October 2023

100 KNOTS

India's Aviation Ecosystem

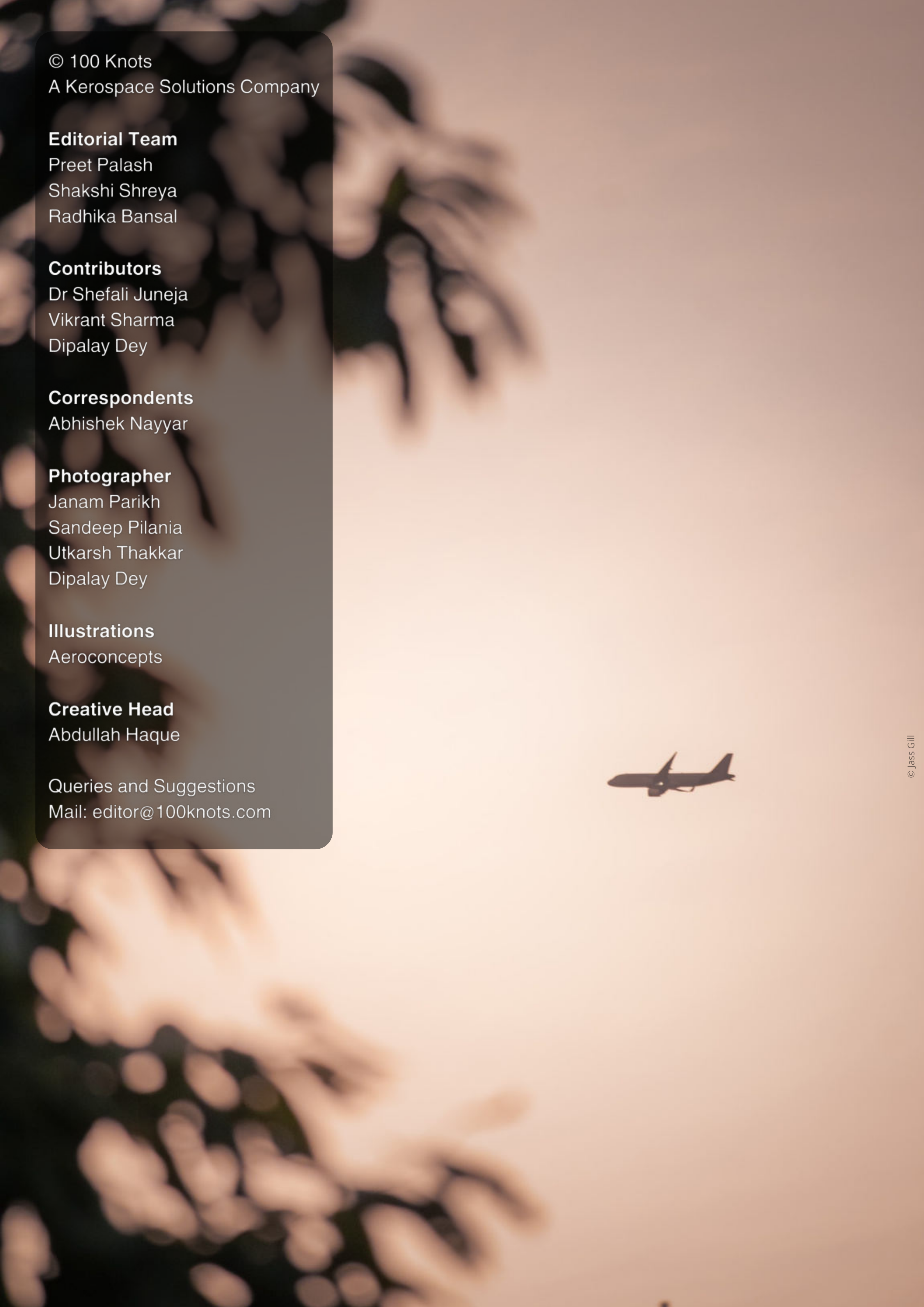
September Fleet Report

Safety
GPS Interference vs GPS Spoofing

Domestic
Growth of Air Connectivity in Northeast India

Science
Next Generation Drag Reduction Technique

Dr Shefali Juneja
Former Permanent Representative of India on the Council of ICAO



Queries and Suggestions
Mail: editor@100knots.com

© Jass Gill

Radhika Bansal
Assistant Editor

EDITORIAL DESK

Dear Colleagues,

Welcome to the October 2023 issue of the 100 Knots Magazine.

In this edition, we shed light on a concerning issue that has emerged in the realm of commercial aviation – the threat of GPS spoofing. As our reliance on GPS systems for navigation grows, so does the potential for malicious actors to exploit this technology, posing significant risks to the safety and security of air travel.

GPS spoofing, a technique where false signals are broadcasted to deceive GPS receivers, has traditionally been associated with cyber warfare and security breaches. However, its implications have now transcended into the aviation industry, casting a shadow over the trust we place in our navigation systems.

In the context of commercial aviation, the consequences of GPS spoofing are dire. Imagine an aircraft, guided by false coordinates, veering off course or landing at an incorrect destination. The results could be catastrophic, not only for those onboard but also for the communities on the ground. Furthermore, GPS spoofing has the potential to disrupt air traffic control systems, creating confusion and chaos in our skies.

It is imperative for governments, regulatory bodies, and the aviation industry to collaborate closely to fortify our defenses against this emerging threat. Enhanced cybersecurity measures, advanced encryption technologies, and continuous monitoring of GPS signals are essential components of a robust defense strategy. Researchers and engineers must work tirelessly to develop more resilient, tamper-proof GPS systems that can withstand spoofing attempts. Additionally, the implementation of multi-sensor fusion techniques, combining GPS data with inputs from other sensors, can provide redundancy and improve the overall accuracy and reliability of navigation systems.

As always, Contributions, comments, and feedback are always welcome. All papers are received with a high degree of enthusiasm and will find a home in future issues.

Our sincere thanks to all the contributors for their support and interest.

We hope to hear from you soon!

Happy Reading!

Disclaimer: Material for publication is obtained from guest authors and does not represent the views of 100 Knots Magazine or the Management. All articles are presented for information only and are not intended to challenge Industry guidelines. For Queries and Suggestions, Mail: editor@100knots.com

Table of Contents

September Fleet Report

Deliveries Scheduled Operations

	VT-AEQ	30-Sep	Boeing B777-300ER	Air India
	VT-TQS	29-Sep	Airbus A320 NEO	Vistara
	VT-IQG	29-Sep	Airbus A320 NEO	Indigo
	VT-ICN	29-Sep	Airbus A321 NEO	Indigo
	VT-BXA	28-Sep	Boeing B737-800	Air India X
	VT-IQF	27-Sep	Airbus A320 NEO	IndiGo
	VT-IRJ	21-Sep	ATR 72-600	IndiGo
	VT-TQR	20-Sep	Airbus A320 NEO	Vistara
	VT-TQR	18-Sep	Airbus A320 NEO	IndiGo
	VT-TQR	13-Sep	Airbus A320 NEO	IndiGo
	VT-TQR	01-Sep	Boeing B787-900	Vistara

