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> *"There's a requirement to safeguard our assets with counter space capabilities. We must build resilience and redundancy in a space-based infrastructure"*
>
> *- General Anil Chauhan PVSM UYSM AVSM SM VSM*

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Indian Military Aviation's French Connection Blossoms Further as Rafale M, Safran Engine Deals Set to Deepen Ties

Air Marshal Anil Chopra (Retd)
Director General, Centre for Air Power Studies |
14 July 2023

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Rafale in France for Bastille Day Flypast. Image courtesy Armée de l'Air et de l'Espace

Indian Prime Minister Narendra Modi is in France as the guest of honour at the Bastille Day Parade. There are plans to move forward in many areas of cooperation ranging from defence, security to energy. Three Rafale fighter jets of the IAF are taking part in the Bastille Day flypast over the Champs Elysees in Paris on 14 July, and a tri-services contingent is participating in the parade along with their French counterparts. There are events and actions that indicate the great bonhomie between the two friendly nations and strategic partners, and the chemistry between the leaders.

But clearly, the loudest buzz is about the aviation deals. The visit may see the announcement of India purchasing 26 carrier-capable Rafale-M aircraft for the Indian Navy. India has been in talks with France's Safran Group for joint development of a fighter aircraft engine for India's fifth-generation fighter, the Advanced Medium Multirole Fighter Aircraft (AMCA). Hindustan Aeronautics Ltd (HAL) has already made the Turbomeca (a Safran company) supported 'Shakti' helicopter engine.

Safran Helicopter Engines and HAL are now set to form a joint venture (JV) for developing an indigenous aero-engine for Indian Multirole Helicopter (IMRH), which will be built in large numbers in the near future. These deals if they go through, would take the relations between the two to the next higher level. Of course, there are also plans to announce the deal to make three additional Scorpene submarines in India. Indian Navy already operates six India-made Scorpene (Kalvari-class) submarines.

France: India's Time-Tested Strategic Partner

Indo-French relations date back to 1674 when the French arrived in India at Pondicherry. They later created colonies at Pondicherry, Karikal, Yanam, Mahe and Chandanagar. All these were peacefully transferred to India in 1954. Paris and New Delhi have had warm and business-friendly relations from the very beginning. French supported India during the Cold War and also tacitly supported India as a nuclear power. India and France signed a strategic partnership in January 1998.

French have been pioneers of world aviation. After WW II, aviation designer Marcel Dassault rebuilt the country's aviation industry. The MD 450 'Ouragan' was the first French-designed jet fighter to enter production. Military aviation is one of the most enduring solid pillars of the Indo-French relationship since the early 50s.

The Military Aviation Connect

In June 1953, India ordered 71 French Dassault Ouragans (Indian name Toofani). Additional aircraft were bought in 1957, taking the total to 104. Toofanis saw combat action in 1961 Goa operations and flew reconnaissance missions in the 1962 Sino-Indian war. The fleet was replaced by another Dassault aircraft, the Mystere IVA in 1957. India procured 104 Mystere and used them extensively in the Indo-Pakistani War of 1965. On 7 September 1965, an Indian Mystere shot down a Pakistani Lockheed F-104 Starfighter during a raid over Sargodha. The fleet was phased out by 1973.

Breguet Alize was a French carrier-based anti-submarine warfare aircraft. Twelve were acquired by Indian Navy and operated from aircraft carrier Vikrant. They took part in Goa operations and in the 1971 Indo-Pak war. Alizes operated till 1991. The Aerospatiale Alouette III a single-engine, French light utility helicopter was manufactured under license by HAL as 'Chetak'. Two more versions, lighter 'Cheetah' and re-engined 'Cheetal' were later developed for high-altitude operations including the Siachen glacier. Over 300 were built and many are still in service in the Indian Armed Forces and Coast Guard.

IAF Cheetah Helicopter in Siachen Glacier. Image Courtesy IAF

After a lull in the Cold War years, the Indo-French aerospace linkage got re-established when IAF purchased the British-led, Anglo-French jaguar Deep Penetration Strike Aircraft (DPSA) in the seventies. IAF later bought a pure French aircraft when they purchased 49 Mirage 2000s in the 1980s. Ten more were bought in 2004. The Mirage 2000 was the first fly-by-wire controlled aircraft of the sub-continent. Its weapon-integrated multi-mode radar gave the Indian Air Force (IAF) look-down/shoot-down capabilities. The aircraft brought IAF's first Beyond Visual Range (BVR) missile the Super R530 F/D and the all-aspect capable Magic 2 missile. IAF got the first comprehensive EW suite on any aircraft with a self-protection jammer, radar warning receiver, chaff and flare dispenser, an escort jammer and an ELINT Pod.

Mirage 2000 performed exceedingly well in the 1999 Kargil conflict. The battle took place over some of the highest terrain in the world, where both the aircraft and weapons were closer to the edges of the envelope. Laser-guided bombs were used against reinforced targets. A very high sortie generation rate made the Mirage 2000 one of the most efficient fighters of the IAF. The aircraft was later upgraded to the Mirage 2000-5 Mk 2 standards and had improved avionics, a glass cockpit and smarter weapons. Mirage-2000 was the platform of choice for the Balakot Strike in 2019 where it hit targets with the Spice-2000 precision glide bombs.

Rafale the Game Changer

The purchase of 36 Dassault Rafale was announced during Prime Minister Modi's visit to France in 2015. The aircraft purchased in a government-to-government (G2G) are now fully operational in two fighter squadrons of the IAF. The twin-engine, fly-by-wire, omni-role fighter can do multiple missions in the same flight, simultaneously flying air superiority, reconnaissance, interdiction, and airborne nuclear deterrent missions. The aircraft has partial stealth features, with reduced radar cross-section (RCS) and low infrared signature. The aircraft is powered by two Safran Snecma M88 engines. A thrust vectoring variant of the engine

designated as M88-3D is also under development. The aircraft's RBE2 AA active electronically scanned array (AESA) radar has already been operationally tested. The SPECTRA integrated electronic warfare suite provides long-range detection, identification and accurate localization of infrared homing, radiofrequency and laser threats. The system incorporates a radar warning receiver, laser warning, and missile approach warning (MAW) features.

The aircraft's 14 hard points can carry 9,500 kg external loads. The air-to-air missiles include MBDA MICA and Meteor. Meteor BVR offers multi-shot capability against long-range manoeuvring targets, jets, UAVs and cruise missiles in a heavy electronic countermeasures (ECM) environment with a range well in excess of 150 kilometres. The no-escape zone of over 60 km is the largest among air-to-air missiles according to the manufacturer. Among the host of air-to-ground weapons is the MBDA Storm Shadow/SCALP-EG cruise missile with a 450 kg warhead and 560 km range. The 60-kilometre range HAMMER (Highly Agile Modular Munition Extended Range) can be fitted on 125 to 1,000 kg bombs. The Rafale has been used in combat in Afghanistan, Libya, Mali, Iraq and Syria. The aircraft is a game-changer and will help India dominate both the Himalayas and Indian Ocean Region (IOR). They have recently flown extended-range deep-sea missions and are regularly operating over the Himalayas.

Air Exercises

Exercise 'Garuda' series with the French Air and Space Force (FASF) began in 2003 at Air Force Station Jodhpur, India. Subsequently, they were held in 2005, 2006, 2010, 2014, and 2019. The other locations included Istres and Mont-de-Marson in France and Kalaikunda in India. French and Indian Rafale fighter aircraft, French A-330 Multi Role Tanker Transport (MRTT) aircraft, Indian Su-30 MKI, LCA Tejas, Jaguar fighter aircraft, the Light Combat Helicopter (LCH), and Mi-17 helicopters have participated. IAF also fielded combat-enabling assets like Flight Refuelling Aircraft (FRA) and AEW&C. The joint exercises were meant to augment the "operational capability and interoperability, while also sharing best practices." In August 2022, a contingent of the FASF made a strategically important stop at the IAF's Sulur base in Tamil Nadu on their way to Exercise Pitch Black 2022 in Australia.

Aero-Engine Connection

India already has experience in the manufacture, overhaul and maintenance of Turbomeca Artouste IIIB and the HAL/ Turbomecca TM 333-2M2 Shakti engine for helicopters. The Mirage 2000 was initially powered by the M53-5, and later with more powerful M53-P2. These are being fully maintained and overhauled in India. The Rafale is fitted with two Snecma M88 engines. All these are Safran group engines. Both the IAF and HAL have worked closely with French companies and are very well-versed with the French fighter and helicopter engine technologies, and working culture. India has already chosen the GE-414 for LCA Mk2 and the same will be produced in India.

At best India will get production technology transfer with that engine, as the engine is already fully developed. India still needs its own home-designed engine with intellectual property rights. Though India's GTRE 'Kaveri' may not have seen sufficient success there is a wealth of experience gained, experienced skilled designers and

manpower, and data available. A joint venture with Safran could ensure that India has its own engine for the indigenous fifth-generation AMCA. It will cost money, but then India must pay if it one day wants to sit on the global defence-manufacturing high table. The details of the deal will evolve in due course of time.

Way Ahead

With the IAF down to 31 squadrons, its edge over Pakistan Air Force (PAF) has reduced from 3:1 to an all-time low of 1.5:1. Gap with the Chinese PLAAF is widening. In view of the two-front threat, and to get back to the authorised 42 squadrons quickly, IAF has been pushing the case to purchase 114 new fighters. These are required, as the LCA and AMCA programmes are still evolving and will take time.

The country seems to have decided to acquire 26 Rafale-M for the Indian Navy. 36 Rafale are already operating with the IAF. India has also paid for one-time India-specific enhancements and has an airbase and technical infrastructure for additional squadrons. Instead of acquiring yet another type of fleet, India may wish to acquire the Rafale for those 114 aircraft for the make-in-India deal.

Delhi considers France as the more reliable Western 'friend'. India has a huge fleet of Airbus civil aircraft. India has now decided to convert pre-used, ex-Air India, Airbus A321 and A319 aircraft into IAF's new airborne early warning and control (AEW&C) and flight refuelling aircraft (FRA). The airframe modifications for both will be done by the OEM. The engine joint venture with Safran, if successful, will be a game-changer. The time to decide and act is now, lest we miss the flight again.

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Multi-Nation Exercise Tarang Shakti: IAF Trains for Global Operations

Air Marshal Anil Chopra (Retd)
Director General, Centre for Air Power Studies | 11 July 2023

Source: First Post | https://www.firstpost.com/opinion/multi-nation-exercise-tarang-shakti-iaf-trains-for-global-operations-12853222.html

courtesy IAF

IAF is planning its biggest air exercise to bring 12 nations to large-force engagements on Indian soil and shores. The "Tarang Shakti" will see fighter combat jets and large transport aircraft in action, supported by force multipliers. IAF's global engagements are on the rise. Three Rafale fighter jets of the IAF will take part in the Bastille Day flypast over the Champs Elysees in Paris on 14 July. Prime Minister Narendra Modi will attend this year's Bastille Day Parade as the guest of honour and a tri-services contingent will participate in the parade along with their French counterparts.

IAF Going Big on Exercises and Interoperability

IAF and USAF participated in the bilateral US Pacific Air Forces (PACAF) sponsored Field Training Exercise (FTX) Cope India series, conducted in India. Beginning at Gwalior in February 2004, the exercise was repeated in 2005, 2006, 2009 and 2018. Cope India-2023 was held in April this year across Kalaikunda, Panagarh

and Agra bases. It included air engagements, demonstrations, as well as lectures on aviation subjects. It helped both sides in evaluating their intercept techniques and tactic. The IAF fielded Su-30s, Mirage 2000s, MiG 27s, Jaguars, and MiG 21s, and the USAF, F-18s, F-15s, C-130 J, among others. Exercise has also included airdropping training.

Exercise Cope India

Exercise Garuda series is with the French Air and Space Force (FASF) since the first in 2003 at Air Force Station Jodhpur, India. Subsequently, they were held in 2005, 2006, 2010, 2014 and 2019. The other locations included Istres and Mont-de-Marson in France and Kalaikunda in India. French and Indian Rafale fighter aircraft, French A-330 Multi Role Tanker Transport (MRTT) aircraft, Indian Su-30 MKI, LCA Tejas, Jaguar fighter aircraft, the Light Combat Helicopter (LCH), and Mi-17 helicopters have participated. IAF also fielded combat-enabling assets like Flight Refuelling Aircraft (FRA) and AEW&C. The joint exercises were meant to augment the "operational capability and interoperability, while also sharing best practices". In August 2022, a contingent of the FASF made a strategically important stop at the IAF's Sulur base in Tamil Nadu on their way to Exercise Pitch Black 2022 in Australia.

