October - December 2026

Vol 9, Issue 35 | ₹300/-

raksha ANIRVEDA

DECODING SELF-RELIANCE & DEFENCE DYNAMICS



IAF SPECIAL

AIR FORCE 2040: SKY TO SPACE

HUGHES PRECISION
ALWAYS ON TARGET

AIM FARTHER

FOUR SNIPER CALIBERS. NOW MADE IN INDIA.



THE ONLY INDIAN COMPANY TO SUPPLY

SNIPER AMMUNITION IN 4 CALIBERS TO INDIAN ARMED FORCES

- 7.62X51
- 7.62X54
- .338 LAPUA MAGNUM
- 12.7X99

MAKE IN INDIA

CUTTING EDGE TECHNOLOGY DEVELOPED UNDER

MAKE IN INDIA

For our fullAmmunition Range,

VISIT: hughesprecisionm.com

KALYANI STRATEGIC SYSTEMS LIMITED

KALYANI



Securing Our Seas

Unmanned Marine Systems

Mine Reconnaissance AUV (MRAUV)

Technology and innovation are the cornerstones of our Marine offerings. The underwater domain remains a key focus area, along with naval guns and marine equipment. We are ramping up our capabilities to align with mission-critical requirements, and to Make in India for global markets.



contact.defence@kalyanistrat.com | defence.sales@kalyanistrat.com | www.kssl.in | Follow us on

TO KNOW MORE ABOUT OUR PRODUCTS

EDITORIAL



Ajit Kumar Thakur
Editor & Business Director

TURMOIL HAS BECOME THE NEW NORMAL

As we enter the last quarter of the year, one big question keeps rebounding: will normalcy in the global order make a comeback? The unanimous answer portrays the grim reality — no. While great-power competition is changing, the debate over the future world order—whether the world will remain bipolar or become multipolar—continues. Both the United States and China continue to explore a competitive middle ground and momentarily stall their ongoing confrontation. Meanwhile, middle powers are actively engaging to carve out an assertive position for themselves.

The Ukraine-Russia war continues with fluctuating intensity. It has become a testing ground for new weapon systems embedded with new technologies. Both Ukraine and Russia have suffered heavy destruction, with the latest reports indicating that Russia's refining capacity has taken a massive hit. All mediation efforts to end the war have been unproductive. Finding itself at a crossroads, Europe is attempting hard to "awaken from its long slumber" to achieve stronger defence through enhanced domestic production and control of critical technologies. Whether an 'October Surprise' awaits is anybody's guess.

The Iran–US conflict remains unresolved. Tehran says talks are meaningless after repeated attacks, while Washington leaves negotiations open but insists on President Trump's craziest ideas. Iran frames its actions as defence and regional control of Hormuz; Gulf states face spillover, and the Houthis threaten wider Red Sea involvement.

Brazil, Russia, India, China and South Africa (BRICS) and the Shanghai Cooperation Organisation (SCO) showed that India can convene across divides, but not presume consensus. Hence, for India the best course is pragmatic multi-alignment: protect energy and security interests, keep diplomatic channels open, and press for de-escalation without choosing a camp.

At a time when global geoeconomic disorder is intensifying and gaining centrality, India will have to tread cautiously to realise its Vision 2047. It will have to focus on a renewed domestic social compact by investing upstream, equalising opportunities early on to pave a path for upward mobility, and sustaining its rise through seamless domestic-global integration.

Recently, Defence Minister Rajnath Singh released the 'RAKSHA' document on India's defence diplomacy. It signals that the country can both project power and offer stability in a world of geopolitical uncertainties. Bringing together diplomatic and security goals, the ten-year policy blueprint codifies defence diplomacy as a central pillar of India's foreign policy. Only time will tell whether it turns strategic vision into enduring reality and converts diplomatic goodwill into durable strategic advantage.

Rapidly modernising its armed forces by building an indigenous "AI spine" and expanding its military drone ecosystem, India is on track to reduce dependence on foreign imports. Domestic drone procurement, backed by the *Make in India* initiative, is projected to scale up significantly in the near future. The focus is shifting towards algorithmic combat to dramatically shorten sensor-to-shooter cycles, expedite tactical decision-making, mass procurement of autonomous loitering munitions with deep-strike capabilities, command swarms and AI-powered counter-drone systems, cost-effective "hard-kill" and "soft-kill" electronic warfare systems, high-speed interceptors and grid frameworks.

A major concern remains regarding India's big bet on innovation and future technology—the government's ₹1 lakh crore *Innovation Fund* is struggling to take off and remains stuck in slow motion due to multiple factors. It requires remedial measures with utmost urgency.

Raksha Anirveda's October-December 2026 edition, with its regular features, in-depth analyses, and diversified content offerings, is an Indian Air Force special. The elaborate coverage — blended with the right flavour on the force that's *Infallible, Impervious and Precise* — will hopefully engage our esteemed readers and initiate vibrant discussions among stakeholders. Team Raksha Anirveda, with deep gratitude and respect, salutes the guardians of India's skies on the 94th IAF Day.

Happy Reading. *Jai Bharat!*



(Ajit Kumar Thakur)

> "*Raksha Anirveda*'s October-December 2026 edition is an Indian Air Force special, featuring its regular mix of in-depth analyses and diversified content. The coverage blends the right flavour on a force that's *Infallible, Impervious and Precise*"









Machinery Images from Shop Floor

AKSI AEROSPACE GROUP

OEM AEROSPACE AND DRONE MANUFACTURING

YOUR PLATFORM. OUR MANUFACTURING ECOSYSTEM

At AKSI Aerospace Group, we have spent years building more than UAV platforms. We have built the engineering and manufacturing capabilities behind them.

Today, that ecosystem brings together precision CNC machining, advanced composites, sheet metal fabrication, UAV airframes, battery systems, propulsion, autopilots, avionics and system integration under one group.

For OEMs, this means access to multiple critical capabilities through a single aerospace ecosystem, whether the requirement is a precision component, a composite structure, a subsystem or support for a complete platform.

From prototype development to production, we work alongside OEMs to manufacture, integrate and scale aerospace and UAV technologies in India.









Machinery Images from Shop Floor

OEM CAPABILITIES

Aerospace Components | UAV Structures | Advanced Composites | CNC Machining | Sheet Metal | Batteries | Propulsion | Autopilots | Integration

1 LAKH+ sq.ft

INTEGRATED AEROSPACE MANUFACTURING FACILITY

BUILD YOUR NEXT AEROSPACE PROGRAM WITH AKSI

+91 93419 71308 | www.aksiaerospace.com | business@aksiaerospace.com

CONTE



30 The Case for a France-India Military SAF Corridor

68 Quantum-Safe Race is on

72 Beyond Drones: Building India's Deep-Tech Ready Military

78 Anchoring Geopolitical Competition in Wargaming

08 LEAD STORY

With the Dragon, Trust But Verify

12 The Defining Decade

16 The Battlefield Data Race: What India Must Learn from Ukraine

24 Critical Minerals Crucial for Self-Reliance in Defence Production

BY INVITATION

VTOL UAS: Shaping the Future Air Power



FROM THE COVER



06 The War That Begins on Day Thirty

20 India's FCAS Gambit: A Leap Towards Generation 6

38 Air Force 2040: Sky to Space

96 India's Proposed Missile Catamaran

33-67 AIR FORCE SPECIAL COVERAGE

The section consists of insightful articles contributed by **Asad Mirza, Lt Gen Rajeev Chaudhry, Air Marshal M Matheswaran**, Tecknotrove's **Shantanu Gupta, Air Marshal Anil Chopra**, Bharati Exicom's **Ashish Padte and Prof (Dr) D K Pandey**. The effort is an attempt to holistically capture a force that's ***Infallible, Impervious and Precise*** and is continuously redefining air power and national security.



NTS

KREMLIN LOGS
Convergence Amid Turbulence



82

86 **INSIGHT**
The Great Nicobar Project: India's Strategic Edge

90 Beyond Assembly: India's Need For Drone Technology Sovereignty

92 Lothal Rising: From Harappan Port to Naval Museum

100 Aim to Impact: Six Factors that Influence Shooting Accuracy

108 BSX 2026: India Transforms From Launchpad to a Global Marketplace

112 AEDEX 2026: Forging New Partnerships Across Aerospace, Defence and Aviation



114
ISRAEL DIARY
AI and the Future of Warfare

118 The Invisible Frontline: Why India Needs a Policy for Spectrum and Dual-Use Technologies

120
SPOTLIGHT
CUMI: Arming India's Quest for Defence Self-Reliance



124 Appointments

128 News Round Up

PBG Media Ventures

raksha ANIRVEDA

RNI NO. DELENG/2018/76856

Editor & Business Director
Ajit Kumar Thakur

Executive Editor
Devendra Singh

Consulting Editors
Asad Mirza
Sri Krishna
Vishal Duggal
Vinay Kumar

Advisory Board
Amb Smita Purushottam, IFS
Air Marshal M Matheswaran
Lt Gen (Dr) SK Gadeock
Lt Gen P C Katoch
Lt Gen P R Shankar
Lt Gen A B Shivane
Maj Gen J S Kataria
Maj Gen Deepak Mehra
Lt Col Narendra Tripathi
Cmde Ranjit B Rai
Cmde Anil Jai Singh
Cdr K P Sanjeev Kumar
Dr Vivek Kumar Rai
Dr Mathew Simon
Amit Cowshish
Sameer Joshi
Natalia Freyton
Dr Punit Saurabh

Advisor-International Outreach
Cdr Sumit Ghosh

International Roving Correspondent
Arie Egozi

Legal Advisor
The LawArmour - Solicitors & Partners

Creative Director
Md Moeen Aijaz

For advertisements, contact us at:
ajit@raksha-anirveda.com
rakshaanirveda@gmail.com

For any complaints or queries, contact us at:
info@raksha-anirveda.com
ajit@raksha-anirveda.com

Raksha Anirveda is printed and published by PBG Media Ventures

Published, Edited & Printed by: Ajit Kumar Thakur on behalf of **'PBG Media Ventures'**
649/4, Konark Residency, Nambardar Colony, Burari, Delhi -110084

Printed at: Star Print-O-Bind, Star House, F-31, Okhla Industrial Area Phase-I, New Delhi-110020

Editor: Ajit Kumar Thakur
All disputes are subjected to the jurisdiction of Delhi, Mobile: +91-9910252485

Disclaimer: Views expressed are those of individual authors and do not represent any policy of this publication.
-Editor

SHARE YOUR VIEWS

Team *'Raksha Anirveda'* looks forward to receiving comments and feedback from the readers on the content of the magazine. Please share your thoughts at *info@raksha-anirveda.com*

THE WAR THAT BEGINS ON DAY THIRTY

India can fight a short war brilliantly. The real test is whether its factories can survive a long one, alone and under attack

VIPUL V TAMHANE



By the time a modern war reaches its second month, the opening salvos have long been fired, the pre-positioned inventories drawn down, and the outcome no longer turns on who struck first. It turns on who can still build. This is the uncomfortable question India's strategic community has been slow to ask of itself: not whether our soldiers can fight - they can, and Operation Sindoor showed a fighting machine that is disciplined, precise, and lethal - but whether the factories behind them can keep the guns fed once the war stops being short.

India has never had to answer it. Every conflict in our history - 1962, 1965, 1971, Kargil - was fought and settled before industrial endurance became the deciding variable. Our war reserves, our doctrine, our planning assumptions all quietly presume a sharp, decisive campaign. The wars of this decade suggest that presumption is a luxury we may no longer be able to afford.

Consider the historical template most often invoked. In the Second World War, American shipyards replaced sunk tonnage faster than U-boats could sink it, launching Liberty Ships in days. But the United States performed that miracle behind an ocean, on soil no enemy bomber ever reached. India will enjoy no such sanctuary. Our defence corridors, shipyards and fabrication units sit well within range of missiles, drones and cyber intrusion. The relevant template is therefore not Detroit in 1943 but Ukraine and Iran today, nations forced to produce while being bombed, to disperse their lines, run on backup power, and reconstitute output after strikes. Industrial resilience has itself become a weapon.

None of this dismisses what India has built. The gains are real. The Army has crossed roughly 90% self-reliance in ammunition. We field one of the world's most diversified indigenous missile families, viz. BrahMos, Akash, Astra, Pinaka, Pralay, and Agni. Our yards are building destroyers, frigates and carriers at a tempo few nations can match. Defence production touched a record ₹1.78 lakh crore in 2025-26, with the private sector's share climbing to a quarter. This is not the fragile base of a decade ago.

And yet beneath the assembly lines lies a paradox that grows more serious the longer one looks. India has become good at the final act of manufacturing, integration, while remaining dangerously dependent on the first. We assemble platforms whose lifeblood is imported. Rare-earth magnets essential to precision munitions, radars and avionics come overwhelmingly from China, our most likely adversary. Advanced semiconductors, the nervous system of every modern weapon, are still largely brought in. The Tejas cannot fly without an American engine; the BrahMos cannot fire without Russian components. The millions of lines of software and combat waveforms that make network-centric warfare possible often belong to foreign vendors who

will not share their source code. This is what a hollow autonomy looks like: sovereign in the showroom, dependent in the supply chain.

Then there is the matter of credibility. Late last year, the Chief of Defence Staff, General Anil Chauhan, said aloud what serving officers had long muttered in private: that Indian firms had over-promised and failed to deliver, that some had branded imported kit as 70% indigenous when it was nothing of the sort, and that they were leaving the forces in a lurch. If industry cannot honour emergency procurement orders in peacetime, the belief that it will triple output under wartime attack is not optimism; it is fantasy. A record order book means little when execution backlogs already stretch across years.

Which brings us to the half of the question the country most avoids, meaning, what if our friends do not come forward? India has partners, not allies sans Russia. There is no Article 5, no treaty binding anyone to resupply us through a long war. Multi-alignment is a brilliant peacetime strategy and a fragile wartime one. The clear lesson of Ukraine and West Asia is that every arms-producing nation empties its own magazines first; exports slow, licences tighten, and stockpiles are hoarded the moment a supplier fears it may need them itself. Russia is consumed by its own war, France's industrial scale is modest, Israel is overstretched, and Washington must weigh a Taiwan contingency before an Indian one. In a simultaneous Indo-Pacific crisis, India would not be receiving preferential supply; it would be competing for it.

Strip away the comforting numbers and the strategic problem reduces to a single equation, i.e., can replacement keep pace with attrition, unaided, while the country itself is under fire? On present evidence, for a short, high-intensity war, yes. For a prolonged, multi-theatre one against a peer adversary, not yet, and not with ease.

The answer cannot be the familiar refrain of 'produce more'. Peacetime



Every conflict in India's history - 1962, 1965, 1971, Kargil - was fought and settled before industrial endurance became the deciding variable. Our war reserves, our doctrine, our planning assumptions all quietly presume a sharp, decisive campaign

output is the wrong yardstick. What India needs is a doctrine of wartime industrial sovereignty, pursued with the seriousness we reserve for military mobilisation. That means a National Defence Industrial Mobilisation Plan with the force of law; mandatory continuity and dispersion plans for critical manufacturers, so no single strike halts a line; strategic reserves of the true chokepoints, semiconductors, rare-earth magnets, propellants, seekers; digital twins of key lines for rapid reconstitution; dual-use plants that can switch from civilian to military output; and annual industrial mobilisation exercises, as routine as our field manoeuvres, to expose the bottlenecks before an enemy does.

The armed forces have long war-gamed the battlefield. It is time we war-gamed the factory. In the clashes now shaping this century, national power is measured less by how huge the first salvo looks, and more by whether the final factory still standing can churn out the next armament on its own, in the dark, while getting struck. India has to earn that answer in quiet conditions, because nobody is going to grant it time to figure it out once war starts.



–The writer is an expert on geopolitics, national security, and counter-terrorism; and he regularly contributes his subject thought-leadership and academic commentary with several publications in newspapers, journals, and periodicals. He works with investigative agencies, regulatory bodies, financial institutions and enterprises, providing strategic and regulatory advisory



WITH THE DRAGON,

A slew of diplomatic developments in recent times marked the broader reset of the Sino-Indian relationship after the Galwan clash. But in view of China's behaviour in the past, it is essential for New Delhi to exercise vigilance

PRANAY K SHOME

Diplomacy, it is said, is an all-weather exercise. Regimes change, leaders come and go, but diplomacy maintains its steady pace. This assumes particular importance in the context of a relationship as comprehensive as the India-China ties. Two Asian behemoths, India and China, have seen their bilateral relationship swing back and forth. Despite the strength of their trade ties, differing interpretations of their respective boundaries have been a sore point, often sparking clashes.

In the June 2020 Galwan Clash, Indian and Chinese troops clashed in the Galwan Valley in Eastern Ladakh over the contestation of the Line of Actual Control (LAC), claiming the lives of 20 Indian soldiers and an unknown number of Chinese troops. Ties plummeted after this, with governments of both sides taking tit-for-tat measures. More than five years later, we are slowly witnessing the thawing of this ice.

It began at the BRICS summit held in Kazan, Russia, in 2024, and gathered pace in 2026. This thawing can be analysed from the perspective of three consequential developments:

NSA AJIT DOVAL's VISIT TO CHINA

Ajit Doval, India's National Security Advisor (NSA), visited Beijing to hold bilateral discussions with the Chinese Foreign Minister Wang Yi. Doval and Yi are the boundary representatives of their respective countries. The visit aimed at finding a solution to the knotty issue of the contested nature of the LAC. In pursuance of that aim, the bilateral discussions yielded eight outcomes: the important ones being an agreement on two new border military hotlines in the eastern and middle sectors of the LAC; two new meeting points for military commander-level meetings; and holding the trans-border river meeting soon.

But perhaps the more substantial outcomes were to advance discussions on "an early and substantial harvest" of the boundary delimitation and border management. This perhaps marks the first step on the long road to ensuring the resolution of the almost 4,000-kilometre-long border. Reaching a definitive agreement on the boundary question is imperative, as the Sino-Indian war of 1962 was triggered by China's



TRUST BUT VERIFY

irredentist behaviour along the eastern sector, prompted by a lack of proper demarcation of the border.

SCO STOPOVER

With the Doval-Yi meeting setting the ground for rapprochement between the two sides, the momentum was carried forward by the 26th Shanghai Cooperation Organisation (SCO) summit held in Bishkek, Kyrgyzstan, in August. Notwithstanding the fact that the bloc is dominated by Beijing due to its financial and diplomatic clout, coupled with the presence of India's arch-nemesis Pakistan, it is considered essential in diplomacy to engage politically and morally problematic actors.

In that regard, PM Modi highlighted terrorism, extremism, and fundamentalism as some of the biggest threats of the 21st century and, underlining the need for the grouping to resolutely act against these, India sought to convey to Beijing that there has been a marked change in New Delhi's stance on these threats. In this context, India's reiteration of its zero-tolerance approach to terrorism should further reinforce the message in Beijing that assisting sponsors of terrorism like Pakistan will carry costs — directly and indirectly. This message assumes particular significance against the backdrop of the revelations that China assisted Pakistan during Operation Sindoor. Therefore, for the sake of the broader nature of the bilateral ties, both sides continued to take their 'positive' engagement in the next high-level summit — BRICS.

NSA Ajit Doval visited Beijing to hold bilateral discussions with Chinese Foreign Minister Wang Yi. The talks yielded eight outcomes, including an agreement to establish two new military hotlines in the eastern and middle sectors of the LAC, designate two new meeting points for military commander-level meetings and hold the trans-border river meeting soon

THE BRICS TOUCH

Held on September 12-13, the 18th BRICS summit was hosted by India. Notwithstanding the many contradictions among the members of the grouping, the stakeholders managed to set aside their mutual differences and formulated the Delhi Declaration. Among the key takeaways,



the ongoing war in the Middle East featured prominently, with the member states calling for restraint in the Middle East alongside the need to protect civilian infrastructure and halt attacks on nuclear facilities; the declaration, however, strategically avoided condemning the US-Israeli strikes or Iran's targeting of Gulf countries in the region as a retaliatory measure. In addition, without naming the United States, the stakeholders criticised the imposition of tariffs by the American administration under Donald Trump, arguing that the global trading order is firmly based on globalisation where no one country can call the shots.

The consensus underlines India's careful balancing act — to become a prominent voice of the Global South without sounding anti-West. In the context of the Sino-Indian relationship, it can be inferred that both sides want to move away from the 'painful memories' of the Galwan setback. In that vein, at a time when the world is bearing the brunt of American misadventures, whether in the form of the Iran war or in the upending of the global financial order, China and India are trying to put aside their differences to come to a modicum of understanding to jointly hedge against this turbulence.

Unlike in the past, idealism won't work this time. It is imperative that we internalise hard-nosed realism in our ties with Beijing. The era of the *Hindi-Chini bhai bhai* is over; it is time that we adopt a formal, transactional and calculated relationship with the dragon

However, this strategy is not without its pitfalls.

TREADING WITH EXTREME CAUTION

For India, a rapprochement with China may be essential, but the matter must not be rushed. George Santayana, the Spanish-American philosopher and essayist, said, "Those who cannot remember the past are condemned to repeat it." This is apt in India's context; throughout our bilateral relationship, India has taken the lead in improving the ties, only to be betrayed again and again.

This time, however, New Delhi should exercise extreme vigilance. Boundary management must involve a quid pro quo. On the trade imbalance, Beijing must open its market to Indian companies; apart from this, it should demonstrate, in a concrete manner, that it is committed to addressing the trade deficit by buying more goods from India. Further, it is necessary for India to brainstorm possible countermeasures in case China again imposes restrictions on the export of rare-earth magnets; this may require establishing alternative sources of supply from other partner countries while working towards exploration and extraction of critical minerals and rare-earth elements on home soil.

Unlike in the past, idealism won't work this time. It is imperative that we internalise hard-nosed realism in our ties with Beijing. The era of the *Hindi-Chini bhai bhai* is over; it is time that we adopt a formal, transactional, and calculated relationship with the dragon.



–The writer, a columnist, is a doctoral candidate in Political Science at Mahatma Gandhi Central University. He is also a Research Associate at Defence Research and Studies (dras.in)

SCHIEBEL INDIA



UNMANNED. UNMATCHED.

CAMCOPTER® S-100 AND CAMCOPTER® S-300

THE DEFINING DECADE

RAKSHA, a ten-year policy blueprint, codifies defence diplomacy as a central pillar of India's foreign policy. But the challenge lies in turning strategic vision into enduring reality by navigating great-power competition, meeting indigenous production timelines and converting diplomatic goodwill into durable strategic advantage



DR ARUNA PRAKASH

Union Defence Minister Rajnath Singh recently released the 'RAKSHA' document on India's defence diplomacy. The comprehensive blueprint outlines a strategic ten-year roadmap aimed at expanding military partnerships, defence capacity building, indigenous manufacturing, arms exports and maritime security.

Defence diplomacy refers to the use of defence institutions for military-to-military cooperation as instruments of foreign policy to build trust, strengthen partnerships, enhance interoperability and promote regional stability without resorting to force.

It is a ten-year policy framework that formally codifies defence diplomacy as a central pillar of India's foreign policy. The RAKSHA document marks a shift from a historically cautious and non-aligned defence posture towards an assertive and proactive global role—as an anchor of regional stability through diversified partnerships based on converging interests.

A first of its kind for India, the document signals that the country can both project power and offer stability in a world of geopolitical uncertainties. RAKSHA brings together diplomatic and security goals. It serves as a coordinated, actionable vision integrating the objectives of the Ministry of Defence (MoD), the Ministry of External Affairs (MEA), and the National Security Council Secretariat (NSCS).

RAKSHA seeks to transform India from primarily a defence equipment importer and security partner into a stronger defence producer, exporter and strategic security provider. It also complements India's objective of Aatmanirbhar Bharat, connecting indigenous defence production with international partnerships and markets.

The framework can enhance interoperability among armed forces, facilitate technology and knowledge sharing, strengthen supply-chain resilience and expand India's strategic influence. Defence diplomacy can also support India's wider Indo-Pacific vision and contribute to a stable, secure and rules-based maritime order.

Let us look at the highlights of this blueprint:

Strategic Partnerships: India is seeking to deepen bilateral and

multilateral security cooperation with friendly, like-minded global and regional partners to counter shared geopolitical threats and ensure collective regional security. India's defence diplomacy will have to navigate intensifying geopolitical competition and balance relations among major powers.

Recent bilateral and multilateral engagements like Exercise Yudh Abhyas 2026 and Exercise Nomadic Elephant 2026 highlight India's active military diplomacy, joint counterterrorism readiness, and strategic partnership. To strengthen defence diplomacy, these continuous engagements serve as key confidence-building measures that cement political and strategic ties across the Indo-Pacific and neighbouring partner nations.

In Exercise Nomadic Elephant 2026, the 18th edition of the India-Mongolia joint exercise commenced on September 21, 2026, at Pithoragarh, Uttarakhand, running until October 3, 2026, focusing on counter-insurgency operations under a UN mandate.

India's military cooperation with Armenia has expanded significantly in recent years. In August 2026, the two countries signed a memorandum providing for cooperation in research, development, innovation and joint production in defence. As both countries navigate complex regional dynamics, they can benefit from a strategic alliance that supports mutual interests in stability and security.

RAKSHA affirms that India can both project power and offer stability amid geopolitical uncertainty, moving from a historically cautious posture to an assertive, proactive role as an anchor of regional stability

Capacity Building and Training: The roadmap places heavy emphasis on strengthening joint military exercises, operational training, and intelligence-sharing mechanisms to counter illegal maritime activities, maritime pollution, and terrorism. The government is promoting specialised military training programmes, exchanging institutional cooperation and assistance, and sharing best practices with partner countries.

India is encouraging specialised training programmes with friendly foreign nations, particularly in the Indian Ocean Region (IOR). India seeks to enhance joint military exercises, targeted training programmes, and the sharing of operational best practices with allied nations, particularly focusing on the Global South.

Through the "RAKSHA" defence diplomacy roadmap, India is actively expanding strategic support, military capacity building and defence exports to friendly neighbouring countries like the Maldives and Sri Lanka.

Indigenous Defence Exports: India is expanding its indigenous defence manufacturing and promoting 'Make in India' defence equipment in international markets. India actively promotes 'Make





in India' and Aatmanirbharta in defence by shifting from a traditional buyer-seller model towards co-development, co-production and technology sharing.

The RAKSHA document aims to transform India from a net arms importer into an exporter of advanced strategic technologies. Highlighting India's self-reliance in shipbuilding (where 97 per cent of Indian Navy and Coast Guard vessels are built domestically), India is increasing the export of indigenously manufactured warships and patrol vessels to partner nations including Mauritius, Sri Lanka, Vietnam, and the Maldives.

Maritime Security: The maritime security pillar focuses on strengthening India's role as a 'Net Security Provider and First Responder' in the IOR. India is reinforcing its commitment to safeguard secure sea lanes, ensure freedom of navigation, and provide immediate Humanitarian Assistance and Disaster Relief (HADR) across the region.

Under HADR, joint exercises regularly integrate disaster response protocols and humanitarian aid frameworks (seen in regional cooperation models like Mitra Shakti and Dharma Guardian) to ensure rapid joint deployment during crises.

It builds on the Navy's sustained operational presence in the region, including mission-based deployments, anti-piracy operations and humanitarian assistance and disaster-relief missions. Interoperability and readiness drills focus on jungle warfare, joint artillery, air defence, and small-unit tactics to handle complex regional challenges.

The RAKSHA framework provides an actionable vision for the next ten years. However, aligning domestic industrial self-reliance with international military cooperation is one thing, delivering on that vision is another

Maritime security is very significant because of India's geographical position in the Indian Ocean. RAKSHA focuses on protecting critical sea lanes of communication (SLOCs) and ensuring freedom of navigation. This also aligns with India's Indo-Pacific vision of a free, open, inclusive and rules-based maritime order, consistent with the SAGAR (Security and Growth for All in the Region) vision.

TAKEAWAYS

The RAKSHA framework complements the Defence Forces' Vision, which seeks to transform India's armed forces into a modern, integrated and technologically advanced military capable of supporting the vision of Viksit Bharat by 2047.

Through recent military exercises and HADR operations, India is strengthening relations and offering help to countries like the Maldives, Sri Lanka, Vietnam and Armenia.

As an economic force multiplier, India's defence exports promote indigenous platforms such as BrahMos, LCA Tejas and artillery systems, generate export revenue, strengthen the domestic defence-industrial base and help to open new markets through Government-to-Government (G2G) engagements.

By securing the global commons as a first responder in HADR and participating in anti-piracy operations, India builds diplomatic goodwill, strengthens trust and enhances operational interoperability with littoral states in the IOR.

RAKSHA marks a shift from conventional defence cooperation towards a more proactive and strategic defence diplomacy. By combining strategic partnerships, capacity building, indigenous defence exports and maritime security, India can convert its growing defence capabilities into greater strategic strength.

Ultimately, the RAKSHA framework provides an actionable vision for the next ten years and seeks to transform India from a cautious observer into a proactive architect of regional and global security. But aligning domestic industrial self-reliance with international military cooperation is one thing; delivering it is another. The next decade will test India's capacity to turn its strategic vision into an enduring reality of peace and stability.



– The writer retired as a Senior Technical Officer at the Central Salt and Marine Chemicals Research Institute, Bhavnagar (Gujarat), and currently contributes articles to research journals and magazines

DELOPT
INSPIRED TO INNOVATE
A Division of JK Paper Ltd

Integrated Defence & Electronics Solutions

for a Safer, Smarter Future



INSPIRED TO INNOVATE

DELOPT is a technology-driven enterprise in Defence Electronics and Electro-Optics, delivering advanced solutions across multiple domains to meet evolving global and national security needs

Unmanned Platforms
Drones, UAVs & Counter-UAS

Electro-Optics
Superior Sensing & Imaging

Communication Technology
Secure & Reliable Connectivity

Avionics
Smart & Reliable Flight Systems

Naval Electronics
For Mission Readiness

Land Electronics
For Modern Land Operations

Digital Automation & Analytics
Turning Data into Decisions

Advanced Technology Solutions
Integrated Innovative Future-Ready

OUR STRENGTH LIES IN

Innovation

Operational Excellence

Long-Term Partnerships

Sustainable Growth

+91-89040 49995 +91-80-6720 0400 info@delopt.co.in www.delopt.co.in

THE BATTLEFIELD DATA RACE: WHAT INDIA MUST LEARN FROM UKRAINE

As war acquires a digital second life, combat data is becoming as vital as hardware. Britain's access to Ukraine's AI database underscores how real-world battlefield observations help refine autonomous systems. For India, this highlights an urgent imperative: to systematically archive operational failures and successes to build resilient, sovereign defence technologies

SAIKIRAN KANNAN

On September 25, 2026, Britain announced that up to twelve companies would gain access to a Ukrainian resource that no defence factory could manufacture, i.e. observations gathered on a real battlefield.

The resource was data. Ukraine's Avengers AI Labs database contains imagery and video from drones using daylight and thermal sensors, with information from more than six million object detections. British developers would use it to build AI for advanced drone swarms, including systems intended to function when communications deteriorate or satellite navigation becomes unavailable.

For India, the announcement deserves attention beyond the familiar fascination with autonomous weapons. It reveals how the experience of war is acquiring a second life, inside the systems being built for the next one.

A combat recording can answer questions that a successful demonstration leaves untouched. What did the sensor see before it lost the target? Which background confused the software? Did an operator intervene because the machine was wrong, or because its recommendation was impossible to verify?

These details rarely make it into the dramatic clips circulated online. Yet, they may be the most useful part of the recording.

THE FOOTAGE AFTER THE HEADLINES

Watch a drone video on social media and the eye follows the explosion. An engineer studying the same footage may be interested in the seconds before it: a change in visibility, an object partly hidden by trees, a target seen from an unfamiliar angle.

The difference matters. A weapon can perform well in a controlled trial and still encounter conditions its developers have never adequately represented. Training data helps a recognition model learn what to look for. Carefully separated test data helps establish whether it can recognise something it has not already been shown.

Ukraine has begun organising access to this experience. In January 2026, its defence ministry announced Brave1 Dataroom, a secure environment built with partners including Palantir. Its initial focus included detecting and intercepting hostile drones, using structured visual and thermal datasets collected by service personnel. Developers would undergo security checks before receiving access.

By June, the ministry reported that more than one hundred Ukrainian companies were using the platform. Its datasets covered aerial targets observed under different weather conditions, at different times of day and through different sensors. These are official accounts of the programme, rather than an independent verdict on every model's effectiveness. They nevertheless show a deliberate effort to bring developers



closer to operational reality.

The British agreement adds another dimension. Battlefield experience can become something a country offers its partners, with access negotiated alongside technology cooperation.

That creates difficult questions about ownership. Who may retain the resulting models? Can the original provider inspect them? What happens when a partnership changes? Governments negotiating these arrangements should treat the answers as seriously as they treat access to sensitive equipment.

INDIA's LESSON CANNOT BE DOWNLOADED

India should study Ukraine's approach without assuming that Ukrainian data will prepare an Indian system for every Indian mission. An aerial target observed against a European landscape presents a different problem from one seen against Himalayan terrain or a crowded urban background. Sensor characteristics matter. So do weather, altitude and the equipment an adversary uses. A model's performance in one setting offers evidence to examine, not a guarantee to carry into another.

For the Indian Air Force, this makes the collection and interpretation of its own experience an operational priority.

A sortie produces more than a mission report. Sensor recordings, equipment behaviour and crew observations may contain lessons that future software needs. Exercises can generate valuable material too, provided their limitations are recorded honestly. Simulations can help cover rare situations, but should be checked against observations from actual systems.

While dramatic explosions capture online attention, engineers focus on the crucial seconds prior – analysing sensor data and background noise to overcome real-world failure scenarios

The danger is that these records remain useful only to the unit or team that collected them. A finding discussed in a debrief may never reach the engineer working on the relevant software. A failed detection may be explained locally, then disappear from the material used to evaluate the next version.

Closing that gap requires some unglamorous work. Records need consistent descriptions, reliable timestamps and a clear account of what was observed and what remains uncertain. Someone must be responsible for deciding which material can be reused and under what restrictions.





RETAIN THE FAILURE SCENARIO

India could begin with a tightly bounded programme for counter-drone detection and airbase protection, bringing together the IAF, defence researchers and approved domestic developers.

The first task should be to assemble representative data and establish a common test process. Companies should demonstrate performance on material they have not used for training. Results should distinguish missed threats from false alarms, because each imposes a different operational cost.

The archive must include difficult and unsuccessful cases. A dataset dominated by clear views and confirmed successes may leave developers poorly prepared for the moment a system struggles.

Retain crew accounts beside the recordings. An operator may know that a track was unreliable, that two sensors disagreed, or that an apparent equipment failure had another explanation. Losing that context can turn a precisely labelled record into a misleading one.

Access would need to be controlled. Selected developers could work within secure environments, with restrictions on copying and a record of how information was used. Contracts should settle rights over derived models, updates and evaluation results before those questions become obstacles.

As battlefield data becomes a key diplomatic currency, nations must strictly regulate data access, retain model ownership rights, and accelerate the loop between operational findings and software updates

The pilot should also measure the time between an operational finding and a tested improvement. Collecting a failure achieves little, if the people able to fix it cannot act.

THE NEXT SORTIE

None of this removes the need for capable aircraft, trained crews or adequate weapons stocks. It helps those investments work better and gives India more freedom to adapt them.

The ambition should be practical. When a sensor misses something important, the next software release should reflect what was learned. When crews repeatedly encounter the same weakness, procurement and testing should respond. Evidence from operations should travel far enough to change the equipment that returns to them.

Ukraine's experience comes at a terrible human cost. Its value to other countries should never obscure that. But India can learn from the institutions being built around that experience, and start organising its own observations before urgency forces the issue.

The explosion is the part of the video everyone watches. The seconds before it, may help determine what happens on the next sortie.



–The writer is an independent journalist based in APAC region. He covers global conflicts, geopolitics, counterterrorism, OSINT and data-based stories. He is also a Data and AI Strategist for leading corporations in the region. His X handle is https://x.com/saikirankannan

Tecknotrove
Defence

INDIGENOUS TECHNOLOGY ADVANCED SIMULATION MISSION READINESS





www.tecknotrove.com

Precise today
Perfect tomorrow

INDIA's FCAS GAMBIT: A LEAP TOWARDS GENERATION 6



India eyes a seat at Europe's sixth-generation table and a shortcut to the future of air power. Pursuing a deliberate dual-track strategy — building indigenously and learning internationally, India's focus should be on becoming a true co-architect of sixth-generation air power, not merely its newest financier

MRIGANK SHEKHAR

For decades, India's fighter modernisation story has been one of chasing timelines set in Moscow, Paris or Washington — buying, licence-building, occasionally co-developing, but rarely sitting at the table where next-generation air power is actually designed. That may be changing. In its 25th report to Parliament, presented on August 7, 2026, India's Ministry of Defence disclosed that it has started work on joining the French-led Future Combat Air System (FCAS), two months after the collapse of the Franco-German fighter that sat at the centre of the programme. It's a short sentence in a dry parliamentary document — but it could mark the moment India stops being a customer of sixth-generation air power and starts becoming its co-author.

WHY FCAS IS SUDDENLY UP FOR GRABS

To understand why this door has opened, rewind to June 8, 2026. France and Germany terminated their joint FCAS collaboration after Dassault Aviation and Airbus failed to resolve disputes over industrial authority, workshare and intellectual property. The friction wasn't superficial — France required a future aircraft capable of carrier operations and supporting the nuclear mission, while Germany did not need those features, and the two nations simply could not reconcile that operational and industrial divergence. What survives is the digital backbone of the programme — Germany and France are reportedly still willing to co-develop the 'Combat Cloud', the AI-driven network meant to link fighters, drones and legacy jets.

Into this vacuum steps India. Unlike the deadlocked three-way European partnership, a France-India deal would have only two capitals to satisfy — a far simpler negotiating table. For France, an Indian partner offers something Dassault badly needs after Berlin's exit: industrial depth and financial resilience. It's a rare alignment of interests — a wounded European champion looking for a well-funded, ambitious partner, and an Indian Air Force staring at a widening capability gap.

WHY INDIA CAN'T AFFORD TO WAIT

The urgency isn't abstract. The Indian Air Force possesses a deficit of 13 fighter squadrons — 31% of its authorised 42 — even as it juggles ageing Jaguars, a modest Rafale fleet, expanding Tejas production, the highly capable Sukhoi Su-30MKI, the indigenous AMCA effort and a fresh 114-aircraft Rafale negotiation. Meanwhile, China's own sixth-generation ambitions are advancing fast. Parliament's own defence committee didn't mince words: it flagged FCAS and the rival British-Italian-Japanese Global Combat Air Programme (GCAP) as the principal sixth-generation projects, warning that delayed participation could leave the Indian Air Force technologically disadvantaged. Notably, India appears to have made its choice between the two — selecting the French-led FCAS over GCAP — likely a reflection of the deep trust already built through decades of Mirage and Rafale operations, and the fact that France, unlike GCAP's three-nation consortium, has historically shown more openness to genuine co-development with India (as seen in the Kaveri-Safran engine talks and Scorpene submarine programme).

NOT A FIGHTER JET — A SYSTEM OF SYSTEMS

Here's what makes FCAS fundamentally different from any fighter deal India has signed before: it was never conceived as 'just' an aircraft. Its objective is to build an entire combat-air ecosystem — a next-generation fighter, unmanned Remote Carrier drones, and a sophisticated digital network called the Combat Cloud — connecting assets across air, land, sea, space and cyber domains. In practical terms, this means sensors on one aircraft feed targeting data to a weapon on another, drones fly ahead as expendable 'loyal wingmen', and a resilient, jam-hardened network holds the entire mesh together under electronic attack.

This is precisely the kind of 'system of systems' thinking that Indian defence planning has talked about for years but rarely built at scale. Legacy platforms are engineered in isolation and networked as an afterthought; FCAS-style architecture designs the network from day one. For India's air force — and by extension its navy and army aviation — genuine exposure to this discipline would be transformative, teaching Indian engineers not just how to build a better aircraft, but how to architect an entire warfighting ecosystem where humans, autonomous drones and AI-driven decision loops operate as one.

Unlike the deadlocked three-way European partnership, a France-India deal would have only two capitals to satisfy — a far simpler negotiating table. For France, an Indian partner offers something Dassault badly needs after Berlin's exit: industrial depth and financial resilience. It's a rare alignment of interests

THE REAL PRIZE: MATURING INDIA's AEROSPACE SECTOR

Fighter programmes are, in the end, workforce-building programmes. What India stands to gain isn't just hardware — it's institutional muscle memory. A sixth-generation workshare with real strategic value would need Indian responsibility for airframe sections designed in India, flight-control or mission-software modules, low-observable materials, sensors, electronic-warfare subsystems and propulsion components. Each of those is a discipline where Indian aerospace — from HAL to DRDO labs to the private sector — has partial capability but has struggled to reach maturity independently.

Consider stealth shaping and radar-absorbent materials, composite airframe structures, AESA radar development, and sensor fusion software — areas where AMCA and FCAS already overlap significantly. Co-development exposes Indian design teams to French systems-engineering rigour, test protocols, certification standards and — critically — the discipline of managing a genuinely distributed, multi-node combat network. This is the kind of skill upgrade that no amount of domestic trial-and-error can substitute for, because it requires working alongside an industry (Dassault, Thales, Safran, Airbus) that has already solved many of these problems at production scale.

There's also a maturity dividend beyond engineering: programme management. FCAS-style projects demand disciplined systems integration across multiple contractors, rigorous configuration control and long-horizon industrial planning — exactly the organisational capabilities Indian aerospace has historically lacked, as seen in the delays that have dogged indigenous programmes. Working inside a French-led framework, even as a junior partner, would force Indian industry to internalise these disciplines or risk being sidelined.

WHAT IT MEANS FOR TEJAS

The immediate, tangible beneficiary could be the Tejas line. Officials in New Delhi have been unusually blunt about wanting engine sovereignty — Defence Minister Rajnath Singh, during a visit to the Gas Turbine Research Establishment in Bengaluru, made it clear that India cannot stop at merely powering the AMCA. Any FCAS-linked propulsion collaboration with Safran — which is already central to the engine debates around AMCA — carries a natural spillover: technologies matured for a sixth-generation power plant (better thermal management, advanced materials, digital engine control) tend to filter down into upgrades for existing platforms. A more indigenised, higher-thrust engine ecosystem born from FCAS-adjacent R&D would directly benefit the long-delayed Tejas Mk2 and future Tejas variants, reducing India's chronic dependence on imported powerplants like the GE F404/F414.

Beyond propulsion, avionics and





sensor-fusion software developed for a networked combat-cloud architecture could be scaled down and retrofitted into Tejas's mission computers, giving the light fighter genuine networked-warfare capability — turning it from a standalone platform into a node that can share targeting data with AMCA, Rafales and even unmanned wingmen.

WHAT IT MEANS FOR AMCA

For AMCA, the calculus is more delicate but potentially more rewarding. India has been careful to stress that FCAS involvement is meant to support, not replace, the AMCA programme, which remains the central pillar of India's fighter modernisation, with rollout targeted by the end of 2028, first flight in early 2029, and induction expected in the mid-2030s. Given that overlap in stealth shaping, composites, AESA radar and electronic warfare, participation in FCAS's technology-maturation work could act as an accelerant — letting Indian design teams validate concepts, materials and subsystems years earlier than they could through solitary domestic effort, then feed those lessons straight into AMCA's Mk1 and the more ambitious, unmanned-teaming-capable Mk2.

Perhaps the biggest single gift to AMCA would be exposure to combat cloud and manned-unmanned teaming architecture — the very technologies AMCA's later increments are meant to carry but for which India currently has the least mature domestic base. FCAS combines a stealthy fighter with remote-carrier drones, loyal wingmen and a combat cloud linking distributed sensors, weapons and command nodes across a contested battlespace. If Indian engineers help build even a slice of that architecture for France, they walk away with blueprints for exactly the "drone swarm plus AI brain" capability AMCA will eventually need — potentially saving years and billions of rupees in independent R&D.

