-xx-will-continue>

<sup>50</sup> Audrey Decker, "Navy Still Picking Winner for F/A-XX Next Year, Northrop CEO Says", Defense One, 25 July 2024, <https://www.defenseone.com/threats/2024/07/navy-still-picking-winner-f-xx-next-year-northrop-ceo-says/398322/>

## V. THE U.S. AIR FORCE : THE NEXT GENERATION AIR DOMINANCE (NGAD) PROGRAM

The **U.S. Air Force's (USAF) Next Generation Air Dominance (NGAD)** program aims to develop a 6th-generation aircraft to replace the aging **F-22 Raptor**. The **NGAD** will incorporate cutting-edge technology in stealth, advanced weapons systems, propulsion, and networked warfare. Its primary role will be to dominate airspace, maintaining air superiority against adversary fighters, drones, and other airborne threats. The **NGAD** fighter will be at the head of a formation of up to five uncrewed aircraft called Collaborative Combat Aircraft (CCA).

### 1. The origins of the NGAD

The **NGAD** program's origins can be traced back to **DARPA's** 2014 Air Dominance Initiative study, which aimed to develop the next air superiority fighter for the 2030s. **DARPA** concluded that no single platform could dominate future air battles.

In 2015, the Pentagon acquisition chief **Frank Kendall** unveiled the strategy for developing a next-generation fighter for the **Air Force** and **Navy** through the **Aerospace Innovation Initiative (AII)**. **DARPA** was to lead the **AII** in developing prototypes for new air dominance platforms, referred to as X-plane programs. Under this program, two separate aircraft would be developed, but they would have shared common parts to meet the needs of the Navy's **F/A-18** replacement and the **Air Force's F-22** replacement.<sup>51</sup>

In 2016, the **U.S. Air Force** released its Air Superiority 2030 study, which proposed replacing traditional fighter jets with a family of systems integrated across multiple platforms. Instead of a single sixth-generation fighter, the **Air Force** considered developing a system combining long-range strike capabilities, cyber and space assets, and autonomous technologies. In 2018, it evolved into the **NGAD** program as we know it today. The focus was to develop a fighter by 2025, prioritizing speed, maneuverability, payload, range, and the right level of stealth.

### 2. Flight testing

In September 2020, Dr. **Will Roper**, Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, announced during the **Air Force Association's Air, Space & Cyber Conference** that an undisclosed demonstrator for the **NGAD** program had begun flight testing.<sup>52</sup> The **NGAD** was to focus on five key technologies to enhance survivability, lethality, and persistence. Propulsion was the only confirmed technology at the time, with other possible

<sup>51</sup> Aaron Mehta, "Kendall Unveils 6th Gen Fighter Strategy", Defense News, 01 February 2015, <https://www.defensenews.com/air/2015/02/01/kendall-unveils-6th-gen-fighter-strategy/>

<sup>52</sup> Thomas Newdick, "The U.S. Air Force Has Secretly Flown A Demonstrator For Its Next-Generation Fighter", The War Zone, 15 September 2020, <https://www.twz.com/36431/the-u-s-air-force-has-flown-a-demonstrator-for-its-next-generation-fighter>

innovations being stealth, advanced weapons, and thermal management. The nature of the aircraft flown and what kind of future system was to come out of the program was still up for debate. It was not clear if the future **NGAD** fighter was to be a manned, unmanned, or optionally manned aircraft. The aircraft that was flown was likely a technology demonstrator that would help test various concepts that could be used in the **NGAD** program. The program's budget for 2019-2025 was \$9 billion, but it was unclear if there were plans to acquire production aircraft or other systems that may result from this research effort.<sup>53</sup>

### 3. Revised timeline and program modifications

In June 2022, the U.S. Air Force Secretary **Frank Kendall** revealed that the original timeline proposed by former Air Force acquisition executive **Will Roper** would not be met. The initial plan was to introduce new **NGAD** variants every five years with small production runs. According to **Frank Kendall**, the **NGAD**'s aircraft design is too sophisticated for such rapid cycles. In contrast, the CCA drones will have modular designs and quicker refresh rates. These drones will handle specific tasks, such as providing sensor data or targeting support.<sup>54</sup>

In March 2023, **Frank Kendall** outlined the initial procurement plans for **NGAD** fighter and the CCA drones. The first estimate shared was to field 200 **NGAD** fighters and 1,000 CCAs. The CCA numbers were based on an estimate of two CCAs per each 200 **NGAD** platforms and an additional two for each 300 **F-35s**.