Exercise Garuda. Jodhpur

The 17-nation Multilateral Exercise 'Pitch Black' was held in Darwin, Australia in September 2022. Exercise Pitch Black is held alternative years since 2006, hosted by the Royal Australian Air Force (RAAF). India began participating in 2018. The aim is to practice Offensive Counter Air (OCA) and Defensive Counter Air (DCA) combat, in a simulated war environment. It traditionally consists of a 'red team' and a 'blue team' based at separate locations, with one attacking the other. As inferred from the name of the exercise, it takes place in low-light conditions. All Quad members and many from Indo-Pacific were part of the exercise, with over 100 aircraft and 2,500 military personnel participating. The IAF fielded four Su-30 MKI and two C-17 aircraft. The participating forces took part in various multi-aircraft combat drills by day & night, simulating complex aerial scenarios, involving large formations, and combined force engagements for enhancing interoperability and strengthening relationships in a dynamic warfare environment. It was also training for European countries' ability to project power into the Indo-Pacific. It gave exposure to a very large cross-section of aircraft including the F-35s.

Exercise Pitch Black

The Republic of Singapore Air Force (RSAF) and the IAF have been carrying out bilateral exercise SINDEX since 2004. They were held at airbases in India and Singapore. The RSAF's F-16 C/D Fighting Falcons and F-5E Tiger fighter aircraft and the IAF's Su-30 MKI, MiG 27, Mirage 2000 and Jaguar have been participating.

IAF and Royal Air Force (RAF), conduct Exercise Indradhanush since 2006, held in both India and the UK. Indian Su-30 MKI and Mirage 2000 could engage with RAF's Eurofighter Typhoons. Force multipliers from both sides take part. Lockheed Martin C-130J Hercules transport aircraft and RAF Regiment Paratroopers also practiced operations. The exercise included close combat and Beyond Visual Range (BVR) engagements.

IAF has also been participating in the US Air Force (USAF) Red Flag exercise in Nellis Air Force Base, and at Eielson AFB in Alaska in

the United States. Desert Eagle is a multilateral exercise organised by United Arab Emirates Air Force. IAF has also been participating in the exercise Eastern Bridge with Oman. Blue Flag is a military aviation exercise held by the Israeli Air Force. In July 2022, the IAF carried out a one-month-long engagement with the Egyptian Air Force (EAF) at the Egyptian Fighter Weapon School, located at Cairo West Air Force Base. This was a first-of-its-kind interaction for both the air forces as it was conducted between their respective Fighter Weapon Schools.

The Japanese Air Self Defence Force (JASDF) and IAF participated in bilateral air exercise SHINYUU Maitri-18 in 2018 at the IAF airbase in Agra. In January 2023, the bilateral air exercise Veer Guardian 2023 was held between the IAF and Japan Air Self-Defence Force (JASDF) in Japan. IAF's Su-30 MKI and JASDF's F-2 and F-15 aircraft participated. IAF participate in Exercise Orion at the Mont-de-Marsan airbase in France and exercise INIOCHOS at Andravida base in Greece, hosted by the Hellenic Air Force, both held in April-May 2023.

Major Planning and Execution Considerations

The large force, bilateral and multilateral air exercises between major professional air forces require months of planning and coordination. Selection of area of operation that allows adequate airbases, radar positioning, para-drop areas and also firing range in case live firing is involved. The planning has to factor in multiple aircraft flying in confined spaces involving slow-flying helicopters and UAVs to very high-speed fighters and engaging in combat manoeuvring. The pace for the exercise is set by initially doing smaller packages and increasing the degree of difficulty in a graduated manner. There is a need to de-conflict flight paths. The air engagements have to be closely controlled or monitored by ground-based and airborne radars. The radio procedures have to be coordinated. The mission commanders have to be designated. Flight safety and operational issues have to be managed. Each mission must have clearly spelt out the aim and detailed briefing. There is always a detailed safety and operational debrief. The air effort must draw lessons for all air and ground crew.

In addition to enhancing combat knowledge by imbibing the best practices of other air forces, it also improves interoperability. Young aircrew get exposure by flying aircraft of other air forces. Social and casual interactions help exchange ideas and imbibe knowledge. Special lectures are organised to educate the participants. These exercises are also a part of defence diplomacy. There are cultural events and exchanges. IAF benefits from exposure to air exercises with all the world's major air forces. The frequency and number of air exercises have gone up in recent years. After a short pandemic-related lull, the pace has picked up. The saying "More you sweat in peace, less you bleed in war" is best exemplified by these air exercises. India must be proud that all Western air forces have rated IAF aircrew as great professionals and very superior in their air combat capabilities.

Why Repeat Exercises

It is pertinent to note that since newer operational equipment keeps inducting and also the crew keep changing, there is thus a need to repeat the exercises every few years. Such international exercises give exposure to large-force engagements with dissimilar aerial platforms. They also expose the IAF crew to different tactics and flight techniques under

electronic and cyber warfare conditions.

Tarang Shakti

The initial inputs on IAF's mega-multilateral exercise 'Tarang Shakti' planned around October-November later this year indicate that the air forces of 12 nations will participate. It will be the biggest air exercise to be conducted in India. Invited air forces will participate with fighter and transport aircraft and other force multipliers. Initial indications are that FASF, RAAF, USAF, and RAF are likely to participate. The location has not been announced but is likely to be in central India. There are likely to be large-force engagements, long-range missions, and maybe joint exercises with elements of Special Forces, and maritime strikes. Also, they will look at "no War No Peace" scenarios.

Air Power And Exercise Tarang Shakti

"Airpower is the most difficult of all forms of military force to measure, or even express in precise terms," said Winston Churchill, many years back. Air power capabilities result directly from its characteristics of speed, range, and elevation. Military operations in the air and space are significantly different from those of the land or sea mediums. The capabilities of air power are operational flexibility, responsiveness, range, precision, and mobility. Aircraft are able to scurry over vast ranges, independent of sea or land boundaries. Air forces provide global range and global power.

Air power is the integrated employment of all air and space forces to control and exploit the air and space environments to achieve national security objectives. Air power exploits the properties of its operating medium to realise unique operational characteristics and thus employ unique capabilities to provide the nation with a broad range of military options. The fundamental strengths of Air Force air power are air superiority, reliable global mobility, rapid global employment, and global situational awareness.

The concentration of force is a product of air power's responsiveness, mobility, and tremendous agility of manoeuvre. Concentration is not measured in numbers, but in overwhelming effect, at the decisive time and place. Centralized control, and decentralized execution, is an important approach to air power and needs training. All these need to be tested and exploited. With very long-range weapons and platforms, and due to the highest impact of changing technology, the platform employment and tactics change. There is thus a need for regular air exercises. These exercises are required not only for the air warriors, and to improve interoperability between friendly air forces, but also to sensitize the joint staff and the political leadership.

IAF is fast transforming from a continental air force to one with global reach. It now has trans-domain operations capability and prides itself on its reach, flexibility, versatility, responsiveness and offensive lethality. In keeping with the evolutionary nature of air power and the need to stay relevant across the spectrum of conflict in an inter-connected environment, there is a need for exercises and doctrinal reviews. Exercise Tarang Shakti will help us understand the nuances of capabilities and application of air power.

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F-35s for India: US Stealth Fighters Good Interim Investment for Indian Air Force to Counter Growing Chinese J-20 Numbers

Air Marshal Anil Chopra (Retd)
Director General, Centre for Air Power Studies |

16 July 2023

Source: Eurasian Times | https://www.eurasiantimes.com/f-35s-for-india-us-stealth-fighters-good-interim-investmen/

F-35/Representational Image

The United States just approved the sale of 24 Lockheed Martin F-35A Joint Strike Fighters to the Czech Republic. The deal will include a plethora of weapons and spares in a contract worth around US$5.6 billion.

The purchase also includes 25 Pratt & Whitney F135-PW-100 engines. It is meant to strengthen NATO operations in the region. They had chosen the fifth-generation fighter over the Lockheed F-16 and Saab Gripen JAS 39 fighter. Interestingly, Czech Air Force already operates 12 Gripen jets.

In another development, Israel announced purchasing 25 more F-35 stealth jets in a US$3 billion deal. It will bring the number of F-35s in Israel's Air Force to 75.

The deal will be financed through Israel's defense aid package from the United States. Israel was the first country outside the United States to acquire the F-35, called "Adir" (Mighty) in Hebrew.

Also, in May 2018, Israel was the first to use the aircraft in combat. Lockheed Martin and engine manufacturer Pratt & Whitney have agreed to allow Israeli defense companies to make aircraft components.

Lockheed Martin F-35 Lightning II

The F-35 is a single-seat, single-engine, all-weather, stealth multirole combat aircraft designed for air superiority and strike missions. It also has electronic warfare and intelligence, surveillance, and reconnaissance capabilities.

The principal partners in the program with Lockheed Martin are Northrop Grumman and BAE Systems. The three main variants are the conventional take-off and landing (CTOL) F-35A, the short take-off and vertical-landing (STOVL) F-35B, and the carrier-based (CV/CATOBAR) F-35C. The aircraft won the Joint Strike Fighter (JSF) program competition in 2001.

Mostly funded by the US, others who made financial contributions included the United Kingdom, Australia, Canada, Italy, Norway, Denmark, the Netherlands, and Turkey. Turkey was excluded after it procured the Russian S-400 air defense system. The UK was the only Tier 1 partner.

The technology demonstrator X-35A first flew in October 2000. The F-35 prototype aircraft first flew in 2006. The F-35B entered service with the US Marine Corps in July 2015, the US Air Force F-35A in August 2016, and the US Navy F-35C in February 2019. The aircraft has a design service life of 8,000 hours.

The very extensive initial flight test phase was completed in April 2018. The US proposes to buy around 2,500 F-35s through 2044 and operate till 2070.

As of June 2023, nearly 950 have been built. The aircraft was expected to eventually replace a large number of US multirole and strike fighters such as the Harrier, F-16, F/A-18, A-10, and F-117.

F-35 Design Features

The F-35 has a wing-tail configuration with two vertical stabilizers canted for stealth. Composites comprise 35 percent of airframe weight. At 13,300 kg empty weight, the F-35 is considerably heavier than the lightweight fighters (F-16, 8,573 kg) it replaces.

Internal weapon carriage reduces drag, and the powerful F135 (191 kN) single-engine allows Mach 1.6 speed with a full internal payload.

The thrust/weight at 0.87 at gross weight (1.07 at loaded weight with 50% internal fuel) compares with 1.095 (1.24) respectively for F-16s. The F135-PW-600 variant for the F-35B incorporates the Shaft-Driven Lift Fan (SDLF) to allow STOVL operations. Roll control during slow flight is achieved by diverting unheated engine bypass air through wing-mounted thrust nozzles.

Aircraft have great high angle-of-attack characteristics and maneuver agility. The avionics and sensor fusion enhances situational awareness and net-centricity. The F-35 has better stealth features than the F-22.

The APG-81 AESA radar is among the best in the class. The helmet display is a key piece of the F-35's human-machine interface, allowing "see-through" the aircraft view and off-bore-sight cuing of sensors and weapons.

The aircraft has a top-end electronic warfare system. F-35 has been tested in a manned-unmanned teaming role.

Weapons Platform

The aircraft has two internal weapons bays with two weapons stations each. For non-stealthy missions, the aircraft can use six external weapons stations. Carriage capacity is 2,600 kg on internal hardpoints, and 6,800 kg on external, totaling 8,400 kg.

These can carry combinations of the latest American stand-off weapons and air-to-air missiles. The internal stations can carry the AIM-120 AMRAAM and, eventually, the AIM-260 JATM. The aircraft also carries chaffs, flares, and towed decoys.

A weapon rack enabling the internal outboard station to carry two AIM-120s is being developed. It will increase the internal air-to-air payload to six missiles in Block 4.

Nuclear weapons delivery via internal carriage of the B61 nuclear bomb is planned for Block 4B in 2024. Hypersonic missiles and direct energy weapons are being considered as future upgrades.

F-35 Further Development

The aircraft is currently at Block 3F standard. The plan is to continually upgrade under Continuous Capability Development and Delivery (C2D2) plan over its lifetime.

The next stage will be Block 4, which will integrate additional weapons, refresh the avionics, and improve ESM capabilities. Also, have agile software, more powerful and efficient adaptive cycle engines, and a directional infrared countermeasures suite.

GE and P&W were awarded contracts to develop a 200kN thrust class engine and improve the baseline F135. The capability packages are planned to be incorporated by the mid-2020s. GE

expects that the A100 can enter service with the F-35A and C in 2027 at the earliest.

Aircraft-Related Concerns

The program did witness scrutiny and criticism for bloating costs, software glitches, and delayed deliveries. The three variants share just 25 percent of their parts, far below the anticipated commonality of 70 percent, thus adding program cost. At around $100 million per aircraft, the F-35 is expensive.

In 2001, the program was expected to cost about $200 billion for acquisition in base-year 2002 dollars. By 2017, delays and cost overruns had pushed the F-35 program's expected acquisition costs to US$406.5 billion, with total lifetime cost, including operations and maintenance (till 2070), to US$1.5 trillion in then-year dollars. The full-rate production has begun only in 2023.