THE HARD CAVEATS

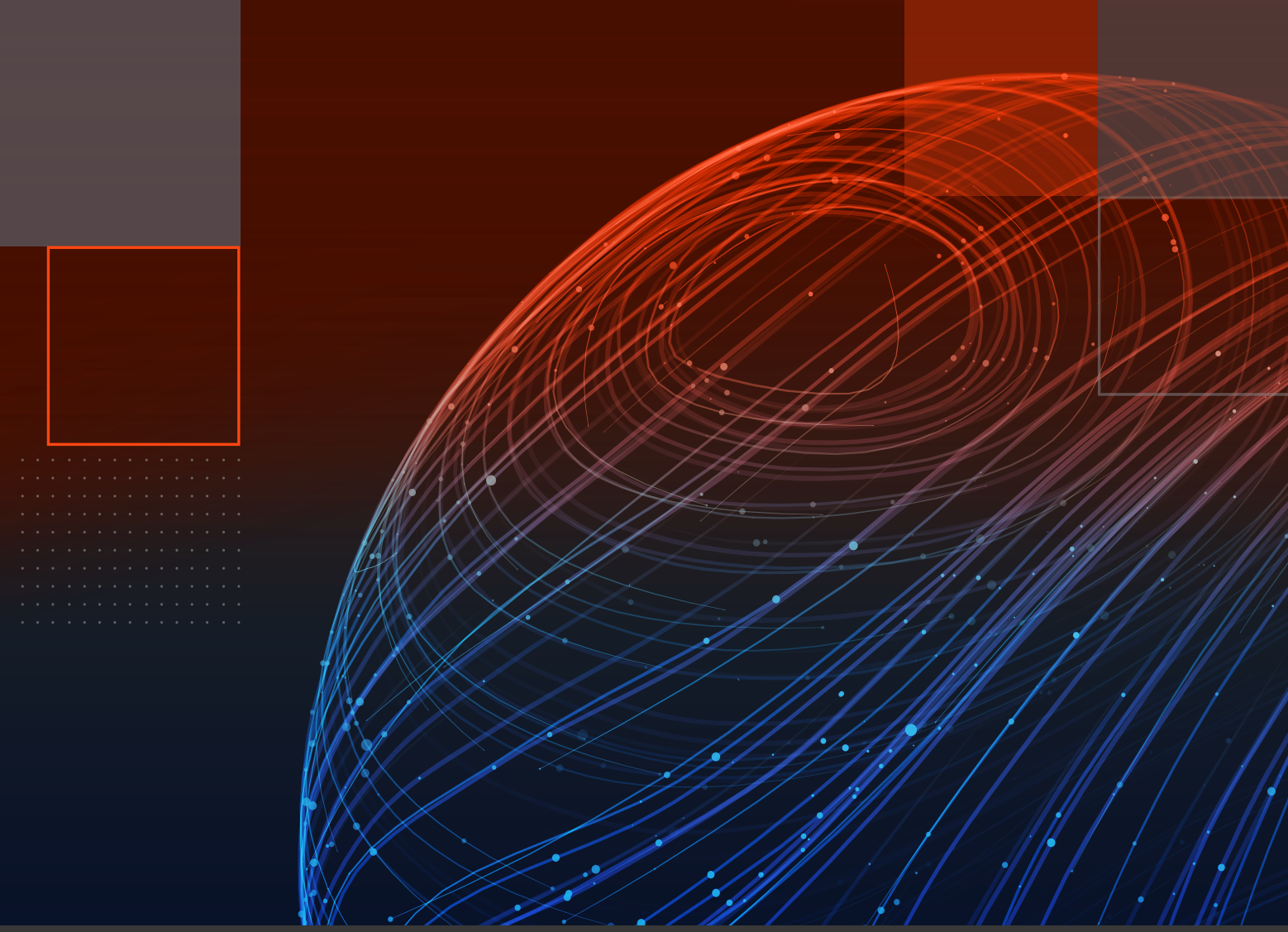
None of this is guaranteed, and enthusiasm should be tempered with realism. No bilateral agreement, financial commitment, industrial workshare arrangement, or legally binding technology-transfer framework had been announced as of mid-August 2026 — what exists today is talks, not a treaty. France is highly unlikely to grant open access to its most guarded secrets — proprietary systems tied to nuclear payload delivery, sovereign mission software, and top-tier electronic warfare will almost certainly stay under strict French oversight.

The tough questions that sank the Franco-German arrangement — who holds design authority, how technology is shared, whether Dassault remains undisputed design lead, and whether India gets genuine design ownership or mostly financing and production work — will resurface in any India-France negotiation too. India's insistence on sovereignty and indigenous IP ownership, hard-won through years of frustrating experience with technology-transfer deals, means these talks could be slow and contentious.

A CALCULATED BET ON THE FUTURE

Still, the strategic logic is compelling. India is not abandoning AMCA to chase a European mirage; it is pursuing a deliberate dual-track strategy — build indigenously, learn internationally. If New Delhi can negotiate genuine design work rather than a subordinate role, FCAS could become the single biggest accelerant to Indian military aerospace maturity since the Su-30 MKI licence-production era — this time not just building someone else's aircraft, but helping architect the network that will define air combat beyond 2040. The parliamentary disclosure is only the opening move. What happens at the negotiating table over the next year will determine whether India becomes a true co-architect of sixth-generation air power — or merely its newest financier.

–The writer is a defence journalist specialising in military affairs, security policy and defence technology. He reports extensively on operation strategies, defence manufacturing initiatives and geopolitical developments across the Indo-Pacific region



EDGE

Always Ahead. Always Above.

Proven where it matters most—EDGE systems are engineered for dominance in the toughest environments. Our autonomous platforms operate longer, faster, and with greater precision, integrating seamlessly across multiple-domains.

EDGE redefines modern defence—showcasing autonomous air platforms, precision munitions, air defence, electronic warfare, secure communications, and more. From AI to radars, electro-optics to precision engineering, secure communications to space technology, we deliver integrated systems for decisive advantage.

Stay Always Ahead. Always Above.

Visit edgegroup.ae

CRITICAL MINERALS CRUCIAL FOR SELF-RELIANCE IN DEFENCE PRODUCTION

Despite adequate availability of rare earth elements in India, production capacity remains limited due to the lack of midstream and downstream industries. The Ministry of Defence must push to minimise the vulnerability that besets India's quest for self-reliance in defence production, as critical minerals are crucial for the clean energy transition, advanced electronics, infrastructure, telecom and aerospace



AMIT COWSHISH

Former Financial Advisor (Acquisition), Ministry of Defence

Absolute self-reliance in defence production is a misconception. Except for China, which is now largely self-sufficient after successfully reverse-engineering many technologies it imported from Russia (earlier USSR) and other countries like Ukraine over the last couple of decades, most other countries, including the United States (US), are not fully self-reliant. Much of this stems from the world's dependence on a very limited supply of critical minerals (CMs), some of which are rare earth elements (REEs).

According to a 2024 US Government Accountability Report, the US imported more than 95% of the REEs it consumed, and from 2019 to 2022, almost three-quarters of these imports came from China. France, the second-largest exporter of arms, accounting for 9.8% of global exports in 2021-25, relies for CMs on its own recycling initiatives and bilateral agreements with countries like Malaysia, Mongolia, Brazil, South Africa, and Sweden, as domestic mining within mainland France is grossly inadequate. This is true of other major arms-manufacturing countries like Russia and Germany.

CMs such as lithium, cobalt, and nickel are non-fuel minerals or materials whose supply chain is prone to disruption because of their limited availability, lack of domestic processing capabilities, and geopolitical risks. Some of the CMs, such as tantalum and tungsten, lack equally efficient substitutes. Within the broad category of CMs, a group of 17 chemically similar metallic elements like neodymium, yttrium, and cerium is classified as REEs, as these are essential for high-tech applications, including permanent magnets for electric vehicles and wind turbines.

Contrary to what the nomenclature suggests, REEs are quite abundant in the earth's crust, but they are not typically found in concentrated deposits, making their extraction difficult. According to a Department of Atomic Affairs Press release issued on March 12, 2026, India holds the world's third-largest REE resources, but these are lean with respect to grade and tied to radioactivity, making their extraction a long, complex, and expensive process. Moreover, heavy REEs like yttrium are not available in economically extractable quantities.

While India has facilities for mining, separation, refining, etc., and also the capability of metal extraction, industrial-scale facilities for extraction from alloys, magnets, etc. are non-existent. In these circumstances, despite adequate availability of REEs, production capacity is limited due to the absence of mid-stream and downstream industries in the value chain. This should be a matter of concern for India as CMs are crucial for clean energy transition, advanced electronics, infrastructure and telecommunications, and aerospace and defence.

In June 2023, a committee constituted by the Ministry

A 2024 US Government Accountability Report says the US imported 95% of the rare earth elements it consumed, and from 2019 to 2022, almost three-quarters of these imports came from China. France relies on its own recycling initiatives and bilateral agreements with countries such as Malaysia, Mongolia, Brazil, South Africa and Sweden, as domestic mining within mainland France is grossly inadequate

of Mines identified a set of 30 CMs, following which the Union Cabinet approved a National Critical Mineral Mission (NCMM) on January 30, 2025, "to secure a long-term sustainable supply of critical minerals (including REEs) and strengthen India's CM value chain encompassing all stages from mineral exploration and mining to beneficiation, processing, and recovery from end-of-life products." Since then, there has been a flurry of activity.

Under the NCMM, guidelines were issued on November 14, 2025, for funding pilot projects for the recovery of CMs from fly ash, red mud, etc., and a project of the Non-Ferrous Technology Development Centre (NFTDC) related to REE separation from multiple feedstocks was approved. A Rare Earth Permanent Magnet Plant (REPM) was also set up at Vizag for indigenous production of permanent magnets for use in atomic energy and defence.

A ₹1,500 crore Incentive Scheme was launched on October 2, 2025, to promote CM recycling, and another 'Scheme to Promote Manufacturing of Sintered Rare Earth Permanent Magnet' was launched on November 26, 2025, to establish 6,000 Metric Tons per Annum of integrated Rare Earth Permanent Magnet (REPM) manufacturing. The Ministry of Mines formulated a policy in December 2025 for Exploration of CMs in New Projects and Recovery of CMs from overburden, dumps, and tailings of existing mines. A Joint Venture company, Khanij Bidesh India Limited (KABIL), was created to acquire overseas mineral assets like Lithium, Cobalt, REE, etc.

Not to be left behind, Atomic Minerals Directorate for Exploration and Research (AMD), a constituent unit of the Department of Atomic Energy, is carrying out exploration and augmentation of REEs along the coastal / inland / riverine placer sands as well as in hard rock terrains in several potential geological domains of the country. By July 2025, AMD had identified the existence of CMs/REEs in parts of Andhra Pradesh, Odisha, Tamil Nadu, Kerala, West Bengal, Jharkhand, Gujarat, and Rajasthan. The Geological Survey of India has also augmented resources of REE ore at various cut-off grades in 34 exploration projects.

India's efforts to minimise its vulnerability in CMs are not restricted to domestic initiatives. It has become a member of the Critical Minerals Partnership, which is "an international agreement between governments and industries to secure, diversify, and responsibly develop supply chains for essential minerals like lithium, cobalt, and rare earth elements." The country is actively participating in the Pax Silica grouping and engaging with countries such as the US, Australia, Argentina, the UAE, Zambia, Peru, Chile, France, Uzbekistan, and the UK to build a resilient CMs supply chain.

India's efforts to minimise its vulnerability in critical minerals are not restricted to domestic initiatives. The country is actively participating in the Pax Silica grouping and engaging with countries such as the US, Australia, Argentina, the UAE, Zambia, Peru, Chile, France, Uzbekistan and the UK to build a resilient CMs supply chain

These developments are heartening, but where does India stand regarding the availability of defence-specific CMs like Titanium, Vanadium, and Platinum Group Elements that are used in the manufacturing of armour, fighter jets, and precision weaponry? The first Defence Production Policy of 2011 and the draft Defence Production and Export Promotion Policy 2020 did not focus on CMs. The currently in-force Defence Acquisition Procedure 2020, or its revised draft of 2026, which is yet to be finalised, also does not prioritise it.

The Defence Research and Development Organisation (DRDO) does not have a directorate dedicated to securing India's strategic interests in CMs, though its Directorates of Materials and Futuristic Technology Management do seem to be engaged in developing, processing and extraction technology for CMs like titanium, tungsten, and nickel, supply chain resilience and technology integration with futuristic defence assets. It is unlikely that, besides focusing on the technology for mining and processing of CMs, securing the supply chain, and creating sufficient CM stockpiles, these also fall within DRDO's purview.

It is instructive that China's dominance in the CM sector is largely on account of decades of government support and strategic investment in building the country's extraction, processing, and refining capabilities. India is moving in that direction. The Department of Mines may have factored in the needs of the defence industry while identifying the country's CMs vulnerability and taking steps to address it, but considering the imperatives of self-reliance in defence production, MoD needs to take stock of the measures taken by other ministries and decide whether some focused leg up is required to ensure availability of defence-specific CMs, so that the vulnerability that besets India's quest for achieving self-reliance in defence production could be minimised. It would be ideal for the MoD to formulate its own policy on securing the supply chain of CMs and REEs that are crucial for the defence industry and integrate that policy with the existing R&D, production and procurement ecosystems. What lends a sense of urgency to this task is that China controls the refining and processing of most of the world's critical minerals. A small nudge from the Standing Committee on Defence would help.

VTOL UAS: SHAPING THE FUTURE AIR POWER

Modern air warfare is shifting toward networked, multi-domain operations where unmanned platforms serve as core combat assets. Vertical Takeoff and Landing (VTOL) systems offer critical flexibility across diverse terrains. Aligning with India's Aatmanirbhar Bharat vision, platforms like Schiebel's CAMCOPTER® series advance Manned-Unmanned Teaming, enhancing battlefield endurance, payload capability and operational superiority

JAJATI MOHANTY

The character of air warfare is changing rapidly. What began with unmanned systems primarily supporting Intelligence, Surveillance and Reconnaissance (ISR) missions has evolved into a new operational reality where drones are becoming an integral part of combat formations, force multiplication strategies and multi-domain operations.

This evolution is particularly relevant for India. As the Indian Armed Forces continue to modernise and prepare for increasingly complex operational scenarios, unmanned systems are transitioning from supporting assets to essential contributors across the battlefield. The Indian Air Force's drone warfare strategy reflects this shift. The future is no longer about operating individual unmanned platforms. It is about integrating manned and unmanned assets into a coherent operational ecosystem.

In this context, Vertical Takeoff and Landing (VTOL) Unmanned Air Systems have a unique role to play.

Unlike conventional runway-dependent platforms, VTOL UAS combine mobility, operational flexibility and rapid deployment. They can operate from remote locations, austere environments, ships, mobile command posts and forward operating bases. This versatility makes them particularly valuable for a country like India, where operational requirements span mountains, deserts, coastlines, islands and dense urban environments.

The CAMCOPTER® S-100 has long demonstrated the advantages of this concept. Operationally proven on multiple continents, it has accumulated extensive real-world experience across a broad spectrum of missions, including ISR, maritime surveillance, border security, search and rescue, environmental monitoring and disaster response. Its ability to operate without launch or recovery equipment and its compact logistical footprint have made it particularly attractive to operators seeking flexible airborne intelligence capabilities.

As operational requirements continue to evolve, however, there is growing demand for systems that provide greater endurance, higher payload capacity and expanded mission flexibility. This development led to the introduction of the CAMCOPTER® S-300.

Drones are transitioning from standalone surveillance units into force multipliers, integrated directly into combat formations and multi-domain networks

Building on the proven CAMCOPTER® heritage, the S-300 significantly expands what can be achieved with a VTOL UAS. With substantially increased payload capacity and endurance of up to 24 hours with a 50 kg payload, the platform allows operators to carry multiple mission systems simultaneously while maintaining persistent coverage over large operational areas.

This is especially relevant in the context of the modern battlespace, where decision superiority increasingly depends on the ability to collect, process and distribute information faster than potential adversaries. Multiple sensors operating simultaneously on a single platform provide commanders with a more comprehensive operational picture while reducing the complexity associated with deploying several separate assets.

For the Indian Air Force, this aligns closely with emerging concepts of multi-domain operations and network-centric warfare. Long-endurance VTOL UAS can support air operations by extending surveillance coverage, conducting reconnaissance missions in contested areas, acting as communication relays and contributing to targeting and battle damage assessment.

Perhaps even more significant is



the growing importance of Manned-Unmanned Teaming (MUM-T).

Around the world, armed forces are investing heavily in concepts that allow unmanned platforms to operate alongside manned aircraft. Rather than viewing drones as separate systems, operators increasingly see them as extensions of manned platforms, providing additional sensors, greater reach, increased survivability and enhanced mission effectiveness.

This trend is particularly visible in programmes built around the "loyal wingman" concept, where autonomous or semi-autonomous unmanned aircraft support helicopter and fixed-wing operations. For attack helicopters, transport helicopters and other airborne platforms, unmanned teammates can extend situational awareness, penetrate deeper into contested environments and reduce risk to aircrews.

Schiebel is actively involved in this evolution. Together with Thales, we are participating in the United Kingdom's Project NYX, a programme exploring future loyal wingman capabilities for the British Army's AH-64 Apache attack helicopters. The CAMCOPTER® S-300 was recently demonstrated successfully in the UK as part of this initiative and is currently among the final contenders being evaluated.



Runway-independent VTOL platforms provide rapid deployment across high-altitude mountains, deserts and maritime environments without heavy infrastructure requirements

Programmes such as Project NYX highlight the growing recognition that future battlefield success will depend on effective collaboration between manned and unmanned systems.

For India, where future air operations will require high levels of adaptability across diverse operational environments, MUM-T represents a significant force multiplier. The concepts being explored today in programmes such as Project NYX are likely to influence how air forces worldwide integrate unmanned systems into future operations.

The Indian Air Force's Dronathon 2026 highlighted the increasing focus on precisely these capabilities. The event brought together leading industry participants to demonstrate technologies that will help shape the future of drone warfare and manned-unmanned integration.

Schiebel was pleased to participate in Dronathon 2026, where the CAMCOPTER® S-100 delivered an outstanding performance throughout the demonstration activities. The event provided an excellent opportunity to showcase the platform's operational maturity, flexibility and suitability for complex mission scenarios.

More importantly, Dronathon reinforced a broader industry trend. Discussions are increasingly moving beyond individual platforms and focusing on how unmanned systems can integrate into larger operational architectures. MUM-T is no longer a future concept. It is rapidly becoming



an operational requirement for modern air forces.

As these requirements continue to mature, the combination of the CAMCOPTER® S-100 and CAMCOPTER® S-300 provides a scalable capability framework. The operationally proven S-100 delivers tactical flexibility, rapid deployment and mission versatility, while the S-300 expands endurance, payload and mission scope.

Together, they offer a layered approach to unmanned aviation that supports both current and future operational requirements.

The story is not only about platforms. It is also about industrial capability.

India's focus on Aatmanirbhar Bharat and Make in India is creating significant opportunities to build long-term indigenous capability across the defence and aerospace sectors. At Schiebel India, we see this as a strategic opportunity rather than simply a policy requirement.

Schiebel India is steadily expanding its local capabilities in areas including MRO, assembly, integration, maintenance, software development and advanced manufacturing technologies. Over time, these activities can contribute to a broader ecosystem supporting both domestic requirements and future export opportunities.

Drones act as autonomous "loyal wingmen", expanding sensor range and survivability for crewed aircraft in contested airspace

The next phase of unmanned aviation will be defined by higher levels of autonomy, deeper collaboration between manned and unmanned platforms and greater integration across services and domains.

The future battlefield will not be shaped by individual systems operating independently. It will be defined by interconnected networks of sensors, platforms and operators working together to deliver information, awareness and operational advantage.

The Indian Air Force's focus on drone warfare, the growing momentum behind MUM-T and international programmes such as Project NYX demonstrate that this future is already taking shape. The successful participation of the CAMCOPTER® S-100 at Dronathon 2026 further reinforced the value of operationally proven VTOL UAS in this evolving ecosystem.

VTOL UAS will be an important part of that journey. The question is no longer whether unmanned systems will transform air operations. The question is how quickly this transformation will occur.



–The writer is Chief Executive Officer (CEO), Schiebel India

SMPP

PROTECTING THOSE WHO PROTECT US

SHAPING THE FUTURE OF STRATEGIC WARFARE



LARGE CALIBER AMMUNITION



PERSONAL PROTECTION



UAVs & C-UAVs



WARHEADS FOR UAVs

ANTI-PERSONNEL | ANTI-BUNKER
ANTI-ARMOR



PLATFORM PROTECTION

LAND | AIR | NAVAL



SCAN QR

@smppdefense

SMPP LIMITED

SMPP HOUSE, 29, OKHLA INDUSTRIAL ESTATE - III, NEW DELHI - 110020, INDIA

Email: contact@smgroupindia.com | Website: www.smgroupindia.com

THE CASE FOR A FRANCE-INDIA MILITARY SAF CORRIDOR

Sustainable aviation fuel can assist civil and military operations when petroleum supply chains are disrupted. Both France and India are exposed to maritime chokepoints including Hormuz, Malacca, Bab el-Mandeb and Suez. Therefore, France and India should develop an Indian-produced SAF blend for the Rafale

BASILE MARIN, ADRIEN DONAT-BOUILLUD AND ANINDITA MUKHOPADHYAY

Combat aviation will remain dependent on energy-dense liquid fuels for decades. Batteries cannot deliver the necessary range, payload, or rapid refuelling, while hydrogen would require new aircraft and air-base infrastructure. Sustainable aviation fuel, therefore, offers armed forces something beyond decarbonisation: an additional source of kerosene-compatible fuel that could sustain operations when petroleum supply chains are disrupted.

France and India should develop this opportunity through the joint qualification of an Indian-produced SAF blend for the Rafale. Their common aircraft platform and complementary capabilities provide a practical starting point: French aerospace and qualification expertise, combined with Indian feedstocks, engineering capacity and industrial scale.

AVIATION FUEL AS A STRATEGIC VULNERABILITY

Air power depends on a continuous chain connecting crude production, refining, maritime transport, storage and distribution to individual air bases. Disruption anywhere can constrain sorties, even when aircraft and crews remain ready. France and India are exposed to maritime chokepoints including Hormuz, Malacca, Bab el-Mandeb and Suez. Interrupted flows can increase prices, lengthen supply routes and delay replenishment.

Strategic petroleum reserves buy time but contain finite volumes. In a prolonged crisis, they must be replenished through substantially the same system whose disruption made them necessary. Fuel security, therefore, requires additional qualified production capacity based on different resources and locations. Fuel may also be available nationally without being deliverable to the base where it is needed. A useful resilience strategy must address both production and the final distribution network, including the capacity to replenish stocks during sustained operations.

SAF could supply that redundancy. Agricultural and forestry residues, wastes, used oils, ethanol and synthetic inputs offer routes to aviation fuel that need not begin with imported crude. The strategic objective is greater resilience through a broader production base.

Agricultural and forestry residues, wastes, used oils, ethanol and synthetic inputs offer routes to aviation fuel that need not begin with imported crude. The strategic objective is greater resilience through a broader production base

AIRCRAFT CONSUME SPECIFICATIONS RATHER THAN FEEDSTOCKS

Aircraft use finished fuels defined by their physical and chemical properties. Rafale documentation identifies authorised fuels within the F-35/Jet A-1, F-34 and F-44/JP-5 families. Relevant characteristics include density, viscosity, freezing and flash points, calorific value, aromatic content and conductivity. Military fuels may also require specific additives.

This creates an opening for SAF, but similar combustion alone is insufficient. Fuel must come from an approved conversion pathway, respect its blending limit and satisfy the applicable finished-fuel specification. Military additives, aircraft and engine approval, and continuing batch-level quality control remain necessary.

Civil certification does not automatically authorise military use. Storage duration, climatic conditions, refuelling procedures and operational profiles may require further evaluation. A 'drop-in' fuel can use existing equipment after qualification; Rafale approval would require the relevant defence, airworthiness and fuel authorities, alongside Safran Aircraft Engines and Dassault Aviation.



Once qualified, however, a SAF blend could use existing aircraft tanks, depots, tankers and refuelling equipment. This compatibility gives it a decisive logistical advantage over propulsion systems requiring replacement aircraft and infrastructure.

A common fuel specification would also simplify allied cooperation. Rather than creating a separate frontline energy network, the partners could retain familiar handling and refuelling procedures. The benefit would depend on demonstrating that the selected blend remains suitable throughout its operational life, from long-term storage to demanding engine conditions.

BUILDING REPLENISHMENT CAPACITY

Resilience would come from qualifying several production routes and supporting facilities in different regions. Most plants would serve civil aviation, whose greater demand sustains commercial production. Defence ministries could contract for reserved volumes, priority delivery or emergency purchase rights, enabling some output to be redirected during a crisis.

Long-term military procurement could also provide a creditworthy demand floor for early projects. Dual civil and military qualification would allow production to move between markets through much of the same blending and distribution infrastructure, without requiring armed forces to finance a separate industry.

SAF would nevertheless supplement petroleum reserves. Its production still depends on electricity, hydrogen, catalysts, equipment and reliable feedstock collection, some inputs may be imported

Diversifying conversion technologies would reduce dependence on any one feedstock or industrial process. Some regions could supply fuels derived from residues, others from waste oils or synthetic intermediates. Domestic and allied facilities could contribute to the same qualified supply system, provided their products meet the required specifications. Production diversity would become especially valuable during a partial disruption, when some inputs and transport routes remain accessible while others are constrained.

SAF would nevertheless supplement petroleum reserves. Its production still depends on electricity, hydrogen, catalysts, equipment and reliable feedstock collection; some inputs may be imported. Diversification must, therefore, cover the entire supply chain. The value lies in having more ways to replenish authorised aviation fuel when conventional supplies become constrained.

A PRACTICAL FRANCE-INDIA PROGRAMME

France brings expertise in the Rafale, its M88 engine, fuel testing and military qualification. India contributes agricultural residues and wastes, established ethanol and refining industries, and engineering capacity suited to industrial production. Expanding Indian civil aviation would provide the main commercial market, with defence demand adding a strategic anchor.

Both countries depend on imported hydrocarbons and attach importance to strategic autonomy. Their existing defence relationship makes a common



framework for production, qualification and procurement achievable. The corridor should connect these functions rather than merely designate a trade route.

India's location in the Indian Ocean adds a strategic dimension. Locally produced aviation fuel could support replenishment closer to operational demand during disruption to maritime energy flows. French laboratories and certification expertise could help establish a recognised testing framework, while Indian industrial capacity would give successful qualification a route beyond demonstration-scale production.

The programme should proceed in three stages. First, select one mature SAF pathway, one credible Indian producer and a conservative initial blend. Compare the product against the finished-fuel specification required for military use.

Second, undertake laboratory characterisation, storage and additive testing, and assessments of materials and seals. Satisfactory results would permit progression to M88 ground tests and staged aircraft trials, subject to approval by French and Indian authorities and the aircraft and engine manufacturers.

Third, establish joint or parallel procurement arrangements covering approved producers, reserved emergency volumes and batch-level quality control. Integrate the qualified blend into existing depots and refuelling systems. A successful Rafale demonstration could then support extension to transport aircraft, naval aviation and other Rafale operators.

Procurement should make this resilience measurable. Contracts would need to identify which volumes are reserved, how emergency access is triggered and how approved batches reach military depots. A demonstration flight alone would not establish a dependable supply chain. The programme should connect technical authorisation to repeatable production, quality assurance and delivery arrangements that remain useful during a crisis.

COST AND OPERATIONAL CONSTRAINTS

SAF's price premium, limited volumes, technical risks and competition for feedstocks favour a focused initial programme. Qualification requires modest quantities, while procurement decisions should account for the strategic cost of interrupted operations alongside peacetime fuel prices. Civil aviation can absorb most output, with military contracts reserving emergency supplies. The initial purpose would be to establish an option that can expand as production grows. Procurement volumes should follow verified availability and operational needs, ensuring that the programme strengthens readiness while building experience with a new source of military aviation fuel.

Progressive laboratory, engine and flight testing would address operational risks while conventional fuel remains available. Prioritising wastes and agricultural or forestry residues would reduce, though not eliminate, competition with food production, land use and other bioenergy markets.

Combat aviation's dependence on liquid fuels will outlast the security of any particular petroleum supply route. France and India should begin with one mature pathway, one producer, one qualified blend and one Rafale demonstration. The purpose is operational insurance: additional production capacity capable of supporting military readiness, with decarbonisation as a further benefit.



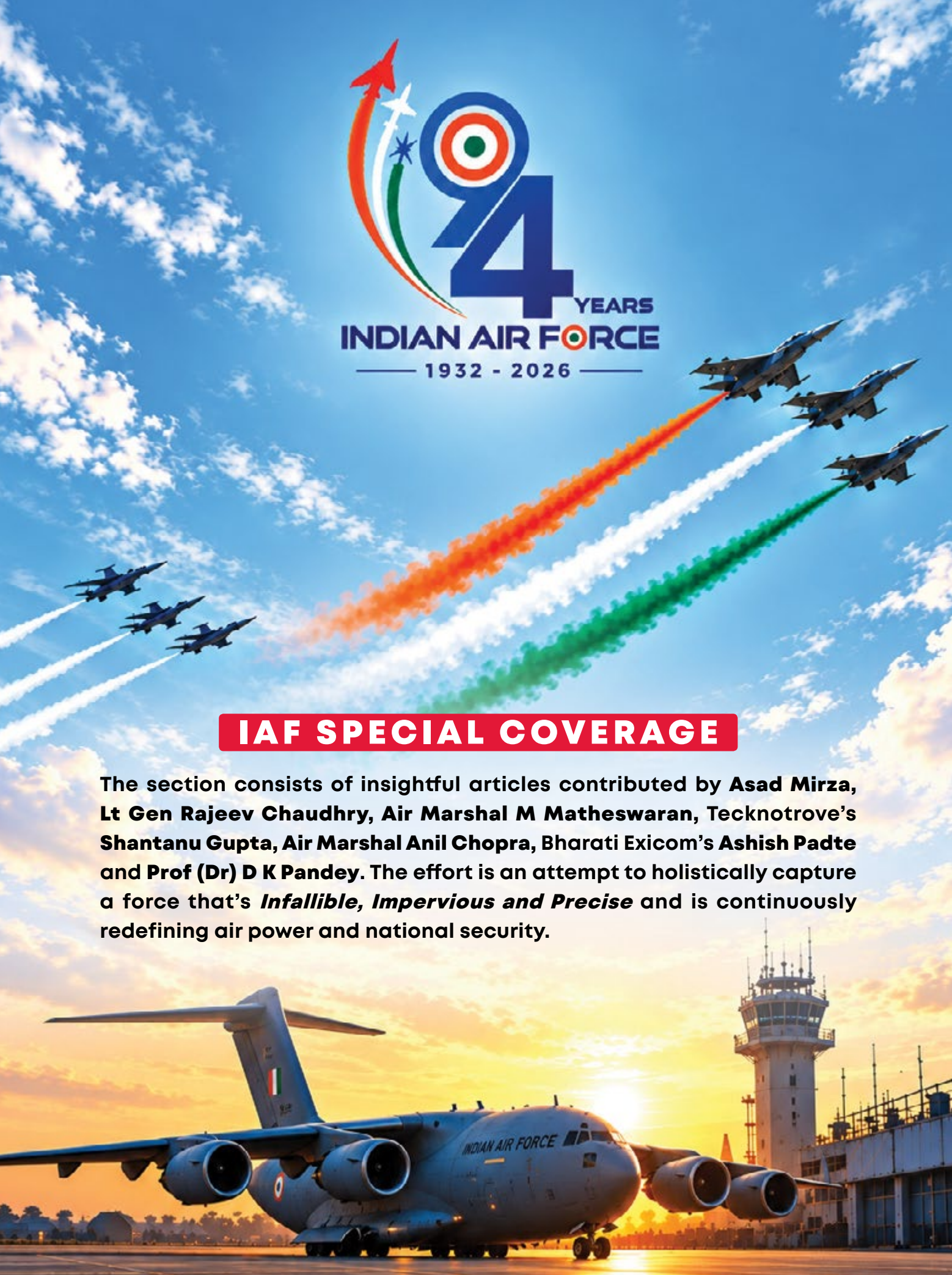
–Basile Marin is CEO and co-founder of Expansion Partners, an institutional investor in bioenergy technology companies and project development firms. He is also a non-resident fellow at l'Observatoire de l'Économie Française. In France, he publishes in Conflits, l'AGEFI, Les Echos, Forbes France, and the Revue Politique et Parlementaire. In India, he publishes in The Diplomatist, Raksha Anirveda and The Imminent



–Adrien Donat-Bouillud is a financial and legal expert specialising in the financing of military exports at Dassault Aviation. He is also an auditor of the French Institute for Advanced Studies in National Defence (IHEDN) and a reservist in the French Army



–Anindita Mukhopadhyay is the Chief Marketing Officer of Expansion Partners and the Chief Editor of The Biofuels Insider, a global weekly magazine on biofuels technologies and projects. She has contributed to research examining the evolution and structure of India's digital marketing ecosystem for Octane Research



IAF SPECIAL COVERAGE

The section consists of insightful articles contributed by **Asad Mirza, Lt Gen Rajeev Chaudhry, Air Marshal M Matheswaran,** Tecknotrove's **Shantanu Gupta, Air Marshal Anil Chopra,** Bharati Exicom's **Ashish Padte** and **Prof (Dr) D K Pandey.** The effort is an attempt to holistically capture a force that's ***Infallible, Impervious and Precise*** and is continuously redefining air power and national security.



Defence Minister Rajnath Singh releasing 'Defence Forces Vision 2047: A Roadmap for a Future-Ready Indian Military'

VISION 2047: MODERNISING THE INDIAN AIR FORCE

India's air-power transformation is no longer limited to acquiring more fighter aircraft. The IAF is transforming into a multi-domain, data-centric force integrating indigenous platforms, airborne surveillance, drones, secure networks and advanced weapons. Its success will depend not only on ambition, but on timely delivery, industrial depth and operational readiness

ASAD MIRZA

The modernisation of the Indian Air Force (IAF) is often presented as a race to restore its fighter strength from roughly 30 operational squadrons to the sanctioned 42. That shortfall is serious, but it is not the whole problem. India's airpower challenge is increasingly an ecosystem challenge involving aircraft numbers, engines, weapons, airborne surveillance, logistics, data networks and doctrine.

A BROADER STRATEGIC FRAMEWORK

The proposed Defence Forces Vision 2047 plan places IAF modernisation within a wider military transformation. Its three principal pillars are technological advancement, jointness and indigenisation. Artificial intelligence, autonomous systems, quantum sensing and advanced surveillance are intended to improve the military's ability to detect, interpret and respond to threats. At the same time, deeper integration among the Army, Navy and Air Force is meant

to reduce traditional service silos.

The vision indicates a shift from an equipment-acquisition approach to institutional transformation. Proposed structures such as a Space Command, Cyber Command, Data Force, Drone Force and Cognitive Warfare Action Force reflect the changing character of conflict.

Most importantly, the doctrine is expected to move from "net-centric" to "data-centric" warfare. Net-centricity emphasises connecting platforms and distributing information. Data-centric warfare goes further: it seeks to fuse information from air, space, cyber, maritime and terrestrial sensors to produce faster and more accurate decisions. This is a move from information superiority to decision superiority.

FIGHTERS REMAIN THE IMMEDIATE PRIORITY

The fighter fleet remains the most visible pillar of modernisation. The proposed acquisition of 114 multi-role fighter aircraft, widely associated with the Rafale, could provide a rapid improvement in combat capacity. A government-to-government arrangement could reduce the procedural uncertainty associated with a prolonged competition.

The reported value of approximately ₹3.25 lakh crore makes the programme, one of India's largest defence procurements. A structure involving a limited number of aircraft delivered directly from France and the remainder manufactured in India could create industrial benefits, but only if indigenous content is meaningful rather than nominal. The demand for substantially higher domestic content than in the original Rafale agreement reflects India's desire to use procurement to build an aerospace ecosystem.

Yet, the exclusion of source-code access and limited transfer of critical technologies remain concerns. A modern combat aircraft is not merely an airframe. Its effectiveness depends on mission software, electronic-warfare libraries, weapons integration, maintenance data, engines and upgrade pathways. Without sufficient control over these elements, India may acquire capability without acquiring full autonomy.

The indigenous LCA Tejas Mk1A is consequently vital. The order for 97 aircraft is intended to strengthen the IAF while expanding India's domestic fighter-production base. However, delays in the supply of GE F404 engines have exposed the vulnerability created by dependence on foreign propulsion.

The proposed increase in HAL's production rate to 30 aircraft annually is encouraging, but production speed must be matched by supply-chain reliability, quality control, weapons integration and maintenance infrastructure. The

Defence Forces Vision 2047 places IAF modernisation within a broader transition towards jointness, artificial intelligence, space, cyber and decision superiority







IAF's reported willingness to accept some concessions in early Mk1A aircraft reflects operational urgency, but such compromises must not become permanent deficiencies.

The Tejas Mk2 is expected to provide a larger and more capable platform capable of replacing ageing Mirage 2000, Jaguar and MiG-29 fleets. Its planned use of the GE F414 engine offers greater performance, although it also reinforces short-term dependence on foreign propulsion. The programme's success will depend on avoiding the delays that have affected earlier indigenous projects.

The Advanced Medium Combat Aircraft (AMCA) represents the longer-term strategic bet. As a fifth-generation aircraft with stealth, super cruise, integrated avionics and artificial-intelligence-enabled systems, it could provide the IAF with a domestically controlled advanced combat platform. The decision to involve private-sector production partners may improve accountability and manufacturing efficiency.

However, AMCA's projected induction in the mid-2030s means it cannot solve the IAF's immediate numerical crisis. India therefore needs a balanced approach: accelerate Tejas production, conclude any interim fighter procurement carefully and protect AMCA from bureaucratic and technological delays.

AEW&C aircraft, aerial surveillance, secure communications and integrated command networks will determine how effectively fighter aircraft operate in contested airspace

FORCE MULTIPLIERS MATTER AS MUCH AS FIGHTERS

An important weakness in public debate is its emphasis on fighter numbers at the expense of force multipliers. Airborne Early Warning and Control (AEW&C) aircraft, aerial refuellers, long-range weapons, intelligence systems and secure communications determine how effectively fighters can be employed.

The IAF's limited AEW&C fleet restricts persistent surveillance and battle-management capacity. The Netra Mk-II programme, based on Airbus A321 airframes and indigenous AESA radars, could substantially improve this situation. A detection range exceeding 500 kilometres and coverage of more than 300 degrees would provide a stronger basis for managing air operations across large theatres.

Transport modernisation is equally important. The proposed ₹1 lakh crore acquisition of 60 multi-role transport aircraft would replace ageing An-32s while expanding strategic airlift. Aircraft in the 18-30-tonne payload category could support troop movement, logistics, disaster relief and operations in remote areas.

The programme would complement the C-295 fleet and reduce the risk associated with relying on ageing Soviet-era platforms. Transport aircraft are often less politically visible than fighters, but they are essential to a two-front strategy. Airpower requires fuel, ammunition, spare parts, personnel and mobility. Without logistics, combat aircraft cannot sustain high-tempo operations.

FROM DRONE DEMONSTRATIONS TO OPERATIONAL CAPABILITY

Unmanned systems offer India a way to expand surveillance and strike capacity without relying exclusively on expensive manned aircraft. The IAF's proposed unmanned force includes small tactical drones, medium-altitude long-endurance systems, high-altitude platforms, combat UAVs and swarms.

The immediate priority should be persistent intelligence, surveillance and reconnaissance. MALE UAVs capable of remaining airborne for 24-36 hours can monitor borders and critical areas more continuously than manned aircraft. Interim procurement of MQ-9 Reapers may address urgent requirements, but the long-term objective must be a domestic ecosystem encompassing sensors, datalinks, propulsion, autonomy and weapons.

The first IAF Dronathon, held at



MALE and HALE UAVs, combat drones and swarm systems are expanding the IAF's surveillance, strike and electronic-warfare options at lower cost and risk

the Pokhran Field Firing Range from 14 to 16 September 2026, marked an important shift in this direction. More than 20 defence companies, start-ups, MSMEs, public-sector units and innovators were assessed in conditions intended to resemble operational environments. The focus extended across surveillance and reconnaissance, autonomous operations, swarm technologies, electronic warfare and counter-unmanned-aircraft systems.

The demonstration of Vayu UTtaM, an indigenous multi-mode Unmanned Traffic Management system, further broadened the exercise's importance. The system detected and tracked military and civilian drones and is intended to support the identification and mitigation of unauthorised or rogue aircraft. Its potential applications extend to airspace safety, critical infrastructure, civil aviation and public security.

The Ghatak stealth UCAV and swarm technologies could eventually transform strike and suppression-of-air-defence operations. However, demonstrations must be followed by rigorous testing, procurement and integration. Drones will be useful only when connected to command networks, supported by resilient communications and employed alongside manned aircraft, missiles and electronic-warfare systems.

THE IMPLEMENTATION PROBLEM

A credible implementation framework should establish empowered mission managers, annual delivery benchmarks and transparent progress indicators. Fighter acquisition, AEW&C, weapons, drones and engines should be managed as time-bound capability missions rather than isolated contracts. Budgets should be linked to rolling five-year plans, enabling manufacturers to invest in production capacity with greater confidence.

Modernisation should also be measured by operational effects: the number of days of sustained air superiority, persistent ISR coverage, sortie-generation rates, long-range strike capacity, electronic-warfare resilience and the ability to operate under communications disruption. This is more meaningful than counting platforms alone.

The IAF's modernisation is therefore both urgent and structurally complex. Indigenisation must likewise be judged by capability, not procurement percentage. India needs domestic competence in engines, radar, electronic warfare, software, composite materials, weapons and maintenance. Foreign partnerships can accelerate this process, but they cannot substitute for indigenous design authority.

The decisive test through the 2030s will not be whether India announces ambitious programmes. It will be whether those programmes produce combat-ready squadrons, reliable engines, persistent surveillance, resilient networks and rapidly deployable logistics before strategic circumstances force the issue.



–The writer is a New Delhi-based strategic, defence and international affairs commentator. He can be contacted via www.asadmirza.in

AIR FORCE 2040: SKY TO SPACE

Air power is no longer just about aircraft, pilots, airfields and weapons. Today, it encompasses an ecosystem of sensors, satellites, networks, algorithms, autonomous systems, precision weapons, electronic warfare and human judgement. The Air Force of tomorrow will be defined by the ability to command the sky, space and the battlespace beneath them

LT GEN RAJEEV CHAUDHRY



The eighth of October is more than an anniversary. It is an opportunity to ask whether the Indian Air Force that served India so effectively through the twentieth century is being prepared for the fundamentally different battlespace of the twenty-first. When the Indian Air Force was established in 1932, air power meant aircraft, pilots, airfields and weapons. Today, air power is an ecosystem of sensors, satellites, networks, algorithms, autonomous systems, precision weapons, electronic warfare and human judgement. The central question is not simply how many aircraft the nation possesses. It is what kind of aerospace combat power India must build as the boundaries between air, space, cyber and the electromagnetic spectrum disappear.

SKY BECOMES A BATTLESPACE

Air superiority can no longer be understood merely as controlling the air above a battlefield. Modern forces compete simultaneously for awareness, connectivity, spectrum access, precision and decision speed. An aircraft may possess formidable weapons, but its effectiveness increasingly depends on what it can see through a wider sensor network, how securely it can communicate, how rapidly its data can be fused, and how quickly another platform can act on that information. The future battlespace will therefore reward connected formations rather than isolated platforms. The IAF must evolve from a force that operates aircraft into a force that orchestrates an integrated battlespace, where every sensor can contribute to the common picture and every shooter can become part of a coordinated kill chain.

BEYOND THE FIGHTER

The fighter aircraft will remain central to air power. Air superiority, interception, escort, deep strike, and deterrence will continue to require highly capable manned platforms and highly trained aircrew. Yet the fighter-centric conception of an air force is becoming inadequate. Alongside conventional fighters will emerge unmanned combat aircraft, loyal wingmen, reconnaissance drones, electronic warfare platforms, decoys, loitering munitions and autonomous swarms. Their value will lie in extending the fighter's reach, increasing awareness

and multiplying options. The future combat aircraft should therefore be viewed less as an independent weapon and more as a node in a larger combat architecture. The decisive question will increasingly be how effectively manned and unmanned systems can cooperate under contested conditions.

