

# Countries developing new concepts and technologies for Sixth-generation Fighter Aircrafts for Air superiority in future anti-access/area-denial environment

The United States, United Kingdom, Germany, Japan, Russia and China are all in early planning stages for a so-called “sixth generation” of fighter jets. The jets won’t fly until the 2030s, but governments around the world are already exploring, a conceptualized class of fighter aircraft design more advanced than the fifth-generation jet fighters which are currently in service.

In the United States, the U.S. Air Force is seeking an extra \$147 million to fund early development of the Next Generation Air Dominance (NGAD) or Penetrating Counter Air Fighter (PCA). PCA is an Air Force program designed to field a fighter to replace the F-22 Raptor. USAF General Mike Hostage has said that they have yet to decide on which features will define the sixth-generation fighters. However, they are searching for an aircraft with enhanced capabilities in areas such as reach, persistence, survivability, net-centricity, situational awareness, human-system integration and weapons effects. PCA could fly as early as 2028.

“Air Force’s future dominance will rest not on a single platform, such as a sixth generation fighter jet, but on an integrated, networked family of systems,” said Brig. Gen. Alexis Grynkewich, who led the Air Superiority 2030 enterprise capability collaboration team (ECCT). That combination of

penetrating and stand-off capabilities includes a fighter plane, but also a number of space, cyber and electronic warfare assets. What that means is that the fighter jet of the future might look more like a sensor node than the dogfighters of the past, Grynkewich said.

The U.S. Navy is pursuing Next Generation Air Dominace F/A-XX fighter. It should have the technological capability to be unmanned, maximum sensor connectivity, super cruise ability and an aircraft with electronically configured "smart skins." Navy planners envision its 6th generation aircraft will likely be engineered for both manned and unmanned missions. Technologies are rapidly advancing in coatings, electromagnetic spectrum issues, artificial intelligence, maneuvering, superiority in sensing the battlespace, communications and data links, Navy leaders have said.

Russia has been testing various hardware elements designed for a future 6th generation fighter jet on a 5th generation prototype currently undergoing flight trials, TASS news agency reveals. Vladimir Mikheev, advisor to deputy general director of the Radio-electronic Technologies Concern stated in July that the 6th-gen aircraft will have space capacities and will be pilotless. At the press conference dedicated to Russia's future jet, head of Russian Aerospace Forces Viktor Bondarev said that the plane would have both a manned and an unmanned version. Bondarev said that the shift to unmanned aircraft is in part because the human body "has limits," presumably for both long flights and extreme maneuvers. Drone equipment, he said, is "much more functional and low-maintenance," and "can withstand any g-force." The aircraft must also be able to "fly at hypersonic speed, be multifunctional, super-maneuverable and unnoticeable."

China is planning its sixth-generation fighter jet, J-28 with capability to conduct accurate conventional hit to counter the nuclear threat from the entire solar system.

Japan and Great Britain have signed an agreement to explore the idea of jointly developing a new fighter for fielding in the 2030s. According to Aviation Week & Space Technology, the two countries will “exchange information on their ambitions” and “advise each other of their capabilities.”

Finally, Germany is also looking to develop a sixth generation fighter, also named Future Combat Air System (FCAS).

“It must be able to operate in the anti-access/area-denial environment that will exist in the 2030–50 timeframe,” says USAF. “The future system will have to counter adversaries equipped with next generation advanced electronic attack, sophisticated integrated air defense systems, passive detection, integrated self-protection, directed energy weapons, and cyber-attack capabilities,” according to USAF.

A2/AD environment can be countered by technologies that Increase Standoff & Accuracy, provide Higher Platform & Weapon Survivability, Alternative PNT for Contested EM Environments, Greater Lethality in Smaller Form Factor, Adaptable Effects / Mission Flexibility, Assured Weapons C2, Ad Hoc networking, Affordable in Quantity, Expedite Future Technology Insertion and Reduce Logistic Support according to AFRL.

“The emerging operational environment demands long-range, survivable, penetrating, persistent systems with deep magazines to prevail against a numerically superior adversary.” Tom Vice, president of Northrop’s aerospace sector, laid out his vision for a long-range, potentially unmanned fighter, featuring laser weapons and advanced “cyber resiliency” to counter threats in the increasingly connected world of 2030.