It is also maintenance-intensive. The F-35A's cost per flight hour (CPFH) was $35,000 in 2019, compared to US$17,716 for the A-10 and US$22,514 for F-16C. Lockheed Martin hopes to reduce it to US$25,000 by 2025. Many question the idea of using the same basic design to create many variants, thus making compromises.

It also meant putting all eggs in a single basket. There was no backup, and delays and costs had to be lived with. Some analysts believe it is much less reliable at a 69 percent readiness rate than the much lighter and cheaper F-16 it was meant to replace. Around 12 F-35s have been lost to accidents to date.

Meanwhile, China has imposed export control on gallium & germanium items. This could impact the production of F-35s and other AESA radar-equipped aircraft.

Gallium is the only element used in AESA radars, and China produces 95% of Gallium. Like the F-22, the F-35 has been targeted through cyber-attacks for intellectual property design theft by China.

Operating Nations

The militaries of Australia, Belgium, Canada, Denmark, Finland, Germany, Israel, Italy, Japan, Netherlands, Norway, Poland, South Korea, Singapore, Switzerland, the United Kingdom, and the United States currently operate F35s.

Taiwan was once keen to acquire F-35s. However, the US was reluctant to sell because of the risk of compromising classified data if the Chinese military officials got access to the aircraft.

The US turned down Thailand's desire to buy 8 to 12 aircraft in May 2023 and offered F-16 Block 70/72 Viper and F-15E Strike Eagle fighters instead.

F-35 sales to Turkey, a founding partner in the program, were banned after it bought the Russian S-400 air defense system.

The United Arab Emirates initially wanted to purchase F-35s but later withdrew as it was not ready to agree to the additional terms imposed by the US.

Operational Deployments

USMC F-35Bs participated in their first Red Flag exercise in July 2016 and flew 67 sorties. The first F-35B foreign deployment was at MCAS Iwakuni, Japan in 2017.

Combat employment began in July 2018 from the amphibious assault ship USS Essex, with the first combat strike on 27 September 2018 against a Taliban target in Afghanistan.

F-35Bs operated from temporary bases in the allied territory within hostile missile engagement zones. The first USMC F-35C squadron became operational in July 2021 and was first deployed on board a carrier in January 2022.

The USAF F-35As conducted their first Red Flag exercise in 2017 and reportedly scored a kill ratio of 15:1 against F-16 aggressors. The first USAF F-35A deployment occurred in April 2019 to Al Dhafra Air Base, UAE, and was first used in combat in an airstrike on an Islamic State tunnel network in northern Iraq in the same month.

The first combat use of an RAF F-35B was in June 2019 as armed reconnaissance flights searching for Islamic State targets in Iraq and Syria. Since January 2022, Norway's F-35As replaced its F-16s for the NATO quick reaction alert mission in the high north.

The Israeli Air Force reportedly flew a test mission of three F-35Is to Iran's capital Tehran and back to Tel Aviv in July 2018. Soon, the Israeli jets had been flown "all over the Middle East" and brought photographic evidence. In July 2019, Israel expanded its strikes against Iranian missile shipments and struck Iranian targets in Iraq twice.

The aircraft is now being used to strike Hamas targets in the northern Gaza Strip. On March 6, 2022, F-35Is shot down two Iranian drones carrying weapons to the Gaza Strip. This was the first operational shootdown and interception carried out by the F-35.

F-35 and India

The US has not offered F-35 to India, but New Delhi's geopolitical interests are drawing it closer to Washington. India has not formally sought an F-35 briefing on the aircraft.

However, some briefings have been given at delegation levels. The F-35s were brought to Aero India 2023, where they conducted daily flight demonstrations.

This was the first time a fifth-generation aircraft operated on Indian soil. Was that a hint to the Indian establishment? However, the US wants India first to buy the F-16, F-18, or F-15 class of aircraft for its fighter aircraft ecosystem. Also, there is the issue of India having purchased the S-400 air defense system from Russia.

India's own AMCA induction with stealth features is at least 15 years away. One school of thought would be to acquire two squadrons of F-35A if the US is willing to give. But an even higher priority for India is to get the 114 fighters for which the Request for Proposal (RFP) has still not been sent out.

Another question is whether India is ready to have yet another small fleet in its already multiple fighter fleets. Another priority area for IAF is additional AEW&C and FRA. Buying and maintaining the F-35 will be an expensive exercise.

But considering that India is already the fifth largest economy and will soon be the third largest, India would have to spend on security.

Due to Russian supplies, hold-up IAF currently has surplus capital funds. China has already inducted 150 fifth-generation J-20s. Pakistan is increasing its fighter squadron strength. India is still at the LCA Mk1 stage. LCA MK1A and Mk2 are important interim stages before AMCA.

Buying around 40 F-35 and their weapons could enhance IAF's operational capability and be a significant deterrent. India's security establishment must take its call. It is important to

get IAF fighter aircraft numbers up quickly. This is also important if theaterization happens soon.

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Air Power

Indian Air Force Moves Tejas Jets in Kashmir for Flying Experience in the Valley

Nisha Anand | 30 July 2023

Source: Hindustan Times | https://www.hindustantimes.com/india-news/indian-air-force-latest-news-tejas-jets-in-kashmir-latest-news-flying-experience-in-valley-101690694113297.html

A still from Tejas.

The Indian Air Force has moved its indigenous Light Combat Aircraft Tejas to Jammu and Kashmir for the fleet to gain experience in flying in the valleys of the union territory situated along the border with Pakistan.

"The LCA fleet has been moved to forward bases for gaining experience in flying in the valleys and other operations. The pilots of the fleet are carrying out extensive flying there," defence officials said.

The Indian Air Force has multiple bases in the Union Territory which are critical for operations on both fronts including China and Pakistan.

The Indian Air Force keeps moving its aircraft in both the union territories in the Northern sector including Jammu and Kashmir and Ladakh to give them the experience of flying there in their unique terrain.

The IAF is strongly supporting the indigenous LCA Tejas fighter aircraft programme by adding more and more capabilities to the aircraft.

The IAF has already operationalised two of its squadrons in the initial operational clearance and final operational clearance versions while a contract has been signed for the 83 Mark1As set to be delivered a couple of years from now.

The Force has also its eyes set on the LCA Mark 2 and the AMCA being developed by the Defence Research and Development Organisation.

The Indian plane is already considered to be far more capable than the Pakistani and Chinese joint venture JF-17 fighter jet and with additions like the HAMMER, the Indian plane would be in a much higher category than them.

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India's RudraM-II Missile Success a Game-Changer for Indian Air Force

Yuvraj Tyagi | 28 July 2023

Source: Republic World | https://www.republicworld.com/india-news/general-news/indias-rudram-ii-missile-success-a-game-changer-for-indian-air-force-articleshow.html

Image: Twitter/@IAF_MCC (Representational)

Defence Research and Development Organisation's (DRDO) successful testing of the RudraM-II missile marks a significant milestone in India's air defence capabilities. This indigenous missile, tested for the first time in October 2020, is designed for deployment on the Sukhoi Su-30MKI fighter jet and Mirage-2000 aircraft, empowering the Indian Air Force (IAF) with enhanced firepower.

With a formidable range of 300 kilometres, the RudraM-II sets a new standard in air defence technology. Unlike its predecessor, the RudraM-I, which utilises a passive homing head (PHH) to target enemy surveillance and guidance radar systems, communication towers, and command centres emitting radiation, the RudraM-II incorporates an Imaging Infrared (IIR) seeker in addition to the PHH.

This powerful combination allows the missile to neutralise various targets, including airstrips, bunkers, and aircraft hangars, making it a versatile and potent asset for the IAF.

Role of Anti-Radiation Missiles in Modern Warfare

Anti-Radiation Missiles (ARMs) like the RudraM-II play a pivotal role in modern air defence warfare. Originally invented to disrupt enemy communication and tracking capabilities by targeting radar stations, these missiles are primarily launched from aircraft to neutralise ground and ship targets. In the ongoing Russia-Ukraine war, the deployment of ARMs has garnered keen interest from the Indian defence establishment, as these missiles prove their mettle in targeting enemy air defences.

The RudraM-II missile's successful testing, confirmed by DRDO's chief Dr. SV Kamat, represents a significant advancement in India's air defence capabilities. Developed for deployment on the Sukhoi Su-30MKI and Mirage-2000 aircraft, this indigenous missile provides a considerable boost to the Indian Air Force's firepower, as it can target the enemy at a range of 300 kilometres.

The RudraM-II missile's successful testing, confirmed by DRDO's chief Dr. SV Kamat, represents a significant advancement in India's air defence capabilities.

As the DRDO's successful testing of the RudraM-II validates India's growing prowess in defence technology, the Indian Air Force gears up to leverage the advanced capabilities of this indigenous missile. The RudraM-II's precision targeting and impressive range establish it as a game-changer in India's air defence arsenal.

With these cutting-edge assets at its disposal, India also strengthens its position on the global stage and advances its commitment to self-reliance in defence manufacturing.

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Rafale to Get More Lethal as IAF asks Dassault to Integrate Astra Missile

Sayantani Biswas | 23 July 2023

Source: Live Mint | https://www.livemint.com/news/india/rafale-to-get-more-lethal-as-iaf-asks-dassault-to-integrate-astra-missile-smart-anti-airfield-weapon-11690106047425.html

Rafale fighter jets (AP)

The Indian Air Force has asked Rafale fighter jet manufacturer Dassault Aviation to integrate Indian made weapons like the 'Astra Air' to air missile on the combat aircraft. The move, if implemented could prove to be a big step for the 'Make in India' initiative, wherein indigenously made weapons would be integrated into the globally popular fighter jet.

The French made Rafale Fighter jets are used by many countries including India, France, Egypt, Qatar and many others along with Greece, Croatia, UAE and Indonesia, have placed orders for these planes.

The IAF has been using the Astra Air since 2020. The Indian weapon systems are already integrated into the Su-30 MKI combat aircraft along with the indigenous LCA Tejas.

"The IAF has asked the original equipment manufacturer Dassault Aviation to integrate Indian-made weapons like the Smart Anti Airfield Weapon (SAAW) and the Astra air-to-air missile with the Rafale which has been in service with the IAF since 2020," defence officials told news agency ANI.

Along with these DRDO-developed missiles and bombs, the IAF also has plans of integrating multiple indigenously designed weapons by private sector firms including long-range glide bombs with the aircraft in the near future, they said.

India operates 36 Rafale fighter jets and has already expressed intent to buy 26 Rafale marine aircraft which are to be used by its Navy.

The Indian Air Force top brass have been pushing for indigenous solutions for their war-fighting requirements to be self-reliant, especially in times of conflict.

A lot of weapon systems acquired by the force during the ongoing standoff with China have also been put on the indigenisation path.

The Indian Air Force has asked Dassault Aviation to integrate Indian-made weapons on the Rafale fighter jet, a move that could benefit the 'Make in India' initiative. The IAF wants to integrate weapons like the Astra air-to-air missile, Smart Anti Airfield Weapon, and long-range glide bombs.

The Astra air-to-air missiles are capable of striking targets up to the 100 Km range but very soon this will be extended to 160 KMs in the Astra Mark 2 while the further upgraded version would be one with a strike range of 300 Kms.

The SAAW can also hit targets at 100 Km plus range and its advanced versions are also being developed.

"The private sector companies have also developed missiles and bombs which can hit targets from long ranges and can be equipped on the Rafale," the officials said.

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Russia-Ukraine Conflict: Ukraine Offensive for Getting Decisive Gains by UJ-22 Drones

Prof (Dr) Dinesh Kumar Pandey | 19 July 2023

Source: CAPS India | https://capsindia.org/russia-ukraine-conflict-ukraine-offensive-for-getting-decisive-gains-by-uj-22-drones/

An unprecedented number of unmanned aircraft have been observed in the conflict between Russia and Ukraine. As the first major conflict to make substantial use of military and commercial drones, the Russia-Ukraine conflict may be portrayed as a drone war. Ranging from kamikaze loitering weapons and bomb-dropping octocopters to airliner-sized observation aircraft, a variety of drones are in action in this war. So much so that the Turkish Bayraktar TB2 has become a symbol of Ukrainian resistance against the Russians. Drones have been used to not only destroy Russian air defences and fuel convoys in Ukraine but they have also sunk patrol boats and set fire to an oil storage facility in Bryansk, which is across the Russian border. Thus drones are proving to be very effective weapons during war combat.

Deep Penetration by Drone

On May 30, 2023, a large-scale drone attack was launched on Moscow. It was the first of such incident in the conflict that has been going on for the past 15 months. There were more than 30 drones involved in the offensive missions. It is the first time that Moscow has been significantly targeted in a single operation, but Ukraine denies being responsible for the strikes. Russia reportedly used the Pantsir-S surface-to-air missile system to shoot down five drones flying around the Moscow region.

Alexander Khinshtein, a member of the Russian parliament, stated that drones were shot down in five different areas in the Moscow region, including at least two flying over Rublyovka. This wealthy suburb is home to much of Russia's political elite as well as Vladimir Putin's Novo-Ogaryovo state residence. Khinshtein said that at least two of the drones were flying over Rublyovka when they were shot down.

