Next Generation Air Dominance

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Abstract

Evolving technologies, aerospace battle scenarios of the future, tailoring doctrines and conceptualizing aerial platforms and weapons are continuous processes of modern air forces. Most air forces are looking to replace the traditional fighter aircraft with a network of integrated systems disaggregated across multiple platforms, with increased dependence on space and cyber. Investments are being made to explore concepts like the arsenal plane, hypersonic and directed energy weapons, autonomous operations, and electronic attack. 'Next Generation Air Dominance' will mean effective combination of speed and manoeuvrability, payload and range, stealth, or low-observability and highly lethal and accurate weapons, and self-healing structures for the new platforms.

Air forces seek a fighter with "enhanced capabilities in reach, persistence, survivability, net-centricity, situational awareness, human-system integration and weapons effects". There is a need for new breakthroughs in propulsion, materials, power generation and weapon technology. The tailless flying wing, "cranked kite" design concept currently appears the way forward for future fighter aircraft. The clear line defining atmosphere and space will get smudged, and more aerospace-craft would routinely transit between space and atmosphere, taking advantage of each. Combat engagements will be at much faster speeds and much greater distances. More and more platforms will be uninhabited, or optionally manned. There will be increased use of Artificial Intelligence (AI). Proliferating Uninhabited Air Systems (UAS) will bring

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in many platforms and players, including non-state actors.

Advanced engines such as 'Adaptive Versatile Engine' technology would allow longer ranges and higher performance. More efficient, easier to cool, Gallium Nitride (GaN) semiconductor material would improve reliability for radars. The Passive Aero-elastic Tailored (PAT) designed composite wing will be lighter, more structurally efficient and have flexibility compared to conventional wings. It is time for India to get its act together and think ahead, lest it gets left behind once again.

Studying and evolving technologies, aerospace battle scenarios of the future, tailoring doctrines and conceptualising aerial platforms and weapons are continuous processes of modern leading air forces. In its quest to dominate the air battlefield of the future, the US Air Force (USAF) is looking to replace the traditional fighter jet with a network of integrated systems disaggregated across multiple platforms. There is a need to develop technology to deter current and emerging threats and to produce the non-linear, game-changing combat capabilities required for national security. A 'family of systems' could address the range of threats in a highly contested environment. This is more so because Russia, and especially China are trying to close the capability gap with United States, by building long-range missiles, anti-satellite and anti-aircraft weapons to foil US forces' ability to penetrate. The new strategy will include capabilities with increased dependence on space and cyber to infiltrate enemy defences and defend own networks. USAF has specially budgeted for experimentation and prototyping in the area of air superiority, and is exploring concepts like the arsenal plane, hypersonic and directed energy weapons, autonomous operations, and electronic attack. Through the effort, called 'Next Generation Air Dominance'[1], USAF is working to find the most effective combination of speed and manoeuvrability, payload, and range for the new platforms. The right level of stealth, or low-observability, will also be considered.

The USAF and US Navy (USN) are leading the evolution of next generation platforms and technologies. Defence Advanced Research Projects Agency (DARPA), US Air Force Research

Labs (AFRL), Boeing 'Phantom Works', Lockheed Martin's 'Skunk Works' and National Aeronautics and Space Administration (NASA) are all aiding the work on concepts of 'Air Dominance' for 2040 and beyond. The Americans, Chinese and Russians are all working on the Sixth Generation fighters which will induct from 2028 onwards.[2] Fighter Bomber as a platform, therefore, is still here to stay. More and more of these will become uninhabited, or optionally manned. There will be dramatic changes in the aerial platform performance and aerial weapons. The clear line defining Atmosphere and Space will get smudged. Aerospace will soon become a common domain with more aerospace-craft routinely transiting between space and atmosphere, taking advantage of each. Combat engagements will be at much faster speeds and much greater distances.

Aerospace - Combined Dimension

Aerospace craft will aim to seize control establishing dominance/ supremacy over the enemy's aerospace assets. They will operate under the control/co-ordination of space-based Early Warning and Control satellites with increased Artificial intelligence (AI). Satellite/ aircraft based kinetic and Directed Energy Weapons (DEW) will soon be a reality and will be used for aerial or surface attack. Even if aerospace supremacy cannot be established, a "degree of dominance" in the air-space bubble in a given area and given time-space without prohibitive interference by opposing air forces will be desired.

Evolving Air Threats

The world already has eight overt nuclear powers, one covert nuclear power (Israel), and at least two nuclear aspirants (Saudi Arabia and Iran).[3] Non-Proliferation (nuclear weapons) Treaty (NPT) is still not fully effective. More and more countries are acquiring missile technology. Missiles are becoming faster, more accurate, have longer range and larger multiple warheads. The weapon delivering air platforms are becoming faster and more efficient for deeper penetration. Airborne radars and missiles have much greater ranges. AI will find more optimum and timely combat solutions. Proliferating Uninhabited Air Systems (UAS) bring in many platforms and players. The non-state actors and rogue regimes which follow no international norms and ethics are trying to acquire weapons of mass destruction. It may become difficult to define threat. Any future air platforms would have to factor in all this.