A319-100	18
A320-200	9
A320 NEO	27
A321-200	14
A321 NEO	4
B777-200	8
B777-300ER	15
B787-800	27
Total	122

B737-800	26
A320-200	23
A320 NEO	5
B737 MAX 8	1
Total	55

A320 NEO	48
A321 NEO	10
B787-900	5
Total	63

IndiGo

A320 NEO	176
A321 NEO	93
ATR 72	41
A320-200	20
A321F	2
B777-300ER	2
Total	334

SpiceJet

A340-300	1
B737-700	8
B737-800	12
B737-900ER	3
B737 MAX 8	9
DHC-8	24
Total	57

Akasa Air

B737 MAX 8	20
Total	20

A320-200	5
A320 NEO	49
Total	54

ATR 42	2
ATR 72	18
Total	20

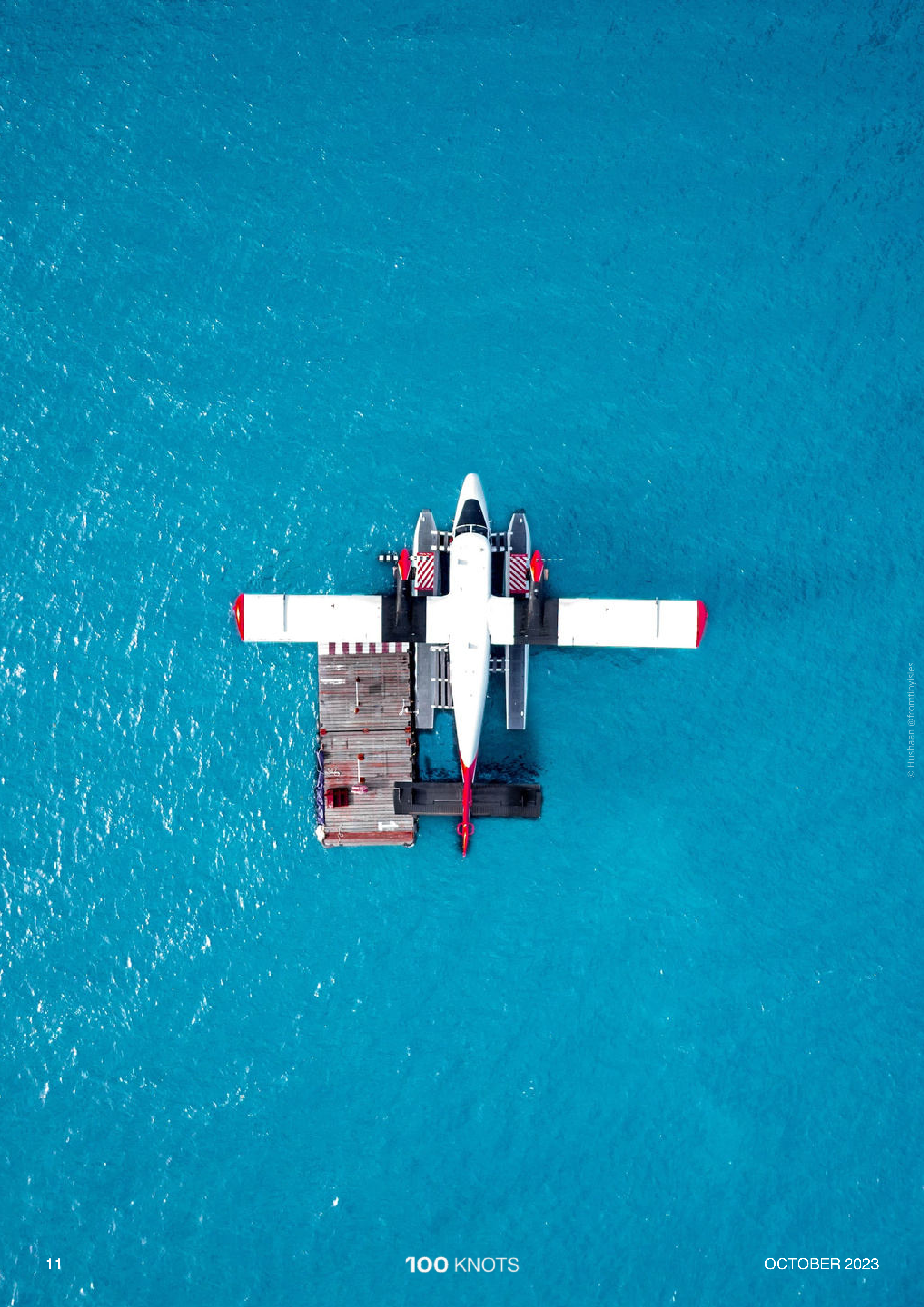
ERJ 145	5
ERJ 175	2
Total	7

BLUE DART

B737-800	2
B757-200	6
Total	8

flybig

ATR 72	3
DHC-6	1
Total	4



© Hushaan @fromtinyisles

Flying Green with Red Fares

Dr Shefali Juneja
Former Permanent Representative
of India on the Council of ICAO

One of the most life-changing innovations of the human mind has been flying in gleaming, large aircraft - airplanes - anywhere around the globe. Pre-Covid and post-Covid, traveling the world has become a beloved activity and even a necessity for global citizens. However, as climate change wreaks havoc around the world, aviation's high visibility has resulted in it being labeled as "guilty-flying" or "flight-shaming" (Flygskam) due to the carbon emissions it produces. Aviation contributes to 2% of global carbon emissions and falls under the hard-to-abate sector. Recently, Schiphol Airport, an important hub in Europe, unveiled plans to reduce flights as part of an effort to mitigate noise and lower CO2 emissions.

International aviation fuels, categorized as bunker fuel, share this classification with international maritime fuels, causing pollution over international airspace or waters. The International Civil Aviation Organization (ICAO), headquartered in Montreal, Canada, has been ambitiously working towards environmental mitigation. In 2010, it adopted the goal of achieving carbon-neutral growth by 2020 and formulated an out-of-sector emission trading scheme known as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016.[1]

Airlines are required to offset emissions beyond the baseline set by ICAO (85% of 2019 levels) by purchasing carbon offsets. While the scheme began in 2021, COVID-related disruptions have led to offsetting delays. By 2027, the scheme will become mandatory for all airlines worldwide.

The Paris Agreement, adopted in 2015, pledged “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels.” In order to implement this goal, ICAO on basis of a feasibility study for achieving net-zero carbon emissions by 2050, adopted the Long-Term Aspirational Goal (LTAG) in October 2022, aiming for net-zero carbon emissions by 2050 in international aviation. This objective is formidable, considering that by 2050, an estimated 10 billion people will be flying annually. This implies that the aviation industry will need to address a cumulative total of 21.2 gigatons of carbon emissions over the next three decades.

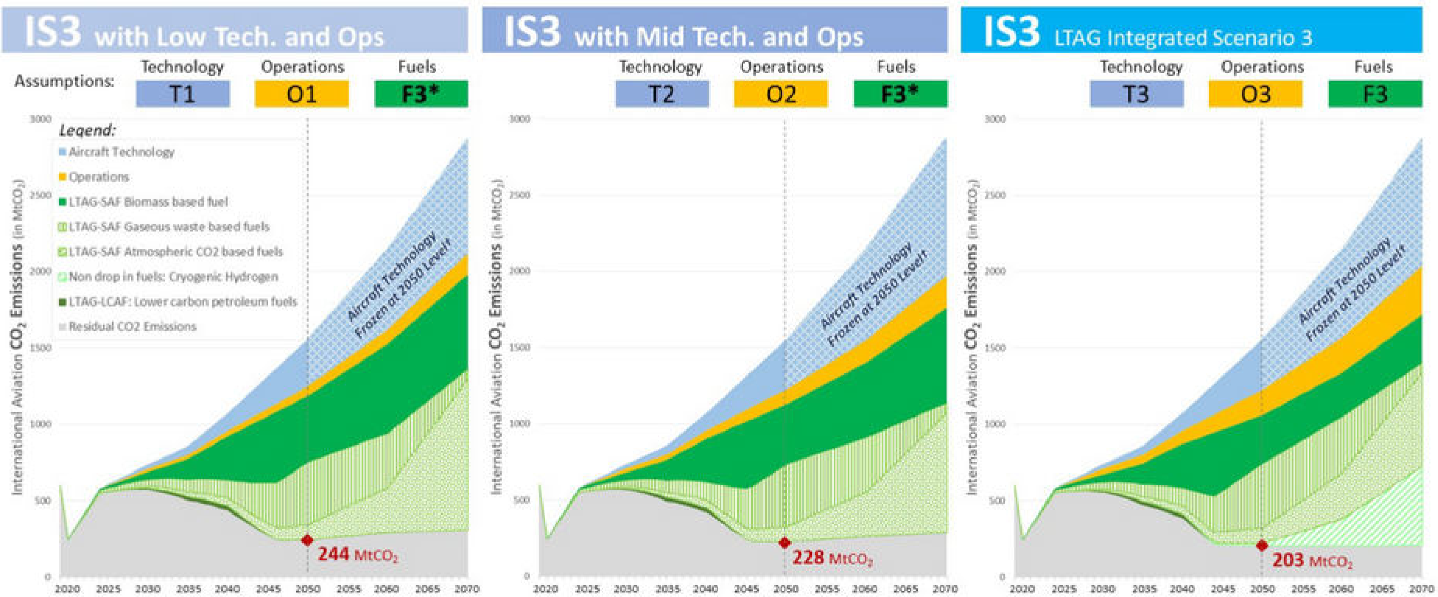
1 Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (icao.int)

India and other developing countries in the ICAO Council, often referred to as like-minded countries, along with other developing nations globally, aim to ensure that LTAG recognizes each state's unique circumstances and capabilities. These factors will determine each state's ability to contribute to LTAG within its own national timeframe. The technical feasibility report outlines three Integrated Scenarios (IS) for achieving net-zero emissions. Among these, IS3 has the potential to yield the highest reductions through technology (21%), operations (11%), and the use of sustainable aviation fuels (55% of CO2).

It's evident that the most significant contributor to the decarbonization process will be Sustainable Aviation Fuels (SAF). ICAO has been diligently developing a 2050 vision for SAF, encompassing Low Carbon Aviation Fuels (LCAF) and other cleaner energy sources for aviation. This year, from April 2023 onwards, a series of regional seminars, industry and state stocktaking sessions, meetings with multilateral development banks, and energy manufacturers have taken place. Recently, ICAO participated in Consultations on the Global Biofuel Alliance, held in Goa on July 22, 2023, on the sidelines of the G-20 Energy Ministers meeting.

Both the Global North and the international aviation industry, represented by IATA, ACI, ICCAIA, and CANSO, share the clear ambition for a strong signal to scale up SAF production. ICAO will host a high-level Conference on Aviation Alternate Fuels (CAAF/3) from November 21-24, 2023, to establish a global framework for quantified SAF and LCAF goals and other cleaner energy sources, with intermediate milestones set for 2030, 2040, and beyond to 2050. This initiative is heavily influenced by EU regulatory policies such as "Fit for 55" and "Refuel EU." These policies mandate fuel suppliers to provide an increasing blending of SAF at EU airports, starting from 2% in 2025 and reaching 63% by 2050.

The US has offered a series of incentives outlined in the Sustainable Aviation Fuel Act. This act aims for a national goal of achieving a net 35% reduction in greenhouse gas emissions from flights by 2035 and net zero emissions by 2050. The bill establishes targets and standards for reducing emissions and provides incentives for the production and use of sustainable aviation fuel.



