CENTRE FOR AIR POWER STUDIES (CAPS)
Forum for National Security Studies (FNSS)

# AEROSPACE NEWSLETTER

Source: @ChiefofAirStaff /Twitter (Ex Cobra Warrior 2023)

VOL III NO 4 05 April, 2023

Centre for Air Power Studies | @CAPS_India
Centre for Air Power Studies | Centre for Air Power Studies

*"Space-based assets significantly enhance the potency of Air Power and outcomes in the space domain will probably decide the eventual victor in future conflicts."*

*-Air Chief Marshal VR Chaudhari PVSM AVSM VM ADC*
*Chief of the Air Staff, Indian Air Force.*

# Contents

## Opinions and Analysis



## Air Power



## Space



## Global Aerospace Industry

## Indian Aerospace Industry



## Technology Development

# Opinions and Analysis

## India Needs a Nodal Organisation for Space Coordination Issues

*Air Vice Marshal Anil Golani (Retd)*
*Additional Director General, Centre for Air Power Studies | 10 Mar 2023*

*Source: Hindustan Times | https://www.hindustantimes.com/opinion/india-needs-a-nodal-organisation-for-space-coordination-issues-101678437719185.html*

*The proliferation of Unmanned Aerial Systems (UAS) for commercial use has been unprecedented and exponential, leading to justifiable concerns for regulation and control to prevent its use against national interest by State and non-State actors (Shutterstock)*

The salience of space as a domain for existence and survival continues to grow by the day. As the militarisation of space takes place at an unprecedented pace, the weaponisation to contest and dominate "global commons" is bound to increase in the coming years. While measures are afoot under the aegis of the United Nations (UN) to decide upon the rules and norms of responsible behaviour, the consensus appears difficult. The discussions are likely to be protracted due to the vested interests of major space-faring nations. The critical infrastructure of nation-States --- communications, monitoring of air and surface traffic, weather, meteorology and defence systems, including satellites, ground stations and data links ---- are dependent upon this domain.

This domain, therefore, becomes vulnerable to cyber, physical and non-kinetic attacks. Past conflicts and the ongoing Russia-Ukraine war vindicate this claim. The threat to the nation's sovereignty via aerospace could come from space-based systems, ballistic and hypersonic missiles, conventional manned and unmanned aerial systems and cyberattacks.

The onus for defending the nation's airspace rests with the Indian Air Force (IAF). But the primary stakeholder in the domain of space is the Indian Space Research Organisation (Isro), which works under the department of space (DoS), with the Isro chairman acting as the executive head of DoS. The DoS reports to the Prime Minister's Office (PMO) and is the primary agency that executes tasks related to space-based applications, space exploration and the development of related technologies.

**This agency could be the single point of contact for formulating all stakeholder policies and directives to ensure aerospace safety and control. Representatives from various agencies/ministries could be a part of this organisation, which needs to be created before it gets too late.**

All organisations under DoS were hitherto oriented towards research and development activities; however, with the opening of the space domain for commercial benefits, the government took the lead and created the Indian Space Agency (ISpA) and New Space India Limited (NSIL) in 2019. ISpA is an apex, non-profit industry body working exclusively towards the successful exploration, collaboration and development of India's public and private space industry. New Space India Limited was established as a Public Sector Undertaking (PSU) of the government and the commercial arm of Isro under DoS to scale up private sector participation in the Indian space

programmes.

The Ballistic Missile Defence (BMD) and associated network, comprising surveillance, command and control and the air defence weapon systems as a part of the National Aerospace Surveillance System, is supposed to integrate various radars and sensors, including the Missile Monitoring System of National Technical Research Organisation (NTRO), which would give an integrated air and space picture of ship-based, terrestrial and space-based sensors covering the ballistic missile domain. However, the networking of these systems and the subsequent sharing of data to operationalise the weapon systems and the defence mechanism are yet to fructify.

The proliferation of Unmanned Aerial Systems (UAS) for commercial use has been unprecedented and exponential, leading to justifiable concerns for regulation and control to prevent its use against national interest by State and non-State actors. The challenges for the security forces will only increase with the exploitation of this capability for commercial and military use.

Though the ministry of civil aviation (MoCA) has come out with Civil Drone Rules 2021, which govern the operation of civil drones in India, there is no clarity on the Unmanned Aerial Systems Traffic Management (UTM), which is a primary requirement for Beyond Visual Line of Sight (BVLOS) UAS flying environment. The Digitalsky portal on the civil internet for registration, regulation and use of civil drone operations is yet to be fully operational.

Though this system enables a proactive approach to safety and security guidelines for UAS operations, it needs to be equipped with real-time tracking, geofencing or other systems to facilitate the safe operation of drones. The conflicting demands of economic growth and security would need to be balanced and coordinated by a host of organisations involved in the process, viz. the ministry of civil aviation, NSCS, ministry of defence, ministry of home affairs, the armed forces, the Border Security Force, National Technical Research Organisation, Intelligence Bureau and the state police departments. The sub-conventional threat of using drones is emerging as a significant threat, giving rogue elements within the country and across borders the benefit of plausible deniability.

The threat from the sovereign airspace of the country is being handled by the IAF. However, with the proliferation of threats from UAS, ballistic missiles, long-range stand-off weapons, cyber and space-based systems and the plethora of agencies that deal with the regulation, detection and control of the aerospace and cyber domain, coordination, command and control going to be difficult in peacetime, let alone war. Therefore, there is an urgent and imminent requirement for a central organisation under the aegis of the NSCS to look at all the inter-agency policy and coordination issues for space, ballistic missiles, conventional aviation and the operation of UAS in the Indian airspace.

This agency could be the single point of contact for formulating all stakeholder policies and directives to ensure aerospace safety and control. Representatives from various agencies/ministries could be a part of this organisation, which needs to be created before it gets too late. As quoted by William Shakespeare: “There comes a tide in the affairs of men, which taken at the flood leads on to fortune; omitted all the voyage of their life is bound in shallows and in miseries. On such a full sea are we now afloat; and we must take the

current when it serves, or lose our ventures."

***

## Analysing the Balloon Drift: Another Perspective

*Air Marshal GS Bedi (Retd) | 03 Mar 2023*

*Source: VIF India | https://www.vifindia.org/article/2023/march/03/analysing-the-balloon-drift-another-perspective*

### Introduction

The US Department of Defense released a photo of the alleged Chinese spy Balloon on February 22. The photo was taken by a U-2 aircraft as it sailed over the balloon on February 3, according to the caption.

A U.S. Air Force pilot looked down at the suspected Chinese surveillance balloon as it hovered over the Central Continental United States February 3, 2023. (Image credit: Department of Defense).

China has maintained that it was a weather balloon that flew off course, in contrast to the US's assertion that it was carrying spying equipment. China has strenuously disputed that it had enough steering ability, despite US claims to the contrary. Whatever it is, it had travelled a great distance before being discovered on the other side of the globe. It was at 60,000 feet in the air when an AIM-9X missile launched by an F-22 Raptor aircraft brought it down.

### Purpose

While there seems to be a general consensus on the Easterly path followed by the balloon under the influence of winds blowing from West to East known as Westerlies, some assertions are intriguing and merit more investigation. An effort has been made to refute the widely held belief and present an alternative viewpoint. The intent is to prompt a fresh perspective on the entire episode.

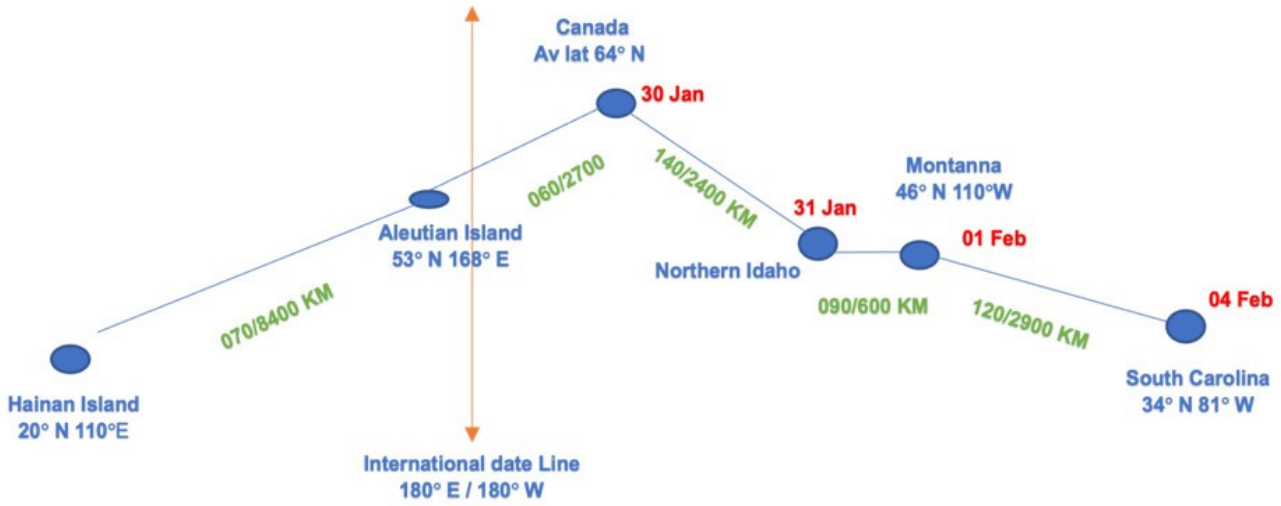
### Probable Launch Site

According to an article from NBC News dated February 18, the balloon's likely launch place was Hainan Island in southern China. It draws the conclusion that the balloon was launched from this island based on the testimony of a US official and a former senior US military officer who are both seemingly familiar with the situation. According to a US official who spoke to Reuters on conditions of anonymity, the initial course of the balloon would have taken it over Guam and Hawaii but it was blown off course by the prevailing winds – implying that the US was tracking the Chinese balloon since its launch from Hainan". Hainan, therefore, can be assumed to be the launch site of the balloon.

### The Travel

The voyage of the balloon is explained date-wise in an article by Helene Cooper and Edward Wong that was published in the New York Times on February 4. According to the report, the balloon was over US territory for seven days before it first appeared over the Aleutian Islands on January 28, which also indicates that all along US authorities were aware of it. It left US territory on January 30 for Canada before returning on January 31 over Idaho, apparently startling NORAD and military authorities. On February 1st, it was over Montanna, and that is when it was first closely watched. This journey of the balloon has also

**Representative Plot of Balloon Flight Path**




**Note.**The drawing is only for illustration purposes and not to scale

been corroborated by another report published in 'The Warzone' dated Feb 06.

After the US raised concern, the Chinese Foreign Ministry stated on 03 Feb that "the machine was a civilian weather balloon that had strayed far — very far — off course and entered U.S. airspace by accident", as per the NYT report quoted above.

The balloon seems to have been influenced, supposedly, by the strong westerly current prevailing in upper atmosphere or stratosphere. As per a report in the Associated Press dated Feb 4th, Dan Jaffe, a professor of atmospheric chemistry at the University of Washington, finds the travel of the balloon in consonance with the Westerly wind pattern prevalent over China.

**Pictorial Travel Plot**

Based on the facts about the balloon's journey mentioned above and using the fundamental knowledge of distances on earth, the balloon's route can be predicted. The distance travelled in one degree along the equator and at any particular longitude is fairly constant at 60 NM. It decreases along a latitude as a function of the cosine of the latitude you are measuring it at due to the convergence of longitudes as you move North or South. For instance, a change of 1 degree in longitude at the Equator will measure 60 NM and only 30 NM at latitudes 60 degrees north or south. On a flattened map, the balloon's journey will resemble the illustration shown below.

**Was the Balloon Controllable?**

China has vehemently denied for it to have any steering ability and that it simply drifted off under the influence of winds. The US on the other hand, appeared confident in stating that the balloon was steerable. China, however, seems to have the requisite technology. As per a report in Forbes, dated Feb 7, China has been working on steerable stratospheric balloons. It reported that, "In particular, the Academy of Opto-Electronics in Beijing, part of the Chinese Academy of Sciences in Beijing… is working on high-altitude balloon systems and "Modern airship including stratospheric airship."

As per National security spokesman John Kirby the balloon was not merely drifting from above Alaska, but had propellers and steering to

give it a measure of control, even as it was swept along in the high-altitude jet stream winds.

**Gaps in the Story**

Although winds can be anything, at those heights they are less likely to change significantly in speed and direction. The balloon is supposed to have changed direction from Northeast to Southeast in Canada, almost through 90º, travelling roughly twice as fast between Aleutian Islands and Montanna as it did between Montanna and South Carolina. Although it must be acknowledged that this is merely an observation and that it is not possible to claim that it is an aberration in the absence of genuine wind data, it nevertheless serves as a crucial link in the chain.

The US claims to have tracked the balloon since its very launch even though the precise date and time of the balloon's launch from Hainan Island have not yet been disclosed. The image shot by the U-2 on February 3rd, which was made public on February 20th, does not identify the balloon's location. Why did the US government ostensibly overlook it when it initially appeared over the Aleutian Islands and crossed into Canada, only to be shocked when it later reappeared over US territory? When spotted over the Aleutian Islands, was it judged to be overhead from the island itself or from a mainland observatory, meaning it may have been considerably further north in Alaska, seen going into Canada? Only after it was reported over Montana on February 1st did NORAD take action. Is it conceivable that the balloon was only discovered over Montana at first even though it was claimed to be known right from its launch? Of course, this is a kind of circumstantial evidence based on the distinct urgency displayed by NORAD when it was seen over Montana as compared to the sighting over Aleutian Island. Sanya Mansoor said in an article published in TIME on February 3 that the suspected Chinese surveillance balloon was first spotted over Billings, Montana, on February 1. She must have cited this either through her research or sources, it is assumed.

