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AEROSPACE NEWSLETTER

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"NISAR is not just a satellite; it is India's scientific handshake with the world,"

Dr. Jitendra Singh,
Minister of State, Department of Space

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Air Power Musings: Silence of the SAMs

Gp Capt VP Naik VM | 01 July 2025

[Source: CAPS India | https://capsindia.org/air-power-musings-silence-of-the-sams/](https://capsindia.org/air-power-musings-silence-of-the-sams/)

Operation Midnight Hammer, was launched jointly by the United States Air Force (USAF) and the US Navy (USN) attacking the Fordow Uranium Enrichment Plant, Natanz Nuclear Facility and the Isfahan Nuclear Technology Center in Iran on June 22, 2025. The American bombers flew for 18 hours from mainland USA, joined up with 4th and 5th generation fighters acting as sweeps and escorts and delivered their load on the intended targets before returning to the US.

Suppression/destruction of Enemy Air Defences (SEAD/DEAD) operations, deception and decoy attacks, and Electronic Warfare (EW) were carried out prior to the main attack. Remarkably, throughout the entire mission, the potent Iranian Air Defence (AD) remained inactive, with not a single Surface-to-Air Missile (SAM) being launched either during ingress or egress. Either the Israelis paralysed the entire AD system of Iran during Operation Rising Lion (most probable), or the USA caught them by surprise (a remote possibility, especially with the Israel-Iran War going on), or the Iranians chose not to fire. Whatever the reason, it is certainly something that warrants further discussion and analysis.

Historical Timeline

Iran's armed forces consist of two separate, parallel militaries – the Artesh (established in 1921), which is the regular force, and the Islamic Revolutionary Guard Corps (IRGC), formed from armed militias during the 1979 revolution. The Imperial Iranian Armed Forces, under the Artesh, evolved into the Islamic Republic of Iran Ground Force (IRIGF), the Islamic Republic of Iran Air Force (IRIAF) and the Islamic Republic of Iran Navy (IRIN). The Artesh, which pre-dated the revolution, focused on defence against external threats. At the same time, the IRGC was created to defend the Islamic regime and Islamic system of government from foreign and domestic threats. In 1985, the IRGC was divided into the IRGC Ground Force (IRGCGF), the IRGC Air Force (IRGCAF) and the IRGC Navy (IRGCN). In 2008, the Khatemolanbia Air Defence Headquarters (KADHQ) was established within IRIAF to oversee the Air Defence requirements of Iran. In 2009, IRGCAF was renamed the IRGC Aerospace Force (IRGCASF). In 2019, the KADHQ was elevated to the Artesh HQ, with the Artesh Air Defence Force subsequently renamed the Islamic Republic of Iran Air Defence Force (IRIADF).

The IRIADF

The IRIADF consists of approximately 15,000 active personnel and features a mix of legacy and modern equipment. The IRIADF is responsible for protecting the Iranian airspace from aircraft, drones and incoming missiles. While less advanced than Western or Russian systems such as the US Patriot and Russia's S-400, Iran's domestically developed systems have shown significant progress over the last two decades. Some key elements of IRIADF include the Arman Long-Range Air Defence System, the Azarakhsh Low-Altitude Air Defence System, the Khordad-15 Air Defence System, the Bavar 373 Missile Defence System, and the S-300 Missile Defence System. These systems are integrated into the C2 architecture for quick response to any emerging threat. Details of a few newly inducted systems available in the open source are as follows: –

(a) **Arman, Long Range Air Defence System**: Unveiled to the world on February 17, 2024, it is a long-range air defence system capable of intercepting ballistic missiles. In English, Arman means "Aspiration". The system can simultaneously engage six targets at a range of 120 to 180 km. The system utilises Iran's indigenously manufactured Sayyad-3 class of missiles and has two versions: one with a passive radar and the other with an active radar.

(b) **Azarakhsh, Low Altitude Air Defence System**: Unveiled to the world on February 17, 2024, Azarakhsh (lightning) is a low-altitude AD system that can simultaneously use radar and electro-optic systems to detect and intercept targets. The system utilises heat-seeking missiles (IR) to lock onto targets, including missiles and aircraft.

(c) **Khordad-15 Air Defence System**: The Khordad-15 was developed by the Iran Aviation Industries Organisation (IAIO) and unveiled to the world in June 2019. The system was designed to detect and intercept a range of aerial threats, including fighters, stealth targets, Unmanned Combat Aerial Vehicles (UCAVs) and Cruise Missiles using Sayyad-3 missiles.

(d) **Bavar-373 Missile Defence System**: The Bavar-373 represents a significant advancement in Iran's air defence capabilities. It is a long-range, road-mobile SAM system developed in August 2016. The name Bavar-373 carries a symbolic meaning, translating to "Belief", with 373 representing a numerical equivalent to "O, Messenger of Allah" in Abjad numerals. It is believed to be an Iranian equivalent of the S-300 system of Russia and also has an upgraded version believed to be equivalent to the S-400 system.

(e) **S-300 Missile Defence System**: The S-300 missile defence system is a formidable asset in Iran's arsenal. Capable of tracking and intercepting airborne threats 300 km away, the system can also engage ballistic missiles. The Iranian configuration features a surveillance radar for search, a command vehicle for target identification and launch orders, an engagement radar for missile guidance and six launch vehicles capable of firing two missiles each. Russia delivered the system to Iran in November 2016, marking a significant milestone in the development of Iran's AD network and infrastructure.

(f) **Radar and Command Systems**: Iran's missile defence network relies on an extensive array of radars and sensors. Indigenous radars like Ghadir and Sepehr can detect targets up to 1,000 km and are integrated into a centralised Command and Control (C2) system, enabling real-time coordination of air and missile defences. Coordination of national-level AD is the responsibility of KADHQ, which controls Iran's AD C2, surveillance radars, SAM systems and a network of visual observation posts. While C2 is centralised during peacetime at the National Air Defence Operations Centre, it can become decentralised for operations, transferring decision-making authority down to a network or the regional Sector Operations Centres (SOCs), which may be either static or mobile. SOCs manage AD operations within their areas of responsibility and coordinate with adjacent sectors to ensure seamless integration and continuity of operations.

(g) **Analysis**: The Iranian AD system is a small and potent organisation capable of taking on a wide variety of threats. A mix of legacy and modern systems, on paper, the AD system appears to be very capable but has not been battle-proven. The system also has limited capabilities when compared to the modern Integrated Air Defence Systems (IADS) due to severe technological constraints resulting from various sanctions imposed on Iran over the last few decades. Iran primarily relies on Russia and China for the import of technology. The airborne AD assets of Iran are "few and far between". Being one of the few countries still operating the F-14A/AM Tomcat, the IRIAF also has the vintage MiG-29 in its arsenal, making its airborne AD a relatively underdeveloped and ineffective system. The system may not be fully capable of withstanding a strike of the magnitude and scale of the US's Operation Midnight Hammer. However, it will have the capability to inflict limited damage on the attacking forces. Iran should have extensively used its indigenously developed AD systems during the strikes but failed to fire even a single shot. The S-300 is a reasonably potent system with long-range capability. Why did this system also fail to fire?

The main reason for the failure of AD appears to be the systematic dismantling of the entire AD network by Israel from the time the war started. Since June 12, 2025, Israel has established air supremacy over Iran with very little prohibitive interference, and the Israeli forces have been enjoying complete freedom of operations in Iranian air space. Israel destroyed all major Iranian AD systems (80 batteries) in the first two days of the Israel-Iran War (Operation Rising Lion), and Iran was left with only passive measures like camouflage and concealment, dispersion and hardened underground structures to defend itself. [9] With the Iranian AD system paralysed, why would the US forces fly in with a force structure as large as 125 aircraft??

Challenges and Limitations

The Iranian AD system faces many significant challenges and limitations. The system is quite old, with newer technology being slowly introduced. The system lacks a comprehensive, multi-layered architecture, a hallmark of modern AD and C2 systems. Iran faces a severe constraint in accessing modern technology, primarily due to the numerous sanctions imposed on it. These technological constraints have limited their system's ability to meet global standards, significantly affecting its range, response, and effectiveness. Iran has significant dependencies on foreign suppliers, mainly Russia, which has limited its autonomy and delayed upgradations. Spare support and supply chain management have also deteriorated over the years, thereby affecting the overall capability of the AD network. The system could easily have been saturated due to the inherent architecture of the network. Overall, the system is highly reactive but may not be able to engage a large-scale strike using modern weapons and aircraft. In addition, during Operation Midnight Hammer, the system had already been targeted by Israel in the preceding days, making it more vulnerable, almost non-existent, on the day of the main attack by the US forces.

Lessons Learnt

There are many important takeaways from this operation, both in terms of AD and C2. Some key takeaways are being listed and discussed.

(a) **Requirement of a Modern IADS**: There is no denying the fact that a robust and effective modern IADS is required, one that can detect and engage the entire gamut of targets, ranging from small drones and quadcopters to ballistic and hypersonic missiles. However, no system has yet been developed which can take on the entire spectrum of threats. Ingenuity, innovativeness and smart integration have the potential to create a system close to a utopian one. A mix of legacy and modern systems with varied capabilities would need to be networked to create a system of systems capable of addressing the majority of perceived threats.

(b) **Indigenous Development**: AD systems often have very niche technology embedded into them. From detection and identification to decision and action, there is a need to develop this technology in-house. The four key processes of AD- namely, Detection, Identification, Interception, and Destruction- need to be infused with indigenous technology to avoid compromising effectiveness in times of need. Modern systems utilise Artificial Intelligence (AI) and Big Data for each of the four functions, and the roles of the indigenous industry and academia have become increasingly crucial.

(c) **Mass, Mix and Mobility**: Smart and modern AD systems are an amalgamation of different calibres of weapons in terms of range and altitude of engagements (mass). The system must also incorporate a mix of varied guidance and homing capabilities to mitigate the effects of Electronic Warfare (EW) and Electronic Attack (EA). The system must also be a mix of different vintages because no country can afford to have only modern weapons in its arsenal. This mix would ensure that the adversary is always thinking of a suitable counter to a varied inventory, which may be difficult to carry on limited platforms. The network also needs to have a healthy combination of mobile, transportable and fixed elements to provide the necessary flexibility for operations.

(d) **Vulnerability of Long Range LRSAMs**: Modern Long-range SAMs are essential components of an IADS. However, they have their associated issues. Most LR SAMs are transportable but not inherently mobile. Their associated systems and support infrastructure is fairly large making them almost static. This makes them vulnerable. Choosing alternate sites, providing the LRSAM intrinsic cover using other weapons systems and transporting them to alternate sites for operations are a few key elements that must be thought of and exercised regularly.

(e) **Airborne Elements**: Airborne elements like AD fighters, Airborne Warning and Control System (AWACS), Airborne Early Warning and Control System (AEW&C), Flight Refuelling Aircraft (FRA) and Special Mission Aircraft (SMA) for EW operations are essential ingredients of the IADS and cannot be ignored. The Iranian AD system severely lacks airborne assets, making it more vulnerable and less effective.

(f) **The Longer Stick**: There is no denying the fact that possessing the longest stick has tremendous inherent advantages in terms of first-shot capability; therefore, Tactics, Techniques, and Procedures (TTP) must be developed to counter them. Additionally, there is a need to integrate long-range aerial weapons on a wider variety of aircraft to ensure multiple threats to airborne targets. Developing the first shot capability is essential in the modern AD environment, and countering it even more so.

(g) **Survivability of C2**: The modern battlespace increasingly relies on information and decision superiority. The survivability of C2 infrastructure will undoubtedly give the defending force a significant advantage. All strikes will be preceded by Counter-Air Operations (CAO); therefore, one must create robust, redundant, and survivable infrastructure to maintain effective C2.

(h) **Stealth**: Low-observable technology is here to stay. Conventional radars may struggle to cope with this new trend in aerial warfare; therefore, there is a need to develop technology, such as VHF radars, to counter the use of stealth by an adversary. Due to their longer operating wavelength, VHF radars have been known to detect stealth platforms. Interestingly, some of the oldest radars have been VHF radars and the time may be right to resurrect this technology for use in the modern battlespace to counter 5th and 6th generation aircraft.

(j) **Developing Anti-Hypersonic Capability**: Hypersonic weapons are the latest class of weapons that have already invaded the modern battlespace and counters are yet to be developed. Counter-hypersonic technology would be very niche and once developed, no country would want to share it. Therefore, indigenous counters to hypersonic weapons must be developed.

(k) **Integrated Application of Combat Fire Power**: The Iranian forces have been arrayed into very rigid verticals with very little or no overlap. Each silo operates independently, thereby reducing their overall effectiveness. Ownership of assets is not important; what is important is the integration of assets. The C2 organisation must have the most appropriate weapon system at its disposal at the right time to be effective and timing is crucial. One cannot afford to act in silos; therefore, the creation of integrated systems, irrespective of ownership, is crucial for winning tomorrow's wars.

(l) **Logistics and Supply Chain Management**: Iran faces numerous challenges in terms of access to spares and modern technology due to sanctions and a lack of indigenous industry. Despite this, Iran has made significant strides in developing a vibrant in-house drone manufacturing industry. Iran has been utilising them for a wide range of missions, including Intelligence, Surveillance, and Reconnaissance (ISR) operations and air-to-ground strikes. While they may not have access to high-end technology, they are making a constant effort to develop the same within Iran. Regular upgrades, spare support, and effective logistics supply chain management would go a long way in enhancing a nation's war-waging potential.

Parting Shots

The Iranian Air Defence was known to be a potent system in its arsenal, and yet it failed miserably. Why did Iran not fire a single SAM? How was the S-300 silenced? Who silenced the S-300? How did all the 125 aircraft involved go unnoticed? Why did China or Russia not warn Iran of the incoming strike? The bombers were in Iranian airspace for twenty minutes, and the support aircraft were within/in proximity of Iran airspace for nearly ninety minutes, yet no SAMs could be fired. The reasons for failure could be many, and some of them have been discussed in this paper. However, the "Silence of the SAMs" is surely very deafening.

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Lessons Observed from the War Between Israel and Iran

Bilal Y. Saab and Darren D. White | 16 July 2025

Source: War on the Rocks | https://warontherocks.com/2025/07/lessons-observed-from-the-war-between-israel-and-iran/

The outbreak of direct hostilities between Israel and Iran in June represents one of the most significant geopolitical escalations in the Middle East in recent history. What began as a calculated pre-emptive strike by the Israel Defense Forces against Iranian nuclear facilities, under the codename Operation Rising Lion, swiftly evolved into a multi-theater war involving cyber, air, and naval engagements.

Within days, the United States entered the conflict through Operation Midnight Hammer, employing more than 125 aircraft and seven B-2 Spirit bombers — the latter dropping 14 bunker-buster bombs, 30,000 pounds each, against Iranian nuclear infrastructure. U.S. Chairman of the Joint Chiefs of Staff Gen. Dan Caine described the operation as the "largest B-2 operational strike in U.S. history."

Iran retaliated through a mixture of ballistic missile and drone strikes, as well as cyber attacks. It would have loved to utilize the firepower of its once robust network of armed non-state proxies in the region — Hizballah in Lebanon, Hamas in the Palestinian Territories, the Houthis in Yemen, and the militias in Iraq — but it couldn't because Israel had done a terrific job of massively degrading their military capabilities (at least Hizballah and Hamas). During the brief but intense Iranian-Israeli confrontation, those proxies remained largely silent either because they couldn't get into the fight in a meaningful way or because they were unwilling due to domestic political constraints.

While a fragile ceasefire was brokered after 12 days of combat, the nature of the conflict underscored the transformation of modern warfare — hybrid, decentralized, and fought across physical and digital domains.

Multi-Domain Combat in Action

The Israeli military's initial operation demonstrated unparalleled coordination of stealth aircraft, intelligence, cyber disruption, and psychological warfare. More than 200 sorties, involving F-35I Adir and F-15I Ra'am aircraft, struck over 100 targets across Iran, including nuclear sites at Natanz, Isfahan, and Fordow. These kinetic actions were preceded by months of intelligence-gathering, sabotage, and cyber intrusions executed by Mossad, the Israeli foreign intelligence agency, and Israel's Unit 8200.

In parallel, Israel's air superiority campaign is reported to have suppressed more than 70 Iranian surface-to-air missile systems, paving the way for deeper strikes. The United States entered the fray days later, targeting deeply fortified Iranian sites using Massive Ordnance Penetrators launched from B-2 bombers. These strikes inflicted damage on key enrichment support structures, but there is an intense debate at the moment about the level of damage and whether Iran still has enriched uranium. Based on early intelligence, European officials claimed that Iran's enriched uranium stockpile is largely intact. However, U.S. Secretary of Defense Pete Hegseth said he was unaware of any intelligence suggesting Iran had moved any of its highly enriched uranium to shield it from U.S. strikes.

Simultaneously, Iran retaliated by launching anywhere from 370 to 550 ballistic missiles and over 1,000 drones against Israel, complemented by cyber operations against Israeli critical infrastructure. Israel claims that the vast majority of the strikes were intercepted by its integrated and multi-layered air and missile defense system (with a 90 percent interception rate) — the Iron Dome, David's Sling, and Arrow systems, all of which were assisted by American Terminal High-Altitude Area Defense batteries. However, the sheer scale of the attacks — unique in Israel's history — revealed stress points in Israel's defensive grid.

Cyber Warfare

Judging by the level of synchronization of cyber actions with kinetic campaigns, the Iranian-Israeli war is a reminder of how cyber warfare is now a core domain of military strategy, not merely a supplement. Both Iran and Israel experienced the limits of cyber deterrence, particularly where private sector networks were inadequately protected.