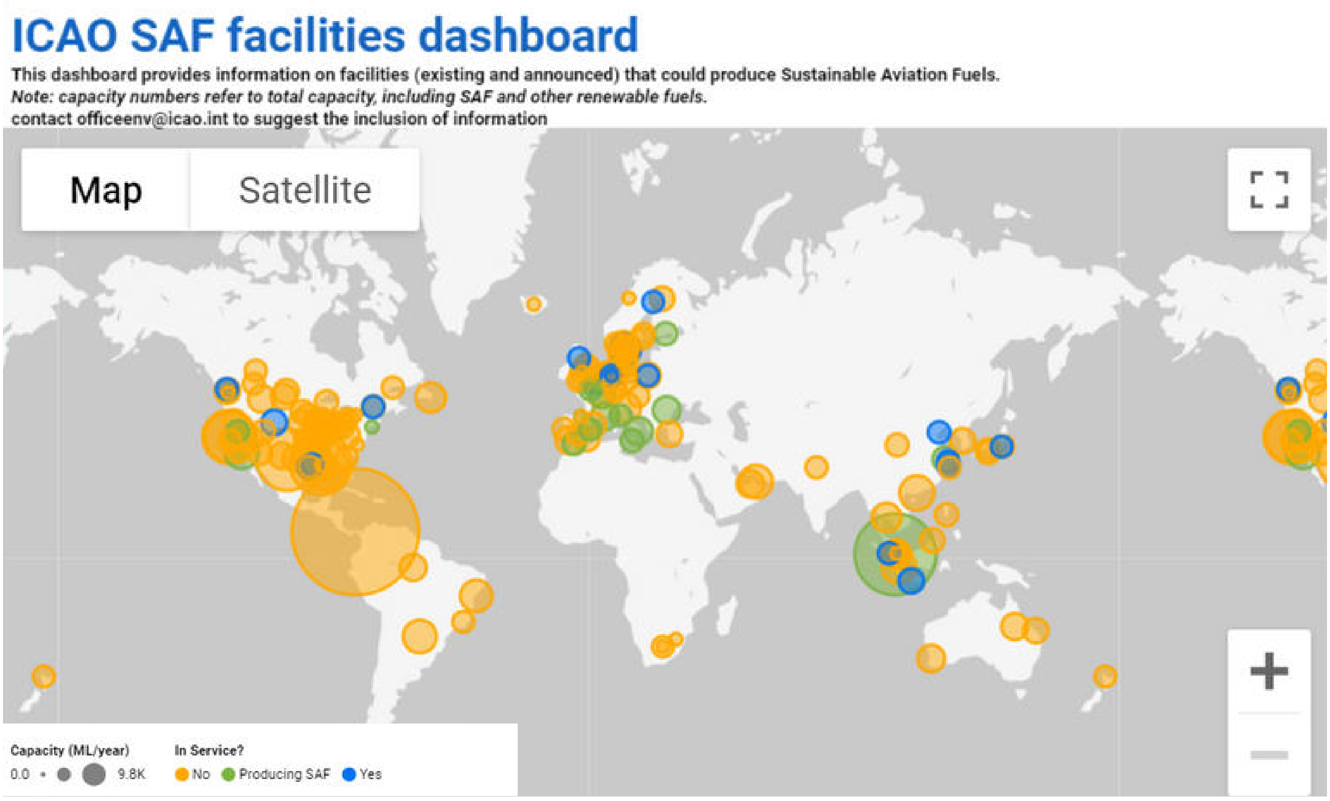
* Amended Fuel Scenario (F3) to align with Aircraft Technology scenarios associated with IS1 and IS2 (i.e., no ACA-T3 hydrogen powered aircraft included in IS1 and IS2) and adjusted to meet fuel volume constraints. Note. – Under a F3* (IS1 Hybrid) scenario LTAG-SAF Atmospheric CO_2 fuel volumes scaled by 1.68 in 2070 (no changes in 2060). Similarly, under a F3* (IS2 Hybrid) scenario LTAG-SAF Atm. CO_2 fuel volumes scaled by 1.33 in 2070 (no changes in 2060).

Carbon Emission from International Aviation and Associated LTAG Scenarios

An accounting system called "book and claim" is under consideration. This system enables airlines to book and buy SAF and claim it for environmental mitigation, even if another carrier physically uses that SAF. While this process offers advantages in terms of transportation and flexibility, there is a concern that this virtual marketplace might discourage local production due to strict sustainability criteria and cost disparities. The cost of SAF production in developing countries may be higher due to the absence of concessions and subsidies available in developed nations. This could concentrate SAF production in the Global North, making the Global South a net importer of SAF. Presently, about 90% of SAF production is located in Europe and North America, as indicated by the ICAO SAF facilities dashboard.

The underlying concern with a global framework for SAF is that it may cause airfares to rise due to the high cost of SAF. Given the current availability of SAF, which stands at just 0.2%, SAF would be much costlier for the Global South compared to the Global North. Certain flight routes could be affected, as airlines from the Global South would need to purchase expensive SAF for return flights, while Global North airlines would have access to heavily subsidized SAF. This could further exacerbate the already skewed nature of connectivity, favoring airlines from developed countries. The recent report from CAEP projects that short-term SAF projections up to 2030 will be dominated by North America (65%), followed by Europe (16%), Central/South America (11.3%), Asia and the Middle East (3.2%), with Africa having no significant contribution.

Regulation, the evolution of SAF, feedstock availability, price elasticity, and the arbitrage risk from food, energy, fertilizer, plastics, and other low-carbon fuels all remain uncertain factors. While ICAO has approved seven pathways, these pathways are still in varying stages of development, and technological reliability for commercial scalability remains untested. Different feedstocks will yield distinct trajectories for scaling up SAF production. Given the lack of international standards for Renewable Low Carbon Fuels, national governments or EU standards may not align with ICAO guidelines. This misalignment could hinder the availability and scalability of SAF for aviation across different regions. Sustainability certification standards for SAF under CORSIA are relatively exclusive compared to other modes of transportation. This exclusivity could deter investments in aviation sustainable fuels, as they would require higher financing. The cost per metric ton of SAF is anticipated to range from Rs 66-90/liter for HEFA, Rs 72-96/liter for ATJ (sugar stream), Rs 108-132/liters ATJ (agricultural residue), and Rs 96-150/liter for gasification, Fischer-Tropsch (municipal waste and agricultural residue).



The central figure in this narrative is finance. The LTAG report estimates that scaling up SAF production will require approximately 3.5 trillion dollars in investments by 2050. The facilitation of financing and the establishment of a finance fund are imperative prerequisites before adopting any quantitative goals. However, the Global North within ICAO is unwilling to commit to funding this transition. Discussions are ongoing on how to mitigate financial risks and bolster blended finance from both public and private sources.

Fatih Birol, the Executive Director of the IEA, remarked, "Countries are not starting on this journey from the same place – many do not have access to the funds they need to rapidly transition to a healthier and more prosperous energy future." He further emphasized that "2/5ths of the world's population lives in developing countries, yet they have access to only 1/5th of the global investment in clean energy." The World Investment Report for 2023 highlights that since the Paris Agreement of 2015, investment in renewable energy has tripled but has been concentrated in developed countries. While developed nations required about 1.7 trillion in annual renewable energy investments, they attracted FDI worth 544 billion for clean energy in 2022.

Addressing climate change and reducing CO_2 emissions is a significant challenge of our time, but other Sustainable Development Goals are equally crucial in many countries. While development remains central to every government and sector, sustainable development must be prioritized. India's Prime Minister, Mr. Narendra Modi, has committed India to high growth in a sustainable manner, relying on renewable energy whenever possible. The old narrative of exploiting nature for economic development followed by developed countries underscores the historical emissions count and the principle of Common but Differentiated Responsibilities.

The aviation sector serves as a multiplier and connector of economies and people, and its growth is essential. India, alongside other like-minded countries, is gearing up for pre-CAAF/3 negotiations on September 25-26 this year. This critical moment presents an opportunity to convey the right message and address all genuine concerns before ICAO transitions to ACT II in pre-CAAF/3 from September 25-26th, 2023.

About the Author

Dr. Shefali Juneja was the Representative of India on the Council of International Civil Aviation Organisation (ICAO) in Montreal, Canada, till recently. A suave speaker and nuanced negotiator, she demonstrated great leadership in ICAO and was known as consensus builder. She was elected as 1st Vice President of ICAO India got this position after 65 years and was also Chair of important committees and groups. She strategically laid foundations for a coalition of like-minded countries in ICAO. Previously, Dr. Shefali served as Joint Secretary and Director in Ministry of Civil Aviation and belongs to the Indian Revenue Service, 1992 batch.