UNMANNED REVOLUTION

The proliferation of drones has altered the economics of warfare. A relatively inexpensive unmanned system can force the expenditure of a vastly more expensive interceptor, reveal a defended position, saturate sensors, or impose operational caution. This has strategic implications for India. The IAF will need a layered unmanned ecosystem ranging from inexpensive attritable systems to sophisticated autonomous combat aircraft. Such systems can undertake surveillance, deception, electronic attack, target acquisition, and strike missions while reducing exposure of human crews. The objective should be operational choice, allowing commanders to select the appropriate combination of human and machine capability for each mission. In future air warfare, mass may return through machines.

AI AND DECISION SUPERIORITY

Artificial intelligence will transform air power most profoundly not because it will eliminate human commanders, but because it can compress the time between observation, understanding and action. Sensor fusion, target recognition, predictive maintenance, mission planning, route optimisation, electronic warfare and battle management can all benefit from machine-assisted analysis. In a saturated battlespace, however, data alone is not power. The advantage belongs to the force capable of converting enormous quantities of information into reliable decisions faster than an adversary can react. The IAF therefore needs an institutional culture in which data, software and algorithms are treated as operational capabilities rather than supporting technologies. Tomorrow's air war may be decided not simply by who sees first, but by who understands first and acts first.



SPACE IS THE NEW HIGH GROUND

No modern air force can remain confined to the atmosphere. Satellite communications, navigation, intelligence, surveillance, reconnaissance and missile-warning systems increasingly underpin every major air operation. Air and space will therefore become inseparable. India needs resilient space-enabled networks capable of continuing to function when satellites are degraded, communications are contested, or navigation signals are disrupted. This requires redundancy, alternative navigation methods, hardened communications and close integration between military and civilian space capabilities. The IAF's future identity may consequently extend from air power towards aerospace power, with operations conceived across altitude layers rather than within a single domain. The force that can connect air and space most effectively will possess an increasingly decisive informational advantage.

SURVIVABILITY AND THE DISPERSED AIR FORCE

The future IAF must also rethink where and how it fights. Concentrated air bases provide efficiency, but they can also become lucrative targets for precision weapons, drones and ballistic or cruise missiles. Survivability will therefore demand a combination of hardened infrastructure, camouflage, deception, rapid runway repair, dispersed operating locations, alternate airstrips, mobile command centres and distributed logistics. India's geography offers opportunities to develop a more resilient operating model, including the greater use of highway and alternate operating surfaces where feasible. Strategic infrastructure should be designed with military mobility in mind, while military infrastructure should increasingly possess redundancy. An adversary should never be able to paralyse air power by striking a few predictable nodes.

IAF CANNOT FIGHT ALONE

The next major conflict will not respect service boundaries. Air operations will interact continuously with Army long-range fires, naval aviation, maritime surveillance, integrated air and missile defence, cyber operations, space assets and strategic forces. The future IAF must therefore be part of a joint multi-domain force rather than a service operating beside others. Jointness should begin not merely with command



structures, but with procurement, communications architecture, training, doctrine and operational planning. A common battlespace picture, interoperable networks and shared targeting processes will matter as much as individual platforms. The objective is one national military instrument able to generate effects across domains at modern-warfare speed.

DESIGNING THE IAF OF 2040

India's future air power should consequently be built around capabilities rather than inventories. The architecture must be able to detect, decide, disrupt, deny, destroy and survive. That requires a balanced combination of fifth-generation and advanced indigenous fighters, unmanned combat systems, airborne early-warning and control, tankers, long-range precision weapons, electronic warfare, counter-drone capabilities, integrated air and missile defence, space support, cyber resilience and artificial intelligence. Indigenous development must remain central because strategic autonomy cannot rest entirely upon foreign supply chains. At the same time, India should pursue carefully selected international partnerships where they accelerate technology absorption, industrial capacity and operational capability. The objective should be an ecosystem in which platforms can evolve rapidly while the underlying network remains coherent.

AIR FORCE DAY TEST

Air Force Day should therefore become more than a celebration of heritage and operational achievement. It should also become a moment of institutional imagination. The IAF has repeatedly adapted to changing technology, geography and strategic circumstances. Its next transformation will be more profound because the character of warfare itself is changing. The service will need new doctrines, new skills, new industrial partnerships and perhaps new organisational boundaries. It will need pilots who understand algorithms, engineers who understand operations, operators who understand space and commanders who can integrate machines without surrendering human judgement. The future will not belong automatically to the force with the largest inventory, but to the one creating the most resilient, intelligent and responsive combat system.

India's strategic environment demands nothing less. The Himalayas, the Indian Ocean, the western frontier and the wider Indo-Pacific create a geography in which reach, mobility, surveillance and rapid response are indispensable. Yet geography alone cannot determine the future. Technology, doctrine, industrial depth and human capital will increasingly shape the balance of power. The IAF must therefore look beyond replacing ageing fleets and towards designing an entirely new architecture of air and aerospace power. Numbers will remain important, but numbers without networks, survivability, precision and decision superiority can become an expensive illusion.

Transformation must begin now, before crisis makes experimentation and institutional change impossible.

The question before India is larger than the future of one service. It is about whether the nation can build a military instrument suited to an age in which wars may begin with invisible signals, unfold through autonomous systems and be decided within minutes by those who control information and precision. The IAF of tomorrow must be capable of fighting alongside machines, through networks, across domains and under conditions of severe disruption. It must be simultaneously more distributed and more connected, more autonomous and more human-centred, more technologically sophisticated and more operationally adaptable, without losing the judgement, discipline and accountability that ultimately make military power credible.

On October 8, therefore, India should honour the men and women who have carried the nation's tricolour into the skies, while also asking what those skies will demand from the generation that follows. The future IAF cannot simply be a larger version of today's force. It must become a different kind of strategic instrument: an aerospace force capable of sensing first, deciding faster, striking precisely, surviving disruption and generating effects across the battlespace.

The Air Force of tomorrow will not be defined by how many aircraft India can fly, but by how intelligently India can command the sky, space and the battlespace beneath them.



–The writer is an army veteran and writes on contemporary national and international issues, strategic implications of infrastructure development towards national power, geo-moral dimensions of international relations, and leadership nuances in a changing social construct

DHRUVA
SPACE

BUILT FOR MISSIONS.
ENGINEERED FOR ORBIT.



- Satellite Platform & Subsystems
- Payload Integration
- Space Technology Infrastructure
- Ground Data Systems
- Mission Operations
- Launch Readiness

Dhruva Space transforms ideas into orbit-ready missions with end-to-end space solutions

Mission Status: Ready

Scan the QR code for more information

INDIA'S FIGHTER ENGINE QUEST AFTER KAVERI

Mastery of aeroengine technologies is a prerequisite for any great power in the 21st century. For India, however, the aeroengine remains a technological challenge despite over four decades of effort. The Kaveri engine development history exemplifies this challenge

AIR MARSHAL M MATHESWARAN



The anarchic nature of the world order entails intense competition among the great powers for dominance and hegemony. Studies by scholars such as Wallerstein (World-Systems Model), Kondratieff and Modelski (long cycles of economic and technological dominance), and Schumpeterian theory of innovation (creative destruction) have clearly established the dictum that no country can be a great power without control over critical technologies. In today's aerospace age, this dictum translates into the need to master the critical domains of nuclear, space, aviation and propulsion, communications, computing and AI. Aeroengine technologies present the toughest challenge to master, and it is no wonder that only the leading great powers possess complete control in this domain. For India, the aeroengine remains a technological challenge despite over four decades of struggle. The Kaveri engine development history exemplifies this challenge.

Over the past six months, the Indian government and industry have announced three routes to develop the fighter engine. In April 2026, GE Aerospace and HAL finalised the technical terms for co-producing the F414-INS6 for the Tejas Mk2 and the first AMCA squadrons. DRDO's GTRE (Gas Turbine Research Establishment) has proposed a joint venture with the French engine manufacturer Safran to co-design and co-produce a 120 kN engine to power AMCA Mk2. The proposal, valued at up to Rs 61,000 crore and envisaging complete IPR for India, awaits clearance by the CCS (Cabinet Committee on Security). In a third and notable development, Reliance Industries and Rolls-Royce announced a "strategic intent" to build a "sovereign indigenous" combat engine. Taken together, these three major steps suggest momentum for the aeroengine project. Measured against what India lacks, they look like three ways of buying time.

LESSONS FROM KAVERI PROGRAMME

Kaveri engine troubles are often attributed to metallurgy. This is too simplistic; the challenges were complex. In 2006-07, GTRE proposed a joint venture with Snecma (the French engine house that later merged into Safran), claiming that Snecma's design assistance would accelerate Kaveri development. At this stage, the Indian Air Force and HAL felt that Kaveri engine development was far behind the LCA (Tejas) aircraft's progress and would delay the whole programme. In August 2007, the IAF constituted a study group, under the author's chairmanship, to examine the programme's status and GTRE's proposed joint venture with Snecma.

The report flagged a few crucial findings. The programme was authorised

in 1989 with an ambitious and impractical seven-year timeframe from development to series production and cost. Kaveri was GTRE's first full aeroengine development. Yet DRDO chose a six-stage core design with full digital control and flat rating, even though such a design had not yet matured, even among established engine houses in the US, the UK, France, and Russia. Indian aerospace metallurgy was in its infancy, the materials database was small, and turbine blade design capability was limited. Established engine houses would have needed 15-20 years for such a project. India should have planned for 20-25 years and at least ten times the allocated research budget of Rs 389 crores in 1989.

The core was at the heart of the problem: a sub-optimal thermodynamic cycle, blade flutter, a faulty combustor, deficient high-pressure turbine and compressor designs, and a low surge margin. The fan and low-pressure turbine had their own failures, and the afterburner would not reliably relight at altitude. After 15 years, the core engines (K1 to K9) had logged about 1800 test hours, of which only 680 were counted as effective, against at least 8000 hours of ground testing required before flight testing. The committee assessed that the Kaveri was at least 15 years away from maturity. Seventeen years later, the dry Kaveri has just completed trials in Russia and awaits certification. The development was also interrupted for 2-3 years due to the programme's closure and subsequent revival.

The Comptroller and Auditor General's (CAG) 2010 audit reached the same verdict independently. Sanctioned in March 1989 at Rs 382.81 crores for completion by December 1996, the programme had seen its cost revised to Rs 2,839 crores, a 642 per cent increase, and its completion date slip by 13 years. The engine weighed 1235 kg against the design target of 1100 kg; the turbine blade design had not been frozen; the control system was not flightworthy; and critical component tests had not been conducted for want of facilities. GTRE had even declined Snecma's offer of joint development in 2001, only to seek a JV seven years later.

Beneath these lie institutional failures that persist. India still lacks a full-scale altitude test facility and a flying test-bed aircraft. GTRE remains a laboratory, not an engine company. India attempted a state-of-the-art, 4.5-generation afterburning fighter engine with no lineage of smaller engines beneath it, whereas every mature engine house grows through derivatives.

THE CAUTION: WE HAVE BEEN HERE BEFORE

The JV with Snecma was intended to solve the above problems through co-design. Instead, Snecma proposed, and GTRE accepted, replacing the Kaveri core with Snecma's ready-made core. Our study concluded that this bypassed co-design and brought in licensed production through the back door. The JV would have produced 88.7 kN of thrust, short of the 90 kN benchmark, and reached 90 kN only through a combat rating that consumed hot-end life. Its 48-month schedule was near impossible even for Snecma alone; we estimated 72 months at best and 84 to 90 months normally, with no allowance for GTRE's learning curve. Almost every important technology was to be bought separately, at extra cost and subject to French government approval, with no visibility on the transfer of core technology. In that form, the JV would have effectively killed the ongoing indigenous programme, instead of assisting.

Kaveri engine troubles are often attributed to metallurgy. This is too simplistic, the challenges were complex. In August 2007, the IAF constituted a study group, under the author's chairmanship, to examine the programme's status and GTRE's proposed joint venture with Snecma. The report flagged a few crucial findings

The recommendations were practical and prescient: delink engine development from the LCA; revise the JV to strengthen the indigenous effort pursuing the Kaveri engine core; link it to the then-proposed MCA (Medium Combat Aircraft); and completely restructure GTRE, integrated with DMRL, HAL, and MIDHANI. The LCA did move to a proven engine. GTRE was never restructured. Because Snecma refused to meet the co-design and technology database access terms proposed in the study, the proposed JV was dropped.

Seventeen years later, the MCA is now the AMCA, and Snecma is now Safran. The questions asked then remain the same: will the partnership build a truly Indian aeroengine, or replace it?

THREE COURSES OF ACTION, ONE BLIND SPOT

India's aeroengine development strategy has been hampered by strategic inconsistency and disruptions. Long-term strategies are built on a clear understanding of what technological sovereignty entails. What matters is the distinction between production sovereignty and design sovereignty. The three partnerships deliver the first, in varying degrees. None yet secures the second.

The HAL-GE deal is a manufacturing transfer. HAL will receive the production technologies for the F414-INS6 engine. Reports envisage HAL achieving 80 per cent localisation by value, including single-crystal blades and coatings, by 2030-31. Effectively, this contract remains built-to-print, transferring the how, not the why. Design tools, test databases, life-prediction methods, alloy development, the engine control software (FADEC) and rights to derivatives remain outside it, and US re-export controls remain in force. The F404 delivery delays of 2023-25, which prevented HAL from delivering the first Tejas Mk 1A despite a three-year delay and affected the IAF's operational capability, show how much leverage the supplier retains.

The Safran programme reflects





lessons from the aborted GTRE-Snecma JV proposal. It is now better conceived: a new engine with Indian ownership of the intellectual property and no right for Safran to reuse the architecture. But owning the IP is not the same as owning the capability. The decisive question is the 2009 question: who designs the core? Who will be the design authority, and will it be a joint design authority, which is unlikely? If Safran designs the high-pressure compressor, combustor and turbine while GTRE handles the fan, nozzle and afterburner (as in 2009), India will own drawings it cannot extend. The unresolved division of labour between HAL and GTRE compounds the risk. The contract's work-share schedule, not the joint communiqué, will decide the outcome.

The Reliance-Rolls Royce announcement is, for now, a press release with no financial terms, timeline, ownership structure, or IP allocation. Reliance brings capital and execution capacity; neither is the binding constraint. Without Indian design authority, this venture becomes a Rolls-Royce manufacturing node in India.

A REALISTIC TIMELINE ASSESSMENT

On realistic assumptions, the Safran engine reaches core testing around 2030-31, first flight around 2034-36, and series production between 2037 and 2040. If India leverages the programme effectively to acquire and develop critical technologies, including design, development, manufacturing, and significant supply chain control, then truly independent aeroengine mastery lies closer to 2050. The 2009 estimate of 20 to 25 years for a first engine has proved, if anything, optimistic. Thirty years is the average price every late entrant has paid.

A global talent drive could save perhaps five to eight years. But export controls limit what recruits may bring; tacit knowledge resides within teams, and it is a moot point whether DRDO can absorb such people. Talent follows institutions.

THE WAY FORWARD: THE IMPERATIVE OF CHANGE

Revisit earlier recommendations on structural reforms. Corporatise GTRE as a national engine company with design authority and production, integrated with DMRL, HAL, and MIDHANI. Write the know-why into the Safran contract: Indian design of the core, engineers embedded in Safran's offices, milestone-based transfer of design authority, FADEC source code, and unrestricted rights to derivatives. Build testing infrastructure, such as an altitude test facility and flying testbeds, as a high priority. Fund a ladder of engines, from the Manik and the dry Kaveri to a Kaveri 2.0, so each generation trains the next. Ring-fence twenty years of funding under a single aerospace authority. Another committee, chaired by the author, recommended in 2014 the critical need to constitute a single aerospace authority, the National Aerospace Commission.

The twenty-first century is the century of aerospace power. Mastery of aeroengine technologies is a prerequisite for a great power in this century, despite advances in AI, robotics, and computing. Engines are learned, not bought. Unless India learns, it will own the drawings and rent the knowledge for another generation.



–The writer, AVSM, VM, PhD (V), is a former Deputy Chief of Integrated Defence Staff (Policy, Plans & Force Development) [DCIDS – PP & FD]. He is currently the President of The Peninsula Foundation, a Chennai-based public policy research think tank

ANANTH TECHNOLOGIES

A GLOBAL AEROSPACE ENGINEERING AND MANUFACTURING FIRM

- Inception in 1992.
- Mission: Indigenization of Space and Defence Systems.
- Leading contributor to Indian defense programs.
- Designed & Manufactured systems for 30+ Indigenous missiles.
- Complete satellite manufacturing facilities with class 10K & 100K Clean Rooms, SMT production lines, MIC Facility, In-house test facilities.





Contributed to

89

Launch Vehicles and

109

Satellites



Areas of Expertise :

- Telemetry & Tele-command Systems
- Navigation, Guidance and Control Systems
- Onboard Computing Systems
- Seeker systems – RF & IR
- Satellites and Launch Vehicles
- Small Sats
- EO Surveillance Systems
- Raman based explosive identifiers
- Laser Designators
- Missile systems
- Radar systems
- Aircraft & helicopter subsystems
- Unmanned Systems





















Electro-Optics Surveillance Systems Development at Ananth for DRDO

Compact Light-Weight Integrated Multi-Sensor Technologies (CLIMT)



Gimbaled Laser Target Designator (GLTD)



Ultra low pitch High Format Detector (UHDT)



Laser Altimeter (LA) & Laser Range Sensor (LRS)





Hyderabad - Head Quarters
Ananth Technologies Pvt Limited 39, Ananth Info Park, Phase - II
Hi-Tech City , Madhapur
Hyderabad, India - 500 081



Bengaluru
Ananth Technologies Pvt Limited No:64, KIADB Bangalore
Aerospace Park, Singahalli Village, Budigere Post, Bangalore
North Taluk, Bangalore, India - 562129



Thiruvananthapuram
Ananth Technologies Pvt Limited, Plot No: 51-(b), Street F,
St.Xavier's PO, KINFRA, Menamkulam,
Thiruvananthapuram - 695586 Kerala, India.

Scan this to view our website

MULTI-DOMAIN AIR OPERATIONS: BUILDING A SOVEREIGN SYNTHETIC BATTLESPACE

Tecknotrove Defence

If the force is to fight as one, it must be trained to operate seamlessly across domains. That is the real challenge of multi-domain training: moving from standalone simulators to create an integrated training ecosystem

SHANTANU GUPTA



Air operations have never been about fighter aircraft and helicopters alone. The way air power is generated and employed is transforming significantly. Future air campaigns will depend on sensors, shooters, command systems, support elements and decision-makers operating as one integrated force, not merely as separate platforms executing separate missions. If the force is to fight this way, it must also be trained this way.

That is the central challenge of Multi-Domain Operations (MDO) training for the Indian Air Force. It points towards a sovereign synthetic battlespace where the entire force can train, rehearse, and learn together.

TRAIN AS AN INTEGRATED FORCE, NOT A COLLECTION OF PLATFORMS

Multi-domain operations demand way more from every combatant. A fighter pilot no longer manages only an aircraft and a mission; the pilot is increasingly a node in a larger network, drawing upon airborne and space-based sensing, ground-based air defence, electronic warfare, cyber and information capabilities, and joint coordination.

Training centred primarily on individual platforms cannot adequately prepare personnel for this environment. Live exercises will remain essential, but cost, airspace, safety constraints and the difficulty of realistically representing contemporary threats impose inherent limitations. The requirement, therefore, is for training that brings multiple actors, at multiple levels, into the same dynamic and evolving operational scenario.

No single simulator can meet this requirement. What is needed is a comprehensive training ecosystem comprising platform simulators, mission rehearsal systems, command and control training, wargaming, sensor and air defence trainers, and ground operations training, while all of these share common scenarios, data standards and assessment frameworks. Standalone systems create islands of capability; an integrated ecosystem creates a continuum of learning from the individual and crew to the formation and command.

Importantly, this ecosystem must also include those elements of air operations that do not fly. Sustained sortie generation depends upon airside operations, specialist vehicles, logistics, ground handling, maintenance and the procedures that bind them together. Yet training investment has traditionally tended to concentrate on aircrew.



A synthetic environment incorporating ground crews can enable turnaround sequences, weapon loading, refuelling, specialist vehicle movements and fault handling to be rehearsed at realistic operational tempos, including the disruption an adversary may impose on an airbase. It enables the force to rehearse sustained operations, not merely the first sortie.

Live exercises will remain essential, but cost, airspace and safety constraints, along with the difficulty of realistically representing contemporary threats, impose limitations. Therefore, training must bring multiple actors at multiple levels into the same dynamic and evolving operational scenario

The same logic applies to the sensor-to-shooter chain. Radar operators, air defence controllers, missile crews and the command elements linking them need to practise detecting, tracking and engaging targets in dense, contested scenarios that are difficult or unsafe to reproduce live. Integrating air defence simulation with aircrew training within the same battlespace allows each participant to better understand the other's operational challenge, improving coordination between those penetrating an air defence environment and those defending it.

TRAINING THE DECISION MAKERS, NOT MERELY JUST THE EXECUTORS

If simulation trains how forces act, wargaming trains how commanders think.

Wargames enable commanders and planners to test courses of action, confront an adaptive adversary and experience the consequences of decisions taken under uncertainty and time pressure. Their real value lies less in predicting outcomes and more in building judgement, challenging assumptions and developing shared understanding across the staff.

This becomes particularly important in multi-domain operations, where an action in one domain can fundamentally reshape options in another. For instance, an electronic warfare action will alter the air defence dynamics, while a logistics constraint will practically limit an air tasking plan.

Wargaming and simulation, however, are still often treated as separate disciplines, supported by separate tools. This separation limits their potential. When a decision taken during a wargame can flow directly into a simulated execution environment, and the results flow back to inform the next decision, training becomes a continuous cycle. A commander could finalise a strike package in the morning, watch crews execute it in a synthetic environment in the afternoon, and review the consequences with the staff by evening.

This requires common scenario databases, interoperable architectures and agreed standards for representing entities, effects and timelines.



This is where a collection of tools becomes an integrated training system; modular enough to incorporate new platforms and threat models; scalable from individual mission rehearsal to large multi-domain exercises; distributed enough for geographically dispersed units to train together without moving people and aircraft; and sufficiently instrumented to capture performance data so that debriefs, training outcomes and doctrinal development are based on evidence rather than impression.

SOVEREIGNTY OF TRAINING IS AN OPERATIONAL IMPERATIVE

A synthetic battlespace is only as trustworthy as the scenarios, threat libraries, models and data that underpin it. These encode how a force fights, what it expects of an adversary and where its vulnerabilities lie. Dependence on external providers for this content — or for the underlying software — creates dependencies in precisely the area where operational confidence and sovereign control matter most.

"A sovereign training ecosystem is not merely about owning simulators. It is about owning the ability to model our threats, rehearse our doctrine, test our decisions and continuously adapt how we fight in an era where warfare is transforming rapidly and significantly," says Amit Baveja, Head, Defence Business, Tecknotrove Systems.

If simulation trains how forces act, wargaming trains how commanders think. Wargames enable commanders and planners to test courses of action, confront an adaptive adversary and experience the consequences of decisions taken under uncertainty and time pressure

Amit Baveja, who leads Tecknotrove's Defence Business, believes that the next phase of transformation must move beyond standalone training devices towards an integrated and sovereign training ecosystem.

Tecknotrove is working towards reinvigorating this ecosystem through indigenous technologies that bring together simulation, wargaming, synthetic environments and data-driven training across different levels of training and operations.

For India, this assumes particular significance. The Indian Air Force operates and is integrating a diverse mix of indigenous and imported aircraft, weapons and sensors, as well as a mix of legacy and modern systems, within an increasingly networked environment. It draws upon a growing domestic defence ecosystem and operates across a geographically dispersed battlespace where many of the most demanding scenarios cannot realistically be rehearsed live without consuming significant resources or exposing sensitive capabilities.

Control over source code, scenario design, threat modelling and data enables the Air Force to evolve its training as rapidly as its operations, technology and doctrine evolve; protect sensitive information; and integrate new indigenous systems without recurring external dependencies. Equally importantly, it builds the domestic industrial and technological expertise required to sustain and evolve the capability over decades.

Building such an ecosystem will require more than individual simulation products. It will require integrators capable of bringing together different simulation modalities, distributed environments and training applications, working closely with the Indian Air Force and India's defence industry.

Multi-domain operations will increasingly favour forces that have trained and rehearsed as integrated wholes. The task, therefore, is to build that capability deliberately, integrate it progressively, retain sovereign control over its critical technologies and data, and develop the expertise to evolve it within India continuously. If the force is to fight as one integrated whole, it must start with training as one.



–The writer is Founder and Managing Director of Tecknotrove Systems India Private Limited

DELOPT: 26 YEARS OF ENGINEERING TECHNOLOGY FOR DEFENCE AND AEROSPACE

The company continues to advance its vision of becoming a Global Technology Enterprise in electronics, electro-optics, digital and analytics

From engineering systems to mission-ready solutions, DELOPT has spent 26 years creating solutions for demanding defence and aerospace environments. DELOPT is delivering indigenised products to various DRDO laboratories, DPSUs and Ministry of Defence (MoD).

A technology-driven enterprise under JK Paper Limited and the JK Organisation, DELOPT brings together expertise in design, development, manufacturing, system integration, field deployment and lifecycle support. This end-to-end approach enables the company to translate complex operational requirements into reliable, application-focused solutions.

FROM PROVEN EXPERTISE TO EMERGING MISSIONS

DELOPT's portfolio spans Electro-Optics, Avionics, Naval Electronics, Land Electronics, Communication Technology, Unmanned Platforms, Drone/UAV and Counter-UAS (CUAS), complemented by Digital Automation & Analytics.

DELOPT's portfolio spans Electro-Optics, Avionics, Naval Electronics, Land Electronics, Communication Technology, Unmanned Platforms, Drone/UAV and Counter-UAS (CUAS), complemented by Digital Automation & Analytics





Its established product and system experience includes thermal imaging, thermal weapon sights, stabilised EO payloads and tracking systems, supporting applications where precision, situational awareness and dependable performance are critical.

Building on this foundation, DELOPT is extending its focus towards Unmanned and Counter-UAS applications, with solutions addressing surveillance, tracking, interception and mission requirements.

ENGINEERING FOR THE NEXT MISSION

Among its emerging developments is a Weapon Control System (WCS) for Unmanned Ground Vehicles (UGVs), integrating EO/IR and thermal imaging, laser range finding, a stabilised weapon platform, AI-based target detection and tracking, encrypted communication and remote operation.

DELOPT is also developing the Counter Balancing Equalisation & Pursuit Module (CBEPM), a high-precision two-axis stabilised gimbal for missile-target applications. The system incorporates servo stabilisation, EO video processing and automatic detection and tracking of fast-moving objects.

INSPIRED TO INNOVATE

DELOPT is advancing towards its vision of becoming a Global Technology Enterprise in Electronics, Electro-Optics, Digital and Analytics.

For more information: www.delopt.co.in

IAF'S MTA PROCUREMENT: THE CHOICE BETWEEN LEGACY AND NEW AIRCRAFT

The Ministry of Defence has issued a Request for Proposal (RFP) for 60 Multi-role Transport Aircraft (MTA) worth ₹1 lakh crore (approximately $10.5 billion). Designed to replace ageing Soviet-era An-32s, the project mandates a payload capacity of 18–30 tonnes, extensive indigenisation and local assembly of 48 units under the Make in India initiative

AIR MARSHAL ANIL CHOPRA

India's Ministry of Defence (MoD) issued the Request for Proposal on August 12, 2026, for 60 next-generation Multi-role Transport Aircraft (MTA) in the 18 to 30-tonne payload class. The ₹1 lakh crore (near $10.5 billion) competition is meant to upgrade the Indian Air Force's (IAF) tactical and strategic airlift capabilities. It will fill the "missing middle" gap between light-to-medium airlifters (like the Airbus C-295) and heavy strategic haulers (like the C-17), while primarily replacing ageing Soviet-era Antonov An-32 fleets. The proposal strongly emphasises domestic manufacturing, technology transfer and engaging hundreds of local MSMEs and Indian suppliers.

The main contenders are Embraer C-390 Millennium backed by a partnership with Mahindra Defence Systems, offering desired performance and a near 26-tonne payload. The 20-tonne load class Lockheed Martin C-130 Super Hercules is also trying to leverage the IAF's existing operational experience with 12 in-service C-130Js and tie-ups with Tata Advanced Systems. The 37-tonne payload Airbus A400M Atlas continued to be in the fray initially, albeit it is so much larger and outside the MTA payload range. Later, it opted out from the bidding. The European aircraft builder already has an existing partnership in India with Tata Advanced Systems (TASL) for licenced manufacture of the C295MW tactical transport.

The RFP has also been issued to Adani Defence and Aerospace, Hindustan Aeronautics Ltd and Reliance Defence. The three companies have reportedly not yet publicly identified their overseas aircraft partners for the programme.

EXISTING TRANSPORT AIRCRAFT FLEET OF IAF

The IAF currently operates a diverse transport fleet of American and Russian aircraft featuring strategic airlifters, tactical workhorses and VVIP transport aircraft. IAF has 11 Boeing C-17 Globemaster III with heavy-lift capability used for long-range strategic transport. 17 Soviet-origin Ilyushin Il-76 heavy airlifters to serve long-haul military



logistics. Over 100 Antonov An-32 tactical medium airlifters form the backbone of the IAF's transport fleet and are used for high-altitude and rugged terrain supply runs. 12 Lockheed Martin C-130J Super Hercules are meant for Special Operations and tactical transport. 16 Airbus C-295 Medium tactical transport aircraft have been inducted, and additional 40 are being made in India.

IAF operates over 60 Dornier Do-228 light utility and transport turboprops used for communication and logistics. There are 40 Avro (Hawker Siddeley HS 748) legacy twin-turboprop transport units nearing the end of their operational lifecycle. The VVIP and specialised transport fleet includes Boeing 777 (Air India One), the dedicated long-haul aircraft for the President, Prime Minister and Vice President. Boeing 737 and Embraer Legacy 600 are used for shorter VVIP/executive domestic and regional transport.

RFP REQUIREMENTS

The core requirements and specifications have been spelt out. The roles include troop and cargo movement, operations from forward and high-altitude airbases, humanitarian missions and potential aerial refuelling (auxiliary tanker roles). The payload capacity has to be 18 to 30 tonnes. Roughly 20 per cent (12 aircraft) will be delivered in fly-away condition from the Original Equipment Manufacturer (OEM), while the remaining 80 per cent (48 aircraft) will be manufactured in India. First deliveries must begin within 36 months of contract signing.



The aircraft will be expected to do more than just move cargo between established airbases. The requirement includes operations from high-altitude locations and unprepared runways, including the Advanced Landing Grounds (ALG) in Ladakh and the Northeast. For the IAF, that combination of payload, range and austere-field capability is important. Transport aircraft are increasingly being used to move troops, vehicles, ammunition and other equipment quickly between distant bases and forward areas.

Local production requires starting with significant domestic content (targeting gradually to 60 per cent indigenisation) under the Make in India initiative. The winning global vendors must partner with Indian companies (such as HAL, TASL, Mahindra Defence or Adani Defence) to establish local final assembly lines and Maintenance, Repair and Overhaul (MRO) facilities. A domestic defence MRO capability that starts with 60 Indian aircraft and becomes exportable to the rest of the region or beyond. That's a sovereignty play where MRO capability intersects with strategic autonomy.

MAKE IN INDIA IMPERATIVE

Other than the performance criteria, a key aspect is the need to set up an industrial base and make the aircraft in India. It will thus be a mix of imported and locally made systems. Gradually, the entire aero-structure will have to be made in India, and bulk of systems and sub-components sourced locally. The Indian partner and the selected OEM will be expected to establish a final assembly line and MRO capability in India. That makes the MTA programme one of the more significant opportunities yet, for India's military transport manufacturing sector.

The 60-aircraft MTA procurement bridges the critical "missing middle" between light C-295s and strategic heavy-lifters like the C-17 Globemaster III

LOCKHEED C-130 SUPER HERCULES

The Lockheed Martin C-130J Super Hercules is a four-engine turboprop military transport aircraft built for tactical airlift, humanitarian relief and combat missions worldwide. Powered by four Rolls-Royce AE 2100D3 turboprops with six-bladed composite propellers, it flies at 643 km/h cruise speed, and has a range of 6,852 km (with no payload). It has a capacity of up to 124 troops, 92 para-troops, or 19,598 kg of cargo. The minimum three crew include two pilots and one loadmaster. It has a short take-off capability and is designed to land and take off on rough, dirt or unprepared runways. The C-130 Hercules entered service with the US in 1956, and over 2,700 were built. The C-130 Super Hercules began inducting in 1999, and over 500 have been built and are operated by 27 countries. The aircraft costs roughly $75 million per unit.

EMBRAER C-390 MILLENNIUM

The C-390 Millennium is a medium-size, twin-engine, jet-powered military transport aircraft. It is the heaviest aircraft that Embraer has ever made, this project began in mid-2000s. The aircraft has been built in partnership with various other aerospace companies, including FAdeA, ENAER and OGMA. Major sub-contractors in the aircraft's manufacturing include Aero Vodochody, BAE Systems and Rockwell Collins.

The first of two prototypes performed



its maiden flight in February 2015. In September 2019, the first production aircraft was delivered to the Brazilian Air Force. Its modular architecture allows for rapid reconfiguration for a wide range of missions like cargo and troop transport, medical evacuation, fire-fighting, search and rescue, humanitarian assistance and the aircraft can also be configured for air-to-air refuelling, both as a tanker and as a receiver. It can carry payloads of up to 26-tonnes, such as two fully-tracked M113 armoured personnel carriers, a Sikorsky H-60 helicopter, up to 80 soldiers or 66 para-troopers with full gear, and loads of upto 19-tonne can be air dropped. Each aircraft costs around $130-150 million.

KC-390 is the aerial refuelling variant. C-390 IVR is the anti-submarine and maritime patrol variant. Of the current operators of this aircraft, Brazil has ordered 22 aircraft (8 in service), Portugal six and Hungary two. It has also been selected by nations such as the Netherlands, Austria, South Korea, Czech Republic, Sweden, Slovakia and most recently by Lithuania and Uzbekistan.

WAY FORWARD

C-390 Millennium and C-130J remain the frontrunners for IAF requirement. The new fleet would also give India more flexibility for humanitarian assistance, disaster relief and special operations.

Lockheed Martin's C-130J has the advantage of already being in service in IAF. The Indian fleet has an air-to-air refuelling receiver capability and is used for missions ranging from airlift and disaster relief to search and rescue.

The C-130J sits at the lower end of India's 18 to 30-tonne requirement, with a payload of about 19-tonnes. The C-130J also has a large international operator base, an established production line and an existing Indian industrial relationship. Tata Lockheed Martin Aerostructures in Hyderabad is the global source for C-130J empennage assemblies, while Tata and Lockheed Martin have also been developing an MRO capability in India. That gives C-130 some level of advantage.

Embraer's C-390 Millennium comes from a newer generation of military airlifters and is larger than the C-130J. C-390 offers more payload. Yet, the C-390 was also designed for operations from semi-prepared runways. Its higher payload would reduce number of sorties and therefore maintenance costs. On the other hand, sometimes, the larger aircraft cannot be filled and remains underutilised.

Brazil is an important Global South Partner of India. India and Brazil share a Strategic Partnership since 2006, characterised by strong bilateral ties and cooperation in international forums like BRICS, G-20 and the UN. Their relationship is built on shared democratic values, financial costs and a vision for a more equitable global order. India already operates the Embraer Legacy 600.

Airbus had previously offered the A400M for the Indian requirement. But the aircraft is substantially larger than the specified category, with a payload of about 37-tonnes, compared with the 18 to 30-tonnes requirement. So, it became a lesser contender in MTA race, considering its suitability was more aligned with the replacement of IL-76.

After the RFP bids are received, there will first be a technical evaluation. Ground and flight trials will be subjected to those that clear the technical evaluation stage. The flight trials will be carried out across all the regions and weather conditions that the aircraft would have to operate in. In particular short field, high altitude, hot weather trials will be crucial.

Meanwhile it is time for India to build its own MTA and a Regional Jet, a project that can be handed over to the private sector.



–The writer is an IAF veteran (PVSM AVSM VM VSM) and former Director-General, Centre for Air Power Studies (CAPS). He is currently the Strategic Adviser for Aerospace at SIDM

Q→NU

ATMANIRBHAR IN QUANTUM SECURITY

END-TO-END SOVEREIGN QUANTUM DEFENCE

Quantum based Security. Made in India. Ready to battle any threat.

From QKD hardware to India's first quantum-safe drone communication, QNu Labs delivers the country's only **end-to-end quantum security stack – hardware and software** – engineered to counter the quantum threats and military communications. Designed, developed, and manufactured in India, for India.

INDIA'S FIRST END-TO-END QUANTUM DEFENCE — EVERY LAYER COVERED

QShield
World's first unified quantum security platform

QConnect
Quantum-safe VPN & secure tunnel against eavesdropping

Quantum Key Distribution
Unbreakable keys for command, satellite & tactical links

QVerse
Quantum-safe messaging & collaboration, data 100% on-prem

Quantum RNG
True quantum randomness – real-time, non-deterministic keys

Quantum-Safe Drone Comms
End-to-end, NIST-compliant secure drone communication

NIST-aligned post-quantum cryptography • **Quantum hardware + software** - not just software alone • **Data sovereignty** by design, on Indian soil

QNu Labs, your partner in securing data and communications in the quantum era & AI-based threats.

qnulabs.com

Scan & Connect with us.

© QNu Labs Pvt. Ltd. · Indigenous quantum-safe solutions for Military / Paramilitary and Critical Government & Private Agencies.

THE NEW AIRPOWER IMPERATIVE: FASTER, SECURE AND INTEROPERABLE COMMUNICATIONS

Honouring 94 years of Indian Air Force's excellence, Bharati Exicom celebrates the IAF's transition toward decentralised, autonomous warfare and network-centric precision. Through sovereign innovation, advanced data links and resilient communication systems, Bharati Exicom remains dedicated to empowering India's air warriors with indigenous technologies built for contested, high-tech battlespaces of the future

ASHISH PADTE



On October 8, 2026, the Indian Air Force completed 94 years of service to the nation. Each year has added something: a lesson learned, a capability built, a doctrine sharpened. The IAF of today is richer in experience and younger in outlook than at any point in its history.

Last year, the world saw what that evolution means. During Operation Sindoor, the IAF demonstrated precision-strike capabilities, defended Indian skies against hostile drones and operated in close coordination with the Army and Navy. It showed that Indian air power can protect and strike with speed, precision and coordination. Bharati Exicom (erstwhile Exicom), is proud to contribute to the technologies that support India's evolving air power.

A CLEAR VISION: DECENTRALISED, AUTONOMOUS, AFFORDABLE

Speaking at a CAPSS seminar on unmanned systems in May 2026, Air Chief Marshal AP Singh described a shift from concentrated air power towards a more decentralised and autonomous model of warfare. Drones are no longer simply eyes in the sky; they are becoming an extension of air power itself.

This changes the economics of warfare. The digital battlefield increasingly rewards affordable, connected systems that can be deployed at scale and sustained over time. A relatively low-cost unmanned platform capable of disabling a high-value radar or command post can deliver disproportionate operational effect.

The IAF's unmanned vision can broadly be viewed through three layers:

- **See:** Persistent ISR to maintain continuous awareness of the battlespace.
- **Strike:** Loitering and precision munitions to engage critical targets.
- **Saturate:** Long-range swarms designed to overwhelm and complicate enemy air defences.

The Swarm Unmanned Munition System programme reflects this approach, with swarms intended to saturate air defences, confuse sensors, and provide commanders with rapid strike options against critical targets. Such capabilities depend heavily on indigenous technology. At the SIDM workshop in July 2026, the Air Chief stressed the importance of developing critical components within India. The message is clear: strategic capability cannot depend on external supply chains.

His emphasis on secure networks, sovereign technology stacks, cybersecurity and indigenous AI also highlights the need for the armed forces, industry, academia, and certification agencies to work together. For Indian defence electronics companies, this represents both a responsibility and an opportunity.

THE NERVOUS SYSTEM OF AIR POWER

An aerial vehicle is only as effective as the communication link connecting

it to the wider battlespace. A swarm without a resilient network is simply a collection of aircraft. In network-centric warfare, communications form the nervous system of air power. They connect aircraft, unmanned platforms, ground stations, command centres, and other battlefield nodes, allowing critical information to move in real time.

Tactical data links are central to this architecture. They connect sensors and platforms with command and control, enabling surveillance information to be shared, decisions to be coordinated, and human operators to retain control over engagements.

Operation Sindoor reinforced the importance of this connectivity. The Air Chief credited the Integrated Air Command and Control System as a key centre for tracking and responding to hostile drones in real time. Advances in secure communications are also making manned-unmanned teaming increasingly practical. Unmanned platforms can operate ahead of crewed aircraft as scouts, decoys, or sensor nodes, extending situational awareness while reducing risk to pilots. Yet, the principle remains clear: humans stay in the loop, with manned and unmanned assets operating as a coordinated team through reliable data links.

THE BHARATI EXICOM JOURNEY: ANSWERING OPERATIONAL NEEDS

For years, the armed forces faced a familiar challenge: critical communication equipment often came from foreign OEMs, while modifications for unique Indian operational environments were never a priority for these foreign OEMs.

This became practically apparent as the Indian Air Force's requirements for advanced downlink and datalink capabilities evolved. When no Indian or foreign OEM could meet these emerging requirements, Bharati Exicom stepped-up and developed a unique downlink solution. The solution not only competed effectively with established solutions in the market,

Bharati Exicom successfully developed custom video downlink solutions tailored to India's unique operational needs, outperforming foreign alternatives with double the required transmission range

but also achieved twice the distance of Indian Army Aviation requirements.

FROM MANNED AIRCRAFT TO UNMANNED PLATFORMS

Bharati Exicom's video downlink journey began with an opportunity from the IAF in 2014. A manpack unit was flown on a C-130 for surveillance and reconnaissance, delivering live video at ranges exceeding 150 km. This marked an important step in developing specialised communication solutions for India's defence requirements.

Today, Bharati Exicom's video downlink systems are deployed on more than 100 rotary-wing aircraft, providing infantry and armoured forces with real-time aerial feeds to support mission planning and situational awareness. The capability has expanded from manned platforms to unmanned systems. More than 500 of Bharati Exicom's radios now support unmanned platforms in surveillance and ISR roles, including:

- Point-to-point links extending up to 200 km for deep ISR.
- Networks supporting formations of 10-15 nodes for unmanned missions.
- Seamless handover from ground control stations to forward tactical headquarters.

These capabilities provide the communication foundation for larger, more resilient unmanned networks and future swarm operations.

HEADING TOWARDS STEALTH: THE INTELLIGENT RADIO

The next frontier of air power will increasingly extend into the electromagnetic (EM) spectrum. A detectable communication signature can become a vulnerability, making spectrum awareness, agility and resilient networks essential. Bharati Exicom is developing communication systems with intelligent capabilities designed for contested RF environments:

- **Spectrum awareness:** Mapping and recording the RF environment to support informed frequency planning.
- **Advanced frequency hopping:** Improving link agility and reducing predictability.
- **Cognitive operation:** Adapting communications to changing RF conditions.
- **GPS-denied operation:** Maintaining connectivity when satellite navigation is unavailable or disrupted.
- **Controlled transmission:** Managing when and how the radio transmits to reduce its EM signature.

Together, these capabilities are aimed at creating tactical communication that remains resilient while operating in contested environments.

As the Indian Air Force enters its 95th year, its evolution will increasingly be defined not only by aircraft and weapons, but also by its ability to adapt to the changing battle landscape, Bharati Exicom is committed to contributing to that transformation with secure, indigenous and resilient communication technologies built for the connected battlespace of tomorrow.



–The writer is Chief Executive Officer (CEO) of Bharati Exicom Technologies India Private Limited

HAL AND DRDO REQUIRE AN OVERHAUL; PRIORITISE DESIGN AND DEVELOP IN INDIA

Air Chief Marshal Rakesh Kumar Singh Bhadauria (Retd), 26th Chief of the Air Staff (2019–2021) and former Commandant of the National Defence Academy, spoke with Ajit Thakur, Editor, Raksha Anirveda, on why India's reliance on imported platforms has persisted and what must change to achieve genuine self-reliance. The discussion covered LCA Mark 2, AMCA, indigenous engines, global talent, procurement reform, and unmanned, long-range, space, cyber, AI and quantum capabilities. This interaction took place against the backdrop of the government's recent move to open India's aerospace ecosystem further to private industry. Excerpts from the interaction follow.