Indeed, cyber operations played a pivotal role on both sides. Israel initiated the conflict with a cyber barrage that disabled Iranian radar systems, electronic warfare stations, and communications. Conversely, Iranian hackers targeted Israeli power grids, train networks, and digital infrastructure, with varying degrees of success.

Operational Successes and Shortcomings

Israel's tactical victories were marked by the achievement of rapid air dominance, high interception rates against Iranian missile barrages, and the disruption of Iran's command-and-control structure. U.S. kinetic strikes reinforced the impression of an overwhelming technological edge. Civil preparedness, with Israeli civilians reacting swiftly to warnings and occupying shelters, further limited casualties and infrastructure damage. Iran's ballistic missile attacks killed 28 people — all but one of them civilians — and wounded over 3,000.

Multi-domain integration — particularly the fusion of cyber, electronic warfare, intelligence, surveillance, and reconnaissance, and kinetic firepower — allowed Israel to operate with tempo and precision. Intelligence-led targeting, coordinated with Mossad's human intelligence network, ensured that Israel's initial strike had strategic depth and psychological impact, especially in the targeted killing of Islamic Revolutionary Guard Corps senior commanders including Saeed Izadi, a veteran commander who led the Palestine Corps of the Quds Force, and Behnam Shahriyari, commander of the Quds Force's Weapons Transfer Unit.

Despite these successes, the conflict exposed limitations in strategic overreach, proxy elimination, and escalation control. Iran's proxy forces, though badly hurt, still had capabilities that could have been used to support Iran's campaign. Hizballah's much reduced but continued missile capacity exposed the difficulty of destroying entrenched non-state actors with conventional force.

The Israeli defense grid experienced signs of fatigue. Batteries had to be rotated and reloaded at an unsustainable pace, underscoring the need for scalable and autonomous missile defense systems. Iran's cyber retaliation also demonstrated that even a state as cyber-capable as Israel remains vulnerable without a robust civilian digital defense strategy.

The effectiveness of American bunker-buster bombs against hardened sites is very much unclear. U.S. President Donald Trump claimed the strikes against Iran "completely and totally obliterated" its ability to produce nuclear weapons. Jeffrey Lewis, a weapons and nonproliferation specialist with the Middlebury Institute of International Studies, argued that the attacks do not appear to have destroyed Iran's nuclear program. A classified U.S. intelligence report was leaked to several U.S. media outlets suggesting that the U.S. strikes damaged but did not eliminate Iran's nuclear capacity. Further, an intercepted call between Iranian officials was leaked to the media: These officials reportedly said they were surprised the U.S. attack on the nuclear facilities had not been larger and more damaging. Absent a comprehensive bomb damage assessment by the U.S. government (which could take weeks for the military to finish and release), it is hard to tell whether the bombs fully destroyed the nuclear facility at Fordow.

Lessons for the Future

The June 2025 conflict between Israel and Iran yielded a range of critical doctrinal insights for modern military planning. It not only reaffirmed the continuing relevance of conventional capabilities but also underlined the importance of cyber integration, information dominance, strategic precision, and alliance cooperation in 21st-century conflict scenarios. From this conflict, we derive nine lessons.

One, try not to fight alone (especially if you have powerful friends). Israel's ability to execute Operation Rising Lion and maintain a credible deterrent posture in the face of Iranian retaliation would have been significantly impaired without the support of strategic partners — chief among them, the United States. The June 2025 conflict underscored the strategic, operational, and technological benefits that arise from such alliances. Direct American involvement sent an unambiguous message of alliance solidarity. U.S. military assets were deployed rapidly, demonstrating America's unique capacity for global strike operations. More importantly, U.S. forces provided critical missile defense support through the deployment of several kinds of advanced missile defense batteries in both Israel and the Gulf region. This operational integration allowed Israel to concentrate its Iron Dome and David's Sling systems on civilian areas, knowing that U.S. systems could help shield military installations and broader regional assets. Such cooperation extends well beyond munitions — it reflects deep interoperability, joint planning doctrines, and shared intelligence frameworks.

Two, establish air superiority. Air superiority remains the cornerstone of operational success, but it ought to be supplemented by cyber dominance, intelligence, surveillance and reconnaissance integration, and electronic warfare. Israel's early success in neutralizing Iranian radar systems and air defenses enabled its air force to carry out long-range operations with minimal resistance. The seamless coordination of stealth aircraft, real-time intelligence feeds, and electronic suppression created the conditions necessary for operational freedom.

Three, ensure strategic precision. The success of targeted strikes on Iran's nuclear infrastructure demonstrated the enduring power of strategic precision. Israeli and U.S. forces, operating in concert, were able to destroy critical enrichment sites, disable support systems, and severely degrade Iran's nuclear research timeline. Although the most deeply buried facilities such as Fordow withstood direct assault due to hardened construction, surrounding infrastructure was incapacitated. These strikes delayed Iran's nuclear progress by an estimated 18–24 months and served as a reminder that targeted, intelligence-led operations can deliver disproportionate strategic effect. Israel's access to U.S. satellite surveillance, AI targeting support, and shared signals intelligence significantly enhanced the precision and tempo of its strikes. Joint intelligence assessments also enabled rapid battle damage assessment and facilitated strategic decision-making within hours of engagements.

Four, master drone warfare. Drones have evolved into a strategic weapon system, capable of saturation, deception, and long-range attritional warfare. Iran's drone swarms, while largely intercepted, tested the limits of Israel's multi-layered air defenses and forced Israel to expend high-value interceptors on low-cost unmanned aerial vehicles. Future warfare will require investment in AI-driven targeting algorithms, directed energy weapons, and low-cost drone countermeasures to neutralize large-scale unmanned threats without depleting strategic resources.

Five, anticipate and embrace hybrid warfare. Hybrid warfare — encompassing physical, cyber, informational, and psychological domains — is now the prevailing model of conflict. Israel's campaign combined high-value kinetic strikes with psychological operations, digital disinformation management, and cyber operations, sowing disarray within Iran's command structure and public communications. In this new battlespace, success demands anticipatory intelligence, rapid adaptability, and strategic messaging that shapes both battlefield perception and international opinion.

Six, invest in integrated air and missile defense. Had Israel not done precisely that, it would have been in a world of trouble. Iran's missile and drone attacks would have caused much more significant infrastructure damage and greater casualties. Thanks to U.S. sponsorship and Israeli technological ingenuity, Israel boasts one of the most effective air and missile defense systems in the world. This is a lesson the Gulf Arab states should learn and should have learned a long time ago. These countries should come together on this issue and waste no more time creating a shared early-warning system across the Gulf region. Such a system, which the Gulf Arab states would have to obtain from Washington, is the most critical element of integrated air and missile defense — the first layer of defense. It provides fast and uninterrupted reporting on the location and trajectory of ballistic missile launches so countermeasures can be prepared, and civilian populations can be warned and protected. Imagine if the Iranian ballistic missile strike on June 23 on the U.S. military base of Al Udeid in Qatar had been more extensive. It would have required the assistance of Doha's neighbors — except that they can't help, at least effectively, because they are not on the same network or information-sharing platform. They need a common regional missile defense architecture of satellite and radar data to counter Iran's missile and drone threats.

Seven, contain and ideally eliminate the capabilities of proxy forces. For years, Iran's reliance on Hezbollah, Hamas, the Houthis, and Iraqi militias has created layered threats across four geographic theaters. These actors not only expanded the battlefield but allowed Tehran to wage indirect war while oftentimes retaining plausible deniability. For states such as Israel, countering this asymmetric depth requires a broader doctrine encompassing sustained counter-proxy disruption, regional coalition-building, and legal frameworks for preemptive and retaliatory action against non-state belligerents.

Eight, don't downplay psychological operations. Psychological operations and strategic information management were key features of Israel's campaign. These tools were used not only to paralyze Iranian response networks but also to potentially influence decision-makers, shape public perception, and manage escalation on both domestic and international fronts. In the early hours of Operation Rising Lion, Israeli operatives reportedly sent direct warnings to Islamic Revolutionary Guard Corps officers moments before airstrikes. While designed to reduce collateral casualties, these calls also served a psychological purpose inducing fear, confusion, and mistrust within Iran's military command. By suggesting intimate knowledge of individual movements and locations, Israel sowed doubt in the security of Iran's internal communications and protection protocols. The psychological impact of Israeli precision strikes (particularly the assassination of high-ranking revolutionary guard officers) was felt beyond the military. Civilian populations across Iran reportedly experienced waves of panic, fueled by social media reports of air incursions, disrupted communications, and conflicting government statements. This internal disquiet, while not amounting to civil unrest, applied pressure on Tehran to consider de-escalation pathways. In effect, psychological operations operated as a non-kinetic force multiplier, amplifying the strategic effects of kinetic strikes without expanding battlefield footprints.

Nine, rethink deterrence. The war demonstrated that deterrence in modern warfare is no longer a static binary. It is fluid, multifaceted, and cumulative. Israel's ability to deliver high-impact strikes while defending its population centers showcased a powerful deterrent capacity. However, Iran's survival, retaliation, and proxy endurance highlight the difficulty of achieving strategic resolution through force alone. Future deterrence ought to be calibrated through visible military capability, political clarity, alliance cohesion, and control over the escalation ladder.

The Changing Character of Regional War

The 2025 conflict between Israel and Iran signaled a profound shift in the character and conduct of regional warfare. It reaffirmed the centrality of alliances, psychological operations, and precision targeting, while also highlighting the evolving role of strategic deterrence and information warfare in shaping outcomes.

The successful targeting of Iran's nuclear facilities — executed with surgical precision and coordinated through joint U.S.–Israeli intelligence — proved that well-executed, pre-emptive action can yield measurable delays in adversarial weapons development. These strikes were not only militarily effective but psychologically disorienting, undermining confidence within Iran's defense establishment and signaling Israel's reach, capability, and intent.

Just as importantly, the campaign revealed that influence is now a force multiplier. Strategic communication, public diplomacy, and psychological operations achieved effects far beyond the battlefield. They neutralized panic at home, destabilized enemy cohesion, and helped shape global narratives. As such, psychological operations and information dominance now sit alongside airpower and cyber warfare as core pillars of modern national defense.

Equally critical was the role of strategic partnerships. Without U.S. intelligence, missile defense assets, and military coordination, Israel would have struggled to execute a campaign of such scale and precision. The conflict reinforced the idea that no nation, however capable, can operate alone in a multi-domain war. Success depends on interoperability, trust, and shared strategic objectives among allies.

The June 2025 conflict was not merely an episode in the Israeli-Iranian rivalry — it was a glimpse into the future of warfare. It showcased the fusion of conventional and unconventional tools, the necessity of operational resilience, and the unpredictability of asymmetric threats. It also raised enduring questions of how tactical victories can deliver strategic outcomes (which Israel has failed to do), and how nations can adapt to a battlefield that is no longer bound by geography or traditional rules of engagement.

As strategists and decision-makers assess the legacy of Operation Rising Lion and Operation Midnight Hammer, they should look beyond the metrics of destruction. The real measure of success lies in whether enduring security, stability, and deterrence have been achieved or whether this was merely the opening salvo in a new era of protracted, hybrid confrontation. The battlefield of tomorrow is not coming — it has already arrived. And only those nations that can operate across domains, at pace, and with strategic discipline will endure.

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Rethinking air superiority — Towards an Integrated Framework for Modern Airpower

Kazunobu Sakuma | 17 July 2025

Source: airforce.gov.in | https://airpower.airforce.gov.au/sites/default/files/2025-07/Sakuma_BP50818947.pdf

For over a century, the concept of air superiority has underpinned the strategic thought and operational doctrine of modern militaries. Rooted in the belief that control of the skies is a prerequisite for effective operations, this notion has traditionally emphasized achieving uncontested access to airspace early and decisively. Yet, contemporary conflict—particularly the war in Ukraine—has disrupted this model, revealing new dynamics where air superiority may never be fully achieved and where denial, parity, and technological innovation define air operations.

This blog outlines the evolution of airpower theory, compares major contemporary perspectives and critiques the limitations of binary thinking on air superiority. To address these limitations, I introduce a new concept, the Two-Parities Model, which expands the linear binary continuum into a multidimensional matrix. I conclude by suggesting an integrated framework for future doctrine and strategy.

Traditional and evolving perspectives on air superiority

Historically, air superiority has been conceptualized as a linear condition: a force either controls the skies or it doesn’t. This view was shaped by 20th-century conflicts like WWII and theGulf War, where uncontested air dominance enabled freedom of manoeuvre, decisive strikes,and rapid joint force integration. In these scenarios, the emphasis was on platforms (fighters,bombers), kinetic destruction, and offensive tempo.

However, evolving threat environments and emerging technologies have made this model less predictive. The conflict in Ukraine revealed a situation where neither Russia nor Ukraine achieved traditional air superiority. Instead, both employed air denial strategies, including layered air defences, mobile surface-to-air missile (SAM) systems, and extensive use of unmanned aerial vehicles (UAVs). This suggests a need to rethink what constitutes "air control" and to explore more flexible conceptual frameworks.

Figure 1. Traditional view of air superiority

Comparative Analysis of Contemporary Air Power Thought

This section compares major contributors to modern air power thought:

- **The Classical, Offensive View**: Deptula & Bowie (2024) represent a traditionalist school, asserting that achieving air superiority early remains essential. They see denial strategies as insufficient and emphasize high-end platforms and decisive offensive action. Their view reflects the legacy of US air power thinking.

- **A Joint-Oriented, Adaptive View**: Hecker (2024) and Bowsher (2023) offer a moderate, joint-oriented perspective, focusing on tailored, integrated, and adaptive use of air power. They accept that air superiority may not be achievable or necessary in all scenarios and stress the importance of cross-domain synergy.

- **The Air Littoral and Air Denial**: Grieco & Bremer (2024) highlight how Ukraine has effectively waged an 'air denial' campaign rather than seeking air superiority and has denied Russian aircraft freedom of manoeuvre in much of the operational theatre. They also emphasize that control of the air littoral can enable strategic effects without requiring dominance in traditional airspace.

Comparing these views reveals a spectrum of thinking. Deptula & Bowie (2024) are more offensive and platform-centric, while Grieco & Bremer (2024) are defensive and systemcentric. Hecker (2024) and Bowsher (2023) bridge the two by advocating flexibility and jointness. Yet all rely, to some degree, on a binary model of control—air superiority versus denial.

The Binary Trap — Limitations of Current Paradigms

This section critiques the traditional binary continuum that places air operations on a line from air superiority to air denial. The binary model obscures important operational realities:

- **Contested vs. Mutually Denied**: Current definitions fail to distinguish between airspace that is contested (where both sides can operate intermittently) and mutually denied (where neither side can exploit the air). This distinction is crucial for campaign design and operational planning.

- **Conceptual Blindness**: Treating denial as a temporary or undesirable phase dismisses the strategic utility of persistent air denial, which Ukraine has effectively used to prevent Russian dominance.

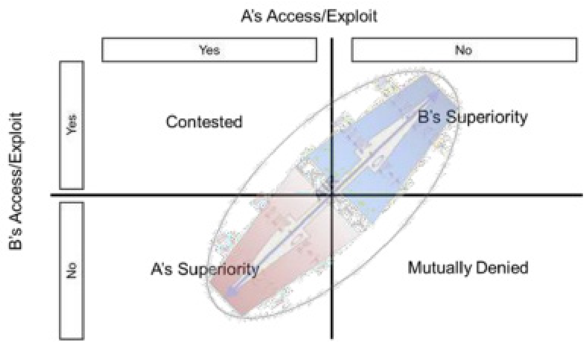
- **Doctrinal Gaps**: Planners and theorists are left without the tools to address environments that fall between superiority and denial. The result is a doctrinal blind spot that underestimates hybrid threats and technological adaptation.

Two-Parities Model — a Multi-Dimensional Continuum of Air Control

To overcome these shortcomings, I propose the Two-Parities Model, which expands the linear binary continuum into a multi-dimensional matrix:

- **A's Superiority**: Player A can access and exploit air without severe interruption by player B. Player B is denied access and exploit the air by player A.
- **Contested Parity**: Both actors intermittently access and exploit the air, often with losses. This resembles many areas of Ukrainian airspace.
- **Mutually Denied Parity**: Neither side can operate effectively, though access may be possible. In such zones, sustained flight is prohibitively risky. However, UAVs can still play a critical role.
- **B's Superiority**: Player B can access and exploit the air without severe interruption by player A. Player A is denied access and exploit the air by player B.

Figure 2. Two-Parities Model



This model clarifies that air control exists in degrees, not absolutes. Figure 2 shows the 2D framework that maps the relationship between access and exploitation-allowing operational planners to assess not just who controls the sky, but how and to what effect.

The Ukraine war provides vivid examples: the use of small UAVs for ISR and strikes under mutual denial, and Ukraine's layered denial preventing Russian air dominance despite numerical inferiority. The model offers a new lens through which such operations can be understood and anticipated.

Towards an Integrated Framework for Air Power Doctrine

This section synthesizes the previous insights into a unified analytical framework. The Two-Parities Model offers several benefits:

- **Conceptual Integration**: It bridges the views of Deptula & Bowie (2024), Hecker (2024), Bowsher (2023), and Grieco & Bremer (2024) by offering a structure that accommodates both offensive and defensive perspectives, kinetic and non-kinetic effects, and the utility of UAVs.

- **Flexibility and Planning**: The model enables more nuanced campaign planning in ambiguous or degraded air environments, accounting for how limited control can still yield operational effects.

- **Beyond Ukraine**: Though grounded in Ukraine's experience, the framework applies to future conflicts involving peer adversaries, A2/AD environments, and coalition warfare where full air superiority may not be achievable or necessary.