On the part of China, a balloon that was launched for weather observation must have been tracked and it should have been in contact with the ground segment in order to communicate the data it was sent for, especially if it was not recoverable owing to claimed absence of any steering ability. The Chinese government should have alerted other countries about this balloon if it started to fly out of control unexpectedly, especially the US. Why did it not do that? It remained silent about it until it was detected. Was China accustomed to such misadventures in the past and certain that it would pass through undetected hence didn't bother? Generally, a responsible nation would warn others, likely to be affected about any incident that went wrong accidentally. Since China did not do that, it can be safely assumed that it was an intentional manoeuver.

**The New Perspective**

If the US claim of tracking the balloon right from its launch is temporarily set aside for a moment -taking into consideration the balloon comportment and its sighting over Montana as the most authentic one, and also assuming that the Chinese had some control over the balloon, there is a possibility that the balloon was launched on a Polar orbit to avoid detection. Steering it Northwards up to about 65ºN latitude would keep it mostly in Chinese territory, going little bit into Russia which of course was of no concern at the moment. It could then travel eastward to reach Northern Canada, aided by the westerly

winds not requiring much power to propel it, and chances of detection in those Polar Regions would be minimal again. It is quite likely that it was sighted on 28 Jan over Aleutian Islands located at 55$^{0}$N, as reported by the US, but it is also possible that it may not have been exactly over it. Probably it was estimated to be over the island but was actually at even higher latitudes in Alaska thus seen to be going to Canada that did not cause any concern to the US authorities. From Northern Canada it would have been made to travel southward through relatively short distance down to Montana, apparently the place of interest it being the missile site.This would also explain the change in direction of the balloon travel. It would have been recovered back the same way, however, an alarm was raised when it reappeared over Montana. Once its presence was announced, the Chinese probably abandoned it and it was left to drift naturally. This could also explain the relative reduction in its speed as compared to the earlier travel. Rest, as they say, is history.

It is not a conspiracy theory but a legitimate concept, even though unconventional, to fill in the blanks to get a complete picture. Details of the equipment it carried are yet not known. Perhaps it would be possible to extract its track that could prove this hypothesis right or wrong. For now, there's wait and watch.

**Lessons for India**

It has become clear that there is significant amount of vertical space – between 20 and 100 KM – that lies and unexplored. It is not free space, but belongs to the nation and in India the IAF is responsible for its air defence. It needs to build an appropriate capability and operational procedures to counter any threat that may emanate from this area. At the same time, this unutilised space is available for exploitation by innovating technology and adapting creative strategies. Today, steered balloons are a reality.

Balloons have been used for observation and tourism and there have been attempts to utilise balloons to launch a satellite into the low earth orbit. A balloon at a high altitude, say 30 to 40 kilometres, would not interfere with regular air traffic, could be configured to stay within the sovereign area while managing drift, and would be very challenging to target.

A unique platform can be designed by combining innovative technologies in HABs (High Altitude Balloon), space launch ability, space communications and long range weapon systems. This platform can sustain itself in near space and dominate the skies over a vast area providing effective A2AD (Anti Access Area Denial) capability. While the technology is feasible, the challenge will be the economy of effort. The industry has the capability; it just needs to be guided in this direction. It will become a reality the day it is more cost-effective to fly this platform than the several Air Superiority Fighters that would be needed to produce a comparable effect. India must get a head start in this new area of capability.

***

# Analysing Indian Air Force's 2022 Doctrine

*Zaki Khalid | 21 Feb 2023*

*Source: CSCR |https://cscr.pk/explore/themes/defense-security/analysing-indian-air-forces-2022-doctrine/?s=08*

During a capstone seminar on warfare and aerospace strategy in June 2022, India's incumbent Chief of Air Staff ACM Vivek Ram Chaudhari released the revised edition of the Indian Air Force (IAF) service doctrine. The 2022 IAF Doctrine, released partially for the public in January 2023, comes a decade after the 2012 edition was released by the government of Prime Minister Manmohan Singh. It encapsulates the contrasting political, security, and economic dynamics generated during the two back-to-back tenures of incumbent Prime Minister Narendra Modi in the centre. Notably, from a Pakistani perspective, these tenures witnessed India transform from a contemporary South Asian country to one that is more assertive and harbours aspirations to become a regional power.

These aspirations have been greatly complimented by the central government and by the Indian Armed Forces, including the IAF, which has been famed for carrying out purported "surgical strikes" in Myanmar (2015) and Pakistan (2019). By and large, the Indian Armed Forces' increasing and diversifying engagements with multiple regional and extra-regional stakeholders have influenced a visible shift away from a somewhat conformist member of the developing world to one empowered to act as a pivot for global actors. This attitudinal change in posturing is energised by various minilateral engagements with competing actors, thus giving India the space to think along the lines of an emerging power.

Many overlaps and differences exist between the doctrines released a decade apart. This article will focus on some of the significant changes only.

**Utility of Air Power**

The previous doctrine was focused more on 20th-century aerial warfare and particularly sub-conventional warfare contingencies. It was also quite candid in discussing the major limitations of air power while highlighting the lack of political will to employ air power in sub-conventional contingencies, an apparent reference to Pakistan.

For now, it seems the IAF has incorporated punitive strikes in its training regimen, a testament to the politicisation of India's military thinking.

The 2022 doctrine makes glowing reference to skirmishes with Pakistan (Balakot) and China (Ladakh) when discussing the might of air power. Beyond territorial defence, it postulates a larger regional role through which the IAF can secure India's "national interests" in the Indian Ocean Region, making due mention of Modi's Security And Growth for All in the Region (SAGAR) policy.

**Air Diplomacy**

The previous doctrine cited cooperation with sister services and Humanitarian Assistance and Disaster Relief (HADR) operations as notable cases of diplomacy. The revised doctrine makes particular reference to bilateral and multilateral exercises with extra-regional actors such as the United States, United Kingdom and Australia.

As mentioned earlier, patronage and "partnership" with these countries during the successive Modi governments have imbued the Indian Armed Forces with greater confidence.

**Air Power to Aerospace Power**

The 2012 doctrine had a timid view of space power, remarking that it could not substitute for all other military capabilities or act as a panacea for informational gaps. Moreover, it was quite vocal about "rationalising" space power requirements instead of exploiting its resources to the maximum extent possible. It refers to this as the "availability and affordability" criteria and suggests an ad-hoc approach toward space power adoption.

In contrast, the 2022 doctrine not only explicitly advocates the shift from air power to aerospace power but also stresses greater space exploitation to achieve "national objectives". It mentions India's illustrious civilian space programme and suggests a civil-military fusion for space control which would also help to reduce dependence on external actors. Furthermore, it is proffered that increased aerospace power capabilities can help India engage more constructively with other nations.

**Jointness**

The IAF's current leadership continues to harbour reservations about the structure of proposed theatre commands, fearing a downgrading of airpower and operational subservience to commanders from the land forces.

The 2012 doctrine claimed that air power "remains the lynchpin of any joint application of combat power in modern warfare". The doctrine revised in 2022 goes a step further and declares aerospace power as the foundation for sustained land and maritime operations beyond physical operating mediums. Beyond doctrine, this assertion appears to amplify the IAF's stated reservations.

**No War, No Peace Strategy**

A key innovation in the IAF's doctrinal thinking is the elucidation of a No War, No Peace (NWNP) strategy, which is based on kinetic as well as non-kinetic prongs. One noteworthy aspect is Shaping Operations which includes Capability Demonstration; the doctrine describes it as the process of undertaking unspecified 'tests' and 'trials'.

In early March 2022, a supersonic cruise missile (speculated to be the BrahMos) landed in Pakistani territory, ostensibly by "accident". While India's political and military leadership was quick to order an inquiry with the hopes of diverting global attention, a large segment of Pakistan's strategic community is of the considered opinion that this launch was a deliberate attempt to assess Islamabad's response. India's Defence Minister Rajnath Singh had admitted subtly before the parliament that the missile was mishandled due to "human error" as opposed to some technical malfunction, which lends further credence to reservations among Pakistan's intelligentsia.

The term "shaping operations" has been borrowed from a draft 1998 US Army field manual which postulates that these consist of the application of military capabilities to set the condition for decisive operations. In his 1999 thesis, then US Army Major David R. Moore (Aviation) builds upon this concept and adds that shaping operations aim to reduce the adversary's capability to coherently resist before or during the execution of a decisive operation. He adds further that the psychological effects of shaping

operations could include preventing confrontation between opposing forces.

Major Kyle J. Wolfley, Assistant Professor at the US Military Academy, says that major powers use shaping "to proactively manage allies, friends, and adversaries in the hope of avoiding the need for warfighting or costly coercion. By using shaping effectively, these powers may obviate the need to react under disadvantageous conditions in the future."

The IAF's concept of shaping already includes Rapid Air Mobilisation and Deterrence through strategic assets; hence the goal of "capability demonstration" might refer to a mix of testing adversarial military preparedness and power projection. As India's nuclear assets are under the control of the tri-services Strategic Forces Command (SFC), the ability to project combat potential through kinetic and non-kinetic tests and "trials" can be independently retained by the IAF as a flexible option in times other than war and peace. In this context, the "accidental" launch of a supersonic cruise missile into Pakistan can be considered the first practical manifestation of a shaping operation through kinetic means.

Another important aspect of the NWNP strategy is the conduct of "punitive strikes" as part of the External Security Operations prong for political signalling. The precedent for such "strikes" seems to be based on the Modi regime's policy of espousing rhetoric and aggression against neighbouring countries to build internal political capital. It is unclear whether this doctrinal approach will continue in case parties other than the Bharatiya Janata Party (BJP) come to power in the centre. For now, it seems the IAF has incorporated punitive strikes in its training regimen, a testament to the politicisation of India's military thinking.

**Conclusion**

A comprehensive reading of the IAF's 2022 doctrine reveals a heightened sense of institutional assertiveness and the desire to achieve regional air power dominance with the help of allies and partners. The foundation of this new thinking rests on political leadership's appetite to uphold an outward-looking posture and the operational utility of aerospace power.

The revised doctrine contrasts sharply with the 2012 version, which is somewhat inward-looking and rather timid in outlook. It goes without saying that the Modi regime's politico-diplomatic engagements have helped inculcate grand strategic thought in the armed forces. Future governments in India's centre will need to promote greater civil-military fusion in space operations to ensure that the IAF's renewed outlook on the concept of warfighting can be realised within budgetary and resource constraints.

***

# February 27, 2019: What Went Wrong?

*Bernard Woolley | 27 Feb 2023*

*Source: Medium.com | https://medium.com/@BernardWoolley/february-27-2019-what-went-wrong-1282ee47eb32*

*An Indian Air Force MiG-21 Bison on a take-off run*

## Introduction

On the 27th of February 2019, exactly four years ago, the Indian Air Force (IAF) fought its first air battle in nearly fifty years. The exact details of what happened on that fateful day are still obscured beneath layers of claims, counterclaims, disinformation, and at times, outright propaganda — with both Indians and Pakistanis trying to prove that their side came out on top.

While the picture is no less confusing today, I hope that enough time has passed that we can leave our fervour aside and examine the events with some degree of objectivity. This is what my analysis aims to do. We'll look at how the battle played out; and review the IAF's performance from a tactical, operational, and strategic perspective.

Some caveats before we dive in: First, I have written this essay from an Indian perspective, and have not subjected the performance of the Pakistan Air Force (PAF) to the same level of scrutiny. Second, my assessment is based on a mix of known facts, media reports of varying accuracy, private information, and reasonable extrapolations. It is sure to contain misinterpretations, errors, and inaccuracies. By no means is it the final word on the matter, although I hope it brings us closer to the truth. And finally, it is impossible to divorce the skirmish that took place on February 27th from the events of the previous day, when the IAF bombed a Jaish-e-Mohammad establishment in Balakot. But because the PAF refused (or failed) to put up a fight that night, the details of what transpired do not interest me as much.

## The Setup

Following the Balakot airstrike, the PAF was expected to mount a retaliatory strike on India to restore deterrence and seize back control of the escalation ladder. Both sides maintained a sizeable aerial presence in the hours and days that followed, with the PAF looking for an opportunity to land a blow, and the IAF attempting to ward it off.

Things came to a head at approximately 9:30 in the morning of February 27th, when a watchful PAF caught the IAF in a position of momentary weakness and commenced Operation Swift Retort.

At this moment, the IAF had four fighter aircraft on a defensive combat air patrol (CAP) over Kashmir. Two Mirage-2000s in the North near Bandipora (called the Ironman flight) and two Su-30MKI in the South near Naushera (called the Avenger flight). Several MiG-21s, and possibly MiG-29s, were on Operational Readiness Patrol (ORP — a state of high readiness with fighters armed, fuelled, and manned; ready to take off at a moment's notice) at multiple bases. Four Su-30MKIs and an AEW&C aircraft (Airborne Early Warning and Control — an airborne radar and command post that provides situational awareness and directs all air activity in its sector)

were rotating out.

The PAF's raid consisted of four distinct packages. One flight of four JF-17s was intended to pin down the Ironman flight. Another flight of four F-16s was to suppress the Avenger flight. They would keep the skies safe for two ground attack packages. The main package consisted of four Mirage-IIIs, and four JF-17s, with four F-16s providing escort. One of its targets was reported to be the Indian Army's Brigade Headquarters in Bhimber. A smaller package of four more Mirage-IIIs was to hit the ammunition dump at Narian. The engagement was directed from a Saab-2000 Erieye AEW&C. A Falcon 20F Electronic Warfare aircraft provided jamming support.

**The Battle**

The two PAF counter-air flights (4 x JF-17 and 4 x F-16) appear to have had two objectives: to keep Indian fighter aircraft from interfering with the ground attack packages, and to try to score kills on Indian fighter aircraft if possible. The first was a success, but the second was not. While the JF-17s engaged the Mirage-2000s in a beyond visual range (BVR) grind, they were unable to generate firing solutions and launch missiles at them. The F-16s were in a stronger position — they climbed up to 40,000 feet and lobbed AMRAAMs at the Su-30MKIs that were flying at around 25,000 feet. With that difference in altitude, they comfortably outranged the defenders. Even so, these missiles were fired from the extremes of their range, and failed to score kills.