Lockheed Martin has called for greater speed, range, stealth and self-healing structures. Northrop Grumman is looking at a supersonic tailless jet, something never created before due to complexity. Britain’s BAE Systems has proposed a modular

design, which would allow a UFO-like rhombus-shaped jet to separate into different functions while in mid-flight.

Boeing plans to have supercruise and fly faster and further than the F-35 Lightning II. Boeing is out with new concept art for the U.S. Air Force's next-generation fighter jet, a sleek, tail-less design featuring conformal engine inlets and what looks like a manned cockpit. "It looks more like a fighter-bomber than a pure fighter, The tail-less airframe, thin swept wings and conformal shaping suggest a stealthy, penetrating aircraft that may be able to fly supersonic. The silhouette of a pilot inside the cockpit indicates Boeing is banking on the Air Force sticking with at least an optionally manned platform for the future capability," according to Aviation Week.

## **Saab's future electronic attack aircraft**

Outlining an increasingly complex and challenging anti-access/area denial (A2/AD) environment, Jonas Grönberg, the company's Head of Product Management for Fighter EW, argued that the emergence of new low-band early warning radars means "low observability is no longer a substantial defence for strike aircraft", advocating instead "high-powered electronic attack to deny shared situational awareness and targeting data, and to negate data networks".

Saab in 2013 began its in-house study to characterise the future air operating environment so as to inform key requirements and technologies for combat aircraft in the 2035–40 period. One key conclusion to emerge from this work was the requirement for a credible AEA capability, supporting suppression of enemy air defences/destruction of enemy air defences, to improve aircraft survivability, and enable penetration of the A2/AD screen. "It turned out that EW came out as a common enabler," Grönberg told Jane's in a subsequent interview. "The survivability of any platform will require

much enhanced EW capabilities. Even the latest low observable technology will not render an aircraft invisible.”

Central to Saab’s thinking is the development of a self-contained (in cooling and power) electronic attack (EA) pod suitable for two-seat variants of the JAS 39 Gripen or other twin-crew fighter aircraft. EA pod concept studies and design, including the build of engineering mock-ups, have been founded on the reuse of technology building blocks previously developed for the Gripen E’s internal self-protection EW suite. The pod design developed by Saab incorporates VHF and UHF antennas in fin surfaces, with L-band and S-band active electronically scanned array antennas, based on gallium nitride technology, fitted front and rear.

The second element of the triad is a miniature air-launched decoy to perform both distraction and stand-in jamming. Saab has conceptualised a small, long-range, long-endurance decoy vehicle with an EW payload that can locate and identify threats and targets, and distract enemy air defence resources. The decoy will support an attack on a target defended by surface-to-air missile systems by acting as a stand-in jammer.

The third piece of the new concept is the development of a back-seat electronic warfare officer (EWO) station embodying advanced sensor data fusion and decision support techniques. Saab has already prototyped the EWO human machine interface in the simulator, and has shown it to the Swedish Air Force

## **Russia testing various hardware elements for a future 6th generation fighter jet on a 5th generation prototype**

The Russian Ministry of Defence (MoD) is reportedly working on developing a sixth-generation fighter jet to enhance the air

defence capabilities of the nation. Russian aircraft manufacturer Sukhoi has presented designs for the sixth-generation fighter, which are planned to be both manned and unmanned.

As reported by the TV channel "Zvezda", the top-secret aircraft, about which limited information began to appear in the press under the name of Yu-71, is part of the project 4202, related to the national missile program. The new aircraft is capable of reaching speeds above 11 thousand kilometers per hour, is super-maneuverable and is capable of maneuvering into the near outer space. The Russian Armed Forces may induct this aircraft into its ranks after 2015.

Russian designers have already started work on the creation of a sixth-generation fighter jet, according to director general of the Foundation for Advanced Research Andrei Grigoryev. The aircraft's body will be made of a highly durable and lightweight composite material. The fighter jet must possess not only supersonic speed but must be able to attain hypersonic – over Mach 6-7 – speeds at certain stages of flight.

Sputnik news reports, "It turned out that Russian scientists have found a way to use the plasma cloud, which gets created during the flight of an aircraft at hypersonic speeds." Thanks to the plasma "cushion", the machine can fly into the Earth's atmosphere at a speed of 4-5 km/s. Moreover, it moves not by the laws of aerodynamics or ballistic trajectory – but by means of a "broken" path. In addition to this, the plasma cloud can absorb radar radiation. Naturally, during the flight on a "broken" path, powerful G-load of over 20 g will occur inside the flying machine. Therefore, hypersonic aircraft are likely to be unmanned

"To destroy such a hypersonic aircraft will be problematic even with the help of lasers. After all, for pointing the laser "gun", one needs to aim at a flying machine, which can

change its trajectory by almost 90 degrees, and the laser beam is bound to miss for sure," according to Sputnik news.