In May 2023, the **U.S. Air Force** formally issued a classified solicitation to industry partners, marking the start of competition for the engineering and manufacturing development (EMD) contract. The **NGAD** solicitation focuses on the fighter and does not include the **CCA** program. An essential aspect of the **U.S. Air Force**'s acquisition strategy is the emphasis on open architecture standards. This would ensure that different systems, subsystems, and components can work together, regardless of the manufacturer, and it would facilitate upgrades that would ensure that the **NGAD** platform remains technologically relevant over decades of service. This would allow the **Air Force** to foster competition throughout the platform's lifecycle, reducing long-term maintenance and sustainment costs.<sup>55</sup>

Numerous companies are expected to participate in developing the **NGAD** and associated systems. According to Assistant Secretary of the Air Force for Acquisition Andrew Hunter, as many as 30 vendors could be involved in building the **CCA** drones.

In July 2023, **Northrop Grumman** decided that it would not submit a bid to build **NGAD** fighter aircraft. **Northrop Grumman** CEO **Kathy Warden** stated that the company

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<sup>53</sup> "Air Force Next-Generation Air Dominance Program: An Introduction", Congressional Research Service, 05 October 2020, <https://s3.documentcloud.org/documents/7222525/Air-Force-Next-Generation-Air-Dominance-Program.pdf>

<sup>54</sup> John A. Tirpak, "Kendall Dispenses With Roper's Quick NGAD Rhythm; System is Too Complex", Air & Space Forces Magazine, 24 June 2022, <https://www.airandspaceforces.com/kendall-dispenses-with-roper-quick-ngad-rhythm-system-is-too-complex/>

<sup>55</sup> Greg Hadley and John A. Tirpak, "Solicitation, Air Force Starts Bidding for NGAD to Replace F-22", Air & Space Forces Magazine, 18 May 2023, <https://www.airandspaceforces.com/air-force-selection-process-ngad/>

was nonetheless open the possibility of bidding on the CCA program. Neither **Boeing** nor **Lockheed Martin** officially had also stated an intent to bid on **NGAD**.<sup>56</sup>

#### 4. Reevaluation of the NGAD program

In July 2024, Air Force Secretary **Frank Kendall** reaffirmed that the **NGAD** fighter was still a top priority. However, he noted that its design needed a more cost-effective approach, particularly as the original plan has escalated **NGAD**'s projected price to nearly \$300 million per aircraft, which is about three times the cost of the **F-35 Joint Strike Fighter**. The **NGAD** fighter may undergo trade-offs to lower complexity and reduce costs. The **U.S. Air Force** is currently facing fiscal constraints, driven in part by efforts to modernize two legs of the nuclear triad and rising personnel costs. The Fiscal Responsibility Act has also imposed budget caps. Another issue straining the program's budget is that Congress has blocked the Air Force plan to retire older **F-22** Block 20 aircraft to free up funds for **NGAD**. These budget issues will likely impact the **NGAD** fighter's advanced, adaptive engines and the overall size of the fleet. The original engines were to have the ability to alter configurations depending on flight conditions. The **Air Force** is now considering less complex, smaller engines to cut costs that would nonetheless still retain advantages, such as enhanced range and fuel efficiency. The **Air Force** may only be able to afford small numbers of aircraft, which would significantly reduce its potential impact.<sup>57</sup> A more affordable platform would allow the **Air Force** to build a larger, more impactful fleet.

The **U.S. Air Force** committed over \$22 billion in research and development funds over five years in its FY2024 budget request. This funding is allocated not only for the **NGAD** fighter but also for the development of the CCA and other technologies.