As soon as the enemy's intent became clear, the IAF's MiG-21s on ORP in Srinagar were scrambled. As they climbed to intercept, they flew in the radar shadow cast by the Pir Panjal range, and remained hidden from the PAF's Erieye AEW&C. They weren't illuminated until they were nearly atop the main strike package. Their sudden appearance on the PAF's battle management system appears to have thrown that package into confusion: It released its munitions in haste and scattered. Those munitions were of the type that required manual guidance all the way to their targets, and thus, missed.

In that melee, one MiG-21, flown by Wing Commander Abhinandan Varthaman, appears to have encountered heavy jamming, and crossed the Line of Control in pursuit of the enemy. In the ensuing furball, Abhinandan was shot down. He ejected, was apprehended by the locals, and was taken prisoner. The IAF claims that he downed a Pakistani F-16 before taking fire, but the evidence supporting this claim is purely circumstantial.

At the same time, an unidentified object showed up on the consoles of the air defence operators protecting Srinagar airfield, and was shot down by a SpyDer surface-to-air missile battery. This object turned out to be an IAF Mi-17V-5 helicopter returning to Srinagar from a supply mission. All six personnel onboard were killed, as was a civilian on the ground.

All this happened within minutes. The IAF rushed more aircraft to the scene, but it was already too late. The raid was over.

**Assessing the Outcome**

The proximate reason the IAF was caught off-guard on that day was its inability to anticipate the quantum of Pakistan's response. Its leadership calculated that the risk of a massive alpha strike — which could potentially have destroyed the bulk of a forward-deployed fleet on the ground — was too great. It therefore moved its most capable assets to bases deeper inside India's interior. Since those assets flew in from great distances,

their time on station was limited. This, in turn, opened up a gap for the PAF to exploit.

In fairness to the IAF leadership, uncertainty is a fundamental characteristic of war, and commanders are forced to trade-off some risks against others. It is only with the benefit of hindsight that a certain of events appears obvious. One must keep this in mind before faulting the IAF for this slip.

What is unforgiveable, however, is the complete absence of long-term planning and foresight within the military leadership as well as the civilian administration. This resulted in a persistent misalignment between desired ends and available means, and made its impact felt in the various shortcomings that the IAF suffered during the conflict. Consider the fact that hardened shelters capable of accommodating heavy fighters were absent at key bases like Srinagar. Or that antiquated MiG-21s had to be sent into combat in 2019. Or that communications between fighters and controllers were carried out using unsecured voice radios (which the PAF intercepted) instead of encrypted data links. None of these paint an encouraging picture of how the military is run, or of civil-military co-ordination.

The deep-set issues in the Indian military apparatus came together in the perfect storm over Srinagar Air Force Station, where base air defences shot down a friendly Mi-17V-5 helicopter. A court of inquiry later revealed that the helicopter's Identification Friend or Foe (IFF) system, which distinguishes friendly aircraft from enemy ones, had been turned off. The reason cited was the interference with civilian frequencies. As a result, the helicopter showed up on the base air defence consoles as an unidentified object. Faced with limited information and a pressing need to make a quick decision, the officer in charge made the unfortunate choice to shoot it down.

This one incident laid bare the many years of omissions, apathy, and inertia at every level of the civil-military system. A military aircraft having to fly with its IFF transponder disabled — in what was potentially contested airspace — was unconscionable.

The outcome was also a strategic setback. The fact that the IAF did not (or was not allowed to) counterattack, came as a shock to a public that had been brought up on tales of the IAF's prowess. Between the IAF's lack of preparation for an all-out air war and the approaching general elections, there was no appetite to initiate a larger conflict. Just as the Balakot raid had exposed the hollowness of Pakistan's nuclear redlines and expanded India's options for military action, Operation Swift Retort had helped Pakistan demonstrate its resolve and restore conventional deterrence across the border.

Still, a handful of bright spots did shine through what was an otherwise lacklustre performance. For instance, the procedures to maintain fighters on ORP demonstrated their effectiveness. The response from Srinagar-based MiG-21s was so quick that they surprised the attackers and scattered their strike package. A slew of indigenous systems that were deployed over the course of the tensions — in particular the Netra AEW&C system, the Samyukta electronic warfare system, and the Integrated Air Command and Control System — gave a strong account of themselves.

Aircrew selection and training also proved to be a key strength. In the initial phase of the clash, just four Indian fighters squared off against a

well-supported strike package that was six times their size without losing cohesion or discipline. This was followed by two MiG-21s showing exemplary aggression and initiative against an enemy that outnumbered and outgunned them.

On the other side, the PAF timed its raid perfectly. It successfully disguised a large operation as an exercise, and kept the IAF guessing as to its intent until the very last moment. It melded together a clutch of disparate assets sourced from multiple countries, and executed an effective operation that achieved its political objectives. But it is also important to recognize that the raid failed in its operational objective — to hit the Indian Army's brigade headquarters and ammunition dumps in Kashmir.

**The Bottom Line**

At the end of the day, Pakistan was seen to win the engagement, because its victories were clear-cut and its shortcomings did not detract from the mission's key goals. The PAF demonstrated the audacity to target Indian Army establishments, scored a kill on an IAF fighter, and paraded the captured pilot all over social media. Conversely, India's failures were public, and successes too abstract to convince a lay audience. Doubling down on a questionable claim of an F-16 kill made it appear as if an embarrassed IAF was cooking up stories to cover up its failures. Being the larger and better-resourced force, it was incumbent upon the IAF to produce an unambiguous, lopsided victory. Anything less was going to be seen a loss, and rightly so.

***

# Air Power

## In Rare Occurrence, 3 International Air Exercises Across 2 Continents for Indian Air Force

*Sidharth MP | 02 Mar 2023*

*Source: Wion News | https://www.wionews.com/india-news/in-rare-occurrence-3-international-air-exercises-across-2-continents-for-indian-air-force-567590*

*The air forces of Indian and Japan are taking part in Exercise Maitri 23. Photograph:(Others)*

In a very rare occurrence, Indian Air Force teams are taking part in three International Air Force Exercises simultaneously - in the UAE, in the UK and Japan. India has deployed a fleet of fighter aircraft and transporter aircraft for the International exercises being conducted on foreign soil. Fighter and transporter aircraft from the IAF and hundreds of Air Warriors are taking part in these exercises that are aimed at building interoperability, exchanging best practices and enhancing mutual understanding.

**What are these Three International Air Force Exercises?**

**Exercise Desert Flag VIII**

An Indian contingent of 110 Air Warriors is at Al Dhafra airbase of the UAE, taking part in Exercise Desert Flag VIII. The Indian Air Force is participating with five LCA Tejas fighters and two C-17 Globemaster III strategic heavy-lifter

aircraft. Notably, this is the first-ever international flying exercise that India's indigenously-built Tejas will be flying in. Exercise Desert Flag is a multilateral air exercise in which the air forces from UAE, France, Kuwait, Australia, the UK, Bahrain, Morocco, Spain, the Republic of Korea, USA would be taking part. The exercise is going on from 27th February to 17th March. The exercise is aimed at facilitating diverse fighter jet engagements and learning from the best practices.

**Exercise Cobra Warrior**

A 145-member team of the Indian Air Force are at UK's Waddington Air Force Base for the multilateral Air Exercise Cobra warrior. Air forces from Sweden, Finland, South Africa, the USA and Singapore would be taking part alongside the Royal Air Force and Indian Air Force. The IAF has deployed five Mirage-2000 fighters, two C-17 Globemaster III strategic heavy-lifter aircraft and an IL-78 mid-air refueller aircraft. The exercise is being conducted from 6th to 24th March.

**Exercise Shinyuu Maitri**

On the sidelines of the Indo-Japan Joint Army Exercise Dharma Guardian, the respective air forces are taking part in Exercise Maitri 23 which focuses on heavy-lift transport aircraft operations. The IAF contingent is taking part in one C-17 Globemaster III aircraft, whereas the Japanese JASDF will be fielding the C-2 transport aircraft. The exercise will comprise discussions on transport operations and tactical manoeuvring, followed by flying drills. The ongoing exercise is being conducted on March 1st and 2nd in Japan.

***

## IAF Inducting In-House System to Identify Friendly Forces in Combat

*Amrita Nayak Dutta | 12 Mar 2023*

*Source: Indian Express| https://indianexpress.com/article/india/iaf-inducting-in-house-system-to-identify-friendly-forces-in-combat-8491420/*

*Wing Commander Vishal Mishra with the Vayulink system. IAF*

The Indian armed forces are in the process of inducting a homegrown innovation along the country's northern and eastern borders which will help commanders identify friendly forces in a joint battlespace.

This will facilitate better coordination during complex operations and curb instances of mistaken fratricide as happened in Budgam in the aftermath of the 2019 Balakot air strikes.

The Vayulink system has been developed by Wing Commander Vishal Mishra, a helicopter pilot with the Indian Air Force (IAF). He said it will not only help enhance battlefield transparency through identification of friendly forces in a combat situation — whether airborne or on the ground — through secure, jammer-proof communication, but will also arm pilots with accurate weather data before they fly.

The Vayulink system was showcased by the IAF at the Aero India 2023 show in Bengaluru last month.

Senior IAF officers said trials for operational deployment of the system have been completed.

"The procurement required for deployment is under process. Once the procurement is completed, mass deployment of the system will start in all forward areas," an officer said.

Air Marshal Narmdeshwar Tiwari, Deputy Chief of the Air Staff, told The Sunday Express that the Vayulink ecosystem is an in-house developed tactical data link system.

"It integrates inputs available from multiple sources in a joint battlefield and provides near real-time data to operators, thereby vastly improving their situational awareness and consequently aiding in effective decision making," he said.

"The IAF has already deployed the system on a trial basis at forward locations in the Western and Northern sectors. We are planning to further enhance the reach and applicability of the system in future," he said.

Wing Commander Mishra said the Vayulink is effectively a data link system which connects all entities, combat and non-combat, through a single link.

"The system can help you get the position of all friendly forces in a battlefield or even those in support roles. When in use in a complex combat situation, the system can help all aircraft see each other's position and location of ground troops," he said.

The system, he said, can have a range of applications and is not confined to one service, but can integrate all combat entities through a single link. It has also been inducted into the Army under the name Trishul link.

The system can improve the efficiency of operations, especially complex ones such as the one launched in response to the Pathankot air base terror attack in 2016.

The counter-terror operations in Pathankot lasted nearly four days, despite IAF helicopters supporting the ground forces. Seven security personnel were killed by the terrorists who had infiltrated the air base.

Explaining how the Vayulink can help, another IAF officer said an attack pilot does not have the capability at present to see on a device the exact position of friendly forces.

"When actual contact battle takes place, you do not know where the friendly forces and where the enemy forces are. So, a pilot going for a busting role can face difficulties in identifying his own troops at that time. A system like Vayulink is going to help," the officer said.

It is learnt that the system can also curb Budgam-like cases of mistaken fratricide by bringing in battlefield transparency that will enable the ground crew to identify friendly forces and be aware of their exact positions.

After the Balakot air strikes in 2019, the IAF had shot down its Mi-17 V5 helicopter at Budgam by mistake, killing six personnel on board. The helicopter's IFF (Identification of Friend or Foe) system was also switched off, which had led to gaps in communication between the helicopter crew and the ground forces.

Asked about the limitations of the existing IFF systems, the officer said that the IFF system is only applicable to an aircraft and requires radars to function. "On the other hand, the Vayulink system can be carried by an aircraft, individual troops or armoured vehicles on ground, distinguishing them from their enemy counterparts. Secondly, the IFF system has limitations with respect to the line of sight," the officer said.

The development team is currently focusing

on its smooth induction into the Indian armed forces.

The Vayulink system can also arm the pilot with real-time weather details before flying, thereby preventing accidents.

***

## Single Pilot C-130J Operations Being Explored by Air Force

*Emma Helfrich | 10 Mar 2023*

*Source: The Drive | https://www.thedrive.com/the-war-zone/single-pilot-c-130j-operations-being-explored-by-air-force*

*U.S. Air Force photo by Senior Airman Stephanie Serrano*

The U.S. Air Mobility Command is expanding the limited-aircrew employment concepts it has been exploring with aircraft like the KC-46 Pegasus to include the C-130J Super Hercules. The initial plan is to get select C-130J pilots and loadmasters trained on exactly how a flight utilizing only one of each would be executed, which will include the loadmaster helping the pilot fly the aircraft. All of this is part of an effort to prepare Mobility Air Forces for emergency scenarios where a threat or series of factors would require reduced crew operations.

Undergoing training on what has been dubbed the 'one pilot-one loadmaster' concept for C-130Js has been aircrew from the 19th Airlift Wing's 61st and 41st Airlift Squadrons based out of Little Rock Air Force Base in Arkansas. These exercises will be held on the ground in a flight simulator at first, with the goal of eventually getting all pilots and loadmasters within the units trained on the concept in this environment.

"We look at it as a solution if crew members are ever in a contingency situation with limited resources and they need to get the airplane out of that danger," said Capt. Abigail Plunkett, 19th Operations Support Squadron (OSS) chief of training. "Normally there would be two pilots and two loadmasters, but this teaches pilots how to safely operate the aircraft with only one other crewmember [a loadmaster] on board."

The C-130J, manufactured by Lockheed Martin, is typically employed to perform tactical airlift missions as the aircraft is designed to be capable of operating from austere locales and rough airstrips while transporting personnel and materiel to potentially hostile locations. A standard C-130J crew complement consists of two pilots and one loadmaster, the latter of which is responsible for mathematically preplanning load placement, loading and unloading cargo, tending to passengers, and a variety of other related duties specific to the C-130J's operation.