According to speculation from Western analysts, at least one of the drones was most likely a UJ-22 model, a drone made in Ukraine by a company called Ukrjet. The UJ-22 Airborne was discovered in a forest approximately 30km from Moscow and is believed to have been rigged with explosives at its discovery.

According to Tass, a Russian state-owned news agency, two more drones fitted with cameras were discovered near Moscow. Following a complaint by Russian authorities a month ago about the presence of a drone approximately 15km northeast of Moscow, which they suspected originated from Ukraine, these three claimed discoveries of drones follow in their footsteps. Russia has asserted that such drones have been used in several previous failed terrorist plots.

Ukrainian 'UJ-22 Airborne'

Ukrjet is an enterprise that specialises in the construction and production of jets as well as multi-purpose unmanned aircraft systems (UAS). The UJ-22 Airborne is a multi-purpose drone capable of flight at any time of day or season, in both favourable and unfavourable weather

conditions, and in the presence of electronic countermeasures. It resembles a miniature version of a light aircraft, like the Cessna 172. The UJ-22 possesses substantial endurance in addition to having an exemplary range. It is a highly competent and flexible piece of aerial hardware designed to carry out a variety of missions. This drone was developed to function in environments with severe weather, making it an excellent choice for tasks that last for extended periods. Because of these capabilities, the UJ-22 Airborne drone is efficient and dependable equipment that can be used for various tasks. The UJ-22 airborne can carry out missions, including intelligence gathering, search and rescue, and other related activities, for the benefit of the Army, the police, and other rescue agencies.

With an inbuilt 64-megapixel camera, the UJ-22 Airborne also provides thermal imaging capabilities. It can offer high-quality battlefield imagery in real-time, making it a valuable tool for acquiring and tracking targets. Because of its capacity to fly autonomously, the UJ-22 Airborne is ideally suited for conducting tests of hostile air defences before deploying drones or missiles that are both more expensive and capable. In addition, it has an effective range of up to 100km. As a result, it can acquire crucial information about the enemy's defences and then relay that information back to ground forces, giving them accurate and timely information.

The UJ-22's vital technical specifications are included in the following table:

Weapons available	Free-fall bombs, four 82-mm mortar mines, or six PG-7VM munitions via an RPG-7 rocket launcher.
Wing Span	5 metres
Flight range	800km (500 miles)
Max speed	160kph (100mph)
Max service ceiling	6,000m (20,000ft)
Max payload	up to 20kg (44lbs)
Cruise speed	120kph (75mph)
Max flight time	7 hours
Min service altitude	50m (164ft)
External crew	4
Operating temperature Limits	-40 to +50°C
Average UAS set-up time (without flight mission input)	About 10 min. Launching an un-manned aerial vehicle takes an average of three minutes of preparation time.

Use in the Russia-Ukraine conflict

The Ukrainian Army officially adopted the UJ-22 Airborne in 2020. Notwithstanding this, Ukraine began using this drone between 2022 and 2023. The UJ-22 can attack static targets with ease. As a result of the drone's ability to drop its payload at predetermined coordinates, it is beneficial for engaging in combat against targets that remain in one place. This function enables precise targeting, resulting in the most significant possible impact on the intended target. The UJ-22 Airborne drone also features several control modes, each of which helps ensure the highest possible level of operating performance. Automatic, semi-automatic, or manual control of the drone and its payload are all viable options, depending on the needs of the operations.

On March 30, 2022, a Pantsir-S missile and gun system was responsible for destroying a UJ-22 Airborne in Ukraine. The video footage of this was provided by the Russian Ministry of Defence. According to reports from the defence department, the UAS was transporting an aerial bomb and 82mm calibre mines under its wings.

The crew of the Pantsir-S fighting vehicle quickly recognised the drone that was being operated by the Ukrainian armed forces and successfully shot it down with a single missile.

Conclusion

The UJ-22 Airborne is a multi-purpose drone that was developed primarily for use in the military. This reduced-size aircraft can function independently or be remotely controlled from a command centre. The UJ-22 Airborne is equipped with highly developed sensors, cameras, and communication systems, enabling it to perform various missions. These operations can range from neutral to offensive, including reconnaissance, surveillance, and target acquisition. In addition, this drone can carry out intelligence operations, search and rescue missions, and support the armed forces, police, and other emergency response services.

There have been few missions by manned aircraft due to air defences, such as long-range radar-guided systems and portable shoulder-launched weaponry. Drones have mostly substituted jets for gathering intelligence and carrying out airstrikes, particularly against armoured vehicles. Drones are familiar, simple to fly, and inexpensive; some are even operated directly by ground unit squads and even individual foot soldiers, who utilise them as weapons or to scan the battlefield. Conventional wars may be significantly configured by drones and UASs.

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Russia has Developed a New Kind of 'Sleeper' Drone Called the 'Joker'

Christopher McFadden | 26 July 2023

Source: Interesting Engineering | https://interestingengineering.com/innovation/russia-sleeper-drone-the-joker

The drones can strike without warning.

Russia has unveiled a new drone called the "Joker," that can sleep or hibernate for long periods before attacking, according to Russian news outlet TASS. Designed to hide from electronic countermeasures, the "Joker" drone could be placed in preparation for attack hours, days, or weeks before its operator wakes it to unleash death from above.

The report, originally posted in Russian (and Google Translated for our report), also explains how the drone could prove pivotal in Ukraine.

Sleeping Killer Drones

"A tool for hibernating FPV drones of the Joker line and its top model, Ultimatum, was developed and implemented at the Central Design Bureau. A drone with a hibernator can take a position for an attack and [hibernate] for several weeks. On the air, a sleeping drone does not manifest itself in any way." Dmitry Kuzyakin (director general of the Center for Integrated Unmanned Solutions) explained to TASS.

"As a rule, dominant heights, roofs of buildings, or other high structures are selected. When the time comes, he does not need to overcome the distance for the target. The drone

is already in place, and [it needs] to turn on and attack," he added.

Kuzyakin also explained that using the hibernation tool can reduce the time required to prepare the device for an attack, “Flying time is saved. A few seconds pass between turning on the drone and attacking, which leaves no chance of launching countermeasure systems. One FPV pilot can place, then 'wake up' and sequentially apply up to 15 'sleeping' drones."

The ongoing conflict in Ukraine has seen increasing use of drones on the battlefield, and the "Joker" drone is a natural progression of that trend. At present, the skies of Ukraine are filled with unmanned aerial vehicles, which both sides use to identify targets with the aid of low-cost commercial drones.

Recently, Ukraine successfully defended against an attack by Shahed-136 drones, loitering munitions made by Iran and purchased by Russia. Due to Western sanctions, Russia faces challenges in producing its munitions, hence the reliance on Iranian-made drones.

There are also reports that Russian authorities have deployed Orlan-10 unmanned aerial vehicles to gather intelligence and disrupt communication networks in Ukraine.

These drones are manufactured by a company based in Saint Petersburg and are exclusively used by the Russian military. The Orlan-10 has a smooth design, making it difficult to detect. It can be launched and landed using a catapult and a parachute.

Drone Revolution Imminent

"We are on the verge of an FPV revolution in armaments. Now, in a situation of a stable front, the scenarios that we see in Telegram channels are most in demand: attacks on enemy strongholds and hunting for armored vehicles. But if you look at the FPV tool wider and improve functionality, you can get ahead of the enemy not only in the technology itself but also in the scenarios of its application," Kuzyakin added.

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Space

PSLV-C56 Successfully Places 7 Singaporean Satellites into Orbit

Utkarsh Mishra | 30 July 2023

Source: Rediff.com | https://www.rediff.com/news/report/pslv-c56-successfully-places-7-singaporean-satellites-into-orbit/20230730.htm

ISRO launches its PSLV-C56 with six co-passenger satellites from Satish Dhawan Space Centre (SDSC) SHAR, in Sriharikota on Sunday morning.

Indian Space Research Organisation on Sunday successfully launched its proven Polar Satellite Launch Vehicle (PSLV) rocket carrying seven Singaporean satellites from Satish Dhawan Space Centre in Sriharikota and placed them into intended orbits.

Around 23 minutes after lift-off, the primary satellite got separated and it was followed by six other co-passenger satellites, which were deployed into the intended orbits sequentially, ISRO said.

This ISRO mission, which comes after the much-awaited Chandrayaan-3 launch earlier this month, is being undertaken by its commercial

arm NewSpace India Limited (NSIL).

ISRO Chairman S Somanath said, "The PSLV-C56 carrying seven satellites including primary satellite DS-SAR and six co-passenger satellites have been successfully placed in the right orbits."

After the 25 hour countdown that commenced on Saturday concluded, the 44.4 metre tall rocket lifted off majestically from the first launch pad at this spaceport, one minute after the prefixed time of 6.30 am, emanating thick fumes on its tail.

The lift-off time which was scheduled for 6.30 am today was later revised to 6.31 am as space debris was expected on the path of the rocket during its journey to the orbit.

"Change of lift-off time occurs when space debris come in the path of rocket. That is what happened today," an ISRO official told PTI.

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Another Journey to the Moon Begins with Chandrayaan-3

TH Anand Rao | 26 July 2023

Source: CAPS India | https://capsindia.org/another-journey-to-the-moon-begins-with-chandrayaan-3/

The launch of Chandrayaan-3 aboard Launch Vehicle Mark-3 (LVM-3) from Sriharikota on July 14, 2023, is much more than a spectacular show of rocketry. The scenes of joy, celebrations, and emotional moments that were witnessed from the launch control centre were the result of years of hard work and redemption from failure after the Chandrayaan-2 lander was lost in 2019. The Indian Space Research Organisation (ISRO) entered a 'zero-error syndrome' after the loss of Chandrayaan-2. For Chandrayaan-3, all efforts were made to ensure that errors that had been witnessed in previous missions were not repeated. To ensure this, a fail-safe model has been adopted by expanding the margins of tolerance to include risks that are likely to be encountered during the mission. These are highly complex missions. The only countries to have been successful in soft-landing on the Moon are the US, Russia, and China. India, Israel, and Japan have attempted Moon landings but have not been successful yet.

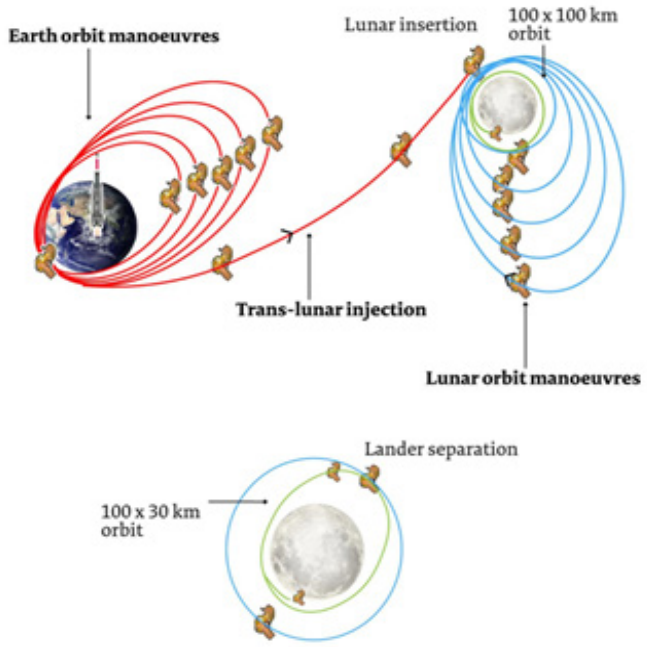
India's tryst with the Moon began 15 years ago with its first Moon mission, Chandrayaan-1, in 2008. Though Chandrayaan-1 was only an orbiter, it became popular for having done the first and most detailed analysis of the lunar surface for tracing water. It also established the presence of an atmosphere around the Moon. The outcomes of Chandrayaan-1 were remarkable and were applauded by NASA, the US space research organisation. Chadrayaan-2, India's second Moon mission, which launched in 2019, was different. It had an orbiter, a lander, and a rover. The mission was promising, and everything went seamlessly until the landing phase when the lander crashed on the Moon's surface due to inadequate deceleration. The orbiter, however, continues to orbit the Moon and has been sending images back to Earth. Chandrayaan-2 mission has been partially successful as the dynamics of reaching the Moon orbit and separation of the lander from the orbiter, as well as the descent phase of the lander, was flawlessly executed, and normal performance was observed till the lander reached an altitude of 2.1 km from the lunar surface. The orbiter is said to have a very high-resolution

camera (0.3 m) and is expected to be active for around seven years.