Basic Concepts and Approach

Concepts evolving from the USAF and industry are mostly around supersonic tail-less aircraft. American sixth-generation fighters will feature AI as a decision aid to the pilot and borrow and expand ideas of advanced sensor fusion from F-22 and F-35. They will also have Positioning, Navigation, and Timing (PNT)[4] and communications that allow big data movement between the inter-service's aircraft. Unlike the previous F-22 and F-35 that depended on new technologies that drove up cost and delayed introduction, USAF is keen to follow a path of risk reduction by prototyping, technology demonstration, and systems engineering before creation of the aircraft actually starts. USAF has analysed over 1450 air-to-air engagements since 1965[5] and found that long-range weapons and sensors have dramatically decreased instances of dog-fighting. Therefore, one approach could be that the next-generation USAF fighter be larger and more resembling a bomber than a small, manoeuvrable traditional fighter. With the increasing air defence systems using electronic and infrared sensors and high-speed weapons, traditional designs relying on small size, high speed, and manoeuvrability may be less relevant and easier to intercept. It is suggested that a significantly larger fighter could rely 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 farther from a combat zone, have greater radar and IR detection capabilities, and carry bigger and longer-range missiles. The USAF Scientific Advisory Board has suggested a Penetrating Counter Air (PCA)[6] platform that would combine long range, supersonic speed, stealth and manoeuvrability. PCA would have substantially longer range to fly long distances over the Pacific, especially in a situation where airbases in the vicinity of China are not available. It would also escort bombers deep into Russia or China, where the anticipated threat includes advanced networked air defence radars. It would include stealth against low or very high frequency radars, which requires an airframe with no vertical stabilisers. Requirement is significantly larger payload than current air superiority aircraft like the F-22.

Uninhabited Aerial Systems

Uninhabited aircraft technologies are already proven, and the future is UAS.[7] World is at a transition. Solar-powered UAS are already flying. Currently, the solar-powered Zephyr holds the endurance record for UAVs, with 14 days in the air. Dual use (optionally manned) aircraft are also flying. USAF has already modified F-4s and F-16s to fly them remotely. In France, Dassault leads a multi nation delta wing UCAV 'Neuron' of the size of Mirage 2000. UK has a Strategic UAS programme 'Taranis'. UAS are taking-off and landing by themselves including on the moving aircraft carrier (Northrop GrummanX-47B). Autonomous air refuelling has been tested. Lockheed Martin's UCLASS drone 'Sea Ghost' looks rather like a stealth bomber and is expected to carry 1,000-pound class weapons. USA is also working on Hypersonic (Mach 6 to 8) Strike Bomber which is likely to be optionally manned. Uninhabited helicopter convoys will deliver supplies to troops deployed on combat front lines. The US Army's dramatic shift to a nearly all-unmanned flight over the next three decades is embedded in the UAS roadmap. USAF's UAS vision document indicates that by year 2047 every mission would be unmanned. Mass air raids with a swarm of UAS leading the manned aircraft strikes have already been tested.

American Next Fighter Approach

The USAF is pursuing development and acquisition of a sixth-generation fighter through the F-X programme to replace its existing aircraft such as the McDonnell Douglas F-15 Eagle and complement existing platforms in service such as the Lockheed Martin F-22 Raptor. The USN is pursuing a similar programme called the 'Next Generation Air Dominance' intended to complement the smaller Lockheed F-35 and replace its existing aircraft such as the Boeing F/A-18E/F Super Hornet. Next-generation fighter efforts will initially be led by DARPA under the "Air Dominance Initiative" to develop prototype X-planes.[2] USAF and USN will each have variants focused on their mission requirements. Dubbed the "Next Generation Tactical Aircraft"/"Next Gen TACAIR"[8], the USAF seeks a fighter with "enhanced capabilities in areas such as reach, persistence, survivability, net-centricity, situational awareness, human-system integration and weapons effects". The future system will have to counter adversaries equipped with next generation advanced electronic attack, sophisticated integrated air defence

systems, passive detection, integrated self-protection, directed energy weapons and cyber attack capabilities. It must be able to operate in the anti-access/area-denial environment that will exist in the 2030–50 timeframe. USAF's new budget request for Fiscal 2019 shows, the service asked for US $504 million for its next-generation air dominance research, development, test and evaluation programme. In the next five years of planned spending, USAF desires to invest roughly US $11 billion on next-gen air dominance. China's quick aerospace advancement pace is driving the USAF to react. There has been explicit recognition "of the re-emergence of great power competition". Similarly, the USN has a much higher priority on range and speed. AI and optionally manned are becoming critical requirements generally. There is a need for survivability. Stealth is just one piece of the survivability equation, others such as ultra-lightweight armour and counter-directed energy capabilities are required. USN acknowledges that the service will need to keep costs low enough to buy a high volume of air vehicles. Numbers matter. Got to be able to have enough aircraft out there.