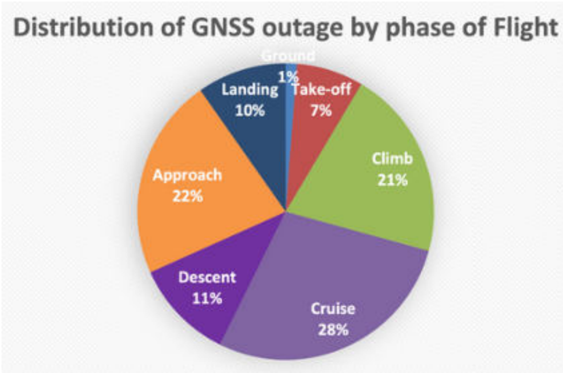
GPS Jamming vs GPS Spoofing

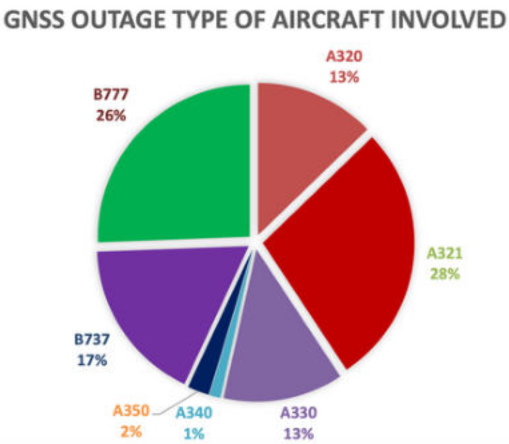
A New Threat Emerges

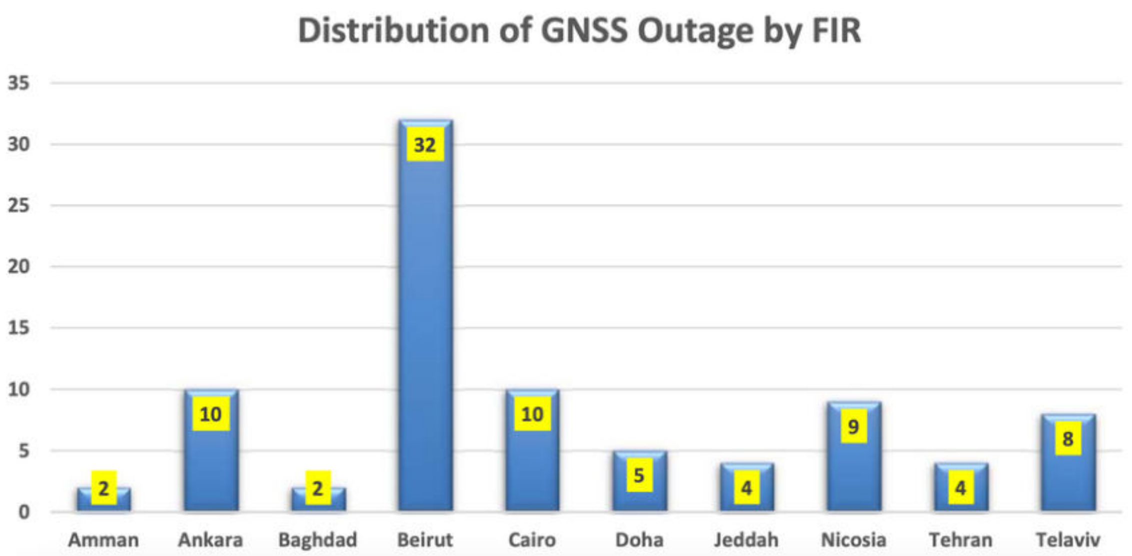
Aircraft navigation has come a long way with the advent of global navigation satellite systems (GNSS), first devised by the U.S. military in the 1960s. The arrival in the mid-1990s of the civilian version of the technology, called the Global Positioning System, meant that aircraft could navigate by satellite and take direct routes from point to point. The GNSS receiver is the primary equipment supporting Required Navigation Performance (RNP) operations and provides position input to many aircraft avionics, such as Navigation Display (ND), Ground-Proximity Warning System (GPWS) and Automatic Dependent Surveillance (ADS). Some business aircraft are referencing GNSS for flight control and stability systems.

GNSS satellite constellations which are currently recognized by International Civil Aviation Organization (ICAO) include the US. Global Positioning System (GPS), the Russian GLONASS, the European Galileo and the Chinese BeiDou. Frequencies for GNSS signals supporting safety-of-life applications, such as aviation, are globally harmonized and legally protected under the International Telecommunication Union (ITU) Radio Regulations. Aircraft GNSS receiver is a safety-critical equipment and the main source of position information which drives aircraft navigation system in most commercial aircraft.

There are several types of threat that can interfere with a GNSS receiver's ability to receive and process GNSS signals, giving rise to inaccurate readings, or no reading at all, such as radio frequency interference, space weather induced ionospheric interference, solar storm, jamming and spoofing. The disruption of GNSS, either performance degradation in terms of accuracy, availability and integrity or a complete shutdown of the system, has a big consequence in critical infrastructure.







GNSS Anomaly for the Period January 2015- June 2018 (MID Region) - ICAO

GPS Jamming

GNSS Jamming occurs when broadcasting a strong signal that overrides or obscures the signal being jammed. The jammer will confuse the receiver by emitting radio signals at the same frequency as the GPS. This interference hampers the ability of the GPS device to determine its correct position. The GNSS jamming might occur deliberately by a military activity or by other sources.

Other GNSS systems, such as Russia's GLONASS, China's BeiDou, and Europe's Galileo constellations, use slightly different frequencies but have similar vulnerabilities, depending on exactly who is conducting the test or attack.

In 2017, the FAA commissioned the nonprofit Radio Technical Commission for Aeronautics to look into the effects of intentional GPS interference on civilian aircraft. Its report, issued the following year, found that the number of military GPS tests had almost tripled from 2012 to 2017. In at least a handful of episodes, the loss of GPS was deemed an emergency.

The GPS technology today found in airplanes and consumer equipment was designed by the U.S. military, for the U.S. military to locate and navigate its aircraft, ships, tanks, and troops. The U.S. military routinely jams GPS signals over wide areas on an almost daily basis.

Radio Frequency Interference (RFI)

The GPS signal is a low power signal. It is comparable to the power emitted by a 60W light-bulb located more than 20,000 km away from the surface of the earth. This means that the signal could easily be disturbed by any ground source located near an aircraft and emitting in the GPS L1 frequency band (1575.42 MHz +/-10 MHz). Main Known Sources of RFI are:

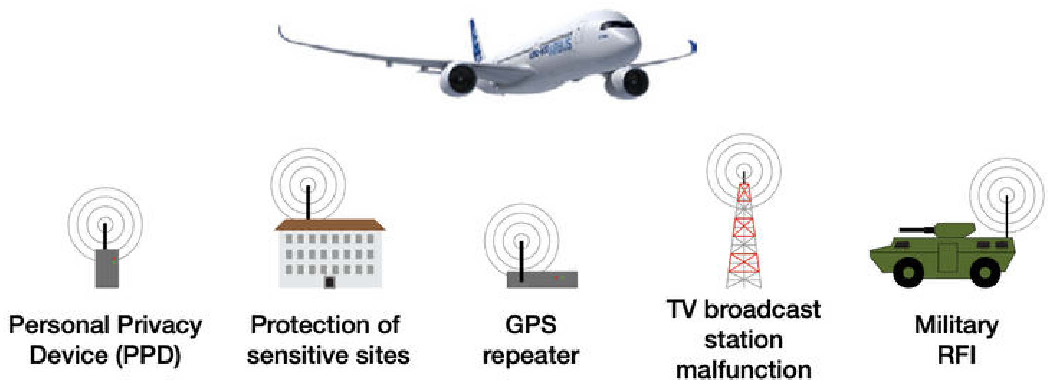
Personal Privacy Devices (PPD)
These Devices jam a GPS signal in the immediate area to avoid tracking.

Protection of sensitive sites and VIPs
Certain sensitive sites may be protected using GNSS RFI for security reasons.

GPS repeater
GPS repeater signals have caused interference with actual GPS signal in some reported events.

TV broadcast station malfunction
A TV broadcast station malfunction reportedly disturbed the GPS signal.

Military GPS RFI in conflict zones
These areas are often close to military conflict zones and known via NOTAMs

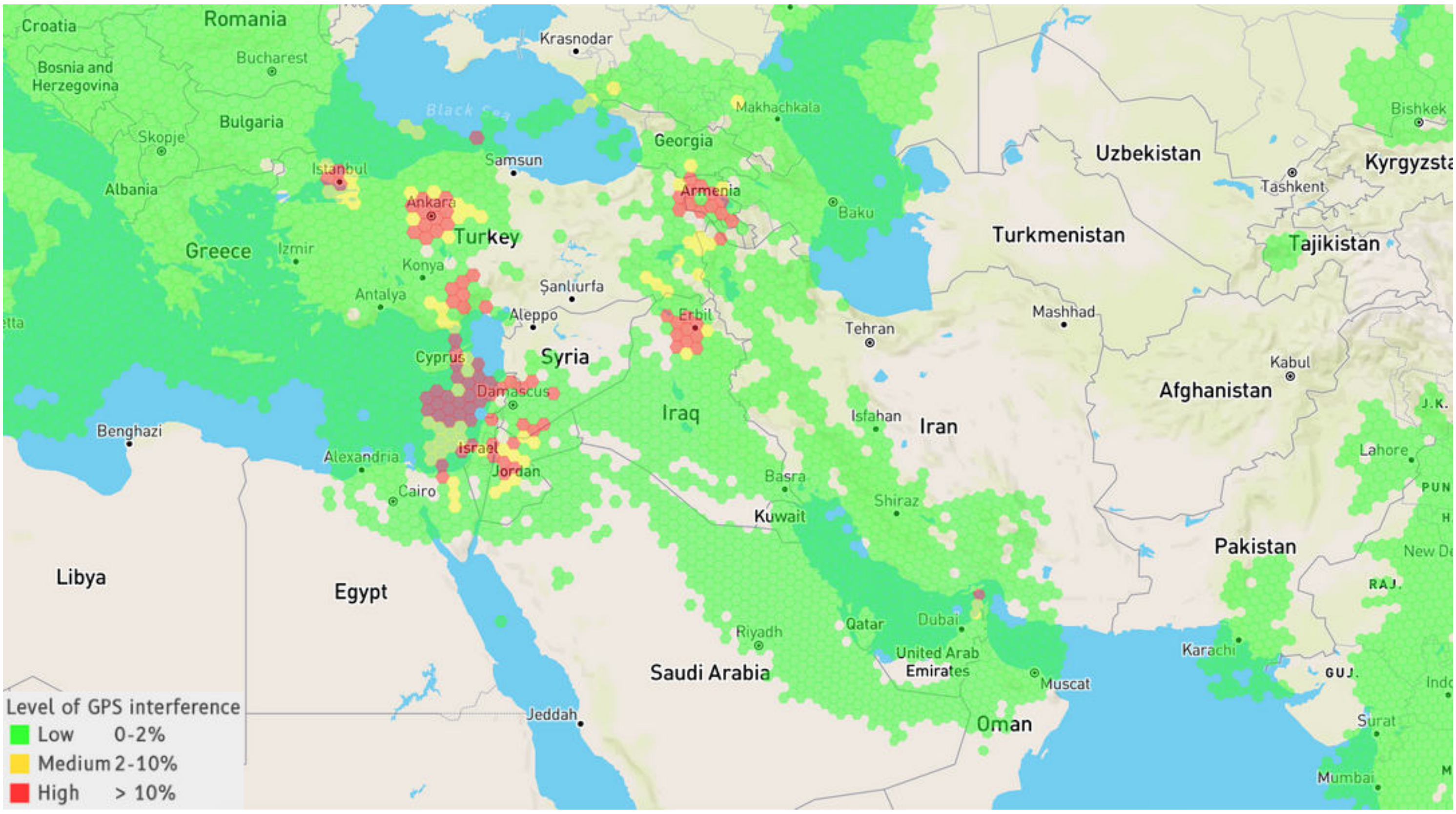


A typical handheld GPS Jammer

Hand-Held Jammers

A hand-held GPS jamming unit is generally small and self-contained, so the user can readily transport and hide it. These Jammers are prompt to start up and are usually ready to operate in just a few seconds. They also use relatively little power. That makes them easy to turn on when needed and switch off quickly to avoid detection. What's more, these illegal devices are readily available on the black market for prices nearly anyone can afford. Some of these sources are also capable of emitting signals that mimic GNSS signals (GNSS Spoofing, discussed later).

