



# *AIR POWER*

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## **AIR POWER**

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**Editor-in-Chief**

Air Marshal **Anil Chopra** PVSM AVSM VM VSM (Retd)

**Editor**

Dr **Manpreet Sethi**

**Distributor**

KW Publishers Pvt. Ltd.

All correspondence may be addressed to

Editor-in-Chief

AIR POWER

Arjan Path, Subroto Park, New Delhi 110 010

Telephone: (91.11) 25699131-32 Fax: (91.11) 25682533

e-mail: capsnetdroff@gmail.com

capsoffice@capsindia.org

website: www.capsindia.org

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## ➤ EDITOR'S NOTE

A more aggressive China and strong statements emanating from the US administration are creating conditions of a continued economic and geostrategic face-off. Analysts around the world are talking of possible military invasion of Taiwan by China. There are others who are worried of possible US compromise over Taiwan. It is far too soon to resign ourselves to such grim options. Liberal democracies must and can protect Taiwan. Meanwhile China has openly challenged Washington's role as global rule-setter. President Xi Jinping says they have taken multi-pronged measures to counter perceived efforts by a US-led "coalition of democracies" to contain China. People's Liberation Army (PLA) has increased the frequency of its "patrols" in the South China Sea (SCS) as well as air force and naval incursions into Taiwan's air defence identification zone and surrounding waters. Through regular incursions, China is conveying signals that it could invade Taiwan. Initially Taiwan was reacting by scrambling its aircraft, but subsequently changed its strategy by putting ground based air defence units on high alert to track the incoming aircraft. US currently has two aircraft carrier groups in the SCS, and US Navy ships are regularly exercising Freedom of Navigation Operations (FONOPS) in the region.

Formally adopted earlier this year on March 11, China's 14th Five-Year Plan marks a shift away from the quantitative growth-focus of Beijing's previous plans. Instead, it aims to usher in a more inward-looking "new developmental stage" that targets "quality development." The Chinese Communist Party (CCP) now believes that there is a need to engage in a global struggle for China's "image sovereignty". They now recognise that "the main battlefield for public opinion" is on the internet, and that requires

a specialised force. China, has created “internet commentators”, and trolls tasked to amplify content favourable to the CCP.

The Chinese leadership’s plan for China’s development from 2021 to 2025 prioritises what it calls the “internal cycle.” They aim to strengthen the domestic economy and consolidate social development. The goal is to cut as quickly as possible the reliance on foreign technology and dependence on imported resources, and to double down on existing plans for industrial modernisation and technological innovation. China’s long pursuit of “indigenous innovation” faced urgency when the US government cut off the supply of semiconductors to ZTE and then Huawei. Washington clearly demonstrated its ability and willingness to destroy leading Chinese tech companies.

China continues its Belt and Road Initiative, and forays into Africa. They have built a seaport in Kenya’s coastal island of Lamu that will be operational in June. But China is facing serious difficulties in Pakistan both for implementation and credit interest. Mismatch between Chinese expectations and Pakistan’s dithering actions on ground have contributed to relative unease in the ties. Very upsetting for China has been the recent uproar over the fencing issue in Gwadar.

China has been under international pressure on human rights in Xinjiang. China has integrated surveillance technologies as part of its strategy of preventive counterterrorism and what they call ‘de-extremisation’ through ideological and political re-education. Chinese consumers finally rallied around a state-media-backed campaign to boycott foreign fashion brands, including H&M, Nike, Adidas, Puma, for their avoidance of Xinjiang cotton due to forced labour allegations. Meanwhile, China is trying sinicisation of Tibet by gradually destroying local culture and introducing “Han” traditions.

Finally, America’s military is leaving Afghanistan in September 2021. Drawdown of the remaining forces will begin in May and “plan is to have all U.S. troops out of the country before the 20th anniversary of 9/11,” according to the White House. Currently there are 9,600 NATO troops and around 2,500 of them are American. NATO troops will also depart; but exactly how many

is unclear. Eliot A. Cohen of SAIS at Johns Hopkins University writes "This is not the end of the war; it is merely the end of its direct American phase."

As Russia and Ukraine forces amass around their borders, in pretext of military exercises, is American and NATO support to Ukraine adequate? Russia's military move is also a test of whether the US will protect its European allies against Russia, as promised, while the US is challenged by China in the South China Sea.

Russian Foreign Minister Sergey Lavrov's visit to India, in April, clarified issues related to the S-400 deliveries being on track. Most diplomatically, he did mention that Russia is concerned over Indo-Pacific alliance, the Quad, being an anti-China alliance. He suggested border disputes with China be resolved within BRICS or RIC meetings. His visit to Pakistan immediately after India did raise concerns in India, but he clarified that issues were mostly related to counterterrorism. Ground reality is that the two countries agreed to boost their relationship in area such as trade, counterterrorism, energy, and defence.

The US threat of invoking CAATSA against India in case of purchase of Russian S-400 system still continues. Many security analysts on both sides have opined that sanctioning India would jeopardise the Quad, and have recommended that the US let India buy its weapons from Moscow. The real strategic threat is Beijing. As the only Quad country that shares a land border with China, India's unique role within the group cannot be overstated. Media reports indicate that France, India and Australia could step up Quad-style cooperation, with China on the horizon. The three countries, are reportedly planning to increase their joint presence in the Indo-Pacific.

There are reports that China is preparing its Navy for a new carrier-launched variant of the J-31. The F-35 look alike doesn't have V/STOL capability. It is more likely be "fourth generation", though China refers to the new J-31 variant as being "comparable" to the US F-22 and Russian Su-57 stealth fighter jets.

Pakistan Air Force (PAF) successfully completed the multinational air exercise Aces Meet 2021-1 at PAF base Mushaf. The two-week long exercise

saw active participation from the Royal Saudi Air Force (RSAF) and the United States Air Force (USAF).

China and Russia have been watching US actions in Afghanistan. Both have problematic relations with Erdogan, and are concerned about Turkey's rise on the Afghan-Central Asian region. A Turkish court rejected China's request to extradite a Uyghur religious teacher. Russia seeks Pakistan's support for its Afghan peace initiative worried that the US and Turkey may beat Moscow to the geopolitical push. There is a move to promote Iran's membership of the Shanghai Cooperation Organisation. Meanwhile, Iran has said that it will enrich Uranium to 60 per cent, in effort to strengthen its hand in nuclear talks.

The US Seventh Fleet's announcement that they had asserted navigational rights and freedom near the Lakshadweep Islands, inside India's exclusive economic zone, without requesting India's prior consent, and that this was consistent with international law, irked India. India requires prior consent for military exercises or manoeuvres in its exclusive economic zone or continental shelf. It was bad timing for the Freedom of Navigation Operation (FONOP) amidst deepening maritime collaboration between India and the US and growing enthusiasm for the Quad. Was that a US way of signalling to China, some are wondering?

Meanwhile, we in CAPS had two major events in the last two months. There was a webinar on "Stock-check Nuclear Power: Ten Years after Fukushima" our annual national event on Nuclear Power held on March 19, 2021. High-level presentations were made by representatives of DAE and NPCIL, as well as our own scholars who have been examining the role of nuclear energy at the national and global level for many years. Over 70 participants showed a high level of engagement on the issue. Later, for two weeks starting April 5, CAPS conducted a Squadron Officer's Capsule for IAF's mid-level officers preparing to go for their staff course in India and abroad.

This issue of the journal covers a wide variety of subjects related to air power and military strategy. With rising China, Indo-Pacific is the theatre for all geo-strategic action. With China's threatening military moves against

Taiwan, questions are already being asked whether US will be able to defend an invasion of Taiwan. There is thus a need to understand the ground realities and "Strategic Balance in the Indo Pacific".

There is an article on "Electronic Warfare-Changing Operational Concepts". Exercising control over the electromagnetic and denying the use to the enemy is crucial in this high technology war era. EW supports command and control (C2). EW is an important component of anti-access/area denial (A2/AD) campaigns. The gambit includes communication radio frequencies; microwaves for tactical data-links, radars, and satellite communications; infrared for intelligence and targeting; and lasers. EW affects all military domains, land, air, sea, space, and cyberspace, and each of the military services has to have its own EW capabilities and programs.

There is an article on "Lessons for air power in Ladakh". As the Air Chief has said, "Over the past few months, the proactive deployment of our offensive capabilities in response to developments in eastern Ladakh, both in terms of deployment of air assets as well as rapid airlifting of army combat elements, demonstrated the IAF's operational readiness today." IAF had also learnt many lessons during the high altitude Kargil war, and these could be applied in Ladakh. IAF clearly has an edge in case of a localised war with ability to pump in much more missions from much more numbers of airbases.

Artificial Intelligence (AI) in military aviation shall provide enhanced air warfare capabilities such as target identification, designation and tracking, optimised attack manoeuvre and autonomous combat engagements. AI will greatly support the transition from fighter jets to autonomous Unmanned Combat Air Vehicles (UCAVs). As US and China compete over AI-enabled military hardware, AI technologies are being incorporated into autonomous drones, new generation missiles with autonomous targeting capabilities and autonomous robotic submarines.

*Atmanirbharta* is a national goal. Make-in-India must succeed for India to one day become a global power. The defence industry, both public and private, has IAF's backing and active support. India has had to adopt joint

venture route with some foreign defence technology giants. It seems to have worked. With success of LCA and ALH, Indian industry is at an inflection point. The way ahead is only up. This is covered in the article "Welcome Steps towards an Indigenously Equipped Indian Air Force".

Airlifts are becoming the lifeblood of military operations and HADR missions. This has been most recently demonstrated during the massive airlift of oxygen containers from across the globe, and within India to support the Covid pandemic relief operations. Over the years, improved aircraft capabilities and new techniques have turned airlift into much specialised operations.

While we in CAPS work tirelessly to create good academic quality content on air power and strategic subjects, it is always our endeavour to promote the habit of reading. Reading not only fuels the development of all aspects of language ability, but also brings clarity on various aspects of human life and its interactions. "Children are made readers on the laps of their parents" said Emilie Buchwald. We in CAPS put content in books and journals on your tables and also soft copies on your electronic devices. Books open new doors. For the strategic community, CAPS publications are a one stop place. We try to promote passion for reading.

Wishing you happy reading!



Air Marshal **Anil Chopra**  
Director General, CAPS

# STRATEGIC BALANCE IN THE INDO-PACIFIC

ANIL CHOPRA

Indo-Pacific is generally understood to be the region between the Indian Ocean and the Pacific Ocean or between the eastern coast of Africa and the western coast of the United States. The two oceans meet around Indonesia. The term was made prominent by Japan's Prime Minister Shinzo Abe, when in his speech to the Indian Parliament in August 2007,<sup>1</sup> he talked about the "confluence of the Indian and Pacific Oceans" as "the dynamic coupling" of "seas of freedom and of prosperity" in the "broader Asia". Prime Minister Narendra Modi later said, "Indo-Pacific is a region with 50 per cent of the world's population, and enormous diversity of religions, culture, languages, history and political and economic systems."<sup>2</sup> On the eve of the Shangri-La Dialogue at Singapore in June 2018, US Defence Secretary Jim Mattis renamed the US Pacific Command as the US Indo-Pacific Command. This was not an off-the-cuff remark but the culmination of a series of events that preceded the eventual declaration.<sup>3</sup>

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Air Marshal **Anil Chopra** PVSM AVSM VM VSM (Retd.) is Director General, Centre for Air Power Studies, New Delhi.

1. New Delhi Times Bureau, "Renaming US Pacific Command as Indo-Pacific: Implications for India", July 9, 2018, at <https://www.newdelhitimes.com/renaming-us-pacific-command-as-indo-pacific-implications-for-india/>. Accessed on March 23, 2021.
2. ANI, "Indo-Pacific region is our lifeline", says PM Modi, *Business Standard*, June 8, 2019, at [https://www.business-standard.com/article/news-ani/indo-pacific-region-is-our-lifeline-says-pm-modi-119060800814\\_1.html](https://www.business-standard.com/article/news-ani/indo-pacific-region-is-our-lifeline-says-pm-modi-119060800814_1.html). Accessed on March 6, 2021.
3. New Delhi Times Bureau, n. 1.

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#### **INDO-PACIFIC—THE TERM EVOLVES**

Since 2011, the term ‘Indo-Pacific’ has been used in global strategic/geopolitical dialogues. The German geopolitician Karl Haushofer first used the term in the 1920s. Many scholars have tried to highlight the economic and strategic influence between the two oceans. The security linkages between the two only evolved around the year 2000. The term was first used in an article authored by Gurpreet Khurana, which was published in the January 2007 issue of the *Strategic Analysis* journal titled “Security of Sea Lines: Prospects for India-Japan Cooperation”.<sup>4</sup> However, the term was first mentioned in an official document in Australia’s Defence White Paper, 2013.<sup>5</sup> Meanwhile, in the same year, US officials first started using the term ‘Indo-Pacific’ as a convenient way of describing the geographic inclusiveness.

The term got a more formal stamp when it was included in the joint statement issued by Indian Prime Minister Narendra Modi and American President Donald Trump during the former’s state visit to the White House on June 26, 2017.<sup>6</sup> The statement read, “As responsible stewards in the Indo-Pacific region, President Trump and Prime Minister Modi agreed that a close partnership between the United States and India is central to peace and stability in the region. The objectives include combating terrorist threats, promoting stability across the Indo-Pacific region, increasing free and fair trade, and strengthening energy linkages.”

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4. Gurpreet S. Khurana, “Security of Sea Lines: Prospects for India-Japan Cooperation”, *Strategic Analysis* (IDSA/Routledge), Vol. 31 (1), January 2007, pp. 139-153.
  5. Australian Government, Department of Defence, Defence White Paper 2013, p. 7, at [https://www.defence.gov.au/Whitepaper/2013/docs/WP\\_2013\\_web.pdf](https://www.defence.gov.au/Whitepaper/2013/docs/WP_2013_web.pdf). Accessed on March 20, 2021.
  6. White House Foreign Policy Briefing, United States and India: Prosperity Through Partnership, June 26, 2017, at <https://www.whitehouse.gov/briefings-statements/united-states-india-prosperity-partnership/>. Accessed on March 20, 2021.

**POWER SHIFTS IN THE INDO-PACIFIC**

The Australian Government's Foreign Policy White Paper of 2017 indicated that economic growth in Asia was going to be the primary factor shaping the strategic landscape in the Indo-Pacific.<sup>7</sup> It also expressed the concern that China's influence was growing in the Indo-Pacific region. Ultimately, how the Indo-Pacific will shape will depend not only on the other regional powers, Japan, Australia and India but also significant Southeast Asian states, such as Vietnam and Indonesia.

China became the world's largest trading nation of goods in 2013,<sup>8</sup> and the world's largest economy in purchasing-power-parity terms in 2014. With that, the relationship between China and the world began changing. It became a major trade partner for many countries and began lending heavily, supporting infrastructure projects. China also increased its spending on defence, especially for maritime and air assets that would give it global reach.

China's regional forays are for its own geopolitical interests, especially so in the increasingly contested Indo-Pacific.<sup>9</sup> Meanwhile, the United States will, for the foreseeable future, remain the wealthiest nation and have the most powerful military.

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7. 2017 Foreign Policy White Paper, Australian Government, pp. 28 and 40, at [https://www.globalsecurity.org/military/library/report/2017/australia\\_2017\\_foreign\\_policy\\_white\\_paper.pdf](https://www.globalsecurity.org/military/library/report/2017/australia_2017_foreign_policy_white_paper.pdf). Accessed on March 20, 2021.

8. Jonathan Woetzel, Jeongmin Seong, Nick Leung, Joe Ngai, James Manyika, Anu Madgavkar, Susan Lund and Andrey Mironenko. "China and the world: Inside the dynamics of a changing relationship", (In Brief) McKinsey Global Institute. July 2019, at <https://www.mckinsey.com/~/media/mckinsey/featured%20insights/china/china%20and%20the%20world%20inside%20the%20dynamics%20of%20a%20changing%20relationship/mgi-china-and-the-world-full-report-june-2019-vf.ashx>. Accessed on March 7, 2021.

9. Bloomberg, "Australia warns of Asia power shift to China if US withdraws from region", *Financial Express*, November 23, 2017, at <https://www.financialexpress.com/world-news/australia-warns-of-asia-power-shift-to-china-if-us-withdraws-from-region/944865/>. Accessed on March 7, 2021.

With a rising and more competitive China, United States' focus has shifted to the security of the Indo-Pacific region.<sup>10</sup> Japan, the Republic of Korea and Australia remain its strong allies. The US is also conscious that major economic and military powers like India and Japan can now play a greater role of balancing in the Indo-Pacific. There are a large number of well identified ongoing maritime and land border disputes. The contested boundary claims are posing challenges to freedom of navigation in the seas, and perceived air violations.

### INDIA AND THE INDO-PACIFIC BALANCE OF POWER

Nitin Pai, Director, Takshashila Institution, says that “ultimately, India’s most important role in the Indo-Pacific is to be a more successful form of itself: demonstrating that strong economic growth can be achieved within a diverse, plural, liberal democracy.”<sup>11</sup> As China bridges the power gap with the United States, India, even though a few notches below, is becoming a balancing power with regional influence. Yet the Indian government is treading with caution and prefers strategic autonomy, and maintaining balanced distance, with issue-based stands. India has had a strategic partnership with the United States since the early 2000s. India also shares the stage with China in the BRICS. It is part of Chinese-led SCO and the Asia Infrastructure Investment Bank (AIIB). India-US nuclear agreement of 2005 and the grant of waiver to India by the Nuclear Suppliers Group flowed from US strategic inclination to strengthen India as a bulwark against China. Meanwhile, China’s assertive behaviour and its strong strategic alignment with Pakistan, has pushed India to seek closer alliance with the United States.

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10. “A Free and Open Indo-Pacific Advancing a Shared Vision”, US State Department Document, November 4, 2019, at <https://www.state.gov/wp-content/uploads/2019/11/Free-and-Open-Indo-Pacific-4Nov2019.pdf>. Accessed on March 20, 2021.

11. Nitin Pai, “India and the Indo-Pacific Balance of Power”, *Indian National Interest*, August 1, 2017, at <https://nationalinterest.in/india-and-the-indo-pacific-balance-of-power-1814c5a5f6a1>. Accessed on March 9, 2021.

## **INDIA'S LOOK EAST POLICY**

India's Look East Policy is a strategic initiative to cultivate and strengthen economic and strategic relations with the nations of Southeast Asia.<sup>12</sup> It will help India counter Chinese strategic influence in the region. According to former Indian Ambassador Rajiv Sikri, "India missed a crucial opportunity during this period to leverage India's shared colonial experience, cultural affinities and lack of historical baggage to build strong economic and strategic relations with Southeast Asia."<sup>13</sup>

Now once again, after a military coup, and in the eye of a storm, Myanmar remains India's main passage to Southeast Asia. India has many one-on-one free-trade agreements with its South Asian neighbours. The multilateral ones include the 2006 South Asia Free Trade Agreement, and the 2010 ASEAN-India Free Trade Area (AIFTA).

The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) and the South Asian Association for Regional Cooperation (SAARC) are also important groupings. The India-Myanmar-Thailand Trilateral Highway will connect Moreh, India with Mae Sot, Thailand via Myanmar. There are plans to extend this route to Laos, Cambodia and Vietnam. Bangladesh is also now keen to join it. The Kaladan project will connect Kolkata port with Sittwe Port in Myanmar by sea. This port will further be linked by road to India's Mizoram. Thus, India will get well connected to its traditional maritime friends on either side of the Malacca Straits. This should somewhat reduce Chinese dominance.

## **BELT AND ROAD INITIATIVE—INDIAN CONCERNS**

India rightly fears that China's BRI is essentially a Chinese Belt and Chinese Road. India's relatively poor neighbours are attracted by low-cost Chinese financing and technical assistance for better connectivity. But, as has happened in Pakistan and Sri Lanka—among others—countries get into a

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12. Jacob Goldberg, "What Is India's Look East Policy?", ThoughtCo.com. Updated November 12, 2019, at <https://www.thoughtco.com/look-east-policy-of-india-1435050>. Accessed on March 2, 2021.

13. Anna Louise Strachan, Harnit Kaur Kang, Tuli Sinha and Rajiv Sikri, "Report. Institute of Peace and Conflict Studies, 2009", at [www.jstor.org/stable/resrep09289](http://www.jstor.org/stable/resrep09289). Accessed on March 31, 2020.

debt trap, having to cede land access to China. Such behaviour and presence of China is to the detriment of India's geostrategic interests in the region. India is concerned that Chinese investments in infrastructure development in different regions have more than just a commercial angle.<sup>14</sup> Some of this often turns into a debt trap, as has happened in the past when China has ended up seeking strategic assets in exchange for debt waiver.

### INDIA'S BALANCING ACT

India is concerned about excessive Chinese dominance of the Indo-Pacific region. In a major foreign policy speech at the Shangri-La Dialogue in June 2018, Prime Minister Narendra Modi repeatedly invoked the principle of equality of all nations. "We see the assertion of power over recourse to international norms," he said, and called for a "common rules-based order for the region ... that must apply to all ... based on sovereignty and territorial integrity."<sup>15</sup>

Most of China's other neighbours are also concerned about China's bulldozer approach and hegemony. Although Prime Minister Modi declared that "India does not see the Indo-Pacific as a strategy", the ground reality seems to indicate something different.<sup>16</sup> While India's 'Look East' and 'Act East' may formally be aimed at closer cooperation with ASEAN economies, countering China is clearly an implicit aim.

### INDIA'S EMERGING ROLE IN INDO-PACIFIC

India has become part of the Indo-Pacific geostrategic system through joint military exercises, patrolling, port calls, anti-piracy missions and humanitarian missions.<sup>17</sup> Indian Navy warships are increasingly sailing east of Malacca. India's reluctance to participate in multilateral military exercises has been shed. India and Japan are moving closer in economic partnership.