By recognizing that mutual denial can be both an intentional strategy and an operational reality, the framework encourages doctrine to move beyond the pursuit of dominance toward a focus on adaptive control and cross-domain leverage.

Conclusion

Air superiority is no longer a binary condition achieved early in conflict and sustained indefinitely. Instead, it must be understood as a dynamic spectrum, shaped by technological evolution, adversary adaptation, and strategic context.

The Two-Parities Model clarifies this complexity by expanding our vocabulary of air control. It captures the reality that contested and mutually denied airspaces demand distinct strategies, capabilities, and expectations. It also underscores how UAVs can reshape access and exploitation, even under conditions previously deemed off-limits.

Most importantly, the model facilitates integration across air power schools of thought, aligning theory with practice. It invites militaries to shed outdated assumptions, rethink operational design, and embrace a more pluralistic, flexible doctrine that reflects the realities of modern war.

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Trends in Military Uncrewed Aerial Systems

Air Marshal Anil Chopra (Retd) | 21 July 2025

Source: IADB | https://www.iadb.in/2024/07/21/trends-in-military-uncrewed-aerial-systems/

Uncrewed aircraft technologies have now matured. The world is in a transition. Dual-use (optionally crewed) aircraft are flying in larger numbers. Uncrewed Combat Air Vehicles (UCAV) are being intensively used in combat with more and more drones being armed with aerial weapons. Uncrewed Aerial System (UAS) are taking off and landing by themselves including on the moving aircraft carriers. Autonomous air refuelling has been tested. Uncrewed stealth bombers are under development. Uninhabited helicopter convoys can be used for delivering supplies to troops deployed on combat front lines.

Coordinated UAS swarms are already a reality and could also act as a multi-strike decoy or jam the enemy defences through sheer numbers. UAS strikes will be a must to lead into territories with integrated air defences. UAS are also being used for missions like electronic attacks or other non-lethal effects. By the year 2050 every conceivable mission, including heavy lift, would be unmanned.

With no pilot inside, there is a risk of lowering the bar to use force. Also, there is the risk of terrorists and non-state actors acquiring such assets. A casual hobbyist could by mistake fly a drone into an airliner. All these issues are being considered by regulators and security establishments. Counter-drone technologies are also evolving.

All militaries are acquiring UAS and drones to undertake a variety of missions. Major Powers are having design and production setups. A significant part of defence budgets is now being earmarked for UAS. India is also working on Artificial Intelligence (AI) based weapon systems and platform technologies.

Under the proposed $3.5 billion mega-deal, India will acquire 31 General Atomics MQ-9B high altitude, long endurance drones, with 15 SeaGuardians for the Indian Navy and eight SkyGuardians each for the Indian Army and the Indian Air Force (IAF). The Indian Navy has been operating two SeaGuardian drones (unarmed variants) on lease from the American Company since 2020. The long-endurance drones supplemented the Boeing P8-I maritime patrol aircraft.

Drones for Military

Militaries use drones mostly for dull, dirty, or dangerous missions. Dull, being long-endurance surveillance missions; dirty could be flying into a contaminated area; and dangerous would be in a highly contested threat area. Drones have been used in military operations for several decades. In the past, they were primarily used for surveillance. However, with advances in technology, drones have become more capable and versatile. They are now used for a wide range of military operations, including combat missions.

Important military missions are intelligence gathering, surveillance, and reconnaissance (ISR) which require high-resolution cameras and sensors. Drones support target acquisition and targeting by ground-based weapons or airborne platforms. They could also be used for laser lasing. Drones support battle damage assessment. Weapon-carrying drones are used for precision strikes, including from stand-off ranges. They can provide offensive air support in the ground battle against armour, gun positions and troops. Drones can perform interdiction missions.

Modern drones also have air-to-air weapons that could be used both for defensive and offensive missions. Drones could fire missiles to neutralize incoming cruise missiles and other platforms. They can be used as an anti-UAS platform or even knockdown a combat helicopter.

Drones help create combat zone situational awareness and in turn force protection. Drones are used for logistics and supply missions. They also act as airborne communications nodes to extend radio range. UAS greatly support search and rescue missions.

Large UAS Advantages but Challenges in Contested Domain

Large UAS platforms have high endurance and thus long loiter time and are ideal for surveillance. They have greater weapon carriage capability. They can fly high above small arms and man-portable AD weapons. In uncontested areas, they have been effectively used to destroy ground targets and also to target individual militant leaders as was done in Afghanistan and elsewhere in West Asia. Large UAS now have a flight refuelling role. Future UAS could be stealth.

But large UAS are expensive. They can be taken down by long-range SAMs and fighter aircraft. They were very effective in Iraq and Afghanistan because of the uncontested environment. American large drones have been threatened by Russians in Syria and the Black Sea despite de-confliction protocols being in place between the two superpowers. Yemen's Houthi rebels' air defences have successfully targeted them in West Asia. At least 5 MQ-9 Reaper drones have been downed.

With the major contest now developing between the U.S. and China and Russia, the environment would not be benign. Similar will be the case between India and its neighbours China and Pakistan. Yet large UAS continue to have a role with stand-off weapons and for large area surveillance such as Oceans and Seas, and across mountains. Large loiter munitions like IAI Harop and Harpy can have significant endurance and then destroy a well-fortified concrete target.

Game-Changing Small Drones – Cheap and Deadly

Small drones could be as little as a few grams to just a few kilograms. Small drones have many roles including operations in confined spaces. Weapon-laden drones can be used for Kamikaze attack roles, as has been very effectively used in the Armenia-Azerbaijan conflict and in the Ukraine-Russia war. These drones are usually as cheap as $3,000 and may go up to about $50,000. They can therefore be held in large numbers in unit inventory. Small drones also provide logistics support to the field commander in the mountains. They are good for across-the-obstacle surveillance. These have been seen to have game-changing roles.

Complexities of Drone Detection

Small size, low radar cross section (RCS), low noise, smoke, and infrared (IR) signature, make drone detection difficult. Drones can be detected by using radio frequency (RF) analyzers, acoustic sensors (microphones), and optical sensors (cameras). Avian radars are being used at airports for checking bird activity. These have a limited range and are expensive, so cannot be deployed across the entire border. The radar that detects drones may also detect birds and make it complicated. The radars do have longer range, are more accurate, and can see more threats in day and night vis-à-vis optical means. Some Doppler radars are being designed to distinguish between drones and birds.

Optical sensors, visible and infrared, can detect drones by day and night. Modern optical sensors have improved resolution and processing power. Also, sets of microphone arrays can be used for detection and rough triangulation. They are passive and great gap fillers. However, they do not work well in high ambient noise. Also, their range is limited to around 500 meters.

Counter Drone Technologies – Area of Action

Drones can be neutralized by physical destruction, jamming, or taking control of the drone. There are RF Jammers to mask the controller signal. But then some drones are programmed to return home automatically under such a scenario. A GPS spoofer could send a new signal to the target drone and replace the communication signal it uses to navigate to its own 'safe zone'. Cyber takeover systems are relatively new. They passively detect radio frequency transmissions to identify the drone's serial number, locate the pilot's position using AI, and then take over the drone.

Kinetic solutions involve shooting the drone using a gun. High-power microwave (HPM) devices can generate an electromagnetic pulse (EMP) capable of disrupting drone electronic devices. However, there is a risk of unintentionally disrupting communications or destroying friendly electronic devices in the area. High-energy lasers defeat the drone by destroying the structure and/or the electronics. Laser could also cause collateral damage. Net guns can fire a net at a drone and entangle drone rotor blades to bring it down.

Drone Swarms and Swarm Counters

Better communications, high-speed computation and AI have greatly supported drones flying in coordinated swarms. Drone swarms have great military applications. Drone swarms can be used as decoy formations. A drone swarm can saturate enemy radars and also air defence weapons. A typical drone swarm may have a mix of surveillance, ELINT, electronic warfare and attack drones. Technology evolved for drone swarms have also been ported onto manned-unmanned teaming (MUMT).

Drone swarms will have to be countered using standard anti-drone methods. Jamming intra-drone links could send them astray. A drone swarm could be used to intercept the adversary drone swarm. Satellite-based directed energy weapons would be used to neutralize drone swarms in the future.

Crewed Uncrewed Teaming

Aircraft automation and data links have allowed crewed uncrewed teaming (CUT). Such a team can use the advantages of both, the less expensive drone, and the much higher flexibility and firepower of a manned platform, without exposing the more expensive manned aircraft and the airborne crew to a high-threat environment. The drones could be launched from the ground or from an airborne mothership. The package members are assigned separate roles and tasks. The uncrewed "loyal wingmen" could perform ISR or tactical early warning missions.

A few could act as decoys. Others could take on electronic warfare and perform Suppression of Enemy Air Defences (SEAD) roles. Significant members could be carrying munitions. Some would have intelligence-gathering roles and also for battle damage assessment.

Major Drone Manufacturers

Because of the high demand for military drones, the market is growing rapidly. Among the major large UAS manufacturers of the world are General Atomics Aeronautical Systems, Lockheed Martin, Raytheon, Northrop Grumman, BAE Systems, Elbit Systems, Israel Aerospace Industries (IAI), Turkish Aerospace Industries, and AeroVironment, among others. Both, China and Russia have significant UAS manufacturing capability. China's Wing Loong series is sophisticated and being sought by many countries. For long the Europeans were dependent on the U.S. for UAS. Dassault Aviation, Leonardo, and Space SAU are producing the future "Eurodrone" which will progressively replace the Reaper drones in France. Turkey's Bayraktar TB2 has had great success and many orders. Pakistan too manufactures UAS with technical support from China.

The small drone market has many players. The top small-drone manufacturers of 2023 were DJI, Yuneec International, and PowerVision, all from China. They control nearly 70 percent of the small civil drone market. The top American companies in this category were AeroVironment and Insitu. Parrot and Delairis are French. The British, German and Italian suppliers have developed different models of tactical drones. Poland's Warmate and Iran's Shahid drones have been used in many conflict zones. Low-cost "off-the-shelf" drones are being adapted for military use by non-state groups like Hezbollah.

Recalibrate Large Drone Op Roles

The Ukraine conflict has shown that significant operational battle-zone effects can be achieved by using low-tech cheaper kamikaze drones instead. These effects will multiply when a drone swarm is used. Large loitering drones such as IAI Harpy and Harop do have significant endurance and can make a kamikaze attack, and have a huge impact, but also cost a lot. There are some expensive drones that can be recovered back if not expended.

Large drones have proved very well for ISR. The US, Russia and China continue to develop large drones. However, in contested domains, they will have to stay far to be safe. There are plans to develop large drones for the contested environment by increasing self-defence capability, and better maneuverability. This would mean airframe design changes and also compromises on endurance. With a large number of space-based constellations coming up in low earth orbit, part of the ISR role can best be done from space.

There is clearly a need to re-design and produce more survivable large drones. They have to be stealthy like the proposed Indian "Ghatak" drone. Also, there is a need to redefine the operational employability and roles of existing ones. More stand-off sensors and weapons perhaps. Improved AESA radar, self-defence electronic suite and air-to-air weapons. Survivability can be increased by using self-protection pods against infrared and radio frequency-guided threats in contested environments. The large drones could also be converted into mother-ships for smaller kamikaze drones. They could be adapted to carry air-to-air interceptors or directed energy weapons to counter air and missile threats to remote and forward bases including during out-of-area contingencies. The USAF is already working on a future Next-Generation Multi-Role Unmanned Aerial System Family-of-Systems.

Large Drones in Indian Sub-Region

China already operates the Chengdu GJ series of drones, also called Wing Loong. These are in both Medium Altitude and High-Altitude Long Endurance variants (MALE & HALE). China has its armed variant and continues to develop more advanced ones. The Wing Loong II, with provision for up to twelve air-to-surface missiles, entered the PLA Air Force (PLAAF) service in 2018. As per media reports, a new generation of high-speed, long-endurance drones powered by low-cost jet engines has entered military service in China.

Pakistan acquired the CH-4 UCAVs from China. They have used them to conduct strikes in Baluchistan. They have the maritime variants also. The indigenous Burraq UCAV has been jointly developed and built by the National Engineering and Scientific Commission (NESCOM) and the Pakistan Air Force (PAF). Shahpar-2 is another indigenous UAV. They also acquired significant numbers of the Turkish Bayraktar TB-2 UAVs. They have ordered the Bayraktar Akıncı HALE UCAV, deliveries for which have reportedly just begun.

Indian armed forces have depended on Israel for its UAS requirements with IAI Heron and Searcher. The Harpy and Harop were the large loiter munitions. India’s DRDO remains the major player for large UAS in India with its Tapas-BH-201 and Ghatak UCAV still evolving. Adani-Elbit makes Hermes UAS in India. India has over 100 drone start-ups, and the market has a big future. Indian armed forces have placed significant orders for small drones. IdeaForge and Newspace Research & Technologies have received significant orders from the Indian Army. Veda Defence Systems has an order from the Indian Air Force (IAF). Many more orders will be placed regularly.

The large drones will continue to have a significant role in maritime surveillance. They are much cheaper to operate than the P-8I Poseidon aircraft and can supplement the air effort. India must accelerate the development and production of indigenous systems. There is a need to work more aggressively on MUMT.

Future Trends

DARPA had funded the development of Skyborg, a software and hardware package designed to allow a variety of low-cost, loyal wingman UAVs to fly and carry out missions autonomously. The Skyborg project is a USAF Vanguard program developing UCAV intended to accompany a manned fighter aircraft. Contracts have been awarded to Boeing, General Atomics, Kratos Unmanned Aerial Systems and Northrop Grumman. A Skyborg-equipped UAS conducted its maiden flight in April 2021. Two General Atomics MQ-20 Avenger UAVs demonstrated in-flight communication with each other and "responded to navigational commands" while monitored from the ground command and control station.

Northrop Grumman Corp's Model 437 stealthy fighter jet with a 4,500 km range will involve flying alongside the F-35 jet fighter. USAF plans to build an airborne, autonomous 'best of breed' system of systems. The UAVs would be paired with the USAF's Next-Generation Air Dominance (NGAD) fighter.

Miniaturization of antennas is being studied to develop smaller and more agile UAVs with enhanced capabilities. Novel materials and manufacturing techniques are evolving. Drones-based flying ad-hoc networks (FANETs) for wireless communications will offer advantages of coverage, increased mobility, and access to remote or inaccessible areas. Tilt rotor designs are also evolving for a seamless transition from vertical take-off and landing (VTOL) to higher-speed forward flight.

Alternative energy sources such as solar and electric hybrid are under testing. Integration of UAVs with Internet of Things (IoT) will support data collection, analysis, and communication. Future UAVs will have collision avoidance systems. They will be able to quickly switch Op roles. Having foldable wings would reduce storage space and make it easy to transport.

The drone market is growing rapidly due to the high demand from militaries. More than 80 countries now have military drones. The rising civil market is adapting to meet the military demands. As per Statista analysis, the global drone market was $26.3 billion in 2021 and will reach $54.6 billion by 2030. The growth is mostly security agencies driven. Countering unmanned aerial systems (CUAS) has also become a big market.

The increased demand is also bringing greater investments in technologies related to photonics, optronics, AI, image analysis, and sensors of all kinds. Actions are on to increase survivability in contested environments.

India's initial MUMT experimentation is being led by HAL with the proposed LCA-based CATS in collaboration with a Bengaluru-based start-up, Newspace Research & Technologies. It will involve a recoverable wingman till the combat radius of 350 km. The range would increase to 800 km for a kamikaze attack on target. India has an ambitious drone development program. There are a large number of start-ups. The plan is being driven at the highest levels of the government. The future is uncrewed, and India must succeed.

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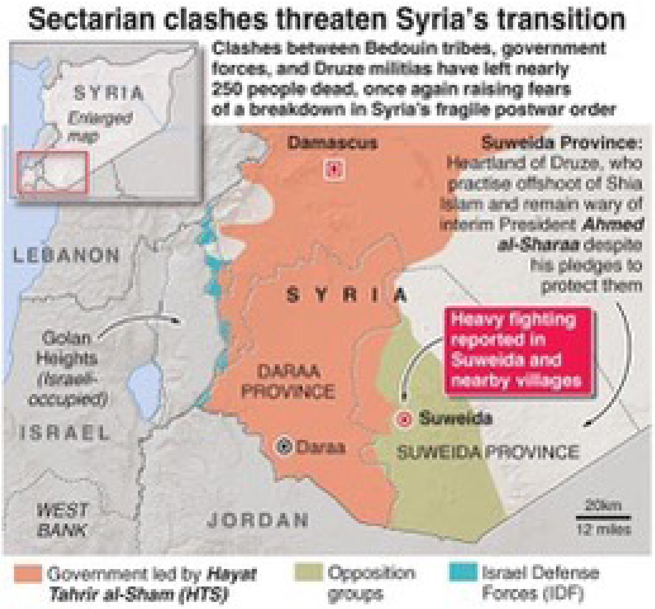
Air Power Musings: Bombing Damascus

Gp Capt VP Naik VM | 28 July 2025

Source: CAPS India | https://capsindia.org/modern-battlefield-warfighting-air-power-sweida-druze/



The Hindu

After the fall of Bashar al-Assad's regime on December 08, 2024, Israel has been upping-the-ante on Syria to prevent the new government from gaining power. Their aim includes stopping chemical weapons from being acquired by the new government, destroying all modern military equipment and maintaining control over the Golan Heights. Over the past six months, Israel has destroyed most of Syria's Air Defence (AD) assets, key missile infrastructure and networks, a so-called stockpile of chemical weapons, Scud weapon systems, Syrian military infrastructure and Syrian naval assets. The Israeli attacks aimed to establish a "sterile defence zone" in Southern Syria, which would be enforced without a permanent troop presence. The objectives included the destruction of strategic weapons and military infrastructure to prevent their use by rebel groups associated with Al Qaeda and the Islamic State. 1 As a result, Israel had gradually managed to increase the amount of territory under its control in Syria and weaken the new government.