Building a basic electronic warfare setup to disrupt these weak signals is trivially easy. “Just Detune the oscillator in a microwave oven and you've got a super powerful jammer that works over many kilometers", said an expert.



© GPSJam

GPS Spoofing

While GPS jamming is something anyone can do with relative ease, GPS spoofing, until now was primarily the work of military operations. GPS spoofing is the term given to attacks in which hackers transmit GPS-like signals and code them in a way that tricks receivers into thinking they are in a different location than they are. Someone conducting a spoofing attack is trying to lie to a GPS receiver through the broadcast of incorrect signals disguised as typical ones. It's also possible to conduct a spoofing attack by broadcasting genuine signals with the wrong timestamp, or signals captured at a different location. The spoofer then modifies these signals to make the receiver believe its position is in a different location, or in the right place at the wrong time. GPS Spoofing can be done in two ways:

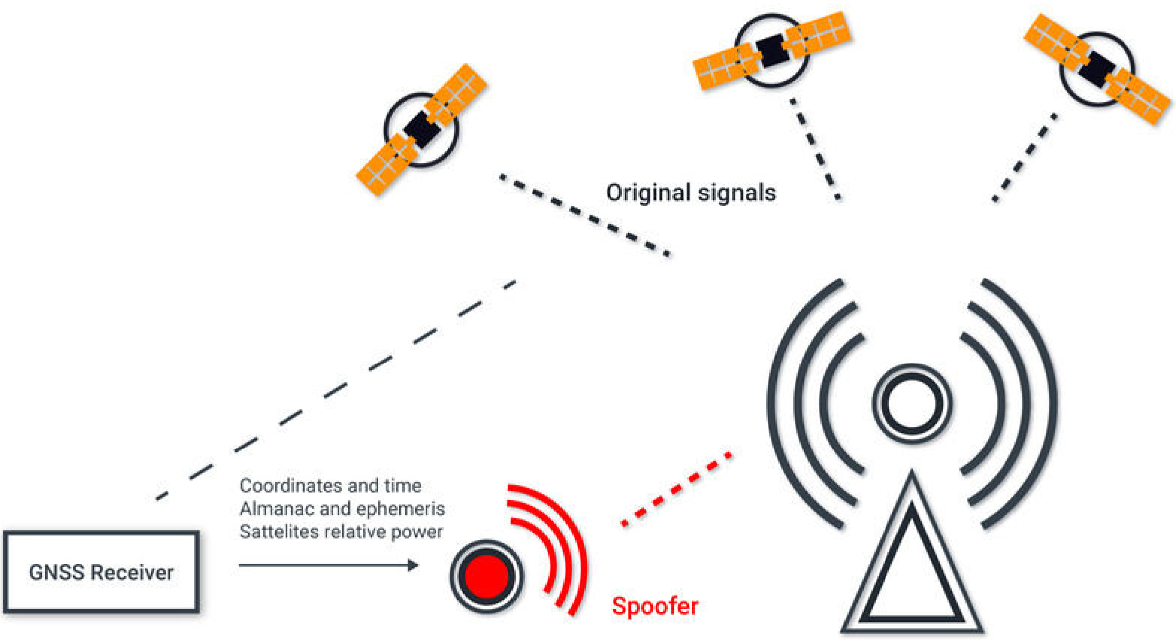
The GPS technology today found in airplanes and consumer equipment was designed by the U.S. military, for the U.S. military to locate and navigate its aircraft, ships, tanks, and troops. The U.S. military routinely jams GPS signals over wide areas on an almost daily basis.

Carry-Off Attacks

This type begins with the attacker broadcasting signals that sync perfectly with the target receiver's legitimate signals. The attacker then gradually increases the power of the signal until it essentially drowns out the genuine one, causing the receiver to track the false signal instead. At that point, the attacker can manipulate the signal so the receiver reports a different location or time than the real one. The goal of carry-off attacks is to evade detection, making them primarily the domain of military operations.

Meaconing

In this form of GPS spoofing, the signals get re-transmitted, rather than altered. GPS repeaters are often the source of meaconing, whether intentional or not. An example of a repeater is the equipment found in airport hangars that allows the detection of GPS signals indoors, usually for testing. If someone increases the power of one of these repeaters — accidentally or on purpose — the result will be the broadcast of an incorrect signal.



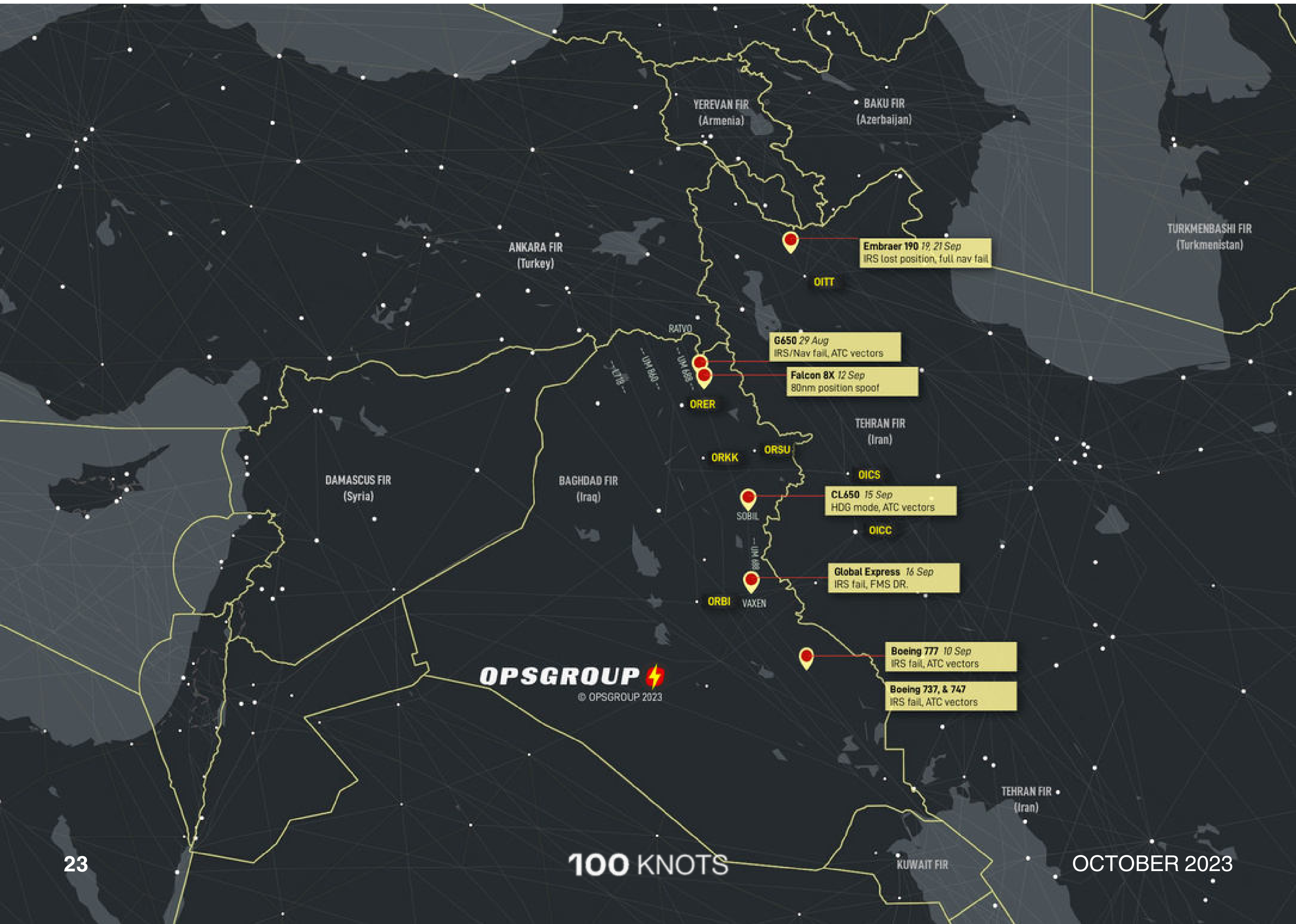
On Aug 29, 2023, Gulfstream G650 in the vicinity of ORER (Erbil, Iraq) lost navigational integrity over nearly entire Iraqi airspace due to enroute high altitude GPS spoofing (Falsified position not jammed as usual). Aircraft then entered full degrade. GPS was 60NM offset, the IRS were considered unreliable. Situation was resolved by receiving radar vectors by ATC to fly along the airway. UM688 RATVO to VAXEN, overhead ORBR and close to ORER at 15:50Z. GPS Signal that was emitted was very strong and could be picked up by both hands held EFB moving maps. Due to the strength of the falsified GPS signal, the GPS was considered valid by the aircraft system causing the large mismatch. (OPS Group)

The IRS is Standalone – How Can it be Affected?

In the past, INS and IRS were fully self-contained systems. However, the technology in the flight deck is now far more integrated. Many modern IRS systems use GPS to update the accuracy of the IRU as the flight progresses.

In general, the system is designed so that if there is a loss of signal or a suspected loss of integrity of the GPS calculated position, then the IRS solution will be isolated and the plane will use the most recent DR solution. If however the system cannot tell it has a bad position solution due to sophisticated spoofing, if might well go ahead and update the IRS with bad data.

FMS and IRS have only been designed to cope with a loss of GPS signal, and not an intentional spoofed signal. Most airliner avionics system know that a shift/gross-error has happened as ground-based updates do not compute the correct position, and will flag a navigation/map/position warning. However, all primary navigation systems end up being corrupted (temporarily) as a result.