A russian sixth-generation fighters will be fitted with a unified electronic warfare system, which will serve as a radar, an electronic warfare system, a data transmission system and as communications equipment. Additionally, it will function as a navigation system and as an IFF transponder. The russian sixth generation fighter jets planned to be unveiled by 2025 will consist primarily of swarms of unmanned aircrafts flying at hypersonic speed with developers saying that the jets would be able to transit through space. The unmanned drones will be equipped with electromagnetic pulse weapons which can disable electronics at a 10km range.

"Number Six" needs a new and powerful engine able to function not only in the atmosphere, but also in airless space. It cannot be excluded that one of the tasks of the new craft will involve exiting into open space and flying in an orbital trajectory.

Also needed are a new antenna system and avionics system capable of functioning effectively and stably in all flight modes and all circumstances and of maintaining constant communication with ground and air command centers and spacecraft, as well as an onboard electronic warfare system designed not only to suppress the communication and control systems of a potential opponent but also to neutralize air-to-air or surface-to-air missiles.

"Standalone solutions that will be applied in the sixth-generation fighter are now being tested on the fifth-generation jet as well as on the ground-based equipment. Separate elements of the flight and navigation system have already been installed on PAK FA", Mikheyev said.

# **China to conduct accurate conventional hit to counter the nuclear threat from the entire solar system**

An awarding ceremony for winners of “Feng Ru Aviation Tech Elite Award” was held on September 16th 2015. And in the stories of Shenyang Aircraft Institute’s general designer Wang Yongqing, “special mission aircraft, the next-generation jet fighter and catapult launching and arrested deck-landing were mentioned.

A Russia media have recently exposed that China’s Aviation Research Institute No. 611 is doing research for the development of J-28, its sixth-generation fighter jet. It is said that J-28 is able to conduct accurate conventional hit to counter the nuclear threat from the entire solar system.

The laser weapon a J-28 carries is so strong that it can melt a nuclear missile launched from any planet or satellite in solar system. The report says as the United States has conducted enough survey to know the Mars, it is expected that the US will establish a nuclear missile base in 2018.

J-28’s speed is so high that even if it fails to intercept a missile the first time, it can chase the missile to hunt it. In addition, it is such a wonderful stealth fighter that it cannot be detected by either radar or radio telescope. J-28 will also act as an information platform or a node of the battlefield network transferring enemy targets information to whole C4ISR system in real-time to provide decisive decision-making as well as utilizing information from network to maximizing combat performance.

Besides, the 6th generation fighter can complete routine air combat and ground attack missions within the atmosphere, and implement accurate precision strikes on selected remote targets from near space.



China is developing a family 6th generation fighters: one heavy fighter, one medium-sized fighter as well as a variety of stealth unmanned combat platforms, such as “dark sword”. Year 2020 will be the deadline of China’s sixth generation fighter, according to report.

Experts believe that the Chinese flying machine called Wu-14 can be the only serious rival to the Russian hypersonic machine. This device underwent trials in 2014. It was found that, like the Russian apparatus, the Chinese was capable of maneuvering at supersonic speeds of 11 thousand kilometers per hour.

## **Japan**

Japan is looking to develop a large, twin-engine, two crewman aircraft to replace the Mitsubishi F-2 fighter. The country’s sixth generation fighter concept, nicknamed Future Fighter, is a large fighter designed for long range missions against China in the East China Sea and possibly North Korea. Currently Japanese F-15 and F-2 fighters flying missions in the East China Sea can only operate from a handful of local airfields—fighters with a longer range fighter could operate from more airfields farther away.

## **UK**

Report UK’s “post-2030 combat aviation force structure” highlighted a possibility of the UK committing to a next generation fighter program to potentially replace the Eurofighter Typhoon post-2030. The UK’s Future Combat Air System (FCAS) will replace the Eurofighter Typhoon starting in 2040. FCAS might be an unmanned aerial vehicle; the UK has been quietly testing the Taranis combat drone since 2012. Unlike current drones, Taranis is being developed to attack aerial targets in addition to ground targets. Unmanned is an option for FCAS, but the UK Ministry of Defense has admitted

the program could still result in a manned fighter.