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14. Nitin Pai, n. 11.

15. Rajesh Rajagopalan, "Evasive balancing: India's unviable Indo-Pacific strategy", *International Affairs*, vol. 96, issue 1, January 2020, pp. 75-93, at <https://academic.oup.com/ia/article/96/1/75/5697517>. Accessed on March 23, 2021.

16. Ibid.

17. Nitin Pai, n. 11.

ASEAN nations have their own issues with China and some may hesitate to antagonise Beijing, preferring to do a fine balancing act. Ultimately, what will count for India is its own economic and military strength for standing and influence in the region.

### **INDIA'S EAST ASIAN CONNECT**

In 1993, India befriended Myanmar's military junta and signed trade agreements. New Delhi is involved in construction of major roads and highways, pipelines and upgrading of ports. Despite Myanmar's close links with China, India is supporting Myanmar by training its military personnel, and cooperating on controlling cross-border separatist militant movements and drug trafficking. India is concerned about China constructing naval and surveillance facilities along Myanmar's coast and the Coco Islands. In response, India has stepped up its own development of facilities in Andaman and Nicobar Islands.

India today has strong commercial, cultural and military relations with Singapore, Vietnam, Cambodia and the Philippines. Sri Lanka and Thailand cooperate closely with India. China's hegemony in the region, its historic animosity and distrust of Japan, its dispute with Japan over island territories, serious territorial water disputes in South China Sea, and frequent border incursions into India have brought Japan and India closer, culminating in the 2008 Joint Declaration on Security Cooperation between Japan and India. The two countries upgraded their bilateral relationship to "Special Strategic and Global Partnership". Japan and India now conduct "2+2" meetings, the annual "Defense Ministerial Dialogue" and "Coast Guard-to-Coast Guard dialogue". In September 2020, the two sides signed the Acquisition and Cross-Servicing Agreement (ACSA) that will permit armed forces of both sides to coordinate closely in services and supplies. Earlier they had signed the Transfer of Defence Equipment and Technology Agreement 2015; Security Measures for the Protection of Classified Military Information (2015); and Cooperation in the Peaceful Uses of Nuclear Energy. Maritime, cybersecurity, military intelligence are areas of common interest. These engagements will

**Japan openly supported India on Doklam. Other south-eastern nations, including Vietnam, watched the reactions of the two sides closely. India's firm stand and mature restraint enhanced Delhi's position as an emerging power.**

be incomplete if the two armed forces don't regularly take part in joint exercises.

While India remains a supporter of the "One China" policy, it has increased its engagement with Taiwan over a common emphasis on democracy, human rights and strategic interests. India has a tri-service Andaman and Nicobar Command, and there is a fresh push for security infrastructure development. India and Singapore have been conducting joint naval exercises (SIMBEX) since 1993. Maritime exercises with Vietnam have been going on

since 2000. The Indian Navy has also carried out joint patrols with Indonesia in the Andaman Sea since 2002.

#### **INDIA-CHINA STAND-OFFS**

The 2017 Doklam border stand-off was caused when China constructed a road in Doklam near the tri-junction border area. After nearly 75 days, both sides withdrew their troops. This stand-off—closely watched by Asian countries—has shown that China's expansionist ambitions are not unstoppable.<sup>18</sup> Japan openly supported India on Doklam. Other south-eastern nations, including Vietnam, watched the reactions of the two sides closely. India's firm stand and mature restraint enhanced Delhi's position as an emerging power. During Chinese Foreign Minister Wang Yi's visit to India in December 2017, he said that, despite the Doklam dispute which had complicated the relationship, China and India have far greater shared strategic interests than differences.<sup>19</sup>

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18. Dipanjan Roy Chaudhury, "India's geopolitical status goes up after Doklam standoff ends", *Economic Times*, July 13, 2018, at <https://economictimes.indiatimes.com/news/defence/indias-geopolitical-status-goes-up-after-doklam-standoff-ends/articleshow/60282585.cms?from=mdr>. Accessed on March 6, 2021.

19. Bharath Gopalaswamy and Aditya Ramachandran, "The Shifting Balance of Power in the Indo-Pacific", December 19, 2017, at <https://www.chinausfocus.com/peace-security/the-shifting-balance-of-power-in-the-indo-pacific>. Accessed on March 31, 2021.

Another stand-off between India and China began around the north and south banks of Pangong Tso in Eastern Ladakh in May 2020. Chinese troops crossed the LAC in four areas. There was a major transgression in Galwan Valley, which became the site of a major altercation between Indian and Chinese troops on June 15, 2020, in which 20 Indian soldiers and an undeclared number of Chinese troops were killed. Meanwhile, the Indian forces gained strategic advantage in the south bank of the lake in late August 2020 by occupying certain heights of the Magar Hill, Mukhpari, Gurung Hill, Rezang La and Rechin La. Both sides had around 50,000 troops in the region. These were supported by a large number of tanks, artillery and air defence assets. The air forces of both sides had moved to forward locations and were carrying out regular patrolling and ISR missions. Transport and helicopters were carrying out logistic support missions. After repeated rounds of talks at the levels of military commanders and diplomatic officials, the stand-off between China and India in Ladakh resulted in a mutually acceptable disengagement agreement in February 2021. China was once again made aware of India's resolve to protect its sovereignty.

**China's rise is a direct challenge to US global dominance and position. The United States is trying to counter this rise by building its own strength through alliances in the region.**

### **TRANS-PACIFIC PARTNERSHIP (TPP)**

The Trans-Pacific Partnership<sup>20</sup> was a proposed trade agreement between Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, Vietnam, and the United States signed on February 4, 2016. It was not ratified, so it did not come into effect. USA withdrew from TPP in January 2017. The remaining countries negotiated a new trade

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20. James McBride and Andrew Chatzky, "What is the Trans-Pacific Partnership (TPP)?", Council on Foreign Relations, January 4, 2019, at <https://www.cfr.org/background/what-trans-pacific-partnership-tpp>. Accessed on March 3, 2021.

agreement called “Comprehensive and Progressive Agreement for Trans-Pacific Partnership”, which incorporates most of the provisions of the TPP and which entered into force on December 30, 2018. It was felt that the deal would have reduced their dependence on China and brought them closer to the US. After all, the TPP agreement was part of President Obama’s Pivot to Asia foreign policy. Meanwhile, China continued to enter into trade deals with key nations in the region, demonstrating a serious decline in American hard and soft regional power.

### **QUADRILATERAL SECURITY DIALOGUE (QUAD)**

China’s rise is a direct challenge to US global dominance and position. The United States is trying to counter this rise by building its own strength through alliances in the region. China’s threat is not only to the US, but also to democratic Taiwan, South Korea, Japan and many South East Asian nations. It is also a threat to India. Any balancing by the US will also support Japan, Australia and India vis-à-vis China.<sup>21</sup> India is considered an important counterbalance to China. Japan and India together have significant economic and military power.

The Quad began as an informal strategic dialogue between the US, Japan, Australia and India initiated by Japanese Prime Minister Shinzo Abe in 2007. The joint military exercise Malabar followed. The Chinese government issued a formal diplomatic protest to its members. The significance of Quad increased after the tensions caused by Chinese territorial ambitions in the SCS. After the meeting of Quad Foreign Ministers in September 2019, the US Acting Assistant Secretary for the Bureau of South and Central Asian Affairs, Alice Wells, spoke to media in New York:<sup>22</sup> “a wide-ranging discussion of our collective efforts to advance a free and open Indo-Pacific, but also touching on counterterrorism,

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21. David Scott, “The Indo-Pacific in US Strategy: Responding to Power Shifts”, *Rising Powers Quarterly*, vol. 3, issue 2, August 2018, p. 20, at [https://pdfs.semanticscholar.org/8891/ee0e0197b4bccebcae4e5684815124ba2fd5.pdf?\\_ga=2.2697648.1605024220.1585743187-1699218414.1583153731](https://pdfs.semanticscholar.org/8891/ee0e0197b4bccebcae4e5684815124ba2fd5.pdf?_ga=2.2697648.1605024220.1585743187-1699218414.1583153731). Accessed on March 7, 2021.

22. Dipanjan Roy Chaudhury, “India’s fine balancing act with Quad and BRICS meet in New York”, *Economic Times*, September 28, 2019.

humanitarian assistance and disaster relief, maritime security cooperation, development finance, and cyber-security.”

### **US-INDIAN MILITARY COOPERATION**

Active US-Indian military cooperation expanded in 1991 following India’s economic liberalisation when the US proposed army-to-army cooperation. A “New Framework for India-US Defence” was signed in 2005. It envisaged increased military, defence industry and technology cooperation. Also, a “Framework on Maritime Security Cooperation” was signed. India and the United States have been participating in regular joint military exercises since then. These include Cope-India (Air Force), Yudh Abhyas (Army) and Vajra Prahar (Special Forces). The two sides are increasingly engaged in multilateral exercises, such as the Malabar, Red Flag, and RIMPAC, covering the broad expanse of the Indo-Pacific.<sup>23</sup>

The US has four “foundational” agreements that it usually signs with its defence partners. India signed the General Security of Military Information Agreement (GSOMIA) in 2002. The agreement enables the sharing of military intelligence between the two countries. The Logistics Exchange Memorandum of Agreement (LEMOA), that permits either side’s military to use the other’s bases for resupplying or carrying out repairs was signed in August 2016. The Communications Compatibility and Security Agreement (COMCASA) was signed during the inaugural 2+2 dialogue in September 2018. It is an India-specific variant of Communications and Information Security Memorandum of Agreement (CISMOA) that enables the two countries to share secure communication and exchange information on approved equipment during bilateral and multinational training exercises and operations. The Basic Exchange and Cooperation Agreement (BECA) was signed in October 2020, and this permits the exchange of unclassified and controlled geospatial products, topographical, nautical, and aeronautical data, products and services.

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23. Amb. Sujan R. Chinoy, “Indo-US Defence Partnership: Future Prospects”, Manohar Parrikar Institute for Defence Studies and Analyses, New Delhi, June 26, 2019, at <https://idsa.in/idsacomments/indo-us-defence-partnership-srchinoy-260620>. Accessed on March 31, 2021.

Harsh V. Pant, Professor of International Relations at King's College, London, has highlighted the importance of India to US strategic planning: "India is key to the US' ability to create a stable balance of power in the larger Indo-Pacific and at a time of resource constraints, it needs partners like India to shore up its sagging credibility in the region in face of Chinese onslaught."<sup>24</sup> The US opened up high-technology defence exports to India, in many cases giving it the same status as its NATO allies. Since 2008, India has purchased the P-8I maritime patrol aircraft, the C-17 and C-130 aircraft, the Chinook and Apache helicopters, M777 Howitzers, and more recently the National Advanced Surface-to-Air Missile System (NASAMS), version II, multilayered air defence shield and 24 MH-60 Sikorsky Romeo multirole helicopters. Currently two Sea Guardian Predator drones are on lease to the Indian Navy. This is considered a prelude to a larger order for the three Armed Forces.

#### **UNITED STATES INDO-PACIFIC COMMAND (INDOPACOM)**

INDOPACOM is the oldest and largest of the unified combatant commands of USA. It covers 260,000,000 sq km, or roughly 52 per cent of the Earth's surface, stretching from the West Coast of the USA to the West Coast of India, and from the Arctic to the Antarctic.<sup>25</sup> It includes a sizeable strength of all US military components, and the US Forces in Japan and South Korea. Originally called the Pacific Command (PACOM), it was renamed US Indo-Pacific Command in May 2018 to cover the Indian Ocean. With headquarters at Hawaii, its area now stretches from San Diego to Diego Garcia. Traditionally, the Commander has always been from the US Navy.

PACAF is the air component command. PACAF has seen combat in the Korean and Vietnam Wars, Operations Desert Storm, Enduring Freedom and Iraqi Freedom, among others. PACAF operates nearly 375 aircraft from nine main airbases in Japan, South Korea, Alaska, Pearl Harbour, and Guam. The US Navy's Pacific Fleet operates nearly 200 ships, five aircraft carrier groups, and nearly 1,100 aircraft.

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24. "India-UnitedStatesrelations", Wikipedia, at [https://en.wikipedia.org/wiki/India%E2%80%93United\\_States\\_relations](https://en.wikipedia.org/wiki/India%E2%80%93United_States_relations)

25. Ibid.

### **US PACIFIC DETERRENCE INITIATIVE<sup>26</sup> (PDI)**

The US Indo-Pacific Command's US\$ 20 billion wish list—to be allotted over 6 years—to deter China has been presented to the US Congress. This includes funding a defensive ring around Guam with an increased stockpile of long-range weapons. The strategy is to regain the advantage. Pacific Deterrence Initiative (PDI) would focus on China. It is also meant to be a message of US commitment to their Asian friends, and sends a strong signal to China that the US is committed to a free and open Indo-Pacific. The PDI will be more focused on Navy and Air Force needs. It will include strengthening allies and partners. There is a need to build land-based anti-ship and anti-air capabilities along the first island chain, and integrated air missile defence in the second island chain.

### **OTHER REGIONAL ASSETS OF USA**

Guam sits in the “second island chain”, which runs from Japan's Bonin Island, and is considered the US “tip of the spear”. Its deep-water facilities enable it to handle aircraft carriers, and its long airstrip at Andersen airbase is able to house heavy strategic B-52 bombers. Guam hosted the US, Japan and India during the June 2018 trilateral Malabar exercises.<sup>27</sup> The US has a significant presence in Japan, with a carrier group at Yokosuka and Ryukyu chain of islands, just off Taiwan. Taiwan and Japan make a great strategic combination in the vicinity of China. The US has basing facilities at Palawan in the Philippines facing the South China Sea. The US also has berthing facilities at Da Nang in Vietnam. Indonesian and US air forces have conducted the Cope West exercises every year since 2012. Indonesia has been described as

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26. Aaron Mehta, “Inside US Indo-Pacific Command's \$20 billion wish list to deter China—and why Congress may approve it”, April 2, 2020, at [https://www.defensenews.com/global/asia-pacific/2020/04/02/inside-us-indo-pacific-commands-20-billion-wish-list-to-deter-china-and-why-congress-may-approve-it/?utm\\_source=Sailthru&utm\\_medium=email&utm\\_campaign=Breaking%20News%2004.02.20&utm\\_term=Editorial%20-%20Breaking%20News](https://www.defensenews.com/global/asia-pacific/2020/04/02/inside-us-indo-pacific-commands-20-billion-wish-list-to-deter-china-and-why-congress-may-approve-it/?utm_source=Sailthru&utm_medium=email&utm_campaign=Breaking%20News%2004.02.20&utm_term=Editorial%20-%20Breaking%20News). Accessed on March 4, 2021.

27. David Scott, “The Indo-Pacific in US Strategy: Responding to Power Shifts”, *Rising Powers Quarterly*, vol. 3, issue 2, August 2018, pp. 21-29, at [https://pdfs.semanticscholar.org/8891/ee0e0197b4bccebae4e5684815124ba2fd5.pdf?\\_ga=2.2697648.1605024220.1585743187-1699218414.1583153731](https://pdfs.semanticscholar.org/8891/ee0e0197b4bccebae4e5684815124ba2fd5.pdf?_ga=2.2697648.1605024220.1585743187-1699218414.1583153731). Accessed on March 25, 2021.

**The JSDF has its focus on China. It has had active military interaction and participation with South Korea, Taiwan, Australia, Singapore and India. The USA and UK have been long-term partners. The Japanese Air Force carries out combat air patrols around Japan, and maintains a network of ground and air early-warning radars.**

“a geographic and diplomatic fulcrum for the Indo-Pacific region.”<sup>28</sup>

The US has defence links with Singapore<sup>29</sup> established since 2005, which were further strengthened in 2015, with special aircraft carrier berthing facilities, and regular aircraft deployments in Singapore. The US has a Marine Rotational Force at Darwin in Australia since November 2011.<sup>30</sup> The UK atoll of Diego Garcia has a major US base since 1977. This gives it a major foothold in the Indian Ocean.

#### **OTHER US FRIENDLY MAJOR AIR FORCES**

The Japan Self-Defense Forces (JSDF) is the unified military force of Japan. It has inducted the latest hardware, including F-35As. The JSDF has its focus on China. It has had active military interaction and participation with South Korea, Taiwan, Australia, Singapore and India. The US and UK have been long-term partners. The Japanese Air Force carries out combat air patrols around Japan, and maintains a network of ground and air early-warning radars. It is estimated to have around 750 aircraft, approximately 375 of them fighter aircraft, such as the Mitsubishi F-2 (based on the F-16), F-15 Eagle, and F-35 Lightning II. Japan operates Boeing E-767 and E-2 Hawkeye AEW&C aircraft, and flight refuelling aircraft. The Royal Australian Air Force has 259 aircraft, of which 110 are combat aircraft, such as F-18 variants, and F-35A Lightning II. They also have P8A Poseidon, C 130J Hercules, C-17A Globemaster III and KC-30A MRTT, among others. The Vietnam People’s Air Force has nearly 300 aircraft, including Sukhoi Su-22, Su-27, and Su-30.

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28. Ibid.

29. Ibid.

30. Ibid.

## RIMPAC

Hawaii based RIMPAC (Rim of the Pacific) Exercise is the world's largest international maritime warfare exercise held every even-numbered year. Hosted by the US Navy, Australia, Canada, New Zealand and the UK participate in it. Chile, Colombia, France, Indonesia, Japan, Malaysia, the Netherlands, Peru, Singapore, South Korea and Thailand have been regular participants. The New Zealand navy is frequently involved. Observer nations are usually invited. These have included China, Ecuador, India, Mexico, the Philippines and Russia.

**Amidst all the volatility in global power equations, India's most important partner, currently, is Japan. Both have been challenged by Chinese territorial claims. India and Japan want to neutralise Chinese forays in the Indian Ocean region through mutual economic assistance.**

## NATIONAL SECURITY STRATEGY OF THE UNITED STATES

The US released its national security strategy in December 2017. It included a specific section on "The Indo-Pacific"<sup>31</sup> that cautioned that "geopolitical competition between free and repressive visions of world order is taking place in the Indo-Pacific region, which stretches from the west coast of India to the western shores of the United States" in which "China seeks to displace the United States in the Indo-Pacific region", but for which "the United States must marshal the will and capabilities to compete and prevent unfavourable shifts in the Indo-Pacific." This was to be achieved through forward deployment of US forces. The Quad nations were expected to participate. Bilateral arrangements were to be made with Indonesia, Singapore and Vietnam. Similarly, the 2018 National Defense Strategy<sup>32</sup> talked of strengthening alliances and attracting new partners.

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31. Ibid.

32. "Summary of National Defense Strategy 2018", US Department of Defense, at <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>. Accessed on March 3, 2021.

### **JAPAN, INDIA'S KEY STRATEGIC PARTNER<sup>33</sup>**

Amidst all the volatility in global power equations, India's most important partner, currently, is Japan. Both have been challenged by Chinese territorial claims. India and Japan want to neutralise Chinese forays in the Indian Ocean region through mutual economic assistance. They are working jointly on development projects with countries in the Indian Ocean region so as to reduce their dependence on China. China has vast resources and these can be only jointly balanced by Japan and India.

### **RCEP AND CPTPP**

Regional Comprehensive Economic Partnership (RCEP) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) are two major strategic economic alignments in the Indo-Pacific. Both groupings have ASEAN as a vital component. All ten ASEAN members are part of RCEP. Singapore, Malaysia, Vietnam and Brunei are also part of the Canada-led CPTPP. India, though eligible for RCEP membership, has opted out currently because it perceives that China will dominate RCEP. Instead, India has opted for bilateral trade pacts with similar arrangements with most participants.

### **BALANCING CHINA—GROUND REALITIES<sup>34</sup>**

China's neighbours "are certain to fear its rise" and "will do whatever they can to prevent it from achieving regional hegemony", including joining "an American-led balancing coalition to check China's rise." While remaining diplomatically and economically engaged with it, they are seeking to preserve their security and sovereignty too. Most, including those who have lost territory or rights in the South China Sea, want to remain equidistant from opposing Superpowers, and distance themselves from military

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33. G. Parthasarathy, "Emerging balance of power in Asia", *The Hindu Business Line*, November 28, 2018, at <https://www.thehindubusinessline.com/opinion/columns/g-parthasarathy/emerging-balance-of-power-in-asia/article25616068.ece>. Accessed on March 31, 2021.

34. Jeff Smith, "China's Rise and Balancing in the Indo-Pacific", The Heritage Foundation, January 9, 2019, at <https://www.heritage.org/asia/commentary/chinas-rise-and-under-balancing-the-indo-pacific-putting-realist-theory-the-test>. Accessed on March 7, 2021.

alliances, exercises, or even naval patrols. Even the members of the “Quad” have reservations about a Cold War-style containment strategy.

Most of China’s neighbours prefer a balancing approach. Regional defence collaboration is mostly limited to multilateral dialogues and joint vision statements. China has pushed Quad members together by heightening concerns about its challenges to the rules-based order, as in South China Sea. This is despite the fact that China is the largest trading partner for all four Quad countries too. Countries like Pakistan, Cambodia and Laos are actually increasing their dependency on China and letting it make security and economic inroads. ASEAN states prefer to be neutral, and hope that international system of justice will prevail and support them in time of crisis or conflict. China is conscious of the economic globalisation and dependence of these nations and exploits the situation to its advantage.

While Beijing freely disregards laws, norms, and international opinion on South China Sea, it has ensured that ASEAN does not form a consensus to oppose it. Most Chinese neighbours, other than Taiwan, don’t fear a kinetic action or Chinese-funded insurgencies. They believe China poses a threat to their interests, autonomy, and grey-zone coercion designed to induce submission. Vietnam and Indonesia could take a somewhat independent line and are possible contenders to come closer to Quad. Some ASEAN member states are concerned that Quad will leave ASEAN out in the cold. Even Quad members advocate defence collaboration privately at a bilateral level. Currently the US is publicly attacking China on human rights, intellectual theft and economic protectionism.