In a press release shared by the 19th Airlift Wing, Tech. Sgt. Benjamin Baughman, 19th OSS group training flight chief, explained that the new one pilot-one loadmaster syllabus will be broken up into two parts. The first will be comprised of instructor-led ground training and the second will focus on training with the simulator.

Expected to fall under the instructor-led ground training leg of the syllabus are general classroom activities like reviewing the necessary materials that will inform the evaluations conducted in the simulator. Once there, loadmasters will be familiarized with the C-130J's flight controls

and learn how to maintain situational awareness aboard the aircraft without getting in the way of the pilot.

According to the press release, however, there are currently no plans to hold any proof-of-concept C-130J test flights with a limited crew. In other words, the one pilot-one loadmaster C-130J syllabus will remain in a simulated environment for the time being.

"We're not trying to train loadmasters to fly, but we're training them to be able to help a pilot safely get an airplane from point A to point B," Plunkett said. "As of now, we will only be accomplishing this training in the sim."

Regardless, the introduction of this concept directly lines up with Air Mobility Command's (AMC) ongoing efforts to examine just how realistic reduced crew operations could be for the command's expansive air transport fleet. In major high-end fights where dangerous, emergency situations could leave AMC crews with limited options, safely getting out of or into the conflict zone by whatever means necessary will be critical, even if that means flying with less crew.

**The flights are being simulated with just one pilot and one loadmaster, with the latter working to support the single pilot in the cockpit.**

This is something that AMC is currently exploring with the KC-46 Pegasus tanker aircraft. Last October, the Air Force completed two sorties using a KC-46A from the 22nd Air Refueling Wing at McConnell Air Force Base in Kansas, which readers of The War Zone can learn about in detail here. The tanker flew with only a pilot and a single boom operator. An instructor pilot was also present, but only to act as a safety observer.

Even though this concept, at least as it relates to the KC-46 specifically, has been called into question by some due to safety concerns and other factors, the Air Force is nonetheless giving it a shot. Just like the C-130J's tactical airlift capabilities, aerial refueling will also be a defining factor of any major conflict in the future, especially one in the Pacific against China.

In a statement that followed the KC-46A's flight test with a limited crew, Air Force Col. Nate Vogel, head of the 22nd Air Refueling Wing, mentioned that the mission was practiced extensively in flight simulators leading up to the evaluation. He explained that doing so allowed his team to carefully consider each phase of the test ahead of time, "taking into account crew safety, aircraft capabilities, and existing federal aviation standards."

While aerial refueling operations with a limited crew present a number of different challenges than one pilot-one loadmaster tactical airlift flight, both concepts are aimed at ultimately providing the Mobility Air Forces more flexibility and operational independence. In a time of war, airfields, bases, and aircraft stationed there will become static targets for enemy missile attacks, making it critical for those platforms and their operators to have the ability to get in the air with their fuel and cargo as quickly and safely as possible. The pace of sustained conflict operations and even the supply of aircrew during a prolonged war are also factors that could impact the relevancy of these new tactics.

Commander of the AMC Gen. Mike Minihan has in the past said himself that "victory will be delivered on the back of the Mobility Air Forces," and to uphold that statement, the service seems to be exploring a number of ways it can adapt to

potential future contingencies in what could be very challenging combat environments.

***

## Iran's Air Force, Going Underground?

*Joseph Dempsey | 10 Mar 2023*

*Source: IISS | https://www.iiss.org/blogs/military-balance/2023/03/irans-air-force-going-underground*

*Iran's combat aircraft are ageing, and many obsolescent, but Tehran is still going to great lengths to protect them. Iranian television on 7 February showed a previously unseen underground hanger complex, referred to as 'Oqab (Eagle) 44', though the location was not disclosed. It is, however, likely 120 kilometres north-west of Bandar Abbas (28.04361, 55.52177).*

### Mountain Deep

Commercial satellite imagery shows the 'new' air base near a mountainous landscape with two pairs of entrances for aircraft at the apparent underground complex. This complex is currently connected to the single runway by a taxiway – the latter including a 150-metre tunnel through a ridge.

While the runway and taxiway remain vulnerable to conventional attacks, they can be repaired within days depending on the extent and types of munitions used. Replacing combat aircraft is another matter entirely, particularly for Iran which – despite the easing of Western sanctions – continues to be reliant on pre-Iranian Revolution United States-supplied aircraft and similar Soviet-era types.

Iran has previously invested in underground complexes, but mainly to protect its ballistic missile forces. In May 2022 images were published of an underground facility with uninhabited aerial vehicles (UAVs) and direct attack munitions displayed in the narrow tunnels. This was reportedly in the Zagros Mountains, though an exact location is still unconfirmed.

The released footage showed several US McDonnell Douglas F-4E Phantom II fighter-ground-attack aircraft, one shown adapted to carry a Chinese-derived anti-ship missile and indigenous glide bomb. A number of UAVS were visible as was the 'Asef' air-launched cruise missile on a Soviet-era Sukhoi Su-24 Fencer attack aircraft, though it is unclear from the imagery if it is the same location as implied.

Underground aircraft shelters have fallen out of favour somewhat, due to the widespread introduction of precision-guided weapons. Access and exit routes are vulnerable to being blocked by attack. Instead, hardened single-aircraft shelters, combined with multiple taxiways and runways, have been preferred, including at some Iranian air bases. Individually the shelters are easier to target in any kind of attack, but as they are also more numerous, they increase the challenge for an attacker.

The rationale behind Iran's investment in this extensive and lengthy project is uncertain. Nevertheless, Tehran may value the long-term preservation of its legacy aircraft more than its short-term availability in a potentially limited conflict or exchange. Another potential factor highlighted by Iranian media was that the complex would better conceal preparations for any strike missions from satellites.

**Build Programme**

Work on the site looks to have been started as early as 2014, judging from satellite images of the area. Development of the runway, however, appears to have begun around 2021. Despite local media asserting the base was complete, some parts appear unfinished with further construction needed.

Satellite imagery from 11 February indicated only one of the four aircraft access points to the underground complex is currently directly linked to a completed taxiway. Deceptive footage shows two aircraft taxiing outside the unlinked western entrances – but this does reflect the underground interconnection. Though shown to be usable, the current lone tunnelled taxiway still appears unfinished at the southern entrance.

**Iran's underground activities reveal the development of an 'airbase' to provide a survivable shelter for combat aircraft. While claimed to be complete, imagery analysis suggests there is still some work to be done.**

Aligned cutaways in two hillsides suggest a further taxiway is also planned, possibly a tunnelled one. So far, visible external structures appear associated only with the long-term construction. It remains to be seen whether support buildings have yet to be constructed, or if the base is intended to provide a survivable site for deployed aircraft, rather than a permanent location.

**Wrong Fit for a Flanker?**

The widely anticipated delivery from Russia of the Sukhoi Su-35 Flanker M multi-role fighter to Iran has led to speculation that Oqab 44 could now be the intended home for the aircraft, given their value to the Iranian Air Force, and there appeared to be a Su-35 mock-up at the site. The size of the Su-35, however, would run counter to such suggestions.

Imagery of Iran's F-4E Phantom II with a wingspan of 11.7 m illustrates the already relatively tight clearances in some parts of the complex. Considering the Su-35 has a much greater 15.3 m span, some areas of the base may be inaccessible for this type. Even those that potentially are accessible, albeit with reduced tolerances, could necessitate a greater reliance on more time-consuming ground crew handling as opposed to the option of the aircraft taxiing under their own power as the Phantoms were shown to be capable of doing.

This airbase's purpose and intended use are still unknown, but Iranian media reports that it is one of several similar facilities built across the country. Given the complex's construction had gone unnoticed by the public for almost a decade, other sites could exist, with some existing known airbases having the associated terrain nearby or providing indication of similar excavations.

***

# Space

## Canada Agrees to ISS Extension to 2030

*Jeff Foust | 25 Mar 2023*

*Source: Space News | https://spacenews.com/canada-agrees-to-iss-extension-to-2030/*

*The International Space Station as seen from a Crew Dragon spacecraft in 2021. Credit: NASA*

WASHINGTON — The Canadian government formally committed March 24 to an extension of the International Space Station to 2030, joining other Western partners but not Russia.

As part of a summit meeting in Ottawa between Canadian Prime Minister Justin Trudeau and President Joe Biden, the two governments confirmed that Canada would participate in the ISS through 2030 as part of a renewed commitment to space exploration that includes contributions to the NASA-led lunar Gateway.

"Prime Minister Trudeau agreed to extend Canada's commitment to the International Space Station (ISS) and support science on the Lunar Gateway," the Canadian government said in a statement outlining overall cooperation between the two countries. "Our country's continued participation in ISS and Lunar Gateway cement Canada's global leadership in robotics in space and on Earth."

The White House announced at the end of 2021 its intent to extend ISS operations through 2030. Since then, the U.S. has been working with its major partners to confirm their participation in the station beyond the previously agreed-to date of 2024. The Japanese government formally agreed to the extension in November 2022, followed shortly thereafter by the European Space Agency at its ministerial meeting.

Canada was expected to also agree to an extension, with timing the only issue. "No one would have expected Canada to make a decision before the U.S. or even ESA or Roscosmos," one Canadian Space Agency official, Christian Lange, said at a January 2022 conference. The White House announcement, he said then, would allow the agency "to propose options and come to a decision in a timely manner" but gave no timeline for doing so.

"The United States strongly welcomed Canada's decision to support the extension of operation of the International Space Station through 2030," the White House said at the end of a fact sheet.

With the Canadian announcement, Russia is the only ISS partner that has not agreed to an extension to 2030. Last July, Yuri Borisov, new head of Roscosmos, said that Russia would leave the ISS partnership after 2024. Officials later clarified that meant some time after 2024, not necessarily immediately after 2024.

In February, a Roscosmos council approved a plan to extend Russian operations on the station to 2028. The agency said it would then prepare documents to get formal approval from the Russian government for that extension.

The U.S. and Canada also promoted the impending announcement of the crew of Artemis

2, the first flight of the Orion spacecraft to carry astronauts. The four-person crew will be announced at an event in Houston April 3.

One of the four will be Canadian as part of an agreement NASA and the Canadian Space Agency announced in late 2020 regarding Canada's contribution to the Gateway. In exchange for providing the Canadarm3 robotic arm for the Gateway, Canada got a seat on Artemis 2 as well as a future, unspecified mission to the Gateway.

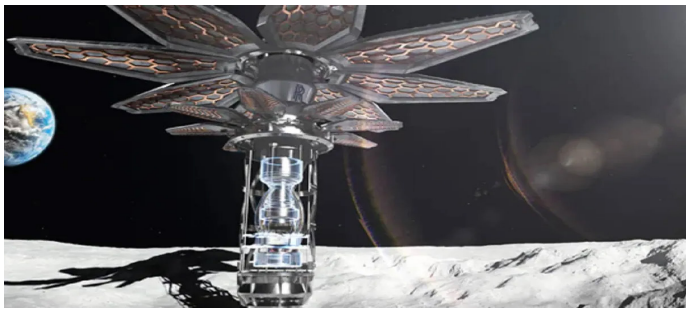
Biden mentioned the Artemis 2 announcement in a speech March 24 to the Canadian Parliament. "In just a few days, NASA is going to announce an international team of astronauts who will crew the Artemis 2 mission. The first human voyage to the moon since the Apollo mission ended more than 50 years ago will consist of three Americans and one Canadian," he noted. "Together we'll return to the moon."

***

## UK to Invest Over $3 Million in Rolls Royce's Moon Nuclear Reactor

*Sandra Erwin | 21 Feb 2023*

*Source: Interesting Engineering | https://interestingengineering.com/science/uk-rolls-royces-moon-nuclear-reactor*



*An illustration of Rolls Royce's Moon nuclear reactor*

The UK Space Agency (UKSA) said on Friday it would invest a significant amount in Rolls-Royce's project to produce nuclear power on the moon.

In a statement, the UKSA outlined how researchers from Rolls-Royce had been working on a Micro-Reactor program "to develop technology that will provide the power needed for humans to live and work on the Moon."

The government agency will now invest £2.9 million (around $3.52 million) in the project in order to "deliver an initial demonstration of a UK lunar modular nuclear reactor."

"All space missions depend on a power source to support systems for communications, life-support, and science experiments," the UKSA said.

"Nuclear power has the potential to dramatically increase the duration of future Lunar missions and their scientific value."

We first reported on Rolls Royce's ambitious plans in September of 2021.

At the time, the firm was looking into how a micro-nuclear reactor could be used to propel rockets while in space at huge speeds and how that technology could then be redeployed to provide energy for drilling, processing, and storage for "Moon mining" and possibly "Mars mining."

The company also claimed it would use its experience in developing nuclear-powered submarines for the Royal Navy for 60 years to apply what it learned to spacecraft since submarines and spacecraft are somewhat similar.

**Growing Nuclear, Science, and Space Engineering Bases**

According to the CNBC, Paul Bate, chief executive of the UK Space Agency, said that "developing space nuclear power offers a unique chance to support innovative technologies and grow our nuclear, science and space engineering skills base."

Rolls-Royce is now aiming to "have a reactor ready to send to the Moon by 2029."

Although the Moon's proximity to the Sun would make it an ideal candidate for solar power, the reality is that its rotation creates too much darkness for the technology to be viable.

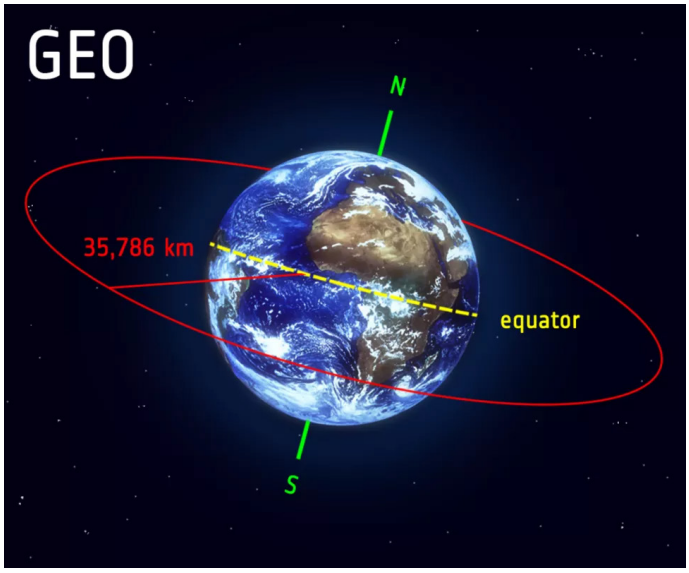
Nuclear power would be an ideal energy source for the celestial object as it can be continually used, whether in darkness or light. However, many kinks still need to be worked out, such as finding the right nuclear fuel and dealing with radioactive waste.