## **Germany**

Finally, Germany is also looking to develop a sixth generation fighter, also named Future Combat Air System (FCAS). FCAS will replace the German Air Force's aging fleet of Tornado IDS strike aircraft and supplement the Eurofighter Typhoon. According to Telegiz, the "FCAS will likely be a twin-engine, twin-tail aircraft piloted by two crewmen"—which actually sounds a lot like what Japan wants—to be operational in the 2030 to 2040 airframe.

FCAS will be a "system of systems" that combines manned and unmanned aircraft into one operational unit. FCAS could be both manned and unmanned, and manned versions could fly alongside and control unmanned versions.

Some countries are even skipping the the 5th generation jet completely, Canada is working toward developing a 6th generation "Arrow II", or "Super Arrow". France has abandoned any attempt to develop an indigenous fifth-generation fighter and have moved resources directly to development of a sixth-generation fighter aircraft.

## **Some of the concepts being explored for sixth generation aircrafts are:**

Artificial intelligence will likely play a role, sorting data and analyzing threats to reduce the pilot's workload.

## **Highly Networked**

In 2009, Air Force Magazine tried to define fighter generations and suggested sixth generation features such as

extreme stealth, morphing capability, smart skins, highly networked, extremely sensitive sensors, optionally manned and directed energy weapons.

Maximum connectivity would mean massively increased communications and sensor technology such as having an ability to achieve real-time connectivity with satellites, other aircraft and anything that could provide relevant battlefield information, said Richard Aboulafia, vice-president of analysis at the Teal Group, a Va.-based consultancy.

## **Super Stealthy**

Stealth will also be a key requirement, he added. It “is the price of admission in future conflicts.” Gen. Hawk Carlisle, the head of Air Combat Command, said that stealth will continue to be hugely important.” “Stealth is wonderful, but you have to have more than stealth,” Carlisle said, according to the Air Force Times. They require new super stealthy features without compromising performance.

CNO Adm. Jonathan Greenert said “I don’t see that it’s going to be super-duper fast, because you can’t outrun missiles,” and stealth may be overrated. In lieu of stealth and speed, Greenert said that the F/A-XX would gain access by deploying “a spectrum of weapons” that could suppress enemy air defenses.

## **Long Range**

Chris Hernandez, Northrop’s vice president for research, technology and advanced design, laid out the basic parameters for the sixth-gen fighter (Northrop refers to it as NG Air Dominance): it must boast long range because it’s unlikely to have many bases to operate from overseas; it must “carry a lot

of weapons;" survivability will be key.

The service wants to cut down on the amount of mid-air refueling, he said. Fighters, which are traditionally small and compact, often have less space for extra fuel, he noted.

"We think it's going to have to be long range, for sure," he said. "If you look at almost any part of the world, even in the Middle East, and look at some of the distances required and the tankers required, we would like to have a fighter with a longer range probably than the standard 500 miles that we have today."

Since the end of the Cold War, combat aircraft have had the luxury of operating from bases that are close to the enemy, like in Iraq, said Mark Gunzinger, a senior fellow at the Center for Strategic and Budgetary Assessments, a Washington, D.C.-based think tank. In the future, where enemies have precision-guided weapons like cruise or ballistic missiles, those bases could be at high risk.

## **Directed Energy Weapons**

While kinetic weapons will be critical, there is also a need for electronic weapons, Sterling Anderson, deputy chief of Air Combat Command's air superiority core function team said. Cyber capabilities, offensively and defensively, will be necessary in the future as the United States faces more advanced adversaries, he said. Emerging technology such as directed energy weapons might be one way to obtain a deeper magazine, he noted.

Air Force Research Laboratory has released a request for information (RFI) for a laser weapon that could be mounted on next-generation air dominance fighters by the 2030s. The Air Force is interested in three categories of lasers: low-power for illuminating, tracking, targeting, and defeating enemy

sensors; moderate-power for protection to destroy incoming missiles; and high-power to offensively engage enemy aircraft and ground targets.

One of the keys to this new weapon, which is in the earliest stages of head-scratching and planning, will be heat management. As Northrop president for aerospace Tom Vice noted, lasers operate at 33 percent efficiency when all goes well. That means there's enormous heat to dissipate and that will be just from the lasers.