Air Chief Marshal Rakesh Kumar Singh Bhadauria (Retd), who led the Indian Air Force from 2019 to 2021, said that India must move decisively toward indigenous defence design and manufacturing, warning that half-measures will keep the country permanently dependent on imports.

On fighters and unmanned systems, Bhadauria stated, "India must go "full throttle" on indigenous development, with the Air Force placing firm orders and HAL, the private sector and every stakeholder responding in unison. LCA Mark 2, AMCA, manned-unmanned teaming, combat UAVs and advanced munitions all need to be designed and built domestically within defined timeframes."



He stressed that continuing to import while simultaneously demanding indigenous development is self-defeating, since money spent abroad starves the domestic ecosystem. Large orders build infrastructure, servicing capacity and confidence, letting successive versions come faster. India already has demonstrated fighter design capability through LCA and its evolution to Mark 2; the harder problem is engines, where some collaboration may still be needed, though even that must now proceed at greater speed.

"India must actively recruit global talent alongside its own engineers, combining experienced international experts, seasoned domestic professionals and the steady stream of fresh graduates from IITs and engineering colleges to accelerate programmes," he emphasised.

Asked whether HAL and DRDO need an overhaul, he answered unequivocally yes, calling it long overdue. He acknowledges both organisations have begun changing, with more private-sector involvement and outsourcing, but insists all defence public-sector units need to substantially quicken their pace of work.

On the medium transport aircraft programme, he declined to comment on specific contenders but said that the winning proposal should be judged not merely on commercial terms but on how much genuine technology transfer and manufacturing capability it establishes in India, since follow-on requirements for that aircraft class will be far larger in future and should increasingly be met domestically.

On government urgency, he credited agencies like ADA and others working on LCA and AMCA for real energy, but stressed that this must become a "whole-of-nation" push, potentially requiring multiple shifts of work. "Results are not yet matching the effort, and there is real risk of missed timelines, driven partly by inadequate staffing. Organisations must hire enough of the right people; the government has shown considerable focus and flexibility, but industry execution is lagging," former Air Chief pointed out.

He also wanted companies to abandon their traditional comfort with assembly and "build-to-print" work, which is attractive because it is fast and lower-risk but stalls development of genuine design capability. Firms should collaborate across competitive lines, borrowing capabilities from rivals when needed. HAL itself has increased outsourcing significantly in recent years after initially trying to do everything in-house, but he still sees considerable room to speed up.



India must go "full throttle" on LCA Mark 2, AMCA and unmanned systems - you can't demand development while still importing

On the unmanned systems sector, he was largely optimistic, praising the range and energy of products emerging despite persistent industrial bottlenecks. ISR drones, loitering munitions, advanced UAVs and armed drones all matter greatly to the Air Force, offering low-cost means of disruption and destruction; he wanted such systems fielded in large numbers.

Beyond drones, he flagged several priority capability areas: heavier-calibre and longer-range weapons (India already fields systems reaching roughly 250 and 450 kilometres, with a need to push further), better terminal guidance, GPS-denial resilience, and comprehensive space-based ISR delivering near continuous coverage of areas of interest through satellite constellations. Communications must also gain a dedicated low-latency, space-based backbone to complement today's largely terrestrial networks, alongside major advances in cybersecurity and network-centric warfare.

On AI, he sees it as the layer that ties real-time ISR, sensors, networks and communications together, enabling systems to process enormous data volumes and eventually operate with real autonomy. He cautioned though, that autonomous systems must come with rigorous control mechanisms, since unchecked autonomy is inherently risky. He was candid that the gap in AI and quantum computing worried him: India is only at an early stage, and needs indigenous AI systems rather than mere users of others' technology. Legacy platforms cannot simply have an "AI layer" bolted on; underlying systems must be re-designed to be AI-compatible, since design itself will increasingly be built around AI over the coming decade. He framed the concern less around the United States and more around countries like China, potentially denying access to critical technologies, which could render Indian systems obsolete unless India prepares now.

Reflecting on the Air Force's innovation initiatives, which began awarding contracts during his tenure as Chief, he stated that maintaining continuity and energy is essential. Often the constraint isn't technology but process and mindset: procurers' default to imported, already-proven equipment rather than risking investment in domestic industry, perpetuating a chicken-and-egg problem. He argued buyers should commit to purchasing domestically wherever Indian industry can deliver, accepting inevitable early setbacks.

On procurement reform, he agreed Indian vendors deserve more flexible trial and clearance processes than



foreign suppliers face, allowing systems performing at a reasonable level to be inducted with continuous upgrades built-in. The Air Force already extends such flexibility to HAL, and he believes similar trust should be extended to private industry and startups, reflecting genuine confidence in the domestic system.

Asked whether India should simply stop importing military equipment altogether, he said the country should pursue indigenous development almost unconditionally, absorbing whatever setbacks come, following the precedent of every major power that built its own industrial base rather than perpetually importing. Niche technologies will always require some collaboration, but over a ten-to-fifteen-year horizon, no door should remain open where domestic capability was achievable but neglected.

He argued indigenous technological capability also gives Indian designers freedom to innovate across configurations - single or twin-engine aircraft, larger platforms, varying degrees of stealth - options currently constrained by industry's comfort with technology-transfer and build-to-print arrangements. Government-imposed restrictions and targets pushing "design and develop in India" would redirect both funding and institutional behaviour toward domestic design capability.

Longer-range weapons, GPS-denial resilience, space-based ISR and a dedicated space communications backbone are all critical next steps

On the shift in terminology from "strategic autonomy" to "strategic optionality", he considered it largely a rebranding of the same underlying idea: the ability to act in the national interest regardless of external pressure, choosing selectively whether to heed outside positions. He believes India has managed this reasonably well in recent years.

Ultimately, he tied this to the vision of Viksit Bharat by 2047, insisting the foundation of strategic autonomy must be genuine design and development within India-for aircraft, carriers, tanks, artillery and unmanned systems-rather than licenced manufacturing of imported technology. Major investment should flow into domestic industry, with narrow exceptions for niche technologies like certain engines or AI hardware requiring collaboration. Greater indigenous investment fuels more startups and innovators, which is the essence of technological sovereignty; he expects AI's importance to keep growing dramatically over the next five years.

On jointness, he said recent military operations demonstrated strong integrated planning and execution across services, successfully combining legacy platforms with modern technology. On theatre commands specifically, he cautioned against treating any particular Western model as something India must replicate wholesale; the underlying goal - integrated services and integrated planning - can be achieved without necessarily creating multiple separate theatres simply because other countries structured things that way. While not privy to current discussions, he noted that substantial integration work has already occurred at the ground level, which is what ultimately matters most of all.

SAFESURE®
Runflat Systems

SAFESURE PROUDLY CELEBRATING 10 YEARS OF TRUST, RELIABILITY & EXCELLENCE 2008 - 2018

Sanathan Allied Industries an ISO 9001-2008 certified company, specialized in the manufacturing of SAFESURE® Runflat Systems, Bead locks for the continuous mobility of bullet proof and armored vehicles used by VIP's, Police, Protection Forces, Special vehicles carrying high value assets and Monorails.

Innovation and technology is paired together to deliver cost-effective, application-suitable, customized reliable Runflat and Beadlock Solution.

SAFESURE® Runflats are servied in more than 15 countries for a decade since 2008. SAFESURE® Runflat Systems are time-tested, proven, acclaimed for its unique and innovative manufacturing process, high quality Runflats and Beadlocks are manufactured in Hyderabad, India.



RUNFLATS



FORGED ALUMINUM WHEELS

SAFESURE 2 PIECE BEADLOCK SYSTEM



To Enhance Mobility, Traction And Steering Control For Vehicle Operation In Soft Terrains Such As Sand, Mud And Snow

RUNFLAT WHEEL ASSEMBLY



UNIT - I
Plot No. 31/B IDA,
Balanagar, Hyderabad
Telangana, India - 500 037.

UNIT - II
C-18, Industrial Estate,
Sanathnagar, Hyderabad
Telangana, India - 500 018.

UNIT - III
Plot No. B-30, Technocrat Industrial Estate,
Balanagar,Hyderabad Telangana,
India - 500 037.

Phone: +91 40 2307 7537, +91 40 2307 7917 Mobile: +91 90005 67917, +91 85000 29898
E-mail: sales@safesure.co.in / visujapala@safesure.co.in **web: www.safesure.co.in / www.safesurerunflat.com**

DRDO'S PHOTONIC RADARS POISED TO DETECT STEALTH AIRCRAFT LIKE F-35s

The Defence Research and Development Organisation (DRDO) is advancing indigenous Microwave Photonic Radar (MPR) technology, including quantum sensing and photonic radars equipped with ultra-low-noise, single-photon detectors designed for mass production, to counter stealth capabilities

PROF (DR) DK PANDEY



The Lockheed Martin F-35 Lightning II is widely recognised as a leading fifth-generation jet because it is optimised for low-observable (stealth) characteristics. It incorporates advanced radar-absorbent materials (RAM) and precise physical shaping to minimise its radar cross-section (RCS) against conventional high-power radio-frequency (RF) radar systems. This technological sophistication significantly reduces its detectability by enemy radar.

In response, radar designs are being updated to detect such stealth aerial targets. The Defence Research and Development Organisation (DRDO) is advancing indigenous Microwave Photonic Radar (MPR) technology, which includes quantum sensing and photonic radars equipped with mass-produced, ultra-low-noise single-photon detectors, to counter stealth capabilities. Additionally, MPR is engineered to resist electronic warfare (EW) jamming and spoofing attacks.

The MPR's advanced signal-processing capabilities enhance its effectiveness against stealth technologies designed to evade conventional radars. This approach addresses bandwidth, resolution, and electromagnetic vulnerability challenges inherent in traditional electronic RF radars.

Traditional radars experience significant signal degradation, high attenuation at ultra-high frequencies, and bandwidth limitations due to electronic signal-processing constraints. DRDO's photonic radar addresses these issues by replacing certain electronic microwave stages with optical components.

PRINCIPLES UNDERLYING THE DETECTION OF STEALTH TARGETS BY PHOTONIC RADARS

Traditional stealth aircraft, including the Northrop Grumman B-2 Spirit, Lockheed Martin F-117, F-35, and Chinese J-20, are engineered to evade detection by conventional RF radar systems through geometric shaping and radar-absorbent materials (RAM) that scatter and absorb microwave wavelengths. However, photonic radar uses several light-based processes that can overcome these stealth features. Key mechanisms are outlined below:

The term 'photonic' refers to using photons (light) to generate, process, and modify ultra-wideband optical signals. This capability enables photonic radar to overcome stealth measures that are effective against traditional narrowband microwave radars.

The photonic RF ultra-narrowband filter offers better frequency selectivity, a crucial characteristic in dense electromagnetic environments, compared with traditional microwave filters.

Photonic radar differs from conventional radar systems by utilising

The term 'photonic' refers to using photons (light) to generate, process and modify ultra-wideband optical signals. This capability enables photonic radar to overcome stealth measures that are effective against traditional narrowband microwave radars





optics-based processing instead of microwave-based signal generation. This approach leverages photonic properties to improve detection, broaden bandwidth, and enhance resistance to electromagnetic interference. In these systems, the radar signal is synthesised using an optical source, typically a laser, and transmitted via a modulated optical carrier. The receiver subsequently converts the optical signal into an electrical signal for further processing.

The operating concept remains the same as time-of-flight measurement: measuring the time it takes for a broadcast signal to bounce off a target and return to the receiver, thereby determining the target's distance.

A significant advancement in sensor technology is integrating microwave signals with high-performance optical components in photonic radar. This technology could overcome many inherent limitations of conventional radars, particularly in detecting low-observable or stealth objects.

DEVELOPMENT PHASES AND TIMELINES FOR DRDO's MPR

DRDO is developing India's first indigenous photonic radar, a next-generation sensing system that utilises light (microwave photonics) rather than conventional electronics for radar signal generation and processing. The Electronics and Radar Development Establishment (LRDE) in Bengaluru leads this initiative, positioning the system as a potential "stealth killer" for future Indian fighter aircraft.

Basic operation begins with generating ultra-wideband radio frequency (RF) signals. These signals are subsequently modulated, distributed, and processed in the optical domain using lasers, electro-optic modulators, and optical delay lines, before being converted back to RF for transmission and further processing upon reception. This would be achieved by using very high instantaneous bandwidths (GHz to tens of GHz) on optical carriers. This enables sub-centimetre range resolution for target classification and inverse synthetic aperture radar (ISAR) imaging.

Replacing heavy coaxial interconnects with fibre-optic cables reduces system weight and volume, while also shielding signal distribution from electromagnetic interference (EMI) and external electronic jamming. The MPR is adaptable for various applications, including air defence, missile guidance, and battlefield surveillance.

DRDO intends to integrate the radar with military platforms such as the Su-30 MKI, Rafale, and Tejas fighters, as well as ground-based air defence networks like Akashteer. Future target platforms



for DRDO's MPR include the Advanced Medium Combat Aircraft (AMCA Mk2), next-generation Unmanned Combat Aircraft (NG-UCAVs), Airborne Early Warning and Control (AEW&C) systems, and other integrated ground-based air defence networks.

Comprehensive trials are scheduled to begin in late 2026 and will cover scenarios such as high-altitude operations, coastal surveillance, and electronic warfare environments.

The project timeline is divided into four phases. They are:

a. **The laboratory prototyping (2023-2025)** phase could achieve proof-of-concept, optical signal generation and integration into modules, which were successfully achieved in the lab, as required.
b. **Ground-based Field Trials & Static Range Testing (2026-2027):** Ground-based field trials and static range testing, as well as initial airborne/mobile platform validation processes, are underway.
c. **System Ruggedisation (2028–2030):** This will involve putting the systems into a miniaturised form and qualification for harsh conditions onto photonic integrated circuits (PICs).
d. **Operational Induction (2030-2031):** It is proposed to be introduced in serial production and integrated into the next-generation fighters (AMCA Mk2) and Navy/land-based sensor grids.

The MPR forms part of DRDO's broader strategy to enhance India's air defence capabilities and serves as a strategic asset by reducing reliance on foreign radar systems and promoting self-reliance in defence technology

Key Technical Challenges: The system is undergoing extensive testing by DRDO, with demonstrations highlighting its capability to detect and track targets at long range with high accuracy. The project team has addressed several technical obstacles during the planning phase, which are outlined below:

a. Although the MPR represents a significant advancement, challenges remain in cost reduction, mass production, and integration with existing defence systems.
b. Future developments are expected to prioritise miniaturisation, enhanced energy efficiency, and integration with other sensor systems to provide a unified battlespace picture.
c. Lasers and optical fiber links are susceptible to extreme temperature fluctuations, vibration, and high G-forces encountered during aircraft manoeuvres. Managing these factors effectively is essential to ensure reliable operation.
d. Advanced digital signal processing (DSP) hardware and ultra-fast analogue-to-digital converters (ADCs) operating in the optical domain are necessary to manage the substantial instantaneous data rates produced by multi-GHz optical bandwidths.

CONCLUSION

The Indian MPR is an advanced radar system under development by DRDO to address low-observable threats. By integrating microwave photonics with traditional radar systems, it achieves superior bandwidth, resolution, and anti-jamming capabilities. The MPR forms part of DRDO's broader strategy to enhance India's air defence capabilities and serves as a strategic asset by reducing reliance on foreign radar systems and promoting self-reliance in defence technology. This initiative aligns with the 'Make in India' programme and fosters indigenous innovation in critical defence sectors. The advancement will strengthen India's regional military position and significantly increase the resilience of its defence systems against detection and countermeasures.



–The writer is a Senior Fellow at the Centre for Air Power Studies. Prior to this, he was Group Captain in the IAF. He served the IAF for more than three decades in various capacities. He was Director Air Staff Inspections and retired as Director, Joint Control and Analysis Centre

BIG BANG BOOM SOLUTIONS
Your Friendly Neighbourhood Defence Company





AGNI QUELL

Suppresses Class A and B fires

High Expansion Firefighting Foam

Indigenously Engineered for enclosed **Naval Spaces**

800x Expansion | Tested by the Navy | No toxic legacy.

IMO International Maritime Organization Certified

ISO

iDEX Innovations for Defence Excellence
PM Awardee

www.bigbangboom.com +91 96259 12345

COUNTING THE WRONG MASS?

The Indian Air Force celebrates its 95th Air Force Day on October 8, completing 94 years of glorious service to the nation. The IAF enters late 2026 with just 29 fighter squadrons against a sanctioned 42.5, its lowest since the mid-1960s. Ageing fleets are retiring while replacements lag: not one Tejas Mk 1A has been delivered, and the 114-Rafale deal remains stalled. The IAF's force structure crisis is alarming amidst the ongoing transformation of war

AIR MARSHAL M MATHESWARAN

Indian Air Force's 29 fighter squadrons, reflect a deepening shortage as ageing fleets retire and replacements lag. Yet, restoring numbers alone is insufficient. Recent wars in Ukraine, Gaza, Iran and Operation Sindoor reveal that massed precision, resilient bases, deep magazines and networked kill chains now define combat power.

TRANSFORMATION OF WAR: WHAT THE RECENT WARS REVEAL

Ukraine-Russia War: Russia, with an air force many times Ukraine's, has failed to win air superiority in over four years of war. Dense, layered, mobile ground-based air defences have denied both sides contested airspace, pushing manned aviation into stand-off roles, with glide bombs and cruise missiles released beyond SAM reach. The defining innovation is the drone: produced in millions, attritable and woven into reconnaissance-strike complexes that compress the kill chain from hours to minutes. On June 1, 2025, Operation Spider's Web used truck-launched FPV drones to destroy Russian strategic bombers on airfields thousands of kilometres from the front. The airbase, not the aircraft in flight, proved the most vulnerable node. The 117 drones reportedly inflicted up to $7 billion in damage at a fraction of the cost. In this future of warfare, anything, anywhere can become a target.

Operation Sindoor: Between May 7 and 10, 2025, two nuclear-armed states fought the first sustained air campaign almost entirely with stand-off weapons. The IAF struck terror infrastructure and then 11 Pakistani air bases with BrahMos, SCALP and loitering munitions were launched from the Indian airspace, while the IACCS, S-400 and Akashteer network blunted Pakistan's drone and missile waves. Hard lessons followed. Restrictive initial rules of engagement and incomplete intelligence on the PL-15 may have cost the IAF aircraft on the first

Air superiority is now contested, local and temporary. The goal is to deny the adversary the air while exploiting it for short windows



night. The J-10C/PL-15 combination and the PAF's integration of China's Link-17 extended Pakistan's reach, aided by live Chinese operational inputs and ISR data. The two-front threat is no longer sequential or hypothetical; it is collusive and present.

Gaza: An air force with uncontested air superiority and AI-enabled targeting, generating targets at industrial rates, still could not convert precision into political resolution. Gaza also exposed missile defence's brutal cost-exchange: interceptors costing tens of thousands of dollars meet rockets worth a few hundred, making saturation a strategy in itself.

Iran versus the United States and Israel: The twelve-day war of June 2025 and the far larger campaign launched on February 28, 2026 showed what first-rate air forces can achieve, and their limits against a determined, resource-innovative adversary. American and Israeli airpower struck over a thousand targets in the first 24 hours and established air supremacy within days. Five months later, the Strait of Hormuz remains contested and political objectives unmet. Iran adapted by dispersing mines, small craft, shore-launched missiles and drones. Interceptor and precision-munition inventories, even American ones, became a binding constraint, and parallel strikes gave way to sequential ones. Air supremacy did not deliver strategic victory. Iran's asymmetric strategy, built on hypersonic missiles and cheap drones with Chinese and Russian intelligence support, has imposed exorbitant costs on the world's most powerful military.



Mass has returned as massed precision: thousands of cheap drones and hundreds of cruise missiles impose costs that a few hundred exquisite fighters cannot absorb



FIVE LESSONS FOR THE IAF

Ukraine and Iran have shown how low-cost weapons, used as massed precision, can impose severe costs on stronger adversaries. The IAF can draw five lessons.

First, air superiority is contested, local and temporary. The struggle is to deny the adversary the air while exploiting it for short windows, placing a premium on SEAD/DEAD, long-range stand-off weapons and electronic warfare over the classic fighter sweep.

Second, mass has returned now, as affordable, attritable massed precision. The side fielding thousands of cheap drones and hundreds of cruise missiles imposes costs that a few hundred exquisite fighters cannot absorb.

Third, air bases are prime targets and frontlines. Spider's Web, Sindoor and the Gulf strikes all targeted airfields. Hardened shelters, dispersal, rapid runway repair and counter-drone point defence are now combat capabilities, not infrastructure.

Fourth, magazine depth determines endurance. These wars consumed munitions and interceptors faster than industry could replenish them. An air force with aircraft but empty magazines is a force in being, not a fighting force.

Fifth, the kill chain is a network. Space-based ISR, AEW&C, secure data links and resilient command and control determine effectiveness more than platform numbers. The PL-15's reach during Sindoor reflected a Chinese-built networked targeting system, not the missile alone.

NUMBERS AND THE FORCE STRUCTURE

Even if Mk 1A deliveries, most optimistically, stabilise at 16 to 24






aircraft a year from 2027, Jaguar, Mirage 2000 and MiG-29 retirements will absorb most gains. The 114-aircraft MRFA, if signed this year, will not yield squadrons before 2030. The Tejas Mk 2 has slipped, and the AMCA is a mid-to-late 2030s proposition. On current trajectories, the IAF will struggle to exceed 32 or 33 squadrons before 2035, while China fields over 1,200 combat aircraft, including more than 200 J-20s, and Pakistan eyes fifth-generation J-35s.

THE WAY FORWARD

Fix the Production Problem. HAL's supply-chain vulnerability and single-source Tejas monopoly cause delays and quality-control problems; a second private-sector production agency would accelerate output and address them.

Technology Access and Control. Netcentric integration of diverse fleets is problematic without source code and ICDs. A Rafale fleet unable to integrate Astra, Rudram or BrahMos without French approval perpetuates dependency at $40 billion; ICD access must be non-negotiable.

Modernise the Backbone. Upgrading the Su-30 MKI fleet on a war footing is the fastest way to add combat value without adding airframes.

Factor Massed Precision. Force-structure calculations must count drones and autonomous systems as squadron equivalents: CATS Warrior, Ghatak UCAV, loitering munitions and Pralay missiles, assessed alongside manned squadrons. Manned-unmanned teaming outperforms manned fighters alone.

Build Magazine Depth. Create large-scale production lines for cheap drones and autonomous weapons, and fund surge-capable lines for Astra Mk2 and Mk3, Rudram, cruise missiles and interceptors as strategic reserves, not consumables.

Harden and Networked. Mission Sudarshan Chakra should integrate S-400, Kusha, Akash and counter-drone systems into one sensor grid anchored in hardened, dispersed air bases. SBS-3 satellites, additional AEW&C and tankers each deliver more than a fighter squadron.

Keep Airpower Indivisible. Multi-front threats demand rapid repositioning of air assets; fragmenting a 29-squadron air force across theatres would leave every theatre weak.

Overall, the 45-squadron force structure remains a necessary floor for a nation facing a collusive two-front threat across 6,000 kilometres of contested frontier, but it is not a sufficient measure of readiness. The future belongs to the air force combining capable manned fighters with attritable mass, deep magazines, resilient bases and a sovereign kill chain. The IAF's challenge is twofold: urgently restore numbers and redefine what they mean. Failing the first leaves India exposed today; failing the second leaves it prepared for a war that no longer exists.



–The writer, AVSM, VM, PhD (V), is a former Deputy Chief of Integrated Defence Staff (Policy, Plans & Force Development). He is currently the President of The Peninsula Foundation, a Chennai-based public policy research think tank

Atul Chaudhari: Building India's Future in Autonomous Defence Technology

From Software Engineering to advanced UAVs, Swarm Intelligence and Unmanned Combat Systems, the Founder and CEO of AYAAN Autonomous Systems is advancing India's indigenous defence technology ambitions

India's defence landscape is undergoing a technological transformation, with autonomous systems, artificial intelligence and unmanned platforms emerging as critical capabilities for modern warfare. At the forefront of this evolution is Atul Chaudhari, Founder and CEO of Pune-based AYAAN Autonomous Systems Pvt. Ltd., whose vision is to develop intelligent, indigenous Autonomous Systems capable of addressing New-Age Defence Warfare.

> **"For AYAAN, the journey ahead is driven by a commitment to indigenous innovation, technological independence and building world-class defence solutions that strengthen India's position in the global defence ecosystem"**
>
> **Atul Chaudhari**
> **Founder & CEO**
> **AYAAN Autonomous Systems**



Atul Chaudhari, Founder and CEO of AYAAN Autonomous Systems, receiving the Mehar Baba Competition -II award from Minister of State for Defence Sanjay Seth at Aero India 2025, in the presence of senior Indian Air Force officials.

JOURNEY OF DEFENCE INNOVATION

Established in 2019, AYAAN has evolved into an indigenous Deep-Tech Defence technology company developing Tactical Surveillance UAVs, Tethered drones, Loitering munitions, Unmanned ground vehicles (UGVs) and Swarm Algorithms.

A software engineer by background, Chaudhari began his entrepreneurial journey by applying drone technology to real-world challenges, including agricultural surveys, geospatial mapping and infrastructure monitoring. Recognising the potential of unmanned technologies beyond civilian applications, he gradually expanded AYAAN's capabilities towards defence and aerospace innovation.

A LANDMARK ACHIEVEMENT WITH THE INDIAN AIR FORCE

A defining milestone came when AYAAN emerged as the winners of the Indian Air Force's prestigious Mehar Baba Competition-II (MBC), focused on swarm drone-based Foreign Object Debris (FOD) detection. AYAAN developed indigenous swarm algorithms, AI compute hardware and AI models during the MBC programme.

Following the rigorous technical evaluations and trials, AYAAN demonstrated its indigenous technological capabilities, earning national recognition. Team AYAAN received the award during Aero India 2025, marking a significant achievement with Rs 300 crore procurement opportunity.



Team Ayaan receiving prestigious DRDO Dare to Dream 5.0 Award

MORE SUCCESS STORIES: DRDO – DARE TO DREAM 5.0 AWARD

Amongst the 800+ proposals from the entire country in open category of *'Unthinkable – Unimaginable'*, AYAAN received DRDO – Dare to Dream 5.0 Award, with unique and disruptive proposition of *Unmanned Unmanned Teaming* (UUT) having a 'UGV carrying Multi-barrel LM's and working collaboratively'. The award is the ultimate recognition and testament of AYAAN's focussed innovation and product development strategy.

BUILDING INTELLIGENT, CONNECTED DEFENCE SYSTEMS

What differentiates AYAAN from the other UAV manufacturers is the entirely in-house developed critical avionics, Flight Controllers, AI Companion Compute Modules, Gimbal Controllers, Telemetry and other smart sub-systems such as battery management systems, GPS/GNSS receivers, Remote Control with GCS Software, necessary firmware etc. as well as AYAAN's indigenous supply-chain eco-system.

With this strong unique selling point, the firm is able to quickly develop reliable products, without having foreign dependence and customise multiple solutions for the defence use as needed.

The company is also exploring Unmanned-Unmanned Teaming, enabling aerial, ground and software platforms to work together for enhanced situational awareness and operational flexibility.

STRENGTHENING INDIA'S DEFENCE SELF-RELIANCE

Looking ahead, Atul Chaudhari aims to strengthen research capabilities and transform indigenous innovations into scalable defence solutions. His ambition reflects a broader national objective: reducing dependence on imported technologies while building globally competitive Indian defence capabilities.

QUANTUM-SAFE RACE IS ON

Nations going quantum-safe are no longer competing only to build the fastest quantum computer. They are racing to protect long-lived data, secure critical infrastructure and control strategic technologies before adversaries can exploit them. From India's 2029 target to the United States' 2030 deadline, migration has become a national-security timetable. QNu Labs' QShield 2.0 is designed to address the operational gap while supporting India's National Cryptographic Assessment and Assurance Framework

SUDIPTAA PAUL CHOUDHURY

Quantum computing remains an uncertain technological horizon, but the cybersecurity response is becoming increasingly concrete. Governments are setting migration dates, updating procurement rules, funding domestic capabilities and building national standards for post-quantum cryptography (PQC). The central concern is not simply when a cryptographically relevant quantum computer arrives. It is whether encrypted information stolen today can be decrypted tomorrow.

That threat, known as "harvest now, decrypt later" (HNDL), changes the timetable. Sensitive data - including defence plans, health records, financial information, intellectual property and government archives - may retain value for decades. Adversaries can collect it now and wait for sufficiently powerful quantum machines. NIST notes that replacing cryptographic systems can take 10 to 20 years, which is why organisations are being urged to begin migration before Q-Day becomes measurable.

WHY THE RACE HAS ACCELERATED

The immediate vulnerability is concentrated in public-key cryptography. RSA, Diffie-Hellman and elliptic-curve systems protect key exchange, authentication, certificates and digital signatures across the internet. A sufficiently capable quantum computer running Shor's algorithm could undermine these mechanisms.

PQC aims to replace vulnerable public-key systems with algorithms designed to resist both classical and quantum attacks. In 2024, NIST finalised three foundational standards: ML-KEM for key establishment, ML-DSA for digital signatures and SLH-DSA as a hash-based signature alternative. These standards provide a common technical basis, although countries are increasingly adding their own requirements and algorithms.

The United States has now connected those standards to federal deadlines. Executive Order 14412 requires high-value federal assets and high-impact systems to adopt PQC for key establishment by December 31, 2030 and for digital signatures by December 31, 2031. It also requires agencies to appoint migration leads, review cryptographic inventories and submit migration plans. The order explicitly identifies the risk of adversaries collecting information now for later decryption.

This is more than a compliance exercise. It makes cryptographic visibility a prerequisite for national resilience. Organisations cannot migrate what they cannot locate.

INDIA PUTS 2029 ON THE CALENDAR

India has established one of the most aggressive deadlines in the emerging global quantum security strategy. The Department of Science and Technology's Quantum Safe Ecosystem in India report targets quantum resilience across critical information infrastructure by 2029 and enterprise-wide PQC adoption by 2033.

The proposed sequence is significant. Critical infrastructure operators are expected to complete cryptographic inventories by 2027, migrate high-priority systems by 2028 and achieve full implementation by 2029. A national testing and certification programme is intended to support assurance and interoperability.

India's approach also links national policy with financial-sector oversight. The Reserve Bank of India established the Q-SAFE expert committee to assess the sector's cryptographic inventory through a Cryptographic Bill of Materials (CBOM) and recommend a quantum-safe roadmap. That places science policy, telecommunications standards and financial regulation on overlapping migration tracks.

The strategic logic is clear: India is not waiting for a foreign technology ecosystem to define its security posture. It is attempting to develop indigenous capabilities while maintaining interoperability with global standards. This is the essence of quantum sovereignty policy - protecting national systems while reducing dependence on external suppliers, algorithms and infrastructure.

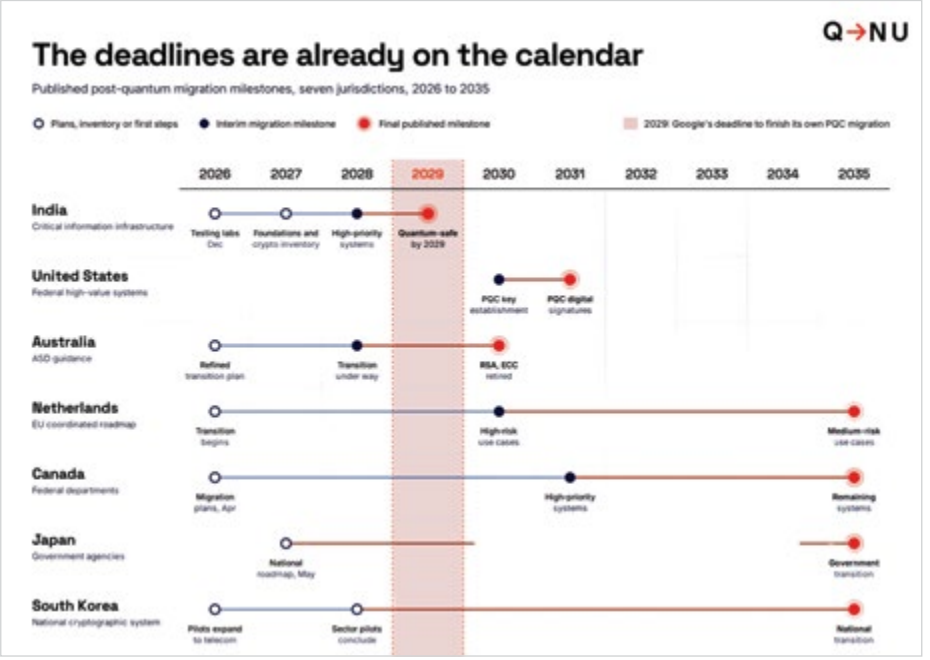
THE UNITED STATES: MONEY, MANDATES AND INDUSTRIAL POLICY

The United States combines the strongest regulatory push with major quantum defence investment. The 2026 executive order provides dated obligations for federal systems, while procurement rules are expected to extend PQC requirements into the contractor and defence-industrial base.

The US is also investing heavily in the supply chain. The Department of Commerce announced letters of intent worth approximately $2.013 billion in CHIPS Act incentives for nine quantum companies. That spending reflects a broader shift: quantum policy is no longer limited to research grants. It now covers manufacturing, hardware access, workforce development, standards and strategic resilience.

The private sector is reinforcing the government timetable. Google has set 2029 as its target for moving its infrastructure to PQC, citing developments in quantum hardware and error correction. Cloudflare has also publicly targeted 2029 for full post-quantum security. These commitments matter because hyperscale infrastructure providers can accelerate adoption across browsers, cloud platforms and enterprise networks.

Yet, the US timeline is not universal. The executive order primarily binds federal agencies. Critical infrastructure, state governments and private companies may face indirect pressure through procurement, regulation and customer requirements rather than one national deadline. That distinction will shape how quickly the broader economy moves.



AUSTRALIA, CANADA AND JAPAN CONVERGE ON THE 2030S

Australia has one of the clearest general-purpose positions. Its Information Security Manual advises organisations to stop using traditional asymmetric cryptography - including RSA, Diffie-Hellman, ECDH and ECDSA - by the end of 2030. It also expects newly purchased systems with long service lives to support approved post-quantum algorithms.

The country is pairing migration guidance with industrial investment. Australia and Queensland committed A$940 million to PsiQuantum's photonics-based quantum computer project near Brisbane. This illustrates a recurring pattern: governments are simultaneously preparing to defend against quantum computing and investing to develop it.

Canada is following a staged civil-and-defence model. Its government migration roadmap required federal departments to create initial PQC plans by April 2026. High-priority systems are due to migrate by the end of 2031, with the remaining systems targeted for 2035. In parallel, Canada launched a Quantum Defence Innovation Secure Hub with C$20.3 million for quantum sensing, secure communications and algorithms.

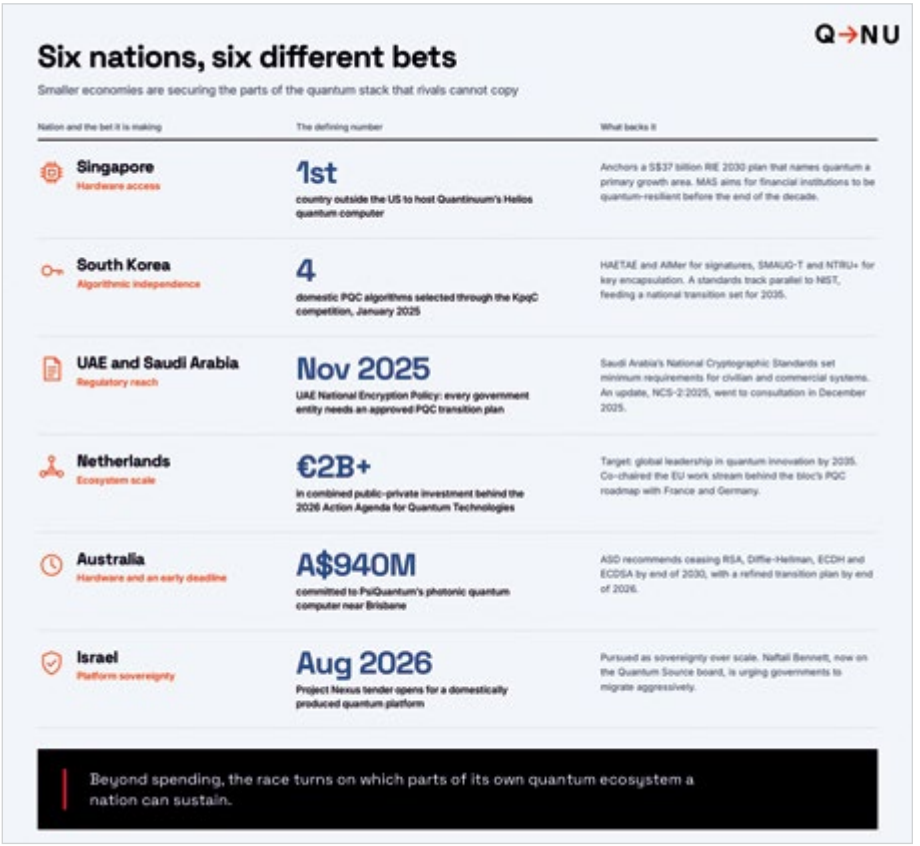
Japan's government agencies are targeting completion of their PQC transition by 2035. The country is also strengthening its domestic quantum industry through approximately ¥50 billion in support for more than ten companies. The approval pathway for ML-KEM through CRYPTREC is important because it links international standards with Japanese government procurement.

Together, these countries show that post-quantum cryptography countries are converging on a practical pattern: inventory first, high-risk systems next, and broad completion between 2030 and 2035.

SMALLER STATES ARE PURSUING STRATEGIC LEVERAGE

Smaller economies are not attempting to match the largest countries dollar for dollar. Instead, they are choosing specific points of leverage.

Singapore is pursuing hardware access, financial-sector readiness and ecosystem control. Its long-term research and innovation plan identifies quantum as a strategic growth area, while its partnership with Quantinuum is intended to provide access to a flagship quantum



computer. The Monetary Authority of Singapore has also funded quantum and artificial-intelligence capabilities for financial services and plans supervisory expectations for quantum resilience.

South Korea has taken a more explicitly sovereign route. Its KpqC competition selected domestic algorithms including HAETAE, AIMer, SMAUG-T and NTRU+. The country's 2035 transition plan includes pilots across telecommunications, finance, transport, defence and space. This creates a parallel standards track rather than complete dependence on NIST algorithms.

The Netherlands is working through the European Union's coordinated roadmap, which calls for member states to begin transitioning by the end of 2026, address high-risk use cases by 2030 and complete medium-risk migrations by 2035. The country is also mobilising more than €2 billion in public and private quantum investment.

The UAE has approved a National Encryption Policy requiring government entities to prepare PQC migration plans. Saudi Arabia is incorporating post-quantum requirements into its national cryptographic standards. Israel, meanwhile, is pursuing domestic capability through Project Nexus, a tender for a nationally produced quantum computer.

These initiatives demonstrate that quantum sovereignty does not have one definition. It may mean owning hardware, developing algorithms, controlling cryptographic libraries, securing supply chains or ensuring that sensitive systems can operate independently during geopolitical disruption.

THE ENTERPRISE DEADLINE ARRIVES FIRST

The common mistake is to treat a government deadline as the date when migration should begin. In practice, the real deadline arrives earlier.

Every organisation must first discover where cryptography is used: applications, APIs, databases, certificates, VPNs, TLS connections, PKI systems, hardware security modules, cloud services, operational technology and third-party platforms. It must then identify which data needs confidentiality for years or decades and which systems depend on vulnerable public-key algorithms.

The practical first step is a Cryptographic Bill of Materials. That inventory should record algorithms, keys, certificates, protocols, owners, dependencies, renewal dates and data sensitivity. It enables risk-based sequencing rather than a disruptive, organisation-wide replacement.

Hybrid deployments - combining classical and post-quantum mechanisms during transition - can reduce interoperability risk. Crypto-agility is equally important: organisations need the ability to replace algorithms, certificates and protocols without redesigning entire systems.

This is the operational gap that QNu Labs' QShield 2.0 is designed to address. Launched in September 2026, the platform supports India's National Cryptographic Assessment and Assurance Framework through three functions: discover cryptographic assets, assess classical and quantum risk, and assure security continuously. Its five modules cover quantum entropy, readiness risk assessment, quantum PKI, quantum vault capabilities and AI security.

The broader lesson is that quantum readiness is becoming a governance discipline, not merely a cryptography project. Nations have begun setting the clock. Enterprises that wait for a final Q-Day forecast may discover that their migration window has already closed.



–The writer is CMO at QnU Labs. An IIM Calcutta alumnus with over 22 years of global marketing leadership experience, she has led quantum security thought-leadership initiatives, positioning India's "Made in India, Made for the World" quantum capabilities across defence, government and enterprise sectors globally

DRONEAI

www.droneai.in | manish.jaggi@emvirt.com

Upgrade your existing fleet with AI and 5G.

Plug our module and C2 into the drones and rovers you already have. AI runs on board, 5G or not.



HOW IT FITS — One module on board. One C2 on the ground.



TODAY

- ✕ Targets spotted by eye
- ✕ No record of target location
- ✕ Link lost past RC range

AFTER UPGRADE

- ✓ AI finds, tracks, geo-tags
- ✓ Works offline, on board
- ✓ 5G beyond RC range
- ✓ All live on one C2

ISR — See more. Know sooner.

AI RUNS ON THE DRONE · WORKS WITH OR WITHOUT 5G



Identify, not just see

On-board AI boxes armour, vehicles and people, even with no network.



Know exactly where

Every detection geo-tagged: lat/long, time, confidence.



Never lose the target

One tap to lock; the drone keeps it centred.



Brief in minutes

Replay any sortie; get a report for any 1 km of the route.

COMMS — Stay connected. In command.

5G ADDS REACH · RC LINK STAYS AS BACKUP



Fly beyond RC range

Control and live video over 5G, tower to tower. RC stays as backup.



Command from anywhere

Every drone and rover on one live C2 map, whatever its make.



One picture for all

Every live feed with AI boxes on one video wall.



The pilot sees it too

Detections reach the operator's tablet over the RC link, no 5G needed.

+91 98866 91115 | manish.jaggi@emvirt.com | www.droneai.in | linkedin.com/in/manishjaggi

Emvirt Solutions Pvt Ltd · Jaipur, India

BEYOND DRONES: BUILDING INDIA's DEEP-TECH READY MILITARY

How AI, autonomous systems, robotics and data-driven decision-making will reshape India's battlefield advantage

LT COL NARENDRA TRIPATHI



The character of warfare is evolving faster than traditional military acquisition cycles can absorb. For decades, combat power centred on sophisticated platforms, aircraft, tanks, artillery, warships and missiles. This platform-centric model is increasingly giving way to non-contact, networked, autonomous and data-driven warfare, where advantage depends on interconnected systems and human–machine collaboration. Recent conflicts, including Russia–Ukraine, have highlighted the growing role of drones and unmanned systems in ISR, targeting, strike, electronic warfare and logistics. India's Operation Sindoor in May 2025 further highlighted the integration of precision strike, intelligence, drones, counter-UAS, electronic warfare and layered air defence. The weapon is therefore increasingly just one node in a larger kill chain linking sensors, communications, AI, command systems, autonomous platforms and precision effects.

This is driving the shift from "platform versus platform" to "system versus system." A platform's effectiveness increasingly depends on its wider ecosystem of sensors, data links, unmanned systems, AI, electronic warfare and precision weapons. At the tactical level, machines can detect and classify targets, AI can assist prioritisation, autonomous systems can act, and sensors can assess outcomes, while humans retain command and responsibility. Drones are only the visible beginning of this transformation. For India, the greater opportunity lies in building the architecture that connects drones with sensors, AI, communications, electronic warfare, precision weapons, command systems and human decision-makers, creating an integrated ecosystem capable of sensing, understanding, deciding and acting as one system.