***

## A Chinese Spacecraft has been Checking out US Satellites High Above Earth

*Andrew Jones | 03 Mar 2023*

*Source: Space.com| https://www.space.com/chinese-spacecraft-tjs-3-inspecting-us-satellites*




*Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east, taking 23 hours, 56 minutes and 4 seconds to circle our planet — the same amount of time it takes Earth to complete one rotation. This makes satellites in GEO appear to be "stationary" over a fixed position. (Image credit: ESA – L. Boldt-Christmas)*

A Chinese satellite launched in 2018 has been inspecting other nations' spacecraft high above Earth in geostationary orbit.

Tongxin Jishu Shiyan Weixing-3 (TJS-3), named vaguely as a communications experiment satellite, was sent up into geostationary orbit in late 2018. It then released a small subsatellite, possibly to help test TJS-3's capabilities.

Orbital data reveals that TJS-3 has been making close approaches to American satellites in recent months. For example, the Twitter account Orbital Focus notes(opens in new tab) that the satellite has been drifting along the geostationary belt, but pausing to take a closer look at satellites USA 233 and USA 298, both

thought to be military communications satellites operated by the U.S. Space Force.

Satellites in geostationary orbit (GEO) operate at 22,236 miles (35,786 kilometers) above Earth, where their velocity matches the rotation of the planet and sees them appear fixed over one point on the surface below. This orbit is thus highly prized for its use for communications and other purposes.

At the same time, a spacecraft that either raises or lowers its orbit a few tens of miles will be able to drift west or east respective to other satellites, allowing a satellite over time to sweep past others and take a look.

Satellite Dashboard, a web tool that collates and analyzes space situational awareness (SSA) data, reveals that TJS-3 approached(opens in new tab) as close as 3.8 miles (6.2 km) to USA 233 on Oct. 31, 2022.

U.S., Russian and Chinese satellites have all increasingly been scouting each others' satellites in GEO in recent years, using close approaches to attain images and other data.

This has led to a game in which countries aim to learn about each others' spacecraft and test their counterspace and SSA capabilities.

Little is known about the TJS-3 satellite, but the U.S. and other nations will doubtless be watching its movements closely.

***

## Australia's Space Command pushes for 'soft kill' capability to take out enemy satellites

*Andrew Greene | 02 Mar 2023*

*Source: ABC Net | https://www.abc.net.au/news/2023-03-03/adf-space-command-pushes-for-soft-kill-capability-for-satellites/102045496*


*The ADF's Space Commander Air Vice-Marshal Catherine Roberts gave an update on the organisation's activities at the Avalon Air Show.(Supplied: Department of Defence, Annika Smit)*

The ADF's Space Commander Air Vice-Marshal Catherine Roberts gave an update on the organisation's activities at the Avalon Air Show.(Supplied: Department of Defence, Annika Smit).

One year since the command was established, Air Vice Marshal Cath Roberts has given an update on its initial activities and the threats posed to Australian assets in space.

**"We are working on making sure that we've got a level of capability so that we can deter attacks on our satellites … through non-kinetic means so that we can have some impact".**

Air Vice Marshal Roberts says since the launch of Defence Space Command in March 2022, the number of satellites in space had more than doubled to around 8000.

"I think it's a really important part of where we're going to is just looking at how we can have that electronic warfare capability to allow us to deter attacks, or certainly interfere."

Speaking at the Avalon Air Show, the inaugural Australian Space Commander said her organisation needed to quickly secure "soft kill", or "non-destructive" capabilities to take out enemy satellites.

Last year, top ranking members of the US Space Force described Australia as a "pot of gold at the end of the rainbow", saying the country's geography was "prime" for future space operations.

"Geography is really important. We need to be able to see to protect, and we can see a lot from here," Vice Admiral Roberts said.

"And that goes for non-kinetic effects from the ground too, because it's what you can see and where you can effect it".

**China Launched more Satellites than US Last Year**

Improved space capabilities are believed to be a central recommendation of the Defence Strategic Review, which the government is expected to formally respond to in coming days or weeks.

"You need access to space to do the 'precision-guided' for the precision-guided weapons; you need it for the intelligence, surveillance, reconnaissance; and you need it for the command and control through the satellite communication systems," Air Vice-Marshal Roberts said.

"What I can talk about is the fact that for many of the capabilities that we need, space is absolutely essential, both from the Australian public point of view but also from a Defence point of view."

The Space Commander said China had done more satellite launches last year than the United States, and said the country was very active.

"So they are launching on a regular cadence. They have many, many satellites in orbit and a large percentage of those 8000 satellites that are up there."

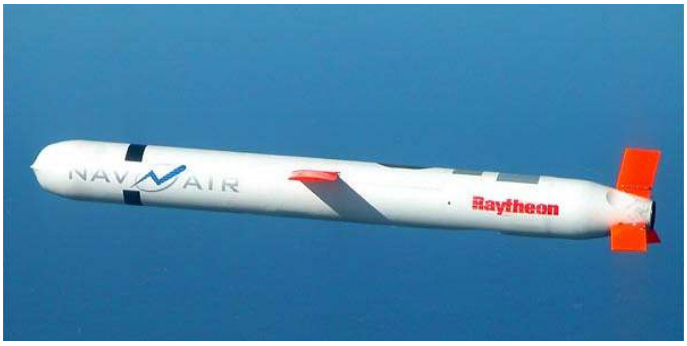
***

# Global Aerospace Industry

## Australia to get 220 Tomahawk missiles from US

*17 Mar 2023*

*Source: Space War | https://www.spacewar.com/reports/Australia_to_get_220_Tomahawk_missiles_from_US_999.html*




*Enlarge / True Anomaly's satellites (not pictured) will spy on each other, using thrusters, radar, and multi-spectral cameras to approach within a few hundred meters.*

Australia said a deal to buy 220 US Tomahawk cruise missiles was essential for keeping "adversaries at bay" Friday, as Canberra ratchets up defence spending to counter growing Chinese military clout.

Defence industry minister Pat Conroy said the potent long-range weapons would be deployed first to existing surface ships and later to a new fleet of nuclear-powered submarines.

A Pentagon agency revealed the sale on Thursday, and put the deal's value at up to US$895 million (Aus$1.3 billion).

The weapons give Australia a large arsenal to strike foes from more than a thousand kilometres away, something that experts say is a fearsome deterrent for any would-be foe.

"Long-range strike is at the heart of this government's commitment to equipping the Australian Defence Force, our national security and our defence interests, keeping adversaries at bay," Conroy told reporters.

Tomahawk missiles first gained widespread public attention during Operation Desert Storm, the 1991 US mission to repel Saddam Hussein's invasion of Kuwait -- hitting targets including the Iraqi Presidential Palace.

Word of Australia's latest big-ticket defence purchase comes days after US, British and Australian leaders unveiled plans to kit Canberra out with up to five US nuclear submarines before co-developing its own model.

Acquiring submarines that can travel vast distances without the need to surface puts Australia in an elite club and at the forefront of US-led efforts to push back against Chinese military expansion.

The Tomahawks will first be used in Australia's existing Hobart class destroyers and then the US Virginia class submarines when they are delivered from the early 2030s.

Conroy also revealed that the Virgina class or Australia's own submarines -- based on a British design -- would one day be equipped with still-to-be-developed hypersonic weapons.

Japan recently announced it would buy about 400 Tomahawk missiles from the United States

Fumio Kishida's government wants to dramatically expand Japan's defence capacity to defend against a rapidly arming China and nuclear-armed North Korea.

***

## Satellogic Sells Earth-Imagery Satellites

*Debra Werner | 18 Mar 2023*

*Source: Space News | https://spacenews.com/satellogic-sells-earth-imagery-satellites/*

*Satellogic operates a constellation of 30 Earth-imaging satellites. Credit: Satellogic*

SAN FRANCISCO – Satellogic, the South American company known for high-resolution multispectral imagery, is selling Earth-observation satellites for $10 million or less.

Satellogic's new Space Systems product is designed to appeal to customers eager to establish or expand their space capabilities rather than simply buying imagery.

"Space agencies around the world want access to this kind of satellite for their own uses, be that civil, research or defensive and intelligence," Matt Tirman, Satellogic chief commercial officer, told SpaceNews. "We've seen huge demand for it."

### Custom Orders

Satellogic is offering delivery in orbit within three months of an order for the company's dishwasher-size satellites. For other customers, Satellogic is offering to transfer intellectual property.

"They want us to come in and advise them

on setting up an assembly, integration and test facilities," Tirman said.

Satellogic is not subject to U.S. export controls like the International Traffic in Arms Regulations and customers do not need National Oceanic and Atmospheric Administration licenses for Earth imagery since the company is not based in the United States.

"Not falling under ITAR and NOAA licensing is a huge value proposition for us and for the market as well," Tirman said.

**Growing Demand**

Satellogic, founded in 2010, operates a constellation of 30 Earth-observation satellites. By the end of the year, Satellogic will have more than 40 satellites supplying customers with Earth imagery, analytics and satellite tasking, Tirman said.

At the core of Satellogic's business is the company's ability "to build at scale very high quality smallsats for not very much money" compared with traditional Earth-observation satellites, Tirman said.

In the last two years, Satellogic has seen growing demand for satellites, especially among emerging space programs in Africa, Asia, Europe and the Middle East, Tirman said. As a result, Satellogic established its Space Systems arm in January.

## Space Industry Deals with Launch Shortage

*Jeff Foust | 19 Mar 2023*

*Source: Space News | https://spacenews.com/space-industry-deals-with-launch-shortage/*

*A Falcon 9 lifts off from Vandenberg Space Force Base March 17, the first of two launches SpaceX conducted that day. Credit: SpaceX*

WASHINGTON — Even as the space industry complains of a shortage of launch capacity, SpaceX said it has room to increase an already surging pace of launches.

In sessions at the recent Satellite 2023 conference, launch vehicle providers noted that a combination of growing demand, particularly from satellite constellations, and a bottleneck in launch supply was affecting the market, making it difficult to find launches and driving up prices.

"Almost every company that we talk to is worried about medium to heavy lift," said Tim Ellis, chief executive of Relativity, during one conference panel March 14. Relativity is gearing up for another attempt for the inaugural launch its Terran 1 small launch vehicle, now scheduled for as soon as March 22. That rocket intended to be a precursor for the larger Terran R.

The timeframe of concern, he argued, is between 2024 and 2027. "You have a lot of people that are trying to hit specific deadlines

to getting spacecraft to orbit," he said, "and you have Amazon Kuiper buying up a lot of capacity at prices that I'm sure were well above the most competitive in the commercial space." Amazon acquired up to 83 launches from Arianespace, Blue Origin and United Launch Alliance last April to deploy its Kuiper constellation.

"There is now, for the first time in 30 years, a global shortage of launch capacity," said Tory Bruno, chief executive of ULA, during another conference panel March 15. That shortage, he said, stems from the rise of megaconstellations as well as the withdrawal of Russian vehicles from the commercial launch market after the invasion of Ukraine. "Now we're in a state of shortage that's going to last about a decade."

That shortage is also linked to the delayed introduction of new vehicles, like ULA's Vulcan Centaur. Bruno said that the company was still planning a first launch of Vulcan as soon as May 4 as testing of the vehicle continues. Separate qualification testing of the BE-4 engines that power the first stage, he noted, is "perhaps a little bit more than halfway" complete. "That is likely to be the pacing item" for the launch, he said.

A successful first launch, he said, would be followed by a second certification launch at least a couple of months later. "Then, after that, we'll ramp up to eventually flying every two weeks."

Stéphane Israël, chief executive of Arianespace, said the company was still working to perform a first launch of the Ariane 6 before the end of the year. But, he cautioned, "we still have some risk and some obstacles to overcome."

Several efforts are going in parallel leading up to that first launch, from combined tests of the vehicle and launch infrastructure in French Guiana to qualification of various vehicle components. "We will see how things are going to progress," he said. "Things are under control. We have passed very important milestones."

Schedules are less certain for Blue Origin's New Glenn rocket. "We're making fantastic progress and we're going to fly when we're ready," said Ariane Cornell, vice president of commercial orbital, astronaut and international sales at Blue Origin. However, she declined to give a date for that first launch.

The company does have one launch date on its manifest: it won a NASA award Feb. 9 for the launch of the agency's ESCAPDE Mars smallsat mission on New Glenn, scheduled for late 2024. "It will be an early New Glenn mission and we're going to be ready," she said.

**"Hitting Our Stride"**

SpaceX, meanwhile, is continuing to launch at a rapid clip. The company performed two launches a little more than four hours apart March 17, launching a set of Starlink satellites on one Falcon 9 from Vandenberg Space Force Base in California followed by two SES communications satellites on another Falcon 9 from Cape Canaveral Space Force Station in Florida.

SpaceX has conducted 19 launches so far this year and company is sticking with a goal of 100 launches this year, up from 61 in 2022 and 31 in 2021. "It's definitely a challenge that we are up to," said Tom Ochinero, senior vice president of commercial business at SpaceX.

He cited the company's three active launch pads in Florida and California and a "fully mature" reusability effort for that increase in launch rate. "Everything is really dialed in at this point," he said. "We're hitting our stride in terms of being

able to deliver on that cadence."