Since July 14, 2025, Israel has launched a series of fresh attacks on Syria, striking the Headquarters of the Syrian Army in Damascus, a compound that also houses the Ministry of Defence. They also struck the Presidential Palace and continued to demolish military infrastructure. This has primarily been in support of the Druze population inhabiting the Golan Heights and the city of Sweida.

The Druze are a religious sect that originated as a 10th century offshoot of Ismailism, a branch of Shia Islam, and comprise a minority community in Syria. Roughly half of its one million followers live in Syria, in a province called Sweida (Suwayda) and makeup about three per cent of the Syrian population. The Sweida province is located in south and south-west Syria, adjoining the Golan Heights and is considered loyal to Israel. According to the Israeli Central Bureau of Statistics, around 1,52,000 Druze people live in Israel and the Israel-occupied Golan Heights and serve as an effective buffer between Israel and Syria. In response, Israel intensified its airstrikes and called for the complete withdrawal of Syrian forces from Druze areas.

What started as a skirmish between Bedouin tribes and the Druze population on July 13, 2025, soon escalated into a clash, killing over 200 Druze people. In response, Israel intensified its airstrikes and called for a complete withdrawal of Syrian forces from Druze areas. After three days of relentless attacks, the Syrian government has unequivocally agreed to halt all military operations, commence withdrawal from Sweida and also agreed to form a committee comprising government representatives and Druze spiritual leaders to supervise the ceasefire agreement.

The Israeli attacks have brought out certain interesting observations that can be juxtaposed with other scenarios and lessons drawn. Whilst enjoying complete air superiority in Syria, the latest series of attacks have primarily been on Military Headquarters (HQ) and the Presidential Palace. What does this show? What can be drawn from such attacks? What is the effectiveness of such attacks? Can such attacks be replicated across other war zones? These are only a few questions this paper seeks to analyse.

(a) **Strategic Targeting for Tactical Results**: While Israel has an underlying motive in ensuring a peaceful Southern Syria, a seemingly innocuous skirmish like the one in Sweida made Israel attack strategic targets to get tactical results. This is possible when one enjoys complete freedom of operations and unopposed air superiority. However, what is of interest here is that a tactical action may have strategic ramifications. In Israel's strategic calculus, Sweida is significant enough to warrant strategic targeting.

(b) **Urban Warfare and Escalation Control**: Urban warfare is here to stay, and therefore, there is a need for specialised weapons and aircraft for the same. Long-range, standoff precision munitions in large quantities will need to become a part of the conventional arsenal. The large-scale use of unguided area bombing may not yield the required results. However, high-value urban targets such as political and military leadership, critical infrastructure and strategic targets can have debilitating effects on the adversary when struck. The threat of targeting them can also demonstrate the capability to control the escalation matrix.

(c) **Importance of Continued Suppression/ Destruction of Enemy Air Defences (SEAD/DEAD)**: The Israeli Air Force has repeatedly been hitting Syrian Air and Missile defences and has practically neutralised Syrian AD capability and gained air superiority over Syrian airspace. This has given the IDF multiple options for responding to situations and enabled freedom of operation for air, sea, and land forces. The practically non-existent AD also allowed Israel the use of Syrian airspace during its strikes on Iran in June 2025.

(d) **Political Signalling and Coercive Diplomacy**: Syrian strikes, as well as operations like Op-Sindoor, have increasingly demonstrated the efficacy of air power as a tool for Political Signalling. The Syrian air strikes were meant to force the Syrian government to withdraw from Southern Syria, demonstrating inherent coercive capability, forcing them to the negotiating table and restoring peace.

(e) **Air Superiority and the need for Constant Presence**: Israel has been systematically targeting Syrian AD for six months, but not continuously. With effective Electronic Warfare (EW), a well-planned SEAD plan, and good Intelligence, Surveillance, and Reconnaissance (ISR), Counter Air Operations (CAO) can be carried out without relying on traditional methods. They could be parallel or simultaneous, need-based and carried out using precision, long-range, standoff weapons, thereby not requiring constant presence and significantly reducing sortie generation rates.

(f) **Short and Swift Wars**: While the world is witnessing long-drawn conflicts in Russia and Israel, the world has also witnessed short, intense, and swift conflicts like the Indo-Pak skirmish and the Sweida imbroglio. Therefore, drawing templates would not be correct as the duration of the conflict would be decided by many interlinked factors. One factor that emerges is that a well-planned and graduated air campaign has the potential to shape adversarial behaviour without triggering escalation into a full-blown conventional conflict.

(g) **Importance of Information Dominance**: The timing, effects, and results of aerial attacks must be a part of the information dominance matrix. Building narratives and shaping perceptions are essential for success in all domains of warfighting. Therefore, air strikes must be leveraged to get the desired effect in the information domain. The latest live stream showing a Syrian newsreader shaken up by Israeli strikes on the Syrian Ministry of Defence sends an important message, also showcasing Israeli precision strike capability. Modern air operations must incorporate information dominance as part of their overall plan to achieve maximum effect.

A peaceful South Syria is beneficial to Israel in the long run, warranting strategic action in response to tactical issues. As Robert Kaplan has very succinctly said in his book 'The Revenge of Geography', "This means that a small state in the midst of adversaries, such as Israel, has to be particularly passive, or particularly aggressive, in order to survive. It is primarily a matter of geography." Geography will ultimately determine the actions a nation takes to safeguard its interests; therefore, if a tactical action warrants a strategic response, it must be done. What does India's geography teach us, and what more needs to be done is food for thought because, as they say, "Maps, in other words, can be dangerous tools. And yet they are crucial to any understanding of world politics." To take a leaf out of the book and adapt our strategy around it would help us understand the nuances of war fighting in the West and North of us, and also bring out instances or areas of interest where strategic actions would be called for in response to tactical actions.

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Frontline Fusion: The Network Architecture Needed to Counter Drones

Anthony Padalino | 23 July 2025

Source: Mestpoint | https://mwi.westpoint.edu/frontline-fusion-the-network-architecture-needed-to-counter-drones/

A squad of infantry dismounts their infantry squad vehicle and begins moving toward the objective. As the soldiers approaches their assault position, an alert pings throughout the squad's command-and-control team awareness kit devices: "HOSTILE GRP 2 DRONE DETECTED, 1.7km, 045°, TRACK-ID 2112." The drone's location populates as a red dot on the map, along with its ID, and the text message drops from the screen. The drone was detected by an acoustic sensor from a forward multifunctional reconnaissance company and a small panel radar mounted on an infantry squad vehicle from an adjacent platoon. Although the sensors are distributed among separate echelons, the drone tracks from each sensor are fused into a single track and populated on the squad's team awareness kit devices. The battalion headquarters sees the same threat and directs its multipurpose company to launch a first-person-view drone with the task of destroying Track 2112. Within seconds, the friendly drone is launched, and the hostile drone is destroyed. As the infantry squad approaches the assault position, the hostile track drops off the map, and a text alert—"Track 2112 destroyed"—is sent throughout the squad.

This is the power of deliberately architected networks and sensor fusion: fast, efficient, shared awareness. One track, one threat, one decision, one common operational picture. As drones proliferate across every theater, this kind of seamless, fused detection will define the difference between successful operations and losses of combat power.

Understanding sensor fusion and network architecture isn't optional to solve the C-UAS (counter–unmanned aircraft system) problem—it's the entry fee to the professional conversation. To repurpose a well-known aphorism, amateurs will highlight the newest kit on the market, while professionals will discuss network integration and sensor fusion.

There are two critical tasks the Department of Defense must accomplish to solve its current C-UAS challenges: first, prescribing a common command-and-control (C2) system for all services, and second, implementing a network architecture to share sensor and effector data from the tactical to the strategic levels. Science and technology bureaucrats beware: The good old days of implementing bespoke systems on hub-and-spoke networks are ending, as leaders become more aware of our archaic and siloed air defense architectures.

Beyond New Gadgets: The Need for Seamless C2 Networks

The early response to drone threats has been to throw hardware at the problem—hundreds of millions spent on handheld jammers, exquisite radars, and costly interceptors. Each comes with limitations, but the bigger issue is that they operate independently, on bespoke networks. These siloed tools offer little beyond point-defense solutions. They lack the ability to tap into the abundance of joint and strategic sensor data to enhance their functions, making them blind to the broader battlefield and disconnected from the fight around them. As drones proliferate, the assumption that newer or pricier tech is the answer must be challenged. That thinking has led to the fragmented set of black-box capabilities that defines much of the C-UAS ecosystem today across DoD. The mindset that the solution is to throw kit at the problem must go. A new culture of stitching sensors and effectors together is the only way forward.

Building the layered defense vision depicted on Pentagon OV-1 charts takes more than a fictional green ring above systems that falsely illustrates to senior leaders that everything is connected. The department requires a common C2 system and network to a globally accessible architecture that can rapidly onboard new technology, fuse sensor tracks across echelons, and maintain common track identity. This means integrating multiple sensors and effectors onto real networks to deliver a single common operational picture on a tailored user interface. When two sensors see the same drone, the C2's common operational picture across the network must show one track—not two. And that fused track needs to be shared in real time across the force so any shooter, at any level, can respond with precision.

No single sensor or shooter is sufficient on its own; success comes from linking assets—sensing, deciding, and acting—in a coordinated web. The term survivable should mean that when a sensor, effector, or C2 system is lost in combat, we should not lose an entire capability.

The same principles of networking and fusion that apply to maneuver formations also extend to the defense of the homeland. Linking sensors and effectors across Department of Defense installations—and integrating those with interagency systems—shouldn't be like a scene out of a futuristic Hollywood thriller. The technology to do this has existed for years. However, our infatuation as a department with chasing kit has caused us to miss the forest for the trees when it comes to the C-UAS mission.

Want to solve the C-UAS problem? First, let's start by having a basic understanding of the essential tasks: transport, fusion, and track management.

Transport is the Backbone

Establishing robust transport to connect diverse sensors and effectors into a unified network is a foundational, yet complex, challenge. Without reliable data transport modes, sensor fusion and cooperative engagement leveraging any effector is not possible. The critical hurdle lies in the network plumbing—the infrastructure that allows combat formations to see the same thing in real time. This is why sensors and effectors at the operational and strategic level must live on actual live networks—not a joint data network, integrated fires network, or some other bespoke enclave that is closed off from reality. Networks must enable a cooperative engagement capability for land forces—both at home and abroad. Strategic-level sensor data needs to get back down to the tactical level, and tactical data needs to cue strategic-level sensors and effectors—it's a two-way street.

Transport is the starting point. Sensor data must move over existing paths to populate C2 nodes with drone tracks. For dismounted infantry or dispersed formations, this typically requires software-defined radios already burdened with voice and operational traffic. At the Army brigade echelon and below, bandwidth becomes a precious and often limited resource, particularly as the number of sensors and effectors increases. In a recent C-UAS exercise in Germany, Project Flytrap, a US Army platoon found 70 percent of its bandwidth consumed by sensor data alone.

Sensors continuously transmit track data—bearing, altitude, range, speed, and time. Higher-fidelity sensors, capable of detecting at longer ranges or generating precise, high-quality track data, will consume more bandwidth, and require lower latencies to enable fire control from exquisite effectors (Coyote, Roadrunner, etc.). Selecting the right sensor at each echelon requires balancing fidelity required (track quality), efficiency, and—most importantly—network capacity. Leaders in the field, and those fielding the kit, must thoroughly understand the bandwidth available for the organization and avoid overwhelming it with high-volume data from sensors that the network cannot support. In short, at the tactical edge, bandwidth is currency.

Sensor Fusion Explained

Sensor fusion is the alignment and merging of detections from multiple sensors into a single object, or track. If five sensors see the same drone, C2 systems across the network must display one track—not five. To stitch air tracks together, sensor fusion requires three things. First, there must be temporal alignment. All sensors, effectors, and C2 nodes must operate on a shared clock). Milliseconds matter for high end effectors. Second, the system must have spatial alignment. Because each sensor has its own frame of reference, fusion engines must translate local sensor detections into a common grid using GPS or inertial measurement unit data. If we put a sensor on a platform or a person, we must ensure we have a way to tell a fusion engine where it is. Finally, deconfliction algorithms are necessary. Techniques like dynamic time warping help correlate data streams with varying latency or reporting intervals. Selection of algorithms at echelon will be important based on compute capability, types of sensors being fused, and most importantly, the track quality requirement.

Ultimately, fusion is a continuous process of hypothesis and resolution: which detections should be grouped into a single track and which should remain distinct. Everything from filtering noise, biological tracks (e.g., birds), and even trash factor into track fusion. Getting this right is essential to avoid mirror tracks, or tracks that clutter the air picture and complicate weapon-target pairing. At scale, fusion enables a common operational picture where the data reflects the battlespace as it truly is—not a fractured collection of guesses.

The Importance of Universal Track Management

Fusion at echelon makes universal track identity management a complex data brokerage problem. Each track must have a unique ID—once assigned, it is maintained or updated across echelons. When a drone is detected by multiple sensors at different echelons, the output of network fusion should result in the same track number.

In an ideal network, a drone detected by a forward-deployed squad sensor will carry the same track number as when it is sensed by brigade, division, or joint-level assets. This continuity is the essence of universal track management—ensuring a single track ID persists across different sensors, C2 nodes, and operational levels.

However, maintaining common identity is especially challenging in a federated network where each echelon fuses its own sensor data locally. Without a shared and enforced track management protocol, the same drone may be assigned multiple IDs by different nodes, resulting in duplicated tracks. These duplicates not only distort the air picture but hinder effective engagement by obscuring which track is valid and which effector should respond.

The consequences are operationally significant. If tactical sensors fuse tracks to refine targeting for long-range interceptors, or if strategic sensors cue short-range effectors, inconsistent track IDs break the chain of custody between sensors and effectors. Coordinated defense becomes guesswork—and weapons cannot be paired to intercept.

Solving this requires robust protocols for track number assignment, deconfliction, and reconciliation across the enterprise. It also demands that track identity management be treated as a core function of C-UAS C2—not an afterthought.

The Path Forward

After years of resources wasted on bespoke kit, and still without an existing solution to tie in all sensors and effectors on a single network across services, it should be apparent that C-UAS isn't about buying better hardware. It's about establishing a network architecture on common C2. Fielding sensors and effectors that cannot pass track data across echelons, commands, and services is a recipe for failure. Likewise, continuing to forgo fusion, transport, and track identity will leave formations with siloed systems that can't leverage the potential of the whole infrastructure.

What's needed now is a deliberate shift in culture: from hardware-first solutions to architecture-driven integration on a common C2 across the department. The technology is here. The concepts are tested. Senior leaders not only understand the challenge, but are actively driving the enterprise toward scalable, connected, and lethal solutions.

To start down the path to success, and a future where sensors and effectors are parts of a complementary ecosystem, there are five immediate actions DoD should take.

1. *Select a common C-UAS C2 for all services*. The US Army, the DoD executive agent for C-sUAS, should immediately prescribe the C-UAS C2 system to be used across the department. The C2 system must have a user interface that is intuitive for all occupational specialties, have a web-based, cloud-enabled architecture, and be capable of over-the-air updates for all systems, sensors, and effectors.

2. *Create, publish, and manage open-source APIs for integration of C-UAS*. The department must define and own the APIs—the application programming interfaces that allow different systems to interact—connecting all sensors, effectors, and C2. This should happen now. DoD's API technical guidance reinforces that government-owned interfaces are essential to prevent vendor lock-in and ensure interoperability across programs. Without government-controlled, open APIs, each new sensor or effector requires bespoke integration, slowing fielding and increasing cost.

3. *Ensure a pub/sub engine at the edge*. A pub/sub (publish/subscribe) engine at the edge and at echelon is essential to stitch together the diverse sensors and effectors. It enables real-time data sharing and track fusion across all sensors—allowing effectors to act on a coherent, shared threat picture. Without this layer, each sensor-to-effector link becomes a bespoke integration problem, slowing response and scaling. A common pub/sub backbone ensures modularity, speed, and interoperability across formations and platforms.

4. *Prioritize remote sensor tasking*. This allows sensors and effectors to be controlled as needed across the network, improving track quality, creating an ecosystem of survivability, and enabling remote fire control and distributed weapon pairing.

5. *Emphasize remote fire control and engagement*. Any C2 node with permissions must have the capability to launch an engagement with any effector on the network, using data from any sensor with sufficient track quality. This removes the need for dedicated sensor-weapon pairings on hub-and-spoke networks, which limit flexibility and create single points of failure. It enables faster targeting decisions, expands coverage, and allows for continued operation even if some sensors or nodes

are lost. This approach replaces the traditional hub-and-spoke model with a more distributed and efficient system.

The drone threat is here to stay, and it has already outpaced our current capabilities. We won't solve it by throwing more hardware or isolated systems at it. Victory in the C-UAS fight will go to the side that builds faster, more integrated networks—where any sensor can feed a common operational picture and any shooter can act on it. Sensor fusion, transport, and track identity aren't back-end tasks; they are foundational elements of the overall C-UAS strategy. The technology exists. What's needed now is DoD to prioritize common C2 and network architectures that enable true interoperability. We don't need more kit—we need smarter networks that sense, decide, and act as one. The kill chain starts with the network. Build it or lose the fight.