In July 2024, the **U.S. Air Force** also asked for an increase of nearly 40% for the CCA program in FY24. This would mean an additional \$150 million in the effort on top of the \$392 million already approved. According to Air Force spokesperson **Ann Stefanek**, these additional funds were necessary because the original estimates for FY24 had been developed two years prior. This refinement of the costs would be based on what is currently known about the program. These funds would be used to conduct analyses, identify technology candidates, perform concept refinement studies, and design, build, and test productions. This request must be signed off by the chairs and ranking members of the four congressional defense committees.<sup>58</sup>

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<sup>56</sup> John A. Tirpak, "Northrop Won't Bid on Air Force's NGAD Fighter, But CCA, F/A-XX Programs Still in Play", Air & Space Forces Magazine, 27 July 2023 | By <https://www.airandspaceforces.com/northrop-out-ngad-fighter-cca-f-a-xx/>

<sup>57</sup> Stephen Losey, "Next-gen fighter not dead, but needs cheaper redesign, Kendall says", Defense News, 01 July 2024, <https://www.defensenews.com/air/2024/07/01/next-gen-fighter-not-dead-but-needs-cheaper-redesign-kendall-says/>

<sup>58</sup> Michael Marrow and Valerie Insinna, "Air Force requests more money for drone wingmen effort", Breaking Defense, 03 July 2024 a <https://breakingdefense.com/2024/07/air-force-requests-more-money-for-drone-wingmen-effort/>

In September 2024, Air Force Secretary **Frank Kendall** emphasized that the **NGAD** program was being reevaluated and that the **U.S. Air Force** was considering developing a less expensive version. The goal is to reduce the price below that of the **F-35**, which costs between \$80 million and \$100 million per unit, while still maintaining critical capabilities such as stealth, lethality, and adaptability in contested environments. According to **Frank Kendall**, some of the trade-offs to achieving this price range could be reducing the range, moving from a two-engine to a single-engine, and reducing the fuel payload. The **NGAD** fighter could rely on air refueling to extend its operational reach. Another potential trade-off would be to transfer some of the mission drone wingmen that could carry sensors and weapons. To try and restructure the program and ensure that the **Air Force**'s assessments align with future operational needs, the **Air Force** formed a panel of senior defense leaders, including former **Air Force** chiefs of staff and acquisition experts.

Following the **U.S. Air Force**'s decision to pause the **NGAD** fighter program **Northrop Grumman** CEO **Kathy Warden** announced that if the company determines that there will be some material changes to the program it could re-evaluate its participation.<sup>59</sup>

The Pentagon's proposed Fiscal Year 2025 budget includes significant developments for the **U.S. Air Force** and **U.S. Navy**'s respective programs to develop crewed sixth-generation fighters. The **Air Force** is looking for \$815 million for its **NGAD** fighter, a substantial increase over last year's request.<sup>60</sup>

The **Air Force** remains committed to delivering a next-generation fighter that ensures air superiority. Nonetheless, the decision to reassess the **NGAD**'s requirements and costs while ensuring that the design remains relevant in light of evolving threats and emerging technologies will impact both the timeline and budget allocation. This decision will have a direct influence on the FY2026 budget. The reimagined **NGAD** fighter will need to strike a balance between advanced capabilities and affordability.<sup>61</sup>

Compared to other countries that are developing six-generation fighters, the timeline for **NGAD** might be too slow. The **Air Force** will potentially have to reconsider its approach, including exploring alternatives such as arming the **B-21 Raider** with long-range air-to-air weapons or focusing on drones.