He suggested that the company could continue to increase its launch rate to meet demand. "In terms of scaling from 100 to 200 launches, we have the hardware, we have the infrastructure, we can scale the staffing," he said. "There isn't any reason we can't keep going. It's just a matter of market needs and how fast Starship develops."

That includes increasing how often Falcon 9 boosters are reused. "The vehicle is capable of way more than 10 flights," he said, with some boosters having flown up to 15 missions. "It's being really smart about making investments on the testing and qualification side. We will incrementally increase the number of launches if market conditions require it."

SpaceX has its own new launch vehicle in development, Starship. "We're so close" to its first launch, with a launch license from the Federal Aviation Administration one of the last milestones before the company announces a launch date. "That should be happening very shortly."

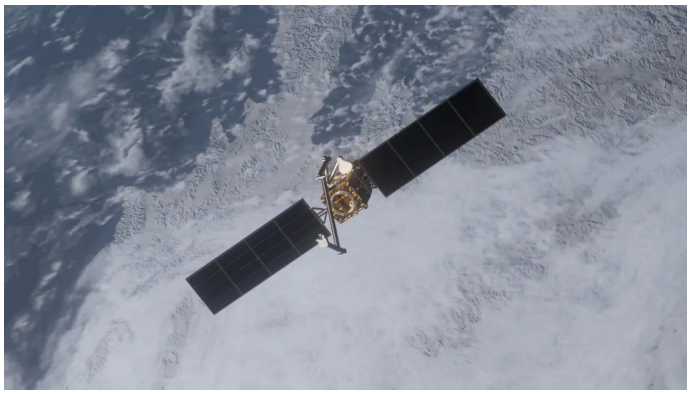
Elon Musk, chief executive of SpaceX, said in a March 16 tweet that the company would be ready to launch Starship "in a few weeks" but that the launch date would then depend on when it gets an FAA launch license. "Assuming that takes a few weeks, first launch attempt will be near end of third week of April," he wrote, after previously predicting first launches in February and March.

***

## Starfish Space Raises $14 Million for In-Orbit Servicers

*Jason Rainbow | 08 Mar 2023*

*Source: Space News | https://spacenews.com/starfish-space-raises-14-million-for-in-orbit-servicers/*



*An artistic depiction of Otter, Starfish Space's satellite servicing vehicle. Credit: Starfish Space*

TAMPA, Fla. — Starfish Space has raised $14 million for its planned satellite life extension and debris removal service in a funding round led by insurance giant Munich Re's venture capital arm, the startup announced March 8.

The Kent, Washington-based startup founded by former Blue Origin and NASA engineers in 2019 has now raised more than $21 million to develop Otter, an all-electric servicing spacecraft slightly bigger than a mini-fridge.

This summer, SpaceX plans to launch a microwave-sized demonstrator for Starfish that will attempt to dock with another test spacecraft in low Earth orbit (LEO).

After getting dropped off at an initial altitude by an orbital transfer vehicle (OTV) from small rocket developer Launcher, Starfish's Otter Pup demonstrator will attempt to rejoin the space tug using electric propulsion and an electrostatic capture mechanism. Launcher's first and latest OTV failed shortly after launching on a Falcon 9 rocket in January.

Starfish flight tested the rendezvous, proximity operations, and docking software it will use for this mission in 2021 during Orbit Fab's spacecraft LEO refueling demo.

Starfish sees growing demand for life extension services in the geostationary orbit (GEO) market, which Northrop Grumman is also targeting with much larger spacecraft currently attached to two Intelsat satellites.

Once docked, the Otter would use its onboard propulsion to extend the lifetime of a GEO satellite by helping to keep it in its orbital slot for several additional years. GEO satellites are typically designed to have enough fuel to operate for 15 years.

The startup's planned LEO debris removal service would work in a similar fashion, Starfish strategy and operations lead Ari Juster told SpaceNews via email.

"Once docked, instead of maintaining the satellite in its station, the Otter pulls the satellite down close enough to the Earth where it will quickly de-orbit from there," Juster said.

"Once the desired altitude is reached, the Otter detaches from the client satellite and boosts itself back up to LEO to conduct further servicing missions. A single Otter is designed to accomplish multiple LEO deorbit missions over its lifetime."

He said the Otter as a platform is being designed to perform both missions with limited modifications, although each Otter vehicle would focus on serving customers in either GEO or LEO.

Juster said funds from the Series A round help accelerate work on its first commercial Otter vehicles, whereas earlier funds primarily supported the Otter Pup mission and developing core software and hardware technologies.

"Broadly speaking, we expect the first launch of a commercial Otter could take place within the next couple of years in line with significant customer demand we are receiving," he said.

The venture plans to add 10-15 employees to its current team of 26 full-time staff by the end of the year across a range of software, hardware, and business development disciplines.

**Rising Investor Appetite for Debris Removal**

Munich Re invested in the newly closed Series A round via Munich Re Ventures, its venture capital arm, which has also invested in Orbit Fab.

Last year, Munich Re Ventures also led a 5.5 million euro ($5.8 million) funding round for Okapi, which is developing space traffic management software to help satellite operators reduce maneuvers to save fuel.

Munich Re is one of the world's biggest insurance providers, and covers assets that include satellites facing a growing threat of colliding with debris in crowded orbits.

"In-orbit servicing such as active debris removal and life extension of satellites will play a key role in enabling a sustainable infrastructure in space," Stephanie Deml, head of aviation and space at Munich Re, said in a recent blog post.

"We are keen to contribute to the success of these missions by developing bespoke risk transfer solutions."

Toyota Ventures, the venture capital arm of Japanese automaker Toyota, also participated in Starfish's Series A, along with existing investors PSL Ventures, NFX, and MaC VC.

Despite challenging macroeconomic conditions, startups with solutions for removing orbital debris have been a bright spot for early-stage space investments this year.

Japan's Astroscale announced Feb. 27 it had raised $76 million in a Series G funding round, bringing the total raised to date for its in-orbit servicing plans to more than $376 million.

A month earlier, Swiss debris-removal startup ClearSpace said it had raised about $29 million in a Series A round, bringing its total to around $140 million.

***

## Space Force to Launch 'Marketplace' for Satellite-to-Cellular Communications Services

*Theresa Hitchens | 03 Mar 2023*

*Source: The Hindu| https://www.thehindu.com/news/national/iaf-issues-tender-to-procure-a-medium-transport-aircraft-to-replace-an-32s/article66467760.ece*

*Iridium, which has 66 operational satellites in low Earth orbit, is teaming with Qualcomm to provide direct-to-cellular 5G communications. (Iridium)*

WASHINGTON — The Space Force is planning later this year to request bids from providers of wireless phones enabled to connect with satellite networks, according to Clare Grason, director of the Commercial Space Communications Office (CSCO).

"The capability itself is very exciting to us," she told a webinar Tuesday sponsored by Breaking Defense and Intelsat, explaining that it will enable the Defense Department "to equip warfighters with smaller and lighter, more capable, less expensive communication devices."

Noting the increasing number of recent partnerships between satellite operators and wireless phone providers, such as that between T-Mobile and SpaceX and Qualcomm and Iridium, she explained that "some of these architectures will enable existing smartphones to seamlessly communicate with satellites using the cellular spectrum that's been allocated to that to that [cell phone] provider."

CSCO is currently working to develop a request for proposals (RFP), Grason said.

"I think we're probably not looking at RFPs being released until later this year. But it is something for industry to keep their eyes open for and, and obviously, our customers. If you have any thoughts on that, we are in the market research phase, we're open to feedback," she said.

CSCO is the sole DoD authority for acquisition commercial satellite communications services and capabilities. It serves as a middleman between commercial satellite operators and then matches them to the needs of various operational commands and other DoD customers — helping manage the contracting process. The office formerly was an arm of the Defense Information Systems Agency (DISA), but was transferred to Air Force Space Command in 2018 and now resides under Space Force's acquisition unit, Space Systems Command, although DISA still handles contracting.

The plan is for CSCO to set up a contracting vehicle that allows military users to buy satellite-direct-to-cellular communications capability as a service, along the lines of CSCO's ongoing initiative to provide DoD customers with satellite communications (SATCOM) and internet access via large constellations in low Earth orbit.

The office released an RFP last fall for use of what is colloquially known as "p-LEO" services, and via DISA expects to make its first contract awards "around the May timeframe," she noted.

"Essentially what that contract will do is establish the p-LEO marketplace for the DoD. Instead of having been a requirements based acquisition — where by we traditionally ask offerers to bid to very specific coverage areas or technical requirements — we've asked offerers to provide essentially any available capability that they are willing to sell us or customized for us from this orbital regime," Grason said.

"Additionally, we plan to have an 'open season' every year, so for companies that are being conceptualized, that once they reach a certain maturity level, they, too, will be able to onboard into this marketplace," she added.

T-Mobile and SpaceX announced last August their plan to connect "vast majority of smartphones already on T-Mobile's network to Starlink satellites." The two firms intend to create a new network, broadcast from Starlink's satellites using T-Mobile's mid-band spectrum nationwide, at first providing text services, adding voice and data coverage at a later stage.

Qualcomm and Iridium in January announced that they are collaborating to bring satellite connectivity for 5G communications to Android phones. Qualcomm's new Snapdragon Satellite service — that the company claims is "the world's first satellite-based two-way capable messaging solution for premium smartphones" — will be use Iridium's L-band satellite spectrum for uplink and downlink.

Further, Hughes Network Systems, working with DISH Network, OneWeb and EchoStar satellite operators, last March scored an experimental contract to develop a military-only SATCOM empowered 5G network. That contract is part of the Defense Department's multifaceted 5G experimentation initiative to wire a number of military bases, called the Next Generation Information Communications Technology program. In 2020, the Pentagon issued contracts to 15 vendors worth approximately $600 million for network building at five military bases, and in 2021 issued solicitations for another seven bases in 2021 to bring the total to 12.

Meanwhile, the Federal Communications Commission (FCC), which licenses US telecommunications firms to access radio frequency spectrum, is eyeing changes to processes that would ease such partnerships between satellite and terrestrial providers.

The FCC on Feb. 23 issued a Notice of Proposed Rulemaking [PDF] that "would facilitate the integration of satellite and terrestrial networks by proposing a new regulatory framework for Supplemental Coverage from Space (SCS)."

The proposed changes would allow satellite-to-cellular communications by letting sats use spectrum already licensed to wireless cell

phone providers, the notices explains.

"Through this novel approach, satellite operators collaborating with terrestrial service providers would be able to obtain Commission authorization to operate space stations on currently licensed, flexible-use spectrum allocated to terrestrial services," according to the notice. "This would enable expanded coverage to a terrestrial licensee's subscribers, especially in remote, unserved, and underserved areas, and would increase the availability of emergency communications."

The FCC will debate the NPRM at its next open meeting March 16.

***

## Government will decide between F/A-18 Super Hornet, Rafale M: Navy Chief

*Dinakar Peri | 04 Mar 2022*

*Source: The Hindu | https://www.thehindu.com/news/national/choice-between-rafale-m-and-f-18-super-hornet-will-be-the-governments-decision-navy-chief/article66581123.ece*

*Chief of the Naval Staff Admiral R. HariKumar. File | Photo Credit: ANI*

Boeing's F/A-18 E/F Super Hornet and Dassault Aviation's Rafale M jets meet the requirements of the Navy and a selection between them will be the government's decision, Navy chief Admiral R. Hari Kumar said on Friday, adding that the Rafale M has commonality with the Air Force in terms of spares and support.

"It will be a decision of the government... Both aircraft are ok. They have proved themselves. Now there will be other issues, like for example, we already have Rafales for the Air Force. There will be commonality of spare parts and support, etc. Each has got its own strengths and weaknesses," Adm. Kumar said on the sidelines of the Raisina Dialogue. The dialogue, jointly organised by the Observer Research Foundation and the Ministry of External Affairs, concluded on Friday.

An indigenous Twin Engine Deck-Based Fighter (TEDBF) is under development by the Aeronautical Development Agency under the DRDO to operate off the Navy's aircraft carriers. The 26 jets planned to be procured from abroad will fill the gap in the interim as the existing MiG-29Ks may not last till then. Adm. Kumar said the Navy may get the TEDBF by 2034 or so.

Adm. Kumar was speaking at a session on the "future of warfare" that saw the participation of several chiefs of Navy from other countries. Maritime domain challenges were not just traditional and non-traditional, but also transnational, he stated. While all countries may not agree on some issues, most come together on others as part of issue-based convergence, he said.

Referring to regional groups in the Indo-Pacific, Adm. Kumar said, "When we work in small groups, it serves a lot of purposes, generates a lot of trust among partner countries, builds capacities, increases interoperability and better domain awareness."

Also on the panel were Gen. Koji Yamazaki, Chief of Staff, Japan Ground Self-Defence Force; Adm. John C. Aquilino, Commander of the U.S. Indo-Pacific Command; Adm. Sir Ben Key, First Sea Lord and Chief of Naval Staff of the U.K. and Vice Adm. Angus Topshee, Commander of Royal

Canadian Navy.

Adm. Aquilino said that the benefit of Artificial Intelligence in the short-term is decision-making in real-time. "However, it's important not to lose sight that the military has a human dimension and interaction as the world moves towards AI and machine learning," he cautioned.

On similar lines, Adm. Key said that AI could crunch data faster than a human. However, it wasn't capable of human instinct, intuitiveness and understanding of risk, he noted.

Gen. Yamazaki noted that cyber space and outer space were two important domains of the future. "Japan is working towards building comprehensive defence capabilities to become secure and resilient in this regard," he said.

Noting that fundamentally naval operations remained the same, Vice Adm. Topshee said that Canada was working with its allies on a range of issues. "The opportunity to interact with other Navies provides us access to various perspectives to formulate a comprehensive way forward," he added.