### **CHINA’S RESPONSE TO THE INDO-PACIFIC CONCEPT**

China is fully aware of the United States’ Indo-Pacific strategy. It is factoring this in its geostrategic plans. The Chinese academic community has debated its possible impact on the future of US-China relations.<sup>35</sup> Clearly, the concept and target are to contain rising China and maintain

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35. Dingding Chen, “Chinese scholars see the free and open Indo-Pacific strategy as containment, but aren’t convinced it’ll stick”, *The Diplomat*, April 27, 2018, at <https://thediplomat.com/2018/05/what-china-thinks-of-the-indo-pacific-strategy/>. Accessed on March 30, 2021.

US global leadership. Meanwhile, China has invested heavily to buy friends, has added many ports, and increased sailings in parts of the Indian Ocean.

### **CHALLENGES AND OPTIONS FOR INDIA**

Rajesh Rajagopalan, Professor of International Politics at Jawaharlal Nehru University in New Delhi, has looked at India's strategic choices.<sup>36</sup> He says,

China is a direct military threat to India, particularly in light of the two countries' border disputes. Though India has considerable military power, China's forces are already stronger and better-funded, and Beijing's outsized wealth will likely allow it to outspend New Delhi for the foreseeable future. Beijing's influence in both established international organizations like the United Nations and in new institutions China is setting up, such as the Asian Infrastructure Investment Bank, gives Beijing opportunities to hamper Indian interests and goals in multilateral forums. China's alignment with Pakistan and deepening relations with other South Asian countries represents a significant challenge to India's position in the region, which otherwise New Delhi had dominated for decades. Beijing's ability to provide financial assistance and balance against New Delhi may tempt India's smaller neighbors to play one power against the other, undermining India in its own backyard. China's economic power allows Beijing to spread its influence around the world, which could be used to India's detriment.

China is clear. It wants to be the only major power in Asia. It wants to call the shots. Asia is its area of influence. It sees India as a challenger. And is trying to hem India in by making strategic friends among India's neighbours. At the very least, it is trying to bring them in its sphere of influence. Some smaller states are playing China against India for short-term gains.

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36. Rajesh Rajagopalan, "India's Strategic Choices: China and the Balance of Power in Asia", Carnegie India, September 14, 2017, at <https://carnegieindia.org/2017/09/14/india-s-strategic-choices-china-and-balance-of-power-in-asia-pub-73108>. Accessed on March 23, 2021.

Every country has to decide and secure its own interests. India has many options to choose from. It can stay non-aligned; be part of regional alliances; align with the United States; align with Russia or China, or both; or opt for issue-based alignments. In all cases, India must build its economic and military strength to be able to have bargaining power or dictating strength. The non-alignment that existed during the initial years of the Cold War is no more relevant. Relations with China are going to remain troubled in the foreseeable future due to serious boundary issues, competing regional interests, and diametrically opposite political approaches of authoritarian communism vs democracy. Russia is a declining power with a not-so-great state of economy. Russia will have to play second fiddle to China in its own strategic relations. India and Russia have historic relations. Nearly 60 per cent of India's defence hardware continues to be of Russian origin. More is still being acquired. The Soviet Union, Russia's predecessor, was of great support to India during the 1971 war. This umbilical cord will have to stay. Yet, close Russia-China relations will not help India to counter China. A closer alignment with Washington or a US-led grouping can be of interest to India. India should preferably align with free-world democracies. India and the US both have an interest in containing China. The US is the only country with state-of-the-art military technologies which will be crucial for India. It is the only power that is stronger than China. A US-led grouping of strong economies in the region would easily counterbalance China.

During the recent Ladakh showdown between India and China, some of the western countries like France and Israel supported India with defence hardware. The US, reportedly, continuously provided intelligence information. Any strategic partnership takes time to mature and build trust. It takes time for militaries to build interoperability. India cannot decide on a suitable strategic partner after a crisis has already developed.

India's current stand remains strategic autonomy. Yet, clearly in the last two decades, India has been gradually tilting towards the USA. With China pulling much ahead of India in most fields that constitute strategic power, India will require to align with someone who can provide support beyond

**As for air power, India is already engaged in supporting ASEAN countries for aircraft spares and maintenance, and for training of air and ground crew. India needs to seek and tie up landing rights and overflight rights with more countries. Also, India can have LEMOA like logistics agreements with other militaries.**

just arms supplies. The strategic partner should be militarily and economically strong, and have means to support India in global institutions. Should India remain suspicious of military-like alliances? Does India have a choice? India will have to take its calls.

In the meantime, India has to build military strength for its own security, a form of insurance that cannot be ignored. Building sufficient military capabilities which will act as a deterrent against Beijing to not open a second front in case of war with Pakistan. India can currently only deter China and can at best be a bulwark and stand up firmly. China cannot take on the combined might of the US and its Asian allies that may surround China, such as Japan, South Korea and others.

Regional balancing is a strategy India must pursue to align with other Asian countries, such as Australia, Japan, the Philippines, Singapore and Vietnam. Other countries that have been affected by China's actions in South China Sea are Malaysia and Indonesia. Perhaps they too would be interested in being part of a counterbalancing grouping. Yet, they are all dependent on China. A regional balancing approach would permit India to balance China without directly aligning with a major bloc led by the United States. To support this, India needs to develop regional connectivity infrastructure quickly, especially through Bangladesh and Myanmar. Unfortunately, this is not happening at the required speed. On the other hand, China's economic might and leverages enable it to neutralise Indian efforts. However, India has the advantage of being a democracy, that makes it easier for most countries to deal with it against a closed and authoritarian China. But, regional balancing alone may not be good enough; India will also need to have economic and military strength and a big-brother approach.

As for air power, India is already engaged in supporting ASEAN countries for aircraft spares and maintenance, and for training of air and ground crew. India needs to seek and tie up landing rights and overflight rights with more countries. Also, India can have LEMOA like logistics agreements with other militaries. India should engage in air exercises with countries like Japan and Vietnam. Landing and logistics rights will give India greater reach.

While India pursues regional balancing and military strength, aligning closely with the United States without a formal alliance is a choice. This will not be easy because of years of suspicion, and the tacit alignment with the Soviet Union and Russia. India's close relationship with the United States is just over a decade old. India needed support of the United States for the NSG waiver, and high-technology military equipment. Any alignment with the United States will be complex, and principally for the need to tackle the challenge created by China's rise. There are already serious trade issues between the two. A close partnership with the US would help India balance China, which no other country can help it do. The United States is powerful, and has a self-interest in partnering with India. The United States has a global network of alliances and partnerships. Russia, India's traditional strategic partner, does not have such strength or global influence. Though, there is the possibility that China may overtake the USA as the leading global power.

The United States will have a greater role in the region, for China is already much more powerful than most Asian nations, including India. Yet India is the only big regional power that can stand-up to China. It has demonstrated the same repeatedly at Doklam, and more recently, in Ladakh. With its current growth trajectory, China is set to overtake the USA in another decade or so. Japan, India and the US are the three countries most concerned about China's rise and expansionist tendencies and the need to contain them.

**China is already much more powerful than most Asian nations, including India. Yet India is the only big regional power that can stand-up to China. It has demonstrated the same repeatedly at Doklam, and more recently, in Ladakh.**

The US' capacity to advance Indian interests in multilateral forums makes it a natural ally for India.

Despite China's rise, the United States will remain the world leader in high-tech research and development, and advanced weapons for some decades. While India is a self-respecting major nation and will not like to hang onto another nation's coat-tails, the US will certainly be an insurance against Chinese foolhardy acts of belligerence. There seems to be an evolving political acceptance of such a partnership. This, of course, will have to balance India's relationships with others, especially Russia. Much to Russia's dislike, currently the US has pushed Russia into Chinese arms. Meanwhile, India and US have different geopolitical positions on many regional disputes which would have to be set aside. That the US partnered or jettisoned many allies in the past, including Russia, China, Iran and Pakistan, also creates doubts.

Vivek Mishra has written about India's nuanced Indo-Pacific Strategy.<sup>37</sup> He says, "Although India has created a robust strategic arc from the Persian Gulf and the Asia-Pacific, its Indo-Pacific strategy is more nuanced, involving careful balancing between multiple stakeholders." He further says, "for instance, though India has promised the United States and its ilk that it will help to shape a regional strategy in line with their multilateral Indo-Pacific vision, its multifaceted relationships with China and Russia demand that New Delhi also create latitude for Beijing and Moscow within this vision." At the Shangri-La Dialogue in June 2018, Prime Minister Narendra Modi confessed that "no other relationship of India has as many layers as our relations with China." India's Indo-Pacific strategy, clearly, is meant to avoid direct confrontation with China despite the support of the United States. India is practising mature balancing. While it exercises with Quad, and many western armed forces, it does the same with Russia and China. India has engaged in hand-to-hand combat exercises and in maritime dialogue with China. These multiple equations of India make things complex and confuse the Americans. Fortunately, the world is conscious of India's historic

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37. Vivek Mishra, "India's nuanced Indo-Pacific strategy", *South Asian Voices*, November 1, 2018, at <https://southasianvoices.org/india-indo-pacific-strategy/>. Accessed on March 7, 2021.

connects, limitations and challenges and that foreign policies are dynamic and take time to evolve. Who would have thought that within a few years of World War II, Germany and Japan would become America's strategic partners? Who would have similarly thought that America would woo an autocratic communist nation like China to become America's friend against the Soviet Union? Washington actually helped build China to become a major competitor and adversary. India is an old civilisation with a high value system. New Delhi's Indo-Pacific policy will be based on its own regional realities and interests. Clearly, the United States and other allies will have to accommodate India's sensitivities and support its aspirations to become a meaningful partner in the new security arrangement in the neighbourhood.



# LESSONS FOR AIR POWER FROM LADAKH

HARSHA KAKAR

## INTRODUCTION

The Ladakh stand-off now appears to be receding after almost nine months of tension. As per the Northern Army Commander, Lt Gen YK Joshi, the occupation of Rezang La and Rechin La on the Kailash Ridge turned the tables. He stated in an interview, “A quid pro quo action was executed by us on the night of 29/30 August by which we occupied the most dominating features of Rechin La-Rezang La complex on the Kailash Range, thus dominating up to Moldo garrison and areas well in depth. In a simultaneous action, we also occupied the heights dominating PLA positions along Finger 4. We were able to place tanks at Rechin La and Rezang La which was unthinkable before. This turned the tables on the PLA and brought them on the negotiating tables.”<sup>1</sup>

General Joshi further added, “When their armour was moving up and we had our red lines absolutely clearly drawn, that is the moment movement was

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Major General **Harsha Kakar** was commissioned into the Regiment of Artillery in June 1979 and superannuated in March 2015. A prolific writer, he writes for a variety of newspapers and magazines. His blog is [www.harshakakararticles.com](http://www.harshakakararticles.com) and can be contacted at @kakar\_harsha

1. Nirupama Subramanian, “Northern Army Commander Lt General Y K Joshi interview: ‘Tanks at Rechin La, Rezang La turned tables on PLA, brought them to talks’”, <https://indianexpress.com/article/india/general-y-k-joshi-interview-indian-army-pla-in-eastern-ladakh-india-china-disengagement-7193282/>. Accessed on February 18, 2021.

**The disengagement to be followed by de-escalation and de-induction will be a long-drawn-out tedious process. While troops may pull back from their current stand-off positions, their return to permanent bases is still miles away. Hence, pressure and determination will remain key to Indian strategy, in addition to a display of offensive spirit.**

really tense. Balloon could have gone up anytime.”<sup>2</sup> The situation was undoubtedly tense and Indian forces were prepared for an escalation. The Chinese had applied pressure in every flag meeting and expected India to withdraw from these heights. They never anticipated India would continue remaining deployed through the harsh winters. Indian determination compelled them to come to the negotiating table. Disengagement is currently in progress and post its success in the Pangong Tso region, it is now being discussed for extension to other sectors.

The disengagement to be followed by de-escalation and de-induction will be a long-drawn-out tedious process. While troops may pull back from their current stand-off positions, their return to permanent bases is still miles away. Hence, pressure and determination will remain key to Indian strategy, in addition to a display of offensive spirit. Simultaneously, a similar misadventure by the Chinese in another sector cannot be ruled out, thus ensuring that forces remain permanently on guard.

### **FACTORS LEADING TO CHINESE PULLBACK**

The occupation of Kailash Ridge, as stated by the army commander, was alone not responsible for pushing the Chinese to accept status quo.

It was a combination of multiple steps, diplomatic, economic and military, with the occupation of the Kailash Ridge being the turning point. The foremost was stalling the Chinese in their tracks, thus sending a message

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2. “Lt Gen YK Joshi recalls most tense moment during India-China standoff in Ladakh”, *India Today*, February 17, 2021, at <https://www.indiatoday.in/india/story/lit-gen-yk-joshi-recalls-most-tense-moment-in-india-china-standoff-in-ladakh-exclusive-1770274-2021-02-17>. Accessed on February 17, 2021.

that any further move would be costly in terms of casualties and Indian forces are prepared for escalation. This was further authenticated by the rapid deployment of reserve forces. The valour displayed at Galwan indicated that the Indian soldier is capable of standing ground and would not relent.

Galwan broke what little trust existed between the nations, opening doors for confrontation. It also set at rest the ghost of the 1962 conflict and brought to fore the vulnerability of the Chinese soldier. China may have hidden its casualty figures from its population; however, its hierarchy realised that Indian forces are neither a pushover nor

would they cede territory to any occupier. The occupation of Rezang La and Rechin La features alongside heights on the North Bank of the Pangong Tso conveyed that India is in no rush to talk peace and would match each action of the Chinese in a similar manner. The speed of occupation was indicative that India possesses multiple options to counter any Chinese misadventures.

Pushing the Chinese to remain in Ladakh through the winters was another success story. A report in the *Taiwan Times* mentions that China faced daily casualties due to weather conditions in the winters. An article of November 26 in the *Taiwan Times* stated, “casualty evacuation of PLA troops through helicopters and stretchers has been observed on a daily basis, with an average of one PLA soldier succumbing to altitude and temperature-related ailments every day. Morale and motivation at the posts have also dipped below the freezing point.”<sup>3</sup> Total Chinese casualties, when considering both Galwan and weather, if announced, would be staggering.

**The decision to bypass the Shanghai Cooperation exercises, which China views as its own creation, conveyed Indian displeasure at their aggression. India ignored Chinese suggestions that border, trade and diplomatic relations should be considered in isolation. The Indian public supported the government by boycotting Chinese products.**

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3. “Chinese Troops Struggle With Low Quality Winter Clothing On Indian Border”, *The Taiwan Times*, November 20, 2020, at <https://thetaiwantimes.com/chinese-troops-struggle-with-low-quality-winter-clothing-on-indian-border/>. Accessed on November 20, 2021.

From the moment the Chinese were stalemated, the government gained confidence that the armed forces possess the potential to stare down the Dragon and prevent them from expanding the conflict. It could thus adopt additional measures, including scaling down Chinese investments, blocking their mobile applications and reducing diplomatic engagement.

The decision to bypass the Shanghai Cooperation exercises, which China views as its own creation, conveyed Indian displeasure at their aggression. India ignored Chinese suggestions that border, trade and diplomatic relations should be considered in isolation. The Indian public supported the government by boycotting Chinese products. However, throughout, India kept doors open for dialogue, both civil and military. Backchannel diplomacy continued unhindered.

China has always been wary of the Quadrilateral Security Dialogue (Quad), currently comprising India, the US, Japan and Australia. Till 2017, it was India which avoided adding teeth to the Quad. India considered it as a grouping of like-minded nations, rather than as a military alliance which could become a challenge to China. The change in Indian approach commenced post-Doklam, when it was realised that China would continue to enhance tensions along the LAC. India accepted the US request of reinducting Australia into the Quad and enhancing its level to that of foreign ministers. Currently, the Quad continues to be a grouping of nations, which the US is seeking to convert into an alliance. Converting the Quad into a military alliance would add to China's challenges and enhance tensions with India. China is aware that it is India which is holding back. In case tensions continue to rise, India may have been left with no choice but to raise the Quad grouping to that of an alliance.

India, throughout the crisis, maintained its One-China policy, leaving doors open for a resolution. China is aware that India holds multiple keys to enhance Chinese concerns, the primary being the Tibet card. Providing additional freedom to the Dalai Lama and the Tibetan government in exile could open doors for increased unrest in Tibet. India sent forth a small message by employing the Special Frontier Force, comprising wards of Tibetan refugees, to occupy heights on the Kailash Ridge.

In addition, ignoring the one-China policy by enhancing ties with Taiwan would hurt Chinese sentiments. China faced a dose of growing Indian national public demand for increasing proximity to Taiwan when posters congratulating Taiwan on its foundation day dotted the Delhi landscape and were followed in multiple newspaper editorials.

It irked the Chinese to the level that the Chinese spokesperson in New Delhi, Ji Rong, issued an open letter to the Indian press. The letter stated, "Regarding the so-called forthcoming 'National Day of Taiwan', the Chinese Embassy in India would like to remind our media friends that there is only one China in the world, and the Government of the People's Republic of China is the sole legitimate government representing the whole of China. Taiwan is an inalienable part of China's territory."<sup>4</sup> The Indian MEA responded by stating that India has a free press, and it will not be curbed.

However, one major factor which has not been given its requisite importance in compelling the Chinese to reconsider any further offensive designs which they may have had, was the role of the Indian Air Force. The air force shone throughout the crisis and proved that it could be a major support factor in an emergency and would have been a battle winning factor, had the Chinese considered escalating. The army never had to look back for air support.

The Chief of Air Staff, Air Chief Marshal Bhadauria, emphasised the role of his force while addressing an online seminar organised by the National Defence College in November 2020. He stated, "Over the past few months, the proactive deployment of our offensive capabilities in response to developments in eastern Ladakh, both in terms of deployment of air assets as well as rapid airlifting of army combat elements, demonstrated the IAF's operational readiness today."<sup>5</sup>

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4. Geeta Mohan, "Indian media is free, MEA tells China after embassy objects to 'National Day of Taiwan' reportage", *India Today*, October 9, 2020, at <https://www.indiatoday.in/india/story/indian-media-free-mea-tells-china-after-beijing-embassy-objects-national-day-of-taiwan-reportage-1729794-2020-10-09>. Accessed on October 18, 2021.

5. "IAF's strong posturing helped ward off threat from China: Air Chief Marshal RKS Bhadauria", *Economic Times*, November 6, 2020, at [https://economictimes.indiatimes.com/news/defence/iafs-strong-posturing-helped-ward-off-threat-from-china-air-chief-marshal-rks-bhadauria/articleshow/79082545.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](https://economictimes.indiatimes.com/news/defence/iafs-strong-posturing-helped-ward-off-threat-from-china-air-chief-marshal-rks-bhadauria/articleshow/79082545.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst). Accessed on February 20, 2021.

## **ROLE OF AIR POWER IN LADAKH**

The use of the air force's strategic lift capability, including C-17 Globe Masters, Il 76s, C-130 Super Hercules and AN-32s as also Chinook and Mi-17 helicopters ensured timely induction of forces to counter the Chinese, surprising them. Troops of reserve formations, armour, guns and stores essential to support forces in contact, were airlifted from peacetime locations and deployed in Ladakh. Three divisions were inducted in almost no time. Their speed of induction displayed Indian resolve.

Critical ammunition and construction material were collected from their places of manufacture and moved to Ladakh. Air power continued to support ground troops by moving supplies and essential commodities to enable forces to sustain operational preparedness even in peak winters. Aerial reconnaissance, including air force and navy assets as also employment of drones, was a major source of intelligence throughout these testing months.

Strategic airlift supplemented normal supplies being moved by road. Roadblocks due to inclement weather conditions were offset by strategic airlift. In winters, it is always the air force which provides the forces deployed in the region with basic necessities once passes close. It lived up to expectations thus offsetting road connectivity adversely impacted by weather.

The deployment of Apache helicopters in Ladakh placed Chinese armoured formations in the open at high risk. Armed with fire-and-forget Hellfire missiles, an Apache can track up to 128 targets a minute and prioritise threats. The missiles equip these gunships with capabilities which were a major threat to Chinese mechanised forces.

Simultaneously, the induction of the Rafale, its early forays into the region displaying its battle-worthiness and repositioning of other air power resources, to challenge the Chinese PLAAF, added to creating necessary counteroffensive capability, in case the Chinese crossed Indian redlines. The continued operationalisation of Daulat Beg Oldi airfield ensured deployment of strategic assets as also maintenance of forces in the region. The air force

provided the army with the confidence that it was present to support any offensive actions undertaken to counter Chinese attempts to enhance the spectrum of conflict.

The Indian army would never have been so confident of thwarting the Chinese advance had it not been for the support of the air force.

Addressing the pre-Air Force day press conference, the air chief stated that the Chinese air force cannot get the better of the Indian Air Force in any conflict scenario in eastern Ladakh, asserting that India is 'very well positioned' to meet any threat from China. The air chief added, 'swift and rapid' deployments were made along the LAC in view of the ground situation, specifically mentioning that Ladakh was just one of the areas where IAF's assets were stationed.<sup>6</sup>

It is well known that the Indian fourth-generation aircraft, which form the backbone of its air fleet, are far superior to the Chinese J series. In addition, India enjoys benefits of lower altitudes of take-off. The initial period of the crisis, involved large numbers of aircraft, flying hundreds of sorties, without a single incident, displaying the professionalism of the Indian Air Force, which could have added to Chinese concerns. This was a vast change from army-air force cooperation during the days of Kargil.

The superiority of air power and its operating in complete cohesion with ground forces led to a scenario where the Chinese realised that enhancing the scope of the conflict could lead to disaster. It boosted the confidence of the political leadership, leading to a determination of not backing down.