The emerging battlefield is therefore likely to be characterised by:

- Stand-off and deep-strike operations rather than physical penetration of the adversary's defended space.
- Persistent ISR through satellites, UAVs, sensors and distributed networks.
- System-on-system warfare, where networks and integrated architectures compete against each other.
- Human–machine teaming, with machines performing sensing, processing and increasingly autonomous tasks while humans retain command authority.
- AI-enabled decision superiority, compressing the sensor-to-shooter and observe–orient–decide–act cycles.
- Mass deployment of relatively low-cost autonomous systems, alongside sophisticated high-end platforms.
- Electronic and cyber warfare aimed at disrupting the adversary's ability to sense, communicate, navigate and coordinate.
- Layered counter-UAS and air-defence systems, making both offence and defence increasingly networked.
- Distributed and resilient command-and-control, capable of operating despite communications degradation or loss of individual nodes.
- Rapid technology iteration, where software, algorithms and payloads may evolve faster than traditional acquisition programmes can accommodate.

The implications for military modernisation are profound. Traditional acquisition cycles spanning a decade or more are increasingly mismatched with technologies where software, AI models, sensors, electronic warfare and unmanned systems evolve within months. Acquisition must therefore shift from simply acquiring platforms to building continuously evolving capability ecosystems. Future operations will still require soldiers to hold terrain and secure objectives, but remote sensing, precision fires, autonomous systems, cyber, electronic warfare and stand-off weapons will increasingly shape the pathway to physical engagement. Military advantage will depend on integrating AI, data, communications, sensors, autonomous systems and human decision-making into resilient, adaptive architectures.

For India, the priority is to build a robotics-ready force where drones, UGVs, autonomous platforms, sensors, AI and personnel operate as an integrated human–machine ecosystem. Given India's diverse environments, this requires secure, sovereign, interoperable and resilient intelligence architectures capable of functioning across contested and disconnected conditions. The objective is not to replace human judgement, but to enable machines to extend the military's ability to sense, understand, manoeuvre and deliver effects, while humans retain intent, judgement and command.

DRONE IS NOT THE REVOLUTION, THE NETWORK IS

The first generation of military unmanned systems largely focused on answering a relatively straightforward question: Can we place a sensor, payload or weapon on an unmanned platform and operate it remotely? The next generation of warfare demands a far more consequential question: Can multiple unmanned systems collectively perceive and understand an operational environment, share information, coordinate their actions and assist commanders in making faster and better-informed decisions? This represents a fundamental shift from the platform to the network.



AI-enabled Drone and Robotics Technology being briefed by the writer at T-works, Hyderabad

The implications for military modernisation are profound. Traditional acquisition cycles spanning a decade or more are mismatched with technologies where software, AI models, sensors, electronic warfare and unmanned systems evolve within months. Acquisition must shift from simply acquiring platforms to building continuously evolving capability ecosystems

A single surveillance drone transmitting video to a human operator remains, fundamentally, an unmanned platform. In contrast, a network of drones and other robotic systems that can share observations, automatically detect and classify objects, correlate information across multiple sensors, compare observations with historical data, identify anomalies and changes, prioritise potential threats, and continuously update a common operational picture begins to resemble an intelligent robotic ecosystem. Such a system does not merely extend the physical reach of a soldier or commander; it extends the force's ability to perceive, analyse and respond across a complex battlespace.

The distinction is therefore critical: a drone generates data; an intelligent network generates understanding. The real transformation will occur when data from drones, unmanned ground systems, satellites, radars, cameras, electronic sensors and other sources can be fused through secure communications and AI into a coherent operational picture. This is where artificial intelligence becomes central, not as a replacement for the human commander, but as the intelligence layer that enables machines and humans to collectively make sense of an increasingly complex and rapidly changing battlefield.

Future military formations are likely to operate not as collections of individual platforms, but as interconnected layers of physical systems, sensors, computing, communications, data and intelligence. Combat effectiveness will increasingly

depend not only on the capabilities of individual platforms, but on how effectively the entire ecosystem can sense, communicate, process, understand and act as an integrated system.

At the physical layer, UAVs, drones, loitering systems, UGVs, autonomous ground and maritime platforms, robotic logistics systems and surveillance systems extend operational reach and persistence while reducing personnel exposure. Above this is the sensor layer, comprising EO/IR, thermal, radar, LiDAR, acoustic, RF, navigation and environmental sensors. As every platform becomes a source of information, the challenge shifts from collecting data to making sense of it at operational speed.

This makes edge computing and edge AI critical. In contested or communications-denied environments, drones and UGVs may need to process information onboard — detecting objects, identifying changes and prioritising relevant events — rather than continuously transmitting raw data. Instead, intelligent platforms can transmit detections, alerts and prioritised information, reducing bandwidth requirements and accelerating decision cycles.

The communications layer must connect these distributed systems securely and reliably despite interference or degraded connectivity. Resilient networks, tactical data links, interoperability, intelligent bandwidth management and store-and-forward architectures will therefore become increasingly important.

The next stage is data fusion, where observations from different sensors and platforms are correlated across time and location. A thermal signature, drone observation, ground-sensor alert and historical intelligence report may each be inconclusive individually, but together can create a stronger operational picture. The objective is therefore not simply to collect more data, but to correlate, contextualise and convert distributed observations into intelligence.

At higher layers, AI, Generative AI and agentic AI can detect patterns, analyse imagery, correlate information across documents, video, maps and databases, and present intelligence through natural-language interfaces. Instead of manually navigating multiple systems, commanders can interact directly with the operational information environment to identify relationships, anomalies and relevant context.

This represents a fundamental shift from platform-centric to intelligence-centric warfare. A drone operating alone is a capability; a fleet of drones connected to sensors, edge AI, communications, data fusion and command systems becomes part of an intelligent operational network. The ultimate objective is a continuous cycle of sense → connect → compute → fuse → understand → decide → act → learn, executed with greater speed, resilience and effectiveness.

Developed by Zenerative Minds as part of an iDEX project, the platform, ZM-Tathya, is designed to enable users to interact with and derive intelligence from large, multimodal datasets through an intuitive, context-aware interface. The company has also begun filing eight patents covering innovations associated with the platform and its underlying technologies

FROM PLATFORM-CENTRIC TO INTELLIGENCE-CENTRIC WARFARE

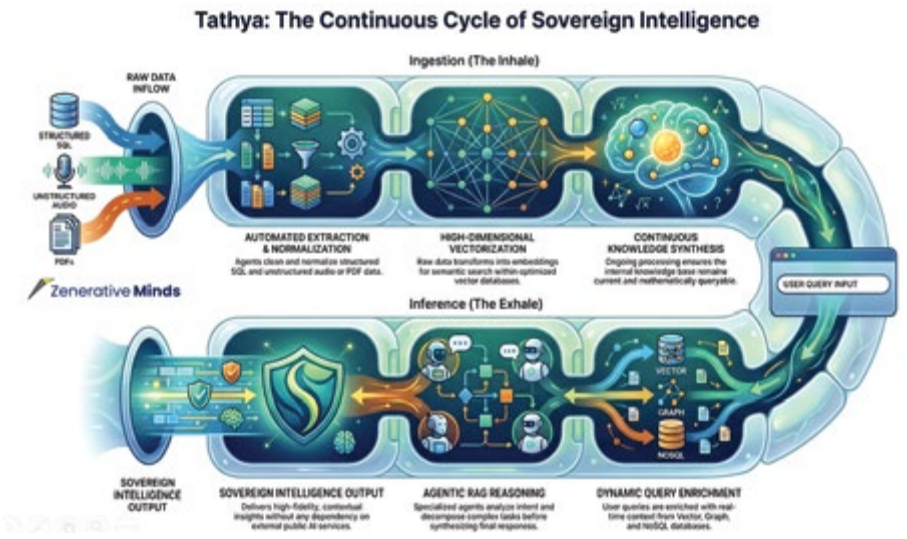
Traditional military information systems generally require personnel to know where information resides, which system contains it, and how to retrieve and interpret it. Generative AI can fundamentally transform this interaction by allowing commanders and operators to engage with the information ecosystem through natural language rather than navigating multiple databases, dashboards and document repositories. A commander could simply ask, "Show me the significant changes detected in this sector during the last 12 hours," and an intelligent system could potentially correlate drone imagery, surveillance feeds, sensor alerts, patrol reports, intelligence documents, maps, historical observations, maintenance records and logistics information to



Generative AI: The New Interface to Military Data



iDEX winner for the Indian Navy's Samvaad AI project at Bengaluru



Tathya Sovereign intelligence, Courtesy: *www.zenerativeminds.com*

generate a contextualised, cited and traceable intelligence summary. The significance, therefore, extends far beyond conversational AI. The real opportunity lies in creating a decision-intelligence layer across the entire information ecosystem, enabling fragmented data to be transformed into actionable knowledge while maintaining traceability to the underlying sources.

Significant progress has already been made in developing a sovereign, data-intelligent Generative AI operating system for India, designed to transform complex and diverse data into actionable insights in a manner aligned with the information needs of commanders and decision-makers. Developed by Hyderabad-based Zenerative Minds as part of an iDEX project, the platform, ZM-Tathya, is designed to enable users to interact with and derive intelligence from large, multimodal datasets through an intuitive, context-aware interface. The company has also initiated the process of filing eight patents covering innovations associated with the platform and its underlying technologies.

DATA BECOMES THE STRATEGIC RESOURCE

The future battlefield will generate unprecedented volumes of data. Every UAV sortie can produce imagery, telemetry, location information and sensor observations; every patrol can generate reports; communication networks continuously create metadata; and vehicles, weapons and other platforms can generate detailed health, performance and maintenance information. The challenge is therefore no longer simply "How do we collect data?" but rather "How do we transform this enormous volume of data into trusted, actionable decisions?" This is where the transition from Data Ready to Decision Ready becomes critical. Raw data, by itself, has limited operational value. It must be systematically collected, cleansed, classified, contextualised, correlated, analysed and presented before it can become meaningful, trusted and decision-ready intelligence. The competitive advantage will increasingly belong to forces that can compress this journey from data to understanding to decision at operational speed.

WHY DATA QUALITY WILL DETERMINE AI QUALITY

The effectiveness of any military AI system will ultimately depend on the quality, structure and reliability of the data ecosystem that supports it. Consider a surveillance environment in which Drone A detects an object at 1030 hours, Drone B identifies a similar object at 1045 hours, a ground unit reports unusual activity at 1100 hours, and a historical intelligence report contains information about the same location. If these sources use different coordinate systems, timestamps, naming conventions, classification structures or data formats, an AI system may struggle to recognise that these observations are related. Future military AI architectures will therefore require a strong and disciplined data foundation, incorporating common



data standards, rich metadata, data lineage and provenance, accurate time synchronisation, entity resolution, secure and role-based data access, classification-aware processing, and mechanisms for monitoring data freshness and integrity. The objective should be to ensure that an AI system does not merely answer "What does the data say?", but can also establish "Where did this information come from, how current is it, what evidence supports it, and how confident should we be?" In defence, where decisions may have significant operational consequences, this distinction between an answer and a trusted, traceable intelligence assessment is fundamental.

THE RISE OF THE AI AGENT

The next evolution of military AI is likely to move beyond individual AI applications towards agentic AI, in which multiple specialised AI agents collaborate to perform a complex operational task. Rather than relying on a single model to process everything, a distributed team of agents could perform specialised functions across the intelligence cycle: a Collection Agent could identify and retrieve relevant information from sensors and databases; a Vision Agent could analyse imagery and detect objects or changes; a Correlation Agent could connect observations across multiple sources; a Knowledge Agent could retrieve relevant historical documents and intelligence; an Analysis Agent could synthesise available evidence; a Verification Agent could examine sources, contradictions and confidence levels; and a Briefing Agent could convert the resulting assessment into a concise, decision-oriented operational brief. Such an architecture is not intended to remove humans from the decision loop. Its purpose is to augment human intelligence and reduce cognitive burden, allowing commanders and operational personnel to spend less time searching, collating and interpreting fragmented information and more time applying judgement, assessing options and making decisions.

A future battlefield operating system could bring together a physical layer comprising drones, UGVs, sensors, vehicles and weapons; a sensing layer incorporating EO/IR, radar, RF, thermal, LiDAR and acoustic systems; and an edge-AI layer providing real-time detection, tracking, classification and local analytics

SOVEREIGNTY IS NOT OPTIONAL

Military AI raises a strategic question beyond technological capability: who controls the intelligence infrastructure on which operational decision-making depends? As armed forces increasingly rely on AI for sensing, data fusion, analysis, and decision support, dependence on foreign cloud services, external APIs, or proprietary platforms can challenge operational sovereignty, data security, and the continuity of mission-critical capabilities. Sensitive defence information cannot always leave the operational environment, nor can critical AI capabilities be dependent on persistent access to external infrastructure. India therefore needs to build an architecture capable of supporting on-premises and private-cloud AI, air-gapped deployments, edge inference, indigenous or sovereign models, secure data pipelines, locally controlled knowledge bases and controlled model updates. The objective is not to isolate the Indian defence ecosystem from global technology, but to ensure that critical operational data, intelligence and AI-enabled decision capabilities remain under Indian control, particularly in contested or disconnected environments.

THE BATTLEFIELD OPERATING SYSTEM OF THE FUTURE

The most consequential military technology of the future may not be a single drone, robot, weapon or sensor, but the intelligence layer that connects them all. A future battlefield operating system could bring together a physical layer comprising drones, UGVs, sensors, vehicles and weapons; a sensing layer incorporating EO/IR, radar, RF, thermal, LiDAR and acoustic systems; and an edge-AI layer providing real-time detection, tracking, classification and local analytics. Above this would sit a secure data layer integrating storage, metadata, knowledge graphs, data fusion and provenance, followed by an agentic AI layer capable of search, correlation, analysis, verification and

continuous monitoring. Generative AI would provide the human-facing interface through natural-language interaction, summarisation, question answering and operational briefing, while the command-and-decision layer would retain human judgement, mission planning, tasking and authorisation. The real transformation will occur when these layers function as a single, secure and interoperable ecosystem, enabling the force to move seamlessly from sensing and data collection to understanding, decision and action, while keeping humans firmly in command of critical decisions.

FROM COMMAND AND CONTROL TO COMMAND, CONTROL AND INTELLIGENCE

Traditional Command and Control (C2) systems have primarily focused on moving information across command levels, but the future battlefield demands a fundamentally different capability: understanding. A modern military information system must go beyond displaying alerts and reports to determine which information matters, whether multiple observations are related, what has changed, how reliable the assessment is, what historical evidence supports it, what information is missing and what requires immediate attention. This creates a new paradigm of Command, Control and Intelligence, in which AI becomes the connective tissue between the enormous volume of battlefield data and human decision-making. For India, this transition must be built around operational reality first and technology second. The country's diverse operating environments, from high-altitude terrain and extreme weather to deserts, maritime areas, dense urban spaces and communications-contested environments, demand systems that can function under unreliable connectivity, electromagnetic interference, dust, heat and cold, and within secure or air-gapped networks. AI and robotic systems must therefore be tested



not merely in laboratories, but under realistic operational conditions with realistic data, communications constraints and battlefield uncertainty. This requires a deliberate focus on sovereign AI infrastructure capable of operating across secure, private and disconnected environments; treating data pipelines, standards, metadata and knowledge systems as critical defence infrastructure; developing modular and interoperable robotic platforms with standardised interfaces wherever operationally appropriate; pushing intelligence closer to the sensor through edge computing; and building effective human-machine teams in which technology augments the judgement and effectiveness of soldiers, operators and commanders rather than pursuing automation for its own sake.

The next military advantage will increasingly belong to the force that can connect sensors, process data, learn rapidly and convert intelligence into action through the shortest and most resilient decision cycle. Drones are only the beginning of a broader transformation towards robotic, autonomous and AI-enabled military ecosystems, where machines sense, communicate and analyse while humans retain command and responsibility. For India, this creates an opportunity to build a sovereign ecosystem integrating AI, Generative AI, robotics, computer vision, autonomous systems, edge computing and secure data infrastructure. The transition is therefore from drone warfare to robotics-enabled warfare, with data and the speed of turning intelligence into decisions at its core.



–The writer is a veteran of the Indian Army's EME (Corps of Electronics and Mechanical Engineers) and a founder/consultant at various deep-tech startups, leading the development of defence technologies in generative AI, drones and robotics. His firm has won the iDEX project for the Indian Navy's Samvaad AI. The information presented is sourced from open sources. The information presented is sourced from open domains

ANCHORING GEOPOLITICAL COMPETITION IN WARGAMING

Wargaming a complex multi-domain competition often devolves into subjective debates due to unquantifiable variables. By replacing abstract narrative arguments with calibrated parameters and networked variables, strategic wargaming can mathematically model the second- and third-order effects of DIME actions, offering a repeatable ltest bed for examining national power dynamics under uncertainty

COL SAIKAT K BOSE

Military operations do not occur in isolation but as part of geopolitical competition alongside other instruments of national power - political, economic, military, diplomatic or informational - often expressed with the shortcut, among others, of DIME. As against military action that can be captured in high-fidelity simulations of weapons and logistics, its less measurable variables, and difficulties of observing cause-effect relations, make it difficult to capture geopolitical competition in wargames.

In any Comprehensive National Power (CNP) competition, developments in any one sphere, say political cohesion, percolate through other spheres in the system - economic resilience, international support, diplomatic influence and willingness to escalate - in a cascade of second- and third-order effects triggering unintended consequences. The qualitative, implicit and semantic nature of involved variables cause wargames of such competition to degenerate to uncontrolled discussions where events, such as military pressure disturbing political cohesion, or instigation of third-country action, are decided through verbal duelling matches where the more eloquent player wins. Also, prolonged periods of such competition are difficult to portray in wargames as variables cannot be tracked effectively.

Geopolitical competition involves non-physical, qualitative variables that make cause-and-effect difficult to track, often causing wargames to devolve into verbal debates won by the most eloquent player

FROM MATRIX GAMES TO CALIBRATED PARAMETERS

The matrix method of wargaming does offer a solution, with consequences



A game examining security developments in the aftermath of the mid-2025 crisis under way, involving subject-matter experts from various think tanks and policymaking echelons.

of decisions adjudicated through a stochastic mechanism integrating argument, evidence and judgement. However, they are difficult to design, require high expertise to conduct, and have associated problems of synchronicity and simultaneity. Moving away from qualitative variables - neither physical nor reducible to figures - by replacing semantics (high, medium or low) by a quantified abstraction using bounded scales, one can create an environment of networked ordinal variables that responds to perturbations with the help of well-designed rules. Such a method would retain human decision-making, formalise adjudication and can be representative, repeatable and open to sensitivity analysis.

The difficulty with this under-explored method of using calibrated parameters lies in identifying variables and assigning values, which also is prone to biases and give illusions of precision. Say the range of values of public perception, economic



By mapping qualitative variables like public perception, political cohesion and leverage onto bounded numerical scales (e.g., 1-10), wargames establish a common analytical baseline for systematic adjudication

resilience, military effectiveness and diplomatic leverage for each country is taken as 1-10, while that of political influence is on another scale from -5 - (+)10, the figures must be seen not to represent degrees of precision but only to provide a common reference scale. A value of 7 would not mean that political cohesion has somehow been measured to seven units, but only defines a condition distinct from 9 or 4, where the former implies ability to sustain coordinated action under pressure and the later a situation increasingly affected by internal disruption; 2 would mean any coherent action is difficult.

These variables could be networked with rules that manage interactions of variables - military victory may increase public enthusiasm, but also harshen international opinion, weakening political cohesion and constraining the government's willingness to continue conflict. For example, strategic behaviour might be impacted opposingly along different routes;

1) military outcome → public perception → political cohesion → strategic behaviour along one channel, and
2) military outcome → international opinion → diplomatic behaviour → strategic behaviour along another.

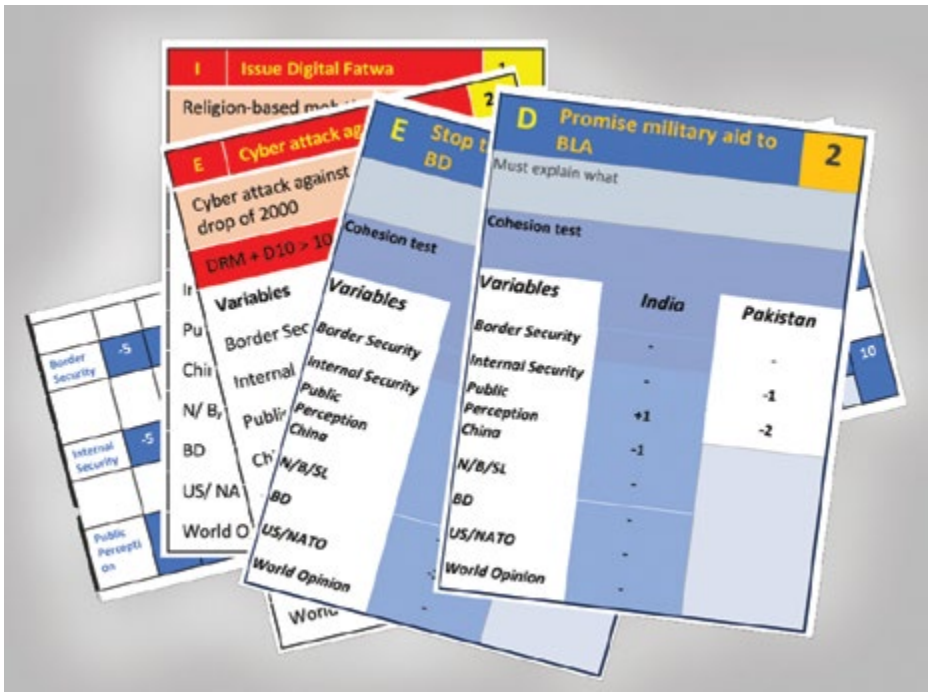
Further, certain thresholds and combinations of variables can be defined to trigger further changes, which would capture second- and third-order effects, and at times precipitate unintended consequences along multiple pathways. As knowledge of the system is incomplete and activities in fields such as economics, military or diplomacy would vary with conditions not all of which are known, the rules, created from the first principles and refined using abductive logic, also would require to factor in uncertainty.

LONG GREY TWILIGHT

The above approach was recently explored within an audience comprising certain echelons of the Indian Army and various think-tanks and research foundations. Titled Long Grey Twilight, the game modelled strategic competition between India and Pakistan, with China and other major influencers acting autonomously, in a multivariate environment.

It had two levels - a CNP and military - with the former modelling national-level behaviour within a network of calibrated variables; cohesion, public perception and economic stability, among others, were internal to countries, while relations with other countries and groups were external variables. The variables defined the start-state and objective values for each country; while the variables moved in response to events beyond the control of the players. The players, who formed sides representing countries (or their internal stakeholders), applied instruments of national power (INP) to nudge the variables towards their objectives through a deck of country-specific DIME cards each with multi-variate impact applied conditionally and stochastically.

While the actual progress and results of the game are withheld, it is mentioned here that as player-decisions whether to escalate or negotiate, mobilise or conserve, attack or wait, seek diplomatic support or accept isolation played out, sides discovered strategic consequences of actions



Some tools and equipment used in the game, alongside four of the first 200 DIME cards representing options available to the various sides involved

and revelations and how application of INP must consider trade-offs and opportunity costs and contend with outcomes not all of which would be favourable.

For example, it was observed that military success could increase internal political confidence but invite international intervention, disrupting economic situations that would restrict freedom to exploit advantages. The ubiquity of unintended consequences, such as bringing about reforms in the disadvantaged country, was also realised, as was how the bouquet of options and variables react along unpredictable pathways and bring about emergent behaviour.

HOW TO IMPLEMENT SUCH GAMES

Like a true wargame, Long Grey Twilight was not a crystal ball to foretell the future but a laboratory for strategic thought. By exerting the system in various manners, it revealed how diplomatic pressure increases with actions, what

Variables are linked through rules so that an action in one domain - such as a military victory - automatically triggers secondary effects, like shifting international opinion or constraining diplomatic leverage

conditions can trigger third-party intervention, when military successes fail to produce political success, how public perception can change government will or when military advantage stop deterring but instead escalates.

While questions such as these have often been independently examined with various models, the calibrated parameters method enables all diverse models to be put in the same analytical framework so that relationships, not obvious when each variable is examined independently, show up. However, while calibrated parameters make arguments experimentally testable in complex situations, the danger is the illusion of precision that must be guarded against. The objective is not to claim: "This is what will happen" but to say that "Under these assumptions, these are the kinds of outcomes that become possible - and these are the variables to which the outcome appears most sensitive."

Enormous designing effort for a single scenario in such a game can be addressed by automating the system, with a development kit with which users can include any set of countries, their varying concerns, and specific behaviour rules. A language model retaining calibrated figures for background processing can create a semantic interface using real-life statements that would elevate the realism of the game.

Such a game is under experimentation at Tecknotrove Systems, a sovereign technology company at the cutting edge of digital frontline, to make the system accessible to a host of users - higher military command echelons, international relations scholars and practitioners including think tanks, and policymaking agencies of the country - and collectively work towards enhanced national resilience and preparedness. The intent is to introduce system-level intelligence that makes third-party countries and non-states behave realistically, and also enable multiple runs of scenarios with controlled variation to understand which outcomes remain stable and which are highly sensitive to policy changes.



–The writer is an Indian Army veteran with three decades of experience in the Indian infantry. He is also a military historian and an avid wargamer

ZUPPA
INTERCEPTOR

RAPID.PRECISE. PROTECTED.

India's Indigenous Counter-UAS Interceptor System

Zuppa Interceptor is a high-performance, indigenously developed soft-kill system designed to detect, track and neutralize hostile drones with speed, accuracy and reliability.

- All weather Operation
- Rapid Response
- High Precision
- Highly Reliable

Securing Skies.
Safegaurding Futures.



askme@zuppa.io
+91 99520 81655
www.zuppa.io

CONVERGENCE AMID TURBULENCE

BRICS has survived despite its internal contradictions and external pressure. India values it as a hedge that broadens its room to manoeuvre, whereas Russia prizes it as a bulwark against isolation. With its rising salience, BRICS has become one of the principal arenas in which India and Russia negotiate



MAJ GEN DEEPAK MEHRA

India hosted the 18th BRICS Summit in New Delhi from September 12 to 13, 2026, under its fourth Chairmanship that was guided by the theme "Building for Resilience, Innovation, Cooperation and Sustainability." It reflected India's focus on strengthening existing achievements and intensifying institutional effectiveness. With the placement of development, sustainability and innovation at the heart of the agenda, it highlighted the aspirations of the Global South and sought to project BRICS as a constructive and solutions-oriented platform. From a boardroom acronym 'BRIC' for four emerging markets in 2001, the 'BRICS' has grown into a geopolitical bloc spanning four continents with a far wider grouping.

Over the years, it has incorporated oil states, African economies, Latin American nations, and Southeast Asian partners. Its members currently represent 49.5% of the global population, 40% of global GDP, and 26% of global trade. These figures underline their substantial demographic and economic weight, and their diversity brings together major markets, natural resources, technological capabilities and varied developmental experiences. Through its successive chairmanships, India has contributed to the substantive development of BRICS as an organisation,

and its 2026 chairship of the expanded membership builds on this experience.

THEORETICAL MOORINGS

Scholars have long debated whether BRICS is a revisionist coalition or a reformist club, a counter-hegemonic block or a parallel order builder. Some even call it a Coalition of the Unlike, where members diverge in regime type, economic size, and alignments, and others call it a proto-institution with work in progress, without a secretariat or binding rules, and still



deciding what it wants to become. Stuenkel, in his work The BRICS and the Future of Global Order (2015), reads the grouping as an instrument for enlarging emerging powers' voice within the existing order rather than toppling it, whereas Nayyar, in his article BRICS, Developing Countries and Global Governance (2016), stresses its advocacy of governance reform on behalf of developing countries.

For India, Harsh V Pant and Julie M Super (2015) question whether the vocabulary of non-alignment still captures New Delhi's selective, interest-driven partnerships, a stance that Jaishankar, in his work The India Way: Strategies for an Uncertain World (2020), articulates as multi-alignment. Many authors describe Russia's approach towards BRICS as a combination of ideational and material motives, including status-seeking and using BRICS to offset the damage of Western sanctions. These differing lenses, depending on what interest one represents, do help explain why BRICS has endured despite its internal contradictions. The pattern can be described as a Constructive Ambiguity in that the bloc holds together partly because each member can interpret its purpose differently. India values BRICS as a hedge that widens its room for manoeuvre, whereas Russia prizes it as a bulwark against isolation.

In his second visit to India since the commencement of the special military operation in Ukraine, Russian President Vladimir Putin arrived in Delhi for a three-day visit and held key bilateral talks with Prime Minister Narendra Modi ahead of the BRICS summit

INDIA-RUSSIA RELATIONSHIP

In his second visit to India since the commencement of the special military operation in Ukraine, Vladimir Putin arrived in Delhi for a three-day visit and held key bilateral talks with Prime Minister Narendra Modi ahead of the BRICS summit. Modi and Putin met for the second time in two weeks, having previously conferred on the sidelines of the Shanghai Cooperation Organisation summit in Bishkek on August 31, where the former had called for a shift from 'endless war towards the end of war'. As per the statement of India's Ministry of External Affairs, Prime Minister Modi reiterated that India was ready to help resolve conflicts and 'assist in peace efforts'.

What has been noticeable for the Russia watchers over the years is that the partnership between New Delhi and Moscow, once conducted almost exclusively through defence contracts and summit rituals, now unfolds inside a multilateral architecture whose membership, ambitions and internal fissures matter as much as the bilateral agendas. This article argues that BRICS has become one of the principal arenas in which India and Russia hedge, negotiate and occasionally contest one another's visions of order. Its rising relevance is as much a symptom of external pressure as of genuine convergence.

NEW DELHI 2026: BRICS AS ARENA

The summit unfolded against the backdrop of two active conflicts and an escalating global tariff war. Amid this, the headline achievement for India during the BRICS summit was 'Consensus'. India chaired a bloc comprising Iran, Gulf powers, China and Russia, and secured a single unanimously adopted declaration deliberately worded so as not to take sides in the Gulf conflict. This was no small feat, since members are split over the Gulf conflict, with Iran and the UAE on opposite sides. India's own Chairship tenor was pragmatic, favouring interoperable payment channels for local-currency settlement, amendments to the Contingent Reserve Arrangement, and a Russian-championed Grain Exchange targeted for launch by 2027. The same document recorded explicit Chinese and Russian support for the aspirations of India and Brazil in a reformed UN Security Council, a diplomatic dividend for Delhi.

The optics of the summit carried as much weight as its text. Chinese President Xi Jinping's visit to India, his first in seven years, alongside Russian President Vladimir Putin's attendance, signalled that despite years of border tension with Beijing and Western pressure on Moscow, India remains a convening power capable of



bringing rival and sanctioned leaders to the same table. Images of Modi, Xi and Putin walking together, laughing and planting Banyan saplings on the Bharat Mandapam lawns went viral, projecting an image of unity among nations, often at odds with Washington.

The bilateral dimension between India and Russia was equally visible. Their agenda, according to an Indian source, spanned civil nuclear energy, fertilisers, defence, critical minerals, railways and steel. The two leaders discussed the West Asia crisis and its impact on maritime trade and the security of Indian seafarers. Also, India's possible role in mediating the end of the Ukrainian conflict came up for discussion.

SANCTIONS, TARIFFS AND OIL: STRESS TEST FOR INDIA's MULTILATERAL ENGAGEMENT

The past year has tested Delhi's autonomy severely. In February 2026, Washington cut its tariffs on Indian goods from 50 to 18 per cent. The accompanying executive order recorded that India had committed to stop directly or indirectly importing Russian oil. Within a month, events overtook that undertaking. As the Iran war disrupted Gulf supplies, the United States issued India a 30-day waiver to purchase Russian crude. By July, Russia's share of Indian crude imports had reached a record 51 per cent, though it moderated in August as China stepped up its own purchases. It shows as to how energy insecurity, not ideological affinity, often governs India's Russia policy. It also shows why Moscow, India and others value BRICS. Members face severe US pressure to limit cooperation with Russia and Iran and to observe non-UN sanctions, particularly on Russian and Iranian oil. BRICS provides a platform for its members that normalises alternative payment channels, providing an alternative to uphold their sovereignty and national interests in difficult times.

The partnership between India and Russia, once conducted almost exclusively through defence contracts and summit rituals, now unfolds within a multilateral architecture whose membership, ambitions and internal fissures matter as much as the bilateral agendas

RUSSIA-INDIA-CHINA: CONVERGENCE WITHIN DIVERGENCE

The BRICS has been seeking over the years to raise its profile by influencing international rules and institutions, even as its members are split over the Gulf conflict with Iran and the UAE on opposing sides. New Delhi, during its chairship, has been engaged in a diplomatic balancing act as it tries to maintain strong ties with the US, Gulf states, Russia, Iran and Israel, while suffering the impact of shipping and trade disruptions due to the Ukraine and Iran conflicts.

Beneath the choreography of unity in the New Delhi BRICS summit, lie divergent conceptions of the bloc. Moscow's is the most oppositional. Putin, during his



Unlike China and Russia, India does not regard BRICS as anti-West. For Delhi, BRICS allows it to engage Russia and China without formal alliances. For India, the grouping's influence depends on reconciling and managing deep political divergences among members

interaction with the business forum in New Delhi, said, "Western competitors are trying by any means necessary to regain their former leadership. They even include direct physical attacks or the destruction of industrial and logistical facilities, pipelines, and so forth." He emphasised that BRICS should build a new platform for global growth free from Western rules. Beijing's vision is expansive. At the summit, it unveiled a "Greater BRICS Initiative". Xi Jinping unveiled proposals spanning areas from AI to trade, as Beijing seeks to weld the grouping into a practical platform for Global South development.

According to Xinhua, he proposed five initiatives on "greater BRICS" cooperation in AI, trade and investment facilitation, digital industry, smart manufacturing and talent development. India's conception is the most cautious. Unlike China and Russia, India does not regard the grouping as anti-Western. For Delhi, BRICS allows it to engage Russia and China without formal alliances while burnishing its image as a voice of the developing world. For India, the grouping's influence depends on reconciling and managing deep political divergences among members.

ASSESSMENT AND OUTLOOK

For India, BRICS 2026 brought out four major aspects. First, BRICS is amplifying, not replacing, the bilateral relationships. It presents a venue where Russia can affirm India's status, as in the Security Council language as stated above, while India extracts financial and logistical instruments that cushion sanctions risk.

Secondly, BRICS is where the triangular tension becomes manageable. Valdai Club analysts even credit Moscow with having acted as a bridge-builder between India and China, an intriguing inversion of the usual fear that Russia's dependence on Beijing erodes its independence.

Thirdly, there are structural limits as consensus decision-making across 11 heterogeneous members produces declarations of the lowest common denominator. India's insistence on a non-confrontational posture may rub against Russian and Chinese ambitions as the chairship passes to Beijing in 2027. Fourthly, BRICS is unmistakably operationalising its organisations in the shifting global power structures and working towards moving from summit forums to operative institutions.

Going forward, some concrete indicators to watch for India would be: the implementation of local-currency settlement, movement towards the $100 billion trade target between India and Russia, a reduced Indian trade deficit with China and Russia, enhanced intra-bloc trade among the BRICS nations, and whether India's oil dependence on Russia proves durable once Gulf supplies normalise.

The most plausible trajectory is a partnership that grows more institutionalised and less sentimental, anchored in interest rather than nostalgia and mediated through BRICS along with continued bilateral exchanges. Its ultimate worth to both capitals will hinge on whether the bloc can deliver practical instruments and robust and effective institutions rather than merely eloquent communiqués.



–The writer, a recipient of the Kirti Chakra, AVSM and VSM, is an Indian Army veteran who has also served as the Indian Military Attaché in Moscow. He is the Founding Director and CEO of ThorSec Global and a Senior Fellow at CLAWS. An accomplished scholar, he specialises in geopolitics, with a focus on Russian Studies, and is currently pursuing his PhD

THE GREAT NICOBAR PROJECT
INDIA's STRATEGIC EDGE

India is shifting its maritime strategy by developing Great Nicobar Island into a high-capacity economic and defence hub. Located near the Malacca Strait, the project aims to transform the island from a remote outpost into a dual-use stronghold, bolstering national security, capturing a greater share of global shipping traffic and ensuring sustainable regional growth

CDR SUMIT GHOSH

Traditionally, India has concentrated on its mainland ports and not on development of port and maritime infrastructure on its island territories. The Great Nicobar Island chain sits very close to the Malacca Strait, one of the busiest shipping lanes in the world. It is being realised that developing this area allows India to build a major maritime and economic hub, reduce its reliance on foreign ports like Singapore and Colombo for cargo shipping, and strengthen its national security and defence presence in the Indo-Pacific region.

Bolstering infrastructure at the Great Nicobar Island will transform it into a major strategic, economic and maritime hub in the Indo-Pacific region and this step is a landmark decision by the Indian Government. This strategically relevant project aims to strengthen India's continuous presence and its maritime eyes in the Andaman Sea, South China Sea and in the Southeast Asia. It further seeks to balance port-led growth with well-calibrated protection of indigenous communities, the flora-fauna and the overall environment at large.

STRATEGIC AND DEFENCE IMPORTANCE

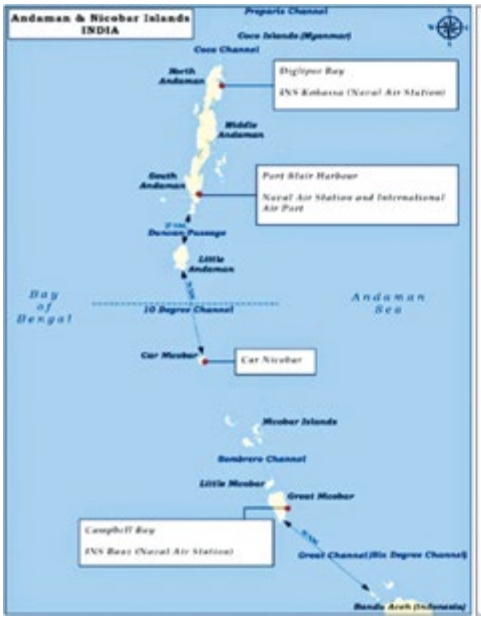
Nicobar is 40 nautical miles from the East-West shipping route and close to the Strait of Malacca, shipping roughly 1/3rd of global seaborne trade & oil cargo. From Great Nicobar, India will be able to maintain a strong, permanent defence presence, extending the reach of the Tri-Service Andaman and Nicobar Command.

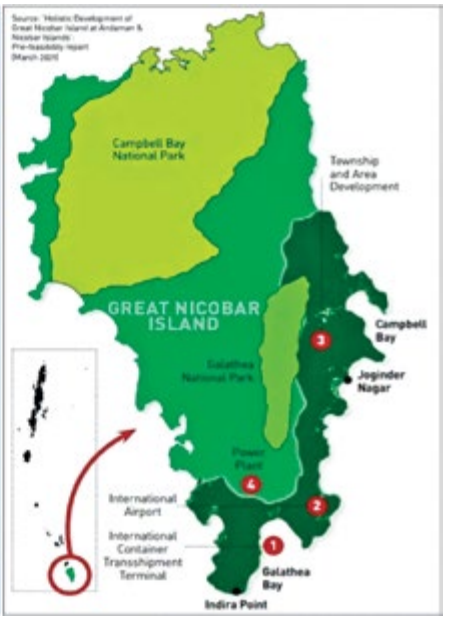


Plethora of new sensors and multi-purpose platforms will effectively improve surveillance of Sea Lines of Communication (SLOCs), help project maritime might through close monitoring and countering the presence of external powers and inimical forces in this part of the IOR. By developing infrastructure viz; airport, radars & communication stations and basing capabilities etc. close to Malacca, India will bolster its leverage in the Indo-Pacific thereby countering China's expanding port access and naval deployments in the region.

ECONOMIC SIGNIFICANCE

Based on high reliability and cost effectiveness, the project shall facilitate opportunities to handle cargo at our own ICTT, instead of Colombo, Singapore or Port Klang. Its positioning makes Great Nicobar a natural logistics and connectivity gateway between





KEY HIGHLIGHTS OF THE GREAT NICOBAR PROJECT

- **14.2 million TEU capacity International Container Transhipment Terminal (ICTT):** As Indian ports lack deep water berths for large ships, hence cargo is routed through Colombo and Singapore. India loses substantial revenue as a result. Countries like Myanmar, China and Sri Lanka are already building deep water facilities to capture this trade. In this context, the International Container Transhipment Port (ICTP) at Galathea Bay is being developed. This transhipment port forms a major infrastructure component of the overall Great Nicobar Project. The port has natural water depth of over 20 metres and its strategic location gives it an advantage to attract both gateway and transhipment cargo, and reduce India's dependence on foreign ports.
- **Greenfield International Airport (GIA):** Great Nicobar has world class ecological resources that can attract international and Indian tourists. This international airport will improve connectivity and open-up the island to tourism being close to other international tourist destinations like Senang City, Phuket and Langkawi Islands. Port Blair airport currently handles approximately 1.8 million passengers annually. GIA is expected to handle at least 1 million passengers, when it opens and grow to approximately 10 million passengers per year thereafter.
- **A 450 MVA gas and solar-based power plant:** Reliable power infrastructure is essential for the operation of the transhipment terminal, airport and associated urban infrastructure. Currently, diesel generating sets are the major source of energy in the Andaman & Nicobar Islands. The primary objective of a new Power Plant is to provide good quality, reliable electrical energy without interruptions. The gas and solar power plant system is designed to ensure continuity of power supply even if one primary component fails. Renewable energy sources will also be planned in the future. An uninterrupted energy supply is a key component in increasing the GDP of the island.
- **A new township spanning 16,610 hectares:** The planned township is intended to support the residential, commercial and institutional requirements arising from the port-led development of the island. It will provide essential urban infrastructure for personnel, service providers and associated economic activities, in line with the overall integrated development framework.
- **Three Phases of the Project:** The GNP covering a total area of 166.10 sq. km, which includes 35.35 sq. km of revenue land and 130.75 sq. km of forest land, is being developed in three phases. Phase I (2025-35, 72.12 sq. km), Phase II (2036-41, 45.27 sq. km) and Phase III (2042–47, 48.71 sq. km). This phased approach allows for systematic infrastructure development, with the underlying objectives of protecting the Island's indigenous communities and ecological resources, balancing environmental, social, and economic goals of India, by pursuing developmental efforts that are sustainable, inclusive, and aligned with national interests, besides expanding military & maritime arm in the Indo-Pacific and SE IOR in pursuance to India's maritime power projection ambitions and blue economy objectives.







South Asia and Southeast Asia, supporting trade, tourism, and digital connectivity (including undersea cable routes). Project shall shift the Andaman and Nicobar Islands from a remote outpost to a growth hub with modern amenities, employment opportunities and efficient goods and services industry.

IMPLICATIONS FOR CHINA

Beijing has long described dependence on Malacca Strait as a strategic vulnerability. A stronger Indian position at the western gate of that strait sharpens China's problem. Indian sensors and patrols closer to the Six Degree Channel will make it harder for the PLA Navy to treat the eastern Indian Ocean as a quiet transit zone. In a crisis, the Chinese planners would have to assume that movements through the Indonesian passages are observed much earlier and more continuously.

A denser Indian presence will complicate the PLAN's growing habit of easily operating West of Malacca. Nicobar shall offer QUAD partners a more useful Indian logistics node and reduce the value of Chinese commercial footholds in the Bay of Bengal and the Andaman Sea. China's likely responses could range from overland energy routes, deeper ties with Bay of Bengal partners, greater use of Sunda and Lombok straits, to diplomacy that frames the project as militarisation of a fragile ecology.

OVERALL IMPLICATIONS FOR INDIA

The Great Nicobar Project ties together defence, energy security (protecting oil routes) and trade competitiveness, giving India more control over critical maritime corridors and reducing vulnerability to external disruptions. The announcement of building Nicobar Island signals India's intent to be a major Indo-Pacific power with the infrastructure to back it up, not just rhetorically but through hard presence near one of the world's busiest shipping lanes.

In short, this project is significant because it simultaneously upgrades India's defence posture, captures high value transhipment traffic and anchors long-term economic and strategic influence in the eastern Indian Ocean and Southeast Asia.

Overall, the Great Nicobar Project is an example of how holistic development can balance economic growth, ecological conservation, and social inclusion. It leverages Great Nicobar's strategic location to strengthen India's national security, maritime and defence presence in the Indo-Pacific, while simultaneously embedding strong environmental safeguards and tribal welfare mechanisms.