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<sup>59</sup> Audrey Decker, "Northrop might jump back into NGAD competition: CEO", Defense One 12 September 2024, <https://www.defenseone.com/business/2024/09/northrop-might-jump-back-ngad-competition/399486/>

<sup>60</sup> Joseph Trevithick, "USAF Seeks NGAD Fighter Boost, Navy F/A-XX Investment Slows In New Budget", The War Zone, 11 March 2024, <https://www.twz.com/air/usaf-seeks-ngad-fighter-boost-navy-f-a-xx-investment-slows-in-new-budget>

<sup>61</sup> John A. Tirpak, "Kendall: New, Re-Imagined NGAD Could Cost Less Than an F-35", Air & Space Forces Magazine, 16 September 2024, <https://www.airandspaceforces.com/kendall-new-re-imagined-ngad-cost-less-f-35/>

## VI. CHINA: THE J-XD

**China** is actively working on the development of advanced combat aircraft to close the technological gap with the **U.S** and other global military powers, all of which are also working on their sixth-generation jets, signaling its growing ambitions to dominate in military aviation. The Chinese military has significantly advanced its aerospace capabilities, especially with fifth-generation fighter planes such as the **J-20**. Its sixth-generation fighter jet program is seemingly inspired by the **U.S. NGAD** program. This program is part of an intensifying arms race with the **U.S.**.

The development of **China**'s sixth-generation fighter is still shrouded in secrecy. Little is known about the advancements, but it is believed that the aircraft will be part of a system of systems and coordinate various military assets such as drones, missiles, and other systems. It might have the ability to be the control platform for various swarms of drones.

In February 2019, **Wang Haifeng**, a chief architect at **Chengdu Aircraft Research and Design Institute**, mentioned in an interview that the six-generation fighter could be ready as early as 2035.<sup>62</sup>

In October 2021, satellite images from **Chengdu Aircraft Corporation**'s test airfield showed a delta wing tailless fighter-like airframe. While the exact nature of this plane was not specified, there has been speculation that it was a mockup of **China**'s sixth-generation fighter.<sup>63</sup>

In September 2022, Gen. **Mark D. Kelly**, the head of **Air Combat Command (ACC)** in the **U.S. Air Force**, noted that **China** was working on a combat system of systems and a sixth-generation manned fighter jet<sup>64</sup>. In November 2022, during the Airshow China 2022 held in Zhuhai, South China's Guangdong Province, the **Aviation Industry Corporation of China (AVIC)** displayed two futuristic sixth-generation fighter models. One had a flying wing with a tailless design, and the other, called a "space fighter," featured a more traditional fighter shape with a futuristic look similar to the **J-11** and **J-16** fighters (Chinese versions of the Russian **Su-27/30/35**).<sup>65</sup>

In February 2023, a video published on the WeChat video channel of the state-owned **Aviation Industry Corporation of China (AVIC)** showed computer-generated images of a futuristic fighter design with diamond-shaped wings and no canards, tails, or fins.<sup>66</sup> Observers

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<sup>62</sup> Ryan Pickrell, "China's eyeing a 6th-generation fighter to beat the US — its 5th-gen fighters probably don't stand a chance in a fight", Business Insider, 11 February 2019, <https://www.businessinsider.com/chinas-reportedly-chasing-a-sixth-gen-fighter-to-beat-the-us-2019-2>

<sup>63</sup> Tyler Rogoway, "Tailless Fighter-Like Airframe Spotted At Chinese Jet Manufacturer's Test Airfield", The War Zone, 30 October 2021, <https://www.twz.com/42937/tailless-fighter-like-airframe-spotted-at-chinese-fighter-jet-manufacturers-test-airfield?xid=twittershare>

<sup>64</sup> Thomas Newdick, "China Is Working On Its Own Sixth-Generation Fighter Program: Official", The War Zone, 28 September 2022, <https://www.twz.com/china-is-working-on-its-own-sixth-generation-fighter-program-official>

<sup>65</sup> Gaétan Powis, "China unveils two models of sixth generation aircraft: flying wing or more traditional aircraft?", Air&Cosmos International, 17 November 2022, <https://aircosmosinternational.com/article/china-unveils-two-models-of-sixth-generation-aircraft-flying-wing-or-more-traditional-aircraft-3587>