## **THE FUTURE DEMANDS ALERTNESS**

While the current stand-off is moving slowly towards resolution, it does not signify that peace would reign across the entire LAC. Incursion attempts may not happen in Ladakh as strong force levels remain but could reoccur anywhere. Reports of Chinese force movements and construction of

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6. Ananya Verma, "IAF Chief Talks Rafale, Tejas & '2-front War' In Pre-Air Force Day Annual Press Conference", October 5, 2020, at <https://www.republicworld.com/india-news/law-and-order/iaf-chief-discusses-rafale-possibilities-of-indo-china-war-says-we.html>. Accessed on February 21, 2021.

**The focus during the Ladakh crisis was on the army as it was the force in direct contact with the enemy and the battle was for territory in Ladakh. However, no operation can be successful, in the current environment, without adequate air support. Air power will be a game changer in any future conflict.**

border villages continue to flow regularly. The current disengagement, possible de-escalation and final de-induction should be considered as a pause in Indo-China relations since the LAC is unlikely to be converted into an IB anytime soon.

Hence, alertness, monitoring and display of offensive spirit will remain the key. This also demands that the government must continue with its current policy of enhancing defence capabilities and developing infrastructure along the northern and eastern borders. India must close the capability gap with China and create conditions where similar misadventures would result in high costs to China.

India is probably the only country in the world which faces two nuclear-powered adversaries working independently or in collusion to grab its territory. Hence, Indian armed forces would need to permanently cater to misadventures seeking to exploit any gap or weakness. Pakistan has faced the wrath of the Indian Air Force when it was struck at Balakot two years ago. It covered its losses from its public, closed down the camp and its airspace for two months and sought to display all was normal. Employing air power sent forth the message that India was willing to escalate in case Pak crosses Indian redlines and put at rest Pakistan's nuclear bogey, once and for all. Pakistan, though aware of the weakness of its economy and forces, would continue to exploit India's internal faultlines, employing terrorist groups and sympathisers.

Currently there is a ceasefire in place with Pakistan. As with China, a serious trust deficit exists. Whether this ceasefire would remain for a reasonable duration to enable talks to commence is a moot question. There is always a doubt that some rogue elements in Pakistan would attempt to break this ceasefire due to their sympathies with terrorist groups. The threat of a retaliatory strike must remain on the Pak hierarchy. This

will ensure that they reconsider any action which could cross Indian redlines.

### TAKEAWAYS FROM THE LADAKH CRISIS

The focus during the Ladakh crisis was on the army as it was the force in direct contact with the enemy and the battle was for territory in Ladakh. However, no operation can be successful, in the current environment, without adequate air support. Air power will be a game changer in any future conflict. The air force, as a deterrent, deployed adequate fighter resources in the region, while backing the army in enhancing its staying power, employing its strategic airlift capabilities. It played a crucial role in pushing the Chinese to reconsider their future plans.

The Indian Air Force's performance throughout the Ladakh crisis was flawless. It operated in close coordination with the army-backed forces on the ground as also projected an offensive spirit. The army-air force coordination worked to ensure that China was stalled in its tracks, options reduced and compelled to discuss restoration of status quo. For India, victory was in ensuring status quo. However, a few takeaways which emerged from the crisis must be considered, especially as the armed forces restructure into theatre commands.

Theatre commands are currently under study and raising. As per inputs there would be two land-based commands, one each for China and Pakistan. Apart from them, there would be a peninsula command, maritime command and an air defence command. Resources from the three services would be allocated to these commands.

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### **MAINTAINING STRATEGIC AIRLIFT UNDER CENTRAL CONTROL**

Air force has the capability of launching its aircraft from bases in the east, engaging targets in the west and landing in the south, employing air-to-air refuelling. Air power resources like those of other services are expected to be allocated to theatre commands as per tasking and possible operational scenarios. Their employment would then be the responsibility of respective theatre commanders. It would be incumbent on theatre commanders to amalgamate allocated resources into their overall offensive and defensive plans. While there would be flexibility in moving resources from one command to the other, it would impact the planning of theatre commands.

Resources of strategic airlift, both aircraft and helicopters, should preferably not be permanently allocated to theatre commands. They should be kept under central control to enable rapid redeployment and support to ground forces, wherever essential, across the country. During natural calamities and disasters, they would also be employed to support the civil administration. Their positioning, training, tasking and employment must remain the responsibility of air HQ. However, considering multiple scenarios they could be located within theatre commands for early deployment and employment.

C-17 Globe Masters, Il-76s and Chinooks are for load transportation, whereas the C-130s are normally earmarked for special operations; however, they can also be employed for load and troop transportation in case essential. Keeping these resources centrally will enhance flexibility. In case allocated to theatre commands, there would be issues of dual control and would add to additional channels for repositioning and tasking. Their concept of employment should be similar to the US Air Mobility Command, which as a support command, is available for major force movement when needed.

### **ENHANCING AIR POWER CAPABILITY**

The second takeaway from Ladakh is that strong air power capability is a major deterrent. The air chief stated during the Air Force Day parade in

October last year, “the rapid deployment of air force assets to forward areas in the ongoing stand-off in eastern Ladakh and support to the army clearly demonstrated the resolve, operational capability and the will to effectively engage the adversary.”<sup>7</sup> Hence, air-power capabilities must continue being upgraded, especially when threats from both adversaries simultaneously are possible.

The government too realised its shortcoming when in the midst of the crisis it fast-tracked a deal with Russia for the supply of 33 fighter aircraft, including 21 MIG-29s and 12 Su-30 MKI fighters. The low allocation of funds for modernisation, over the years, and tedious processes of procurements had pushed modernisation behind. The Ladakh crisis led to the government allocating an additional Rs. 20,000 crore to the forces to make up their shortfalls.

Funds would remain an issue and hence, planning for enhancing air power needs consideration. The air chief had highlighted this during an interaction with the Vivekanand Foundation in January this year, “While we have our needs, we have factored in the current constraints and we are aware that it will take a while for the economy to get back and for us to have the kind of budget we had earlier ... We can’t expect we will have some unlimited budget even with the security scenario in the north.”<sup>8</sup>

With a CDS firmly in place, joint planning being the norm, the current concept of service specific budgets being announced by the Finance Minister, as part of the annual budget, must end. The Department of Military Affairs (DMA) should take on the responsibility of allocating funds based on a common procurement plan from a central allocated budget. This would give a boost to procurement plans based on enhancing requisite capabilities.

*Atmanirbhar Bharat* is the order of the day. Hence, the air force would largely need to base their future plans on indigenous production. The

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7. “IAF chief Bhadauria commends Air Force for ‘prompt response’ on Ladakh stand-off”, October 8, 2020, at <https://theprint.in/defence/iaf-chief-bhadauria-commends-air-force-for-prompt-response-on-ladakh-stand-off/519254/>. Accessed on February 24, 2021.

8. Rahul Singh, “Chinese air force heavily deployed in Ladakh theatre in support of PLA’: IAF chief”, *Hindustan Times*, December 29, 2020, at <https://www.hindustantimes.com/india-news/chinese-air-force-heavily-deployed-in-ladakh-theatre-in-support-of-pla-iaf-chief/story-duR2XbH4hNKlfGAgI9RwhN.html>. Accessed on February 24, 2021.

Tejas, would in time, become the backbone of the air force; 83 Tejas Mk 1A have been cleared for induction. These are in addition to 40 Tejas Mk 1 already ordered in 2016. There is a need for strict monitoring of the Tejas production line and its quality control. Delays in production and weak quality checks, the hallmark of the HAL, cannot be permitted to remain. Its hierarchy may need to be revamped with the air force playing a major role.

The air force's demand for induction of 114 multirole fighters must be considered on priority if India is to maintain a credible deterrent against a two-front conflict. The air chief had stated in his press conference prior to air force day, "Around 400-450 indigenous aircraft of various types are to be inducted in the IAF in the next 10-15 years. By the end of the decade, the target is to have around 37-39 squadrons."<sup>9</sup> By then, China is expected to possess around 50 squadrons of fourth-generation fighters, though all may not be employed along the LAC. However, India has an advantage when operating in Tibet due to its multiple bases in the north and east. The capability gap must reduce over time and not increase.

Outer space and drones are the future and must form part of futuristic defence planning. The Indian armed forces have raised a tri-service Defence Space Agency, coordinated by the air force. It conducted its first exercise termed as the IndSpaceEx in July 2019. US, China and Russia are already major space powers. As per Air Marshal Anil Chopra, a space power seeks to, "dominate space and have space-based systems that allow the destruction of enemy targets in space and on earth and deny the enemy full access to space including preventing the enemy from launching satellites and destroying or degrading enemy satellites in space."<sup>10</sup> India demonstrated its space capability when it destroyed a live satellite in low orbit in July 2019.

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9. Huma Siddiqui, "Air Force to add more fire power! IAF to induct 450 different aircraft in the next decade, says Air Chief", October 7, 2020, at <https://www.msn.com/en-in/news/other/air-force-to-add-more-fire-power-iaf-to-induct-450-different-aircraft-in-the-next-decade-says-air-chief/ar-BB19MxiG>. Accessed on February 26, 2021.

10. Anil Chopra, "Militarisation of Space: Imperatives for India", Issue Vol. 34.4 October-December 2019, October 15, 2020, at <http://www.indiandefencereview.com/news/militarisation-of-space-imperatives-for-india/>. Accessed on March 5, 2021.

India currently possesses the ability to neutralise hostile satellites; however, it needs to develop directed energy weapons and plan for establishing a permanent space station, if it wishes to remain relevant in this realm.

The future of drones on the battlefield cannot be understated. Post the Armenia-Azerbaijan war, their relevance has increased. Targeting of weapon platforms on ground, gathering of information and guidance of precision weapons are some areas where they can be effectively employed. They are likely to play an extensive role in any future conflict. China is currently well ahead of India in this field. India needs to invest in developing drones as also in developing capabilities to counter them.

Post the attack on the AMARCO oilfield in Saudi Arabia in 2019, the air force instituted measures to counter this rising form of threat on critical installations. The IAF Chief RKS Bhadauria has acknowledged that, "The small drones are a new threat. It is a space violation issue and to deal with this, steps have been initiated."<sup>11</sup> The Chief of Army Staff recently stated, "the Indian Army is steadily inducting niche capabilities to enhance our combat proficiencies in Multi-Domain Operations." He added, hinting at China, "As we fixed our gaze on building core capacities in land, sea and air, they took the battle to the newer domains of space, cyber, and informatics."<sup>12</sup> The army had demonstrated multiple drone capability during the Army Day parade in January this year.

Each service is seeking its own collection of armed and surveillance drones, leading to duplicity in an age of enhanced jointness. While small drones for surveillance in the immediate vicinity may be essential at the battalion level, larger drones and UAVs need to be procured and employed based on a tri-service philosophy.

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11. Huma Siddiqui, "Future warfare and drones: AI-enabled stealthy combat drones in Indian skies", *Financial Express*, October 9, 2019, at <https://www.financialexpress.com/defence/future-warfare-and-drones-ai-enabled-stealthy-combat-drones-in-indian-skies/1730955/>. Accessed on March 9, 2021.
  12. Abhishek Bhalla, "Drones future of warfare to take on tanks and artillery: Indian Army chief", *India Today*, February 11, 2021, at <https://www.indiatoday.in/india/story/drones-future-of-warfare-to-take-on-tanks-and-artillery-indian-army-chief-1768343-2021-02-11>. Accessed on March 11, 2021.

**The Ladakh operations were seamless and happened despite both HQ functioning under respective service chiefs. While broad directions would have been given by service HQ, daily tasking, employment and coordination was being done by the two HQ working in coordination. The dividends were visible on ground as forces were rapidly inducted and subsequently deployed with all supporting elements alongside.**

the government must continue pushing in regions where they have yet to be created. Infrastructure development along the borders is an ongoing process, though remains time-consuming.

The fastest movement of forces, stores and equipment, in any critical scenario, remains by air. Shortfall of ALGs, especially in the remote regions, could impinge rapid deployment to counter any attempted misadventures by the Chinese. These also assist the state during natural calamities in moving supplies, resources and manpower. A strong airlift capability currently available can only be exploited if ALGs exist.

#### **THEATRE COMMANDS AND JOINT PLANNING**

Fourth is the importance of joint planning and implementation between the air force and the army. The coordination between Northern Command

Simultaneously, the air force may have to resort to alternate means including enhancing destructive capability of air power as being done by amalgamating the BrahMos and the Anti-Radiation Missile (Rudram-1) or similar armaments with the existing fleet.

#### **CREATION OF FORWARD AIRFIELDS AND ALGS**

The third takeaway is the importance of forward airfields and ALGs. While Leh, Thoise and Daulat Beg Oldi were extensively employed in Ladakh, there is a need for similar ALGs or forward airfields in the eastern and central sectors, where the Chinese pressure is now likely to be felt. A few have been constructed over the years, however, and

and AOC J&K is a lesson which must be carried forward when theatre commands begin to see the light of day. The Ladakh operations were seamless and happened despite both HQ functioning under respective service chiefs. While broad directions would have been given by service HQ, daily tasking, employment and coordination was being done by the two HQ working in coordination. The dividends were visible on ground as forces were rapidly inducted and subsequently deployed with all supporting elements alongside. The employment of naval Poseidon P-8I aircraft added to enhancement of surveillance capabilities.

The Indian armed forces have never given joint training due emphasis and importance. For decades, the forces have been discussing a bottom-up approach to integration, aware that this is never a solution. Even within the services there was a disagreement on how to implement jointness. The creation of a CDS with a clear mandate removed all doubts. This top-down push has forced the services to integrate rapidly. Even in joint training institutes like the DSSC, emphasis on jointness, tasking of other services and integrated employment are still being given lip service. Planning and control of operations currently remains service specific. It would have been ideal if the Northern Command had been converted into an ad hoc theatre command during the Ladakh crisis and the army and air force elements amalgamated into a cohesive HQ. It could then have been placed under the Chiefs of Staff Committee. However, this was never considered.

Hence, the organisation structure of future theatre commands must include lessons which flowed from the current seamless planning and execution. All major branches must have officers from both services working together. Simultaneously, emphasis on joint training must be enhanced. The CDS must lay down a time period by when officers of the armed forces are in a position to understand the concept of employment, deployment and

**Since drones and UAVs currently exist with all services they should be employed under a central agency, preferably staffed by members of the forces employed in the theatre. This would optimise their effort.**

limitations of the other services. Technical aspects should remain specific to respective services.

### **EMPLOYMENT OF DRONES/UAVS AND JOINT INTELLIGENCE CENTRES**

Fifth is the need to establish a central coordinating agency for employment and tasking of drones, UAVs and other intelligence gathering sources. Since drones and UAVs currently exist with all services they should be employed under a central agency, preferably staffed by members of the forces employed in the theatre. This would optimise their effort. It would also result in better control of the airspace in case of operations. Its nature of functioning should be on lines of the current Joint Operations Centre, created at Corps and higher levels. This organisation should also be responsible for interpretation of data, which is received from multiple sources, and dissemination to all concerned.

In Ladakh the assets of all three services were employed for surveillance. With the creation of theatre commands, there is a need to reassess the requirement of all services holding holding a similar variety of drones and UAVs. Currently each service is bidding for its own eyes, ears and destructive power from the skies. The holding, tasking and employment of drones and UAVs would remain within a theatre, under the theatre commander, operate under his directions and plans. Each service operating its own would only clutter the airspace adding to problems as also lead to duplication in inputs and additions in expenditure. It would be ideal if their holding and employment is centralised and a single service made responsible.

### **THE AIR DEFENCE COMMAND**

Finally, the importance of the air defence command currently under consideration. Currently, the three services maintain their own AD resources which are meant to counter specific threats perceived by each service. However, the responsibility of air defence of the nation rests with

the air force. With the induction of even more lethal weapon systems, there is an opinion within the government that all resources must be integrated. There are counter views to the same.

A potent air defence would be a major deterrent factor for any future operations, considering a similar concept adopted by the Chinese. The better the integration of resources of all services, the greater would be its effectiveness. A major problem which the air force would need to consider is that most of its current fourth-generation aircraft are multirole. Allocation of them to theatre commands would impinge on their being available for air defence. Similarly, allocating them for air defence could impact planning of air operations to support operations of the theatre commands.

A decision to be considered is the philosophy which must be adopted for national air defence, deterrence by denial or deterrence by punishment.

## CONCLUSION

The Ladakh crisis was an excellent demonstration of inter-service cooperation. The army would never have achieved such success had it not been for the support and close cooperation of the air force. While credit is certainly due to the army for its tenacity and doggedness in capturing and holding onto crucial heights, the silent support provided by air power can never be ignored. The timely induction of troops, supplies, stores and ammunition provided the army with the staying power in the harsh climate of Ladakh. It offset the advantage which the Chinese possessed of better lines of communication.

The air force changed the complexity of the crisis, gave the government the confidence to not rush into talks, accept the Chinese diktat and change the LAC forever. For troops on the ground, knowing air power is close and available is in itself a major morale booster. The Indian air force must be given credit for pushing the Chinese onto the discussion table and accepting to revert to status quo ante.

The lessons learnt from this crisis need to be assessed and implemented, especially as the armed forces gravitate into theatre commands. The

organisation structure of theatre commands needs careful consideration, the more so as the forces have yet to integrate and operate jointly. Individual demands of services, including procuring UAVs and drones, to enable them to fight in isolation, need to be curbed as they would operate as a single entity under a single commander. Space is the next frontier where India has to gravitate into. It is already way behind China.

India, with nuclear powered adversaries on both borders, can never be lax in developing the capabilities it needs as a deterrence. The development of air power can and must not be curtailed. It remains the most potent force to ward off threats as also enable speedy build up to counter any misadventures. HAL must be pushed to adhere to its delivery and quality schedule. Budgets must remain realistic and enable planned development of military capabilities. With a still persistent high trust deficit on both fronts, creating capability to deter by punishment must become the national intent.

# ELECTRONIC WARFARE: CHANGING OPERATIONAL CONCEPTS

DALJIT SINGH

Electromagnetic spectrum was first employed for military applications as a communication system by the navies more than a century ago. During the World Wars major developments in radar technology and radio navigation systems gave a distinct advantage to the armed forces by providing early warning of air attacks and accuracy in bombing targets. The opposing forces evolved techniques and tactics to defeat the radar and radio navigation advantage. This act of ensuring the freedom of friendly use of electromagnetic (EM) spectrum, and preventing the same to the adversary, added a new dimension to warfare—‘Electromagnetic War’, in short, ‘Electronic Warfare’ (EW). Since then, there has been tremendous development in exploitation of the EM spectrum and ways to deny, degrade or disrupt the use of EM spectrum by hostile forces.

With technological advances, a much wider range of electromagnetic spectrum is employed in the Armed Forces in the areas of Command, Control, Communication and Intelligence (C3I) network, sensors, weapons, navigational systems, and others. Today, almost all the operational systems, weapons and sensors employ some part of EM spectrum. It is, therefore, aptly referred to as the ‘Fourth Dimension’ of warfare, which needs to be dominated

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Air Marshal **Daljit Singh** was commissioned in the Fighter stream of the Indian Air Force, in June 1976. During his illustrious career of 38 years, he commanded a Mirage 2000 squadron and Air Force Station Gwalior. At Air Headquarters, he has held key staff appointments of Director, EW Operations, Assistant Chief of Air Staff (Air Defence) and Director General (Air Operations). He retired in October 2014 as Air Officer Commanding-in-Chief SWAC.

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with freedom of operation. The competition between EM spectrum employment and countermeasures continues perpetually and the operational concepts continue to evolve to exploit the technological advances. Even today, the communication network is as vulnerable to intelligence gathering and disruption, as it was a century ago. There are many historical examples, where importance of EW was neglected and training suffered, resulting in operational setbacks. It is, therefore, important to examine the EW developmental process, advances in operational concepts, and consider a roadmap to achieve superiority in this field.

### **WORLD WAR I PERIOD**

Radio communications were developed and matured for use by the naval ships of many countries at the dawn of the twentieth century. The communications were used to report hostile force movements or to guide indirect firing under adverse weather conditions and atmospheric obscurity. During the Russo-Japanese War of 1904, the Russian ships used to monitor the exchange of signals within the Japanese ships, and when their volume increased, it warned Russian fleets of imminent attack.<sup>1</sup> As the transmissions were on fixed frequency and without encryption, it was easy to monitor the signals and gainfully exploit them. Cryptography gained more importance during this period to retain secrecy of communication. Some of the nations like Austria, Italy and Britain gained proficiency in successfully decoding the important messages exchanged between the political leaders and the embassies. At present, when the technology has matured to frequency hopping techniques with encryption, Signal Intelligence (SIGINT) plays an important role in EW. But, in the year 1904, the Russian ships jammed

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1. Mario de Arcangelis, *Electronic Warfare* (Poole, Dorset, UK: Blandford, 1985), p. 11.

the communication between the Japanese ships that were providing the guidance for bombarding. As a result, the Russian ships remained undamaged, and the Japanese ships withdrew.<sup>2</sup> Communication jamming is considered the first act of offensive EW in “preventing effective use of EM spectrum to the adversary”.

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resilience and other means. During World War I, EM spectrum was employed mainly for communication between land, sea and air elements. Another major development that took place in the field of electronics was the capability of finding the direction of the originating signals. The technique of Direction Finding (DF) was based on the principle of goniometry, and it was possible to ‘triangulate’ the location of the signal transmitters and establish the ‘Electronic Order of Battle’ (EOB), which every force strives to do even today.

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## WORLD WAR II

During the intervening period, there were technological developments taking place in many countries based on the research work done on the characteristics of EM waves. The three main successful products of the research were Radar, Radio Navigation and Communications.