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AIR POWER

IAF Conducts CAPSTONE Seminar of No 4 Warfare & Aerospace Strategy Programme (WASP)

25 July 2025

Source: PIB | https://www.pib.gov.in/PressReleasePage.aspx?PRID=2148543

Warfare and Aerospace Strategy Programme (WASP) was conceived by IAF to cultivate critical thinking in its future leaders. Operational decisions must be informed by a clear understanding of context, consequence, and long-term intent. WASP prepares officers to think through politico-military environmental layers, to interpret the frameworks within which decisions are made, and to assess outcomes including second-order effects. The graduates of WASP subsequently go on to occupy positions in NSCS, Air War Strategy Cell, Think-tanks, and military educational institutes.

This edition of WASP featured the participation of twelve officers, comprising ten from the Indian Air Force and two from the Indian Navy. The participants engaged in an intensive curriculum that blended military theory with political, technological, and behavioral analysis. Each module was structured around analytical reading, written submissions, and detailed discussions led by subject matter experts from military, academic, and policy backgrounds.

The programme was conducted under the aegis of the Centre for Air Power Studies and College of Air Warfare. The theme for this year's seminar was, "Aerospace Power: Preserving India's Sovereignty and Furthering National Interests". The Capstone Seminar of No. 4 WASP marked the culmination of a six-month journey of strategic inquiry and cross-domain learning by selected officers of the armed forces, with the Chief of Defence Staff as the Chief Guest. He spoke on the evolving role of the military professionals and the growing relevance of a 'Scholar Warrior'. He underlined the importance of decision-makers who have the ability to move across domains without hesitation, linking strategic intent to executable plans. He emphasised the value of in-depth strategic knowledge and intellectual clarity in shaping military outcomes.

The seminar featured presentations from WASP participants on the topics which included "Contours of Security Environment", and "Aerospace Power: Imperative for Deterrence and Victory in War".

WASP continues to support the IAF's path to build intellectual depth within its leadership. Officers emerging from this programme are equipped to engage across operational and policy levels. They bring with them the ability to think independently, speak across disciplines, and align military thinking with broader national aims. The sustained support to this programme reflects the IAF's intent to embed nuanced thinking into military planning and execution.

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Fighter Jets Flying Towards Scary Parity with Pakistan

Rudroneel Ghosh | 24 July 2025

Source: Times of India | https://timesofindia.indiatimes.com/india/fighter-jets-flying-towards-scary-parity-with-pakistan/articleshow/122879702.cms

File photo of an IAF MIG-21 passing in front of Sukhoi-30 jets before a drill at Kalaikunda airbase in Bengal

October onwards, India will have just 29 fighter jet squadrons- Pakistan has 25. That's near-parity and a scary one, especially because Pakistan's 'iron brother' China has 66 squadrons. A squadrom typically has 18-20 fighter jets. In two months' time, India will have 522 fighter jets. Pakistan has 450, and China, 1,200.

Air chief A P Singh said India needs to induct at least 40 fighter jets every year. That, currently, looks worse than impossible.

Some pundits say that unless India ups its game, more squadrons with old fighter jets, Mirage, Jaguar and other MiG variants, will be phased out, it will have the same number of fighter squadrons as Pakistan in less than 10 years. The proximate cause for this worry is IAF phasing out its last two MiG-21 squadrons. But the bigger reasons have been at play for years.

The MMRCA Shock: The 2015 cancellation of the 126-jet Medium Multi-Role Combat Aircraft deal made a huge difference. The 36 Rafale jets India acquired through a govt-to-govt deal with France were nowhere near enough given IAF's ageing fighter fleet. India has ordered 26 more Rafales, but for the Navy.

Plans, Plans, Plans...: There are plans to buy 114 Multi-Role Fighter Aircraft. But nothing's moved on this.

Made In India? The grand plan was that indigenous Tejas Light Combat Aircraft will maintain India's air superiority over Pakistan. IAF currently has just about two squadrons, 38 fighters, of Tejas Mark-1. Delivery of the improved Tejas Mark-1A jets, 83 of which are supposed to be delivered by HAL, has blown through multiple production deadlines. Not even one is in service. This is in part thanks to massive delays in the delivery of GE's F-404 engines, and partly because of so-far-unsolved issues with integrating Astra air-to-air missiles and fixing certain critical avionics.

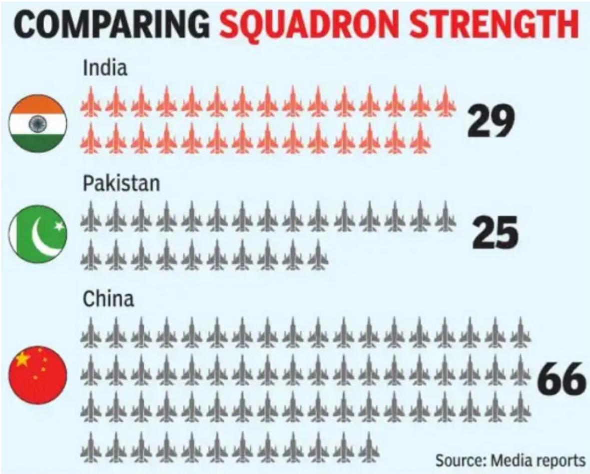
IAF hopes another 97 Tejas Mark-1A will come through, along with another 108 Tejas Mark-2 variant with the more powerful GE F-414 engine. The engine is to be co-produced in India with 80% transfer of technology. But it's all on paper now.

Then, there's the proposed 5th generation Advanced Medium Combat Aircraft. The most that can be said about this is that it's an idea.

Engine Failure: The key hurdle in Made in India programme is the inability to produce an indigenous jet engine. The old Kaveri engine development project failed to meet standards. Modern fighter jet engines are complex machines with thousands of parts that must withstand high pressure and temperatures. It requires billions of dollars to develop a fighter jet engine.

Essentially, an engine has four parts- compressor, combustion chamber, turbine and nozzle.

The hot part of the engine, combustion chamber and turbine blades, is tricky to get right, requiring advanced ceramics. But India's talent depth in material science is shallow. Only a few thousand materials engineers graduate each year. India even struggles to manufacture basic stuff like ceramic-coated electrodes, required in the production of green hydrogen. These are imported. So, forget about fighter jet engines made here, at least in the near future.



Are Drones The Solution?

Many pundits reckon large military platforms like fighter jets and warships are becoming redundant, given the changing nature of warfare. Ukraine has done amazing things with drones in its war against Russian aggression, taking out Russian warships and fighter jets with UAVs that cost a fraction of the price of a jet.

Ukraine will produce 4 million drones this year. India's armed forces have talked about using many more drones. But there are two issues. Any domestic production will have to account for ever-evolving drone tech. And India needs a specialist corps to operate drones or specialist drone subunits.

Those who challenge the drones-are-it strategy point out that India's strategic security theatre is very different from Ukraine's, and fighter jets provide a penetrative, offensive capability that drones can't, at least not now.

So, the reality that India and Pakistan are almost at parity when it comes to fighter jets is still scary.

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Air Power is about a System, not Merely Fighter Jets

Chappy Hakim | 29 July 2025

Source: The Jakarta Post | https://www.thejakartapost.com/opinion/2025/07/29/air-power-is-about-a-system-not-merely-fighter-jets.html

An Airbus A330 Multi Role Tanker and Transport (MRTT) operated by the 112th squadron of the Republic of Singapore Air Force (right) prepares to refuel two Indonesian Air Force F-16 fighter jets (left) on May 16, 2025, the third day of the 10-day Elang Indopura joint exercise at the Roesmin Noerjadin Air Force Base in Pekanbaru, Riau. (Instagram/@militer.udara)

The golden era when fighter jets alone symbolized air superiority has completely faded. That chapter of history is definitively over. In the past, particularly from the Cold War through the 1990s, fighter aircraft like the Grumman F-14 Tomcat were heroic icons, glorified in films such as Top Gun, representing the spearhead of national pride and aerial supremacy.

That paradigm has been fundamentally reshaped, however. The essence of airpower is no longer defined by aggressive-looking jets, but by a fully integrated and multilayered national air defense system (Hanudnas) that must be sophisticated, agile and systemically networked. The air battle over Kashmir in May between India and Pakistan serves as a compelling illustration. Although advanced aircraft platforms like the Rafale and F-16 were deployed, the decisive outcomes were shaped not by aerial dogfights, but by radar networks, command and control (C2) architecture and information maneuvering capabilities. Similarly, during the flare-up between Iran and Israel in June, the true game changers were not traditional fighter duels but long-range cruise missiles, drone swarms and satellite-based early warning systems. Air combat has now transitioned into the domain of cyber operations and algorithmic warfare, where milliseconds and electromagnetic dominance matter far more than sheer speed and thrust.

This is precisely why Indonesia must abandon the outdated metric of airpower as simply the number of fighter jets in its inventory. Pursuing such a populist, procurement-driven approach leads to inefficient defense spending, often driven by narrow political interests tied to five-year election cycles.

In reality, building credible airpower demands farsighted vision, cross-generational planning and institutional continuity that transcends political transitions. In the modern era, airpower is a complex system. It consists of long-range surveillance radars, real-time C2 centers, passive and active sensors, space-based detection platforms, multirange surface-to-air missile systems and unmanned aerial vehicles (UAVs) for reconnaissance and strike, as well as other elements. Without this complete ecosystem, even the most advanced fighter jet becomes a blind and vulnerable asset in increasingly contested airspaces. Moreover, air supremacy now hinges on dominance over the electromagnetic spectrum and cyberspace. Discussions of hypersonic missiles and anti-satellite weapons are no longer futuristic: They are today's operational realities.

As the largest archipelagic nation on Earth, Indonesia faces a uniquely complex challenge. The scale of airspace to monitor, secure and defend is immense. Thus, it is no longer sufficient to merely acquire fifth-generation fighter aircraft. What is truly required is the development of a comprehensive, adaptive and layered integrated air defense system (IADS) that covers point defense, area defense and anti-access/area-denial (A2/AD) capabilities at strategic locations across the country. Yet none of this is feasible without a grand design, a long-term national defense blueprint that is immune to political whims. Indonesia must craft a coherent defense white paper and a national airpower road map, developed through interministerial coordination and multiservice collaboration and safeguarded by institutions independent of short-term political cycles. The modernization of Indonesian airpower must move beyond the euphoria of reactive procurement and instead focus on indigenous technological mastery, defense industrialization and the development of skilled and professional human capital. It is critical to emphasize that no amount of fighter jet acquisitions, regardless of their cost or sophistication, will automatically translate into a credible air defense system. Fighter jets are merely one element within a vastly larger operational matrix. Without seamless integration with radar coverage, missile batteries, sensor networks and centralized command structures, such platforms remain nothing more than window dressing, devoid of real deterrent or combat value. A resilient air defense architecture cannot be built in fragments. It must rest firmly upon the foundation of the national defense and security system (Sishankamnas) and involve not only the Indonesian Military (TNI) but also key ministries, academic institutions and the domestic defense industry. A truly respected airpower posture will only emerge when it is embedded within a broader, holistic concept of total defense, not through ad hoc, headline-driven acquisition campaigns.

Ultimately, the question is not who owns the most fighter jets, but who can synthesize all defense elements into a coherent system that functions strategically, adapts dynamically and sustains operational superiority across time. Indonesia needs a visionary leadership capable of laying down systemic foundations rather than harvesting short-term popularity. Without such foresight, we risk remaining spectators in the evolving global theater of air warfare while our own airspace remains alarmingly porous in the face of modern threats. That said, before venturing further into discussions of multilayered systems or cutting-edge technology, there is one urgent and foundational matter that must be resolved: Indonesia must first and foremost assert full and unequivocal control over its sovereign airspace. Not a single millimeter of our skies should be under the control or management of foreign entities, as is still the case in parts of our airspace over Riau, Natuna and the Malacca Strait. Without total sovereign control of our own airspace, all talk of strategic planning, sophisticated systems or expensive fighter aircraft will remain a hollow fantasy, an illusion of strength atop a landscape not yet truly independent. Sovereignty is nonnegotiable. A robust air defense system can only stand firm upon the unshakable foundation of full and undivided national airspace sovereignty.

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US, Allied Forces Advance Joint Training, Strengthen Readiness

Sgt. Daniel Brosam | 02 July 2025

Source: Decam Herald | https://www.af.mil/News/Article-Display/Article/4233726/rfa-25-2-us-allied-forces-advance-joint-training-strengthen-readiness/

A Japan Air Self-Defense Force F-15J Eagle pilot performs pre-flight inspections prior to takeoff during Red Flag-Alaska 25-2 at Eielson Air Force, Alaska, June 17, 2025. The exercise strengthens interoperability between the U.S. and Japan while enhancing readiness for real-world operations. (U.S. Air Force photo by Staff Sgt. Daniel Brosam)

EIELSON Air Force Base, Alaska (AFNS) -- Red Flag-Alaska 25-2, a Pacific Air Forces-directed field training exercise, concluded June 27 after two weeks of multinational flight operations over the Joint Pacific Alaska Range Complex.

RFA 25-2 was hosted at Eielson Air Force Base with primary operations based out of Joint Base Elmendorf-Richardson. The exercise brought together more than 1,500 service members and over 70 aircraft from the United States and three allied nations, all focused on improving interoperability, refining combat tactics and strengthening regional readiness.

Forces from the Japan Air Self-Defense Force, Republic of Korea Air Force and the Belgian Special Forces joined U.S. forces on the flightline and in the air, conducting integrated missions across the Alaska range.

"The PACAF objectives for Red-Flag 25-2 is principally the key integration of our partners and allies into our joint force," said U.S. Air Force Col. Derrick Franck, RFA 25-2 deployed forces commander. "We are here to train in peace time with our Korean and Japanese [allies] and accomplish training objectives that show the dominance of air power in the 21st century."

Their participation highlights the strength of long-standing alliances and reinforces a shared commitment to regional security, joint readiness and tactical integration in the Indo-Pacific.

"The heart of Red Flag today is that mission planning function of how we work together with multiple, different diverse background platforms and capabilities," Franck said. "The best part of Red Flag is that should we have to fight tonight or take it north, we have already learned the lessons of how the ROKAF and JASDF operate and we know how to put that all together in a time of crisis."

Now in its 50th year, Red Flag-Alaska continues to serve as a cornerstone of coalition airpower training in the Indo-Pacific. It aims to provide realistic, high-end scenarios designed to prepare aircrews and support personnel for expeditionary operations in contested environments.

The expansive 77,000 square miles of airspace in the JPARC remains unmatched for pushing the limits of integrated air combat training, especially for fifth-generation fighters like the F-35 Lightning II.

"The Joint Pacific Alaska Range Complex is a national treasure," said U.S. Air Force Col. Paul Townsend, 354th Fighter Wing commander. "It is a tremendous air space that allows our air crew to execute their advanced tactics, techniques and procedures against a credible surface-to-air and air-to-air adversary."

Red Flag-Alaska 25-2 strengthened joint airpower, deepened allied partnerships and ensured participating forces are better prepared to operate together in the Indo-Pacific.

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F-AIR 2025: AFSOUTH Demonstrates Regional Partnership and Airpower in Colombia

Sgt. Ariel OShea | 17 July 2025

Source: Economic Times | https://www.dvidshub.net/news/543152/f-air-2025-afsouth-demonstrates-regional-partnership-and-airpower-colombia

Photo By Staff Sgt. Ariel OShea | U.S. Air Force Maj. Taylor "FEMA" Hiester, F-16 Viper Demonstration Team commander and pilot, performs aerial maneuvers at F-AIR 2025, the Colombia Feria Aeronáutica Internacional, at the José María Córdova International Airport in Rionegro, Antioquia, Colombia, July 9, 2025.Activities like F-AIR strengthen international partnerships, enhancing interoperability and improving our collective readiness to conduct a range of potential future operations – from humanitarian assistance and disaster relief to security operations – so we can respond quickly to support our neighbors in times of crisis. (U.S. Air Force photo by Staff Sgt. Ariel O'Shea)

RIONEGRO, Colombia – Nearly 60,000 attendees were present to witness the enduring partnership between the United States and Colombia during the 12th edition of the International Aeronautics and Space Fair, F-AIR 2025, at the José María Córdova International Airport, July 9-13.

The U.S. Air Force F-16 Viper Demonstration Team from Shaw Air Force

Base, South Carolina, delivered a thrilling aerial performance, showcasing the F-16C Fighting Falcon's capabilities—a single-seat, multi-role fighter with the ability to switch between an air-to-ground and an air-to-air role at the touch of a button.

"As an American fighter pilot, the opportunity to take the airplane overseas in a diplomatic way is always extremely special," said Maj. Taylor Hiester, F-16 Viper Demonstration Team commander and pilot. "To be able to share the combat capabilities of the F-16 to the people of Colombia is a dream come true for me. I can't tell you how warm the hospitality has been and how beautiful the country is."

Also featured was the Wings of Blue Parachute Team from the U.S. Air Force Academy, who performed precision parachuting alongside their Colombian counterparts, Águila de Gules, descending to the ground in a cloud of colored smoke and streamers, trailing both partner nations' flags.

The airshow's high energy was met with enthusiasm from Colombian spectators, who warmly engaged with the American personnel. The camaraderie between Wings of Blue and Águila de Gules parachute teams was evident in shared smiles and high-fives, reflecting the strong bonds between the two nations.

"The presence of the United States Air Force at the Rionegro International Fair, represents the bonds of friendship and cooperation that exist between the two countries," said Colombian Aerospace Force Col. Alexander Sanchez. "That commitment ensures regional security and the strategic capabilities of our country."

On the ground, the California Air National Guard's 146th Airlift Wing displayed a static C-130J Hercules, where Airmen were able to interact with airshow attendees and answer questions about the four-engine turboprop military transport aircraft.

"Airshows like F-AIR are invaluable," said Lt. Col. Jeffrey Budis, mission commander and air boss for U.S. participation. "They offer a unique platform to strengthen our partnership with Colombia, while simultaneously enhancing our operational readiness."