The project will not only make India dominant in the Indo-Pacific but also indicate India's continued presence at a chokepoint that already shapes Chinese energy security and global trade. By committing to wildlife conservation, compensatory afforestation, disaster preparedness, and social inclusion, the government demonstrates that development need not come at the expense of the environment. Ultimately, the project represents a model for future large-scale infrastructure initiatives in ecologically sensitive regions to serve national and global interests.



–The writer is a former Indian Navy submarine officer and a specialist in missiles, underwater weapons, sensors and anti-submarine warfare. He is also a deep-sea diver and writes regularly on strategy, tactics, warfare and modern military technologies. He is an active member of national strategic think tanks, including the USI, the Chakra Foundation and STRIVE

NAVANTIA, L&T TO COLLABORATE FOR INDIA's LPD RACE, SIGN MOU

Navantia and Larsen & Toubro have signed a pact to offer a Spanish-derived design for India's four-ship amphibious programme, combining foreign design expertise with domestic construction ambitions

RA NEWS DESK

Spanish shipbuilder Navantia and Indian engineering major Larsen & Toubro (L&T) have agreed to collaborate on a proposal for the Indian Navy's planned four landing platform docks (LPDs), adding a new partnership to a high-value competition that has yet to reach contract award.

The memorandum of understanding was signed in Madrid on October 9. The companies said the arrangement would combine Navantia's experience designing and building naval vessels with L&T's engineering and shipbuilding capabilities, while supporting local capacity to construct large warships. It establishes a framework for collaboration; it is not a shipbuilding contract or confirmation that the companies have won the programme.

The proposed design would draw on Navantia's landing helicopter dock (LHD) family, which includes Spain's Juan Carlos I and Australia's Canberra and Adelaide. Navantia said the proven designs would provide the basis for its offering. The companies have not publicly disclosed a final configuration, price or construction schedule for an Indian version.

The difference in terminology reflects the programme's evolution. India calls the planned vessels LPDs, or landing platform docks, while the through-deck, helicopter-operating design described in the Navy's earlier requirements resembles an LHD. Such ships are intended to carry troops and equipment, operate helicopters and landing craft, and support amphibious operations from offshore.



Indian Navy issued a request for information in 2021 seeking proposals from domestic shipyards for four vessels. The requirement allowed Indian builders to work with overseas design or technology partners, but stipulated construction in India and a share of indigenous content. The initial information request described ships about 200 metres long, with a through flight deck and capacity for roughly 900 troops.

The government advanced the acquisition in October 2025, when the Defence Acquisition Council granted Acceptance of Necessity for LPD procurement. The council's announcement said the vessels would help the Navy conduct amphibious operations alongside the Army and Air Force, as well as peacekeeping and humanitarian assistance and disaster relief missions. That approval is a key acquisition step, but it does not itself select a design or place a construction order.

The Indian Navy's existing amphibious fleet underscores the operational need. It operates INS Jalashwa, a former US Navy landing platform dock, alongside landing ships and smaller landing craft. New ships would give the service greater capacity to move personnel and equipment, support operations ashore and provide a platform for helicopters and other capabilities.

Navantia and L&T are not alone in pursuing partnerships. Mazagon Dock Shipbuilders signed a teaming agreement with Swan Defence and Heavy Industries in October 2025 for the programme. Cochin Shipyard subsequently agreed to cooperate with South Korea's HD Hyundai Heavy Industries, which is to provide support in areas including planning, procurement, productivity and personnel training. The emerging field highlights the government's model: Indian yards lead construction, while foreign partners can contribute design and industrial expertise.

The latest pact also revives a Navantia-L&T pairing previously associated with the Indian requirement. Their new agreement formalises a collaboration around Navantia's ship-design experience and L&T's domestic manufacturing base. L&T executive Arun Ramchandani said the partnership could support maritime capability and greater autonomy in building complex platforms. Navantia executive Gonzalo Mateo-Guerrero said the company intended to support L&T, the Navy and other stakeholders across the ships' lifecycle.

The contest now moves beyond announcements and partnerships to the requirements, evaluation and procurement process. The Navy will need to assess competing offers against operational needs, cost, delivery schedules and the extent of indigenous participation. Until the government selects a design and signs a contract, the Navantia-L&T proposal remains an offer-not a confirmed fleet order.

BEYOND ASSEMBLY: INDIA's NEED FOR DRONE TECHNOLOGY SOVEREIGNTY

India's drone industry should be measured not only by how many aircraft we manufacture or deploy, but by how much of the underlying capability we can develop, test, manufacture and evolve ourselves. AKSI Aerospace Group follows this approach to technological sovereignty

PANKAJ AKULA

When we started building drones, we thought the hardest problems would come from engineering. We have learned that geopolitics can shape those problems too, influencing what we can access, build, and change. For us, it is not enough to build the aircraft in India. We need to build the capabilities that allow us to keep developing it, even when the world around us changes.

But the issue goes deeper than production numbers. The availability of a critical component can depend on decisions that have little to do with engineering. Export controls, sanctions, trade restrictions, and changing national-security priorities can determine whether a technology remains accessible. A component that is available today may not be available when an aircraft needs its next upgrade, replacement, or iteration.

That is where the experience of building aerospace systems changes the way self-reliance needs to be understood. The concern is not simply whether a component can be sourced. It is whether an engineer has the freedom to keep developing the aircraft when that source is no longer available.

For those of us working in aerospace, this is where the real question of self-reliance begins. It is not about eliminating every external dependency. It is about knowing which dependencies matter, understanding their consequences, and building enough capability at home to retain the freedom to act when circumstances change.

THE TECHNOLOGY BEHIND THE DRONE MATTERS

It is easy to look at a drone manufactured in India and assume that India controls the technology. But the aircraft tells only part of the story. The more important question is what sits underneath it.

Who controls the flight-control system? Who owns the software and firmware? Where does the navigation technology come from? How dependent is the aircraft on a particular propulsion system, battery, sensor, or communication module? And what happens if access to one of those technologies' changes?

These questions matter because India no longer needs to prove that drones have a place in the economy. We are already seeing wider deployment across agriculture, infrastructure, surveying, logistics, public safety and defence. The challenge now is whether the capability behind that growth is deep enough.

Export controls, sanctions, trade restrictions and changing national-security priorities determine whether a technology remains accessible. A component that is available today may not be available when an aircraft needs its next upgrade, replacement or iteration

A drone can carry an Indian manufacturer's name, come out of an Indian facility and still depend heavily on technologies developed elsewhere. We see the difference when a critical technology becomes unavailable. Replacing it is rarely as simple as finding another supplier. The new system has to work with the aircraft, meet its requirements, and go through integration, testing, and qualification.

BEYOND ASSEMBLY: BUILDING THE CRITICAL LAYER

That is why, from a manufacturing standpoint, local assembly and technology ownership cannot be treated as the same thing. Building the aircraft is one capability. Having the freedom to modify, sustain, and improve its critical systems is another.

India's defence policy has increasingly placed greater emphasis on indigenisation across the UAV and counter-UAS ecosystem, extending beyond the airframe to flight control, software, propulsion, batteries, communications and other critical subsystems.

We see the same need across the wider drone industry. India's ecosystem is expanding rapidly, but the specialised

capabilities supporting that growth need to deepen alongside it.

That means building strength across flight control, navigation, avionics, propulsion, batteries and BMS, communications, sensors, embedded electronics, software and advanced materials. If we build platforms faster than we build these capabilities, we risk creating scale without enough technological depth.

FROM COMPONENTS TO ENGINEERING CAPABILITY

This is where our work at AKSI Aerospace Group connects with the larger question of technological sovereignty. We have deliberately looked beyond the finished aircraft towards the capabilities that enable it. KKA Autopilot addresses flight control, LiHi Smart Batteries builds capability in energy storage and battery management, while our work in propulsion and composite manufacturing adds further depth to the aircraft architecture.

The objective is not simply to replace an imported component with an Indian one. It is to build the engineering capability to understand, modify, and evolve the system.

Aircraft, missions, and requirements change constantly. Payloads change. Endurance requirements change. Operating conditions change. Customers ask for new capabilities. The ability to respond depends on how much of the underlying system we control.

SOVEREIGNTY DOES NOT MEAN ISOLATION

That does not mean India needs to manufacture everything domestically. Technological sovereignty should not become technological isolation. Aerospace will continue to rely on global supply chains, international partnerships and specialised technologies from around the world. The question is which dependencies are too critical to leave entirely outside our control.

Manufacturing alone, however, is not enough. India also needs the R&D, testing, qualification and certification



KKA Autopilot addresses flight control, while LiHi Smart Batteries focuses on energy storage and battery management

infrastructure to turn indigenous technologies into dependable systems. Engineers need to be able to prototype, test, understand failures, modify designs and qualify the next iteration.

India is building this foundation, with growing attention to areas such as propulsion, batteries, inertial navigation, flight control, communications, cameras and sensors, alongside domestic testing capabilities for drones and their subsystems. These capabilities may attract less attention than a new aircraft, but they are what allow indigenous systems to mature.

The same applies to exports. When an international customer buys an Indian UAV, the relationship continues well beyond delivery. Spares, maintenance, software support, technical assistance and upgrades all depend on the manufacturer's ability to support the aircraft over its life. Technology ownership therefore has a commercial value as well as a strategic one.

THE REAL TEST OF SELF-RELIANCE

India's drone ambition should therefore be measured not only by how many aircraft we manufacture or deploy, but by how much of the underlying capability we can develop, test, manufacture and evolve ourselves.

AKSI is one example of this approach, but the requirement extends far beyond one company. India needs a wider network of capability centres across the UAV ecosystem, supported by research institutions, testing facilities, manufacturers, academia and users.

No country can control every geopolitical shift or guarantee that global supply chains will always remain open. What we can control is the depth of capability we build at home.

That is the real test of self-reliance: not whether we can manufacture a drone when every component remains readily available, but whether we can continue to develop, operate, repair, and improve it when they are not.

If we can do that, we will not simply be manufacturing drones in India. We will have built the capability to keep developing, sustaining, and improving them, whatever changes around us. That is the foundation of technological sovereignty.



–The writer is Group Managing Director, AKSI Aerospace Group

LOTHAL RISING: FROM HARAPPAN PORT TO NAVAL MUSEUM

Four thousand years ago, Lothal was a thriving port city on India's western coast. Today, this small archaeological site in Gujarat's Bhal region is being transformed into India's first National Maritime Heritage Complex that will showcase the country's maritime history from the Harappan era to the present day

CMDE RANJIT B RAI



Lothal is a small, deserted historical site 80 km southwest of Ahmedabad, set in the wilderness of the Bhal region of Gujarat and known as "The Cradle of Ancient Global Maritime Trade." The name comes from two Gujarati words: "Loth," meaning death, and "Thal," meaning mound. It is not far from its sister city, Mohenjo-daro—"Mount of the Dead" in Sindhi—in Pakistan.

Lothal and Mohenjo-daro represent the southernmost frontier of the Indus Valley Civilisation, or what is commonly called the Harappan culture, and are among the most significant archaeological wonders of the ancient world. The sea today is only 39 km from Lothal, and an airport at Dholera nearby has come up with good road connectivity across the region—something Gujarat is known for. Rail links are being planned, and two helipads have been set up.

Four thousand years ago—as proved by carbon dating—Lothal was a vibrant coastal city with a dry dock for trading vessels on the western coast of Cambay, in what is now Kutch. But Lothal was discovered only in 1954 by the legendary archaeologist Dr S R Rao, and the site was excavated between 1955 and 1960 under



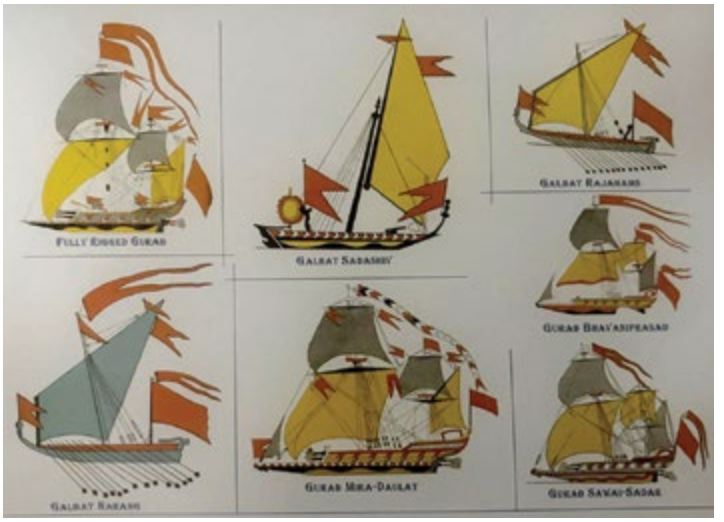
the auspices of the Archaeological Survey of India (ASI). The results show Lothal was an advanced, well-planned, prosperous tidal Harappan port city, directly connected to the Arabian Sea via river channels.

Over the last 4,000 years, tectonic shifts, siltation, and changing river courses caused the coastline to retreat. Lothal decayed, and its ruins still sit there—including a landlocked dry dock, now filled with water. Undoubtedly, under the high tides of the Arabian Sea, ocean-going vessels could navigate directly upstream









Lothal was a vibrant Harappan port city with a dry dock for trading vessels, providing access to the Arabian Sea. Carbon dating helps establish its antiquity, while tectonic shifts and siltation are believed to have contributed to its decline

with the incoming tides to drop anchor right outside the city walls of Lothal. The few excavated structures at Lothal have been preserved, marked for visitors and barricaded, and a small museum there displays many excavated objects. Only visiting the place can bring about the reality of ancient times.

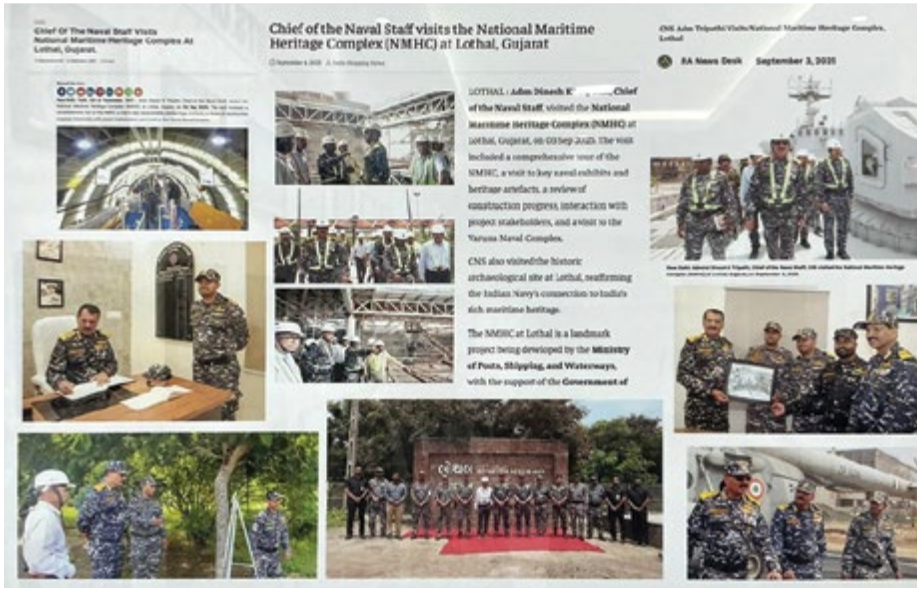
Prime Minister Narendra Modi, conscious of showcasing India's heritage to Indians and the world, resolved to make Indians proud of the country's rich cultural and religious heritage, and his choice rightly fell on Lothal—to build India's first-ever National Maritime Heritage Museum, demonstrating that Harappans had an unparalleled understanding of regional navigation, geography and the environmental physics of the Indus Valley to foster a civilisation.

The Gulf of Khambhat possesses one of the highest tidal ranges in the world. The National Maritime Heritage Complex (NMHC) in Gujarat is being built in six sections in phases over 400 acres and will display maritime history, glory and achievements from ancient times to the present day. It will include an Indian Naval Museum with merchant navy and lighthouse sections, featuring the tallest lighthouse in the world. These will be co-located with the National Maritime Research Institute under the Indian Maritime University and a Maritime Heritage Conservation Park with resorts, hotels and tourist attractions. The plots have been demarcated and sales have begun.

The masterplan was finalised in March 2019, and NMHC features 14 galleries and theme parks. The lead architect of the complex is the renowned Indian architecture firm of Hafeez Contractor, with key design contributions from senior architects like Karl Wadia and Apoorva






Chief of the Naval Staff visits the National Maritime Heritage Complex (NMHC) at Lothal, Gujarat



Sharma. The foundation stone was laid by PM Modi on 4 March 2019. The project is being built in phases under the Sagarmala scheme of the Ministry of Ports, Shipping and Waterways. The ancient cities of Lothal and Dholavira will be recreated in a small area of 25 acres with attractions for children. Tata Projects is building the prestigious project on an Engineering Procurement Construction (EPC) basis, ensuring precision in every step and promising a world-class heritage complex.

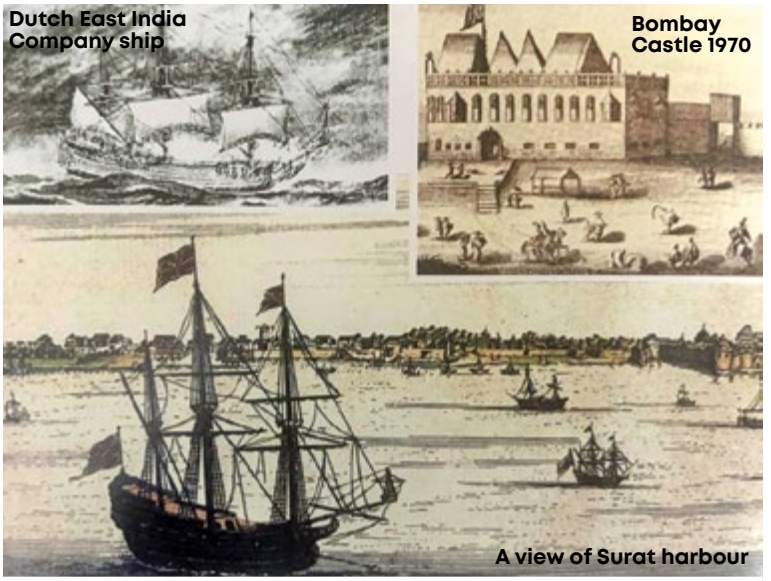
THE PROGRESS OF THE NATIONAL MARITIME HERITAGE COMPLEX

The Indian Navy and the Indian Coast Guard signed a Memorandum of Understanding (MoU) with the Indian Port Rail & Ropeway Corporation Ltd (IPRCL) on 2 July 2023 in Gandhinagar. The agreement focuses on developing a dedicated Naval gallery themed "Evolution of the Indian Navy & the Indian Coast Guard" at the NMHC in Lothal. The large main complex has already come up with an imposing entrance, a lake full of water, and many galleries with air-conditioning and conveniences.

The complex houses India's history and modern military displays and is progressing fast for an early soft opening in 2027. It features a large retired IL-38 Maritime Reconnaissance aircraft with







Spread over 400 acres, India's first National Maritime Heritage Complex will feature an Indian Naval Museum, a merchant navy gallery, the world's tallest lighthouse, a Maritime Heritage Conservation Park and collaborations with 13 countries



its signature umbrella radar, a No 608 Sea Harrier and weapons, missiles and torpedoes, and a cutaway of a submarine. INS Nashak (K87)—the 500-ton historic Osa-class fast attack missile boat of the Navy's 25th "Killer" Missile Boat Squadron, commissioned on 19 March 1971, and armed with Soviet-supplied P-15 Termit (SS-N-2 Styx) anti-ship cruise missiles—took part in the legendary attack role during the 1971 Indo-Pakistan War on 4 December (Operations Trident and Python), sinking and attacking Pakistani naval assets in Karachi. The 56-metre-long ship was broken at Mumbai into sections and re-welded to original with battle station firing positions by Shoft Shipyard Ltd.

This writer, having experience of running a Maritime Museum in Delhi, visited the site in early September and was impressed to see the Ministry of Ports, Shipping and Waterways and all implementing agencies, including Tata Projects, with engineers and architects wrapping up interior panels, mural work, ceiling fabrication, flooring, and testing air conditioning and escalators. A total of 1,492 distinct historical artefacts has already been prepared and readied for installation.

The project includes global collaborations and international alliances with 13 countries, including Portugal as the lead—offering support from the famous Lisbon Museum with details of Vasco da Gama's era to India's annexation of Goa in 1961—along with the UAE, Vietnam, Thailand, the Netherlands, Denmark, Oman, Israel, Germany, South Korea, Italy, New Zealand and Singapore, which have signed MoUs to collaborate on the project. The Dholera Expressway is fully complete, and a high-speed rail corridor plan has been finalised. The Government of Gujarat has completed major water, power and utility installations for the complex and for the Indian Port, Rail and Ropeway Corporation Limited. PM Modi personally visited NMHC on 20 September 2025 to review the project.



–The writer is a former DNI and DNO who curates a maritime museum at C-443, Defence Colony, New Delhi. He is the author of India's Elephant and China's Dragon Navy (ISBN: 978-93-49934-73-3)

DISTRIBUTED LETHALITY AT SEA: INDIA's PROPOSED MISSILE CATAMARAN

To secure vital maritime corridors across the Indo-Pacific, the Indian Navy is exploring distributed force structures. The proposed 60-metre, 500-tonne missile catamaran provides a flexible, cost-effective solution, combining high-speed mobility, modular containerised weapons, optionally manned autonomy and integrated drone operations to deliver massive firepower from a highly survivable, compact platform

RAHUL VATSYAYAN



Modern naval warfare is undergoing a fundamental structural shift. As India's economic growth, maritime trade and strategic imperatives grow increasingly dependent on secure Sea Lines of Communication across the Indian Ocean Region - spanning the Persian Gulf, Arabian Sea, Bay of Bengal and the broader Indo-Pacific - the demand for a versatile, survivable, and economically viable force structure has become paramount. Traditional capital ships like aircraft carriers, destroyers and frigates remain the foundational backbone of blue-water projection; however, hyper-velocity precision strike weapons and saturation tactics have made heavy reliance on a few concentrated, high-cost assets inherently risky.

To address these vulnerabilities, naval doctrines worldwide are embracing distributed lethality by dispersing offensive and defensive firepower across numerous smaller, networked and lower-cost platforms. The proposed 60-metre, 500-tonne missile catamaran embodies this modern philosophy, serving as a highly mobile, heavily armed maritime battery designed to complement India's existing fleet assets.

CONCEPT OVERVIEW AND DESIGN ARCHITECTURE

The proposed 500-tonne missile catamaran is engineered as a light combatant capable of delivering the strike volume of surface combatants multiple times its displacement. Built around a high-speed catamaran hull, the vessel leverages a wide beam to overcome the operational constraints that historically plagued traditional monohull missile boats, such as poor sea-keeping, restricted payload space, minimal endurance and inadequate self-defence.

In terms of technical specifications, the platform features an overall length of 60 metres, a beam of approximately 13.7 metres and a displacement of 500 tons. Driven by an efficient waterjet propulsion system, the twin-hull catamaran form allows the vessel to reach sustained speeds between 30 and 35 knots. It is multi-mission capable, serving in missile strike, air-defence, anti-submarine warfare and littoral or island defence roles. Crucially, the vessel accommodates up to four standard 40-foot ISO mission containers, features dedicated aviation facilities including a small unmanned aerial vehicle landing deck, hangar and maintenance workshop, and carries a shipboard 50-tonne Safe Working Load electro-hydraulic knuckle-boom crane mounted along its centreline.

The hydrodynamic selection of a catamaran hull rather than a conventional monohull offers major operational advantages. First, the wider beam offers superior transverse stability, which reduces vessel roll in moderate sea states and provides a steady baseline for launching supersonic missiles, operating high-gain radar sensors, and safely launching or recovering drones. Second, the structural architecture creates an expansive central deck footprint capable of housing the four ISO containers, mission workshops, drone support gear and the flight deck. Third, twin hulls distribute displacement to yield a shallow draft tailored for littoral zones, coastal archipelagos, shallow straits and strategic chokepoints like the Malacca Strait. Finally, its waterjet-driven high speed allows for rapid repositioning, fast strike sorties and immediate post-launch dispersal to evade counter-battery fire.



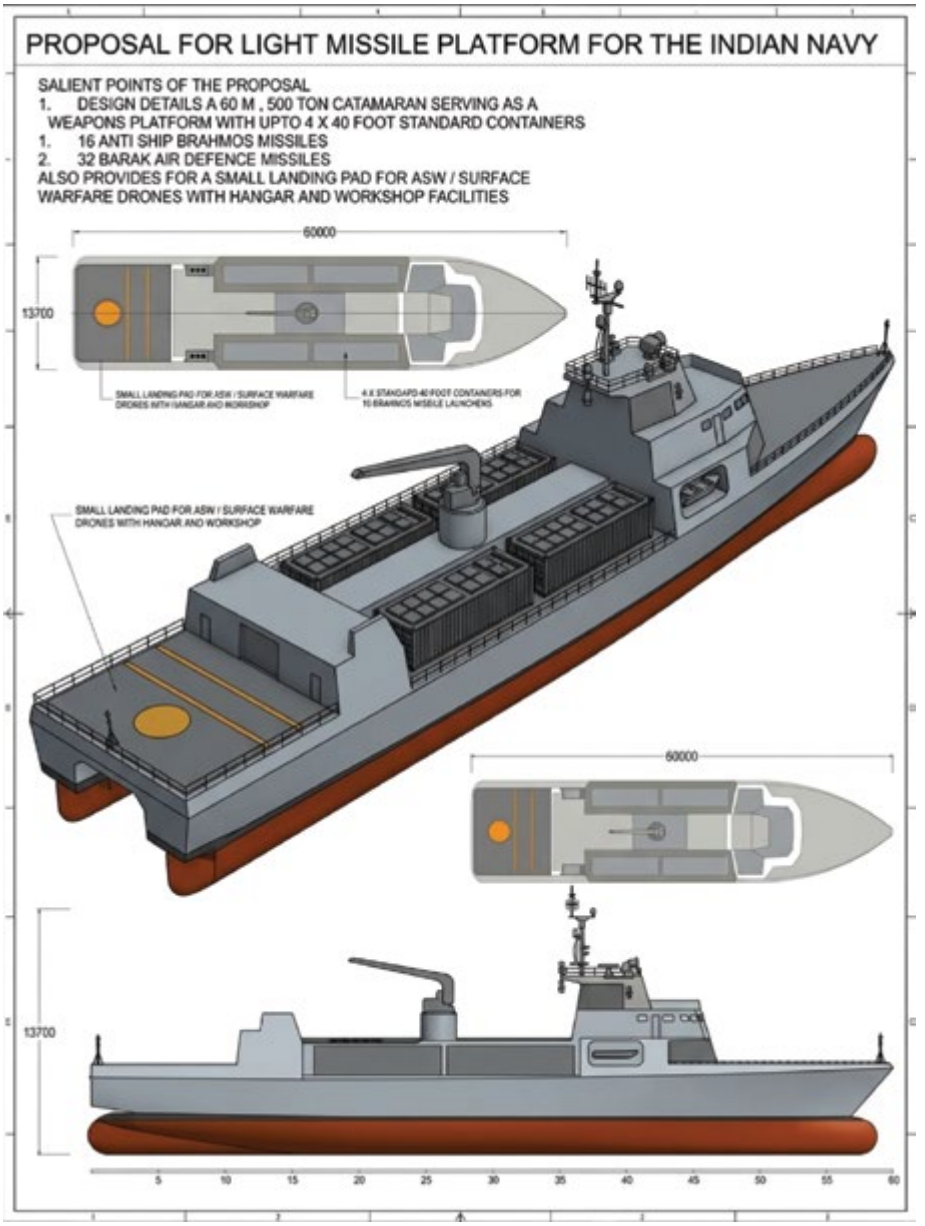
The proposed 60-metre, 500-tonne catamaran shifts the Indian Navy toward distributed lethality, delivering heavy combat capability without relying solely on large, expensive warships

FIREPOWER AND DISTRIBUTED LETHALITY

The primary combat power of the missile catamaran stems from its ability to carry dense weapon inventories within standardised, modular footprints. Through four 40-foot containerised mission modules, the ship can be tailored for heavy surface strike, air defence, or hybrid operations carrying electronic warfare equipment, loitering munitions or sonobuoys.

Configured as an offensive sea-going battery armed with 16 BrahMos supersonic anti-ship missiles, a single catamaran wields offensive firepower comparable to or exceeding that of a modern destroyer or frigate. The BrahMos missile's supersonic cruise speed, low reaction time, sea-skimming flight profile and land-attack capability present an extreme challenge to hostile anti-air networks. By distributing these missiles across small, low-cost hulls, the Indian Navy achieves high weapon counts without placing major fleet assets at risk. While a traditional destroyer carries 16 to 24 BrahMos missiles and a frigate carries 8 to 16, a small four-ship catamaran flotilla can deploy a combined total of 64 BrahMos missiles. This allows a catamaran squadron to launch a coordinated 64-missile saturation salvo from multiple vectors, overwhelming an adversary's combat systems through sheer volume and multi-axis arrival times.

Alternatively configured with 32 Barak air-defence missiles, the catamaran transitions into a fleet escort and point-defence platform. In high-threat environments, these interceptors shield the vessel and nearby commercial convoys from anti-ship cruise missiles, armed drones, maritime patrol aircraft and loitering munitions. When integrated into a major naval task group, these vessels act as auxiliary missile magazines at sea, absorbing defensive engagements and preserving the vertical launch system cells of primary capital ships.



Despite its light 500-tonne displacement, the platform packs dense firepower by housing up to 16 BrahMos supersonic anti-ship missiles or 32 Barak air-defence missiles in modular containers

MODULARITY AND UNMANNED SYSTEMS INTEGRATION

The platform departs from rigid structural design by utilising standard ISO container infrastructure. This modular design lowers acquisition costs, simplifies supply chains and accelerates modernisations. Standardised containerisation allows rapid reconfiguration, enabling vessels to switch roles between anti-surface strike, electronic warfare, loitering munition deployment, or anti-submarine warfare in hours simply by swapping out modules.

It also simplifies logistics, as missile modules can be stored, maintained, and fully certified inside secure ashore bunkers before being mounted onto the deck. Furthermore, the open container deck provides a future growth margin that can accommodate emerging naval technology, including directed-energy weapons, autonomous surface vessel control stations, and swarm-drone launch systems, eliminating the need for mid-life structural hull refits.

Equipped with an aft landing pad, fully enclosed hangar, and maintenance workshop, the catamaran supports unmanned systems across multiple combat domains. Airborne reconnaissance drones flying 100 to 150 kilometres ahead extend the ship's sensor horizon for intelligence gathering and over-the-horizon targeting, identifying targets and relaying mid-course guidance updates to in-flight missiles.

For anti-submarine warfare, specialised drones can deploy sonobuoy fields, perform acoustic processing, and transmit submarine tracking data back to the task group. Surface and electronic warfare drones function as decoys, signal relay nodes and precision strike platforms to enable effective manned-unmanned teaming in high-risk zones. Additionally, the vessel features optionally manned capability: during routine peacetime patrols, it operates with a reduced core crew, but in high-threat scenarios, it can transition to remotely supervised autonomous modes to eliminate risks to personnel.

FORWARD LOGISTICS CONCEPT: RELOAD OPERATIONS AT CAMPBELL BAY

A major operational highlight of the concept is its capacity for rapid forward rearming away from major mainland naval bases. Situated on Great Nicobar Island directly adjacent to the Malacca Strait's western entrance, Campbell Bay provides an ideal forward operating node for monitoring critical maritime choke points. Operating from this hub, catamarans utilise

container replacement instead of slow, crane-sensitive individual missile hoists, drastically slashing turnaround times.

To remain fully independent of shore-based heavy-lift cranes, the catamaran features a centreline 50-tonne Safe Working Load electro-hydraulic knuckle-boom crane positioned between the bridge and container deck. This crane weighs between 18 and 25 tonnes, offers a maximum lift capacity that easily exceeds the 30-tonne maximum weight of a fully loaded ISO container, provides an outreach range of 3 to 22 metres to reach both port and starboard container locks, and features 360-degree continuous slewing with full container transfer capability in conditions up to Sea State 3.

Using either the onboard crane or port equipment, replacing all four mission containers requires minimal downtime. The process per container includes ten minutes for rigging and hook-up, ten minutes for lifting and transfer to the pier or barge, ten minutes for positioning the replacement module, and fifteen minutes for coupling data and power buses, equating to roughly 45 minutes per container. A full offload and onload cycle for all four containers takes approximately three hours, followed by one to two hours of combat system diagnostic verifications. This yields a total turnaround time of five to seven hours, which can be compressed to four to six hours during emergency wartime protocols while fuel replenishment, drone servicing, stores loading and crew rotations occur concurrently.

OPERATIONAL DEPLOYMENTS AND STRATEGIC ROLES

The versatility of the missile catamaran supports a wide variety of operational missions across regional waters. In coastal defence roles near Mumbai, Kochi, Visakhapatnam or Port Blair, catamarans function as mobile coastal missile batteries that quickly shift positions to prevent adversaries from establishing naval dominance near key harbours. For island territory defence in the

Equipped with a dedicated landing pad, hangar and workshop, the optionally manned vessel deploys air and surface drones to extend its sensor horizon and execute over-the-horizon targeting

Andaman and Nicobar or Lakshadweep archipelagos, these ships create dense sea-denial umbrellas across critical maritime choke points.

During sea-denial operations, catamarans utilise hit-and-run tactics, low radar cross-section profiles, and drone-relayed targeting to lay in wait near coastal islands and execute surprise missile attacks against high-value enemy formations. Additionally, when equipped with Barak air-defence modules and drones, catamarans execute escort missions to protect replenishment ships, amphibious landing docks, and commercial merchant convoys from air threats without forcing the navy to detach primary destroyers. Serving as networked force multipliers, these vessels link satellites, submarines, aircraft and shore bases to expand overall missile counts at a fraction of traditional fleet costs.

OPERATIONAL CHALLENGES AND MITIGATION STRATEGIES

While offering clear advantages in firepower and economics, the 500-tonne design presents operational constraints that require specific countermeasures. Regarding survivability, a 500-ton hull cannot absorb direct anti-ship missile hits like a heavy surface combatant; therefore, its defence relies on high speed, active electronic warfare jammers, soft-kill decoys, point-defence missiles and signatures lowered by stealth shaping.

Environmental limitations also pose a challenge, as severe Indian Ocean monsoon sea states can impair drone handling, missile reloads and crew stamina. To offset this, advanced active motion-damping systems and automated container-latching rigs are integrated to mitigate rough seas. Finally, compact hulls cannot carry massive, long-range radar arrays to overcome sensor horizon limits. To maximise the range of its 16 BrahMos missiles, the vessel relies on network-centric warfare, fusing real-time targeting feeds from satellites, P-8I Poseidon maritime patrol aircraft, submarines, ashore radar grids and offboard drones.

STRATEGIC VISION: THE FUTURE DISTRIBUTED FLEET

The 60-metre, 500-tonne missile catamaran provides the Indian Navy with an innovative approach to expanding its combat power across the Indian Ocean Region. For the procurement cost of a single guided-missile destroyer, the navy could acquire and deploy a large, dispersed squadron of these platforms. By combining the heavy strike capabilities of BrahMos and Barak missiles with modular container architecture, high-speed catamaran hulls, autonomous operations, and organic drone support, this concept offers an effective, resilient and adaptable force structure. As modern naval engagements shift toward networked operations, autonomous systems and distributed lethality, these missile catamarans ensure the Indian Navy maintains persistent maritime presence, robust sea denial and credible deterrence across its key strategic waters.



—The writer is an architect by profession, with 37 years of experience working with leading corporates in India's real estate industry. However, his passion is naval matters, likely due to his family ties with the Indian Navy. He has been drawing warships since the age of 12 and has long followed warship design in the Indian Navy. Recently, he completed a study on the design of new Mine Countermeasure Vessels (MCMVs) using modular design technology, which is both cost-effective and time-effective

AIM TO IMPACT: SIX FACTORS THAT INFLUENCE SHOOTING ACCURACY

Continuing the 'Biting the Silver Bullet' series, the writer in this article explores the key factors that influence the accuracy and performance of ammunition

SANJAY SONI



Several factors influence the accuracy and performance of ammunition:

1. Grain Weight of the bullet
2. Case design and material
3. Type of firearm being used
4. Type of ammunition being used
5. Weather Conditions
6. Tolerances That Affect Ammunition and Rifle Performance

Let us take a look at each of these to understand how they affect the accuracy of your shots.

HOW GRAIN AFFECTS ACCURACY AND PERFORMANCE IN AMMUNITION

When it comes to ammunition, the weight of the bullet is a crucial factor that affects its accuracy and performance. Measured in grains, the weight of a bullet can determine its velocity, trajectory, and terminal ballistics, making it a significant factor in the overall performance of a firearm.

In this section, we will explore how grain affects accuracy and performance in ammunition.

a. Velocity

The weight of a bullet can affect its velocity, as lighter bullets tend to travel faster than heavier ones. However, higher velocity can also result in a less stable trajectory, making it more difficult to hit the target accurately.

On the other hand, heavier bullets tend to have lower velocity but a more stable trajectory, making them a better option for long-range shooting. Ultimately, the velocity of a bullet must be balanced with its weight to achieve optimal accuracy and performance.

b. Trajectory

The weight of a bullet can also affect its trajectory, which is the path it takes from the barrel of the firearm to the target. A heavier bullet will typically have a flatter trajectory, meaning it will maintain its trajectory for a longer distance before dropping. This can be beneficial for long-range shooting.

A lighter bullet may have a more curved trajectory, making it a better option for shooting at shorter distances. The trajectory of a bullet must be considered when selecting the appropriate grain weight for a particular firearm.

c. Terminal Ballistics

The weight of a bullet can also affect its terminal ballistics, which is the behaviour of the bullet upon impact.



The weight of the bullet is a crucial factor that affects its accuracy and performance. Measured in grains, the weight of a bullet can determine its velocity, trajectory, and terminal ballistics, making it a significant factor in the overall performance of a firearm

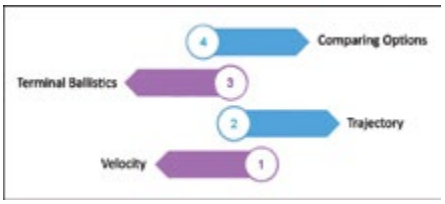
Heavier bullets tend to have more kinetic energy upon impact, resulting in greater transfer of energy to the target. This can be beneficial for hunting or self-defence, as it increases the likelihood of stopping the target.

Conversely, a lighter bullet may penetrate the target more deeply, resulting in a higher likelihood of hitting vital organs. The terminal ballistics of a bullet must be considered when selecting the appropriate grain weight for a particular situation.

d. Comparing Options

When selecting the appropriate grain weight for a firearm, it is important to consider the intended use of the ammunition. For example, a heavier bullet may be a better option for long-range shooting, while a lighter bullet may be more suitable for self-defence situations. It is also important to consider the firearm itself, as some firearms may be better suited for certain grain weights.

Ultimately, the grain weight of a bullet must be balanced with other factors, such as velocity, trajectory, and terminal ballistics, to achieve optimal accuracy and performance.



How grain affects accuracy and performance in ammunition

THE IMPACT OF BULLET CASE DESIGN ON ACCURACY AND PERFORMANCE

Bullet case design is an essential aspect of ammunition production that is often overlooked.

The design of the case has a significant impact on the accuracy and performance of the bullet. In this section, we will explore the factors that affect the design of bullet cases and their impact on accuracy and performance.

a. Case Length

The length of the case plays a crucial role in determining the accuracy of the bullet. A shorter case results in a smaller powder capacity, which can lead to a decrease in velocity and accuracy. On the other hand, a longer case can increase the powder capacity, resulting in higher velocity and accuracy.

However, longer cases may not fit in some firearms, and reloading longer cases requires special dies.

b. Case Wall Thickness

The thickness of the case wall affects the strength and durability of the case. A thicker case wall can withstand higher pressure, resulting in higher velocity and accuracy.

However, thicker case walls increase the weight of the cartridge, which can affect the trajectory of the bullet. Thinner case walls reduce the weight of the cartridge, resulting in a flatter trajectory, but they are not as durable and can deform under high pressure.



c. Case Material

The material used to make the case affects its strength, durability, and weight.

Brass is the most common material used for bullet cases due to its strength, durability, and ability to expand and contract during firing. Steel cases are cheaper but not as durable or malleable as brass. Aluminium cases are

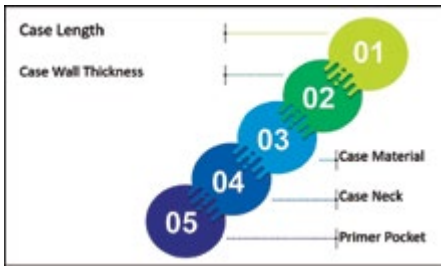
lightweight but not as strong or durable as brass or steel.

d. Case Neck

The neck of the case holds the bullet in place and affects the amount of tension applied to the bullet. A tighter neck provides more tension, resulting in better accuracy, but it can also increase pressure. A looser neck reduces pressure but can result in decreased accuracy.

e. Primer Pocket

The primer pocket holds the primer in place and affects the ignition of the powder. A tight primer pocket can result in more consistent ignition, resulting in better accuracy.



The Impact of Bullet Case Design on Accuracy and Performance

A loose primer pocket can cause misfires or inconsistent ignition, resulting in decreased accuracy.

Overall, the best bullet case design depends on the specific application and firearm. For example, a hunter may prefer a lighter weight cartridge with a flatter trajectory, while a long-range shooter may prefer a heavier cartridge with higher velocity and accuracy.

It is essential to consider all these factors when selecting the best bullet case design for your specific needs.

TYPE OF FIREARM BEING USED

Different firearms have different levels of accuracy and shooting speed. From the calculated precision of a sniper rifle to the rapid response of a handgun, each type of firearm serves a unique purpose.

Sniper rifles and their ammunition are engineered for long-distance engagements. In stark contrast, handguns

When selecting the appropriate grain weight for a firearm, it is important to consider the intended use of the ammunition. For example, a heavier bullet may be a better option for long-range shooting, while a lighter bullet may be more suitable for self-defence situations. Besides, some firearms may be better suited for certain grain weights

are optimised for close-quarters combat efficiency. Designed for swift draw times and rapid-fire capabilities, these compact firearms excel in situations where speed is paramount.

Whether navigating tight urban environments or engaging in sudden, unexpected confrontations, a well-trained individual with a handgun can quickly neutralise threats with precise close-range shots. The compact nature of handguns allows for easy manoeuvrability, making them a preferred choice for those anticipating dynamic, fast-paced encounters where split-second decisions can mean the difference between life and death.

TYPE OF AMMUNITION BEING USED

The type of ammunition being used can also play a role in bullet speed and accuracy. Each type of ammunition serves a specific purpose, whether it be for target shooting, self-defence, hunting, or military applications. Understanding their differences is crucial for firearm users to make informed decisions based on their circumstances and needs.

a. Full Metal Jacket ammunition (FMJ) is often favoured for military applications due to its reliability and ability to pierce body armour. These rounds feature a soft lead core encased in a harder metal, such as copper or steel. However, they are less effective at expanding rapidly upon impact, making them less ideal for hunting or self-defence.

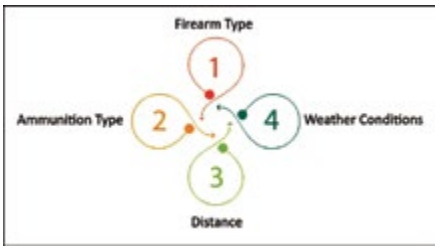
b. Hollow Point (HP) ammunition is designed for maximum stopping power. These rounds have a hollow cavity at the tip, which allows them to expand upon impact. When the bullet strikes a target, the hollow point mushrooms outward, creating a larger wound channel and transferring more energy to the target. This design makes HP rounds highly effective for self-defence and hunting, as they are more likely to incapacitate a threat or take down game animals quickly. However, they are typically more expensive than FMJ rounds and may not feed as reliably in some firearms.

c. Unlike the bullets used in handguns and rifles, shotgun ammunition comes in the form of shells. Shotgun shells contain multiple pellets, also known as shot, or a single slug. Shotguns are versatile firearms, capable of firing a variety of loads depending on the intended use. Birdshot, which consists of numerous small pellets, is commonly used for hunting birds and small game. Buckshot, larger pellets designed for increased stopping power, is favoured for self-defence and hunting larger game. Slug rounds, on the other hand, are solid projectiles used for hunting big game at closer range or in situations where greater penetration is needed.