**Radar.** One of the most useful inventions was radar which was first employed by the Germans for detecting hostile ships through the mist or at night. On realising this advantage, the British started studying ways to neutralise and degrade radar with countermeasures. The same situation

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2. Ibid., p. 12.

exists today even as much advanced technology is being applied to improve radar performance. The British also developed their own radars capable of detecting aerial platforms. As the Germans prepared to launch aerial attacks on British airfields and aircraft production industry, the British had established a chain of radars all along the coast, which proved effective in detecting and intercepting incoming raids right from the first one on August 12, 1940. The first Electronic Intelligence (ELINT) mission undertaken by the German airships failed to detect the radars for some reason. Having pinpointed the radar locations subsequently, the Germans launched a bombing mission to destroy the British radar stations with 500 kg bombs.<sup>3</sup> This was the first mission now known as Destruction of Enemy Air Defence (DEAD). The Germans had initially concentrated on offensive air action and did not deploy the radars even though they had developed them well. As the Battle of Britain commenced with Bombing Offensive over Europe during day and night, the Germans employed an integrated Air Defence set-up which was the beginning of the present-day multilayered Integrated Air Defence System (IADS).

**IADS and Countermeasures.** Germany had installed radars (Freya)<sup>4</sup> operating at 120-130 MHz with a range of 120 miles to detect the incoming raids. As the radar operated on fixed frequency, the British employed an electronic countermeasure (ECM) Jammer "Mandrel" to degrade the radar. The Germans then employed another more advanced type of radar (Wurzburg) capable of providing 3D inputs including the height, while operating at higher frequency ranges (560-570 MHz). These radars could not be jammed by Mandrel Jammer. Simultaneously, the Germans installed a radar on board their night fighters which could detect the raiders up to a limited range. As the bombing campaign intensified in Europe, the Germans conceived and employed an Integrated Air Defence System comprising one Freya Radar for initial detection, two Wurzburg radars with an Operations Direction Centre for directing anti-aircraft guns and night fighters, and searchlights. The control of the interceptors shifted

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3. Abdul Karim Baram, *Technology in Warfare* (Abu Dhabi: Emirates Centre for Strategic Studies and Research, 2009), p. 84.

4. *Ibid.*, p. 106.

from 'close control' to 'area control' which required only initial vectoring for interception by on board radar. This was the first IADS system employed successfully which imposed prohibitive attrition on the RAF. The British had no technical knowledge of the Wurzburg Radar and so they physically picked up the radar to analyse the characteristics and developed "Carpet" jammer. The Germans by then had developed multi-frequency Wurzburg radar with a much wider frequency range to counter the ECM. A similar concept of physically picking up the radars can be seen during later conflicts. The next major jamming technique employed by the British was deployment of thin metallic strips (chaff) of half the radar transmission wavelength dimension that saturated the radar screens and concealed the actual target blips. Sometime later, the Germans developed Doppler processing to discriminate between the real targets from the stationary window. The Germans reintroduced a multi-frequency Radar, "Neptune", operating at six frequencies in the 158-189 MHz Range, which was unaffected by jammers and chaff. This is the typical spiral of EW in which the countermeasures catch up with radar technology only to find the radars employing technology beyond the capability of the jammers. The radar operating frequency ranges have been increasing since then, and now the radars operate in Ku band and beyond. However, the jammers have been keeping pace with advances and are capable of much wider frequency coverage, and this spiral of countermeasure and ECM and ECCM continues all the time.

**Radio Navigation.** As early as 1933, the Germans had experimented with using electronic beams transmitting with different modulations as guidance for landing under poor visibility conditions.<sup>5</sup> The same principle was employed by the Germans for blind bombing at night. The main electronic beams were crossed by another beam to mark the target location. The British also developed similar means of radio navigation for night bombing. These navigational beams were interfered with by transmitting noise on the same frequency, and deception beams were transmitted that confused the pilots completely. While the present navigation has switched to the satellite-based

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5. Mario de Arcangelis, n. 1, p. 42.

Global Positioning System (GPS), interference with the GPS through jamming and spoofing is a standard countermeasure which must be countered by adaptive GPS receivers.

**Radar Warning Receivers (RWR).** With development of airborne radars for navigation, tail warning radars for tail guns and air intercept radars, the Germans developed radar warning receivers which could detect radar transmissions and guide the fighters to catch the bombers “by the tail” or carry out successful interception onto the “Pathfinder” bombers equipped with Navigational Radars. Submarines were equipped with such RWRs to alert them against ‘Hunter Aircraft’ out to locate them. This is a good example of the defensive equipment used judiciously in offensive mode to shoot down the intruders. Ingenuity in equipment application is important to retain the upper edge in EW.

## VIETNAM WAR

After World War II, while the EW equipment went into disuse, a propaganda campaign transmitted on Voice of America and BBC was continuously jammed by the Russians. Communications jamming continued and most of the European countries and Russia developed a chain of radars for warning against surprise air attack. Electronic espionage campaign prevalent at that time continues to this day to map the electronic order of battle (EOB) of adversaries.

During the Vietnam War, on July 24, 1965, the US F-4 Phantom fighter was shot down by the Russian built SA-2 SAM, the first SAM kill during a hot war.<sup>6</sup> The US had lost 160 aircraft by the end of 1965. Proliferation of SAMs during the Vietnam War changed the operational concepts drastically. While low level attacks were risky due to radar controlled Anti-Aircraft Artillery, high level missions were vulnerable to the SAMs. The US pilots studied the SAM characteristics and devised anti-SAM manoeuvres while effective ECM jammers were being developed. The Americans also developed a crystal video RWR which could compare the received

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6. Mario de Arcangelis, n. 1, p. 160.

transmission parameters with the programmed radar signature and warn the pilot with audio and visual alarms. The ECM jamming technique was mainly a generation of noise, saturating the radar receiver. Having seen the effectiveness of ECM jammers, as an ECCM measure, SAM Radar operating frequency was changed from S Band (2965-3060) to C Band (5010-5090) which rendered the RWR and ECM equipment ineffective. The US later developed Anti-Radiation Missile (ARM) AGM 45 Shrike, to counter the SA-2. The ARM had an electronic seeker in the nose that homed onto the main beam transmissions of the radar and destroyed it. This induction brought in the concept of 'Wild Weasel' missions, where in a package of two to four RWR and ARM equipped packages used to precede the strike package and physically destroy the SA batteries. Later, the more compact jamming equipment was developed which could be carried externally to provide 'self-protection' against hostile surface-to-air AD weapons. This equipment now called Airborne Self-Protection Jammer (ASPJ) is a standard fit on all fighters. Heavier bombers like the B-52s were escorted by Wild Weasel missions and later ECM dedicated aircraft like EA6B which are now termed Stand-off Jammers or ECM escort jammers.

For destroying important bridges and military installations, low level strikes were planned to improve delivery accuracy, and this profile made them vulnerable to the anti-aircraft guns, and the forces suffered heavy losses. Once again, technological developments in sensor technology brought in Laser Guided Bombs (LGBs) which could be released at heights beyond the ranges of Anti-Aircraft Artillery (AAA) and provided accurate delivery on target. Gimballed designation Pods were developed to provide continuous guidance to the LGBs while the mother aircraft could continue to manoeuvre. US Navy also deployed television guided "Walleye" glide bomb for accurate delivery. Thus, Precision-Guided Munition (PGM) became a preferred weapon during subsequent operations.

The Vietnamese started deploying dummy SA-2 transmitters on known strike routes. The US Forces exhausted their ARMs on dummy transmitters before they reached the target area. While the operational concepts changed

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with advancing technology, it was the operational applications of tactics that exploited system weaknesses, which changed the endgame result. This important lesson is applicable even today.

The nearly 10-year Vietnam War ushered in many new technologies; the jammers became smarter by resorting to ‘deception’ jamming, programmable digital RWRs improved situational awareness, dedicated escort jammers protecting bigger bombers, PGMs were inducted to improve survivability and weapon accuracy, ARMs got inducted as DEAD weapons. All these systems kept improving as the matching technology evolved. SAM systems also improved in lethality and mobility as SAM

IIIs were developed by the Russians. Due to employment of EW systems and operational concepts, the attrition rate of the US Forces, which was 14 per cent at the beginning of the war, dropped to 1.4 per cent at the termination of operations.<sup>7</sup> With advancement in ECM capabilities, ECCM technology kept improving and this race to counter each other continues today.

### **ARAB-ISRAELI WAR 1973**

Following a well-orchestrated and well-planned surprise attack on Egypt by the Israel Air Force on June 5, 1967—during which the Israel Air Force decimated the Egyptian Air Force within two hours to achieve air superiority—Russia started rearming Egypt and Syria with better MiG-21s and supplied more capable and mobile SAMs and AD Guns. The Israelis received deception jammers which were more effective against AI radars and SAM III radars. Regular skirmishes continued after the Six-Day War of 1967, during which

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7. Mario de Arcangelis, n. 1, p. 173.

the raiding teams continued to destroy the military assets of the adversaries. On October 6, 1973, Egypt and Syria launched a massive simultaneous attack on Israel when the nation was on a religious holiday. They destroyed the frontline military fortifications and installations and achieved complete surprise. Their ground troops with tanks moved in fast and deep into Israeli territory. The Israelis reacted with attacks by the Israeli fighters. However, despite being equipped with modern EW equipment, they suffered many casualties as their ECM systems were ineffective against the newly inducted SAM-6 Gainful missiles, Gun Dish radar controlled Shilka AAA, and IR-guided Strella SAM-7.<sup>8</sup> The Gainful Radar employed continuous wave transmissions, the Gun Dish Radar operated in Ku Band, which were beyond the capability of the Israeli EW arsenal. The SAM IIIs were mobile, and Israeli intelligence failed to update the EOB and suffered heavily. The Israelis were supplied with appropriate chaff and flares which could degrade the new systems operating at much higher frequency ranges, when deployed with appropriate manoeuvres. The weak spots of the Gainful radar were studied, and the Israeli pilots devised appropriate attack profiles which made SAMs less effective. Subsequently, new RWRs were supplied to detect CW illumination and the Ku Band transmissions.

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The lesson that clearly stood out was the need to update the EOB regularly and avoid surprises. In today's environment, the EW equipment cannot be made to tackle specific threats but should be upgradable to tackle new threats as well.

### **1982 LEBANON WAR**

**The Bekaa Valley Conflict 1982.** During the intervening period after the Yom Kippur War, the Israeli Air Force modernised itself with modern fighters F-15 and F-16 with look-down/shoot-down capability, modern EW equipment that could be programmed to operate autonomously with

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8. Mario de Arcangelis, n. 1, p. 190.

effective jamming techniques, Airborne Early Warning Aircraft E2C and a few advanced weapons like AGM 45 Shrike ARM, and AGM 65 Maverick PGMs. The Israeli defence industry developed a number of different types of UAVs that could “see” the battlefield in real time, act as decoy to stimulate the AD Radars and operate as SIGINT platform. The Boeing 707 aircraft was configured with EW jamming capability. The other significant technological development was networking of C2 Centres with airborne sensors and shooters. The attack commenced with launch of Remotely Piloted Vehicles (RPVs) to map SAM locations, followed by stimulating the AD Radars, SAMs and C2 Centres. The Israeli Air Force commenced electronic jamming of all radars, SAMs and communication networks. This was followed by PGM and ARM strikes to gain air superiority. The entire operation was coordinated by E2C Hawkeye Airborne control aircraft.<sup>9</sup> Successful Suppression of Enemy Air Defences (SEAD) operation, effective communications jamming and excellent networked and coordinated operations demonstrated the new effective way of conducting operations. This campaign changed the way wars were planned and executed post-Bekaa valley campaign. The entire world took note of the importance of Electronic Warfare, PGMs, ARMs and UAVs. The lesson from Bekaa Valley was that EW would continue to play an important role in deciding the outcome of operations. However, the competition between the SAMs and aircraft would continue unabated. Post-1982 Bekaa valley conflict, the operational concepts changed rapidly and technological advances in sensor technology, propulsion systems, computer power and networked operations brought in quantum advances in the fields of radars and EW.

### **FIRST GULF WAR 1991**

During the first Gulf War, many advanced technologies for military operations were available to the US and Coalition Forces which provided a high degree of asymmetry against the Iraqi Forces. As Iraq occupied Kuwait in August 1990, the Americans employed many geostationary SIGINT satellites, missile

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9. Abdul Karim Baram, n. 3, p. 374.

launch detection satellites, Imaging Reconnaissance satellites and Synthetic Aperture Radar (SAR) satellites which provided complete intelligence on the Iraqi Forces deployment and dispositions. These satellites were well networked with ground stations to provide data not only to the Pentagon, but also to the field formations. Geospatial Navigation Satellite System provided accurate navigation capability. As airborne element, E-8A Joint Strategic Targeting and Attack Surveillance (JSTAR) aircraft, deployed for the first time, had the most advanced system capable of tracking all movements of tanks, vehicles, guns and missile launchers. The JSTAR data could predict the movements by comparing the historical data and share this information with the field formations. In addition, AWACS provided a comprehensive air picture and airborne C2 capabilities. Other advanced airborne systems included the TR-1 high-altitude Reconnaissance aircraft, EC-130H EW and communication jammer and many types of UAVs. The US stealth fighter F-117 was employed for the first time in combat and with great success. All types of aircraft that were planned to cross the border were well equipped with ECM systems. The F-117, being a stealth fighter, relied mainly on its stealth capability and operated 'silently'.

The EW campaign of the coalition forces played a dominant role in achieving complete air superiority over the Iraqi Forces. Mainly, the template of the first Lebanon War was employed to achieve air superiority over Iraq and Kuwait. Comprehensive intelligence gathering campaign provided clear EOB picture of the AD systems and C2 Network. The attack campaign began by stimulating UAVs and Tactical Air Launched Decoys (TALD), while attack helicopters intruded at low level to destroy two AD radars and create a gap. This was followed by a wave of Tomahawk cruise missiles launched from the warships and the B-52s. The next wave comprised the F-117As and other fighters that were well equipped with ECM equipment and IR countermeasures. Dedicated stand-off jammer aircraft like EF 111 and EA 6B protected the strike force and other fighters employed ARMs, which were used extensively to deter and destroy the SAM sites. 'Wild Weasel' missions were undertaken by the F-4G for the last time, as they were phased out in 1995.

## **CURRENT TECHNOLOGICAL DEVELOPMENTS**

**Radar.** Initial development of the Radar involved HF, V/UHF Band employment with limited range capability. By the end of World War II significant developments in three-dimensional tracking capability, doppler processing and bistatic radars had taken place. Later developments took place in transmitter technology and signals processing. However, mechanically steered antennae were not efficient in tracking multiple targets and in undertaking multimode operations simultaneously. Since the 1980s, there has been significant development in radar technology as digital technology, computational processing and digital signal processing improved. The modern radars employ Active Electronic Scan Array (AESA) technology with use of array of Transmitter Receiver Modules (TRM), which facilitates electronic beam steering without any moving parts. This ensures simultaneous multiple modes of operation as the beams can be steered electronically in any direction. Airborne Interception Radars (AIR) on board fighters can operate both air-to-air and air-to-ground modes simultaneously for better situational awareness. Sharper beam steering ensures diminished sidelobes and multiple transmitters facilitate multi-frequency operations with graceful degradation. With advances in digital processing, scan rates, tracking priorities, dwell times and scan zones can be optimised as per operational scenario. Overall, AESA radars are more resistant to ECM action and have Low-Probability-of-Intercept (LPI) capability. The modern radars are now 'software defined' to operate efficiently in different operational scenarios of low Radar Cross Section (RCS), low-speed targets like UAVs as well as high level high-speed targets like fighters and ballistic missiles. With application of Artificial Intelligence (AI), cognitive radars which would self-learn from past engagements would make them tough targets for EW action. Overall frequency bands of operation of ground-based radars are so diverse that it would be extremely difficult for one ECM equipment to counter all the radars.

**Stealth Technology.** Since its development in the 1930s, radar has been the most effective means of detecting airborne objects. While active ECM has

been deployed to degrade and reduce effective detection range of the radar, another means of the RCS reduction by appropriately shaping the aircraft structure gained traction during the Cold War Period, when the US deployed U2R and SR-71 SR spy planes with some stealth features. During the 1980s, the US developed F-117 'Night Hawk' stealth fighter and B-2 Bomber in complete secrecy and employed them operationally during the First Gulf War in 1991, with great success. Stealth technology aims to reduce the RCS by shaping the aircraft structure to deflect or absorb the radar transmissions and reduce the strength of beam reflections towards the radar. In fact, the USAF perceived the stealth technology as the 'Silver Bullet' which would defeat the radars without any ECM action. After retiring the EF-111 EW support aircraft, no other replacement was planned by the USAF, whereas the US Navy replaced the EA-6B Jammer with the G 18 'Growler Escort Jammer'. The stealth technology has some limitations which have now been exploited to neutralise its effectiveness. The stealth design of the F-35 class of fighters is likely to be effective against X-Band tracking radars and that too in frontal aspect. It is not as effective against low band radars operating in L band or V/UHF Bands.<sup>10</sup> Russia has effectively developed and upgraded low band radars like Nebo M that can effectively detect stealth fighters. The stealth technique is mainly effective in frontal aspect and not as effective in broad and rear aspect. Even though stealth features would be embedded in all future designs of all platforms, they would mainly supplement other effective countermeasures to defeat the AD systems. The current developments in counter-stealth radars operating in V/UHF bands and employing multi-static radar technology have reduced the stealth fighter advantage to a great extent.

**Sensor Technology.** With overall advances in digital technology and miniaturisation, there has been rapid advancement in the field of multi-spectral sensors. Employment of EM spectrum has spread beyond what has been employed for radar and communication systems. Electro-optical and

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10. Serdar Çadirci, "RF stealth (or low observable) and counter-RF stealth technologies: Implications of counter-RF stealth solutions for Turkish Air Force", p. 97.

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infra-red sensors are now capable of detecting and pinpointing targets at much further ranges and with more clarity. Combination of EO and IR sensors provide detection and tracking capabilities in almost all types of atmospheric conditions, as wider spectrum in the IR regime covering near IR and wide IR are being employed. All modern fighters would have an array of passive sensors like Infrared Search and Track (IRST), missile approach warners, in addition to optional carriage of aircraft targeting pods like the Litening. Multi-sensors employed for terminal guidance of missiles has enhanced resistance to countermeasures. David Sling Interceptor Missile manufactured by Rafael Advance Defense Systems is known to employ multispectral sensor for jam resistant terminal target acquisition. Mica AAM has option of either IR or RF-based seeker, which improves its success against countermeasures. The main advantage of such sensors is that they are passive in nature that do not trigger any warning. In ground-based sensor regime, passive electro-optic sensors have achieved much better detection and tracking capability under adverse atmospheric environments. The Rafael manufactured Sky Spotter is a passive EO surveillance early warning system capable of detecting, identifying, classifying and tracking multiple targets at long ranges.<sup>11</sup> The system is also capable of detecting stealth aircraft. Such passive sensor-based systems are inherently unaffected by normal ECM actions faced by radars. From EW aspect, the EM spectrum employment has spread across many regimes including UV, Optical and IR.

**EW Technology.** Technological developments have been equally well applied to improve the performance of EW systems. In the field of ESM, application of interferometry principle has improved the accuracy in detection and geolocation of hostile radars and communication centres. The RWRs on board fighters are as good as ESM receivers in terms of accuracy in detection,

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11. Sky Spotter Brochure available at [www.rafael.co.il](http://www.rafael.co.il). Accessed on March 30, 2021.

classification and geolocation of radars and communication centres. The frequency coverage has been enhanced from 2-18 GHz to 1-40 GHz. With AI embedded algorithms, these programmable receivers can analyse and correlate unknown transmissions with identified transmitters. Networked ESM platforms with ESM receivers would further improve geolocation accuracies in a congested EM environment. ECM systems have also adapted the AESA technology to simultaneously jam multiple threats emanating from different directions. With more directive transmissions the ECM can pump in more EM energy. The provision of Digital RF Memory (DRFM) ensures more authentic deception techniques to break tracking locks of hostile radars. **Size, weight, and power requirements of systems have been reducing, which make the ECM systems more potent to tackle hostile systems. Modern radars have much more robust ECCM capabilities as they operate with more complex transmission patterns over a much wider frequency band, frequency agility and much reduced sidelobes.**

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## **CURRENT OPERATIONAL DEVELOPMENTS**

**Net-centric Operations.** Rapid development in computer and communication technology has led to robust, resilient, secure, and adaptive networks in military operations. Various ground-based, airborne and space-based sensors can now be networked to have a comprehensive filtered operational picture available to commanders and warriors. Commands, data, voice, and videos are exchanged online with all networked operators. Sensors, decision makers and shooters are now on the same grid to ensure a much faster decision and execution cycle. Inputs from various ISR assets can be best exploited by fusing the inputs from sensors operating on different

frequency regimes. The networks can ride on terrestrial, WiFi and space-based networks seamlessly. Net-centric operations inherently ensure redundancy in connectivity, sensors, and shooters. Resilience and capability of data links would be crucial in future to ensure uninterrupted massive flow of information.

**Integrated Air Defence.** Net-centric capability has been well exploited by military forces to integrate Air Defence assets and Command and Control elements. Integration of multispectral active and passive ground-based, and airborne sensors ensures good resilience against countermeasures and graceful degradation. Multilayered Air Defence set-up ensures effective engagement of all types of threats in the entire airspace volume from ultra-low level to the stratosphere. The SAMs have much longer engagement envelopes, making the attackers vulnerable at much longer ranges. S-400 SAM system has a kill envelope extending to 400 km. These ranges push the EW Support Forces further away from the sensors to be jammed.