Budis emphasized that there's value gained in deploying aircraft internationally, providing essential experience to U.S. Airmen in coordination and logistics skills necessary to meet future mission requirements in the U.S. Southern Command's area of responsibility.

"We are deeply grateful to our Colombian partners for hosting this incredible airshow," said Budis. "Opportunities like this allow us to train together, deepen relationships and build the trust."

Events like F-AIR put that trust on full display, showcasing the U.S.-Colombia partnership and the importance of deepening military ties across every domain.

The U.S. Air Force will also participate in the upcoming Relámpago de los Andes, a Colombian-led exercise focused on enhancing techniques, tactics and procedures. The exercise will feature U.S. air assets to include F-16, KC-135, C-17, and HC-130 aircraft from multiple Air National Guard and active-duty units.

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China Showcases full Spectrum of Drone Technology in 'Border Control' Exercise

Liu Zhen | 22 July 2025

Source: SCMP | https://www.scmp.com/news/china/military/article/3319159/china-showcases-full-spectrum-drone-technology-border-control-exercise

Live operations across six phases of the futuristic battlefield scenario covered reconnaissance, AI planning, infiltration, aerial attack, elimination and anti-access, state media report says. Photo: CCTV

China has staged a warfare demonstration using a full spectrum of uncrewed systems, underscoring its role as a leading global drone supplier, according to a state media report on Monday.

The drone and counter-drone exercise at a testing ground in the Inner Mongolia autonomous region simulated the "seizure and control of critical border locations", state broadcaster CCTV reported.

It said numerous domestically made systems were deployed in live operations across six phases of the futuristic battlefield scenario, covering reconnaissance, AI planning, infiltration, aerial attack, elimination and anti-access.

Unmanned aerial vehicles (UAVs) on display included intelligence, surveillance and reconnaissance or ISR drones, long- and short-range loitering munitions, uncrewed helicopters, as well as tactical first-person view or FPV devices.

Ground equipment, from smart command and control systems to anti-drone defences, was also on show at Monday's exercise.

An OW-5 anti-drone laser weapon carried out a live-fire demonstration in a rare public display. Its "high-energy beam barely visible to bare eyes" shot down a target drone "a few kilometres away", the CCTV report said.

The OW5 series was first unveiled at the Zhuhai air show in 2021 as a static exhibit, and the latest presentation showcased the upgraded OW5-A50 with a 50-kilowatt power output. The system integrates the command-and-control station, radar and electro-optical sensors, power module and laser gun into one 8x8 Dongfeng heavy-chassis truck. It can perform key point air defence either with a stand-alone vehicle or as part of an integrated network protection system.

According to the CCTV report, the advantage of laser weapons as a drone countermeasure is that they can lock on and destroy targets instantly with unlimited ammunition for as long as the power supply lasts.

The exercise also featured a display of drone-artillery coordination, with a 155mm howitzer rapidly engaging targets using real-time coordinates transmitted digitally from a reconnaissance UAV.

CCTV also aired footage of a group of small tactical drones putting on a live demonstration of their capabilities. Among them was a large flying jammer able to interfere with the electro-optical equipment of other UAVs within a range of several kilometres.

The special combat tactical drones display included the Flying Frog, a vertical take-off and landing or VTOL reconnaissance drone, as well as the Flying Falcon – a high-speed loitering munition, and the grenade-throwing Black Bee, along with the bomb-dropping Flying Whale.

"With these smart partners, our infantry soldiers can evolve into future nodes with full-domain situational awareness and precision strikes, to win by intelligence on the modern battlefield," the report said.

State-owned China North Industries Group Corporation – the country's largest arms maker and exporter, commonly known as Norinco – organised the event, where it also introduced its loitering munitions family, Feilong or Flying Dragons.

The series ranges from the anti-personnel Feilong-10, which is small enough to be carried and has a range of less than 10km, to the Feilong-300A – an anti-radiation tactical drone that can target air defence radars up to 300km away.

The Feilong-60 can be fired from normal rocket launchers and works as a reconnaissance data source for guiding rocket fire or as a hoverable cruise missile. The smaller Feilong-30's launchers are designed to be loaded onto various platforms, including trucks, combat vehicles and ships.

All of these suicide drones could be combined to form a networked swarm that is capable of conducting a saturated attack, according to the CCTV report.

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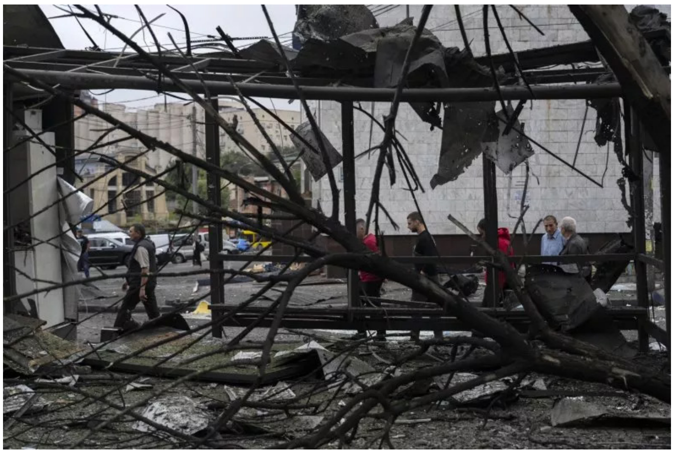
Russia and Ukraine Exchange Series of Major Strikes

Brendan Cole | 21 July 2025

Source: News Week | https://www.newsweek.com/russia-ukraine-drones-missiles-bombardment-2101561



People walk past wreckage near a metro station following a Russian attack in Kyiv on July 21, 2025. OLEKSII FILIPPOV/Getty Images

Moscow faced a Ukrainian drone attack for the fifth night in a row, the city's mayor has said, as Russia launched yet another bombardment on Ukrainian infrastructure.

Video shared on social media showed chaos at Moscow's airports after the Ukrainian drone threat disrupted flight paths.

Meanwhile, at least one person was killed and several were injured in Ukraine's capital Kyiv following Moscow's latest bombardment.

Newsweek has contacted the Ukrainian and Russian defense ministries for comment.

Why it Matters

Russia is showing no sign of letting up in its drone and missile attacks on Ukrainian infrastructure, despite President Volodymyr Zelensky's invitation to hold peace talks with Moscow in Turkey later this week.

Kyiv's use of drones on Russia follows a warning in May by Serhii Bratchuk, from the Ukrainian Defense Army's Southern Division, about Ukraine's plans to disrupt aviation to make the Russian population pay for Vladimir Putin's aggression.

What to Know

Russia repeated its mass drone and missile attacks on Kyiv overnight Sunday in strikes which local authorities said killed at least one person and injured six.

Ukraine's Air Force said Russia launched 450 drones and missiles targeting Kyiv, the western city of Ivano-Frankivsk and Kharkiv.

Explosions rocked Kyiv in the early hours of Sunday, with outdoor kiosks burning and smoke pouring from the entrance of the damaged Lukianivska subway station.

In Ivano-Frankivsk, air defenses were deployed during what the city's mayor Ruslan Martsinkiv described as the largest attack on the western region since the start of the war.

Meanwhile, more than 230 Ukrainian drones had been shot down downed over Russia since Saturday morning, including 27 over the capital, according to Russia's defence ministry.

Moscow Mayor Sergey Sobyanin said the Russian capital faced a fifth night of Ukrainian drone attacks, but that the devices had been shot down by air defenses. Footage on social media showed debris hitting residential areas where several explosions were recorded.

Damage to a railway station in Kamenolomni, in the Rostov region further south caused by falling drone debris was also reported, causing hours-long train delays.

The threats posed by drones prompted restrictions to be imposed on flights from Moscow's Domodedovo and Zhukovsky airports, according to Russia's state aviation agency Rosaviatsia.

Two other major airports in Moscow were also temporarily closed and at least 140 flights were cancelled as images on social media showed disgruntled passengers trapped at the crowded airports for up to 12 hours.

Open source intelligence X channel Visoner said Ukrainian forces had been launching waves of drones at various regions of Russia, including Moscow, with the aim of overloading Russian air defense systems.

What People are Saying

Ukraine's president Volodymyr Zelensky said: "Russian strikes are always an assault on humanity."

Moscow's Mayor Sergei Sobyanin: "Two drones attacking Moscow were shot down. Emergency service specialists are working at the crash site."

What Happens Next

After months of facing increased attacks by Russia on Ukrainian cities, including Kyiv, Ukraine's military appears to have intensified efforts in targeting Russia's capital.

Meanwhile, despite Zelensky's offer for talks, Kremlin spokesman Dmitry Peskov said "the main thing for us is to achieve our goals". These include Ukraine withdrawing from Russia-annexed regions and abandoning its aspirations to join Nato – terms that Kyiv and its Western allies have rejected.

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Space

4 Astronauts Splashdown on SpaceX Capsule to end Axiom Space's Private Ax-4 Mission

Dr Martand Jha | 11 July 2025

Source: CAPS India | https://capsindia.org/mission-axiom-4-a-long-wait-ends/

Axiom Space

The Mission Axiom-4's long-awaited journey to the International Space Station (ISS) began on June 25, 2025, at 2:31 am (Eastern Time). The mission lifted off using the SpaceX Falcon-9 rocket and the Dragon Spacecraft. The precise venue for the launch was Launch Complex 39A at the National Aeronautics and Space Administration's (NASA) Kennedy Space Center, situated in Florida.

From India's perspective, this mission launch was extremely crucial as it marked the first time in 41 years that an Indian had the opportunity to travel to outer space. Although astronauts like Kalpana Chawla and Sunita Williams had been to outer space, it is worth noting that they were not representing India in their respective missions. So, in that sense, India's Shubhanshu Shukla has become the second Indian after Rakesh Sharma to go on a crewed mission to outer space and the first to reach the ISS. During Rakesh Sharma's voyage to outer space, the ISS hadn't come into existence, as it only became operational in 1998.

For India, this mission is seen as a prequel to the much-awaited Mission Gaganyaan–India's first human spaceflight mission to outer space. This mission was announced by the Indian Prime Minister, Narendra Modi, on India's 72nd Independence Day in 2018 from the Red Fort in his address to the nation. Then, the launch date for the mission was set for August 15, 2022. The reason for choosing this specific date was that on this day, India would complete 75 years as an independent nation-state. The policymakers must have thought that if Mission Gaganyaan were to be launched on that day, it would enhance the feelings of patriotism among citizens and give them a new reason to cheer and smile.

As they say, life has different plans than one's own. Unfortunately, this plan was severely impacted by the COVID-19 pandemic. The pandemic brought systemic disruption on a global scale, affecting global supply chains, thereby leaving its impact across various industries. In such difficult circumstances, it was but natural that the Mission Gaganyaan would get delayed. Multiple waves of COVID-19 from the start of 2020 until 2022, along with new variants of the virus, continued to push back the timelines for the Mission Gaganyaan. In hindsight, this might have been a blessing in disguise, as there is now no set launch date for this mission, unlike earlier. Although 2027 is earmarked for the launch, the timeline is subject to change depending on prevailing circumstances.

India's participation in Mission Axiom-4 was a result of a collaboration between India and the United States. The mission was envisaged during the Indian Prime Minister's visit to the United States in 2023. During his meeting with Joe Biden, the then-President of the United States, it was agreed upon to send an Indian astronaut to the ISS as part of a broader Indo-US bilateral partnership. Last month, an Indian delegation led by the Indian Space and Research Organisation (ISRO), chairman visited the United States, traveling to the Johnson Space Center in Houston, Texas, the Kennedy Space Center (KSC) at Merritt Island, Florida, and various facilities of SpaceX, Axiom Space, and Blue Origin.

As per ISRO, "The larger purpose of this visit was to meet with the senior leadership of multiple agencies to oversee the progress and preparation, and to facilitate and enable India's participation in the Axiom-04 mission, as well as explore new cooperation opportunities in the space sector". The timing of this high-profile delegation's visit coincided with the launch of Mission Axiom-4, which had been delayed multiple times over a four-week period, starting from May 29, when the launch was initially scheduled.

India's two astronauts, Shubhanshu Shukla and Prashanth B. Nair, selected for this mission, underwent extensive training exercises at multiple simulator facilities. These training modules prepared them to be ready for each and every aspect of this mission. Although this is just a two-week mission for Shubhanshu Shukla, the sheer experience gained from this will hopefully help India in its preparations for Mission Gaganyaan. Outer space requires intensive physical training and considerable physical and mental effort. This mission will be a massive learning experience in that pursuit. No number of simulation exercises on the ground can match a live experience in outer space.

India has never been a participant in the space race, nor does it intend to participate in it now. However, space exploration has been a part of India's space policy since the Cold War era. The Axiom-4 mission is precisely a pursuit of that step. When Shubhanshu Shukla returns home, it will be a good time to assess and reflect on the lessons learnt from this mission.

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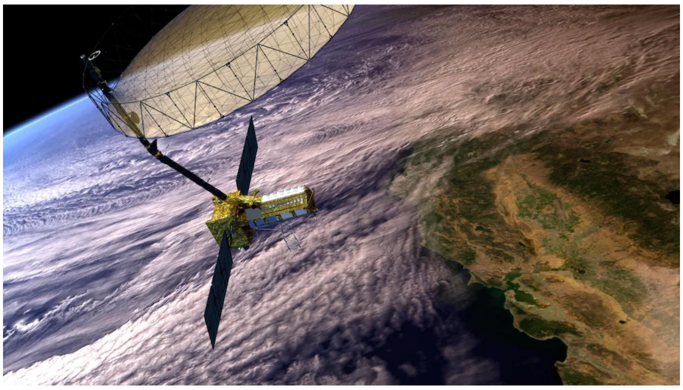
Earth Imaging Satellite NISAR Exposes NASA's Weaknesses, ISRO's Strengths

Pallava Bagla | 26 July 2025

[Source: NDTV | https://www.ndtv.com/world-news/earth-imaging-satellite-nisar-exposes-nasas-weaknesses-isros-strengths-8954611](https://www.ndtv.com/world-news/earth-imaging-satellite-nisar-exposes-nasas-weaknesses-isros-strengths-8954611)



The way human power is distributed is also very different between NASA and ISRO.

The upcoming rocket launch from Sriharikota can be aptly summed as 'NASA's envy, India's pride!'

The rocket the Americans tried to kill will now launch a billion-dollar bird.

The very unique Earth imaging satellite jointly made by India and US named the 'NASA ISRO Synthetic Aperture Radar' (NISAR) satellite, is a technological marvel and would be a game-changer in saving lives from impending natural disasters. That the world's oldest democracy, US, and the world's largest democracy, India, are working together on this most expensive satellite that has cost upwards of $1.3 billion. It is a testament to the growing Indo-US bonhomie and strategic ties.

But this mission also exposes the double standards the US exercised on India in yesteryears and is also ironical that America's most expensive civilian Earth imaging satellite ever made will be launched using an Indian launcher - the same rocket Americans wanted to desperately scuttle and kill its development in the early nineties.

ISRO persevered relentlessly for nearly two decades and succeeded so much so that now top officials from NASA will actually be present at India's space port to witness the historic liftoff on July 30.

According to ISRO, the NISAR satellite weighs 2,392 kg, and it will scan the entire globe and provide all-weather, day-and-night data at a 12-day interval and enable a wide range of applications. NISAR can detect changes in the Earth's surface, such as ground deformation, ice sheet movement, and vegetation dynamics. It will be launched using the Geosynchronous Satellite Launch Vehicle Mark 2 (GSLV Mark 2), which will be powered by an indigenously developed cryogenic engine - the same technology that the US administration, especially its Bureau of Export Control, wanted to deny to India by working overtime with the then USSR.

It was the 1990s and India was steadily developing its rockets and wanted to acquire the sophisticated cryogenic engine technology from the then USSR. It was under American pressure that Russia did not do technology transfer to India, but instead gave about half a dozen ready-made cryogenic engines to India.

Subsequently, India struggled for nearly twenty years before mastering the complexities of cryogenic engine technology. The Americans used all the power of technology denials, sanctions at their disposal to try and make sure

India did not acquire this technology. But then these tech-denials turned a blessing in disguise, and the scientists at ISRO toiled hard, and today it is the home-made cryogenic engine which will launch the NISAR satellite.

Some would say this is an irony of ironies, and some would say it is egg on the face of US.

Dr V Narayanan, chairman of ISRO, had helped India master the cryogenic engine, which makes it a proud moment for him to see the NISAR sticker on the payload fairing of the rocket that houses the cryogenic engine inside.

At the end of the day, the US scientists have swallowed their pride and are sheepishly going to watch the launch of a satellite where they have invested nearly $ 1.15 billion. It is this exorbitant cost by NASA that should also be a reason for Americans to squirm and be uncomfortable.

Wendy Edelstein, NISAR's Deputy Project Manager at NASA's Jet Propulsion Laboratory (JPL), asserted, "NISAR is a 50-50 partnership between NASA and ISRO. It represents the largest collaboration in space between the United States and India."

Interestingly, India has spent about Rs 800 crores on the NISAR project, which works out a little less than $100 million. NASA confirmed that it included 'ISRO investment for development, launch operations, and mission operations'.

NASA has contributed the L-band radar, which penetrates vegetation and soil to reveal subsurface changes, while ISRO has provided the S-band radar, optimised for detecting surface-level features like foliage and terrain. These radars are mounted on a 12-meter mesh reflector antenna, roughly the size of a school bus, allowing the satellite to scan nearly all of Earth's land and ice surfaces twice every 12 days.

India has not only contributed the equivalent S-band radar, but is also providing the rocket and the launch port and launch services, so why NASA's cost is $1.1589 billion and ISRO's cost is just $100 million? Here lies the heartwarming tale of Indian frugal engineering and cost optimization: It shows the profligate approach to engineering adopted by NASA.