Sixth Generation Fighters

Sixth Generation fighter proposals are looking at greater speed, range, stealth and self-healing structures; developments that will require new breakthroughs in propulsion, materials, power generation and weapon technology. Self-healing structures in particular would pose a significant advantage over modern-day aircraft, remaining airborne despite taking heavy fire. The system comprises pockets epoxy resin and a hardener, installed around vulnerable parts of the aircraft such as the underbelly, hatchways and wheel wells. If the area is damaged, the contents of the pocket are released to form a temporary plug, helping the aircraft to operate in spite of the damage. New generation of engines will allow ultra-high altitude super-cruise. The avionics are supposed to withstand next generation electronic attack and cyber-attack, have passive detection, and integrated self-protection. The tailless flying wing, "cranked kite" design concept currently appears the way forward for future fighter aircraft. Major action is unfolding. The combat pilot still has backers and still has a place onboard.

Evolving Engine Technologies

The sixth-generation fighters are expected to use advanced engines such as 'Adaptive Versatile Engine'[9] technology to allow longer

ranges and higher performance, where the ratios of bypass and compression airflow can be made variable to improve efficiency. The engines are expected to be ready when fighters are introduced by the USN in 2028 and the USAF in 2032. The systems are to work at altitudes from sea level to 65,000 ft at speeds from Mach 0.6 to Mach 2.5. The newer engines could vary their bypass ratios for optimum efficiency at any speed or altitude. That would give an aircraft a much greater range, faster acceleration, and greater subsonic cruise efficiency. A variable cycle engine could configure itself to act like a turbojet at supersonic speeds, while performing like a high-bypass turbofan for efficient cruising at slower speeds. A low-bypass configuration would be used for take offs and supersonic flight, and a high-bypass configuration would have high propulsive efficiency for cruising. Companies involved with next-generation engine development include General Electric and Pratt & Whitney.

Weapons of the Future

Future weaponry would utilize scramjets for the production of faster missiles. Despite failing its recent tests, Boeing's X-51A Wave-rider[10] scramjet remains in development as it hopes to reach hypersonic speeds approaching Mach 6, a speed at which a missile could not be stopped by conventional air defence technology. X-51 technology is proposed for use in the High Speed Strike Weapon (HSSW), a Mach 5+ missile which could enter service in the mid-2020s. Continued experiments with DEW and lasers, used for defensive as well as offensive measures, delivering effects at the speed of light, are also likely to shape precisely what sixth generation fighters are equipped with. New aircraft will be as much about reusable weaponry (lasers) as it is about expendable weaponry. USAF 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. USAF is developing a new air-to-air missile, dubbed the Small Advanced Capabilities Missile (SACM)[11] for 2030s. SACM would promise an improved solid rocket motor having synergized control enabled by combined aero, attitude control and thrust vectoring. The missile will have improved 'high off bore-sight' for rear hemisphere kills and 'lower cost-per-kill'. The missile would also incorporate energy optimising guidance, navigation and control.

The Miniature Self-Defence Munitions (MSDM), will enhance future platforms self-defence capability, without impacting the primary weapon payload. A sixth-generation missile could replace AMRAAM. A survivable, long-range missile with combined air-to-air and air-to-ground capabilities[12] is being evolved. Range would be a big factor to counter potential adversaries with Chinese PL-15. It will be multiband, broad spectrum – which aids it in survivability and reaching the target. DARPA's the triple target terminator (T3) programme envisions combined capabilities of Raytheon's AIM-120 and AGM-88 High-speed Anti-Radiation Missile (HARM). No aircraft is invisible, and using standoff weaponry early in an air campaign to open up weaknesses in an enemy's air defence will be required even for 5th generation fighter aircraft to operate in the area without assuming excess risk. Development of solid-state airborne laser capability is already underway.[13] The solid-state laser systems defensively create a sanitised sphere of safety around the aircraft, shooting down or critically damaging incoming missiles and approaching aircraft with the laser turrets. Even attacking targets on the ground, such as individual people, with pinpoint precision, or shooting down ballistic missiles and other traditional targets are possibilities. Controlling aircraft's heat signature while using laser weaponry will be an issue. One option is to develop a thermal accumulator. Alternatively, off-board venting to manage the heat. Newer liquid based lasers promise enough energy to bring down an aircraft (about 150kw) yet is small enough to fit on a truck, and should be able to be mounted on a jet fighter. A laser weapon is expected to be mounted on next-generation air dominance fighters by the 2030s.