Recommended Procedure

Before Entering Risk Area

- Check enroute FIR NOTAMs for any GPS spoofing/Jamming advice (in time this will likely be published)
- Cockpit Preparation: Perform full IRS alignment if entering known area with GPS spoofing risk
- Be aware of typical sensor hierarchy for FMS position: GPS, then IRS, DME/DME, VOR/DME, DR.
- Consider de-selecting GPS sensor input if option available (Check respective FCOM)
- Review differences between GPS Jamming and GPS Spoofing.
- Perform time check and set correct time on personal device or watch.

Inside Active GPS Spoofing/Jamming

Look for clues that the aircraft may be being targeted:

- Large increase in EPU (eg. 1-2nm to 60nm)
- Aircraft clock changes – incorrect UTC time
- Incorrect FMS position
- Large shift in GPS position displayed
- Obvious ND/PFD warnings about position error
- Other aircraft on ATC freq/121.5/air-to-air report clock issues, position errors, or request vectors.

If active spoofing/ Jamming confirmed:

- Revert to heading mode
- De-select GPS inputs as soon as possible (IRS infection is not immediate)
- Confirm IRS integrity
- Consider using OFP/CFP computed track between waypoints as guidance
- Report to ATC so other aircraft is aware, and check position.
- Remain IRS only until clear of risk area

After Flight with Suspected Spoofing/Jamming

- Report to Maintenance
- File report to your civil aviation authority

Conclusion

GNSS Vulnerability has been identified as a safety issue and one of the main challenges impeding the implementation of PBN. While GPS jamming or spoofing incidents typically always indicate malicious intent, aviation cybersecurity teams face an uphill battle in defending the onboard component. A completely unprotected GNSS receiver is susceptible to attacks of even the simplest caliber, but fortunately, a variety of secured receivers can alert people and organizations to spoofing. They do this by searching for anomalies in the signal, or through the use of signals specifically created to make spoofing more difficult.

Just like other operational risks, this requires continuous monitoring and the execution of response plans. The bottom line is that through collaboration and impactful guidance, we can collectively address GPS concerns.

Credits

https://spectrum.ieee.org/faa-files-reveal-a-surprising-threat-to-airline-safety-the-us-militarys-gps-tests

https://ops.group/blog/gps-spoof-attacks-irs/

https://www.duncan-parnell.com/blog/whats-the-difference-between-gps-spoofing-and-jamming

© Preston Lane

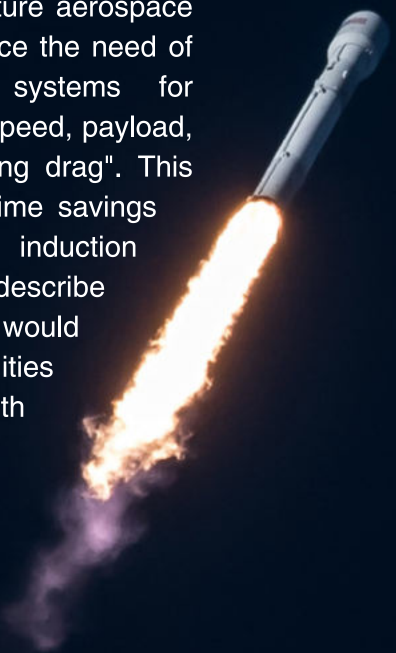
Next Generation Drag Reduction Technique

Pioneering Technology for Airborne Vehicles

Vikrant Sharma
Instructor & Flight Test Engineer
National Test Pilot School

I am Vikrant Sharma. I was a Scientist in BrahMos Aerospace for 9+ years. I worked on development and testing of world's best supersonic cruise missile the BRAHMOS. When I joined BrahMos, our visionary founder Dr. A Sivathanu Pillai took me under his wings and gave me responsibilities that 22 years old can never imagine. I was put in charge of all the aerodynamic testing which includes CFD and wind tunnel testing in India and Russia for the BrahMos Air-version project in which we integrated BrahMos missile on the Sukhoi SU-30 MKI aircraft. I was also involved in the R&D of BrahMos hypersonic missile and BrahMos mini. I left BrahMos in 2019 and went to the National Test Pilot School to undergo Flight Test Engineer course on full scholarship thereby becoming the first Indian to undergo the Flight Test Course without sponsorship from any Indian government organization. I am presently an Instructor at the National Test Pilot School, USA where I teach Test pilots and Flight test engineer students from all over the world about the art and science of Flight Testing.

I was recently awarded a patent on drag reduction methods for supersonic vehicles (Patent No. US11655055B2 issued May 23, 2023). The patent has military as well as civilian applications. The technique described would also enable our launch vehicles to carry heavier payloads in the orbit. Incorporation of the patent will result in capabilities enhancements to the present and future aerospace systems and would eliminate or reduce the need of designing expensive aerospace systems for capability enhancements in terms of speed, payload, range and fuel efficiency by "reducing drag". This would result in enormous cost and time savings and would also reduce the time for induction of new capabilities. Here I briefly describe the basic concept of the patent. I would be happy to discuss the possibilities and the techniques in detail with anyone interested.



Aerospace systems occupies an ever-increasing role in today's world with applications in a variety of domains like transportation, space, Defence and many more. Aerodynamics is the study of the motion of air over a body. The complex interaction of air with the physical body gives rise to aerodynamics forces like lift and drag. Performance of the aerospace systems greatly depends on drag. Reduced drag can result in longer range, increased speed and increased payload. Current practical drag reduction techniques are primarily based on optimizing the shape of the system (supercritical aerofoil, wave rider etc.) which basically boils down to 'make the nose pointy'. Even the new systems (like US Navy's new low drag High Velocity Projectile (HVP)) are designed with the same technique. These are Passive techniques which reached its maturity in 1960s. On the other hand, in active flow control techniques, the flow-field around a body is altered somehow to achieve a favourable flow field which results in the reduction of drag.

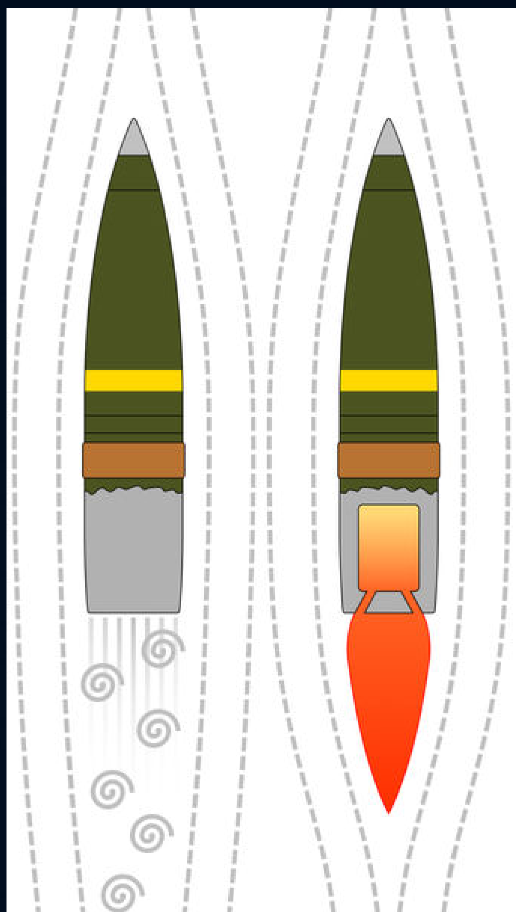


Figure-1: Base-Bleed

As mentioned previously, most of the systems today employ passive drag reduction techniques, in which the shape of the body is optimized to reduce the drag. A point has been reached where drag reduction by existing techniques has practically been exhausted. Some active flow controls techniques are however employed in some systems. In order to better understand the active flow control techniques, lets look at a Russian torpedo 'Shkval'. Shkval was capable of speeds in excess of 200 knots. The high speed was made possible by supercavitation, whereby a gas bubble surrounded the torpedo which minimized the physical contact of the torpedo with the water. So even though the torpedo was travelling in water, but it was surrounded by air which is a rarer medium. This reduced the hydrodynamic drag experienced by the torpedo.

In airborne systems, lets consider some examples of active flow control. Base-bleed is a system used on some artillery shells to increase the range. When the projectile travels in the air, base drag is one of the major drag components which increases the overall drag of the projectile. When the projectile travels in the air, wake is developed in aft of the projectile which is a low-pressure region. This pressure difference gives rise to base drag. In base bleed system, a gas generator is fitted aft of the projectile which expels gas in the low-pressure region to reduce base drag. UGM-96 Trident ICBM uses an aerospike on its nose cone which reduces forebody pressure aerodynamic drag of blunt bodies in supersonic speeds.