When quizzed by the US media on the issue of costs, Nikki Fox, Associate Administrator for NASA's Science Mission Directorate, said at a briefing, "I will defer to them [ISRO] on their final costs".

There are many reasons behind the huge cost incurred by NASA, one of them being that most of the development of the instruments and payloads they fly are made by huge multi-national corporations and they not only need huge profits but also need to share dividends with their share-holders. ISRO, on the other hand, being a national entity does these things in-house and has no reason to pad up the cost to share profits with share-holders.

Additonally, an ISRO official said that when their scientists travel to the Jet Propulsion Laboratory in Pasadena in California, they would stay in shared $100 a day room while the NASA scientists when they travel to the UR Rao Satellite Center in Bengaluru would stay in an over $500 a day room. This automatically inflates the costs.

Also, India usually makes only one instrument the one that will fly into space, while NASA makes an engineering model and flight model, which leads to doubling the cost.

The way human power is distributed is also very different between NASA and ISRO at the Indian space agency.

In the case of NISAR, which has taken over 11 years to build, the teams at ISRO working on multiple satellites and the salaries in India also turn out to be much lower when converted into dollar terms. The top manager at ISRO also pointed out that ISRO engineers are willing to put in long hours and work over weekends, while the US contract engineers are reluctant to put in long hours.

The premium for insurance also adds to the costs at ISRO since the government takes the full liability and no insurance is taken, In other countries, insurance premiums can be a huge cost. Incidentally, when India launched its communication satellite using the SpaceX Falcon-9 rocket, India also took insurance.

This huge difference in NASA's and ISRO's costs remains a huge enigma for the making of the NISAR satellite, which was made with an understanding of equal partnership.

Not just NISAR, there are still many bitter-sweet oddities in the Indo-US space relationship. India's first rocket launched from Thumba on November 21, 1963. It was an American Nike Apache rocket and the world got its first direct-to-home television broadcast - thanks to the Satellite Instruction Television Experiment (SITE) in 1975 pioneered in rural India.

Then came the era of sanctions, which ended only when the Indo-US Civilian Nuclear Deal was inked in 2008. Despite the sanctions, ISRO opened its heart out and flew two American instruments to the moon on Chandrayaan-1 in 2008 free of cost. This is contrast with the 2025 Astronaut mission of Shubhanshu Shukla to the International Space Station using the Axiom-4 flight where India shelled out hard cash of about $70 million for this single seat to the Americans.

Interestingly, when the two democracies have worked together, they have had fruitful outcomes.

It was Chandrayaan-1 which discovered the presence of water on the lunar surface, opening up flood gates for the colonisation of the moon. And now, on the NISAR mission, when NASA had all but given up the making of this costly satellite as its other foreign partners had backed out, it was ISRO that stepped in in 2014 and said ,'let us forge this partnership to make the world's single most expensive civilian Earth imaging satellite'. Hence, today the $1.3 billion NISAR satellite, which is sometimes also referred to as the NISARGA satellite, has been conceived in the true spirit of 'Vasudhaiva Kutumbakam' or the 'world is one family,' concept, and sits atop the rocket ready for lift off from Sriharikota in the true spirit of 'vishwa bandhu'.

The contrast in cost structures, the cultural differences in engineering ethos, and the historical ironies are a compelling story of resilience, frugality, and strategic partnership. Life, in a way, is coming full circle for US and India, as the friendship grows to explore the unknown frontiers of space.

India's frugal technology development, when clubbed with the US high technology can lead to a huge cosmic leap.

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India Launches NASA-ISRO Earth Observation Satellite

Hemanth C.S. | 31 July 2025

Source: The Hindu | https://www.thehindu.com/sci-tech/science/gslv-f16-with-nisar-satellite-onboard-lifts-off-from-sriharikota/article69873660.ece

ISRO's launch vehicle GSLV-F16 carrying the NISAR earth observation satellite lifts off from the launch pad at the Satish Dhawan Space Centre, in Sriharikota, Andhra Pradesh, on July 30, 2025. | Photo Credit: PTI

The NASA-ISRO Synthetic Aperture Radar (NISAR) satellite was successfully launched on Wednesday (July 30, 2025) from the Satish Dhawan Space Centre at Sriharikota in Andhra Pradesh.

The Geosynchronous Satellite Launch Vehicle (GSLV)-F16 rocket carrying the earth observation satellite lifted off from the second launch pad of the space centre at 5.40 p.m. Eighteen minutes later, it injected the satellite into a sun-synchronous orbit.

"The GSLV-F16 vehicle has successfully and precisely injected the NISAR satellite weighing 2,392 kg into its intended orbit," Indian Space Research Organisation (ISRO) Chairman V. Narayanan said after the launch.

First Joint Venture

The NISAR, which has a mission life of five years, is the first satellite jointly developed by the ISRO and the U.S.'s National Aeronautics and Space Administration (NASA).

Casey Swails, Deputy Associate Administrator at NASA, said NISAR will give decision-makers the tools to monitor critical infrastructure, respond faster and smarter to natural disasters such as earthquakes, floods, and landslides, as well as map farmland to improve crop output and more.

24-hour Data

The NISAR satellite will scan the earth and provide all-weather, day-and-night data at 12-day intervals, and enable a wide range of applications.

"NISAR can detect even small changes on the earth's surface, such as ground deformation, ice sheet movement, and vegetation dynamics. Further applications include sea ice classification, ship detection, shoreline monitoring, storm characterisation, changes in soil moisture, mapping and monitoring of surface water resources, and disaster response," the ISRO stated.

NISAR is the first satellite to observe the earth with a dual-frequency Synthetic Aperture Radar (SAR) — NASA's L-band and ISRO's S-band — both using NASA's 12-metre unfurlable mesh reflector antenna, integrated with ISRO's modified I3K satellite bus.

It will observe earth with a swathe of 242 km and high spatial resolution, using SweepSAR technology for the first time.

According to NASA officials, its Jet Propulsion Laboratory (JPL) built the radar antenna reflection, radar antenna boom, L-Band SAR and engineering payload, while the ISRO developed the spacecraft bus, solar array S-band SAR and the launch vehicle.

The NISAR mission is broadly classified into different phases – launch, deployment, commissioning and science phases.

The launch phase has been accomplished with the launch of the GSLV-F16 rocket.

During the deployment phase, a 12-metre reflector antenna will be deployed in orbit nine metres away from the satellite by a complex multistage deployable boom. The deployment process will begin on the 10th day after the launch. This will be followed by the commissioning phase.

"The first 90 days after launch will be dedicated to commissioning, or in-orbit checkout, the objective of which is to prepare the observatory for science operations. Commissioning is divided into sub-phases of initial checks and calibrations of mainframe elements followed by JPL engineering payload and instrument checkout," the ISRO said.

The final science operations phase begins at the end of commissioning and extends till the end of NISAR's five-year mission life. "During this phase, the science orbit will be maintained via regular manoeuvres, scheduled to avoid or minimise conflicts with science observations. Extensive calibration and validation activities will take place," the ISRO said.

This is the first time that a GSLV has put a satellite in a sun-synchronous polar orbit.

Relief to ISRO

The successful launch of the NISAR comes as a relief to the ISRO as it had suffered back-to-back setbacks. Its previous launch, the PSLV-C61/EOS-09 mission on May 18, 2025 could not be accomplished due to a technical glitch.

The space agency also suffered a setback with the NVS-02 satellite, which was launched by a GSLV on January 29, 2025. Post launch, the ISRO was unable to perform the intended orbit-raising operations for the NVS-02 satellite due to a valve malfunction.

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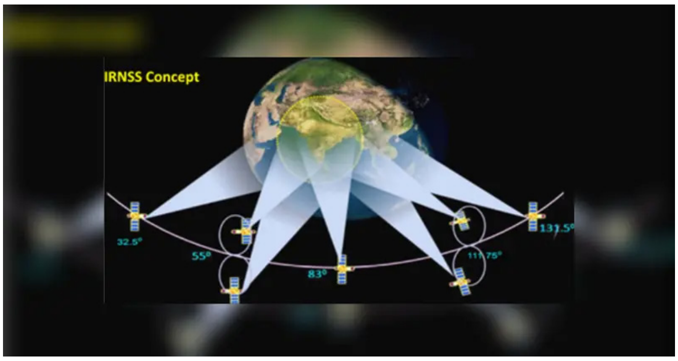
India's Desi-GPS NAVIC is Near-Defunct; Satellites need Urgent Replacement

Sidharth MP | 24 July 2025

Source: WION News | https://www.wionews.com/india-news/india-s-desi-gps-navic-is-near-defunct-satellites-need-urgent-replacement-1753359574919



India's strategic NAVIC (Navigation with Indian Constellation) series of satellites Photograph: (Courtesy: Space Applications Centre, ISRO)

India's strategic NAVIC (Navigation with Indian Constellation) series of satellites, built and maintained by the space agency ISRO, are nearly defunct, with only a bare minimum of four among 11 satellites fulfilling their core purpose, government data shows. Of these four operational satellites, one (IRNSS-1B) has already exceeded its planned life of 10 years and could stop functioning anytime, while another (IRNSS-1F) has less than a year to complete its decade in service and has suffered partial equipment failure. NAVIC is India's own version of America's GPS, Russia's GLONASS, China's Beidou and Europe's Galileo systems. According to ISRO, India's NAVIC constellation is meant to have five or seven operational satellites. At present, the depleted and near-defunct fleet of NAVIC satellites requires urgent replacement, given that they serve India's strategic forces and are meant to augment warfighting capabilities.

While GPS, GLONASS, Beidou, Galileo provide global coverage, India's NAVIC provides services only in the Indian neighbourhood (Indian mainland and 1,500 km beyond Indian borders). The Indian Government decided to fund and operationalise the NAVIC series of satellites, after precise GPS services were denied to the Indian military amid the 1999 war against neighbour Pakistan. It is well established that all operators of GPS-like satellite constellations use them for civilian and military purposes.

According to the Indian space agency ISRO, which builds and operates NAVIC, the constellation of satellites serves terrestrial, aerial, and maritime navigation, precision agriculture, emergency services, and fleet management, Location-based services in mobile devices, marine fisheries, timing services for financial institutions, power grids, and other government agencies, Internet-of-Things (IoT) based applications, and strategic applications.

As is the case with GPS and other foreign services, NAVIC is also meant for use by the Indian armed forces for navigation, assigning targets to and guiding drones, missiles, smart bombs, precision-guided munitions, among others. It is learnt that NAVIC-based systems are in active use and are also being integrated with more warfighting systems of the Indian Armed Forces.

Five of Eight First-Generation NAVIC Satellites Failed

Between the year 2013 and 2018, ISRO launched a total of nine NAVIC satellites, which were then known as Indian Regional Navigation Satellite System (IRNSS). These satellites in the first-generation series were designated as IRNSS 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I.

Of these nine, IRNSS 1H failed to reach orbit, due to a rocket-related failure. Therefore, only eight IRNSS satellites were successfully placed in orbit.

Of these eight IRNSS satellites in orbit, over the years, five satellites (1A, 1C, 1D, 1E, 1G) have experienced a total failure of all three atomic clocks. Each satellite carries three onboard atomic clocks and all of them failed, government data sourced via RTI shows. Further, the 1F satellite has witnessed the failure of two of three atomic clocks. According to ISRO, these atomic clocks have been sourced from Swiss firm SpectraTime, a leading provider of such high-precision atomic clocks.

As per government data, of the eight first generation satellites only three—1B, 1F, 1I—satellites are fully functional and providing Position, Navigation, Timing Services. Among these three, 1B has already exceeded its planned life of 10years (which means it could become defunct soon), while 1F has less than a year to complete its planned decade in service, but it also faces partial atomic clock failure. 1I was launched it 2018 and it expected to work till 2028, but doubts remain given the other five premature failures.

One of Two Second Generation NAVIC Satellites Failed

In order to replace the ageing fleet of IRNSS (first gen NAVIC) satellites, ISRO began launching the NVS-series of satellites. NVS is meant to be a constellation of five satellites. ISRO launched NVS-01 in May 2023 and that satellite has been working as designed, but the successor satellite NVS-02 which launched in January 2025 failed to reach its destined orbit. The satellite remains stuck in its initial orbit, as the satellite's onboard engine could not fire to lift it higher. Stuck in the initial orbit, NVS-02 cannot provide Position, Navigation, Timing services. So far, ISRO has not publicly revealed the exact cause that led to the engine not firing.

NAVIC Satellites need Urgent Replacement; ISRO must Speed Up

With only four operational satellites (1B, 1F, 1I, NVS-01), another failure could render NAVIC completely ineffective and inaccurate, which also affects Indian Armed Forces and their warfighting capabilities. Therefore, ISRO needs to urgently launch NVS-03, NVS-04, NVS-05. The Indian government has said in Parliament that all three remaining NVS satellites would be launched by the end of 2026. However, this seems like an unrealistic timeline, given ISRO's pace so far.

ISRO launched NVS-01 in May 2023; NVS-02 was launched in January 2025, which shows a gap of 19 months between the two launches. With NVS-02 having failed, ISRO would have to conduct thorough studies and work towards preventing similar failures in subsequent missions, and this whole process could take time. Further, the flaws identified must be corrected and software/hardware changes must be implemented in the upcoming

NVS satellites.

At the time of writing, ISRO has conducted only two launches in seven months of 2025 and both these missions have failed. In the first mission, NVS-02 satellite failed to reach orbit, and in the second mission the PSLV-C61 rocket failed mid-flight and the EOS-09 Earth-imaging satellite was also destroyed in the process.

In recent years, ISRO has been performing a maximum of five or seven launches in a calendar year. Therefore, ISRO needs to work on both the rocketry front and the satellite front to ramp up its launch activity, ensure a higher rate of mission success and reliability, so that India's public-funded NAVIC can get back on track, in addition to a host of other critical missions.

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How US Space Command is Preparing for Satellite-on-Satellite Combat

27 July 2025

Source: Economist | https://www.economist.com/united-states/2025/07/27/us-space-command-is-preparing-for-satellite-on-satellite-combat

Photograph: Alamy

Towards the end of last year a pair of military satellites, one American and the other French, prepared for a delicate orbital minuet. They were about to conduct a so-called rendezvous and proximity operation (RPO)—in which one or more satellites approach another to inspect or manipulate it—near an enemy satellite. They have not said which, but it is not hard to guess. "The French have talked about Russian manoeuvres [near French satellites] over the years," says General Stephen Whiting, speaking at the headquarters of US Space Command in Colorado Springs. "And so…we demonstrated that we could both manoeuvre satellites near each other and near other countries' satellites in a way that signalled our ability to operate well together."

The exercise was so successful, he says, that there are plans to repeat it later this year. It is a milestone: the first time that America has conducted an RPO like this with a country outside the Five Eyes, a spy pact whose members co-operate closely in space, and the first time it was done as a "purpose-built" operation, rather than in response to events. It also embodies America's new, more muscular approach to space. Space Command was re-established in 2019 during Donald Trump's first term. In recent years it has focused on building its headquarters and developing staff. Now it is ready. "We now have a combatant command focused on war fighting" in space, says General Whiting.

The impetus for that is two things. The first is that the American armed forces' reliance on satellites has "compounded exponentially", says an official, pointing obliquely to America's strike on Iran in June. "The majority of that operation is space enabled." The other is what the government sees as a change in the threat. Since 2015 there has been an eight-fold increase in Chinese satellite-launch activity, says the official. The People's Liberation Army has become much better at operating in space, including conducting electronic warfare in orbit, he says, with China eclipsing Russia. China, Russia and India have tested destructive anti-satellite weapons in 2007, 2021 and 2022 respectively. America also accuses Russia of developing an orbital nuclear weapon that could destroy thousands of satellites in low-Earth orbit (LEO) at once.

A few years ago Space Command was wary of talking about its own offensive capabilities. Now it embraces the idea. "It's time that we can clearly say that we need space fires, and we need weapon systems. We need orbital interceptors," said General Whiting in April. "And what do we call these? We call these weapons." He points to Mr Trump's Golden Dome plan for a missile-defence shield, which includes space-based interceptors to destroy enemy missiles. In theory the same weapons could also target enemy satellites. "Space to space, space to ground, ground to space" would all play a role in achieving the "lethality that is necessary to achieve…deterrence," says an official.

America's allies are also becoming more open about this. In a defence review published this year, Britain said for the first time that it would develop anti-satellite weapons deployed on Earth and in orbit. America leads a small but tight-knit club of spacefaring allies. In Operation Olympic Defender, Space Command works with six countries—Australia, Britain, Canada, France, Germany and New Zealand—to "deter hostile acts in space". In April the initiative reached "initial operational capability", with all seven countries signing a joint campaign plan whose details will be finalised this summer.

Space Command is also thinking about the tactical demands of war. While "everything in space is moving", says General Whiting, America has thought of its satellites as "individual forts" that sit in one place. That is because moving a satellite takes fuel, which can shorten its lifespan. There are three solutions to that, he says. One is for satellites to carry more fuel. Another is to refuel in orbit—something that China demonstrated in June. "That could give them a military advantage," he says, "so we need that capability."

The third approach is to operate so many satellites that each one can be treated as expendable. American officials have been talking about such "proliferated" constellations in LEO for years—think of SpaceX's Starlink. Now they are being built. America's National Reconnaissance Office, which runs classified spy satellites, has launched more than 200 since 2023, with a dozen launches scheduled for this year alone. SpaceX is also rumoured to be the front-runner to build a 450-strong constellation that will eventually relay missile-tracking and other data from sensors to interceptors and weapons.