The mechanics of Chandrayaan-3 will be a repeat of its predecessor as a follow-on mission. Although it has no orbiter of its own, it will make use of the Chandrayaan-2 orbiter for relaying and communicating with the Earth station. The objective is to demonstrate the end-to-end capability of Earth-to-Moon transfer, landing, and roving on the lunar surface. This will be a precursor to all lunar missions in the future. The landing site was selected at the south pole of the Moon, a place yet to be explored. The lander is carrying four payloads, while the rover is carrying two payloads for conducting experiments on the Moon and its atmosphere. Chief among these are the instruments to measure near-surface plasma density and thermal properties and the instruments to assess the seismic activity at the landing zone. Instruments on the rover would do a qualitative and quantitative analysis of minerals on the Lunar surface, including an assessment of their chemical composition.

A journey to the Moon should normally take four to seven days, as was the case with the Apollo lunar landing missions of the US, which flew between 1968-1972. They used the powerful Saturn rockets, which could inject the spacecraft into lunar orbits in much lesser timeframes and cover a distance of around 3,84,000 km, one way to the Moon. Chadrayaan-3, however, has been launched on the LVM-3 rocket, which inserted the spacecraft into a much lower elliptical earth orbit that will take around 40 days to reach the Moon through a series of orbit-raising manoeuvres leading to a lunar orbit insertion. The soft landing on the Moon is likely to be attempted on August 23, 2023.

Figure 1: Chandrayaan 3's Path to Moon



Source: "Chandrayaan-3 | What it takes to soft-land on the moon," The Hindu, July 14, 2023, https://www.thehindu.com/news/national/chandrayaan-3-what-it-takes-to-soft-land-on-the-moon/article67045114.ece. Accessed on July 21, 2023

The Chandrayaan-3 mission has four phases, which include the Earth orbit phase, the Lunar orbit insertion phase, the Lunar landing phase, and the Lunar exploration phase. Though each phase has its own complexities and requires precise manoeuvres, the Lunar landing phase is the most critical one. Most unknowns are likely to occur in this landing phase as compared to the other phases. It was in this landing phase that the Chandrayaan-2 was lost. ISRO scientists have taken great care in incorporating the lessons learnt from the Chandrayaan-2 mission. Changes have been made in the Vikram lander module by strengthening the legs to withstand higher landing forces. The other changes include a higher fuel capacity to cater to repeated attempts at landing or moving to alternate landing sites and the inclusion of a laser Doppler instrument for more accurate velocity and altitude measurements. The lander engine software and design have also been modified to have more tolerance to variations and

disruptions. The spacecraft will have the capability to autonomously select a suitable landing site within the localised area. While modifications were critical, more emphasis was given to testing. The spacecraft has been subjected to drop tests and rigorous tests in various flight conditions for the past two years.

A successful landing on the Moon will place India in the select group of Moon-faring nations, with India being the fourth to achieve this feat. India will also be the first nation to land at the south pole of the Moon, which has immense significance for lunar exploration efforts. Having signed the Artemis Accords, India will certainly find prominence in international cooperation for future joint Lunar missions. India is already partnering with Japan in a joint Lunar exploration programme called the Lunar Polar Exploration Mission (LUPEX), which could be the next Lunar mission for India. If all goes well, a successful Chandrayaan-3 will achieve a one-way ticket to the Moon. To complete the capability cycle, a return journey also needs to be attempted. This is an even more complex process. Eventually, Moon missions need to aspire for sample returns for mineral resources and become human-rated to facilitate human presence on the Moon. This is a desirable capability for India to stay abreast of the developments in deep space exploration.

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Experts Warn of Blurring Line between Military, Commercial Satellites

David Roza | 27 July 2023

Source: Air and Space Force | https://www.airandspaceforces.com/military-commercial-satellites-blurring-line/

An artist's rendering of different Maxar Technologies satellites. Image courtesy of Maxar

As the Pentagon and other government agencies become more reliant on information provided by commercial satellites, the line between military and civilian targets in space will become increasingly blurred in future conflicts, three former Air Force space experts-turned-commercial space executives said during a panel discussion hosted by the Hudson Institute on July 26.

As a sign of things to come, the executives pointed to the role that communications and imaging satellites owned by SpaceX and Maxar Technologies have played in Ukraine's defense against Russia's invasion. Much of the U.S. military's current communication system also runs through commercial satellite systems, the panelists said.

"I think we're not spending enough time talking about the coupling between the commercial operators and the [Department of Defense] in a conflict that extends into space," said Even Rogers, former Air Force space operator and CEO of the space technology company True Anomaly.

"Commercial operators become targets when

they support the DOD," Rogers added. "In fact, I suspect that there are some incentives that would cause commercial operators to be targeted first as a strategic off-ramp in a broader conflict, because it is a gray zone, there is uncertainty about whether the United States intends to defend and protect … commercial providers."

Indeed, the same day of the Hudson Institute panel, the nominee for the next leader of U.S. Space Command, Lt. Gen. Stephen N. Whiting, told the Senate Armed Services Committee that the military ought to work more closely with industry to accelerate fielding new technologies.

Whiting's testimony also seemed to confirm the "gray zone" status of commercial space assets. When Sen. Jeanne Shaheen (D-N.H.) asked if an attack on U.S. commercial satellites constitutes an act of war, the general demurred, calling it a policy question and stating SPACECOM's job is to provide decision-makers options for defending commercial space capabilities.

"We must continue to partner with those companies, so that they look to build resilience into their systems," he said, so that, "if we do need to actively defend them, we have the communication avenues open to be able to do so."

Executives at the Hudson event made similar calls for close cooperation. The way to deter gray zone aggression and preserve the capabilities that the government relies on is to establish "rules of the road" for what constitutes acceptable behavior in space, said retired Air Force Col. Dean Bellamy, now executive vice president of national security space for Redwire.

Specific examples of behavior that could be normalized include rendezvous and proximity operations, where two spacecraft have to draw up close to one another in orbit, said Jason Kim, a senior policy analyst at the National Oceanic and Atmospheric Administration.

Commercial operators could hold a certain distance and broadcast what they are up to in order to promote transparency during such an operation, Kim suggested. But transparency requires constant awareness of events in orbit and an established process for dealing with bad behavior. Rogers pointed out that a similar system already exists on Earth in the form of air-to-air intercepts.

"Very rarely do air-to-air intercepts result in any sort of catastrophic activity," he said. "There's ways that I think industry partners and the government can work together to establish those procedures, demonstrate those procedures, and adhere to them."

Rogers' company, True Anomaly, produces Jackal, an autonomous orbital vehicle built to carry out rendezvous and proximity operations. Another panelist and former Air Force officer, Chris Shank, is vice president of defense and space programs at Maxar, whose imagery-producing satellites can track activity both on Earth and in orbit.

Both military leaders such as Whiting and civilian government officials like Kim say stability in space, secured with industry's help, benefits everyone.

"Space sustainability in general is a huge concern for all of us, not just for national security but for commercial and civil space," Kim said. "It's in all of our collective interest to maintain the sustainability of space and to not allow a war to escalate into space."

India Needs a Military-Space Doctrine, must Bet Big on Private Sector Firms

Manvendra Singh | 13 April 2023

Source: The Print | https://theprint.in/opinion/india-needs-a-military-space-doctrine-must-bet-big-on-private-sector-firms/1515449/

Mission Shakti tableau at R-Day parade | Wiki commons

The last frontier in physics has opened up applications of combat across all spectrums, so much so that "Space is a domain which is enhancing capabilities of other domains of land, sea, air and even cyber. The military application of space is the dominant discourse from which we cannot remain divorced," said Chief of Defence Staff Gen Anil Chauhan. His observations followed the recent announcement of the Indian Space Policy, 2023 by the Cabinet Committee on Security. That a seemingly business-oriented and pacific policy is announced by the CCS is a reflection of how important a domain space has evolved to be.

In a remarkable situational adjustment, Gen Chauhan provided some vital inputs on veterans' welfare at the long-awaited 31st Kendriya Sainik Board meeting on 11 April. And on the same day he addressed the next challenges of warfare in the inaugural session of the Indian DefSpace Symposium organised by the Indian Space Association (ISpA). This is ultimately how this combat domain is going to evolve, and the essence of the proceedings was about using space for greater situational awareness. The Defence Research and Development Organisation (DRDO) chief Samir V Kamat also stated that his organisation has increased its focus on the space domain.

The New Frontier

The ISpA seminar brought together public and private players active on the space front. This included the pioneering body Indian Space Research Organisation, along with DRDO and still nascent Defence Space Agency (DSA). The event is part of deliberations under 'Mission Def-Space', under which 75 challenges have been identified for development by the industry, said Lt. Gen. A. K. Bhatt (retd), Director-General, ISpA, the industry association of space and satellite companies. As former Director-General of Military Operations, Lt. Gen. Bhatt is aware of the military utility of space as a domain and the assets deployed there, as elaborated by the CDS.

"There's a requirement to safeguard our assets with counter space capabilities. We must build resilience and redundancy in a space-based infrastructure," Gen Chauhan said. The counter-space capability required for the objectives stated above is far more than the anti-satellite accomplishment demonstrated by India on a defunct low-earth orbiter on 27 March 2019. Most domestic analysis tends to believe that a successful demonstration of capability is deterrence enough, but the space domain is far bigger than that, as are the current and future challenges. Chinese counter-space capabilities, currently the only likely threat, are unequally placed in favour of Beijing. And they are growing.

The challenge posed by space-based platforms, and even the commercially available ones, was vividly observed when Ukraine made

deft use of the SpaceX and Maxar technologies for combat. A challenge every professional military person must acknowledge as the CDS said, "the invasion of the space domain by commercial enterprises, as seen during the Russia-Ukraine conflict by SpaceX and Maxar, had unfolded a new area in the war on convergence…This combined with the intense race towards militarisation of space has resulted in the battlespace becoming expanded and the very nature of warfare is at a major cusp of transformation."

In such a situation, it behoves on the military and political authority to invest in organisations that truly stand up to the challenges posed by the frontier as it fast approaches India. In some ways, it is already upon us. The DSA, headquartered in Bangalore, is the premier tri-Service organisation handling space matters, but as things stand it is a work in progress. India's space-based military assets are limited in number and use, while the challenges are enormous. For starters, a doctrine is needed.

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Global Aerospace Industry

US Rushes to Sell F-16 Fighters to Argentina; end of Road for Chinese JF-17 & Indian LCA Tejas?

Ritu Sharma | 29 July 2023

Source: Eurasian Times | https://www.eurasiantimes.com/us-rushes-to-sell-f-16-fighters-to-argentina-end-of-road-for/

The Indian Air Force Tejas performs at the opening ceremony of the Singapore Air Show on February 15, 2022.

Recent reports suggest that the Capitol is seeking Congress' authorization to allow Denmark to sell F-16 fighters to Argentina.

Argentina has been actively scouting for fighter jets to add to its inventory to fill the gap left by the retirement of Mirage aircraft in 2015. Its current operational inventory includes at least 10 A-4 fighter bombers, which armed IA-63 Pampa jet trainers supplement.

The Argentinian defense ministry has allocated US$664 million to acquire 12 new fighter jets in September 2021. With the UK putting an arms embargo in place against Argentina, the choices for it have been reduced to Russian-built MiG-29 and MiG-35, China-Pakistan-built JF-17, and Indian-made LCA Tejas.

A recent report in local media claimed that the US had pressurized Argentina to choose Danish F-16s over Chinese or Indian fighter jets. The US

is close to authorizing the sale of 24 F-16 fighter jets to Argentina, aiming to become the leading arms supplier since the Malvinas or Falkland War.

"The White House has once again pressured Congress to approve the sale of 24 F-16 fighter jets to Argentina, which has not yet decided whether to buy the Pakistan-made Chinese JF 17 Thunder or the Indian-made HAL Tejas," the report read.

The report pegged Washington's reservations about the deal to "the global geopolitical dispute between the Western and Asian powers." The main obstacle to the sale is the UK's embargo on the export and trade of goods judged to enhance the Argentine military capability.

The US exigency to stall the burgeoning influence of Eastern powers, especially China, could end India's plan to sell homegrown Light Combat Aircraft (LCA) Tejas to Argentina.

The EurAsian Times reported that during his visit to India earlier this month, the Argentinian defense minister Jorge Taiana flagged the issue of British components in LCA.

"We have sent our pilots to fly and consider different aircraft worldwide. One issue is that if the plane has even one British component, the British do not allow it to sell it to Argentina. LCA has 16 such components. The issue is to change or replace these components," the Argentinian defense minister added.

According to the report, the MiG-35 proposed by Russia was initially ruled out, and the armed forces see little chance for the Indian HAL Tejas. But, the recent trip to India by Defense Minister Taiana, alongside Foreign Minister Santiago Cafiero, seemed to revive the government's interest in purchasing HAL Tejas fighter jets.

Argentina, however, signed a Letter of Intent for the prospective purchase of 20 Light Combat Helicopters and Light Utility Helicopters.

The report quotes sources indicating that the UK has already lifted that barrier at the behest of the US, and now only the financial conditions need to be agreed upon. And if the US Congress passes the law enabling the sale from Denmark, the aircraft can be delivered as early as August.