Figure-2a: Skhval torpedo

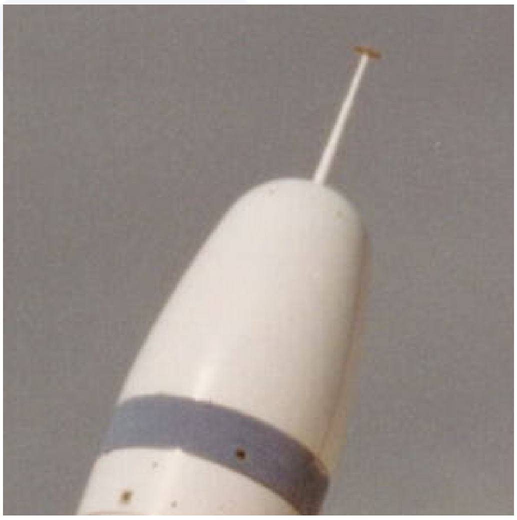


Figure-3: Aerospike

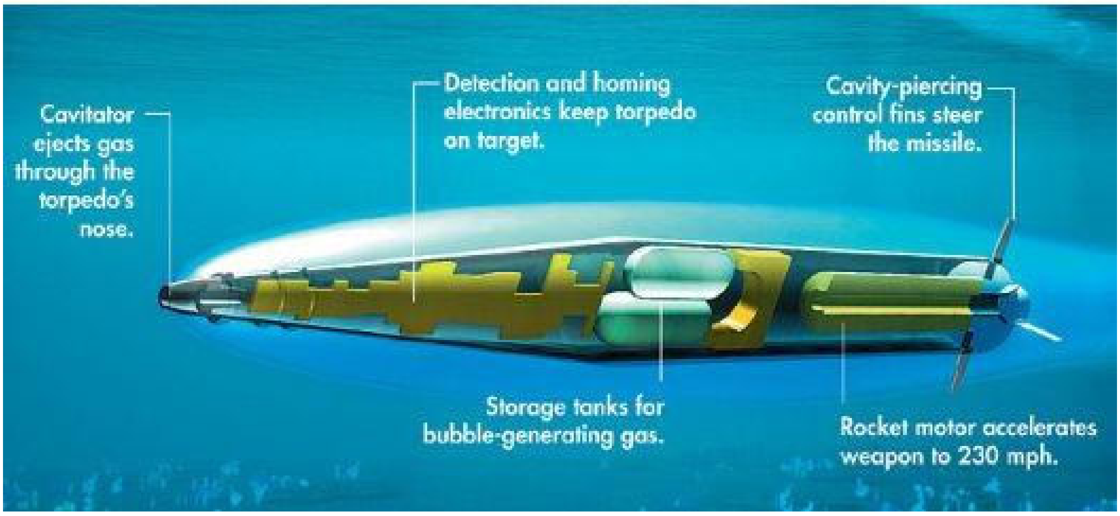


Figure-2b: Skhval torpedo

Figure-4: Hyper Velocity Projectile (HVP)

Multiple very advanced Active drag reduction technique have been proposed and feasibility have been demonstrated by the researchers. These techniques include turbulence reducing methods, counter-flow mass injection, plasma/ electric discharge, energy deposition method etc. Even though the physics of these methods is well understood, these techniques have not been applied on any working system. In order to understand these techniques, let's go back to our previous example of Skhval. When a body is placed in a flow field in which plasma is impinged on it, the body is surrounded by plasma flow field. Plasma is rarer than air hence the aerodynamic drag experienced by the body is reduced. Other active flow control techniques include fluid injection, hot gases injection, plasma arc discharge among others. Such techniques are presently not implemented in any system due to system integration challenges. This patent provides a practical approach to implement active flow control techniques to actual supersonic systems, new as well as pre-existing.

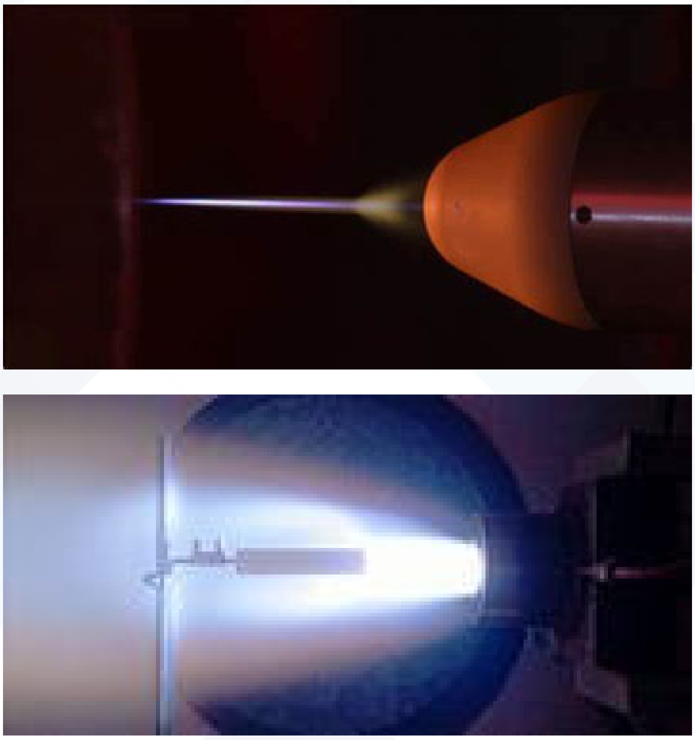


Figure-5: Plasma injection on body for drag reduction (Wind tunnel)

Brief Description of the Invention

This patent describes a practical approach to implement active flow control techniques. The technique for active flow control is based on energy deposition. We know that Drag = ½ * Density * Speed^2 * Area * Drag coefficient. If the body is engulfed by hot gases, then following will happen:

Energy deposition -> Reduced air density -> Reduced pressure zone -> Extended region of low density and negative overpressure developed.

That means that the pressure on the surface of the body will be lower than the what the pressure would have been if no energy deposition had been there. This fall in pressure and density leads to reduction in pressure and wave drag as the shock standoff distance increases and stronger shocks are replaced by weaker shocks. The virtual shape of the body is also altered, thus the body will 'appear' to be more aerodynamic. Let's take the example of a projectile. An add-on kit was designed to implement the invention on an existing artillery shell.

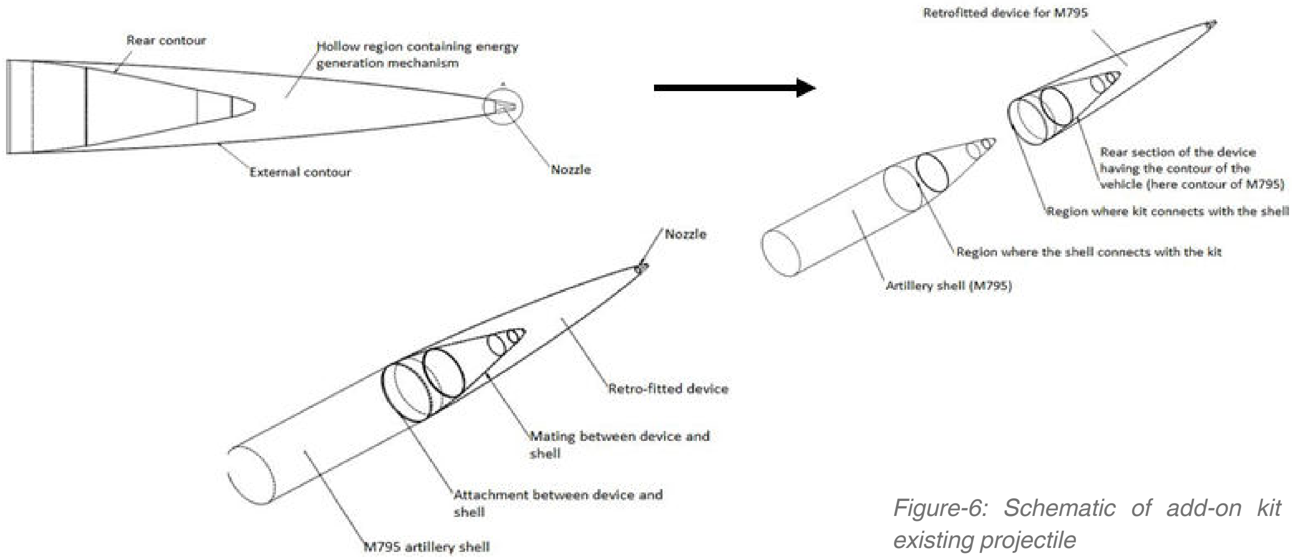


Figure-6: Schematic of add-on kit on an existing projectile

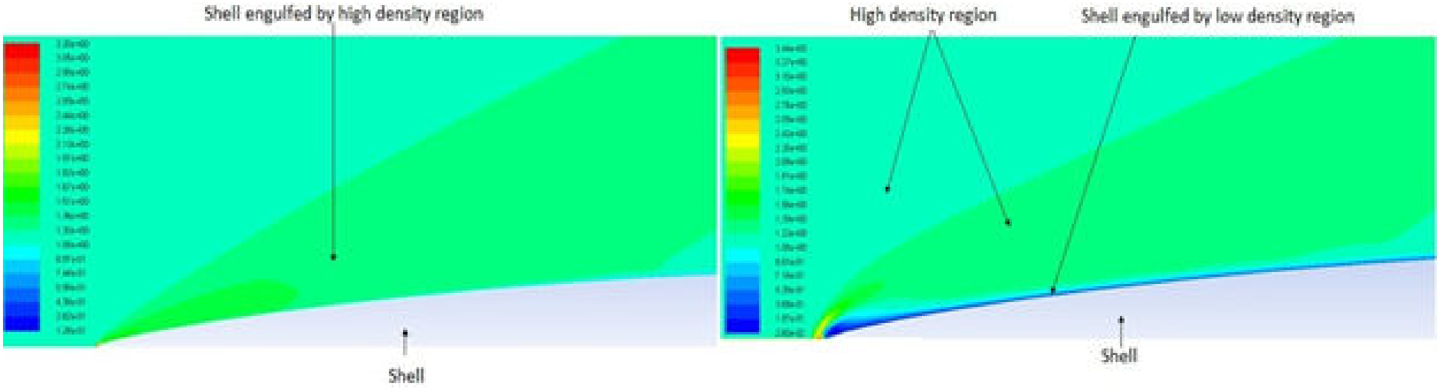


Figure-7: Flow pattern over the shell with and without the add-on kit

The add-on kit comprises of a hollow structure configured for retrofitting on the flying body. The hollow structure comprises an internal contour and an external contour. The internal contour of the hollow structure was configured for physically attaching with the vehicle. The kit contains the energy injection mechanism inside. The hollow structure further comprised of nozzle on the external contour of the structure. The nozzle is configured for energy injection into the flow-field in the neighbourhood of the vehicle. The also device alters the external profile of the vehicle. The external contour is a low drag shape (selected from plurality of shapes such as Haack-series, power based nose cone, Von- Karman etc). Thus, the device is configured to reduce the drag by two ways. The two ways include energy deposition in the neighbourhood of the vehicle and by changing the shape of the vehicle upon installation of the device. It was also found that the region of energy deposition and the Mach number at which the gases are injected also influences amount of drag reduction.

For case study, the external contour of the device was Von-Karman nose. The hollow internal structure houses the energy generation and deposition mechanism. CFD studies shows that due to energy deposition, the body is engulfed by a region of low density. CFD studies also showed considerable drag reduction.