A fourth method might be added to that list: making the satellites more intelligent. General Whiting says he would love to have AI on board satellites that would allow them to detect "nefarious" objects nearby and to move out of the way without human intervention. In time, suggests Christopher Huynh, a major in the US Space Force, AI-enabled satellites could fly in close formation, meaning they could act as "defender satellites to protect high-value assets in orbit".

For now, the AI is mostly on the ground. In the past few months, General Whiting says, his staff has built a large language model that has been trained on all of the command's threat and planning data. Officers can quiz "SpaceBot" on gaps in their knowledge or on how to respond to a fictional or real-world attack in space. "What would once have taken ten people five hours of work", he suggests, "can be done at machine speed—a space-age achievement."

Satellites keep Breaking up in Space. Insurance won't Cover them

Tom Brown | 28 June 2025

Source: Space | https://www.space.com/space-exploration/satellites/satellites-keep-breaking-up-in-space-insurance-wont-cover-them

An illustration of debris in orbit around Earth (Image credit: Getty Images)

Airplane passengers crossing the Indian Ocean who peered out their windows on Oct. 19, 2024, might have seen what looked like a fast-moving star suddenly flash and fade. Above their heads, a $500 million satellite was exploding.

Operators confirmed the destruction of the Intelsat-33e satellite two days later. There was a bright flash as the satellite's fuel ignited, followed by the flickering of the debris cloud as it fragmented into at least 20 pieces. Those satellite parts are now zooming around Earth, along with around 14,000 tonnes of space debris. The satellite wasn't insured.

As space junk increases, more operators are choosing to launch without any insurance at all. To compensate, companies are cutting back on the cost of satellites and launching more of them at faster rates, thus creating a feedback loop as the cheaper satellites break up more easily and add to the problem.

"I don't think it's sustainable," said Massimiliano Vasile, an aerospace engineer and professor at the University of Strathclyde Glasgow.

Behind the predicament are two vectors moving in opposite directions: The cost of launching satellites is falling, while the cost of insuring them continues to soar.

Even as record-low-cost launches are improving internet coverage and cell service, they're worsening the space junk problem. Low Earth orbit, where most communications satellites are circling, is becoming increasingly crowded.

Satellite insurance, meanwhile, has never been more expensive. 2023 was likely the worst ever for the market, with reports suggesting satellite insurers faced loss claims of more than $500 million. 2024 may have been even worse, according to Insurance Insider.

Satellite operators are responding predictably, by foregoing coverage. There are 12,787 satellites above the Earth as of the time of publication, according to the website Orbiting Now, which tracks active satellites, but only about 300 are actually insured for in-orbit accidents, David Wade, an underwriter at Atrium Space Insurance Consortium, told Data Center Dynamics.

European and UK operators are legally required to insure their satellites, which puts them at a cost disadvantage compared with India, China, Russia and the U.S. American companies such as SpaceX have also been able to reduce launch costs because of reusable rocket parts. Europe's upcoming Ariane 6 rocket program, for example, is expected to cost between $80-120 million per launch, compared with SpaceX's Starship program which is anticipated to cost between $2-10 million per launch because of its reusable rockets.

In the U.S., launchers are required by law to procure liability insurance for launch, but once the satellite is in orbit, insurance is no longer needed. SpaceX, for example, is self-insured, meaning it seeks third-party insurance for almost none of its Starlink satellites.

"Typically, the launch cover is literally just for that [launch] stage, and once a satellite gets into orbit, you are off risk," said Steve Evans, owner of insurance data provider Artemis (which is unaffiliated with NASA's lunar program of the same name). The satellite "either makes it, or it doesn't," he told Space.com.

The space insurance market began in 1965, when Lloyds Bank insured Intelsat I, which broadcast the Apollo 11 moon landing. The first known satellite failures occurred in 1984, though some later recovered, including the $87 million Intelsat 5 ($2.82 billion in today's money).

The industry has generally hovered around a 5% failure rate since 2000, with Data Center Dynamics reporting that there have been only 165 claims for more than $10 million across the history of the industry.

The 2019 failure of a military observation satellite for the United Arab Emirates, called the Vega rocket, led to $411 million in claims — the largest such loss in history, Reuters reported. That year, total satellite insurance losses became greater than insurance premiums for the first time, according to Bloomberg. Insurers were hoping to claw that money back in following years, but Reuters reported in 2021 that Assure Space and AmTrust Financial were both stopping insurance due to collisions.

Insurers were looking for a payout in 2023, but instead, that year saw close to $1 billion in claims and some $500 million in losses. For many long-standing insurers, it was the last straw; Brit, AGCS, AIG, Swiss Re, Allianz and Aspen Re all exited the space insurance market. Canopius, a specialist space insurance provider acquired by Lloyds in 2019, told Space.com via email that it was no longer underwriting space business.

Of the satellites in Earth orbit, around 42% are inactive, according to Seradata. The number of active satellites increased by 68% from 2020 to 2021 and by more than 200% from 2016 to 2021. Much of space insurance is modeled off the aviation industry, but space premiums are 10 to 20 times aviation premiums, Reuters reported in 2021.

A satellite in low Earth orbit typically needs $500,000 to $1 million of coverage, whereas a satellite in geostationary orbit requires $200 million to $300 million, according to the same report.

Behind the rush to exit the satellite insurance industry is a fundamental problem with satellite insurance: There's usually no way to determine who was at fault. When a house burns down or a car crashes, insurers often send investigators to verify a claim before approving a payout. But in the dark reaches of space, they can't operate that way.

"In the event of a loss and a claim by the insured, it is almost impossible, if not entirely impossible, for insurers to investigate the cause of the loss, whether total or partial, and thus determine the amount to compensate the insured," José Luis Torres Chacón, a professor in the department of economic theory and history at the University of Málaga in Spain, told Space.com. "I think this is where the root of the problem lies."

Liability insurance is problematic for satellites, too, since it's extremely difficult to tell whether a satellite broke up because of an internal explosion or because of a collision with someone else's space junk. And if the latter, it's very hard to identify where the debris came from.

"At the moment, it's not possible to say it was actually a fragment from that original explosion or collision that damaged the satellite," Vasile said. "So, in terms of insurance, it's a bit of a nightmare.”

Vasile believes the market is moving toward legal liability for any operator responsible for creating space debris at all. "I think the government needs to set the rules, precisely as the government sets the rules for road traffic or shipping," he said.

But a switch to stricter liability could create big problems for an increasing number of launch companies that are moving to cubesats — cheaper, short-duration satellites that are eventually abandoned by their operators as gravity slowly pulls them into Earth's atmosphere.

Some climate satellites are in danger of colliding with space junk. Analysis of data from NASA's Land Data operation Products Evaluation, which tracks research satellite maneuvers, reveals at least seven occasions where NASA's Terra and Aqua climate satellites lost data while having to avoid space debris.

Spacecraft in low-earth orbit are already under continuous threat. On Nov. 19, 2024, the International Space Station shifted its orbit to avoid another piece of space debris — this time, from a destroyed meteorological satellite. "Even a speck of paint is enough to destroy a satellite," Jakub Drmola, who studies the politics of satellite and missile defense systems at Masaryk University in the Czech Republic, told Space.com.

The worst-case scenario is Kessler syndrome, a chain reaction in which the breakup of a few satellites cascades into a wipeout of everything in orbit. Some researchers think Kessler syndrome is already happening, only very slowly, and that we've already reached the stage where the cost of cleaning up space far outstrips the benefits.

"The world has now begun to depend on space in ways that we never thought were going to be possible," said Gen. C. Robert Kehler, former head of Air Force Strategic Command, speaking to reporters at the 2024 Outrider Nuclear Reporting Summit in Washington DC. He favors introducing a regulatory system similar to air traffic control. "We need rules of the road," he said.

The problem isn't staying above our heads. On March 8, 2024, a discarded piece of hardware from the International Space Station fell through the Florida home of Alejandro Otero, shaking the whole house. His 19-year-old son was inside. NASA had jettisoned the spare battery carrier, assuming it would either burn up or land in the Gulf of Mexico. But the agency's calculations were wrong.

If the debris had landed just a few feet away, someone likely would have been seriously hurt or killed, according to Mica Nguyen Worthy, an attorney who is now litigating the first-ever case of property damage from space debris against NASA.

Nguyen Worthy described space debris litigation as the "next frontier" of outer space law. Without a clear set of rules, she said, future satellites launches and space travel itself could become impossible. "I think it's important for the space community, and why they do take it so seriously, because they don't want there to be a situation where we have trapped ourselves on Earth, [and] we can't get out."

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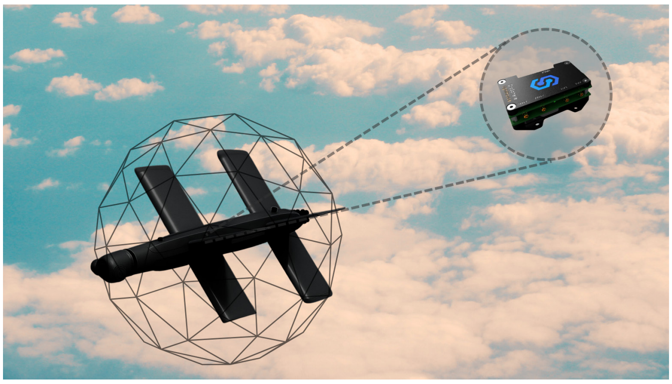
Aerospace Industry

As Electronic Warfare Pervades Battlefields, Israeli Firm is Thinking Smaller with Anti-Jam Tech

Seth J. Frantzman | 24 July 2025

Source: Breaking Defense | https://breakingdefense.com/2025/07/as-electronic-warfare-prevades-battlefields-israeli-firm-is-thinking-smaller-with-anti-jam-tech/



An artist's rendering shows Israeli firm infiniDome anti-jamming tech, GPSdome-SunStone, designed for small UAVs. (infiniDome)

JERUSALEM — As modern militaries confront increasingly electronic warfare-saturated battlefields, an Israeli defense firm says it sees an opening in providing anti-jam capabilities to increasingly small platforms like drones and, eventually, GPS-guided munitions themselves to "make smart munitions smart again."

"You can get a small, handheld jammer on a random Chinese website that can kill GPS signals for hundreds of meters or take down UAVs from kilometers away," Omer Sharar, cofounder and CEO of infiniDome, told Breaking Defense in a recent interview. "That is the jamming threat. It is like in cyber with a denial-of-service attack. When you flick the switch on, nothing has a GNSS [Global Navigation Satellite Systems] signal."

Beyond jamming, there's also spoofing, the tactic of feeding false location and navigation information into a platform — a tactic that often spills out beyond the battlefield.

After Israeli military operations began in response to Hamas's Oct. 7, 2023 attack, "we had this problem on a daily basis. There isn't one Israeli who didn't have a questionable experience [with their GPS location] showing up in Cairo or Amman or Beirut airports due to spoofing. It can happen in a blunt way throwing you off track by tens or thousands of kilometers; or it can be delicate, drifting your positioning, which is more dangerous because it's harder to recognize," Sharar said.

"The fact is that [some GNSS] signals are incredibly weak," he said. "By the point they are received on earth by an iPhone or autonomous vehicle, they are as weak as a 20-Watt lightbulb in California trying to receive it in New York. … Because the signals are weak, it is easy to disrupt them."

Sharar said that Israeli forces discovered issues with jamming during military operations in response to Hamas's attack, not because of Hamas's capabilities but because of the Israel Defense Force's own. "The biggest problem we had in Israel was not 'red' jamming from the enemy, but it was 'blue' by the IDF."

There are, of course, countermeasures. Defense firms the world over are developing navigation systems that don't rely on satellite navigation, whether by using AI to aide in visual or gravitational navigation (Opens in a new window)or even returning to wire-guided missiles (Opens in a new window). Larger airborne systems, like category five drones for example, also carry tech that harden the link to satellite navigation systems.

"The more you pay, the better backup to GPS you have. It's just backup. [But] as a function of time though you start losing where you are," Sharar said.

But as modern militaries rely more and more on electronic warfare, they're also relying more on small drones — down to quadcopters and FPV drone — platforms that Sharar suggested generally aren't capable of carrying much jamming tech. That's where he said infiniDome comes in.

"We use a technology called 'null steering.' … It has been on large anti-jamming solutions on [US] Department of Defense or [Israel's Directorate of Defense, Research and Development], and they are big and expensive and protect helicopters and fighter jets and battleships when weight and size and power consumption and price don't matter."

InfiniDome, he said, is "building a module that sits like a filter between the receiver and antennas. We don't need special antennas or receivers. Whatever GPS receiver you are using, disconnect the antenna and connect to our box … we combine with antennas to get a new receiving pattern," all meant for small platforms.

The company is looking smaller too, to tech that can fit on 155mm artillery munitions, the kind used so much in the Ukraine conflict that it's created a global shortage (Opens in a new window).

"If you look at Excalibur (Opens in a new window), the GPS-guided munition, it had 90 percent accuracy," Shara said, "but now in Ukraine that has dropped (Opens in a new window) to five to 10 percent accuracy. … So we want to make smart munitions smart again."

GNSS denial or manipulation is a problem for modern militaries that Sharar said isn't going away, and has prompted demand for ways to combat it around the world.

"We see huge traction in India and Europe. We had success with Indian military trials and in eastern and northern Europe. Everyone is waking up," he said. "Everyone knew about it. It became a reality. It became a painful reality."

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Rolls-Royce, Safran in Race to Co-Develop Engines for India's 5th-Gen Fighter Jets

11 July 2025

Source: Money Control | https://www.moneycontrol.com/news/india/rolls-royce-safran-in-race-to-co-develop-engines-for-india-s-5th-gen-fighter-jets-report-13264695.html#google_vignette

The DRDO may soon collaborate with foreign players to co-develop aircraft engines for India's fifth-generation fighter jet project, an Indian Express report said on Friday.

The report states that France's Safran and Britain's Rolls-Royce are among the main contenders for the project. Citing a senior official, the report further adds that a Cabinet Note will soon be prepared by the DRDO regarding the matter.

Engine technology has been a key factor in aircraft manufacturing in India, and the report says the Centre is actively looking to resolve this issue. The Indian Express report also mentions that both Rolls-Royce and Safran have made an offer to the DRDO for the full spectrum of aircraft engine development.

This includes the setting up of a Gas Turbine Research Establishment lab. Both companies are also offering full IPR and Transfer of Technology (ToT), the report adds.

Persistent delays in the supply of engines for the Tejas combat jet have made India acutely aware of how engine technology can be a key constraint. India has faced delays in the supply of the F404-IN20 engine, manufactured by GE Aerospace.

These engines are at the heart of Hindustan Aeronautics' Tejas Light Combat Aircraft Mk 1A fighter jet production. The delays have been attributed to the American company's struggle to revive its downstream supply chains, which were hampered due to the COVID-19 pandemic.

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Air Force, Navy and Coast Guard to get Airbus C-295 Aircraft Soon

Shivani Sharma | 30 June 2025

Source: India Today | https://www.indiatoday.in/amp/india/story/indian-air-force-navy-and-coast-guard-to-get-c-295-transport-aircraft-soon-2760736-2025-07-24

Indian Air Force's first C295 aircraft landed in Vadodara from Spain in September 2023. (Photo: Airbus)

The Indian Air Force is enhancing its capabilities along the borders by phasing out older aircraft and replacing them with modern ones. The vintage Avro transport aircraft of the Indian Air Force will soon be replaced by the new C-295MW tactical transport aircraft.

Along with the Indian Air Force, Indian Navy and Coast Guard is also going to induct C-295 aircraft. According to sources, the induction process is set to begin this year. A Request for Proposal (RFP) for the marine version of the C-295 was issued in March 2025 and the Defence Acquisition Council has approved the Acceptance of Necessity.

A total of 15 C-295MW aircraft will be procured, out of which nine will be for the Navy and six will be for the Coast Guard. The deadline for submitting commercial bids is December 2025.

India signed a deal in 2021 with Spain for 56 C-295MW aircraft. These aircraft are being manufactured in Gujarat's Vadodara. The Indian Air Force has already raised its first C-295 squadron at the Vadodara facility.

Prime Minister Narendra Modi inaugurated this facility in the presence of the Spanish President. The project is being executed in partnership with the Tata consortium and Airbus. This marks the first time a private Indian company is developing military aircraft indigenously.

As per the agreement, 16 aircraft will be manufactured in Spain and delivered to India, while the remaining 40 are being built in India. So far, the Indian Air Force has received 15 C-295 aircraft. The first Made-in-India C-295 is expected to be delivered by August next year.

The C-295 can carry between 5 to 10 tons of cargo, transport up to 70 soldiers or 50 paratroopers with full battle gear. It features a rear ramp for paradropping troops and cargo. Designed for tactical missions, the aircraft is capable of low-level flying and can operate from short runways, taking off in just 670 meters and landing in 320 meters.

These features make it ideal for operations along the Line of Actual Control with China. It can fly for up to 11 hours at a speed of 480 km/h and comes equipped with an indigenous electronic warfare suite. The aircraft can have 24 stretchers during medical evacuation operations.

While newer aircraft like the C-17 Globemaster and C-130J Super Hercules do not require replacement, the ageing Avro fleet is being replaced by the C-295MW. Other ageing aircraft such as the AN-32 and IL-76 are also due for replacement.

The AN-32 will begin retiring after 2032, and the IL-76 will serve for a few more years. The Air Force has already issued a Request for Information (RFI) for a new medium transport aircraft to replace the AN-32.

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Airpower has revolutionized tactics, operations, and strategies but not the nature of strategy, war, or warfare.

- Colin S. Gray

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

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

Advisor : AVM Ashish Vohra VSM (Retd)
Editor, Concept & Content : Ms Gowri R

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