<sup>66</sup> "China Reveals Tailless Concept for Next-Generation Fighter Jet", Defense Aerospace, 02 February 2023, <https://www.defense-aerospace.com/china-reveals-tailless-concept-for-next-generation-fighter-jet/>



speculated that it might be **China's** next-generation fighter jet. Concept art and mockups from the **AVIC** also emphasize emphasizing stealth and maneuverability.<sup>67, 68&69</sup>

In June 2024, according to Chinese media reports, **China** completed a test flight of a prototype of its sixth-generation fighter jet near the Tengger Desert in Ningxia. The most remarkable feature was that part of the wings detached from the fighter jet and transformed into two flying wing drones. Despite some aerodynamic challenges, the test was deemed a success, demonstrating advanced manned-unmanned coordination. According to **Du Xin**, senior engineer at the **China Aerodynamics Research and Development Center (CARDC) Aerospace Technology Research Institute**, this test flight validates a “new concept” for **China's** next-generation fighter aircraft.<sup>70</sup>

Experts like **Rick Joe**, a commentator on the **People's Liberation Army (PLA)**, and **Dr. Brendan Mulvaney**, Director of the **China Aerospace Studies Institute (CASI)** at the **U.S. Department of the Air Force**, predict that a prototype could fly sometime in the 2030s. **China's** sixth-generation fighter will probably not outmatch U.S. aircraft like the **F-22** or **F-35** in direct combat, but by coordinating various systems on the battlefield, it might be able to neutralize U.S. technological advantages.

## CONCLUSION

Sixth-generation fighter programs are set to revolutionize military aviation by introducing unprecedented levels of technology and capability. These aircraft will surpass fifth-generation fighters, drastically enhancing military strength and reshaping global defense capabilities for decades. These fighters, which are expected to enter service in the 2030s, will significantly influence future military doctrines, ensuring air dominance on a scale unseen before.

The development of sixth-generation jets is also fueling a new arms race, intensifying geopolitical tensions among the world's leading military powers. Nations possessing these aircraft are likely to hold a significant upper hand in combat scenarios, while their development will help forge new alliances and strengthen existing ones. Countries lagging in development or unable to acquire these fighters may seek closer ties with leading powers to secure access to the technology.

Several sixth-generation fighter programs already reflect international cooperation and industrial collaboration, pooling resources to overcome technological and financial hurdles. With advanced systems such as AI-driven decision-making, manned-unmanned teaming,

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<sup>67</sup> Liu Xuanzun, “China reveals tailless concept for next-generation fighter jet”, Global Times, 01 February 2023, <https://www.globaltimes.cn/page/202302/1284646.shtml>

<sup>68</sup> Gordon Arthur, “When will China have a sixth-gen fighter jet?”, Defense News, 24 June 2024, <https://www.defensenews.com/air/2024/06/24/when-will-china-have-a-sixth-gen-fighter-jet/>

<sup>69</sup> Sébastien Roblin, “China's Sixth-Gen Fighter Jet Sure Looks Like the Air Force's Sixth-Gen Fighter Jet”, Popular Mechanics, 16 February 2023, <https://www.popularmechanics.com/military/aviation/a42929062/sixth-generation-fighter-jet-leaked-images-us-air-force-china/>

<sup>70</sup> “China's 6th Generation Shapeshifting Fighter Jet Completes Test Flight”, China Arms, 29 June 2024, <https://www.china-arms.com/2024/06/chinas-6th-generation-shapeshifting-fighter/>

enhanced stealth, directed-energy weapons, and hypersonic missiles, these aircraft will have far-reaching implications for global military strength and geopolitics. They are more than just technological advancements; they are strategic assets that could tip the balance of power in the coming decades.

However, these projects are not without economic and technical challenges. The cost of developing sixth-generation fighters is estimated to reach tens of billions of dollars, imposing a significant financial burden on participating nations. International cooperation will help alleviate some of these costs. Countries like the **U.S.**, **China**, and **Russia** will need to balance these military investments with domestic priorities, potentially sparking internal political debates. Developing reliable directed-energy weapons, perfecting manned-unmanned cooperation, AI decision-making systems, and hypersonic propulsion could also delay timelines.