***

# Indian Aerospace Industry

## India Conducts Back-to-Back Tests of VSHORAD Air Defence System

*Rajat Pandit | 14 Feb 2023*

*Source: IMR India | https://imrmedia.in/india-conducts-back-to-back-tests-of-vshorad-air-defence-system/*

*Indigeous VSHORAD system was tested successfully on 14 March*

India, on 14 March, carried out two back-to-back tests of an indigenous air defence weapon, the very short-range air defence system (VSHORADS) missile, from the Integrated Test Range at Chandipur off the Odisha coast, the defence ministry said. The VSHORADS, a man-portable air defence system, can neutralise low altitude aerial threats at short ranges.

The tests come two months after the defence acquisition council (DAC) set the ball rolling to buy the VSHORADS, designed and developed by Defence Research and Development Organisation (DRDO), for the army. DRDO, which conducted the twin tests successfully on 14 March, has tested the weapon earlier too.

"The flight tests were carried out from a ground-based man portable launcher against high speed unmanned aerial targets, mimicking approaching and receding aircraft. The targets were successfully intercepted, meeting all mission objectives," the defence ministry said in

a statement.

Defence minister Rajnath Singh said the missile, equipped with new technologies, would give further technological boost to the armed forces.

In January, DAC had cleared the purchase of military hardware worth ₹4,276 crore including the air defence weapon and indigenous helicopter-launched anti-tank guided missiles. DAC is India's apex munitions procurement body.

Under India's defence procurement rules, the acceptance of necessity (AoN) by the council is the first step towards buying military hardware.

The DAC's clearance to the VSHORADS and other military hardware on January 10 was under the most important category of acquisition for indigenisation under the defence procurement policy, or the Indian-IDDM category. IDDM stands for indigenously designed, developed and manufactured.

This category has been accorded top priority for procurement of equipment. It refers to the purchase of military hardware from an Indian vendor, with the equipment having a minimum of 50% indigenous content (IC) on cost basis of the total contract value.

"In view of recent developments along the northern borders (with China), there is a need to focus on effective AD (air defence) weapon systems which are man portable and can be deployed quickly. Procurement of VSHORADS, as a robust and quickly deployable system, will strengthen air defence capabilities," the ministry then said.

India has been locked in a border standoff with China for nearly three years. The army is swiftly upgrading its capability along the border with China with a variety of weapons and systems, including artillery guns, swarm drone systems that can carry out offensive missions in enemy territory, longer range rockets, remotely piloted aerial systems and high mobility protected vehicles, while also pursuing the development of light tanks for mountain warfare and futuristic infantry combat vehicles (FICVs).

***

## Aerospace – the Next Big Bet for India

*Niranjan Kalyandurg | 26 May 2022*

*Source: Financial Express | https://www.financialexpress.com/defence/aerospace-the-next-big-bet-for-india/2538764/*

*Urban air mobility (UAM) and advanced air mobility (AAM) will be the next big disrupter of the aero industry and there is huge potential in India to be a leader in designing and developing these.*

The last two years have been highly challenging for the aerospace and aviation sectors globally. Ripple effects have been felt by the Indian aerospace industry as well. All private and commercial flights were stalled for the longest time possible, and business leaders faced the dual challenges of navigating through COVID-19 and maintaining the sector's resilience in the face of this crisis.

If 2021 was the year of recovery, 2022 is going to be a turning point. Globally, cash flows and investments have started to increase in space tech companies – an industry long viewed as too risky

for serious investment. This has also translated into increased investments in aerospace. In India, policy interventions with government schemes such as UDAN, which focuses on strengthening regional connectivity and aviation infrastructure, and national programs like Atmanirbhar Bharat have opened up a plethora of opportunities for the private sector to develop core expertise, accelerate research and development (R&D) and invest in manufacturing in the country.

The pandemic has also accelerated adoption of new technologies at a pace not witnessed before. This has further led to demand in areas like data science, cloud computing, cyber security, artificial intelligence (AI), machine learning (ML), and big data analytics. Companies are now investing in expanding their portfolio and digitalizing processes.

**The Big Tech Play**

Innovation is the bedrock of every industry. As we move into a future dotted with revolutionary new realities such as aerial ride-sharing and autonomous vehicles, rapid adoption of advanced technologies will bring in radical efficiencies and operational benefits that were previously unimaginable. These technologies are here to stay and will redefine the future of transportation. At the level of design philosophy, businesses are slowly moving away from hardware product design – the 'nuts and bolts' manufacturing – and becoming more focused on software applications that solve problems. The promise of affordable mobility across commercial, civil and defense applications in aerospace is thus deeply embedded in software.

Within the domain of product design, AI algorithms evaluate and streamline design and manufacturing systems in a shorter timeframe. Apart from making systems energy-efficient, AI-powered generative design, when combined with 3D printing, brings aesthetic, practical designs to life. Additionally, cloud-based applications facilitated by AI make maintenance simpler and easier.

Urban air mobility (UAM) and advanced air mobility (AAM) will be the next big disrupter of the aero industry and there is huge potential in India to be a leader in designing and developing these. The next generation of innovation will be super compact, fly-by-wire control systems and super-small, sense-and-avoid radar systems. The best thing is that not only does this technology enable autonomy and urban air mobility; it also has applications in other industries.

**Building India's R&D capabilities**

According to the industry body NASSCOM, India is a hotbed for R&D and digital talent. India's engineering R&D services sector is expected to reach a valuation of $63 Bn by 2025, up from $31 Bn in 2019.

India's attractiveness as the destination of choice for aero R&D includes the ability to develop strategic business impact, strong focus on continuous innovation, large digital talent pool, and differentiated service delivery. India has one of the largest R&D talent pools in the world to address the scalability needs of global enterprises.

To develop and nurture the right talent for the aero industry and to emerge as a new global leader in this space, reskilling and upskilling should be the nation's number one priority for both private and public sectors. Industry-academia collaboration, including joint R&D initiatives, curriculum design, and internships will be key to

developing a future-ready workforce.

**Achieving Sustainability Goals**

The global aviation industry has also been an early adopter of cleaner fuels. Significant progress has been made in developing sustainable aviation fuel (SAF) as a drop-in substitute to fossil fuel-based aviation fuels. Progress has also been made on developing SAF as a 100% replacement to existing jet fuel. To achieve carbon neutrality in aerospace, companies are focusing on sustainable propulsion alternatives along with incremental technology improvements and operational efficiencies. SAF made from renewable resources such as biomass currently offers 70-80% reduction in carbon emissions. Environmental, social, and governance (ESG) priorities are now also becoming imperatives in corporate governance. Finally, with multiple signatories to climate conventions (such as the recently-concluded COP26) starting to promote "test and learn" mechanisms and driving sustainability through industry certifications, we should soon expect large players in multiple industries to collaborate with a single-minded focus on achieving sustainability goals for organizations, sectors and entire economies.

**Flying into the Future**

Rising incomes, a growing mid-segment, competition among low-cost carriers, investment in airport infrastructure and conducive government policies have led to a healthy growth of the aviation sector in India. The country is expected to become the world's third-largest aviation market by 2024.

The big leap forward can be expected when companies move above incremental gains towards an era of exploration, with the next generation of product and service innovation. With innovation at the forefront, organizations can focus on maintaining a high degree of competency in managing technology, while handling their workforce and improving their global footprints. The transition from bricks to chips and in bringing Internet and computing technology together have led to tremendous cost and process optimization for the aerospace industry. As these technologies mature and become smarter, it is not just the ecosystem that grows – our entire concept of mobility does.

***

## HAL loses Malaysian LCA contract to South Korea's KAI

*Huma Siddiqui | 20 Mar 2023*

*Source: Financial Express | https://www.financialexpress.com/defence/hal-loses-malaysian-lca-contract-to-south-koreas-kai/3016010/*

*While the Tejas fighter jet has a lower price tag of about US$28 million and is more capable in areas such as range and service ceiling, the FA-50's established brand name and proven capabilities proved to be decisive factors in Malaysia's decision. (Image used for representative purpose)*

Malaysia has awarded a contract worth $920 million to Korea Aerospace Industries (KAI) for the supply of 18 aircraft under its Fighter Lead-In Trainer-Light Combat Aircraft (FLIT-LCA) program. KAI will deliver the FA-50 Golden Eagle, a weaponised version of the T-50 trainer, in 2026. The decision was made after a competitive tender that included India's Tejas fighter jet made

by Hindustan Aeronautics Limited (HAL).

**HAL Confirms**

"We were short-listed for the Malaysian LCA contract. We were hopeful as we were very competitive on several criteria but unfortunately this has not gone our way," sources in HAL said.

The FA-50 Golden Eagle was chosen due to its superior service record and reputation, having been combat-tested by the Philippine Air Force in various missions against militants, including the 2017 Marawi campaign. This operational experience is expected to be crucial for the Royal Malaysian Air Force (RMAF), which is likely to use the aircraft for air patrols and interceptions due to low availability rates of its mainstay fighters, the F/A-18 Hornet and SU-30 Flanker, and the suspension of the Multi-Role Combat Aircraft (MRCA) program over budgetary issues.

While the Tejas fighter jet has a lower price tag of about US$28 million and is more capable in areas such as range and service ceiling, the FA-50's established brand name and proven capabilities proved to be decisive factors in Malaysia's decision. Some 200 of the FA-50 aircraft are currently in service with South Korea, Iraq, and ASEAN members, including Indonesia, the Philippines, and Thailand. South American nation Colombia also recently placed an order for 20 FA-50s, and KAI is confident of striking an FA-50 deal with Egypt, its first venture into the African market.

The acquisition of the FA-50 marks the first step on Malaysia's Capability Development Plan 2055 (CAP55) transformational journey. The roadmap outlines Malaysia's plan to acquire a total of 36 aircraft under the FLIT-LCA initiative, which could potentially mean the procurement of another 18 FA-50s. As part of CAP55, the RMAF plans to streamline the types of combat aircraft from five to two (the MRCA and FLIT-LCA) to reduce operating costs.

**Background**

In November 2022, Financial Express Online had reported that the deal might get bagged by the South Korean company, even though HAL had set up its first overseas office in Kuala Lumpur the capital city of Malaysia. India's LCA was among the front runners in the race for the Royal Malaysian Air Force contract which is in the process of phasing out its old Russian MiG-29s.

Others in the race besides India and South Korea were the Sino-Pakistani JF-17 from Pakistan Aeronautical Complex and Chengdu Aircraft Corporation, the Russian Yak-130, and the Italian M-346 from Leonardo.

Other countries in the Asean region have evinced their interest in the Light Combat Aircraft. South American nation Argentina, has expressed its interest too. But there are reports in the public domain that the Chinese could bag that deal.

Reports in the public domain suggest that HAL's reputation may have been a factor in Malaysia's decision to select the FA-50 over the Tejas.

***

# HAL LCA Tejas Mk1A and the Continuing Struggle with Botswana F-5 Fighter Replacement Efforts

*Parth Satam | 25 Feb 2023*

*Source: Frontier India | https://frontierindia.com/hal-lca-tejas-mk1a-and-the-continuing-struggle-with-botswana-f-5-fighter-replacement-efforts/*


*LCA Tejas Mk 1A*

The Botswana Defense Force (BDF) is now negotiating with the state-owned Hindustan Aeronautics Limited of India to purchase several of the company's LCA Tejas fighter planes, according to the website 'African Intelligence.' Botswana's interest in the plane has been reported numerous times, and the website has provided no specifics about the transaction.

Since 2013, the BDF has been attempting to replace its ageing fleet of fighter jets. The BDF currently deploys about 13 Former Canadian Northrop/Canadair CF-5D combat trainers (3 no's) and CF-5A Fighters (10 no's) acquired from Canada in 1996.

BDF wants the newer aircraft in the context of neighbouring governments' strengthening of their air forces. Zambia, for instance, upgraded eight MiG-21 fighters to the MiG-21-2000 version with the assistance of the Israeli business Israel Aerospace Industries, while Namibia received 12 Chengdu F-7NM fighters and two FT-7NM trainers, an enhanced copy of the MiG-21, from China. In addition, Zimbabwe ordered Chinese FC-1 fighter jets in 2004.

Botswana has repeatedly alleged airspace violations by the air forces of her neighbouring countries. In the past, South African Defence Force helicopters had attacked a Botswana military base in 1990. Botswana's prospective adversaries include South Africa and Zimbabwe.

The Air Arm commander commands the Z28 fighter squadron located at Maparangwane Air Base (Thebephatshwa Airport, Molepolole region), located closer to South Africa, which consists of BF-5 fighter aircraft (as designated in Botswana). The aircraft is primarily intended for daytime air superiority and a capable ground attack platform. BDF rarely engages in international exercises but has the unique distinction of contributing some of its transport planes and helicopters to the UN for African missions.

The Botswana Self-Defence Forces air wing was established in 1977, as the country's domestic situation deteriorated and there was widespread instability. The prefix Z was assigned to all squadrons, and the major base is located in Molepolole, which international companies developed in 1992-96. Furthermore, aircraft and helicopters are stationed at Gaborone International Airport and Francistown. Botswana initially received 13 ex-Canadian CF-116s (Canadair CF-5). The planes arrived in 1996 to replace the previous BAC 167 Strikemaster. Three further single-seat planes and two combat trainers were delivered in 2000. Out of 18 aircraft, two F-5s are known to have crashed. The condition of 3 DF-5s is unknown.

## Upgrading the Fighter Fleet

Major General Odirile Mashinyana, the head of the BDF's air arm, presented a report in 2013

advising modernising the BF-5 fighter fleet rather than acquiring new aircraft owing to budgetary restrictions.

Even though the BDF Air Arm is lagging behind comparable countries in the region, particularly regarding air capabilities, the report states that by upgrading the F-5s, Botswana could keep them airworthy for at least another ten years, thereby saving money on the acquisition of new aircraft. The report recommends upgrading the BF-5 platform to the extensively updated F-5E variant.