The Argentinian newspaper also observed a flurry of activities between the two countries as two US defense heavyweights, the number two in the State Department, Wendy Sherman, and the head of the Southern Command, Laura Richardson, were in Argentina.

"The urgency of the United States to seal the aircraft deal with Argentina is aimed at countering the proposal for the JF-17s produced by China and Pakistan, which comprises fewer units (15) but are new and offer the possibility of ordering a second and third batch," the report added.

In the technical specifications, the F-16 qualifies as a more powerful aircraft with more weapons capacity than the JF-17, according to the FAD experts. However, it has a very low engine intake port that tends to ingest many foreign objects and 'would require investment in improving airport infrastructures."

Argentina Jumping Through Procurement Hoops

Argentina's contestation with the UK over Malvinas or the Falkland Islands is proving to be a major hurdle to securing a deal for its Air Force. Currently, JF-17 is the 'most' available fighter jet for it.

Britain has been throwing a spanner in the

Argentine plans of acquiring fighter jets by placing embargoes on components of aircraft that belong to the UK. It pressured Spain to ditch a deal to supply surplus Mirage F1M fighters to its neighbor.

A deal for Israeli Kfir jets also seems to have fallen apart due to Britain's pressure and US control of the aircraft's J79 engines. In addition, the UK essentially vetoed the export of the Brazilian-license-built Swedish JAS Gripen and the South Korean KAI FA-50 Fighting Eagle.

Even Argentina's attempt to procure five French Dassault Super Etendard Modernise jets was rebuffed due to a Britain-levied arms embargo over the Martin Baker-manufactured MK6 ejection seat used in the aircraft. This resulted in the cancellation of the potential deal.

The multitude of canceled deals has left Argentina, whose neighbors Chile and Brazil are better equipped with fighter planes, in a lurch. The Brazilian Air Force is set to receive 36 Saab Gripen E fighters.

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Turkish Aerospace, Aselsan Ink $2B in Deals to Upgrade F-16 Jets

Burak Ege Bekdil | 18 July 2023

Source: Defense News | https://www.defensenews.com/industry/2023/07/18/turkish-aerospace-aselsan-ink-2b-in-deals-to-upgrade-f-16-jets/

Then-Turkish Defence Minister Hulusi Akar, left, salutes from inside an F-16 jet in 2020 before a training flight.

(Turkish Defence Ministry via AP)

ANKARA, Turkey — Turkish Aerospace Industries has signed two contracts worth nearly $2 billion with the country's largest defense company to upgrade F-16 fighter jets.

The deals announced by Aselsan, a military electronics specialist, were for $1.2 billion and 20.7 billion liras (U.S. $789.2 million).

The Biden administration has backed Turkey's desire to buy 40 new F-16s as well as modernization kits from the U.S. It's a move some in Congress, most notably Senate Foreign Relations Committee Chairman Bob Menendez, D-N.J, have opposed over Turkey blocking NATO membership for Sweden, its human rights record, its relations with Greece and other concerns.

Neither TAI nor Aselsan revealed details of the contracts, inked July 13. But a government procurement official and sources with the businesses told Defense News that the contracts are related to a program to upgrade Turkey's aging F-16s, starting with the Block 30 level.

The upgrade program will include a new mission computer, an active electronically

scanned array radar and new avionic suites for about 150 Turkish F-16 aircraft. The program will also include new cockpit color displays, a new indigenous identification friend or foe system, a new system interface unit, a hydraulic fuel gauge, new radar warning receivers, and an inertial navigation system.

The backbone of the upgrade program is a subsystem dubbed Ozgur ("free" in English) that aims to develop and produce Turkey's first AESA radar, which Aselsan officials hope will extend the flight time for some of the country's F-16 aircraft by half, to 12,000 hours.

Per upgrade plans, the AESA radar will first be retrofitted onto the Akinci, a drone built by TAI; then on a batch of 36 F-16 Block 30 aircraft; and, in the longer term, the TF-X, Turkey's first indigenous fighter jet in the making. Block 30 is the only F-16 model whose source codes are available to Turkey.

"This deal has two implications: One, it is part of Turkish efforts to balance Greece's increasing air superiority over the Aegean Sea, especially by buying new French-made Rafales; and two, once [the upgrade is successful and the aircraft is] combat proven, it may pave the way for Aselsan and TAI to penetrate into the world's large F-16 modernization market," said Ozgur Eksi, who runs the media outlet TurDef.

In 2019, Turkey requested the Link 16 tactical data link, among other technology, for 199 F-16 jets. Then, acording to January 2023 media reports, the Biden administration "informally notified Congress of its intent to sell 40 new F-16s in the Block 70/72 Viper configuration (F-16Vs) and Viper upgrade packages for 79 existing fighters, along with 900 air-to-air missiles and 800 bombs, at an estimated total value of $20 billion," a document from the Congressional Research Service noted.

And in April, the U.S. State Department publicly approved the sale of equipment and services to Turkey in support of upgrading the European nation's F-16 fleet in a potential deal worth an estimated $259 million. The Congressional Research Service wrote this possible sale appears to include the Link 16.

The Turkish Air Force declined to comment for this story, citing national security.

Aselsan is the biggest defense company in Turkey, and the 49th largest in the world based on defense revenue, according to the Defense News Top 100 list.

The company reported its total sales in 2022 reached 35.3 billion liras, and that its pretax depreciation and interest profit was 9.5 billion liras, a 77% rise from the year prior. Its net profit in 2022 rose by 70% to 11.9 billion liras.

Aselsan also reported that, during fiscal 2022, it successfully "localized/nationalized" 160 systems, meaning the business indigenously produced technology that the country was previously importing. Overall, the company boasts to have done so for a total of 670 systems.

For its part, Turkish Aerospace Industries ranked 67th on the Top 100 list.

After his re-election on May 28, President Recep Tayyip Erdoğan shuffled the government's procurement hierarchy. Ismail Demir, who led the Presidency of Defence Industries, or SSB, was appointed board chairman of government-controlled steel and iron producer Kardemir. Haluk Gorgun, Aselsan's CEO, replaced Demir.

A June 22 statement from the company said

Aselsan's new CEO is Ahmet Akyol, formerly the firm's deputy general manager. He continues to serve as a board member at Aselsan.

Akyol is a computer engineer who underwent training at the U.S. college Stanford University and the U.K. school Cranfield University.

Akyol has a background in industry and government, having worked at military software provider Havelsan and simulation specialist Quantum3D, and with the Ministry of Industry and Technology as well as the Ministry of Defense, plus the state scientific research agency Tubitak. He also previously served as the head of electronic warfare and radar systems at the SSB (then known as SSM).

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Turkish Aerospace to Upgrade Azerbaijan's Su-25s

Jeremy Binnie | 28 July 2023

Source: Janes | https://www.janes.com/defence-news/news-detail/idef-2023-turkish-aerospace-to-upgrade-azerbaijans-su-25s

An Azerbaijani Su-25 is loaded with a glide bomb during Exercise 'Anatolian Eagle' held at Turkey's Konya Air Base. (Ministry of Defence of the Republic of Azerbaijan)

A contract to upgrade Azerbaijan's Sukhoi Su-25 ground attack aircraft was signed on 26 July during the International Defence Industry Fair (IDEF) held in Istanbul.

The Azerbaijani Ministry of Defence (MoD) released a statement saying the contract was signed with Turkish Aerospace (TUSAŞ) in a ceremony attended by Azerbaijani Deputy Minister of Defence Agil Gurbanov and Haluk Görgun, the head of Turkey's Defence Industry Presidency (SSB).

"The main purpose of signing the contract is the integration of Turkish-made smart bombs and missiles into the aircraft used by the Azerbaijan Air Force and the implementation of modernisation activities for their avionics," it said.

It then suggested the contract has not been finalised when it said the Su-25 modernisation project is under consideration by the two countries' presidents.

TUSAŞ described the Su-25 agreement as one of three "modernisation co-operation protocols" it had signed, the other two being with local companies for upgrading Turkey's F-16 multirole fighters and E-7T Hik airborne early warning and control (AEW&C) aircraft.

Azerbaijan has at least one squadron of Su-25s operating from Kurdamir Air Base. Satellite imagery shows some were forward deployed to the newly constructed airbase at Nakhchivan International Airport during the war with Armenia in 2020.

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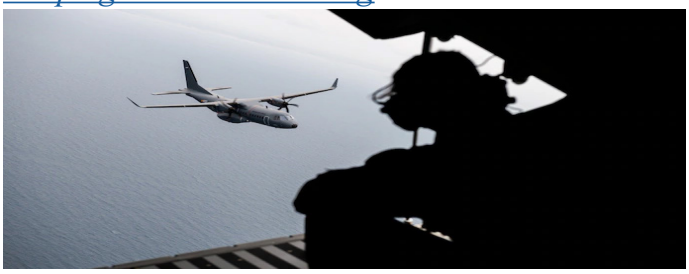
Indian Aerospace Industry

1st C295 Aircraft for Indian Air Force in Sight, Programme Shifts into top Gear

Shiv Aroor | 19 July 2023

Source: India Today | https://www.indiatoday.in/india/story/indian-air-force-c295-military-transport-aircraft-airbus-tata-group-program-shifts-into-top-gear-2408709-2023-07-19?utm_source=washare&utm_medium=socialicons&utm_campaign=shareurltracking



The deal for 56 aircraft was signed by India in October 2021.

Compared to the decade of inertia that the project had to navigate before being approved, the next few weeks will see a rapid burst of major milestones in India's acquisition of the C295 new generation military transport aircraft.

The Indian Air Force will receive its first Airbus-built C295 military transport aircraft in September, the first of 16 that will be built by the European conglomerate in southern Spain while rapidly scaling up its partnership with Tata Group to build another 40 at a sprawling upcoming factory in Vadodara starting in 2026.

The deal for 56 aircraft, signed by India in October 2021, is the first-ever aircraft manufacturing enterprise in the country led by the private sector. So far, military aircraft manufacturing has been a total monopoly of state-owned Hindustan Aeronautics Ltd (HAL).

The Air Force depends hugely on transport aircraft for the movement of personnel, weapons, fuel, and hardware across vast distances in the country and beyond. While the C295 will fulfill the lighter end of air transport duties, the IAF also operates American C-130J Super Hercules planes in the medium category and the giant C-17 Globemaster III for very heavy loads.

Alongside preparations for delivery of the first C295 aircraft, an inaugural batch of Indian Air Force pilots has completed flight training and will shortly make way for a second batch. The Indian pilots are all qualified on the IAF's existing British vintage HS748 Avros – which the C295 airplanes will directly replace – and workhorse Ukrainian Antonov An-32s – which the C295 could potentially replace going forward.

But building the first sixteen C295s in Spain is the easy part for Airbus, given that the aircraft are rolling out from an established decades-old factory. It's the second bit – making 40 aircraft in India at the Tata facility for delivery between 2026-31 – that has the Airbus team at battle stations. Executing the programme on time, efficiently, and on budget makes it one of the most high-pressure projects ever embarked upon by Airbus.

"It is unprecedented for Airbus," says Jorge Tamarit, head of the C295 programme in India. "This is the first time the company is deploying a full production system to another country.

What's happening in India is, therefore, of enormously greater complexity and significance. While Tata began 'metal-cutting' last November for the first of 40 C295s it is tasked to build, things shift into top gear next week in Hyderabad when a group of parts,

technically described as the main constituent assembly (MCA), begins being unboxed from Tata's warehouses and put together to create major components of the airframe, including its tail and fuselage.

Tata's Hyderabad facility will fabricate and churn out major sections of the aircraft, after which they will be transported to Vadodara where each C295 will get its final shape starting late 2024, be fitted with engines and electronics, and delivered to the IAF at a maximum rate of a dozen aircraft per year. While the percentage of Indian material in the aircraft will scale up progressively with each delivery, it is aircraft No.32 that will be closest to being a fully Indian C295.

While the C295 fleet will necessarily operate from a number of air bases, the aircraft will initially be situated in Vadodara. In March, IAF officials and Airbus representatives conducted a bhoomi pujan ceremony at the Agra air base for the C295 crew training center that will be ready in late 2024.

The IAF C295s being built in Spain also have a handful of crucial Indian systems, including radar and missile warning systems supplied by the state-owned Bharat Electronics Ltd (BEL) and a counter-measure dispensing system supplied by Bharat Dynamics Ltd (BDL). With these systems fully integrated, the first aircraft flew on May 8, with the second aircraft in final assembly. Airbus will deliver seven aircraft in 2024 and the final eight of its share of 16 in 2025. A year later, the first Made-in-India C295 will be ready, making for what is intended to be an uninterrupted stream of supply till 2023.

To be sure, the Vadodara facility is almost certain to build more than 40 C295 aircraft. Both the Indian Navy and Indian Coast Guard are interested in at least nine and six C295 aircraft, respectively, configured for the maritime surveillance role. The Border Security Force could be on board for a handful of the type, apart from a passenger version of the C295 potentially feeding into a hungry short-haul civil aviation space.