**Stand-off Attack Weapons.** Improvements in sensor technology, propulsion systems and precision navigational systems have ushered in a variety of weapons that can be fired from stand-off ranges of hundreds of kilometres. These weapons are capable of autonomous target engagement and they could be data linked to mother aircraft for target updates and real-time bomb damage assessment. AGM 86 air-launched cruise missiles carried on board B-52G bombers were launched aggressively during the first Gulf War in 1991. The B-52G can carry 14 missiles for independent targeting. AGM 158 B Joint Air-to-Surface Stand-off Missile was developed in the 1990s to attack high-value targets while staying out of reach of the hostile AD missiles. The missile has an effective range of 370 km with precision delivery accuracy. The IAF has acquired SCALP air-launched cruise missile which has stealth features and an effective range of more than 250 km. During the Aero India 2021 airshow, Rafael Advanced Defence System showcased SPICE 250 ER PGM with an effective range of more than 150 km and capable of attacking moving targets. Medium-class fighters can carry 16 such bombs

and can independently attack 16 targets simultaneously. With this kind of stand-off ranges the mother aircraft stays outside the lethal AD envelope and, therefore, does not require active ECM to degrade the hostile sensors. However, such weapons are expensive and are available in limited quantities for high-value targets.

**UAVs.** Unmanned Aerial Vehicles have been employed in most of the wars post World War II. The Israelis pioneered the employment of UAVs as decoys, SIGINT and ISR platforms during the First Lebanon War, and the world took note of the UAV potential as integral to all types of operations. Recent conflicts in Syria, Libya and Azerbaijan are testimony to UAV destructive power at the lowest cost. UAVs are being employed as the loitering munition, airborne ‘sniper’ and persistent ISR and SIGINT platform. Azerbaijan inflicted heavy attrition on the Armenian Forces by effective employment of UAVs. The US Navy has planned induction of the aircraft carrier-based MQ-25A Stingray autonomous air refuelling UAV, to extend the operational range of the fighters. Employment of UAVs will continue to expand in many roles in future.

## **RECOMMENDED APPROACH FOR INDIA**

**EM Spectrum Management.** The EM environment will keep getting more and more congested as almost all the platforms and systems will use some segment of EM- spectrum. Net-centric operations require massive exchange of data that will generate heavy EM flow. However, the frequency bands for military operations are limited and they are required to be shared amongst the services. To ensure ‘clean’ operation in the EM spectrum, the first step would be to segregate operating frequencies (as far as possible) during the planned induction of radars, communication systems, data links and other sensors. For example, AI radars of all fighters generally operate in X-Band. An overlap of operating AI radar frequencies of SU-30 fighter with the Rafael could lead to interference, degrading the performance. The same is applicable to ground-based and AWACS radars. This EM spectrum management needs to be addressed at the tri-service level.

**Net-centric operations would require more robust and secure data links. Monitoring and mapping of hostile data links would provide crucial inputs on hostile activity. While own forces employ more robust and resilient and LPI data links, the nation must acquire the capability to map hostile datalinks.**

**Embedded ECM Suite.** The LCA has been inducted into the IAF without any self-protection jammer. Integrated Self-Protection Suite must be included during the platform design stage as later add-on will always have compatibility issues with other sensors. This is applicable across the board for all platforms, including the UAVs.

**Upgradable Systems.** The life of inducted ECM equipment is more than ten years. However, the threat environment would change at a fast pace and the ASPJs should be able to tackle more advanced evolving threats of the future. The EW systems should have open architecture and be upgradable as the technology develops.

**Exploit Net-centricity.** During operations, unknown hostile systems are bound to be encountered. The ECM effectiveness would be ascertained based on the engagement results. The EW systems should exploit net-centricity to upload latest and effective jamming techniques to the ECM equipment in the air. SIGINT assets when networked would improve the geolocation accuracies and resolve ambiguities.

**AI for Analysis.** The data acquired by SIGINT Platforms, AWACS, ASPJs RWRs and other EW equipment would be very large and it would be impossible for specialists to analyse it in a short time. Artificial Intelligence and Machine Learning techniques would be essential for faster data processing.

**Data Link Mapping.** Net-centric operations would require more robust and secure data links. Monitoring and mapping of hostile data links would provide crucial inputs on hostile activity. While own forces employ more robust and resilient and LPI data links, the nation must acquire the capability to map hostile datalinks.

**Multispectral Sensors.** All future airborne platforms would have some degree of stealth features. Integrated Air Defence Network must

have multispectral sensors to ensure redundancy against active ECM action as also the ability to detect stealth aircraft. Induction of Passive Location systems and EO sensors capable of accurate tracking of airborne objects would address these issues.

**ECM Escorts.** With dense EOB of powerful radars operating at lower frequency bands, the ASPJs would not be able to handle all threats. Modern ECM escorts would ensure better protection against such powerful and frequency diverse radars. Any degradation in detection and range ambiguity would adversely impact the composite operational picture and, in turn, the executive decisions.

**Stand-in Jamming.** With ground-based AD weapons acquiring much longer kill ranges, the ECM escort jammers would be vulnerable in these envelopes. Jamming from further would degrade jamming effectiveness. ECM action by UAVs as stand-in jammers is a viable concept as a larger number of UAV-borne jammers could be deployed at different radials to protect the incoming attack force.

**Realistic Training.** Performance of ECM equipment and effectiveness of jamming techniques need to be checked against realistic hostile emitters. General training conducted against own sensors and SAMs does not generate enough realism and confidence. An Instrumented EW Range with programmable EW emulators and simulators would provide better tools for generating effective jamming programs. Airborne EW trainer aircraft could be employed for training the SAM operators. This way the operators would be able to realistically evolve EW tactics. All the three services should train together in such an environment.

**The satellites have communication uplinks and downlinks with ground stations for data exchange and housekeeping. These links are vulnerable to interference if security and secrecy is not planned. All such data links would require reassessment to ensure their uncompromised operation and satellite redundancy is considered essential.**

**Space Assets.** The satellites have communication uplinks and downlinks with ground stations for data exchange and housekeeping. These links are vulnerable to interference if security and secrecy is not planned. All such data links would require reassessment to ensure their uncompromised operation and satellite redundancy is considered essential.

**DEW.** Directed Energy Weapons are maturing to a stage of operationalisation. Lasers as weapons against sensors and UAVs have been deployed by many forces. India should accelerate its research in this field.

**DEAD Capability.** With other countries acquiring S-400 class of SAMs, it is imperative that own forces must have capability to geolocate and target the crucial radars from stand-off ranges. Induction of SCALP missile provides this capability; however, geolocation of the SAM site is required to attack the target. Anti-Radiation Missile (ARM) would be able to geolocate and attack the SAM sites in real time. Provision of such weapons would be good deterrence and effective counter to Long Range SAM systems.

**Cyber and EW Operations.** EW is one of the 'arrows' in the quiver which would have other arrows as well. The forces must develop as many options as possible to degrade the hostile military machinery. Application of cyberattacks along with stand-off PGMs and decoys would be a good option to achieve EW superiority.

## CONCLUSION

Electromagnetic spectrum has been exploited by military forces for more than a century. World War II saw significant progress in use of EM spectrum in radars, communications, and radio navigation. The opposing forces applied ingenuity in degrading these systems till a more robust system was fielded. The contest to retain freedom of EM spectrum use while denying the same to the adversary started right from the beginning and this fight would continue in the foreseeable future. Induction of SAMs in the battlefield changed the concept of operations and EW applications during the Vietnam War. During the Lebanon War of 1982, the Israeli Forces demonstrated the

power of EW applications in paralysing and neutralising the opposing forces in all domains of operations. Nearly a decade later the Allied Forces once again exploited technological superiority in EW application to defeat the Iraqi Forces, with minimum attrition.

Today, most of the forces conduct net-centric operations and have Integrated Multi-Layered AD systems with extended kill ranges. The operational concepts of EW application are also undergoing significant changes. Employment of UAVs and their operational potential has opened up more options of their employment in the EW Role. Stand-off attack weapons, though available, would be in limited numbers to attack high-value targets. Other attack profiles with shorter range attack weapons would continue to require EW protection.

While density and congestion in the military allocated EM spectrum is increasing by the day, it is important to manage the EM spectrum usage right from the stage of platform or system procurement plan. All platforms would require integrated EW suite at the design stage itself as later add-on would always be a challenge. Data link mapping of the adversary and making own links more robust and secure requires attention as all future engagements would be in a networked environment.

Training in a realistic environment is important to validate EW tactics and jamming techniques. This requires an arena created with multiple emulators and simulators to emulate realistic hostile EOB and derive meaningful lessons. With massive data downloads collated from all the sensors, analysis by humans would be near impossible in a short time frame. AI and ML would help in this area.

EW is a highly specialised field when it comes to programming the systems and jamming techniques. The forces must nurture this specialisation to get the best out of the EW equipment. During hostilities, time is at a premium and only trained manpower would be able to perform. At the same time, the national industry should be geared to upgrade the systems in a short time to counter new threats. For this the systems need to be manufactured indigenously with open architecture and provision of upgrade. The Indian

defence industry needs to catch up EW technology through collaboration with more experienced players in the world. It is quite evident that control of EM spectrum would play a decisive role in all domains of operations and national effort is required to achieve this superiority.

# ARTIFICIAL INTELLIGENCE IN MILITARY AVIATION

AK SACHDEV

## INTRODUCTION

Persistent depiction of Artificial Intelligence (AI) in military and strategic journals as an “arms race” is as hackneyed as it is inaccurate (some call it an experimentation race<sup>1</sup>). AI is a technology which, along with its subset technologies (Machine Learning (ML), etc.), is certainly not classifiable as “arms”; Elon Musk’s famous remark<sup>2</sup> that, “I think the danger of AI is much bigger than the danger of nuclear warheads by a lot” may subtext AI’s weapon connotation, but not adequately to qualify it as “arms”. However, the “race” part is certainly true and is manifest in feverish pursuit of AI by all major global powers in every facet of national security (in addition to other fields). Thus, national security strategies (inclusive of defence strategies), having identified weapons with applied exploitation of AI as critical to future warfare, are embracing military AI with enthusiasm.

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Group Captain **Ashvani Kumar Sachdev** (Retd) was a Senior Research Fellow of Manohar Parikkar Institute for Defence Studies and Analyses for two years and served on the faculty of the Defence Services Staff College, Wellington for three years. He was the Commodore Commandant of a prime helicopter unit and holds M Phil, M Sc, MA degrees in addition to an MBA.

1. Peter Layton, “The Artificial Intelligence Battlespace”, RUSI Commentary, p. 1, at <https://rusi.org/commentary/artificial-intelligence-battlespace>. Accessed on March 9, 2021.
2. Melia Robinson, “Elon Musk Thinks Artificial Intelligence is Ultimately More Dangerous Than Nuclear Weapons”, *Business Insider*, March 12, 2018, p. 1, at <https://www.businessinsider.in/elon-musk-thinks-artificial-intelligence-is-ultimately-more-dangerous-than-nuclear-weapons/articleshow/63273433.cms>. Accessed on March 14, 2021.

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Currently, the US is at the head of the pack. As far back as November 15, 2014, at the annual keynote address<sup>3</sup> at Reagan National Defense Forum in California, US Secretary of Defense Chuck Hagel declared that, “Today I’m announcing a new Defense Innovation Initiative—an initiative that we expect to develop into a game-changing third ‘offset’ strategy.” He elaborated that the initiative was an effort to sustain and advance US military dominance for the 21st century and outlined some actions. Two years later the government released a

National Artificial Intelligence Research and Development Strategic Plan<sup>4</sup> which, without belabouring military aspects much, set the scene for the establishment of Joint Artificial Intelligence Centre (JAIC) in 2018 by US Department of Defense (DoD) to exploit AI technology for the benefit of national security. In February 2019, President Trump signed an executive order with a plan for US leadership in AI development;<sup>5</sup> DoD promptly followed up with an unclassified document entitled “Summary of the 2018 Department of Defense Artificial Intelligence Strategy”. The National Security Commission on Artificial Intelligence (NSCAI) was tasked around then to make recommendations to the President and Congress to “advance the development of artificial intelligence, machine learning, and associated technologies to comprehensively address the national security and defense needs of the United States.”<sup>6</sup> Its report,<sup>7</sup> submitted on March 1, 2021 accentuates US apprehension of Chinese ambitions to be the global AI leader by

3. Keynote speech by US Secretary of Defense, Chuck Hagel, at the Reagan National Defense Forum, November 15, 2014, para 26, at <https://www.defense.gov/Newsroom/Speeches/Speech/Article/606635/>. Accessed on March 10, 2021.
4. *The National Artificial Intelligence Research and Development Plan* (Washington, D.C.: White House Office of Science and Technology Policy, 2016), at [https://www.nitrd.gov/PUBS/national\\_ai\\_rd\\_strategic\\_plan.pdf](https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf). Accessed on March 1, 2021.
5. Executive Order 13859 of February 11, 2019, *Maintaining American Leadership in Artificial Intelligence* (Washington, D.C.: White House, 2019), at <https://www.govinfo.gov/content/pkg/FR-2019-02-14/pdf/2019-02544.pdf>. Accessed on March 3, 2021.
6. *Final Report National Security Commission on Artificial Intelligence* (Arlington: National Security Commission on Artificial Intelligence, 2021), Introductory Chapter, p. 15, at <https://www.nsc.ai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf>. Accessed on March 4, 2021.
7. *Ibid.*, p. 25.

2030 and belabours possible loss of US military-technical superiority to China in the coming years.

This misgiving is premised on an official Chinese document<sup>8</sup> entitled “New Generation Artificial Intelligence Development Plan released on 20 July 2017” which stipulates three objectives, the last one (to be achieved by 2030) as “...China’s AI theories, technologies, and applications should achieve world leading levels, making China the world’s primary AI innovation centre, achieving visible results in intelligent economy and intelligent society applications, and laying an important foundation for becoming a leading innovation-style nation and an economic power.”

Russian President Putin, in a 2017 meeting, warned in the context of AI that “the one who becomes the leader in this sphere will be the ruler of the world”, offering to cooperate with other nations to eliminate a monopolistic situation. In Europe too, AI is being revered in military terms and an example is the Future Combat Air System (FCAS) joint project between France, Germany and Spain. Other notable nations pursuing AI are the UK, Sweden, Turkey, Israel and India, with Saudi Arabia and UAE the latest entrants. This paper reconnoitres the demands of military aviation from AI and the munificence of AI in meeting them.

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## **AI AS A FRAME OF REFERENCE FOR MILITARY AVIATION**

AI is a term used loosely and hence perceptions about it vary widely. According to US DoD,<sup>9</sup> “AI refers to the ability of machines to perform

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8. *China’s New Generation Artificial Intelligence Development Plan 2017* (full translation), chapter entitled, “II. The Overall Requirements”, Section entitled, “Strategic Objectives”, at <https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/>. Accessed on March 2, 2021. Original Chinese document ostensibly at [http://www.gov.cn/zhengce/content/2017-07/20/content\\_5211996.htm](http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm) according to translators.

9. *Summary of the 2018 Department of Defense Artificial Intelligence Strategy* (Washington, D.C., 2019), p. 5, at <https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF>. Accessed on March 12, 2021.

tasks that normally require human intelligence—for example, recognizing patterns, learning from experience, drawing conclusions, making predictions, or taking action—whether digitally or as the smart software behind autonomous physical systems.” In essence, AI is being demonstrated by any machine imitating human brain functions; the problem lies in understanding how the human brain functions. For decades computers have been executing tasks that the human brain can; they have attained much higher speeds than the human brain but those tasks could be generally clubbed under Common Artificial Intelligence (CAI). The term General Artificial Intelligence (GAI) pertains to cognition functions, i.e., thinking faculty of the brain. Current research endeavours aim at understanding how the brain functions and then mimicking the processes in AI machines.<sup>10</sup> The laudable, and apparently technologically achievable, aim is to make GAI machines think like human brains although such machines may be functional many years ahead in future.

Starting with second-generation fighter aircraft, some human functions were getting delegated to on board avionics; fly-by-wire (FBW) was an extension of that rationale—by accelerating the process of computing and predicting flight conditions, safe control of the aircraft could be assured. Speed mattered critically but FBW still functioned within the envelope defined beforehand and every deed by FBW was a response to ‘If... Then...’ preset parameters; in other words, no intelligence was displayed by the machine. GAI aims at reacting to situations as they develop with a capability to learn from each situation or interaction; some examples are speech recognition, mastery of games like chess and Go, autonomous systems, flight and combat simulations, etc. The challenge lies in moving up from, say, carrying out guided missile attacks on designated targets to making decisions on which target should be attacked. While AI, replete with super-fast computers, can almost instantly access and analyse huge amounts of data to provide inputs for command and control decisions, subjective problem solving is still not possible by AI (and

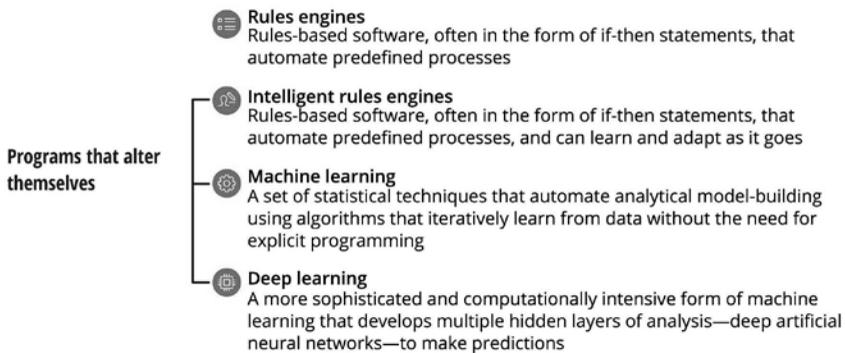
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10. Paul Yaworsky, *A Model for General Intelligence* (New York: Information Directorate, Air Force Research Laboratory, 2018), p. 2, at <https://arxiv.org/ftp/arxiv/papers/1811/1811.02546.pdf>. Accessed on February 27, 2021.

GAI is the objective that will do so). According to a Deloitte Insights paper<sup>11</sup> a hierarchy of AI based on how it works is depicted in Figure 1.

Figure 1

**Artificial intelligence: Model classes**



Source: Deloitte analysis.

Military aviation, constantly in need of very fast decision making, is locatable in this frame of reference; as AI moves towards Deep Learning, military aviation moves towards applied GAI. Let us look at current and emerging AI applications in military aviation.

**AI IN THE COCKPIT**

In August 2019, US Defense Advanced Research Projects Agency (DARPA) proclaimed that, “No AI currently exists, however, that can outduel a human strapped into a fighter jet in a high-speed, high-G dogfight.”<sup>12</sup> A year later, under DARPA’s famous AlphaDogFight trials, a simulated F-16 fighter with AI in the cockpit defeated a top gun from US Air Force (USAF) in five bouts of mock air combat. Deeper analysis would show that the simulation trial conditions were biased in favour of AI; the human pilot was not in an actual

11. Frank Strickland, Joe Mariani and Isaac Jenkins, “Military readiness through AI”, in *Deloitte Insights*, April 24, 2019, pp. 1-2, at <https://www2.deloitte.com/us/en/insights/industry/public-sector/ai-military-readiness.html>. Accessed on February 24, 2021.

12. DARPA Outreach, “Training AI to Win a Dogfight”, August 5, 2019, p. 1, at <https://www.darpa.mil/news-events/2019-05-08>. Accessed on February 24, 2021.

aircraft which he was trained to fly, and had only a Virtual Reality (VR) headset to give him situational awareness. However, the demonstration was historic inasmuch as it validated the very concept of AI replacing a pilot in the cockpit for something as fast moving as a dogfight.

This was a step forward from civil aviation precedents of AI in the cockpit like the Autonomi system from Garmin which enables, in case of pilot incapacitation, for on-board systems to take over either automatically or on activation by the pilot or a passenger, stabilise the aircraft and then autoland it, if required. Interestingly, this system, now certified by US Federal Aviation Administration (FAA), is not projected as an AI system but as automation. The patent application for Emergency Autoland System<sup>13</sup> does not use the term 'artificial' or 'intelligence' anywhere. Xwing, a US-based company, claims its software integrates sensors and maps with on-board flight control systems to allow regional aircraft to navigate, take off and land; indeed it has secured FAA certification for unmanned cargo operations on a converted Cessna 208B Grand Caravan. Xwing is already flying with a single pilot on board and autonomous operations are expected to start in 2022.

While civil aviation has its own problems accepting AI in the cockpit (including the expected iron wall of resistance to passengers boarding a pilot-less aircraft), military aviation grapples with the problem differently. On December 15, 2020, USAF flew a single-seat U-2 on a simulated missile strike mission<sup>14</sup> with an AI algorithm called ARTUμ as a working crew member; a human pilot flew the aircraft and coordinated with ARTUμ which was responsible for sensor employment and tactical navigation. The system is designed to be transferable to another type of aircraft with ease and has the potential to be a cockpit occupant in modern fighters as well as future ones. The implication is that pilot workload of flying and fighting can be reduced by AI in the cockpit taking over complex tasks of managing data

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13. United States Patent Application Publication No. US 2017/0249852 AI dated August 31, 2017, at <https://patentimages.storage.googleapis.com/04/81/09/55bcc0207e50fd/US20170249852A1.pdf>. Accessed on February 20, 2021.

14. Secretary of the Air Force Public Affairs, "AI Copilot: Air Force achieves first military flight with Artificial Intelligence", Official US Air Force website, December 16, 2020, p. 1, at <https://www.af.mil/News/Article-Display/Article/2448376/ai-copilot-air-force-achieves-first-military-flight-with-artificial-intelligence/>. Accessed on February 22, 2021.

from multiple sources and sensors. An ARTU $\mu$  (or similar system) could also manage autonomous systems teamed with the fighter it is located in (manned-unmanned teams are discussed later in detail). There have been reports of Japan developing an unmanned fighter to be operational by 2035,<sup>15</sup> and AI in the cockpit appears to have caught the attention of military aviation grippingly.