WEATHER CONDITIONS

Weather conditions such as wind, rain, and humidity can also affect bullet speed and accuracy. Wind can cause the bullet to veer off course, while rain and humidity can affect the bullet's trajectory. These factors are often unpredictable.

To illustrate, let's take the example of a person who is trying to dodge



Factors that affect bullet speed and accuracy

bullets in an open field. If the shooter is using a sniper rifle from a distance, the target may have more time to react and dodge the bullet. However, if the shooter is using a handgun from a close range, the target may have less time to react and dodge the bullet. Additionally, if the weather conditions are windy, the bullet may be more likely to veer off course, making it even more difficult to dodge.

The distance between the shooter and the target can greatly affect bullet speed and accuracy. At long distances, the bullet is more likely to lose velocity and accuracy due to weather conditions, making it easier to dodge. On the other hand, if the shooter is too close, the target may have less time to react and dodge the bullet.

When it comes to long-range shooting, one of the most challenging aspects is mastering wind calls. The wind is a formidable adversary that can significantly affect the trajectory of a bullet, making it crucial for precision shooters to understand and account for its influence.

Let's delve into the various factors that come into play when dealing with wind calls, exploring different perspectives and providing in-depth information to help shooters hit their mark with confidence.

a. Wind Speed and Direction

Wind speed and direction are the fundamental factors that determine how much the wind will impact a bullet's flight path. Understanding the wind's velocity and angle is essential for accurate wind calls. Shooters must assess the wind at various distances between themselves and the target, as the wind can vary in intensity and direction at different points along the bullet's trajectory. An experienced shooter knows that even a slight change in wind speed or direction can lead to significant deviations in bullet impact.

For instance, let's consider a scenario where a shooter is engaging a target 1000 yards away. At the shooter's position, the wind might be blowing at 10 mph from the left. However, halfway to the target, the wind could be gusting at 15 mph from the right. Such variations require the shooter to make precise adjustments to compensate for the changing wind conditions.

b. Wind Angle

The angle at which the wind is blowing relative to the bullet's flight path plays a vital role in determining the amount of drift the bullet will experience. Headwinds and tailwinds have different effects on bullet trajectory compared to crosswinds.

A headwind slows down the bullet, causing it to drop more rapidly, while a tailwind has the opposite effect, increasing the bullet's velocity and reducing the amount of drop. Crosswinds, on the other hand, push the bullet sideways, causing it to drift off course.

The length of the bullet case plays a key role in determining the accuracy of the bullet. A shorter case results in a smaller powder capacity, which can lead to a decrease in velocity and accuracy. On the other hand, a longer case can increase the powder capacity, resulting in higher velocity and accuracy

Imagine a shooter aiming at a target with a crosswind blowing from left to right. The shooter must compensate by holding slightly into the wind, adjusting their aim to counteract the lateral drift caused by the crosswind. Failing to account for wind angle can result in missed shots and frustration.

c. Wind Mirage

Wind mirage is the visual distortion caused by varying air densities along the bullet's path. This can make it challenging to accurately gauge the wind's effects on the bullet's trajectory. Shooters often use mirage patterns to estimate wind speed and direction. By observing how the mirage moves or shimmers, experienced shooters can make more informed wind calls.

For example, a skilled shooter might notice that the mirage appears to be moving slowly from left to right, indicating a light breeze blowing in that direction. By using this information in conjunction with other factors, such as wind flags or vegetation movement, the shooter can refine their wind call and make adjustments accordingly.

d. Terrain Effects

The terrain over which the bullet travels can significantly influence wind patterns and, consequently, the bullet's trajectory. Features such as hills, valleys, buildings, or dense foliage can create wind tunnels or cause turbulence, altering the wind's behaviour. These terrain effects can be particularly challenging for long-range shooters, as they introduce unpredictable variables into the equation.

Let's consider a scenario where a shooter is positioned on top of a hill, engaging a target downhill. As the wind hits the slope, it may rise or fall, creating an upward or downward draft that affects the bullet's flight path. In such cases, shooters must carefully analyse the terrain to make accurate wind calls.

Mastering wind calls is a skill

that takes time, practice, and a deep understanding of the various factors that affect bullet trajectory. By considering wind speed and direction, wind angle, wind mirage, and terrain effects, long-range shooters can make more precise adjustments to compensate for the wind's influence.

Through experience and observation, shooters can develop a keen sense of wind calls, enabling them to consistently hit their mark at extended distances.

TOLERANCES THAT AFFECT AMMUNITION AND RIFLE PERFORMANCE

The rifle with a barrel shorter than 24 inches will shoot slower than a factory load advertises.



The rifle with a barrel shorter than 24 inches will shoot slower than a factory load advertises

As we explore both ammunition and firearms mass production techniques and tolerances, we need to understand that when millions of anything are being manufactured, it is impossible to make them all the same. That's why there are tolerance ranges around a specification or standard.

Imagine you set a velocity standard of 2,600 feet per second (fps). Because of the variables involved, you have to allow a tolerance of +/- 30 fps. The manufacturer will test samples before loading this ammunition. If rounds test between 2,570 and 2,630 fps, that would be considered acceptable.

The same applies to the groove dimensions of a barrel. If the minimum-allowable diameter is .3080 inch, then the manufacturer has to allow some tolerances that they can maintain

The best bullet case design depends on the specific application and firearm. For example, a hunter may prefer a lighter-weight cartridge with a flatter trajectory, while a long-range shooter may prefer a heavier cartridge with higher velocity and accuracy

in production, say .3095 inch. Any barrel's groove diameter that measures from .3080 to .3095 inch would be considered acceptable.

The ammunition and the firearm are a system. One affects the other and vice versa. There are certainly manufacturing tolerances in ammunition that affect performance. There are also a number of dimensional tolerances in firearms that have a significant impact on the ammunition performance.

Let's start by examining production issues that can occur with ammunition.

ESTABLISHING STANDARDS

Ammunition manufacturers go to extreme lengths to control variables when testing ammunition. This effort dates back to 1926, when the Sporting Arms Ammunition Manufacturers Institute (SAAMI) was established by ammunition and firearms companies to establish and maintain production standards and specifications for ammunition.



SAAMI has established test-barrel dimensions and chambers with extremely tight tolerances. Test barrels are meticulously measured and calibrated with reference ammunition to ensure that testing equipment produces consistent results across the entire industry. If a barrel does not conform to the dimensional specifications or does not produce the desired performance with reference ammunition, it is discarded. Test barrels are retested with reference ammunition at regular intervals, and if they are not within the performance specifications, they are removed from service.

As an example of how a very simple thing can affect ammunition performance, let's look at barrel length. The test barrel length for virtually all SAAMI-standardised rifle cartridges, and the barrel length used for advertising rifle ammunition, is 24 inches.

Would you expect the Browning X-Bolt Micro with a 20-inch barrel to produce the same velocity as the 26-inch barrel on the X-Bolt Hell's Canyon Long Range of the same caliber? A rifle with a barrel that is shorter than 24 inches will shoot slower than advertised with factory ammunition.

CARTRIDGE	APPROXIMATE VELOCITY CHANGE (FPS)
.223 Remington	15
.308 Winchester	15-20
.30-'06 Springfield	20-25
.300 Winchester Magnum	30-35

The approximate velocity change for each 1 inch of barrel length for several different cartridges

Manufacturers test ammunition at regular intervals to ensure performance is held as close to these specs as possible.

a. Ammunition Variables

Ammunition manufacturing involves many variables. Projectile diameter can vary by several tenths of a thousandth over a production run of millions of projectiles. Cartridge case capacity, dimensions, and hardness can also vary slightly over production runs of millions of pieces.

Consider the SAAMI drawing for the .308 Winchester, for example. SAAMI drawings always show the dimensions for a cartridge with a maximum dimension with a minus tolerance and a minimum dimension chamber with a plus tolerance. You can see that the cartridge dimensions can have fairly large differences and still be an in-spec cartridge.

Of course, whenever these dimensions vary, the performance will differ slightly.

Propellant performance can also vary from container to container. Keep in mind that propellant is also mass produced at tens of thousands of pounds at a time, but can only be blended into the final product several thousand pounds at a time. The performance across an entire lot of propellant invariably varies a little.

Expect a 30-to-50 fps variation in ammunition because of the variables mentioned above. Manufacturers do their best to control these variables and adjust for them during a production run. If the goal was to load every cartridge to the same performance, little would be produced, and no one could afford to purchase it. This is where handloading comes in.

Ammunition manufacturers deal with these issues by establishing performance specifications and tolerances on velocity and pressure for production loading ammunition. They will test at regular intervals to ensure that the ammunition performs within this tolerance range. At any test firing, if ammunition does not perform within the tolerance range, adjustments will be made.

Full Metal Jacket ammunition (FMJ) is often favoured for military applications due to its reliability and ability to pierce body armour. These rounds feature a soft lead core encased in a harder metal, such as copper or steel. However, they are less effective at expanding rapidly upon impact, making them less ideal for hunting or self-defence

So, what are these tolerances?

SAAMI allows a +/- 90 fps tolerance range on rifle ammunition velocities from the standard published velocity. This is a pretty significant range and leads us into tolerance ranges that manufacturers use.

If you are purchasing low-cost ammunition, a manufacturer will generally use most of the SAAMI +/- 90 fps velocity tolerance. It allows them to test less and keep the production machine running longer before stopping for adjustments. This lowers the cost.

At the other end of the spectrum, if you purchase high-cost, premium ammunition, the manufacturer will generally have a much tighter tolerance range on performance to justify the higher cost and higher-performance expectation. Velocity tolerances on premium or match-grade ammo are usually in the +/- 20 to 40 fps velocity range.

Remember, the ammunition could still be 20 fps slower than the advertised velocity, and it could also be 20 fps above the advertised velocity. As I said, nothing can be mass produced by the millions to be exactly the same.

b. Firearms and Variance

Just like ammunition, it is virtually impossible to mass-produce firearms that are all exactly the same and have exactly the same dimensions. As with ammunition, firearm manufacturers have dimensional tolerance ranges that are used during production.

Raw materials can vary slightly from lot to lot. Tooling wear, such as wear on a chamber reamer or rifling tooling, is a big issue for barrel manufacturers. Lathe or mill accuracy and repeatability must all be considered. These issues force manufacturers to establish a tolerance range for virtually any dimension on a firearm.

BORE AND GROOVE DIMENSIONS

There are two sets of dimensional tolerances in firearms that have a significant effect on ammunition performance. The first is bore and groove dimensions. Ammunition manufacturers religiously use the SAAMI minimum dimensions for safety and uniformity. A firearms or barrel mass producer cannot economically produce barrels that are all made to the absolute minimum bore and groove dimensions. The costs to manufacture and gauge barrels to these minimum dimensions would be astronomical.

This is not to say that mass-produced barrels are of poor quality or even sloppy. With recent advancements in machine and production processes, the tolerance on bore and groove dimensions is considerably tighter than 25 years ago. Hammer forging of barrels has been a major factor in improving the dimensional quality of mass-produced barrels.

Groove Diameter	.2640	2.2625
Pressure (psi)	58,500	75,500
Velocity (fps)	2,690	2,810

Data from the under-size groove test barrel

BITING THE SILVER BULLET



Typical bore and groove dimension tolerances in mass-produced barrels are about +.001 to .0015 inch above minimum.

Large grooves can allow the projectile to tilt or yaw in the bore. This yaw will be present when the projectile exits the barrel, which degrades a projectile's accuracy.

This phenomenon works in the opposite direction, too. Groove dimensions larger than the minimum dimension cause pressure and velocity decreases.

OTHER TOLERANCES

The other dimensional tolerances in a firearm that can have a large effect on ammunition and rifle performance are the chamber reamer and, consequently, chamber dimensions.

If you consider the SAAMI .308 Winchester drawing, you will see that the chamber dimension tolerances are pretty generous: +.002 inch on diameters and .015 inch on lengths. Firearms manufacturers will use reamers near the maximum dimensions on a new reamer to extend the life of the reamer and reduce production costs. This way, as the reamer wears and gets dull, they can sharpen it several times and get more life out of the tool and reduce production costs.

Ammunition manufacturers go to extreme lengths to control variables when testing ammunition. This practice dates back to 1926, when the Sporting Arms and Ammunition Manufacturers Institute (SAAMI) was established by ammunition and firearms companies to establish and maintain production standards and specifications for ammunition

If you get a rifle that is near the maximum of the reamer/chamber dimensions, the chamber and throat are going to be rather big. This causes energy loss, swelling of the case, gas blow-by around the projectile, increased jump to the rifling and a loss in pressure and velocity.

Gas-operated semi-automatic firearms can also cause small losses in ammunition performance. Some of the gas that would otherwise be pushing the projectile is bled off to operate the action.

Revolvers present a whole different set of dimensional tolerance challenges that affect performance. The forcing cone dimensions can allow gas to escape around the bullet. Cylinder gap variations can cause fluctuations in gas lost out of the gap. Small differences in these dimensions can have a significant effect on the performance ammunition will produce.

Hopefully, after reading this, you will have an appreciation for the many things that affect firearms and ammunition performance in combination. The next time you want to dispute marketing and sales numbers as inaccurate, remember the factors that can affect those nominal specifications.

To all of us who choke when looking at custom gun prices, remember to stop and think why such guns cost so much. Generally, when you buy a custom-made firearm, you are paying for the extra effort to control all the variables discussed above to a much higher level than can be done in mass production.



–The writer is the Managing Director of Hughes Precision Manufacturing Pvt Ltd, India's first small-calibre manufacturer in the private sector. An MBA from the Indian Institute of Management (IIM), Bangalore, he has been involved in the ammunition industry in India and abroad for more than a decade

India's JWALA Micro-Missile Completes Solid Rocket Motor Test

Indian defence start-up IG Defence has test-fired two solid rocket motors under its JWALA micro-missile programme, according to a company statement. The test was successfully conducted at approximately 04:00 Hours, advancing JWALA towards its objective of providing a cost-effective interceptor capability against hostile drones.

JWALA is India's first indigenously developed private micro-missile programme, focused on creating a robust, affordable and scalable hard-kill Counter-UAS system to neutralise drones.

The company calls it a significant step toward a hard-kill counter-unmanned aerial system (C-UAS) built entirely in India. Hard-kill systems physically destroy a drone, unlike jamming or spoofing. The test details come from IG Defence's own announcement, and no independent performance data has been released.



FROM UNVEILING TO HARDWARE

IG Defence, an Odisha-based start-up, first showed JWALA publicly at the North Tech Symposium in Prayagraj in May 2026. The system was presented as a privately developed short-range surface-to-air and surface-to-surface missile, alongside the KAL long-range one-way attack drone. The company says it uses a solid-fuel dual-pulse rocket motor, which gives rapid acceleration at launch and extra speed in the final attack phase. That configuration was shown with a larger warhead and a stated reaction time of about 15 seconds.

The company's counter-drone push has since sharpened. In September, IG Defence showed its Jwala-MK1 short-range surface-to-air concept to Indian Air Force officials at Dronathon 2026. The company says it is designed mainly to engage UAVs, with an engagement range of 2-5 km and an altitude envelope from 50 metres to 5,000 metres.

IG Defence also claims a launch reaction time under seven seconds, a circular error probable below 2 metres at maximum range, and a small 0.5-1.5 kg pre-fragmented warhead with a proximity fuse. The planned launcher is a truck-mounted multi-canister unit that can be fitted to 4x4 transporters used by the Army and Air Force.

GRID DEFEND: AI-POWERED MISSION MANAGEMENT

JWALA is being developed as part of IG Defence's broader GRID ecosystem, its AI-powered Battle Management System designed to connect sensors, effectors and command systems.

GRID Defend is designed to enable an integrated Counter-UAS response by bringing together detection, identification, tracking, threat assessment and engagement management within a common operational architecture.

The system is designed to support the autonomous execution of authorised Counter-UAS missions. GRID can process information from multiple sensors, build a common operational picture, identify and track aerial threats, assess the developing situation and coordinate an appropriate available effector. This creates a sensor-to-shooter architecture in which JWALA provides the hard-kill interceptor while GRID provides the intelligence and mission-management layer.

The combination of an affordable interceptor with an AI-enabled battle management system is intended to address one of the fundamental challenges of modern Counter-UAS operations: defending against large numbers of increasingly capable and affordable drones without relying exclusively on high-cost defensive effectors.

The successful solid rocket motor test represents an important step in the JWALA programme as IG Defence continues development of indigenous propulsion, interceptor and Counter-UAS technologies. The company will continue the development and testing of JWALA with a focus on system maturity, reliability, manufacturability and scalability.

IG Defence's leadership frames the effort as meeting real operational needs while strengthening India's domestic defence ecosystem. Founder and CEO Bodhisattwa Sanghapriya has said the aim is deliver platforms for the nation, with precision and suited to today's battlefield realities.

For now, the successful motor firings give the company something tangible to show. Whether JWALA becomes a fielded counter-drone interceptor will depend on what comes next: flight trials, user feedback and eventually, orders.

INDIA TRANSFORMS FROM LAUNCHPAD TO A GLOBAL MARKETPLACE

The ninth Bengaluru Space Expo (BSX) 2026 marked a pivotal shift in India's space trajectory, transitioning from state-led launches to a commercial hub. Supported by a historic Italian national pavilion, alongside the UK and US presence and strong global diplomacy, the event emphasised joint co-development, dual-use technologies and market integration to shape the future space economy

ASAD MIRZA

Bengaluru Space Expo (BSX) 2026, held from September 7 to 9 at the Bangalore International Exhibition Centre, placed India's fast-growing private space sector at the centre of an international conversation. Governments, agencies, manufacturers, startups, investors and research institutions gathered in the city, and the message was consistent: India's ambitions now extend beyond launch capability and state-led missions towards a commercial ecosystem built on partnerships and shared technology development.

ITALY STEPS FORWARD AS PARTNER COUNTRY

Italy's presence gave the ninth edition its strongest diplomatic and industrial flavour. Antonietta Baccanari, Director and Trade Commissioner of the Italian Trade Agency (ICE) in India, told Raksha Anirveda on the eve of the show that the 2026 edition was significant because it marked Italy's first-ever national pavilion at BSX. Italy's aim, she said, went beyond showcasing technology: it wanted to strengthen the Made in Italy brand, foster long-term industrial partnerships and open new avenues across the global space economy.

She pointed to India's goal of capturing roughly ten per cent of the global space economy by 2035, calling it one of the world's most dynamic space markets. For Italian firms, BSX offered direct access to ISRO, IN-SPACe, NSIL, private companies, research institutions and investors. Early engagement, she argued, lets Italian companies become trusted partners in India's growth story.

Baccanari described the wider relationship as having entered a new phase in which trade, technology and industrial collaboration are increasingly interconnected. Bilateral trade is targeted at 20 billion euros by 2029, leveraging the EU-India Free Trade Agreement. Italy's strengths in advanced manufacturing, precision engineering, aerospace and defence systems complement 'Make in India' and 'Aatmanirbhar Bharat'. Rather than a traditional buyer-seller relationship, she said, the two sides are moving towards co-development, technology partnerships, local manufacturing and resilient supply chains, with Italian firms viewing India as a strategic manufacturing and innovation base as well as a market.





According to Baccanari, the pavilion spanned the entire value chain, from satellite platforms and components to ground infrastructure, Earth observation, space communications and in-orbit technologies. Leonardo Space showcased end-to-end capabilities in Earth observation, geospatial intelligence, space surveillance, secure connectivity, robotics and in-orbit services. Among the SMEs, Officina Stellare presented optical and electro-optical technologies for space and defence, while Zoppas Industries offered space-qualified thermal management systems.

OTHER DIPLOMATIC VOICES

Italian Ambassador Antonio Bartoli called India a key space partner. He described the relationship as part of the wider India-Italy Special Strategic Partnership and said Italy wanted to identify practical opportunities for joint projects, investments and market access, rather than merely display national capabilities.

US Ambassador Sergio Gor said India-US space ties were moving from cooperation to "co-creation", implying joint design, shared intellectual property and integrated supply chains.

Australian High Commissioner Philip Green stressed complementary strengths, citing Australia's access to equatorial and polar launch profiles and its expertise in remote operations. Officials from IN-SPACe, ISRO and NSIL reiterated that private enterprise is meant to complement, not replace, the national agency.

INDIAN COMPANIES IN THE SPOTLIGHT

Dhruva Space drew particular attention. The company showcased its A.S.T.R.A.V.I.E.W, a mobile command-and-control station built on an Ashok Leyland all-terrain vehicle and designed for constellations of over 300 satellites. It receives and processes satellite data near the point of need, aiming to cut the cycle from tasking to finished intelligence from 48-96 hours to roughly four to eight. It uses Safran Data Systems tracking antennas and handles optical, SAR and hyperspectral data,











serving defence and disaster relief. It complements Dhruva's AstraView imagery service, which connects users to more than 250 satellites.

GalaxEye announced a United States patent for its satellite-imaging technology, which combines sensing methods to produce imagery through cloud, darkness and bad weather. Astrogate Labs presented what was described as India's first indigenous optical inter-satellite link terminal, enabling high-speed laser communication between spacecraft.

Skyroot Aerospace, represented by co-founder Pawan Kumar Chandana, showcased its ambition to build a long-term launch business. Samtel Avionics announced a collaboration with South Korea's BULL Co Ltd on space-debris mitigation, reflecting growing concern for orbital sustainability. Other Indian firms presented offerings in satellite manufacturing, propulsion, ground systems and space data.

Indian officials from the Indian National Space Promotion and Authorisation Centre, or IN-SPACe, emphasised the importance of creating an enabling environment for private space companies. IN-SPACe is responsible for facilitating and authorising private-sector participation in space activities, including satellite development, launches and associated services.

The organisation's role has become increasingly important as more startups seek approvals, access to testing infrastructure and opportunities to work with public-sector institutions. Officials have stressed that India's ambition to expand its space economy will require stronger partnerships between startups, ISRO, universities, manufacturers and investors.

ISRO representatives highlighted the continuing importance of public-sector research and national space infrastructure. For startups, ISRO remains a source of technical expertise, launch opportunities, testing facilities and institutional credibility. At the same time, the growth of private companies is expected to allow ISRO to focus more heavily on advanced missions and strategic national programmes.

Representatives from Indian space associations called for closer coordination across the industry. They pointed to the need for standardisation, access to finance, skilled manpower, insurance, export support and clearer procurement pathways. Industry bodies also stressed that startups must be connected to larger aerospace companies and government users if innovative technologies are to reach operational scale.

BSX 2026 therefore became more than a technology exhibition. It served as a platform for diplomatic engagement, industrial networking and commercial positioning. The speeches by the US Ambassador, the Australian High Commissioner and Indian officials converged around a common theme: India's next phase in space will depend on partnerships that produce tangible technologies and markets.



–The writer is a New Delhi-based strategic, defence and international affairs commentator. He can be contacted via www.asadmirza.in

BonV Aero Supplies 45 UAVs to Indian Army's Eastern Command for Tactical Logistics

BonV Aero, a heavy-payload UAV manufacturer from Odisha, has supplied 45 unmanned aerial vehicles (UAVs) to the Indian Army's Eastern Command to support tactical missions, including moving critical supplies and other mission-specific payloads. The deployment extends the company's aerial mobility solutions to support missions across Northeast India's challenging terrain.

The move comes as the Ministry of Defence recently floated a tender for 2,715 logistics drones. The scale of the request reflects the growing role of UAVs in frontline operations, including moving essential supplies and other mission-critical payloads across challenging terrain.

The delivered UAV systems are purpose-built for multi-role frontline operations, providing a resilient aerial logistics capability to transport critical supplies, operational equipment, and mission-configured payloads and enhancing operational reach in complex environments.

The Eastern Command operates across a diverse geographical area, from forested and riverine stretches to high-altitude Himalayan posts. During the monsoon, flooding and landslides can disrupt road routes, while higher-altitude locations face snow, steep approaches, and rapidly changing weather.

The Indian Army has been seeking drone-based solutions to move essential supplies across inaccessible areas in the Northeast, while also addressing the region's persistent security challenges. The deployment of 45 BonV Aero UAVs responds directly to this operational need.

BonV Aero has previously carried out drone operations and trials for the Army in Tawang, Siliguri, Dimapur, Kargil, Dras, Nyoma, Baramulla, and Kupwara. In addition, the company has trained more than 150 Army personnel on its systems in the Northern Command.



Boeing Awarded $20 Billion Contract for Sixth-Gen Strike Fighter

Boeing has won the US Air Force's high-stakes contract to develop the F-47, the crewed centrepiece of the Next Generation Air Dominance (NGAD) programme. The award, announced by President Donald Trump on March 21, 2025, is valued at more than $20 billion for the engineering and manufacturing development phase.

The F-47 is intended to become the successor to the Lockheed Martin F-22 Raptor, the United States' principal air-superiority fighter. Although details of the aircraft remain classified, the programme is expected to combine advanced stealth, long-range performance, sophisticated sensors and highly automated mission systems.

The fighter will not operate alone. It is being developed as part of a wider "family of systems" that includes Collaborative Combat Aircraft - uncrewed platforms designed to fly alongside crewed fighters. These drone wingmen could perform surveillance, electronic warfare, targeting and weapons missions, allowing the F-47 to extend its reach while reducing the risks faced by pilots.

The Air Force has said the F-47 will be capable of operating in heavily contested airspace, where advanced surface-to-air missiles, electronic interference and enemy aircraft could limit the effectiveness of existing platforms. Its planned combination of stealth, sensors and unmanned support is intended to preserve US air superiority against increasingly capable rivals.

The programme has already involved experimental aircraft used to test key technologies. The first flight of the operational design is expected in 2028, with fielding planned for the 2030s.

Boeing's selection represents a major setback for Lockheed Martin, which produces the F-22 and F-35. Lockheed had competed for the NGAD contract but was not chosen. The decision also gives Boeing's military aviation division a significant boost after years of difficulties involving commercial aircraft production, defence costs and delays.

For Boeing, the F-47 contract is both a technological challenge and a corporate lifeline. For the Pentagon, it is a bet that a smaller fleet of highly connected crewed aircraft, supported by autonomous drones, can maintain American air dominance in the decades ahead.

FORGING NEW PARTNERSHIPS ACROSS AEROSPACE, DEFENCE AND AVIATION

The AEDEX + Airport Expo 2026, held in New Delhi, highlighted opportunities for indigenisation, technological innovation and global collaborations

RA NEWS DESK



AEDEX + AIRPORT EXPO 2026, held from September 10–12, 2026 at Yashobhoomi, IICC, Dwarka, New Delhi, brought the aerospace, defence and civil aviation industries together on one platform for three days. The event highlighted India's evolving industrial landscape and provided an opportunity for businesses, technology providers, manufacturers, investors and decision-makers to explore emerging opportunities, forge partnerships and build the next generation of India's aerospace, defence and aviation ecosystem.

The event was inaugurated by the Chief Guest Vishwajit Saha, Secretary (Defence Finance), Ministry of Defence, Government of India; alongside Guest of Honour Tejpal Singh, Air Marshal PVSM, AVSM, VM, Deputy Chief of the Air Staff, Indian Air Force; Ravi K, Chairman & Managing Director, Hindustan Aeronautics Ltd and other eminent dignitaries, namely, Dr VK Saraswat, Former Member - Niti Aayog & DG DRDO.

In all, 227 exhibitors from PSUs, OEMs, State Pavilions, Country Pavilions, MSMEs etc. participated and the event attracted 9,145 footfalls. Delegations from 18 countries also visited the expo.

Major exhibitors included Hindustan Aeronautics Ltd.(HAL), Bharat Electronics Ltd (BEL), Cochin International Airport Ltd. (CIAL), Council of Scientific & Industrial Research (CSIR), along with its Laboratories, Defence Research and Development Organisation (DRDO) alongwithitslabs,IndianSpaceResearch Organisation (ISRO), Directorate General of Quality Assurance (DGQA), Department of Defence Production, Ministry of Defence, 3M India Ltd., Advanced Weapons & Equipment India Limited (AWEIL), BrahMos Aerospace, GMR Hyderabad International Airport, Gujarat State Aviation Infrastructure Company, Indian Oil Corporation (IOCL), Hindustan Petroleum Corporation (HPCL), Larsen & Toubro, Ontario Ministry of Economic Development, Safran, Smiths Detection, Continental Carriers, Apollo Micro Systems, Base Repair Depots of IAF, Amphenol, AMI Polymer, Axens, Bosch Rexroth India Pvt. Ltd., Big Bang Boom Solutions, Blue Star, Divyanshi Aviation & Vandana Aircraft, DRIIF AI, Huber+Suhner Electronics, HCL Software, Jeanuvs, Motorola Solutions, Millenia Technologies, PHPL Defence and Aerospace Systems, Tamil Nadu Industrial Development Corporation Limited (TIDCO) Pavilion and many more.

The event had special visit by Chris Cooter, High Commissioner, High Commission of Canada and a large



number of foreign delegations from Canada, Philippines, Russia, South Korea, Germany, Singapore, Korean Airways, France, United Kingdom, Taiwan, USA, Maldives, UAE, Australia, Oman, Spain and Sri Lanka marked the highlights of the event.

Concurrently, two high level conference were held, AEDEX conference theme: India's Aerospace & Defence Ecosystem: Innovation, Indigenisation & Global Leader on Day One. On Day Two, AIRPORT conference theme: Future-Ready Airports: Smart, Sustainable & Passenger-Centric Aviation Ecosystems was held. These were power packed sessions bringing 50 high level speakers and 514 delegates over 3 days.

A "Buyer Seller Meet" was organised for industry requirements and procurement opportunities. The programme connected OEMs, Defence PSUs, Armed Forces, Government Agencies and Private Sector Buyers with MSMEs, Startups and Tier-II/Tier-III suppliers.

Final of the 3 days was an insightful programme - "Reaching for the Stars": How India's Space Dreams are Shaping Industry, Innovation & Young India", wherein Group Captain Shubhanshu Shukla AC shared his inspiring experience of living and working in space during the programme. He described the awe of viewing Earth from orbit, the challenges of adapting to zero gravity, and the discipline required for daily tasks in space. He spoke about the importance of teamwork, training, and resilience in successfully completing mission responsibilities. The full hall audience including students, listened to him with rapt attention.

The convergence of aerospace, defence and civil aviation is creating a larger industrial opportunity, where technologies developed for one sector can increasingly support another. Artificial intelligence, robotics, autonomous systems, advanced materials, electronics, simulation, digital engineering and cybersecurity are becoming critical across the entire aviation and defence value chain. This convergence is also creating opportunities for partnerships between global companies, Indian manufacturers, start-ups, MSMEs, research institutions and government organisations.

These events were organised by the Society of Indian Aerospace and Defence Technologies and Industries (SIATI) in association with TAFCON, and supported by the Ministry of Civil Aviation, the Ministry of Defence, the Ministry of Commerce and Industry, the Ministry of MSME, DRDO, and the DGCA. The expo reaffirmed New Delhi's standing as a convening point for the region's aviation and defence sectors.

AI AND THE FUTURE OF WARFARE

Artificial intelligence is reshaping modern warfare by accelerating decision-making, coordinating autonomous systems and strengthening missile defence. Israel illustrates this transformation through AI-enabled tanks, navigation, active protection and air-defence networks. Yet, the technology also raises questions about human oversight, infrastructure vulnerability, technological sovereignty and the risks of hastening lethal decisions

ARIE EGOZI



Artificial intelligence is rapidly transforming defence systems by automating threat detection, accelerating decision-making and enabling increasingly autonomous platforms. Systems such as the Pentagon's Maven project use computer vision and machine learning to process vast quantities of satellite and drone imagery at speeds beyond human capability. Militaries are also deploying unmanned aerial and ground vehicles that can coordinate in swarms, plan routes and operate with limited human input. Other AI platforms, including Pandora, are designed to automate real-time incident response and strengthen military networks.

The need for such systems has been driven by the enormous volume of information generated by modern sensors. Commanders cannot realistically monitor every satellite image, radio transmission, camera feed and battlefield report. Algorithmic filtering and data fusion have therefore become essential to identifying threats and maintaining operational effectiveness. However, compressing the decision-making cycle also creates serious risks: AI-assisted systems may accelerate lethal engagements before human operators have adequately assessed the wider context.

According to the material collected and reported so far, on February 28, 2026, AI systems combined information from satellites, radio signals and cameras within seconds rather than hours. Military forces reportedly struck more than 1,000 targets on the first day of the conflict, using AI-assisted decision tools to prioritise targets and recommend weapons. Systems such as the Maven Smart System were used to support these processes. The conflict also demonstrated the vulnerability of the global technology sector, after Iranian forces reportedly targeted critical infrastructure, including Amazon Web Services data centres in the Persian Gulf region.

These developments reflect a broader transformation in the nature of strategic competition. Hadas Lorber, a researcher at Israel's Institute for National Security Studies, told Raksha Anirveda that the global race for artificial intelligence is changing how states understand technological power. In previous decades, competition focused largely on data, digital platforms and AI models. Increasingly, however, strategic advantage depends on control of the physical AI value chain: critical minerals, advanced semiconductor

manufacturing, high-performance computing, data centres, energy supplies and frontier models.

The contest is therefore no longer centred on a single component of the AI system. It concerns the ability of states to secure meaningful positions across the entire AI stack. This includes access to the infrastructure required to develop, train, deploy and sustain advanced models. As AI becomes central to national defence, the physical foundations supporting the technology are becoming targets of strategic competition.

Israel is among the countries most advanced in integrating AI into combat systems. Although many of its applications remain classified, some details have emerged from the country's combat experience in Lebanon and Gaza. The Israel Defence Forces are enhancing the use of AI in the Merkava main battle tank and the Eitan armoured personnel carrier.

In the advanced Merkava Barak variant, AI reportedly helps manage routine tasks, process sensor information in real time and prioritise potential targets. AI is also being used to improve the Iron Vision helmet worn by tank commanders. Linked to external cameras, the augmented-reality system provides a 360-degree view of the surrounding environment, allowing commanders to observe conditions outside the vehicle as though they could see through its armour.

The IDF Intelligence Corps has also developed an intelligent routing and navigation system that recommends secure tactical paths through difficult terrain and dense urban environments. Meanwhile, the Trophy active protection system has been enhanced through AI and sensor fusion to detect, track and counter incoming anti-tank guided missiles, rocket-propelled grenades and drones. In the eight-wheeled Eitan programme, AI supports target acquisition and autonomous route planning. An Israeli source described the expanded use of AI in critical combat situations as a "force multiplier".

Israel is also undertaking a major effort to strengthen its multilayered air-defence architecture, drawing lessons from its recent conflict with Iran. The Israeli Air Force, now known as the Israeli Air and Space Force, is expected to upgrade the existing network built around Iron Dome, David's Sling and Arrow. According to a senior defence source who spoke to Raksha Anirveda on condition of anonymity, the effort will cover both the lower and upper tiers of the current system and may include other advanced technologies, including systems operated from space.

One objective is boost-phase interception: destroying an enemy missile on its launcher or within seconds of launch. The concept is not new, but Israel may now seek to develop it with the assistance of advanced AI. Researchers Yehoshua Kalisky and Iky Hazan of the Institute for National Security Studies explain that the boost phase of a missile generally lasts between one and five minutes, while its engine remains active and accelerates the missile.

This stage presents several potential advantages for interception. The missile remains within the atmosphere, its speed is comparatively low, its manoeuvrability is limited and its engine is still attached to the main body. Heavy fuel consumption also causes rapid shifts in the missile's centre of gravity, creating instability during launch. Although ballistic missiles can theoretically be intercepted at different points in their flight, the boost phase offers a particularly valuable opportunity.

AI can assist these systems by rapidly combining information from multiple sensors, distinguishing genuine launches from false alarms and calculating interception options. A future breakthrough in space-based boost-phase interception could further improve these capabilities. The United States may





eventually pursue such systems to counter threats from Russia and China, and any resulting advances could benefit Israel.

Space-based kinetic interceptors would offer an advantageous position, free from many geographical constraints. Nevertheless, such systems face substantial engineering, financial and strategic obstacles. Continuous global coverage would require a large constellation of satellites; each involving significant manufacturing and launch costs. The satellites would also be vulnerable to anti-satellite weapons, potentially undermining their long-term viability.

The strategic importance of AI extends beyond battlefield systems. Lorber identifies recent restrictions imposed on Anthropic-including measures limiting access to certain models by users and entities outside the United States on national-security grounds-as a significant development in the relationship between technology, national security and foreign policy.

For much of the past decade, debates over digital sovereignty focused on privacy, data localisation, regulation and cloud infrastructure. Recent developments suggest that the debate is entering a new phase, in which access to advanced AI capabilities is itself becoming a strategic asset. Governments are no longer concerned only with data and semiconductors; the models themselves are increasingly becoming objects of policy.

While AI continues to become a standardised capability across air-defence networks, combat vehicles and individual equipment, defence leaders emphasise the need to keep a human operator in the loop to prevent autonomous firing and unintended military escalation

The Anthropic case is therefore part of a wider trend in which artificial intelligence is emerging as a central component of national power. Access to advanced models could become a policy instrument, a source of geopolitical influence and a means of advancing strategic interests. For Israel, this development requires a reassessment of technological sovereignty, AI policy, computing capacity and critical infrastructure, as well as a broader reconsideration of national security planning.

The Israel Defence Forces continue to integrate AI across a wide range of systems, from equipment carried by individual soldiers to major combat platforms and air-defence networks. A senior defence source told Raksha Anirveda that AI would become a standard feature of many defence systems: "This process has just begun and will continue." At the same time, the source stressed that Israel would retain a human operator in the decision loop and would not permit an AI-controlled weapon system to fire independently.

This principle reflects the central tension surrounding military AI. The technology can improve situational awareness, accelerate responses and help forces manage overwhelming volumes of information. Yet, the faster and more autonomous these systems become, the greater the need for meaningful human judgment, clear accountability and safeguards against unintended escalation.



–The writer is an Israel-based freelance journalist


IAI
We make in India,
for India and for the world
Celebrating India's Independence Day
and four decades of trusted partnership
HELA
HELA Systems Pvt. Ltd.
(IAI-ELTA Group)
AEROSPACE SERVICES INDIA
ELCOM SYSTEMS
IAI NEUSPHERE
ELTX SYSTEMS
www.iai.co.il • iai-in@iaiworld.co.il • Find us on:
Discover More

THE INVISIBLE FRONTLINE: WHY INDIA NEEDS A POLICY FOR SPECTRUM AND DUAL-USE TECHNOLOGIES

The next conflict may be decided in a domain no one can see. India has the talent and industry to compete in electronic warfare and dual-use technologies. However, the country's policies still treat the spectrum as a telecom resource and dual-use products mainly as a risk. That balance needs to change

WING COMMANDER HARIKUMAR

Every modern weapon system depends on something invisible. A drone needs a control link. A missile needs navigation. A radar needs clean frequencies to see. A commander needs his radios to work. All of these run on the electromagnetic spectrum, and in recent conflicts it has become one of the most fiercely contested spaces on the battlefield.

In Ukraine, both sides jam and spoof each other's drones and navigation signals every day. Units that once relied entirely on GPS have had to relearn older methods. Drone makers keep changing frequencies, adding fibre-optic control cables, or building in autonomy, simply because the radio link can no longer be trusted.

Civil aircraft over the Baltic and parts of West Asia have faced repeated GNSS interference, with pilots seeing positions that are nowhere near where they actually are. Indian operators have reported similar problems, and our aviation regulator has had to issue guidance on it.

The lesson is clear. Control of the spectrum is no longer a support function. It is a warfighting domain in its own right, as important as air, sea or cyber. The question is whether our policies have caught up.

A STRATEGIC DOMAIN WE STILL MANAGE LIKE A UTILITY

In India, spectrum is largely viewed through a telecom lens. It is allocated, auctioned and regulated mainly for commercial use, with defence requirements negotiated alongside. That approach made sense when the main concern was mobile networks. It makes far less sense when the same bands carry drone links, navigation signals and military communications, and when an adversary can disrupt them from across a border.

This creates three practical problems. The first is coordination. When a new threat appears, such as unidentified drones over a sensitive installation, there is often no single body that can quickly decide who acts, on which frequencies, and under what authority. Decisions happen case by case, and time is lost.

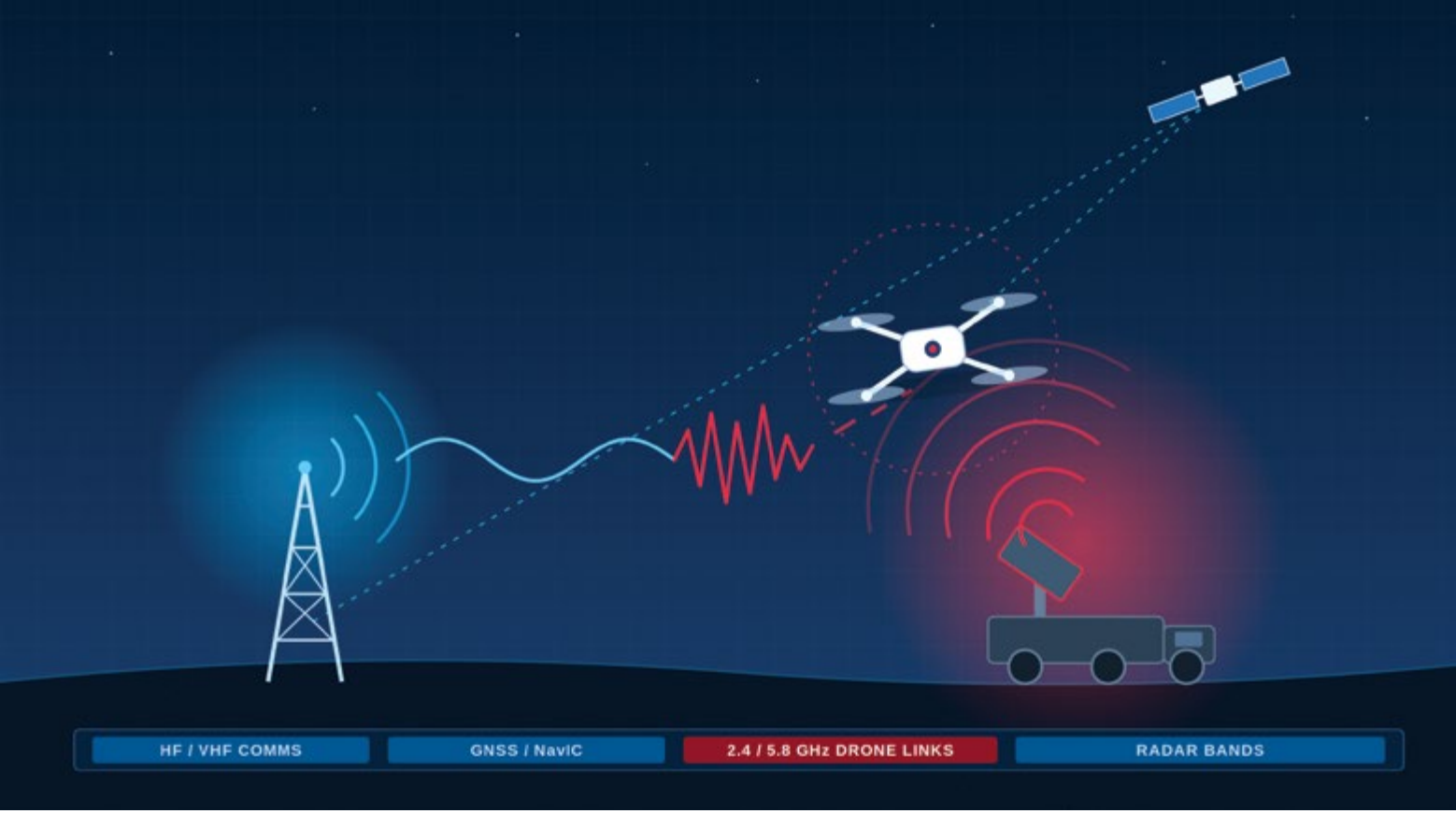
The second is legal clarity. The use of jammers in India is tightly restricted to a small number of authorised agencies. Yet the people who most often need protection from drones are airport operators, refineries, power plants, prisons, police forces, and organisers of large public events. Many of them can buy detection systems, but they have no clear legal authority to act on what they detect. Detection without the ability to respond is only half a solution.