"We're focused on the delivery of 56 aircraft. But there is definitely a future beyond the 56. 56 is a lot, and not a lot at the same time," says Jean-Brice Dumont, executive vice president of Airbus's military air systems division.

Apart from filling a long-standing requirement of the IAF and giving India its first private sector military airframer, the C295 project is crucial in another way – it is the first Make-in-India programme that also has a 30% offset obligation. Which means, other than the stipulated license manufacture of the aircraft in India, Airbus must also use nearly a third of the Rs 21,935 crore deal value investing in or sourcing from India. What might seem like a win-win for Indian industry is being seen cautiously, however, given India's shaky handling of offsets thus far in the defense space.

With 15,000 immediate skilled jobs and 10,000 indirect jobs over the next decade, the C295 programme is a major boost for India's aerospace ecosystem, but the optimal absorption and channeling of offset billions will be crucial to the big picture success of the programme.

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India-US Jet Engine Deal and it's Significance for Aatmanirbhar Bharat

Air Commodore Savider Pal Singh | 30 June 2023

Source: CAPS India | https://capsindia.org/india-us-jet-engine-deal-and-its-significance-for-aatmanirbhar-bharat/

The long wait of more than ten years seems to have ended with India and the US signing the much-awaited defence agreement to support the state-run Hindustan Aeronautics Limited's (HAL) partnership with American company General Electric (GE) for jointly producing indigenous fighter jet engines.[1] In order to strengthen and broaden bilateral strategic technology partnerships and defence industrial cooperation between the governments, companies, and academic institutions of the two countries, US President Joe Biden and Indian PM Narendra Modi announced the US-India Initiative on Critical and Emerging Technologies (iCET) in May 2022. As a follow-up of the strategic initiative by the two heads of state, the main focus of National Security Advisor (NSA) Ajit Doval's discussions with his American counterpart Jack Sullivan in February this year, when they also operationalised the US-India iCET, was the Transfer of Technology (ToT) for jet engines.

The Plan and Process

One of India's enduring challenges in military and civil aviation has been the inability of Indian industry and research agencies to design and produce an indigenous jet engine. Jet engine technology has been more closely guarded by nations and their corporations than even nuclear reactor know-how. Jet engines are famously complex machinery, containing at least 30,000 moving and static parts and requiring high-end metallurgy research as well as a very high degree of precision and skill in forging, casting, and machining. The big three jet engine manufacturers, viz., Rolls Royce, Pratt and Whitney, and General Electric, have always kept the design a closely guarded secret. The US, France, the UK, and Russia are the only countries that have such capability, and no other country, including China, has been able to develop jet engines on its own.

In India, in August 1983, the indigenous Light Combat Aircraft (LCA) Tejas project was approved with an initial cost of Rs 560 crore to replace ageing MiG-21s.[2] For almost 30 years thereafter, the Gas Turbine Research Establishment (GTRE) of India's Defense Research and Development Organization (DRDO) struggled to produce aero engines for the LCA.[3] An Indian design, the *Kaveri* engine was originally intended to power production models of the LCA and was being built by the Aeronautical Development Agency (ADA). However, the *Kaveri* programme failed to satisfy the necessary technical requirements or keep up with its envisaged timelines and was officially delinked from the Tejas programme in September 2008. The major reasons for the failure of the *Kaveri* programme were:

-Technological problems faced on account of development due to the complexities of engine systems

- Lack of availability of raw materials and critical components

- Inadequate manufacturing, infrastructure,

and test facilities within the nation

- Lack of availability of skilled or technical manpower in aero engine technology

- Increased scope due to changing requirements during development

As the *Kaveri* engine project was delinked, a replacement GE F404-GE-IN20 engine from GE[4] was selected as a suitable replacement for LCA MK-I and MK-IA, as it was already in use in the Boeing F/A-18, Lockheed Martin F-16 (some variants), and Lockheed F-117 Nighthawk. Such an arrangement helped India progress with the project of LCA MK-I and MK-IA as an immediate replacement for the Mig-21 fleet. However, it did not meet the requirements of India for a more powerful engine or indigenous capability. The long-term plan in India for the next 30 to 40 years is to develop more advanced aircraft like the Tejas Mk-II, Advanced Medium Combat Aircraft (AMCA), and the indigenous Twin Engine Deck Based Fighter (TEDBF) for the Indian Navy (IN) towards replacing the ageing M-2000 and MiG-29s. Obviously, for this plan to be successful, the need for a more powerful and indigenous engine was an inescapable requirement.

The recent visit of PM Modi to the US from June 20 to 24 has resulted in meeting this critical requirement of the aerospace industry of not only getting the much-needed engine but also its manufacturing in India, along with the opportunity of getting its technology to some extent. The more powerful engine that is now being contracted for manufacturing in India is the F414-GE-INS6, which is an after-burning turbofan engine with a thrust rating of 22,000 pounds (98 KN). Among the aircraft powered by this engine are the Gripen fighter jet and the Boeing Super Hornet. Indian aircraft like the Tejas Mk-II, AMCA, and TEDBF will be powered by it once production on it begins in India.

Is it a Triumph of India-US Diplomacy?

The significance of the US agreeing to not only manufacture its engines in India but also the likelihood of part transfer of this technology cannot be overstated. While India is a close ally of the US, it has never actually aligned itself with the US-led bloc of nations, such as the UK and Japan. In fact, India has consistently emphasised its own strategic independence and has never capitulated to outside pressure to, for example, sever or even weaken its ties with Russia. Therefore, from the perspective of the USA, such an arrangement of ToT would make a deal with India somewhat risky due to the possibility of leaks, even unintentional ones. This crucial aspect, in a way, explains why, despite GE being prepared to handle the technical aspects of the deal, it has been in limbo for a while. Therefore, it is not without reason that the US Congress's final review and approval, which is a requirement for compliance with the country's Arms Export Control Act, has to be met to complete the deal.

In recent years, the US has repeatedly highlighted the critical role that India plays, not only in furthering the Free and Open Indo-Pacific (FOIP) strategy of the Quad in checking the advancement of China, but also in brokering peace in the ongoing Russia-Ukraine conflict. India, despite the multiple pressures, has made its stand very clear on both issues and has been appreciated by all the nations as well as the United Nations Security Council (UNSC). Keeping these factors in view, in order to advance American interests in the

Indo-Pacific region, where the US is engaged in Cold War-style competition with China, the US is attempting to strengthen its strategic ties with India, more out of compulsion than out of choice. Thus, it is evident why the US is willing to hedge its bets on closer ties with India despite its various reservations about the ToT with countries outside of its small, close-knit group of allies. This is being pursued, obviously, to further American foreign policy objectives.

Another Step towards AatmaNirbhar Bharat

Jet engines are a proprietary technology that is the exclusive preserve of a select few countries, and undoubtedly, jet engines are technically challenging and extremely complex to manufacture. In addition to the difficulties involved in manufacturing jet engines, it is also challenging to design them because they necessitate a complex interplay of aerodynamics, metallurgy, etc. It would still be a big deal, not just for India-US relations but also for India's drive toward self-sufficiency in its defence requirements, even if the new agreement for the joint production of GE-F414 jet engines (see Figure 1) did not reportedly include a 100 per cent technology transfer.[5] India's decision to collaborate with the US to produce advanced jet engines is a significant development that will aid the nation in ending its overt reliance on Russia for jet engines, which is presently a major limitation due to Russian jet engine production is currently constrained by Western sanctions in the wake of the ongoing Russia-Ukraine conflict. The ToT, which is the main constituent of this mega deal, will give India all the necessary authorisations and capabilities to produce certain parts, if not the complete jet engine, domestically. It will also give India room to improve the jet engine for subsequent iterations, further increasing the value of the agreement for *AatmaNirbhar Bharat*. It may be worth noting that the US is now willing to share its critical technology in aviation with India under the iCET. Thus, India would truly move towards the *AatmaNirbharta* sooner than envisioned.

Figure 1: F414 Engine by GE

Source: Snehesh Alex Philip, "India & US close to mega defence deal: Pact for fighter jet engines 1st, ship engines likely next", *The Print*, May 31, 2023, https://theprint.in/defence/india-us-close-to-mega-defence-deal-pact-for-fighter-jet-engines-1st-ship-engines-likely-next/1602974/. Accessed on June 26, 2023.

What's Next for India?

India seems to have won the first major diplomatic megadeal from a superpower that would have otherwise remained firm in preserving its critical technological prowess. The US may eventually share even more proprietary technology with India to advance their shared strategic objectives, including but not limited to the top-secret American nuclear propulsion technology that was recently shared with Australia under the Australia-UK-US (AUKUS) pact, if these new defence ties pan out, which is a possibility. Notwithstanding these hopes and aspirations, in the present deal, India must firm up its stand, increase its diplomatic pressure, and take advantage of the urgency of the US in deepening its strategic ties with India, to ensure that 100 per cent ToT remains the core area of the deal while other details are negotiated.

The exclusive meeting of PMs with the

CEOs of global tech giants like Google, Microsoft, and Apple has opened the gates for collaboration on emerging technologies like artificial intelligence (AI), quantum computing, and blockchain technology. With most companies pulling out of China, finding a skilled workforce is a key component of the US effort to restart advanced semiconductor manufacturing. India can push itself and leverage its population to fill this gap. It would not only create multiple job opportunities but also bring in technology and investment into India, which would further boost *AatmaNirbharta*. India can also play a pivotal role in the diversification of established supply chains in the area of semiconductors. There are many such areas that can be explored for close cooperation and collaboration with US companies that help India build a stronger economy and strengthen strategic partnerships between the two like-minded nations.

Conclusion

India today is fast emerging as the most valuable strategic partner on the global map for the US and Europe on one side and as a pivot in the Global South as well as in the Indo-Pacific construct on the other. The outcome of years of efforts by India has now started to show results, and this historic Indo-US deal for engine manufacturing in India under the *AatmaNirbhar* concept along with ToT is ample proof of that. An important step has been taken in India and the US's defence cooperation with their agreement to give priority to co-development and co-production of new and existing technologies. The road map finalised during the recent bilateral meeting between the US Secretary of Defense and the Indian Defence Minister will direct US-India defence industrial cooperation policies for the foreseeable future. The historic deal for the manufacturing of the GE-F414 engine in India has paved the way for many more opportunities for future collaboration to build resilient supply chains, identify opportunities for joint technology development and production, and enhance collaboration between defence start-up ecosystems in India. Recognising the growing significance of its status on the global strategic construct, India must now take full advantage of it and strengthen its ties with countries like the US to not only acquire critical technology but also to be in step with the changing dynamics of the rapidly changing geo-political and geo-strategic environment.

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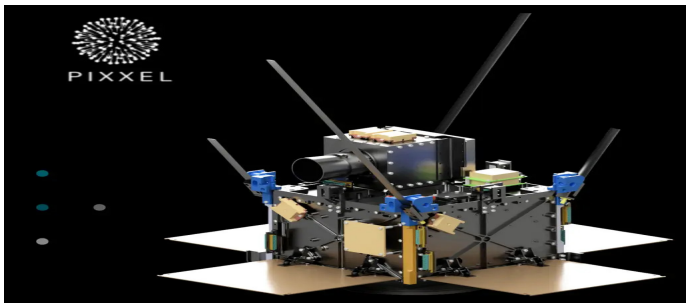
Pixxel Secures Grant from Ministry of Defence to Develop Satellites for Indian Air Force

Posted | 29 July 2023

Source: Currentaffairs.adda247 | https://currentaffairs.adda247.com/pixxel-secures-grant-from-ministry-of-defence-to-develop-satellites-for-indian-air-force/



Pixxel, a prominent space-tech startup supported by renowned entities such as Google, Blume Ventures, and Omnivore VC, has been awarded a significant grant from iDEX (Innovations For Defence Excellence), an initiative established by the Ministry of Defence. This grant will enable Pixxel to develop small, multi-purpose satellites for

the Indian Air Force, contributing to India's ambitious space and defense plans. The grant is part of the Mission DefSpace Challenge under the broader iDEX Prime (Space) initiative.

Pixxel's Background and Mission

Pixxel, founded in 2019 by Awais Ahmed and Kshitij Khandelwal, specializes in crafting hyperspectral imaging satellites. These cutting-edge devices provide real-time, AI-facilitated data on various environmental phenomena. With an impressive funding pool of $71 million, including a recent Series B round contribution of $36 million, Pixxel has rapidly ascended in the space-tech domain.

The iDEX Grant and its Significance

The grant received from iDEX remains undisclosed in its exact value but is known to be in the multi-crore range. This funding positions Pixxel to develop agile satellites weighing no more than 150 kilograms. These multi-purpose satellites will be designed to perform electro-optical, infrared, synthetic aperture radar, and hyperspectral tasks, bolstering India's defense architecture and expanding the country's space technology capabilities.

Understanding the iDEX Initiative

The iDEX initiative is a strategic plan by the Ministry of Defence aimed at stimulating technological evolution in the defense and aerospace sectors. It brings together an eclectic mix of MSMEs, startups, and R&D institutes to foster innovation in these domains.