Current technological prowess encourages optimism about military aviation accommodating incremental AI participation in cockpit workloads. The AlphaDogFight series of demonstrations is part of DARPA's Air Combat Evolution (ACE) programme which aims to progressively automate aerial combat and foster confidence in unmanned cockpits. Evolving fighter designs, prevalently clubbed into sixth-generation fighters, stand to benefit immensely from the inexorable tiptoe of AI into modern cockpits. A promising example is DARPA's Aircrew Labor In-Cockpit Automation System (ALIAS) which is aimed at developing a flexible, drop in, removable kit that would permit appending high levels of AI driven automation into an existing aircraft; the ultimate aim is to execute an entire mission from take-off to landing.<sup>16</sup>

## **AI AND EVOLVING COMBAT AIRCRAFT**

There is no universally accepted classification of combat aircraft into "generations" but the first-generation is generally considered to be the earliest jet fighters entering service during the fag end of World War II; and the second, those that operated during the Korean War period, many with swept wings. Technology in the late 1950s and 1960s ushered in the third-generation with supersonic speeds and sophisticated engines. The fourth-generation brought in impressive degrees of avionics and automation in the 1970s (fly-by-wire (FBW), Full Authority Digital Engine Controls (FADEC), etc.) while the fifth-generation is characterised by, among others,

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15. Smriti Chaudhary, "Japan to Deploy Unmanned Fighter Jets By 2035 With Aim to Counter Rising Chinese Military Might", January 1, 2021, p. 1, at <https://eurasianimes.com/japan-to-deploy-unmanned-fighter-jets-by-2035-with-aim-to-counter-rising-chinese-military-might/>. Accessed on March 7, 2021.

16. Dr. Stuart H. Young, "Aircrew Labor In-Cockpit Automation System", DARPA official site, undated paper, p. 1, at <https://www.darpa.mil/program/aircrew-labor-in-cockpit-automation-system>. Accessed on March 12, 2021.

**It is the sixth-generation which is still evolving that promises to incorporate hypersonic speeds, adaptive shapes, dual mode engines along with many emerging and astonishing technologies, but, most importantly, very potent levels of AI.**

high stealth, Active Electronically Scanned Array (AESA) radars and plug and play electronics with automation permitting the aircraft limited autonomy in some areas. It is the sixth-generation which is still evolving that promises to incorporate hypersonic speeds, adaptive shapes, dual mode engines along with many emerging and astonishing technologies, but, most importantly, very potent levels of AI.

The US is leading in the race to produce 6th-generation, AI-endowed fighters; US Air Force Research Laboratory (AFRL) released news of F/X, also known as Next Generation Air Dominance (NGAD) or Penetrating Counter Air (PCA), with a projected date of induction of 2030 into USAF. Another programme called F/A-XX, which the US Navy also calls NGAD, relates to a sixth-generation replacement for US Navy's F/A-18E/F.<sup>17</sup> Not much is known about this programme yet but some analysts aver that the NGAD will most likely have an AI co-pilot.<sup>18</sup>

In Europe, France, Germany and Spain are collaborating on a Future Combat Air System (FCAS) which is aimed at producing the Next Generation Fighter (NGF) connected to a variety of Unmanned Aerial Vehicles (UAVs) with offensive and surveillance roles through cloud connectivity driven by AI; the objective is to turn the NGF into a battlefield management platform commanding one or more UAVs for multifarious roles. The FCAS was initially slated to go operational by 2040<sup>19</sup> but that seems doubtful at the time of writing this.

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17. Valerie Insinna, "Congress has questions about the Air Force's and Navy's next-generation fighter programs", *Defense News*, June 23, 2020, p. 1, at <https://www.defensenews.com/air/2020/06/23/congress-has-questions-about-the-air-force-and-navys-next-generation-fighter-programs/>. Accessed on March 9, 2021.

18. Theresa Hitchens, "NGAD Likely to Carry AI Copilot: Next Step Certifying Them Flight Ready: Roper", *Breaking Defense*, December 18, 2020, p. 1, at <https://breakingdefense.com/2020/12/ngad-likely-to-carry-ai-copilot-next-step-certifying-them-flight-ready-roper/>. Accessed on March 10, 2021.

19. Justin Bronk, "FCAS: Is the Franco-German-Spanish Combat Air Programme Really in Trouble?", *RUSI Commentary*, March 1, 2021, p. 1, at <https://rusi.org/commentary/fcas-franco-german-spanish-combat-air-programme-really-trouble>. Accessed on March 9, 2021.

Russia is working on MiG-41, a long-range sixth-generation interceptor, with a projected entry into service after 2030; informed conjecture has it that an unmanned variant may also emerge from the programme. This is in addition to the Su-57 programme which is a fifth-generation aircraft, born out of Russian Air Force PAK FA programme. It first flew in 2010; India was a development partner but pulled out in 2018 due to slow progress and less than satisfactory technological progress. According to a RAND Corporation commentary,<sup>20</sup> the Su-57 is somewhere between a fourth and a fifth-generation design and the Izdeliye 30 engine intended for it is not yet ready. Reportedly, 76 aircraft will enter service with the Russian Air Force in the late 2020s. However, the fact that the Su-57 falls short of fifth-generation criteria is a portent of similar dearth of delight from the MiG-41 sixth-generation aircraft as also of almost certain delays in the programme's fruition.

The UK is working on the Tempest sixth-generation combat air system in collaboration with Italy and Sweden to produce an aircraft that will enter service with RAF and others in 2035. It would be able to work in cooperation with UAVs for coordinated offensive or defensive operations. China's AI-loaded sixth-generation project, expected to come to fruition by 2035, is also looking at UAV control (including swarm control) and to be an improvement over its existing leading-edge fighters—the J-20 and the J-31. Japan is also planning to develop at Mitsubishi, in collaboration with a foreign partner (possibly the US or UK) a new design called the F-X or the F-3 to replace

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20. Ryan Bauer and Peter A. Wilson, "Russia's Su-57 Heavy Fighter Bomber: Is It Really a Fifth-Generation Aircraft?", RAND Blog, August 17, 2020, p. 1, at <https://www.rand.org/blog/2020/08/russias-su-57-heavy-fighter-bomber-is-it-really-a-5th.html>. Accessed on March 12, 2021.

its F-2 aircraft. The F-3 is expected to be a sixth-generation aircraft although its design is yet to be finalised and so it could well turn out to be a fifth-generation one. A Nasdaq report<sup>21</sup> said that Japan had picked Mitsubishi Heavy Industries (MHI) to lead the development of the new fighter jet but the MHI site (mhi.com) refrains from mentioning this development. It is safe to presume that, given Japan's diligence over the F-3 design (and rejection of three US and UK OEM proposals for collaboration), the final aircraft will incorporate leading-edge AI features.

As the fighter aircraft progressed through successive generations, increasing complexity of technology rendered their development arduous and their costs astronomical. US F-22 and F-35 sport exorbitant price tags and sales have been muted, despite their unquestionable credentials as fifth-generation leading-edge machines. Indeed, the US is the only aerospace power to have fifth-generation aircraft, all the other nations/nation groups with sixth-generation programmes having leapfrogged the fifth! Not surprisingly, there is a current rethink over fifth and sixth-generation aircraft in favour of rejuvenating fourth-generation ones—with some additional features of later generations, obviously those that can be retro-fitted without major design changes. This thought process points towards the emergence of a 4.5th generation which achieves a compromise between cost (far less than a fifth/sixth-generation aircraft) and capability (decidedly better than fourth generation). There is no doubt that the capability enhancement will embrace AI to the extent that refurbishment will permit.

Indeed, retrofit of AI is already being undertaken on some older battle-proven aircraft; according to one report,<sup>22</sup> "The Air Force has over 600 projects incorporating a facet of artificial intelligence to address various mission sets." The B-2 bomber, dating back to the 1980s, has been given new flight management control processors and fibre optic cables are replacing the old wiring. The on

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21. Reuters, "Japan picks Mitsubishi Heavy to lead development of new stealth jet fighter", *Nasdaq*, October 20, 2020, p. 1, at <https://www.nasdaq.com/articles/japan-picks-mitsubishi-heavy-to-lead-development-of-new-stealth-jet-fighter-2020-10-29>. Accessed on March 3, 2021.

22. Kris Osborn, "Air Force Has Plans to Turn the B-2, F-35 and F-15 Into Even More Deadlier Killers. Here's How", July 31, 2018, p. 1, at <https://nationalinterest.org/blog/buzz/air-force-has-plans-turn-b-2-f-35-and-f-15-even-more-deadlier-killers-here%E2%80%99s-how-27327>. Accessed on March 5, 2021.

board memory and its networking speeds are being enhanced manifold so as to enable AI perform essential procedural functions (database access, information organising, scanning, viewing, organising, targeting, radar warning, images and video) and fusing sensor information autonomously thus lowering pilot workload related to flying and navigation, and leaving his cognitive faculties free for mission related tasks. The F-15 is also being re-engineered with Advanced Display Core Processor (ADCPII), one of the fastest processors in the world, so as to permit faster and more reliable processing capability on board; there is also a plan to apply cognitive AI and ML algorithms to enhance the capabilities of its EW systems<sup>23</sup> under the cognitive EW concept. The EA-18G Growler is also getting AI injected into its systems to give it enhanced Electronic Warfare (EW) capabilities: an illustration is a system called Reactive Electronic Attack Measures (REAM).<sup>24</sup> Northrop Grumman was awarded a contract for the development of this capability of transitioning Machine Learning Algorithms (MLAs) to the EA-18G's airborne electronic attack suite to achieve capabilities against agile, adaptive, and unknown hostile radars or radar modes. REAM technology is expected to join active Navy fleet squadrons around 2025.<sup>25</sup> Many of the AI applications mentioned above are already available in varying degrees of sophistication and could be grafted on to existing or evolving aircraft types with ease.

As in-cockpit AI permits aircraft to perform more and more vital combat functions at speeds far exceeding those human pilots are capable of, combat aircraft could move from AI sharing cockpits with human pilots (as the U-2 illustration mentioned above) to manning them independently. Thus, an "optionally manned cockpit" design is a key attribute of the sixth-generation fighter. As is also evident from the discussion on sixth-generation fighters above,

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23. John Keller, "Air Force asks industry for artificial intelligence (AI) cognitive electronic warfare (EW) for F-15 jets", *Military & Aerospace Electronics*, March 15, 2021, p. 1, at <https://www.militaryaerospace.com/computers/article/14199230/electronic-warfare-ew-cognitive-artificial-intelligence-ai>. Accessed on March 17, 2021.

24. US Department of Defense, "Contracts for April 25, 2018", April 25, 2018, sixth item under NAVY, at <https://www.defense.gov/Newsroom/Contracts/Contract/Article/1503297/>. Accessed on March 2, 2021.

25. John Keller, "Vadum to support electronic-warfare project to counter waveform-agile enemy radar with machine learning", *Military & Aerospace Electronics*, February 20, 2019, p. 1, at <https://www.militaryaerospace.com/sensors/article/16722184/vadum-to-support-electronicwarfare-project-to-counter-waveformagile-enemy-radar-with-machine-learning>. Accessed on March 3, 2021.

a quintessential element of ongoing sixth-generation fighter programmes is the AI-driven capability to team with UAVs for the performance of sundry offensive and defensive roles; this teaming is discussed next.

### **AI AND MANNED-UNMANNED TEAMING**

Manned-Unmanned Teaming (MUM-T) has been around as a concept even before it was juxtaposed on to combat aircraft, and more specifically, to sixth-generation fighters. Interestingly, it was the US Army which pioneered the concept in 1997 with four concept evaluation programmes which blossomed into two current systems involving the Apache AH-64D and the Apache AH-64E linking with UAVs.<sup>26</sup> Perhaps the most eye-catching accomplishment of that MUM-T has been a demonstration (in October 2020) involving a live missile fire through cooperative engagement between an Apache AH-64E helicopter, a Shadow RQ-7BV2 Block 3 tactical unmanned aircraft system (TUAS) and an MQ-1C Gray Eagle Extended Range (GE-ER) UAS.<sup>27</sup>

Fixed wing MUM-T involving fighters has not been far behind but, in the context of fighters and high-speed UAVs, cooperative engagements demand more immersive AI for successful operations. US AFRL has been working on the 'Loyal Wingman' concept entailing a manned command aircraft with an unmanned aircraft serving as an adjunct flying platform, scouting for threats and taking them on, if required (hence the term loyal wingman). Live demonstrations with one manned and one unmanned F-16 were impressive<sup>28</sup> and promising enough for all sixth-generation aspirations to envision such an option as part of the design requirements. According to a paper from NATO's conglomerate of

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26. Lt Col Steven G. Van Riper, "Apache Manned-Unmanned Teaming Capability", Association of the United States Army site, p. 2, at <https://www.ausa.org/sites/default/files/apache-manned-unmanned-teaming.pdf>. Accessed on February 23, 2021.

27. Becky Bryant, "Aerial MUM-T reaches new heights at DPG", US Army site, October 27, 2020, p. 1, at [https://www.army.mil/article/240283/aerial\\_mum\\_t\\_reaches\\_new\\_heights\\_at\\_dpg](https://www.army.mil/article/240283/aerial_mum_t_reaches_new_heights_at_dpg). Accessed on March 1, 2021.

28. Joseph Trevithick, "This Is What the US Air Force Wants You to Think Air Combat Will Look Like in 2030", *The Drive*, March 26, 2018, see section entitled "Loyal Wingmen", at <https://www.thedrive.com/the-war-zone/19636/this-is-what-the-us-air-force-wants-you-to-think-air-combat-will-look-like-in-2030>. Accessed on February 4, 2021.

analysts (called Joint Air Power Competence Centre<sup>29</sup>), while the F-16 tests were conducted in a semi-autonomous mode based on predetermined parameters, future plans include “flocking” wherein more than one unmanned wingman would operate under the manned command aircraft which would give more abstract commands than exercise direct control over them, and “swarming” which would obviate the possibility of the command aircraft having situational awareness over each of a huge swarm of UAVs but permit it to exercise command over the swarm as an aggregate. A demonstration related to this concept was made in October 2016 with three F/A-18 Super Hornets releasing a swarm of 103 autonomous micro-drones which then proceeded to exhibit “collective decision-making, adaptive formation flying, and self-healing.”<sup>30</sup> The swarming UAVs are especially alluring as they represent myriad possibilities: some UAVs could have offensive roles, some could be sheer decoys, some could carry out Intelligence, Surveillance and Reconnaissance (ISR) tasks, some could carry EW payloads, some others could aid in target recognition and tracking, and yet others could be loitering munitions with possibly air-to-air capability so that they can sacrifice themselves in defence of their command aircraft; the possibilities are boundless.

As the foregoing suggests, UAVs present a compelling alternative to exposing progressively expensive (witness the almost unaffordable F-35!), scarce, manned aircraft to high threat environments. Not only can they be used again and again like manned aircraft, but are comparatively so economical that greater risks can be taken with them, with no danger of losing a valuable human pilot. They are variously referred to as Low Cost Attritable Aircraft (LCAA) and Attritable/Reusable (A/R) UAVs,<sup>31</sup> designed for short life spans (in comparison to manned fighters), recoverable (if not attrited during a

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29. Andy J. Fawkes and Lieutenant Colonel Martin Menzel, “The Future Role of Artificial Intelligence”, *Joint Air Power Competence Centre Journal*, 27th edn., Autumn/Winter 2018, p. 73, at [https://www.japcc.org/wp-content/uploads/JAPCC\\_J27\\_screen.pdf](https://www.japcc.org/wp-content/uploads/JAPCC_J27_screen.pdf). Accessed on March 2, 2021.

30. US Department of Defense, “Department of Defense Announces Successful Micro-Drone Demonstration”, US DoD Release, January 9, 2017, p. 1, at <https://www.defense.gov/Newsroom/Releases/Release/Article/1044811/department-of-defense-announces-successful-micro-drone-demonstration/>. Accessed on March 3, 2021.

31. Col Mark Gunzinger and Lukas Autenreid, “The Promise of Skyborg”, *Air Force Magazine*, November 1, 2020, p. 1, at <https://www.airforcemag.com/article/the-promise-of-skyborg/>. Accessed on March 4, 2021.

**Skyborg was launched in 2018 by AFRL's Strategic Development Planning and Experimentation (SDPE) and AFRL calls it "an autonomy-focused capability that will enable the Air Force to operate and sustain low-cost, teamed aircraft that can thwart adversaries with quick, decisive actions in contested environments."**

mission), low cost, and usable with multiple manned aircraft. The crucial AI technologies that are lodged in these UAVs enable them to be part of MUM-T programmes like the US Skyborg, one of three Vanguard programmes launched by AFRL.

Skyborg was launched in 2018 by AFRL's Strategic Development Planning and Experimentation (SDPE) and AFRL calls it "an autonomy-focused capability that will enable the Air Force to operate and sustain low-cost, teamed aircraft that can thwart adversaries with quick, decisive actions in contested environments."<sup>32</sup> Accompanying UAV programmes include the Kratos-built XQ-58 Valkyrie which completed a successful

flight in March 2019 under AFRL's Low Cost Attritable Aircraft Technology (LCAAT) project. Skyborg related contracts have also been awarded to General Atomics, Northrop Grumman and Boeing. Skyborg's eventual loyal wingman could well be an unmanned fighter (as in the 2018 trials of manned/unmanned F-16s flying together).

In May 2019, DARPA launched Air Combat Evolution (ACE) programme to adopt AI in individual and team aerial combat tactics and to develop Air Combat Manoeuvring (ACM) algorithms for visual 1-versus-1, 2-versus-1 and 2-versus-2 engagements with a broad spectrum of performance. The AlphaDogFight trials mentioned earlier were a part of ACE which embraces manned and unmanned aerial combat. While ACE is aimed at developing AI software capable of close combat by unmanned platforms autonomously, Skyborg has modern capabilities (Beyond Visual Range (BVR) missiles and long-range sensors) in mind for loyal wingmen. However, as both programmes look at unmanned wingmen, they may be merged at some

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32. Air Force Research Laboratory, "What Is Skyborg?", p. 1, at <https://afresearchlab.com/technology/vanguards/successstories/skyborg>. Accessed on February 23, 2021.

future point in time as the programmes mature. That will remove the dividing line between close aerial combat and BVR engagements by AI-enabled UAVs toiling as wingmen.

Boeing, which has a stake in US Skyborg programme, is also designing and developing in collaboration with Royal Australian Air Force (RAAF) the Airpower Teaming System (ATS)—its first unmanned system in Australia. On March 1, 2021, Boeing announced<sup>33</sup> the first test flight of its loyal wingman, a UAV slightly smaller than an F-16 (its length is 11.6 metres) which can fly like a fighter (as loyal wingman) to say an F-18 or F-35 class of aircraft (up to six could fly with one manned aircraft), or fly on roles like EW and ISR along with P-8 Poseidon or E-7 Wedgetail aircraft.

Moving to Europe, the decision to develop FCAS was taken in 2017 by Germany and France but they signed an investment agreement only in February 2020 with Spain joining up in December that year. Within the programme, the Next Generation Weapon System (NGWS) aims at teaming sixth-generation manned fighters (possibly NGFs) with UAVs (called Remote Carriers (RCs) under the programme) which will be appendable in a scalable and flexible manner. RCs from 200 kg to several tons All-Up Weight (AUW) are envisaged under NGWS with EW, ISR, Target Acquisition, Air-to-Ground strike and Suppression of Enemy Air Defences (SEAD) as the possible roles. Airbus Defence and Space was working with US-based ANSYS, an engineering simulation company but, reportedly, there are some problems faced by the programme<sup>34</sup> and its future is uncertain.

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33. Boeing Media Room, "Boeing Loyal Wingman Uncrewed Aircraft Completes First Flight", March 1, 2021, p. 1, at <https://boeing.mediaroom.com/news-releases-statements?item=130834>. Accessed on March 5, 2021.

34. Justin Bronk, "FCAS: Is the Franco-German-Spanish Combat Air Programme Really in Trouble?", RUSI Commentary, March 1, 2021, p. 1, at <https://rusi.org/commentary/fcas-franco-german-spanish-combat-air-programme-really-trouble>. Accessed on March 9, 2021.

Russia has also been working on developing new UAVs to function as autonomous loyal wingmen; reportedly 'Grom' (meaning thunder), developed by Kronstadt Group was presented at Army 2020 Arms Expo in Moscow. Grom is designed to operate in conjunction with Su-35/Su-57 fighters for reconnaissance and missile firing (500 kg payload) under their command.<sup>35</sup> It resembles the XQ-58 Valkyrie but is longer by half a length (13.8 metres to Valkyrie's 8.8 metres). According to TASS, Russia's state news agency, Kronstadt has stated that the Grom will be able to control a swarm of ten smaller drones called 'Molniya' (or lightning).<sup>36</sup> Another UAV, the S-70 Okhotnik-B (Hunter) designed by Sukhoi Design Bureau and Russian Aircraft Corporation MiG first flew in 2019 and is also designed to be a loyal wingman capable of carrying 2 tons of internal payload including missiles and bombs, or be installed with electro-optic targeting, communication and reconnaissance equipment. The actual AI capability and content of these two UAVs is not ascertainable as all information about them is from Russian state media (and hence susceptible to scepticism).

Sixth-generation programmes appear intent on MUM-T capabilities but not all of them will survive the onslaught of shrinking defence budgets; already there is a mild clamour on about revitalisation of fourth-generation aircraft with additional AI retro-fitted to give them capabilities transcending fourth generation. Without a doubt, there would be built into the MUM-T UAVs the modular capabilities to dovetail into partnerships with aircraft hierarchically lower than the sixth-generation designs they are being developed for originally. An interesting consequence of this happening could be the realisation that a UAV is as effective in MUM-T roles with sixth-generation aircraft as it is with less-than-sixth ones.