The third is testing. Developing a jammer, a direction finder, or a resilient military radio requires transmitting on real frequencies under controlled conditions. Indian firms often have limited access to test ranges and temporary spectrum permissions, which slows development and sometimes pushes testing abroad. It is hard to build world-class electronic warfare products when you cannot easily switch them on at home.

THE DUAL-USE DILEMMA

The technologies behind electronic warfare rarely stay in one category. Software-defined radios, RF components, AI-based signal analysis, cyber tools, satellite communication, and advanced materials all serve both civilian and military markets. That is their strength, and it is also why governments watch them closely.

India has done well to build credibility here. Joining the Wassenaar Arrangement in 2017, along with the MTCR and the Australia Group, placed India among the world's responsible technology holders. Our SCOMET list aligns national



export controls with these regimes. That credibility took years to earn, and industry has every reason to protect it.

But credibility and speed are not opposites. For many companies, the difficulty is not the rules themselves. It is the uncertainty around them. Does a product need a licence? Which category does it fall under? How long will approval take? Anyone who has worked in international defence sales knows that a delay of a few months can decide whether a deal is won or lost.

Customers in the Middle East, Africa, South-East Asia and Central Asia usually have alternatives, often from countries whose export systems move faster and whose governments actively support their industry abroad.

There is a domestic cost too. When the export path is slow and unpredictable, investors see a smaller market and companies hesitate to commit to dual-use R&D. Over time, this weakens the same industrial base that our armed forces will depend on in a crisis.

WHAT A SENSIBLE POLICY COULD LOOK LIKE

None of this requires dramatic reform. A few practical steps would make a real difference.

Recognise the spectrum as a strategic domain. A national spectrum security framework, with a standing civil-military body, could coordinate allocations, respond quickly to interference and set clear priorities during emergencies.

Give civil agencies clear counter-drone authority. Defined legal powers and standard procedures would allow police and critical infrastructure operators to detect, jam or neutralise hostile drones, with proper accountability and safeguards against misuse.

Open up testing for industry. Designated frequencies, test locations and fast-track permissions would let Indian companies develop and validate electronic warfare and RF products within the country.

Make dual-use licensing predictable. Early product classification, time-bound decisions and wider use of general authorisations for trusted partner countries would give industry the certainty it needs, without weakening controls.

Invest in the building blocks. RF chips, radio platforms, antennas and signal processing hardware remain heavily import-dependent. No policy on paper can fix a supply chain vulnerability of that kind. Only sustained investment in indigenous capability can.

SUMMING UP

Those of us who have worked with radar learn early that what you cannot see can still hurt you. The spectrum is exactly that kind of space. It carries our communications, guides our weapons and protects our skies, and it can be denied to us without a single shot being fired.

India has the engineers, the start-ups and a growing defence industry capable of competing with the best. What it needs now is a policy framework that treats the spectrum as the strategic asset it has become, and treats dual-use technology as an opportunity to be managed well rather than a risk to be contained. Get that balance right, and India will be better protected at home and far more competitive abroad.



–The writer is an Indian Air Force veteran with 22 years of expertise spanning radar systems, aircraft maintenance, and aircrew. After taking voluntary retirement in 2018, he transitioned to the defence industry, leading international business development and strategic partnerships. He is currently the President – International Business at BBBS Pvt Ltd, with extensive global defence market exposure

CUMI: ARMING INDIA'S QUEST FOR DEFENCE SELF-RELIANCE

A seven-decade-old materials science major is turning ceramic powder into battle-ready armour - and building an entire MSME ecosystem around it. For 70 years, Carborundum Universal Limited (CUMI) has built its business around abrasives and advanced materials. Today, the Murugappa Group company is grinding out something far more consequential: the ceramic armour, composite structures and specialised powders that are helping India build a defence industrial base it can call its own

RA NEWS DESK

India's defence manufacturing landscape is in the middle of a quiet but consequential rewiring. For decades, critical technologies sat locked inside a handful of monolithic public-sector institutions. That model is giving way to something more distributed - a network of Technology Transfers (ToTs) from government laboratories, absorbed and scaled by private industrial anchors, who in turn pull in hundreds of small and medium enterprises (MSMEs) to execute the work. It's a shift from single points of production to a resilient web of capability, and Carborundum Universal Limited (CUMI) - a part of the 125-year-old Murugappa Group - has emerged as one of its clearest case studies.

CUMI's own defence and aerospace journey is a relatively recent chapter in a much longer materials story. Built on more than 70 years in abrasives and three-to-four decades of advanced ceramics expertise, the company recognised roughly three years ago that its ceramics know-how had a second life protecting soldiers and machines, not just cutting and grinding them. Inbound inquiries about add-on ceramic armour and bullet-resistant protection, arriving just as the Make in India push gathered momentum, and convinced the company that defence and aerospace deserved to be a standalone growth vertical.



CUMI uses advanced manufacturing processes to transform engineered ceramic materials into high-performance components for aerospace and defence applications

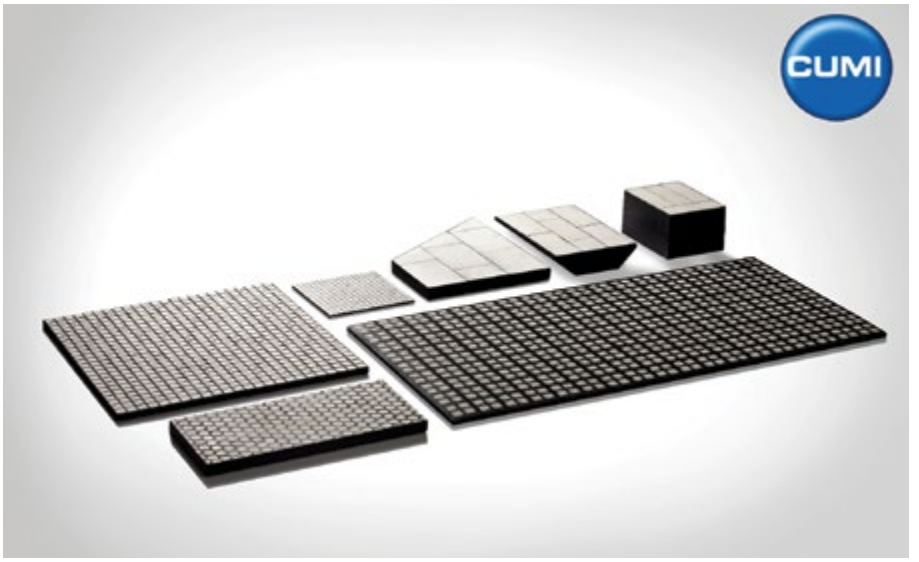
CUMI takes ceramic powders synthesised at its Kochi plant through sintering at Hosur into finished RbSiC and ZTA armour cores - a rare powder-to-panel capability within one company

The underlying science is straightforward, even if the engineering is not. Advanced ceramics combine high impact resistance with high thermal conductivity - when struck by a high-velocity round, the ceramic fractures and absorbs kinetic energy, blunting the impact before it can penetrate. That

CUMI's Technology Transfer from DRDO-DMRL covers add-on composite armour for the indigenous Wheeled Armoured Platform, alongside its own in-house RbSiC innovation



CUMI's materials science expertise spans advanced ceramics, composites and coatings developed to meet demanding aerospace and defence requirements



CUMI's advanced ceramic portfolio includes lightweight armour materials and composite panels designed for body and vehicle protection

single property has opened doors across an unusually wide set of applications: bullet-resistant jackets and helmets, vehicle and tank armour, thermal barrier linings inside aero-engines, radomes and metallised ceramics for missiles, ceramic substrates for avionics and satellites and lightweight carbon-fibre composite structures for drones.

A POWDER-TO-PANEL VALUE CHAIN, ENTIRELY IN-HOUSE

What sets CUMI apart is how much of that value chain it actually owns. At its Kochi facility, the company manufactures ultra-fine, high-purity powders - silicon carbide, alumina, zirconia and, more recently, graphene - that feed not only its own armour lines but its abrasives, refractories and electro-minerals businesses too. From there, CUMI's Hosur plant in Tamil Nadu - strategically positioned inside the Tamil Nadu Defence Industrial Corridor - takes those powders through sintering and reaction-bonding into hard ceramic cores: Reaction Bonded Silicon Carbide (RbSiC), Zirconia Toughened Alumina (ZTA) and high-alumina grades ranging up to 99.6% purity. Composite drone parts, meanwhile, are built at the company's Ranipet facility using vacuum infusion, resin transfer moulding, pultrusion and filament winding.

The finished ceramic tiles - square, rectangular, hexagonal or cylindrical - are only half the product. For vehicle armour, CUMI or its MSME partners "rubberise" the tiles, sandwiching them between backing layers to create bolt-on composite panels. The resulting solutions have been qualified against a genuinely demanding spread of international benchmarks: NIJ Level III+ and IV for personal armour, BIS Levels V and VI, and STANAG 4569 Levels 2 through 4 for vehicle protection, with STANAG 5 and 6 development under way. Independent ballistic trials, including multi-hit tests run at Germany's IABG laboratory and India's National Forensic Sciences University, have shown CUMI's RbSiC and ZTA composite panels stopping everything from 7.62mm armour-piercing rounds to 14.5mm API rounds with no perforation on the reverse side.

DRDO's HAND IN THE ARMOUR

A significant part of this capability did not originate in CUMI's own labs. The company holds a Technology Transfer from DRDO's Defence Metallurgical



CUMI develops engineered ceramics including Reaction Bonded Silicon Carbide and Zirconia Toughened Alumina for lightweight, high-performance protection solutions



CUMI's R&D capabilities support the development and characterisation of advanced materials for aerospace and defence applications

Research Laboratory (DMRL) to manufacture add-on composite armour panels for the indigenous Wheeled Armoured Platform (WhAP), alongside in-house R&D that produces its own RbSiC ceramics. Development cycles for major platforms like WhAP or the Future Infantry Combat Vehicle are necessarily long, given the rigour of DRDO and armed-forces prototyping. But CUMI keeps these ToT-derived technologies for domestic use rather than export, treating them as contributions to national security infrastructure first, a company representative told Raksha Anirveda.

The company's ambitions extend well beyond armour tiles. Its refractory products serve investment casting of superalloys for aircraft turbine blades, and its nitride-bonded silicon carbide is used both in ballistic protection and as thermal heat shields on the underside of space re-entry vehicles. Elsewhere in the portfolio, thermal spray powders protect aero-engine components from wear and corrosion, and bonded and super-abrasive product lines support precision grinding of turbine blades, aerospace fasteners and even gun-barrel honing.

BUILDING THE MSME ECOSYSTEM AROUND IT

Perhaps the more structurally important part of CUMI's story is how it treats smaller manufacturers - not as competitors to be shut out, but as necessary partners in scaling national capability. Composite armour panel fabrication, precision CNC machining of ultra-hard ceramic profiles, CFRP structural parts for UAVs, and thermal/fire-protection components are all areas where CUMI has identified high-potential entry points for MSMEs. The obstacles are real: ballistic testing infrastructure is expensive, capital requirements for precision equipment are steep, and imported raw materials often undercut domestic ones on price. CUMI's answer has been to absorb some of that risk itself - supplying pre-qualified raw materials, sharing testing access and providing structured quality mentorship so smaller firms can move from being basic build-to-print vendors to genuine technical partners, the company representative further added.

That mentorship model gels well with the government's own indigenisation push. Since 2022, successive Positive Indigenisation Lists have brought thousands of previously imported defence items - including armoured platforms, radars and ammunition types - into the domestic development pipeline, with import substitution already running into thousands of crores. Materials science companies willing to de-risk that process for smaller suppliers, as CUMI has done in ceramics and composites, are becoming an underrated piece of how India intends to hit those targets.

None of this makes CUMI's armour business large yet - by the company's own account it remains a small contributor next to its broader materials turnover. But the direction of travel is unmistakable: from powders to panels, from a single ceramics plant to a distributed MSME network, CUMI is positioning itself as one of the technical anchors of India's evolving, and increasingly self-reliant, defence-industrial base.

Milipol India

The Indo-Pacific leading International Event for Homeland Security

16 - 18 March 2027

Bharat Mandapam, New Delhi

Bharat Mandapam, New Delhi





3rd Edition

Exhibitor Profile

Surveillance
Border Protection
Cybersecurity
Law Enforcement
Counter-Terrorism Solutions

Exhibitior Query

Harish Khanduri
(Project Manager)
8800138543
Harish@Interads.In

Nizam Khan
(Sr. Sales Manager)
72107 97174
Nizam@Interads.In

Visitor Query

Pragya
+91 89296 00517
Pragya@Interads.In

Organised By

COMEXPOSIUM

INTER ADS EXHIBITIONS PVT. LTD.

Media Partner

raksha ANIRVEDA

www.milipolindia.com

Air Marshal Ashutosh Dixit to Lead IAF

Air Marshal Ashutosh Dixit is set to become India's 29th Chief of the Air Staff, succeeding Air Chief Marshal Amar Preet Singh on October 31, 2026 as IAF modernisation gathers pace

The government has appointed Air Marshal Ashutosh Dixit as the next Chief of the Air Staff, placing an experienced fighter pilot, test pilot and senior military planner at the helm of the Indian Air Force.

Dixit, currently serving as Vice Chief of the Air Staff, will assume the rank of Air Chief Marshal and take charge on the afternoon of October 31. He will succeed Air Chief Marshal Amar Preet Singh, who is scheduled to retire on the same day after leading the force through a period of heightened operational and modernisation demands.

The appointment makes Dixit the 29th Chief of the Air Staff. According to the government notification, his tenure will continue until December 31, 2028. He will inherit responsibility for a force confronting a complex security environment, including challenges along India's northern and western borders and the need to sustain air operations across a large and diverse geography.

Dixit was commissioned into the fighter stream of the IAF on December 6, 1986. During a career spanning nearly four decades, he has flown more than 3,500 hours on a wide range of aircraft, including the Mirage 2000, MiG variants, Jaguar, Tejas, Hawk, Kiran, IL-78, An-32, Avro and HPT-32. He is also an Experimental Test Pilot and a Qualified Flying Instructor.

His operational experience includes participation in Operation Safed Sagar during the 1999 Kargil conflict and Operation Rakshak. He has also been associated with major exercises, including Cope India, and more recent operations such as Operation Sindoor, according to reports on his service record.

Dixit has held several important command appointments. He commanded a Mirage 2000 squadron, a frontline fighter base in the western sector and a fighter training base in the southern sector. He later served as Air Officer Commanding-in-Chief of Central Air Command, one of the IAF's major operational commands.



Dixit has held several important command appointments. He commanded a Mirage 2000 squadron, a frontline fighter base in the western sector and a fighter training base in the southern sector

His senior appointments have also involved policy, planning and force development. Before becoming Vice Chief, Dixit served as Deputy Chief of the Air Staff and held positions including Principal Director of Air Staff Requirements, Assistant Chief of the Air Staff for Projects and Assistant Chief of the Air Staff for Plans. He also served as Chief of Integrated Defence Staff at Headquarters Integrated Defence Staff.

The incoming chief is widely associated with the IAF's efforts to promote indigenous aerospace programmes, particularly the Light Combat Aircraft Tejas and other Indian aircraft projects. His appointment could give further momentum to the government's Aatmanirbharta agenda in defence aviation.

The IAF is working to expand its fighter fleet, improve air-defence networks, strengthen unmanned and surveillance capabilities, and accelerate the induction of indigenous platforms. It is also managing the transition towards newer systems such as the Tejas Mk1A, while preparing for longer-term programmes including the Advanced Medium Combat Aircraft.

Dixit's test-pilot background may prove especially relevant as the service evaluates new aircraft, weapons and electronic systems. His experience across operational command, procurement planning and indigenous development gives him exposure to both battlefield requirements and the institutional challenges of modernising a technologically demanding force.

He is an alumnus of the National Defence Academy, the Defence Services Staff College in Bangladesh and the National Defence College in New Delhi. His decorations include the Vayu Sena Medal, Vishisht Seva Medal, Ati Vishisht Seva Medal and Param Vishisht Seva Medal.

His appointment signals continuity in operational preparedness, while placing renewed emphasis on domestic aerospace capability and long-term transformation of the Indian Air Force.

DRONE EXPO 2027
Exhibition & Conference
ADVANCING GIS, UAV, AI & ROBOTICS

✦ Delhi Edition ✦
concludes on a high note






80+ BRANDS

12,000+ VISITORS

ENDLESS OPPORTUNITIES



Bengaluru is next
and it's going bigger

16TH | 17TH APRIL 2027

BANGALORE INTERNATIONAL EXHIBITION CENTRE (BIEC) , BENGALURU



BE THERE **REGISTER NOW**

ORGANISED BY: SI SERVICES INTERNATIONAL BUILDING B2B PLATFORMS

ASSOCIATION PARTNER: DRONE TECH EXCELLENCE ASSOCIATION

PODCAST PARTNER: TECH UDAAN Drones & Beyond

KNOWLEDGE PARTNER: COHERENT MARKET INSIGHTS

DIGITAL BROADCAST PARTNER: DroneTv

CONTACT US

+91-9354688923, +91-8882210038, +91-7838337522
info@droneexpo.in, conference@droneexpo.in

www.droneexpo.in

FOLLOW US ON:

Air Marshal KAA Sanjeeb Takes Over as Air Officer-in-Charge Maintenance of the IAF

Air Marshal KAA Sanjeeb, AVSM VSM assumed the charge of Air Officer-in-Charge Maintenance of the Indian Air Force (IAF) on September 01, 2026. The Air Officer was commissioned in the IAF on September 03,1988 in the Aeronautical Engineering (Mechanical Branch). He has extensive field experience on IL-76, Airborne Warning and Control System (AWACS) and Boeing 737-200 aircraft.

He was the Lead Engineer and Team leader of the Air HQ Project Management Team for induction of the first IL-78 Flight Refueller Aircraft (FRA) into IAF in 2003. He also holds credit of being one of the pioneers involved in inducting and operationalising the AWACS fleet in the IAF. The Air Officer is an alumnus of Bangladesh Flight Safety Institute and the prestigious Indian Institute of Public Administration. In his distinguished career spanning more



than three decades, the Air Officer has held various important field and staff appointments. Prior to assuming the present appointment, the Air Officer held the appointment of Director General (Aircraft). Director General (System) and Assistant Chief of the Air Sraff (Maintenance Plans) at Air HQ.

In recognition of his distinguished service and devotion to duty, the Air Officer has been awarded with the Presidential Award 'Vishisht Seva Medal' (VSM) in 2015 and 'Ati Vishisht Seva Medal' (AVSM) in 2026.

SkyDrive Appoints Former Toyota and Airbus Executives to Accelerate Global Commercialisation

SkyDrive Inc., a leading compact eVTOL aircraft developer based in Japan, recently announced the strengthening of its executive leadership to accelerate global commercialisation and business expansion. The company announced the appointments of Taiji Ono as executive vice president and head of global business, and Gonzalo Ramos as global commercial officer. Under this new executive leadership structure, SkyDrive will accelerate its preparations for commercial operation and service launches in Japan and around the world, specifically advancing route development and establishing operational frameworks. Taiji Ono brings a nearly 17-year career at Toyota Motor



Corporation, and will oversee our global business strategy, commercial models, and sales strategy worldwide. Gonzalo Ramos brings over 22 years of experience in commercial aviation and Advanced Air Mobility (AAM), including almost 18 years at Airbus. He will lead commercial expansion across key international markets, including the United States, Middle East, Europe, and Australia.

Raghu Vamsi Group Appoints Amit Pathak as Group Chief Business Officer



Raghu Vamsi Group, the Hyderabad-headquartered precision aerospace and defence manufacturing group, has appointed Amit Pathak as its Group Chief Business Officer. In his new role, Pathak will lead the group's commercial strategy and growth across all five business segments.

Amit Pathak brings 27 years of experience in the global aerospace and defence industry, with a career spanning role in engineering, business development, sales, strategy, product marketing, customer support, and programme management. He joins Raghu Vamsi Group from Collins Aerospace, part of RTX Corporation, where he most recently served as Regional Director for Asia Pacific, the Middle East and Africa, leading international defence account management and sales. Before joining Collins Aerospace, Pathak served as General Manager and Board Member for Pratt & Whitney's aircraft engines business in India. He began his career with Honeywell as avionics engineer and went on to lead engineering product development programmes across the company's facilities in India, Europe and the United States. Over the course of his career, he has also worked with Cobham.

Amit Pathak has also served as industry co-chair of the skills development sub-committee of the US-India Aviation Cooperation Programme and mentors startups developing artificial intelligence and computer vision applications for the aerospace industry. He holds a Bachelor's degree in Electronics and Communication Engineering and an MBA from the Indian Institute of Management, Bangalore.

Anoop Kumar Rai Assumes Charge as Director (Marketing) of BEL

Anoop Kumar Rai assumed charge as Director (Marketing) of Navratna Defence PSU Bharat Electronics Limited (BEL) on August 13, 2026. Prior to this appointment, he served as Executive Director of BEL's Central Research Laboratory (CRL), Ghaziabad, from 2025, following a distinguished tenure as Chief Scientist. With a prolific career spanning 34 years, Anoop Kumar Rai is a visionary leader in defence and niche technologies, with extensive experience in translating complex military requirements into indigenous technological solutions.



Anoop Kumar Rai has played a significant role in advancing BEL's capabilities in Artificial Intelligence (AI) and unmanned systems for national defence. He spearheaded the development of 'Saksham', an AI-powered state-of-the-art Drone Warfare System, in collaboration with the Army Air Defence. The counter-drone and interception solution leverages Edge-AI for real-time threat detection and autonomous neutralisation, addressing critical operational requirements. He has also been a key driver in the conceptualisation of the AI-based Command Information & Decision Support System (CIDSS). His initiatives include the integration of AI into NMDA for predictive maintenance and real-time automated anomaly detection. His vision for the Space Domain encompasses the use of AI for Space Situational Awareness, strengthening BEL's capabilities in emerging technologies. Anoop Kumar Rai played a pivotal role in the conceptualisation and deployment of advanced technologies under the IACCS Project, a major initiative integrating S-400 and MRSAM systems. His leadership contributed to the successful deployment of battle-proven solutions such as 'Sanjay' (BSS) and 'Akashteer' (ADC&RS), which played an important role during Op Sindoor.

Former Airbus Japan President Stéphane Ginoux Appointed as Advisor to SkyDrive

SkyDrive Inc. (SkyDrive), a leading compact eVTOL aircraft developer based in Japan, announced August 14 that Stéphane Ginoux has joined SkyDrive as an advisor, effective August 1, 2026. In his previous role, Ginoux was concurrently the President of Airbus Japan and the Head of Airbus operations in North Asia.



Ginoux has approximately 30 years of experience in the aviation industry. During his tenure at Airbus, he spearheaded business expansion across the Japanese and North Asian markets, fostering collaboration with corporations, government agencies, and research institutions. After joining SkyDrive, Ginoux will help the company achieve its declared mission of "leading a once-in-a-century mobility revolution", creating a world in which eVTOL travel becomes a regular feature of city life.

SkyDrive aims to harness Ginoux's broad network of government and business partners, in addition to the extensive business development experience gained at Airbus. Ginoux will provide strategic support across a wide range of areas including business development in Japan and Asia, stakeholder engagement with governments, local authorities, and industry associations, and also collaboration with business partners.

Ambrish Tripathi Appointed Director (Human Resources) of BEL



Ambrish Tripathi assumed charge as Director (Human Resources) of Navratna Defence PSU Bharat Electronics Limited (BEL) on August 13, 2026. Prior to this appointment, he was General Manager of BEL's Kotdwar Unit since January 1, 2024.

Tripathi holds a BE degree from National Institute of Technology (NIT), Allahabad and has done Executive Post Graduate Diploma in Management with specialisation in HR from Symbiosis Pune. He also has PMP certification from PMI USA. During his career at BEL, he has held various important assignments and has made significant contributions in the areas of Human Resources, workforce development, digital transformation, employee engagement and organisational capability building. As General Manager of BEL's Kotdwar Unit, Ambrish Tripathi provided holistic leadership for the HR function, aligning people policies with organisational objectives, strategic frameworks and corporate directives. He translated his strategic HR vision into measurable outcomes through structured policy implementation, governance excellence, workforce capability enhancement and institutional capacity building.

Ambrish Tripathi has been instrumental in transforming the HR function through digitisation and alignment of organisational objectives with technological advancements. His experience in strategic HR management, capability development, employee engagement and digital transformation is expected to further strengthen BEL's human capital and support the company's continued growth and its contribution to the national mission of Aatmanirbhar Bharat.

Hical Technologies Opens Devanahalli Facility

Hical Technologies, a Bengaluru-based precision electromechanical manufacturer for global aero-space and defence platforms, on October 6 announced the launch of its new aerospace manufactur-ing facility in Devanahalli, Bengaluru. The 60,000-square-foot facility will house partnerships and dedicated lines for complex Electro-magnetics, Electromechanical, Hydraulic and Control Systems for commercial aircraft and Rafale programmes. It will also feature an experience centre to showcase Hical's other facilities. The ex-pansion is part of Hical's broader strategy to build the scale, capability and manufacturing depth re-quired to support increasingly sophisticated aerospace and defence programmes.

The Devanahalli facility complements Hical's 160,000-square-foot aerospace-qualified facility un-der development in Hosur, where groundbreaking was completed in July 2026. Designed for preci-sion machining, fabrication and special processes, the Hosur site is on track for NADCAP qualifica-tion. Together, the facilities will expand Hical's programme-linked manufacturing capabilities, with a focus on quality, traceability and process discipline. With the Devanahalli and Hosur facilities, Hical is positioning itself to play a larger role in India's ex-panding aerospace and defence manufacturing ecosystem while serving the evolving requirements of global programmes.



IWI's ARAD 5 & 7 Selected by Argentina's Armed Forces





Israel Weapon Industries (IWI), an SK Group company and global leader in small arms manufactur-ing, announced that Argentina's Armed Forces have selected the company's ARAD 5 and ARAD 7 rifles, in a government-to-government (G2G) agreement led by the Israel Ministry of Defence's Inter-national Defence Cooperation Directorate (SIBAT). The selection marks an important milestone in the platform's established presence among military and law enforcement customers worldwide.

Argentina's Ministry of Defence formally presented the ARAD 5 and ARAD 7 earlier this week, un-derscoring the rifles' role in modernising the country's individual weapons capabilities. The selec-tion reflects the ARAD's ability to deliver the reliability, precision and modularity required by to-day's military and law enforcement users.

Developed for professionals who operate in the most unforgiving conditions, the combat-proven ARAD weapon system redefines what a 5.56mm rifle can do. Its advanced AR platform foundation is enhanced with short-stroke gas-piston operation, full ambidextrous controls, and a free-floating hammer-forged barrel that delivers pinpoint precision under pressure. An integrated Picatinny rail and M-LOK handguard provide extensive flexibility for optics, accessories and mission-specific con-figurations.

The rifles supplied to Argentina are equipped with Meprolight M5 red-dot sights, complementing the ARAD's design with an integrated aiming solution. The M5 product family features combat-proven LED technology combined with rugged MIL-STD design and provides thousands of operating hours in day mode using a single "AA" battery. The wide dynamic range of brightness levels supports effec-tive use in sunny desert environments, partially illuminated jungle conditions, Close-Quarters Battle (CQB) and covert operations with NV devices.

The ARAD weapon system is engineered to maintain its performance over an extended service life, with major components designed for a minimum of 20,000 rounds. Its combination of durability, accuracy and modularity gives users a platform built to deliver consistent performance over the course of its service life.

The selection by Argentina adds to the ARAD's established presence among military, special opera-tions and law enforcement customers globally. Designed for broad applicability across missions and operating environments, the platform combines a proven AR architecture with modern ergonomics, fully ambidextrous controls and extensive modularity, giving customers the flexibility to configure the rifle for their specific operational requirements.

ideaForge Enters Long-range ISR and UCAV segments

IdeaForge Technology Limited on October 6 launched two new variants of its multi-role tactical UAV platform, ZOLT: ZOLT Hybrid and ZOLT Unmanned Combat Aerial Vehicle (UCAV), strengthen-ing its tactical UAV portfolio and marking its entry into the Long-Range ISR and UCAV segments. ZOLT UCAV is powered by a battery, while ZOLT Hybrid combines an IC engine with battery power to deliver extended flight time.

From persistent ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance) to preci-sion effects, ZOLT brings together long-range reach and mission versatility in a single recoverable platform. Designed for day and night operations across varied terrain, environmental conditions, and altitudes, it supports a broad range of tactical missions in demanding Electronic Warfare (EW)-contested environments. At the core of ZOLT is ideaForge's indigenous EW-resilient technology stack, built around Anti-Jam Communications, GNSS-Denied Navigation, and Onboard Intelligence. These capabilities support communication and navigation resilience when signals are degraded, disrupted or denied, while onboard processing supports decision-making at the edge and reduces dependence on continuous data links.



The ZOLT UCAV variant is built for tactical missions and precision effects, with 2-3 hours of endur-ance, 30-50 km Line of Sight (LOS) transmission, and launch altitude up to 4,500 m AMSL; whereas the ZOLT Hybrid is built for extended missions and persistent overwatch, with 6+ hours of endur-ance, up to 100 km LOS transmission, and launch altitude up to 2,000 m AMSL.

Building on the ZOLT Hybrid platform, ideaForge is soon set to also introduce a High-Altitude vari-ant designed for operations in contested terrains, with a launch altitude capability of up to 4,000 m AMSL.

Across configurations, ZOLT supports border and frontier surveillance, tactical reconnaissance, bat-tlefield and fire-support intelligence including Direction of Own Artillery Fire (DOOAF), target ac-quisition, day and night long-range surveillance. The platform can be configured with ideaForge's NAKSH family of ISR payloads for electro-optical, infrared and Mid-wave infrared (MWIR) observa-tion, laser ranging, and tracking.

EDGE Strengthens Morocco's Air Power with Precision Weapons

EDGE has signed a contract with Morocco's Administration of National Defence (ADN), the body overseeing defence procurement for the Royal Armed Forces, to supply its DESERT STING 16 (DS-16) guided-glide weapon and THUNDER P-31 precision-guided munition to the Royal Moroccan Air Force (RMAF). Signed at the Marrakech Air Show 2026, the contract covers the supply of both weapons and their integration across the RMAF's fleet of unmanned combat aerial vehicles (UCAVs). The contract reflects EDGE's long-term commitment to the Kingdom of Morocco and to Africa, one of its priority growth markets. EDGE works with its partners through flexible, open business models, shaping each programme around the customer's operational requirements and integrating its systems onto the platforms they already operate. Under the contract, EDGE will integrate both weapons across the RMAF's UCAV fleets, covering the aircraft modifications and software required to carry and employ them operationally.

Smart Shooter Awarded $150 Million Contract by US Army

Israeli company Smart Shooter, announced that it has been awarded a 36-month, single-award indefinite-delivery/indefinite-quantity (IDIQ) contract by the US Department of War's Joint Interagency Task Force 401 (JIATF-401), with a maximum ordering ceiling of up to $150 million. Under the agreement, Smart Shooter is the sole supplier of the SMASH fire control systems, training, and related services covered by the contract. JIATF-401 coordinates counter-UAS efforts across the US military and federal agencies, working with government and industry partners to address evolving drone threats.

The contract supports JIATF-401's Domestic Shield programme and associated global operational missions, addressing force protection, base defence, and counter-UAS requirements in the United States and overseas. The contract's scope includes hardware, software and updates, training, and support services. The quantity, scope, and timing of future deliveries will be determined through individual delivery orders.

Combining artificial intelligence, computer vision, and advanced target-tracking algorithms, Smart Shooter's lightweight, rifle-mounted SMASH fire control systems track the target, calculate the firing solution, and synchronise shot release when the weapon is precisely aligned. This brings precise kinetic counter-drone capability to the individual soldier through the standard service weapon, while preserving its normal use against ground targets. The operator retains the decision to engage, and the system can connect with external sensors and battle management systems. The agreement follows Smart Shooter's earlier contract with JIATF-401, announced in March 2026, and a series of new and follow-on awards Smart Shooter secured over the past year to support the US Army, Navy, Air Force, and Marine Corps. Thousands of SMASH systems are already deployed across US military services.

QNu Labs, BISAG-N and IIT-Gandhinagar Demonstrate

QNu Labs, an Indian deep-tech company, carried out the demonstration of India's first free-space quantum key distribution (QKD) link in collaboration with Bhaskaracharya National Institute for Space Applications and Geo-informatics (BISAG-N) at the Indian Institute of Technology, Gandhina-gar. The field trial, spanning 5.6 kilometres was conducted on the night of September 27-28.

The Ministry of Electronics and Information Technology described the achievement as an im-portant advance in the development of quantum-resilient communication systems. Unlike conven-tional quantum key distribution experiments that rely on fibre-optic cables, the new link transmit-ted quantum signals through the atmosphere, demonstrating secure key exchange across an open-air path.

The system used QNu Labs' Armos hardware-based quantum key distribution platform and its Pointing, Acquisition and



Tracking system. The latter is essential for maintaining alignment between transmitting and receiving terminals, particularly when optical signals must travel over several kil-ometres through the atmosphere.

During the trial, the link maintained a Quantum Bit Error Rate below 5 per cent and generated en-cryption keys at between 230 and 260 bits per second. The keys were subsequently integrated with BISAG-N's Vedic Kavach

Mahindra Group and Embraer Advance Plans for C-390 Millennium

Mahindra Group and Embraer are continuing preparatory discussions and planning activities re-garding an industrial and support ecosystem for the C-390 Millennium in India, as the companies jointly pursue the Indian Air Force (IAF) Medium Transport Aircraft (MTA) programme.

As part of their ongoing preparations, Mahindra and Embraer are working with the Government of Maharashtra and have identified Nagpur for a potential Final Assembly Line for Embraer C-390 Mil-lennium aircraft production in India. The proposed facility would support the local assembly and industrialisation of the aircraft in India, subject to the Embraer C-390 Millennium being selected by the Government of India and an order being placed under the IAF's MTA programme.

The companies are working closely with the Maharashtra Government on completion of the associ-ated processes,



with the objective of ensuring that the required industrial infrastructure can be pro-gressed expeditiously if the programme is awarded to the partnership.

The proposed Nagpur facility would be a state-of-the-art facility in India bringing knowhow on air-craft assembly, system integration, manufacturing engineering, local supply chain development and others into the country. Subject to the programme award, the partnership intends to progressively integrate Indian aerospace companies into the C-390 Millennium ecosystem, to deliver manufactur-ing, aftermarket services, training and lifecycle support, in line with the Government of India's Make in India and Aatmanirbhar Bharat objectives.

Embraer and Mahindra entered into a Strategic Cooperation Agreement in October 2025 to jointly advance the C-390 Millennium for the IAF's MTA programme, building on their earlier MoU signed in February 2024. The agreement envisages

India's First 5 km-Scale Free-Space QKD Link

platform, which combines post-quantum cryptography with quantum ran-dom-number generation.

Test messages were successfully encrypted and decrypted end to end. The architecture therefore combined two layers of protection: QKD at the hardware level and post-quantum cryptography at the software level. This arrangement is intended to preserve secure communications even if the quantum channel is temporarily disrupted.

QKD does not directly transmit ordinary messages. Instead, it creates and distributes encryption keys using quantum states of light. Because observing or measuring those states can disturb them, an interception attempt may introduce detectable errors. The communicating parties can then re-ject a compromised key and generate another one.

The technology is attracting attention as quantum computers threaten to weaken some widely used public-key systems, including those based on integer factorisation and elliptic-curve mathematics.

However, QKD is not a complete cybersecurity solution by itself. It requires specialised optical equipment, authenticated conventional communication channels and careful protection against im-plementation flaws. Post-quantum cryptography remains important because it can be deployed across existing digital networks.

India's latest demonstration extends an earlier free-space experiment by the Defence Research and Development Organisation and IIT Delhi. That 2025 trial covered more than one kilometre, record-ed a secure key rate of approximately 240 bits per second and maintained a quantum bit error rate below 7 per cent.

The result also aligns with the objectives of India's National Quantum Mission, ap-proved in 2023 with a budget of ₹6,003.65 crore. The programme seeks to build domestic capability in quantum computing, communication, sensing and materials, while supporting a future satellite-based secure communications network between ground stations separated by up to 2,000 kilome-tres.

Free-space systems could prove especially valuable where laying fibre is expensive or impractical, including mountainous regions, military theatres and links between ground stations and satellites. Atmospheric turbulence, weather, line-of-sight requirements and precise terminal alignment re-main significant engineering challenges.

For India, the latest trial is therefore both a technical achievement and a field test of commercial readiness. Its success offers a platform for longer terrestrial links and future space demonstrations, while strengthening the country's push to develop secure communications using domestically built technology.

Industrialisation

collaboration on industrialisation, local manufacturing, assembly, supply chain development and MRO activities in India. In February 2026, the companies also announced plans to work towards establishing a C-390 Millennium MRO capability in India, subject to the aircraft's selection under the MTA programme.

The C-390 Millennium is a multi-mission military transport aircraft designed to perform a range of missions including troop and cargo transport, airdrop operations, medical evacuation, search and rescue, firefighting and humanitarian missions. The aircraft has a payload capacity of up to 26 tonnes and is designed to operate from temporary or unpaved runways.

The proposed industrialisation programme would leverage Embraer's aerospace engineering and aircraft manufacturing expertise with Mahindra's established manufacturing capabilities and exten-sive Indian industrial ecosystem.

Bharat Forge and RTX's Pratt & Whitney Canada Sign Contract for Critical Aerospace Engine Components



Bharat Forge Ltd (BFL), a global leader in advanced forging and precision engineering, has secured a long-term contract with Pratt & Whitney Canada, a world-renowned aerospace engine manufactur-er, for the supply of mission-critical aerospace engine components. The components will be manufactured at BFL's state-of-the-art aerospace facility in India, specifi-cally developed to produce high-performance, high-value, aero-engine products. The facility inte-grates advanced manufacturing technologies and operates in accordance with the highest global standards of quality, precision, reliability, and traceability required by the aerospace industry.

The partnership reflects the confidence leading aerospace OEMs place in Bharat Forge's engineering expertise, manufacturing excellence, and commitment to delivering mission-critical high-value so-lutions that meet the global aerospace industry's stringent performance requirements.

FN Browning Group Launches FN® M3M ENDURANCE



FN – the iconic brand of FN Browning Group's Defence & Security division, which includes FN Herstal, FN UK and FN America has introduced the FN® M3M ENDURANCE, the latest in the international series of M3 .50 calibre machine guns.

FN has taken the most powerful, combat-proven .50 calibre weapon system and increased its service life by 50% while also extending maintenance intervals by three times, all while retaining its worldwide-recognised high firing rate for maximised hit probability.

Backed by over 135 years of empowering those who serve, defend and protect us with the most dependable defence and security solutions, the FN M3M ENDURANCE is part of a cutting-edge, fully integrated pintle system designed to counter current and emerging threats, including C-UAS. The globally warrantied system includes not only weapons, but also ammunition, mounts, ILS support services, operator training and accessories such as the FN ELITY® LITE laser range finder and IR laser pointer/illuminator, plus the FN SMARTCORE® shot counter for maintenance tracking and optimisation.

Fully integrated and qualified by FN, the FN M3M ENDURANCE is the next generation .50 calibre machine gun, still delivering a high rate of fire of 1,100 RPM and specifically designed for seamless integration onto new or in-service FN crew-served weapon systems across air, land, sea and ground-based platforms. It is the answer to users who want to reduce maintenance workloads and increase machine gun operational availability.

FN expertise in pintle weapon systems has been recognised for decades. In the late 1970s, the company – already a global leader in the design and development of small calibre firearms and ammunition – began to integrate its unequalled machine guns into pintles for use on a wide range of air, land and sea vehicles. The FN M3M ENDURANCE takes this approach to new levels, improving both in-service time and ease of maintenance. In addition, it can also be mounted on a ground-based pedestal and used for perimeter defence and C-UAS missions.

Building on the only proven open-bolt .50 calibre FN M3 machine gun platform in service worldwide, the FN M3M ENDURANCE increases lifetime from 40,000 to 60,000 rounds while extending preventive maintenance intervals from 5,000 to 15,000 rounds.

The FN M3M ENDURANCE is a fully automatic .50 calibre machine gun designed to fire Ball, Tracer, AP, API, APIT and APEI ammunition. With full control in any firing position, the open-bolt weapon has an effective range of 2,500 metres and a maximum range of 6,500 metres, plus can be fed from the left or right side.

IAI Unveils POINT@ AIR, A New Tactical Aerostat-Based Radar

Israel Aerospace Industries (IAI), a world-class aerospace and defence leader, will unveil POINT@AIR, a new mobile aerostat-based radar solution, at the Association of the United States Army (AUSA) Annual Meeting & Exposition in Washington, D.C. taking place this week.

POINT@AIR brings long-range radar detection and persistent surveillance to a compact, highly mobile aerostat platform. Its elevated position extends line of sight beyond terrain and other ground-level obstructions, supporting earlier detection of low-altitude threats while enabling forces to adapt surveillance coverage as mission requirements evolve.

Designed for persistent operation and rapid relocation, the system can operate without reliance on permanent infrastructure and can detect and track multiple aerial, maritime and ground targets. It supports multiple missions simultaneously, prioritise targets according to operational requirements, and interface with command-and-control systems to contribute to an integrated operational picture.

Based on the proven ELM-2083 radar family, POINT@AIR incorporates advanced Active Electronically Scanned Array (AESA) technology, with electronic scanning in both azimuth and elevation combined with mechanical rotation to provide 360-degree coverage.



BIG BANG BOOM SOLUTIONS

Your Friendly Neighbourhood Defence Company

PORTABLE SHOOTING RANGE

Unleash Precision Anywhere with Our Portable Shooting Ranges.

Your Compact Solution for Professional Training and Tactical Readiness

- COST-EFFECTIVE & SPACE-EFFICIENT
- HIGH-SAFETY STANDARDS
- REAL-TIME SHOOTING PERFORMANCE TRACKING
- ADVANCED AI-BASED SHOOTING
- VERSATILE TRAINING SCENARIOS
- WEATHERPROOF & ALL-SEASON OPERATION



MOBILITY

The containerized shooting range can be easily transported and deployed to virtually any location, offering flexibility for both permanent and temporary training setups. Its mobility is highly beneficial for remote areas or missions that require quick setup and takedown.



MODULARITY

These ranges are modular and customizable to meet specific training requirements, such as different shooting distances, ballistic standards, and target systems. Multiple containers can be combined to create larger or more complex range systems, such as multi-room tactical training environments.



SAFETY

Equipped with advanced anti-ricochet materials, ballistic-rated walls, and soundproofing. Our ranges ensure the highest levels of safety for users. These materials are designed to absorb rounds, preventing hazards from ricochet and stray bullets, while also minimizing noise pollution.

www.bigbangboom.com

+91 98925 99220

#TheDecisiveEdge

www.Larsentoubro.com



Aerospace Solutions

THE DECISIVE EDGE

across the spectrum



Unmanned Platform Solutions

Land Platforms and Equipment



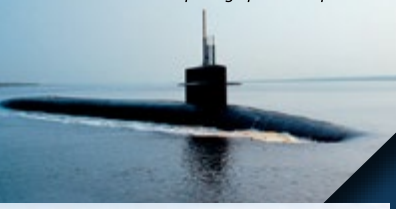
Larsen & Toubro is leading the change with future-ready equipment, fully-integrated platforms and autonomous systems; designed and developed to deliver the decisive edge across land, sea and air.



Shipbuilding Solutions

Subsea Vehicles and Platforms

The photograph is for representational purpose only.



L&T's Shipyard at Kattupalli



Strategic Systems Complex, Talegaon



Precision Manufacturing & Systems Complex, Coimbatore



Armoured Systems Complex, Hazira

L&T Precision Engineering and Systems

A brand of Larsen & Toubro Limited

For more information on our defence systems contact: pes@Larsentoubro.com

Regd. Office: Larsen & Toubro Limited, L&T House, N. M. Marg, Ballard Estate, Mumbai - 400 001, INDIA ON: L99999MH1946PLC004768

The company does not manufacture any explosives or ammunition of any kind, including cluster munitions or anti-personnel landmines or nuclear weapons and also does not customise any delivery systems for such munitions.