Evolving Other Technologies

For long military aviation doctrines and requirements drove technology. Today technologies are offering enhanced capabilities that are driving operational employment and tactics. Artificial Intelligence (AI), smart structures, and hybrid systems will dictate the future. Demand for streaming high-quality data requires bandwidth, which involves innovating sensor/processing systems. Mission computer systems and network-centric payload processing units enable onboard data fusion prior to sending to digital links. Thermally efficient, high-performance computing onboard the aircraft is essential. Next-generation avionics would be smaller, more efficient and capable of operating under extreme conditions. Gallium

Nitride (GaN) is a semiconductor material that is more efficient, easier to cool, and improves reliability for radars. Any system must be designed with aim for maintaining a competitive advantage in an austere budget environment. The Passive Aero-elastic Tailored (PAT)[14], a uniquely designed composite wing will be lighter, more structurally efficient and have flexibility compared to conventional wings. This wing will maximize structural efficiency, reduce weight and conserve fuel. Hypersonic cruise, fuel cell technologies, hybrid sensors, improved human-machine interface using data analytics and bio-mimicry, combination of materials, apertures and radio frequencies that ensure survival in enemy territory are under development. Things will be built faster, better and more affordably, using 3D printing yet ensuring quality and safety standards. Additive 3D manufacture creates a world with spare parts on demand, faster maintenance and repairs, more effective electronics, and customised weapons. The development of a hypersonic aircraft would forever change ability to respond to conflict. Nano-materials will control sizes, shapes and compositions, and significantly reduce weight yet create stronger structures for air and spacecraft, yet drive down costs.

Heavy Aircraft Stealth

Fighters like the F-35 and F-22 may be stealthy, but their support assets, like aerial tankers, JSTAR, AWACS etc. are not. USAF needs 'heavy stealth revolution' for low observable tankers, transports, bombers and 'flying sensor and communications trucks'[15], as these will be targeted. USAF could adapt the new stealth bomber design for the stealth tanker role. It will also give ability to insert special operations teams deep behind enemy lines via a stealthy high-altitude penetrating transport.

Other Sixth Generation Aircraft Programmes

Japanese sixth-generation fighter would be based on concept of aircraft informed, intelligent and instantaneous. Japan already conducted the first flight of the Mitsubishi X-2 Shinshin[16] test-bed aircraft for this project. Russia says the aircraft will most likely be pilotless. For now the FGFA Sukhoi Su-57 is being inducted. The Mikoyan MiG-41 is reportedly a sixth-generation jet fighter interceptor aircraft currently being developed for the Russian Air Force. France and Germany announced they would jointly develop

a new combat aircraft to replace the Eurofighter, Tornado and Rafale. It is likely to be a twin-seat "system of systems" aircraft acting as a combat platform as well as controlling UCAV's. France has abandoned any attempt to develop an indigenous fifth-generation fighter and has moved resources directly to development of a sixth-generation fighter aircraft. UK is committed to a next generation fighter programme to potentially replace the Eurofighter Typhoon post-2030. China is still evolving its J-20 and J-31. Some Chinese publications are talking of a sixth generation aircraft. referred to as Huolong (Fire Dragon). But as on date China has serious limitations on radar, avionics, and engine technologies.

Wake Up Time India

IAF today has 4th Generation fighters in upgraded Mirage 2000, MiG-29 and Su 30 MKI. Other than Mirage 2000, all are twin engine. The soon to induct Rafale is of 4th Gen-plus class. In the not so far future LCA will be the only single engine aircraft. IAF needs more 4th Gen-plus aircraft. The LCA production is slow and the initially planned 123 aircraft could take at least 8 to 10 years to induct. The 200 LCA Mk II will earliest start induction around 2030. The Sukhoi/HAL Fifth Generation Fighter Aircraft (FGFA) ran serious developmental and cost road-blocks, and has been abandoned. The HAL Advanced Medium Combat Aircraft (AMCA) is an Indian programme of a fifth-generation fighter aircraft. It is a single-seat, twin-engine, stealth super-manoeuvrable all weather multirole fighter aircraft. Lessons learnt from LCA programme need to be imbibed and used to get the AMCA become a success to propel India into the new league. As on date the AMCA is still at project definition stage. At best the first flight could be around 2028 and induction around 2035. With fast depleting squadrons IAF will require 500 fighter aircraft of 4th Gen-plus class. In the long term, IAF should have a good mix of 300 Su-30 MKI, 250 LCA Mk II, 36 Rafale, 114 MMRCA class new fighters, and 150 AMCA. It is time to get the act together and think ahead, lest India get left behind once again.

Endnotes

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