Pixxel's Ambitious Roadmap

As part of its ambitious roadmap, Pixxel plans to launch six satellites into orbit in 2024, followed by an astonishing 18 satellites in 2025. These satellites will harvest crucial hyperspectral images of the Earth, gathering data across various electromagnetic spectrum wavelengths, significantly enriching our understanding of the planet's wellness.

India's Space-Tech Sector Progression

Pixxel's recent grant underscores the swift progression of India's space-tech sector, with other pioneering companies like Agnikul and Skyroot Aerospace also making strides. Forecasts suggest that India's space-tech market may reach an impressive $77 billion by 2030, demonstrating the country's dedication to fostering deep-tech innovations in this field.

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'Breakthrough Moment for Indo-US Ties': General Atomics CEO on MQ9B Drone Deal

Akshara Parakala | 28 July 2023

Source: Janes | https://www.janes.com/defence-news/news-detail/skyhawk-aerospace-reveals-pushpak-and-c35-e-uavs

Skyhawk Aerospace C35-E VTOL UAV displayed at the 4th Drone International Expo 2023. (Janes/Akshara Parakala)

India-based Skyhawk Aerospace showcased its indigenously designed fixed-wing vertical take-off and landing (VTOL) multirole Pushpak and C35-E unmanned aerial vehicles (UAVs) at the 4th Drone International Expo held in Delhi on 26 and 27 July.

The Pushpak is a tactical UAV designed to

conduct high-altitude cargo operations. The UAV features a skid landing gear system and can fly up to a maximum altitude of 5,700 m in what company CEO Jayesh A described as "near gale conditions" and at temperatures between -30° C and +e55° C.

Speaking to Janes , Jayesh said, "The development of the UAV started in November 2020 primarily to support cargo operations based on the inputs given by [the] Army Design Bureau (ADB)."

The design of the Pushpak includes shoulder-mounted moderately tapered straight wings spanning a length of 6.28 m, a twin-boom-mounted tail that has vertical stabilisers joined by a horizontal stabiliser at the top, and a hook placed beneath the fuselage near the wing section to carry the cargo.

The UAV has twin booms in the inner wing section ending in the tail and each of these is fitted with four electrically powered rotors (two upwards and two downwards), which enable VTOL operations. Forward flight is enabled by a pusher propeller driven by an 80 hp turboshaft engine with a total fuel capacity of 20 litres. The engine is being imported from a European manufacturer with time between overhauls of around 1,000 hours.

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French Aerospace Giant Safran to Set up Largest Aircraft Engine MRO Facility at GMR Aerospace Park

Swati Bharadwaj | 18 July 2023

Source: Times of India | https://timesofindia.indiatimes.com/business/india-business/french-aerospace-giant-safran-to-set-up-largest-aircraft-engine-mro-facility-at-gmr-aerospace-park/articleshow/101834956.cms?from=mdr&utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

HYDERABAD: One of French aerospace giant Safran'slargest aircraft engines MRO (maintenance, repair &overhaul) facilities are all set to come up in Hyderabad.

The facility, which will be spread over 23.5 acres with a built-up area of 36,500 sq ft, will come up at the SEZ area of GMRAerospace & Industrial Park with a capacity to service 300engines per annum by 2035, GMR Group said on Monday.

While construction work on the facility is expected to commence in September this year, the MRO facility is expected to be handed over in December 2024 and operations are slated to kick off in 2025 with about 1000 jobs to be created at peak operation capacity.

GMR Hyderabad Aviation SEZ Limited (GHASL), a 100% subsidiary of GMR Hyderabad International Airport Ltd (GHIAL), has already inked a land lease agreement with Safran Aircraft Engines Services India Pvt Ltd

(SAESIPL) for building and operating engine MRO facilities for Safran's LEAP turbofan engines.

GMR Airport Land Development CEO Aman Kapoor said Safran zeroed in on the GMR Aerospace & Industrial Park after a thorough global assessment. "Safran has entered a lease agreement to set up one of the largest engine MROs in the world. The facility will initially have the capacity to service 100 engines per annum, which will gradually increase to around 300 engines per annum by 2035," he added.

Safran Aircraft Engines vice president of support & services Nicolas Potier said the MRO project was a significant investment in Safran's future in India and would bring additional key capacity to support operations of its airlines customers.

Safran already operates two industrial facilities for cable harnessing and aircraft engine component manufacturing in the GMR Aerospace & Industrial Park's SEZ area, even as a Safran-GE joint venture, CFM, operates an engine maintenance training facility at the park.

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Technology Development

Exploring the Role of AI and Robotics in Shaping the Future of Warfare and National Security in Aerospace and Defense

30 July 2023

Source: Fagenwasanni | https://fagenwasanni.com/news/ai-and-robotics-the-future-of-warfare-and-national-security-in-aerospace-and-defense/54121/

Artificial Intelligence (AI) and robotics are rapidly transforming the landscape of warfare and national security in the aerospace and defense sectors. The integration of these advanced technologies into military operations is not only enhancing the capabilities of armed forces but also redefining the strategies and tactics used in modern warfare.

AI, with its ability to process vast amounts of data and make decisions in real-time, is becoming an indispensable tool in the defense sector. It is being used to improve the accuracy of missile systems, enhance the efficiency of surveillance operations, and streamline logistics and supply chain management. AI algorithms can analyze satellite imagery and detect potential threats, enabling quicker and more informed decision-making. Moreover, AI-powered predictive analytics can forecast potential security threats, allowing for proactive defense measures.

Robotics, on the other hand, is revolutionizing

the way military operations are conducted. Unmanned aerial vehicles (UAVs), or drones, are now commonplace in reconnaissance missions, reducing the risk to human life. Ground robots are being used for bomb disposal, while autonomous underwater vehicles are employed in naval warfare for tasks such as mine detection and disposal. Robotics is also playing a crucial role in medical evacuation and casualty care in combat zones, thereby saving lives.

The integration of AI and robotics in aerospace is equally transformative. AI is being used to optimize flight paths, improve fuel efficiency, and enhance the safety of both military and commercial aircraft. Robotics is being employed in the maintenance and repair of aircraft, reducing downtime and improving operational efficiency. Furthermore, AI and robotics are being used in the development of autonomous aircraft, which could revolutionize air travel and warfare.

However, the adoption of AI and robotics in warfare and national security also raises several ethical and legal questions. The use of autonomous weapons systems, for instance, has sparked a debate about the moral implications of machines making life-or-death decisions. There are also concerns about the vulnerability of AI systems to cyberattacks, which could have catastrophic consequences in a military context.

Despite these challenges, the potential benefits of AI and robotics in the aerospace and defense sectors are undeniable. These technologies are not only enhancing the capabilities of armed forces but also reducing the risk to human life in dangerous missions. They are enabling more efficient and effective operations, from surveillance and reconnaissance to logistics and supply chain management.

In conclusion, AI and robotics are set to play a pivotal role in shaping the future of warfare and national security in the aerospace and defense sectors. As these technologies continue to evolve, they will undoubtedly bring about significant changes in the way military operations are conducted. However, it is also crucial to address the ethical and legal issues associated with their use to ensure that they are employed responsibly and effectively.

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Are Advanced Materials The Future of the Aerospace and Defence Industry?

28 July 2023

Source: Airport Technology | https://www.airport-technology.com/comment/advanced-materials-future-aerospace-defence/

An understanding of materials processing is essential in the

design of high specification engineering components. Credit: Andrei Armiagov via Shutterstock.

The innovative application of key materials has long been pivotal in the development of new technologies. However, the impact of materials science and its broader market is often overshadowed by the platforms and advanced tech capabilities such as quantum computing and AI within the aerospace and defence sectors, despite its outsized impact on capability modernisation over the past several decades.

How a material has been processed determines how it can be used – the physical and mechanical properties of a material, as well as its expected service life are all a result of how it has been processed – so an understanding of materials processing is essential in the design of high specification engineering components.

Metals: The fastest air-breathing manned aircraft to have ever existed, the Lockheed Martin SR-71 Blackbird, owes much of its place in the history books to the role played by the advanced materials (AdMs) in its construction. Titanium, a very cutting-edge material in the mid-20th century which previously had very limited applications, was used to construct 93% of the SR-71's aerostructure due to several innate benefits. Titanium alloys can provide a unique combination of strength, lightness and thermal resilience which is unmatched by materials such as steel or aluminium. Heat resistance was of particular importance in the development of the SR-71, given its target cruising speed of Mach 3+. At hypersonic speeds, aerodynamic heating – heating of a solid body produced by its high-speed passage through air – requires not only significant heat dissipation but also a resistance to thermal expansion. Titanium was, therefore, an ideal material for this application, as it has thermal and tensile strength properties similar to most steels while being 50% lighter. Since the retirement of the SR-71 in 1999, titanium alloys haven't seen use as extensive as in the SR-71, but instead, development has focused on optimising alloy compositions for specific applications. The Airbus A380 uses titanium in many places where other materials would not be sufficient. For example, pure titanium has replaced many elements of the airframe where steel was previously used, due to its comparable strength and significantly smaller weight. This has only been possible due to the precipitous drop in the price of titanium over the last 50 years. The A380 also employs several titanium alloys for some high-temperature (600°C) components in the fan and compressor in the front of the engine, for similar reasons as their use in the SR-71.

Alloys: In the second half of the 20th century, many of the material improvements centred around the adaptation of widely used metals (i.e. steel, aluminium and nickel) into alloys through the addition of other elements, thereby adapting their microstructures and enhancing their macroscopic properties. In the simplest cases, this involved basic alloy compositions, such as the addition of lithium to aluminium, reducing aluminium's weight without significantly affecting strength. However, it is possible to engineer alloys of more complex composition to produce a far greater benefit. For example, the development of nickel alloys and superalloys, usually containing a combination of nickel, aluminium and titanium, significantly diversified nickel's applications by enhancing its maximum working temperature. Alloying nickel facilitates its use in temperatures greater than 70% of its melting temperature as a result of both the exceptional oxidation and creep resistance – time-dependent deformation of a material under constant stress – afforded by the alloying elements. The widespread use of nickel alloys in turbine blades and engine components enabled far greater operating temperatures, greatly improving the fuel efficiency of modern jet engines, which operate most optimally at higher temperatures. However, nickel superalloys remain incapable of reaching the most optimal combustion chamber temperature

of 1,700°C, thus research in this field continues as experts seek to develop thermal barrier coatings capable of withstanding those extreme temperatures.

Composites: Composite materials are becoming an increasingly prevalent form of AdMs and are being used in a growing multitude of commercial and military applications. One of the most striking examples in recent years is Boeing's 787 Dreamliner aircraft, with 80% of its airframe's volume being comprised of composites (50% by weight) such as carbon or glass fibre-reinforced polymers (FRP) within different structural architectures (fibres, laminates and sandwiches). This provides several structural benefits such as improved strength and reduced weight compared with aluminium alloys-based airframes, as FRPs are 2-5 times stronger and 50% lighter equivalent aluminium alloys. The resulting benefits include improved fuel efficiency by a factor of 20%, increased maximum range and reduced necessary maintenance as a result of the greater design simplicity afforded by composite architectures. The fatigue behaviour – or initiation and propagation of cracks in a material due to cyclic loading – of composites is also superior to that of common industrial metals such as aluminium, steel and titanium, consequently making composites ideal materials for aircraft fuselage which are subjected to stress in cyclic loading throughout their lifetimes as a result of cabin pressurisation and depressurisation.

Overall, it's safe to say that the development of new and cutting-edge advanced materials has always been inextricably linked to innovations within the aerospace and defence industries, and though procurement priorities continue to shift the overarching importance of materials science will likely remain undiminished. In addition to further enhancements in composites and alloys, nanotechnologies, metamaterials, and energy storage and generation materials all look to be set to disrupt the engineering status quo over the coming decades and facilitate the development of truly transformative capabilities within the aerospace and defence sectors.

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Commentary

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"The term 'Aerospace' was introduced in 1958 by the USAF Chief of Staff, General Thomas D White, as a new construct that depicted air and space as a seamless continuum stretching from the Earth's surface to infinity."

The Centre for Air Power Studies (CAPS) is an independent, non-profit think tank that undertakes and promotes policy-related research, study and discussion on defence and military issues, trends and developments in air power and space for civil and military purposes, as also related issues of national security. The Centre is headed by Air Marshal Anil Chopra, PVSM AVSM VM VSM (Retd).

Centre for Air Power Studies
P-284 Arjan Path, Subroto Park, New Delhi - 110010
Tel.: +91 - 11 - 25699131/32 Fax: +91 - 11 - 25682533
Email: capsnetdroff@gmail.com
Website: www.capsindia.org

Supervised by : AVM Anil Golani (Retd)
Editor & Content : Gp Capt T H Anand Rao

Composed by Mr Rohit Singh
Tel.: +91 9716511091
Email: rohit_singh.1990@hotmail.com