The following was discovered:

(a) Energy deposition at optimized region in front of the body results in lowest drag.

(b) Flow injection creates a 'reverse thrust' which was found negligible compared to drag reduction.

(c) Maximum drag reduction occurs for an optimized Mach number.

(d) Fluid injection volume is <1% to the volume of the flow engulfing the body.

(e) Interaction of the heated gases and ambient air results in altered flow field.

Applications

Artillery projectiles, launch vehicles, missiles, hypersonic vehicles, supersonic systems will be greatly benefitted from the invention. Upon incorporation of the technique on the legacy and future missile systems the drag will be reduced immensely which will greatly increases the 'Thrust-Drag' characteristics of the system which would in turn result in the system accelerating to higher speeds. It is widely agreed that for the next generations of weapons to be effective in the future battlefields they need to be hypersonic. The invention will enable development of more capable boost-glide systems. For civilian launch vehicles, reduction in drag would result in same launch vehicle capable of carrying heavier payloads.

Future

The inventor is open for discussions and collaboration on implementation of the patent so that the country can be benefitted.

About the Author

Vikrant Sharma's career began as a Scientist at BrahMos Aerospace, where he played a pivotal role in the development of the world-renowned 'BrahMos' cruise missile. Over nine years, he was core team member and contributed significantly to the R&D, testing, and program management for various missile variants including the BrahMos-NG project. His expertise expanded to hypersonic weapons development. Uniquely, Vikrant pursued Flight Test Engineer training at the National Test Pilot School, USA, independent of government sponsorship, becoming the first Indian to achieve this distinction. Now an NTPS Instructor, he imparts the art and science of flight testing to future test pilots and engineers.

© SpaceX

The Growth of Air Connectivity in Northeast India

© Raju Srivastava

Dipalay Dey
Aviation Analyst

Air connectivity in the Northeast always finds a special mention in the success and failure chapters of India; it plays an essential role in uplifting the region because the Northeast's development is equivalent to India's development and further to the development of India’s Southeast Asia policy. We are all aware of the beauty of the Northeast. This region gives you multiple colors through its beautiful landscapes, like iridescence, a known phenomenon where certain surfaces gradually change color as the angle of view changes.

A decade ago, air connectivity in India's Northeast expanded slowly, with limited flights per week and limited airlines operating those routes. Talking very precisely, we saw a complete void regarding an air link to an essential state like Arunachal Pradesh. Although helicopters were there, fixed-wing civilian aircraft were missing, and even the helicopters were irregular.

The last time Northeast saw a revolution in the air was during the bygone Vayudoot era from the 1980s to 1990s and the 2003-2013 period of Alliance Air’s rapid connection era with their ATR 42-320s under the financial assistance from the North Eastern Council (NEC). After that, there was a long pause in the development; also, the end of Kingfisher Airlines in 2012 put a huge gap as the airline used to operate some monopoly and unique routes inherited from the erstwhile Air Deccan.

The U-Turn

Things took a U-turn post 2016, and today, a series of flights are taking off every hour and with the Government of India's UDAN initiative, almost all the cities of the Northeast are now connected with Guwahati and Kolkata and further to the national capital in Delhi and other metro cities in the country. UDAN broke all the barriers and limitations; it helped aviation to propel the region and become a bridge to strengthen the Government of India’s Act East Policy. The central Government is leaving no stone unturned to bring a change in the aviation sector. It allows all the people in the eight sister states to fly in an aircraft and see their valley from 10,000ft or above.

The region has started contributing considerably to India's tourism sector with its natural beauty. As per the government data, it is reported that 118.45 lakh domestic and 1.04 lakh foreign tourists visited the Northeast in 2022, and aviation plays a considerable role in this development. The data also stated that 16 airports were operationalized in the region under the UDAN scheme.

Flights in the Northeast are now available in all directions, be it Tezu to Imphal, Rupsi to Guwahati, Itanagar to Guwahati, Agartala to Dibrugarh, etc., which were earlier not even imagined. Reviving abandoned airports, building a new airport, and further collaborating with our defense forces to jointly operate civil enclaves are the three key reasons Northeast is blooming with flights. The refurbishment of Rupsi Airport in Assam, the construction of Donyi Polo Airport in Hollongi near Itanagar, and the start of flights from civil enclaves like Ziro are examples.

The Government's initiative to modernize the existing airports with upgraded facilities is another section where improvement is continuous. The construction of upcoming terminal buildings in Guwahati and Imphal and the recently inaugurated new terminal at Agartala are seen as a progressive step towards modernization. Plus, almost all the regional airports are upgrading through the extension of the existing terminal building, lengthening the runway and apron, or installing modern equipment to smoothen operations.

Flying Training School

While discussing the development of aviation in the Northeast, mentioning the existence of the Redbird Aviation Training School in Lilabari Airport of Assam's Lakhimpur district is mandatory. This flight training school is one of its kind for Northeast after the now defunct Assam Flying Club, which is also in talks of revival. A dedicated flight training school was missing in the region for a long time, which forced the talented AvGeeks from the area to leave their hometown and take flying training in other states. Today, with the Redbird School, students from various corners of the Northeast can come forward and pursue their dream of flying high in the sky.

© Redbird

The Expansion of Airlines

Right now, more than eight airlines operate flights across various regional airports, including fixed-wing and helicopter-operating airlines; among them, FlyBig and Alliance Air have also based aircraft in the Northeast for flying extensively in the area. Alliance Air's Dornier228, which is specifically tasked with connecting Arunachal Pradesh, proves to be a welcoming step in the growth of the state; with flights to Ziro, Itanagar, Tezu, and Pasighat, the Dornier228 is keeping itself busy, the entire week serving the people of the state. On the other hand, airlines like IndiGo, SpiceJet, Air India, and Air India Express also connect important routes that provide inter-state and inter-district flights.

A new upcoming regional airline, JettWings from Guwahati, is also getting included in the beautiful chapters of Northeast. The airline's claim to be the only airline with a complete root in the Northeast is well received among the AvGeeks and the media. We must remember that in the past, we have seen airlines from the Northeast like Northeast Shuttles, which began operations with full fun fare but lost all its glory with a short run and eventually collapsed; JettWings should consider a proper case study before flying solid and high as Northeast is not a static but a dynamic market.

Challenges

Apart from all the positivity around the Northeast, some severe challenges are pulling it back in many ways; prime among them is the absence of international flights and limitations in operating to many airports and also the absence of night flights to most of the airports.

International demand, especially for Southeast Asian countries from the Northeast, is immense. Lack of flights is forcing passengers to go to Kolkata or Delhi to catch a flight to destinations like Thailand, Malaysia and even Bangladesh. Earlier, Nok Air used to fly between Guwahati and Bangkok, but after operating for a short period, the service was withdrawn. Similarly, Guwahati to Dhaka by Spicejet was also terminated a few months after the inauguration. Only Bhutan's Druk Air remains the lone international airline to provide international flights from Guwahati to Paro and Singapore. Talks are going on for Agartala to Chittagong and Imphal to Mandalay flights, but all of these are a distant dream.

In a recent development, Thai Air Asia announced flights from Bangkok to Guwahati in December, and it will be interesting to see the updates across it as this might be a pivotal factor to open the potential and could become a boon for Northeast's international aspiration.

© Aeroconcepts by Alaqmar

The region's geography is another barrier to operating flawless flights; airports like Pakyong in Sikkim are prime to suffer due to the challenging geography. Tabletop runways, hills in proximity, and rapid weather dives always hamper flight operations, especially during winters; the lone operator SpiceJet is restricted to operating only seasonal flights using their turboprop fleet.

The absence of night flights remains another factor where Northeast needs to improve itself. Its geography might have a role to play here as the sun sets early, and the terrains across it might make it challenging to operate, but if this issue is adequately addressed, Northeast can excel in many factors. Only Guwahati, Agartala, and Imphal see flight operations post-sunset; we can expect more flights if most of the airport becomes operational at night.

One more critical challenge is the failure of helicopter service to take off high in the Northeastern skies. Even after many years of advancement, a dedicated helicopter service in the region still needs to be added. Even though fixed-wing aircraft are operating successful routes to cities, remote districts and villages that don't have easy access to any means of road or air connectivity and whose distance from the serving airport is far away are struggling.

Transportation of organic agricultural products by air is another sector that needs to be improved. The Northeast is a hub for producing some of the finest organic fruits, but transportation to international and domestic markets could be better. Just like UDAN, the Government's Krishi UDAN scheme can play a vital role in doubling farmers' income and uplifting the remote villages' remotest. State Government and Central Government can come together to help spread and educate locals to take this benefit.

Overall, the growth of civil aviation in the region is tremendous, and yes, we are witnessing a golden period where options for flying are growing and helping to boost the area's tourism potential. If development goes the same way, then the Northeast will become one of the prime regions of India, which will heavily contribute to the country's economy, primarily through its natural organic land and tourism. The ongoing decade from 2020-2030 will be crucial for aviation in the Northeast, and we expect to see more and more flights flying in and out of the eight sister states.

About the Author

Dipalay Dey is from Assam and currently works for VSYNC Marketing Consultants Pvt. Ltd., a marketing firm based in Gurugram that provides various marketing solutions to airlines. The client list of VSYNC includes airlines like IndiGo, Akasa Air, AIX Connect, and the upcoming new regional airline FLY91.

Dipalay is known for his Plane spotting hobby, and other than spotting the metal birds in the air, he takes a keen interest in spotting and exploring the retired military warbirds or any other old aircraft that are preserved or kept on public display at various corners of the country.

His work on aviation photography, articles related to aviation, and handmade paper model ground handling equipment are published in various online and offline media papers, and he has also contributed columns for in-flight magazines.

You can connect with him through email or his social media accounts:
Twitter: @dipalay
Instagram: dipalay
Facebook: Dipalay Dey

© Raju Srivastava

© Airbus