Even if it is cost-effective to continue deploying the BF-5, the changing dynamics of air power in the Southern African Development Community (SADC) render the BF-5 obsolete from a strategic standpoint, according to the report. Although the BF-5 can be outfitted with current weapons systems, a preliminary cost-benefit study indicated that it would not be cost-effective for the BDF.

Nevertheless, in November 2013, Botswana Minister of Defence Ramadeluka Seretse and other BDF officials met with South Korea's Korea Aerospace Industries (KAI) over the potential acquisition of the T-50 and FA-50 aircraft, which resulted in President Ian Khama visiting South Korea and KAI in October 2015. Interest in the KAI T-50/FA-50 fighter/trainer jet had diminished by 2016.

Parallely, an attempt was made to obtain 16 used F-16 Block 40 Fighting Falcon fighters from General Dynamics but was rejected by the US in 2014, stating that Botswana did not require such expensive military gear and that acquiring the F-16 could potentially trigger an arms race in the SADC area. The F-16s were to join a fleet of 10 F-5 Freedom Fighters at Tebe Fatshwa Air Base.

Botswana then shifted its focus to Saab's JAS-39C/D Gripen fighters, with Sweden offering eight to twelve JAS-39C/D Gripen fighters at a projected cost of $1.7 billion. Afterwards, former Botswana President Ian Khama visited Saab's Swedish headquarters between June 19 and 21, 2017, when he met Swedish Prime Minister Stefan Lofven. Unfortunately, the Gripen project stalled once he left office. The deal was also harshly criticised, particularly because the nation has no adversaries.

Budgetary constraints also hampered efforts to acquire the Gripens since more funds would be needed to proceed with the acquisition, based on the requirement of the 2013 report.

In addition, according to a May 2017 KAI analysis titled "FA-50 for the Botswana Defence Force: The Right Choice for the Future," Gripen's life-cycle cost was "three times" that of the FA-50, including higher procurement and operational costs.

South Korea KAI revived its efforts in 2018 to sell the FA-50 Golden Eagle lightweight fighter to the BDF.

However, Gaborone military leadership expressed concerns that, while the FA-50 is a proven aircraft (and, according to KAI, the FA-50's radar, avionics, and weapons suite are comparable to the Gripen C/D, HAL Tejas, and PAC JF-17 Thunder), its operational capabilities do not match those of Gripen, which has a larger combat radius, ferry range, payload and significantly greater radar and weapons capabilities.

Some other Gaborone military officers were pitching a Gripen purchase because of its possible interoperability with Botswana's neighbour, South Africa, which also employs the JAS-39C/D. The

BDF could benefit from South Africa's Gripen training and maintenance, repair, and overhaul (MRO) infrastructure.

During a briefing to the parliamentary Public Accounts Committee, BDF commander Lt. Gen. Gaolathe Galebotswe explained that the government needs something cost-effective yet capable of carrying out our aerial defence duty because the BDF should be able to operate in both contested and uncontested areas.

BDF investigated the F-16, Russian MiG versions, the Gripen, and certain Chinese fighters when looking for a replacement. According to him, Gripen has the lowest operational costs. If this agreement is reached, it will be between the governments of Botswana and Sweden.

According to the minister, the government has invested significantly in establishing the BDF Air Wing. Botswana must maintain it and keep it from deteriorating, he emphasised. He stated that the country had trained pilots requiring air assets access.

**Renewed Efforts**

As the BF-5Es' serviceability and usability deteriorate, there is a renewed clamour to replace the fleet. Canadair no longer maintains configuration control for the CF-5, and there are no active production lines; these aircraft are obsolete and costly to repair. As a result, speciality manufacturers must individually machine each component, which considerably increases costs and causes lengthy delivery delays. To keep their fleet airworthy, the BDF must rely on unreliable private suppliers or cannibalise parts from the foreign military. This has already developed into a big issue.

For the National Development Plan 11, which runs from 2017 to 2023, the Botswana Defence Force has been allocated P14.8 billion ($1.35 billion). Following President Mokgweetsi Masisi's election, Botswana is considering purchasing a different aircraft from the Swedish Gripens.

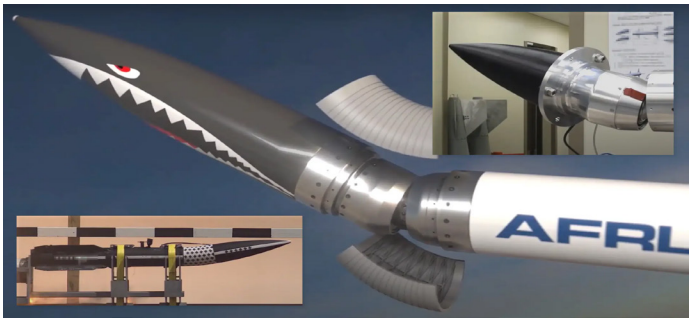
Several aircraft manufacturers have pitched their products to the BDF, including General Dynamics with its F-16 Fighting Falcon, SAAB with the JAS 39 Gripen, Leonardo (formerly Alenia Aermacchi) with the M-346 Master, Embraer with Super Tucano turboprop, HAL with LCA Mk1 and KAI with the T-50/FA-50.

# Technology Development

## USAF Testing 'Mutant' Missiles that Twist in Mid-Air to Hit their Targets

*Joseph Trevithick | 09 Mar 2023*

*Source: The Drive | https://www.thedrive.com/the-war-zone/usaf-testing-mutant-missiles-that-twist-in-mid-air-to-hit-their-targets*




*USAF*

The U.S. Air Force is exploring a novel concept for increasing the likelihood of scoring a hit in air-to-air combat. The idea is to use an air-to-air missile with a nose that bends to get at the target before it can get away. The service views this as one path to giving current and future combat aircraft, including a sixth-generation stealth jet being developed under the Next Generation Air Dominance program, a new way to engage increasingly maneuverable threats.

The Air Force Research Laboratory highlighted what is formally known as the Missile Utility Transformation via Articulated Nose Technology (MUTANT) project at this week's 2023 Air and Space Forces Association's Warfare Symposium in Aurora, Colorado. AFRL says that MUTANT leverages work that has been done over the past six years on related technologies, but notes the core concept takes advantage of related research and experimentation dating back all the way to the 1950s.

"A more effective missile tends to have more range, maneuverability (g-capability), and agility (airframe responsiveness) with limited weight. The missile control actuation systems (CASs) affects all three of these metrics, and hence the ability to effectively close in on targets," AFRL's webpage on MUTANT explains. "Each CAS, or CAS combination, such as dual canards and fins, have distinct and strong implications to overall missile performance."

"CASs good for range (fins only) tend to be bad for maneuvering and agility," it adds. "CASs good for maneuverability and agility (canards, wings, jets, thrust vectoring) tend to be bad for range due to drag or additional weight."

MUTANT seeks to upend this basic calculus. In terms of traditional control surfaces, the conceptual missile designs that AFRL has been working with only have tail fins. As noted, this helps make the missile less draggy and extend its range.

Typically this comes at the cost of maneuvering and agility. However, the MUTANT concept adds a conformal section in the forward portion of the missile body that allows the entire front end to articulate away from the center axis.

With a traditional air-to-air missile, if the target begins to move away from the point of intercept that its guidance system has calculated, the entire weapon has to change course. With MUTANT, the idea is that this 'course correction' essentially can be achieved by having the front portion of the missile physically move to bring it more in line with where the threat actually is.

The articulating nose section could also help better focus the force of the weapon's warhead, which is typically relatively small on air-to-air missiles, on the target. It might help ensure

the missile seeker, or seekers plural in the case of multi-mode designs, retains a lock, as well. Missiles with multi-mode seekers, especially ones that combine imaging infrared and active radar comments, often have those elements installed in complex ways that could impact the sensors' fields of view in certain engagement scenarios.

AFRL does note that "historically, [the] size, weight and power [requirements] of morphing technology has been prohibitive to a missile system level benefit," but says that "MUTANT is in the midst of tipping the scale in the morphing weapon's favor."

To make this work in a missile-sized form, "AFRL developed an electronically-controlled actuation system comprised of compact electromagnetic motors, bearings, gears, and structures," the official MUTANT website says. "Careful design allows a circular pass-through for component wiring into the aircraft body."

MUTANT's articulating component is similar, in very broad strokes, to the articulating exhaust nozzle used on the short and vertical takeoff and landing capable F-35B variant of the Joint Strike Fighter, according to AFRL.

The potential technological hurdles also extend into the realm of material science. To be effective when utilized in an air-to-air missile, the articulating structure has to be able to withstand the high temperatures and other forces associated with high-speed flight. Furthermore, the weapon's entire front end has to be capable of withstanding the effects of rapidly changing direction in flight.

With these demands in mind, AFRL has been working on a "composite structure involving a metallic internal skeleton that is infilled with an elastomer." The MUTANT website says it expects the final design of this structure to be suitable for use on missiles traveling at high-supersonic speeds, where components could be exposed to temperatures in excess of 900 degrees Celsius, or 1,652 degrees Fahrenheit.

There is clearly more testing needed to fully prove out the MUTANT concept before any steps are taken to actually integrate it into a real missile. AFRL has already conducted a number of ground tests of various components of the system in laboratory settings, as well as through the use of rocket sleds. The initial prototype design is based on a heavily modified AGM-114 Hellfire air-to-ground missile.

AFRL says another round of ground testing is set to wrap up by the end of the 2024 Fiscal Year, "culminating in dual articulation and fin control in maneuvering" of the Hellfire-based prototype. Its website stresses that "the Hellfire is used for research purposes and is not necessarily the intended application" of the articulating system.

AFRL makes clear that developments like this are viewed as critical to the Air Force's broader future aerial combat vision.

"Next Generation Air Dominance (NGAD) requires broad advancement in manned and unmanned aircraft, their family of weapons systems, and the communication between them," AFRL says on its MUTANT webpage. "ACAS [articulation control actuation system] technology is directed at fulfilling future NGAD requirements through the intercept of highly maneuverable targets or threats at longer range with limited cost."

The Air Force's NGAD initiative is a multi-faceted effort that includes the development of advanced new aircraft, crewed and uncrewed,

as well as new weapons, sensors, networking and battle management capabilities, advanced jet engines, and more. The expectation is that all of these systems will ultimately work together in a collaborative ecosystem and will help ensure the service maintains its qualitative edge, even against near-peer opponents like China or Russia. You can read more about NGAD, as a whole, here.

With regards to MUTANT, specifically, the project comes as the U.S. military as a whole is faced with a future that includes a growing number of increasingly maneuverable aerial threats, including advanced combat jets, drones, and missiles. Uncrewed platforms, which do not have to account for the physical limitations of a human pilot, have the potential to be capable of particularly extreme maneuvers. This could make existing missile systems less effective against them.

Many of these potential future advanced aerial threats could well be flying at high supersonic or even hypersonic speeds while also maneuvering. The ability to intercept maneuverable hypersonic missiles is of particular concern to the U.S. military and is one area where MUTANT could possibly be of value.

The Air Force is, of course, also in the process of developing other advanced air-to-air missiles with more traditional designs, as is the U.S. Navy.

It will certainly be interesting to see how the MUTANT project progresses and whether that technology ultimately winds its way into existing or future air-to-air missile designs.

## Commentary

1. Space is next frontier: As China pushes ahead, India needs to bridge the gap - https://www.firstpost.com/opinion/space-is-next-frontier-as-china-pushes-ahead-india-needs-to-bridge-the-gap-12315462.html
2. Overview of the development of foreign military navigation in 2022 - https://www.toutiao.com/icle/7192536871061307964/?wid=1679890298638

## Further Reading

1. Russia pounds Ukraine with barrage of rare hypersonic missiles - https://www.spacewar.com/reports/Russia_pounds_Ukraine_with_barrage_of_rare_hypersonic_missiles_999.html
2. Ukraine's 'Most Dangerous' Weapon Hitting Russian Military With Deadly Accuracy Can Now Be Intercepted - https://eurasiantimes.com/ukraines-most-dangerous-weapon-blasting-russian-military/
3. 'Tip Of The Spear' Against China: Why F-35B Is The Best Suited Fighter Jet To Burst The Chinese A2/AD Bubble - https://eurasiantimes.com/tip-of-the-spear-against-china-why-f-35b-is-the-best-suited-fighter/
4. Qantas pilots told to fly through radio interference reportedly coming from Chinese warships - https://www.theguardian.com/business/2023/mar/17/qantas-pilots-told-to-fly-through-radio-interference-reportedly-coming-from-chinese-warships

5. The Space Race's Shifting Center of Gravity - https://foreignpolicy.com/2023/03/08/space-race-moon-lunar-artemis-accords-united-states-russia-china/

6. 'Affordable Mass' Concept Driving Air Force's New Advanced Drone Initiative - https://www.thedrive.com/the-war-zone/affordable-mass-concept-driving-air-forces-new-advanced-drone-initiative

7. What has the war on Ukraine revealed about Russia's non-strategic missiles? - https://www.iiss.org/blogs/analysis/2023/03/what-has-the-war-revealed-about-russias-non-strategic-missiles

8. The Air Force Wants a Stealthy Aerial Refueling Tanker by 2040 - https://www.popularmechanics.com/military/aviation/a42941315/next-generation-air-refueling-system/

9. How Air-To-Air Missiles Have Completely Changed The Dynamics Of Aerial Battles As Dogfighting Takes A Back Seat - https://eurasiantimes.com/how-air-to-air-missiles-have-completely-changed-the-dynamics/

10. How Elon Musk's Starlink is Still Helping Ukraine's Defenders - https://www.defenseone.com/technology/2023/03/black-swan-starlinks-unexpected-boon-ukraines-defenders/383514/

11. Poland and Slovakia to transfer MiG-29 planes to Ukraine - https://www.spacedaily.com/reports/Poland_to_transfer_four_MiG-29_planes_to_Ukraine_in_coming_days_999.html

12. Canadian military orders space surveillance micro satellite - https://spacenews.com/canadian-military-orders-space-surveillance-micro-satellite/

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

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

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

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

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