Add in all the aircraft's power and thrust systems, and you have an enormous heat challenge. It needs to be managed on a system level because of the aircraft's assumed low observable requirements, Hernandez told COLIN CLARK. The level of complexity will make this aircraft something like an advanced satellite, where electromagnetic interference, heat offload and power requirements pose compelling and existential challenges to the system.

## **Cyber Resiliency**

One major problem the Pentagon must confront is protecting aircraft data and lines of communications in a world where cyber hacking is the norm. The government can't thwart every cyber attack – instead, it must be able to detect the intrusion and prevent damage, Vice said. The next generation of air dominance will leverage a digital version of a white blood cell, able to inoculate a system to prevent a cyber infection from spreading, Vice said.

A future fighter fleet could include a mix of manned and autonomous aircraft, lead by a "mission commander" who directs the unmanned assets, Hernandez said.

But mindless robots can't replace the human brain, which does not require software installations to adapt to new

information, Vice pointed out. Northrop is working to design software that can not only learn and evolve, but has a set of values necessary to make real-time decisions, he said.

## **“Large Bomber,” suggest Center for Strategic and Budgetary Assessments (CSBA)**

The next-generation U.S. Air Force fighter should be larger and more resembling a bomber than a small, maneuverable traditional fighter, concluded a report from Center for Strategic and Budgetary Assessments (CSBA).

After analyzing over 1,450 air-to-air engagements since 1965 it found that long-range weapons and sensors have dramatically decreased instances of dogfighting. With the increase of air defense systems using electronic and infrared sensors and high-speed weapons, traditional designs relying on small size, high speed, and maneuverability may be less relevant and easier to intercept.

As a result, the CSBA suggests building a fighter significantly larger relying on enhanced sensors, signature control, networked situational awareness, and very-long-range weapons to complete engagements before being detected or tracked. Larger planes would have greater range that would enable them to be stationed further from a combat zone, have greater radar and IR detection capabilities, and carry bigger and longer-range missiles. One airframe could be fitted with various attachments to fill several roles. The concept of a small number of large, intercontinental and heavily-armed combat aircraft could link itself to the development of the Long Range Strike Bomber.

## **Not Fighter but Swarm of Drones**

Andrew Hunter, director of the Defense-Industrial Initiatives Group at the Center for Strategic and International Studies, a Washington D.C.-based think tank, said the sixth-generation aircraft might not actually be a fighter jet.

“It could be a swarm of” drones, he said. “It could be missile trucks that don’t look anything like current fighter aircraft but operate at much longer ranges.”

It can be extremely expensive to try and put capability on top of capability on an airframe while also making it as stealthy as possible, he said. Officials and experts are mulling over whether it is a better payoff to disaggregate some capabilities and reduce vulnerability to losses by distributing the various parts of a fighter in a more networked approach, he said.

## **DARPA’s Systems of Systems**

DARPA’s System of Systems Integration Technology and Experimentation program aims to disaggregate aircraft capabilities into a swarm of cooperative, low cost expendable air vehicles to operate in this A2/AD environment.

Prabhakar says that DARPA has “very deliberately” chosen a “systems approach” to the problem. “This is not a question about what does the next aircraft look like, this is a question about what are all the capabilities that it will take, layered together, in order to really comprehensively extend air superiority,” she says.

Open architecture design is also favored, being able to plug different sensors, different payloads and weapons to enable

multiple different missions on different days, or different sorties. Jonathan Greenert, chief of naval operations says “Getting the right payload in the right place, at the right time is also critical.”

Most importantly, a 6th generation fighter should be affordable using Off-the-shelf technology whenever possible. It should not be too expensive to build, maintain and upgrade, too expensive to fly, or so overly complicated that it never gets out of development future needs.

### **The article sources also include:**

1. <http://www.defensenews.com/story/defense/air-space/strike/2016/01/15/northrop-cyber-resilient-next-gen-fighter/78833308/>
2. <http://www.nationaldefensemagazine.org/archive/2016/March/Pages/MilitaryEyesSixthGenerationFighter.aspx>
3. [https://in.rbth.com/economics/defence/2016/09/07/the-shape-of-us-and-russian-6th-generation-air-power\\_627601](https://in.rbth.com/economics/defence/2016/09/07/the-shape-of-us-and-russian-6th-generation-air-power_627601)
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