## AI ON UAVS

Beginning with a spectacular flight in 1969 by Israel's Military Intelligence Directorate using toy drones mounted with 35 mm still cameras programmed

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35. "Russia's top long-range attack drones", *Air Force Technology*, November 27, 2020, p. 1, at <https://www.airforce-technology.com/features/russias-top-long-range-attack-drones/>. Accessed on February 3, 2021.

36. "Russia's latest combat drone to control swarm of reconnaissance UAVs", TASS news site, March 15, 2021, p. 1, at <https://tass.com/defense/1265961>. Accessed on March 17, 2021.

to click pictures every ten seconds to harvest details of trenches, signals cables and deployments over Egyptian territory along the Suez, UAVs have grown impressively—in size and in capability. Incrementally additive AI has added value to UAVs by providing autonomy for myriad roles and tasks. UAVs are being used in combat during military conflicts for long; a US Predator first fired a missile in 2001.<sup>37</sup> More recently, Azerbaijan and Armenia saw wide (and decisive!) use of UAVs in the latter half of 2020. Autonomous UAVs can now execute accurate strikes against ground targets carrying out target selection and firing premised on AI (which is either on board or on a platform they are in data communication with). The MQ-9 Reaper has been used to test Agile Condor, an AI pod designed to detect, categorise and track potential objects of interest; this AI pod has the potential to identify targets and determine priorities for engagement. The loyal wingman UAV developed by Boeing for RAAF has similar target detection, prioritisation and engagement capabilities, as claimed by Boeing. This is applicable to loitering munitions as well, AI enabling them to carry out their suicidal missions without an operator in the loop but investing them with enough autonomy to recover safely if no worthwhile target is unearthed. An interesting European project is NeurONN, a demonstrator for the development, integration and validation of European technologies for next-generation combat aircraft and UAVs. Russian UAVs Okhotnik and Grom (both with AI capability for working with fighters) have been mentioned earlier; Altius, Sirius and Orion are three other Russian UAVs with autonomous/semi-autonomous capabilities.

AI has been quietly and surreptitiously making its way into UAV operations and each episode of success for UAVs strengthens the motivation to embed AI in diverse forms to enhance their capabilities. The US Navy X-47B has demonstrated not only deck launches, landings and go-arounds, but even an aerial refuelling, all carried out autonomously.<sup>38</sup> The QF-16,

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37. Lee Ferran, "Early Predator Drone Pilot: I Had bin Laden in My Crosshairs", ABC News Network site, November 18, 2014, p. 1, at <https://abcnews.go.com/blogs/headlines/2014/11/first-pilot-to-fire-missile-from-predator-drone-breaks-silence>. Accessed on February 24, 2021.

38. Andy J. Fawkes and Lieutenant Colonel Martin Menzel, "The Future Role of Artificial Intelligence", *Joint Air Power Competence Centre Journal*, 27th edn., Autumn/Winter 2018, p. 72, at [https://www.japcc.org/wp-content/uploads/JAPCC\\_J27\\_screen.pdf](https://www.japcc.org/wp-content/uploads/JAPCC_J27_screen.pdf). Accessed on March 2, 2021.

an unmanned platform derived by converting old F-16s, has the capability to fly autonomously on predetermined routes for decoy roles or used as aerial targets for testing air-to-air missiles and guns. Looking ahead, it is easy to imagine UAVs that will be primed for fully autonomous missions with their designs hybrid to accommodate MUM-T errands when tasked to. Automatic target detection using optical, thermal and/or electromagnetic sensors would empower them for offensive roles while long-range sensors would render them invaluable for autonomous operations, including in hostile environments. A demonstration in 2020 showed a USAF MQ-9 Reaper engage a cruise missile using an AIM-9X air-to-air missile, thus revealing another aspect of AI-enabled UAVs' offensive potential.

Last year, US Army's Combat Capabilities Development Command (CCDC) released a Request for Information (RFI) for Air Launched Effects (ALE)<sup>39</sup> which would be a new family of UAVs air launched from scout and assault helicopters which would have multifarious capabilities including scout role, EW, attack, decoy, suicide munitions and swarm capabilities. The RFI stipulates that these UAVs need to be capable of semi-autonomous and fully autonomous operations and specifies that the camera systems on the UAVs would also be paired with AI-driven machine learning algorithms to automatically identify potential targets of interest. The steady rise of AI technologies is matched by the wants and needs of military aviation for a wide spectrum of AI capabilities.

Several spectacular demonstrations of UAVs operating in swarms have caught military attention in the recent past. Their small size and Radar Cross Section (RCS), low cost (permitting proliferate numbers to be used together), and AI to connect them together to seemingly think like one, makes UAV swarms objects of desire for military. Dramatic swarm attacks like the one on Saudi Aramco oil facilities at Abqaiq and Khurais in September 2019 have helped keep that interest live. DARPA's Offensive Swarm-Enabled Tactics

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39. Joseph Trevithick, "The Army Has Unveiled Its Plan for Swarms of Electronic Warfare Enabled Air-Launched Drones", *The Drive*, August 20, 2020, p. 1, at <https://www.thedrive.com/the-war-zone/35726/the-army-has-unveiled-its-plan-for-swarms-of-electronic-warfare-enabled-air-launched-drones>. Accessed on March 3, 2021.

(OFFSET)<sup>40</sup> programme has contracted with nine companies to develop AI technology that will enable 250 small air and/or ground units to collaborate; aimed primarily at facilitating operations in dense urban environments, the programme showcases the promise of swarming UAVs. The interest in swarming UAVs is not restricted to US military only. China is making significant strides in that direction as also the European Union where several joint military programmes are on to produce AI-driven swarm technologies; the DRONEDGE-E project, for example, is aimed at designing an edge computing platform for the autonomous control of UAV swarms in real time with automatic generation of algorithms through AI. Details of some other swarm related projects can be found in a recent document called “Artificial Intelligence in European Defence: Autonomous Armament?”<sup>41</sup> authored by GUE/NGL, the left-wing group of the European Parliament. Roborder is another European project that is aimed at developing AI-piloted UAVs which would be tasked to patrol European borders autonomously; working in swarms, these UAVs will corroborate and coordinate information among air, ground and seaborne platforms.

Edge computing,<sup>42</sup> already being talked about as the next major revolution in information technology, is the emerging solution to the problem that, when it comes to high speed, highly manoeuvrable swarm UAVs collaborating with each other tactically in close proximity to each other and to hostile aerial platforms, cloud computing is too slow for their cooperative communication. Edge computing eliminates the time taken for devices/UAVs to communicate through cloud computing (which connects through centralised data centres or servers) and processes data on the spot at the “edge” of the network,

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40. DARPA Outreach, “OFFSET Awards Contracts to Advance Swarm Tactics for Urban Missions, Enhance physical Testbeds”, April 13, 2020, p. 1, at <https://www.darpa.mil/news-events/2020-04-13#:~:text=DARPA%20has%20awarded%20contracts%20to,operate%20in%20dense%20urban%20environments>. Accessed on February 14, 2021.

41. Christoph Marischka, *Artificial Intelligence in European Defence: Autonomous Armament?* (THE LEFT Group in the European Parliament: Brussels, 2020), pp. 28-30, at <https://documentcloud.adobe.com/link/track?uri=urn%3Aaaid%3Aascds%3AUS%3A1884c966-f618-4110-a5f3-678899e4c8ee#pageNum=1>. Accessed on March 5, 2021.

42. Paul Miller, “What is edge computing?”, *The Verge*, May 7, 2018, p. 1, at <https://www.theverge.com/circuitbreaker/2018/5/7/17327584/edge-computing-cloud-google-microsoft-apple-amazon>. Accessed on March 6, 2021.

**Mosaic warfare visualises all military forces as plug and play tiles that conjointly form a mosaic which is constantly morphing with changing circumstances.**

i.e., at or near the source of the significant data. This munificence of the information technology is quintessential to the progression of swarm UAVs; so is their employment of AI. Their copious use in future military kinetic action can be predicted with no risk of being proved specious.

#### AI IN MOSAIC WARFARE

With manned and unmanned aerial platforms being operated by more than one service under the Joint All-Domain Command and Control (JADC2) operations concept, DARPA has an admirable project in hand called Air Space Total Awareness for Rapid Tactical Execution (ASTARTE)<sup>43</sup> as a part of its mosaic warfare programme. As the name suggests, mosaic warfare visualises all military forces as plug and play tiles that conjointly form a mosaic which is constantly morphing with changing circumstances. The ASTARTE programme has three parts: first, algorithms that identify and predict airspace usage conflicts and determine restricted operating zones; second, sensors that in real time can detect and track manned and unmanned platforms; and third, a virtual lab testbed that enables modelling, simulation, and virtualisation of military airspace management systems. The idea is to leverage AI to handle diverse data sets to prevent fratricide between different services and to facilitate continuation of mosaic warfare even when some of its components get attrited or are withdrawn.

North Atlantic Treaty Organisation (NATO) has similar plans to use AI to help multinational coordinated air attacks<sup>44</sup> by using a new Alliance Ground Surveillance (AGS) technology to connect USAF RQ-4D Phoenix Global Hawks which gather, organise, analyse, process and transmit ISR

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43. Theresa Hitchens, "DARPA Builds AI to Avoid Army, AF Fratricide", *Breaking Defense*, February 17, 2021, p. 1, at <https://breakingdefense.com/2021/02/darpa-builds-ai-to-avoid-army-af-fratricide/>. Accessed on March 6, 2021.

44. Kris Osborn, "Upgrade You: NATO's Global Hawk Drones Are About to Get Even Better", March 9, 2021, p. 1, at <https://nationalinterest.org/blog/buzz/upgrade-you-nato%E2%80%99s-global-hawk-drones-are-about-get-even-better-179711>. Accessed on March 10, 2021.

data among platforms from other member nations (of NATO). The objective is to enable uninterrupted operations. The two illustrations cited above are just a whiff of how AI is being yoked to reinforce operations; many other applications of AI exist, or are emerging. DARPA itself has approximately 30 programs focused on AI and another 90 that are leveraging AI technologies, according to Matthew Turek, programme manager in DARPA's Information Innovation Office.<sup>45</sup>

#### AI IN TRAINING AND SIMULATION

USAF has been exploiting AI for accelerating pilot training through its Pilot Training Next (PTN) programme since 2018 with some remarkable success in speeding up the training and in the assessed quality of programme graduates. When Virtual Reality (VR) was added on to AI, the training became even better and meaningful. As one instructor put it, "Students that get into the seat and start flying in the virtual environment are reacting like they would in the actual aircraft within minutes."<sup>46</sup> AI, in tandem with VR and high-volume data analytics, was instrumental in garnering and analysing the feedback from the trainees' actions thus empowering the instructors with individual training and correctional requirements for each trainee. Another development enabled by AI in pilot training is Live, Virtual and Constructive (LVC) training: Live refers to a pilot in an actual cockpit, Virtual relates to a pilot in an aircraft simulator, and Constructive is a purely software simulated training asset. According to CAE, global leader in the development and

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45. GCN Staff, "DARPA developing AI into a mission-critical partner", *GCN Digital Version*, March 12, 2021, p. 1, at <https://gcn.com/articles/2021/03/12/darpa-ai-mission-partner.aspx>. Accessed on March 16, 2021.

46. Geneva Gaimo, "Pilot instructor training 'embraces change' through virtual reality", Air Education and Training Command official site, October 22, 2018, p. 1, at <https://www.aetc.af.mil/News/Article-Display/Article/1667413/pilot-instructor-training-embraces-change-through-virtual-reality/>. Accessed on February 3, 2021.

delivery of integrated LVC training solutions for defence forces, “A truly integrated LVC training environment also provides infinite space to conduct training, variable threats needed for added realism, and the ability to test and exercise fifth generation platforms.<sup>47</sup>” This capability is critical to training for, say, the fifth-generation F-35, which does not have a dual seat version at all, all three versions being single-seat!<sup>48</sup> Worthy of mention here is USAF’s RPA Pilot Training Next (RPA: Remotely Piloted Aircraft) which has advanced AI infusion that helps faster and more efficient pilot training with provision to cater to their individual training needs as assessed by AI.<sup>49</sup>

The Chinese have also been planning to achieve similar arrangements using L-15 jet trainer aircraft; reportedly, the aircraft would be fitted with an AI-driven virtual tactical training system which could be linked to other aircraft or a ground simulator with the two being interconnected. According to *Global Times*, a Chinese English newspaper, Zhang Lang, L-15’s Chief Designer, has reportedly stated that, “With the development of AI technologies in the future, we will be able to identify different habits each pilot has in flying...”<sup>50</sup>

Akin to AlphaDogFight (and indeed based on it), there are projects afoot to provide pilots in real aircraft but with Augmented Reality (AR) headsets to pit their combat skills against AI driven virtual fighters mimicking enemy aircraft. One remarkable experiment in this direction was the AR dogfight between a Berkut 540, a US-made piston engine, canard wing, pusher type, under one ton aircraft, and a simulated Chinese J-20 created by technology from EpiSci, a US-based AI company.<sup>51</sup> Clearly, AI, in tandem with VR

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47. CAE, “Live-Virtual-Constructive (LVC) Training”, CAE official site, undated, p. 1, at <https://www.cae.com/defence-security/training-systems-integration/live-virtual-constructive-lvc-training-1/>. Accessed on March 18, 2021.

48. “The Most Advanced Fighter Jet in the World”, at Lockheed Martin official site, undated, p. 1, at <https://www.lockheedmartin.com/en-us/products/f-35/f-35-about.html>. Accessed on March 15, 2021.

49. “Air Force flight training experts eye artificial intelligence (AI) to help hone skills of unmanned pilots”, July 2, 2020, p. 1, at <https://www.militaryaerospace.com/unmanned/article/14178834/artificial-intelligence-ai-unmanned-flight-training>. Accessed on February 6, 2021.

50. Liu Xuanzun, “China’s future fighter trainer could feature AI to boost pilot’s combat capability: top designer”, *Global Times*, November 15, 2020, p. 1, at <https://www.globaltimes.cn/content/1206906.shtml>. Accessed on February 8, 2021.

51. Thomas Nedwick, “Pilot in a Real Aircraft Just Fought an AI-Driven Virtual Enemy Jet for the First Time”, *The Drive*, November 16, 2020, p. 1, at <https://www.thedrive.com/the-war->

and AR, is moving at an impressive pace towards providing speedier and superior training and simulation solutions for military aviation.

### **AI AND AIRCRAFT MAINTENANCE**

Aircraft maintenance is hugely expensive and any reduction in maintenance repairs or replacements can save large amounts of money while maintenance lapses or material/component failures before prescribed schedules can have air safety implications, not to mention expensive hull losses and catastrophic pilot casualties. AI is proving to be a useful tool in predictive and preventive maintenance. Preventive maintenance is regular and routine maintenance so as to keep an aircraft flying and prevent any costly unplanned downtime from unexpected equipment failure. Predictive maintenance uses AI and data analytical tools to predict how long an aircraft component will last and can be seen as a subset of preventive maintenance. Early endeavours to automate preventive maintenance date back to Lockheed Martin's Autonomic Logistics Information System (ALIS) designed for the F-35 in 2015 but, since then, technologies (and especially AI/ML technologies) have come a long distance.

USAF has four Advanced Technology and Training Centres (ATTCs); the one in Pittsburgh, a city considered a hub in the industry of robotics, AI and machine learning, has been tasked to develop, among others, predictive maintenance algorithms that will identify potential maintenance issues on aircraft faster. According to Nathan Parker, USAF Rapid Sustainment Office (RSO), "Historically, 70 percent of weapon system lifecycle costs are in the operation and sustainment phase. The ATTCs are one tool to help reduce future costs..." The RSO is also working with C3.ai since 2017 and is now expanding that relationship for more predictive analytics while JAIC issued an RFI last year for a Holistic Aircraft Component Health Predictor (HAC-HP) programme for the H-60 helicopter. These are some of the programmes that showcase AI/ML in preventive/predictive maintenance.

Predictive maintenance is theoretically possible based on what has happened in the past; it is but the use of data and ML techniques to identify the probabilities

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[zone/37647/pilot-in-a-real-aircraft-just-fought-an-ai-driven-virtual-enemy-jet-for-the-first-time](https://www.airpowerjournal.com/zone/37647/pilot-in-a-real-aircraft-just-fought-an-ai-driven-virtual-enemy-jet-for-the-first-time). Accessed on February 7, 2021.

of future outcomes based on historical data. The problem is that with complex technologies and exceptional data collection tools, the quantum of data that needs to be analysed has grown tremendously. The information overload makes manual analysis impossible and that is where AI-powered predictive analysis comes in for handling “big data”, a term first used in 1997 to describe data sets that “are generally large, taxing the capabilities of main memory, local disk, and even remote disk.” Today’s context of cloud computing renders that definition mirthful but certainly the term big data can be visualised as data that cannot be handled by computers without machine learning to assist (and, of course, extensive server space on cloud). The use of AI/ML to handle big data by software designed for use on board UAVs under Project Maven is in trouble (discussed later), but use of AI/ML for preventive and predictive maintenance does not invite the same objections that Project Maven did.

USAF has two initiatives for predictive maintenance: Condition Based Maintenance Plus (CBM+) being used for B-1, C-5 and KC-135 aircraft, and Enhanced Reliability Centred Maintenance (ERCM) which has a large number of aircraft and weapon systems under it with more being added. These are but two of the predictive maintenance programmes using AI/ML for predictive maintenance while JAIC has other projects too in various stages of fruition.<sup>52</sup> Although maintenance activities are not as visible as the operations end, the deployment of AI into the maintenance domain is certainly a largesse that military aviation can benefit from, and be grateful for.

### **ETHICS IN MILITARY AI**

Henry Kissinger, former US Secretary of State and National Security Advisor (NSA), writing in 2018 about AI, raised a profound and ponderable question, “...It may be impossible to temper those mistakes, as researchers in AI often suggest, by including in a program caveats

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52. Frank Wolfe, “Air Force to Add 12 Weapons Systems for AI/ML-Informed Predictive Maintenance This Year”, July 9, 2020, p. 1, at <https://www.defensedaily.com/air-force-add-12-weapons-systems-ai-ml-informed-predictive-maintenance-year/army/>. Accessed on March 12, 2021.

Full recording of Mitchell Institute for Aerospace Studies virtual discussion with Lt Gen Warren Berry can be viewed at [https://www.youtube.com/watch?v=Zaezgg9xjN0&ab\\_channel=TheMitchellInstituteforAerospaceStudies](https://www.youtube.com/watch?v=Zaezgg9xjN0&ab_channel=TheMitchellInstituteforAerospaceStudies). Accessed on February 15, 2021.

requiring ‘ethical’ or ‘reasonable’ outcomes. Entire academic disciplines have arisen out of humanity’s inability to agree upon how to define these terms. Should AI therefore become their arbiter?<sup>53</sup> Many individuals and groups before that have articulated misgivings about the increasing role of AI in military spheres. Since October 2012, a “Campaign to Stop Killer Robots”, a coalition of Non-Governmental Organisations (NGOs), has been opposing fully autonomous weapons on the grounds that they, as machines, “would lack the inherently human characteristics such as compassion that are necessary to make complex ethical choices”,<sup>54</sup> and canvassing for a complete ban on their development, production and use. Another notable initiative is a “pledge”<sup>55</sup> introduced by the Future of Life Institute, a Boston-based charity organisation, which avers that AI developments can contribute to future danger. Elon Musk and Google’s DeepMind co-founders Demis Hassabis, Shane Legg and Mustafa Suleyman are among the (more than 3,000) individual signatories; a large number of organisations have also signed up.

Within the US, which is currently the leading global military AI power, there is noteworthy opposition to military use of AI; one DoD programme that has brought this to the fore is Project Maven. Also called Algorithmic Warfare Cross-Function Team, or AWCFT, it was launched in April 2017 and is aimed at developing and deploying AI-based algorithms to integrate and manage big data—largely video collected in support of counter-insurgency and counterterrorism operations—into actionable intelligence; a major thrust was analysis of videos amassed by UAV missions. In 2018, around 3,000 Google employees, fearing that the project would eventually be used for military purposes, signed an open letter affirming their belief that Google should not be in the business of war to Sunder Pichai, CEO, who then

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53. Henry A. Kissinger, “How the Enlightenment Ends”, *The Atlantic*, June 2018, p. 1, at <https://www.theatlantic.com/magazine/archive/2018/06/henry-kissinger-ai-could-mean-the-end-of-human-history/559124/>. Accessed on March 3, 2021.

54. Campaign to Stop Killer Robots official site, “The Problem”, p. 1, at <https://www.stopkillerrobots.org/learn/>. Accessed on February 4, 2021.

55. Future of Life Institute, “Lethal Autonomous Weapons Pledge”, Future of Life Institute official site, p. 1, at <https://futureoflife.org/lethal-autonomous-weapons-pledge/>. Accessed on February 7, 2021.

**The outcry over Project Maven and the trepidation over possible civilian casualties led DARPA to launch a programme called Urban Reconnaissance through Supervised Autonomy (URSA); its most innovative feature is the inclusion of ethics from the very start and to develop technology to enable autonomous systems that US ground forces supervise and operate to detect hostile forces and establish positive identification before any US troops or UAVs assault them.**

published on his blog seven “Objectives for AI Applications”<sup>56</sup> and also a list of what AI applications Google would not pursue. Eventually Google bowed out of the Project but not before posting a sticky note on public attention about ethics in military use of AI. In February 2020, DoD was forced to adopt ethical principles for AI and designate JAIC as the nodal implementation agency.<sup>57</sup> At least one analyst has identified an “ethics gap”<sup>58</sup>—the higher ethical hurdle that the US faces as compared to its adversaries (mainly China) to developing and deploying military AI.

In 2012, US DoD had issued a directive on AI that specified that, “Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate

levels of human judgment over the use of force.”<sup>59</sup> The outcry over Project Maven and the trepidation over possible civilian casualties led DARPA to launch a programme called Urban Reconnaissance through Supervised

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56. Sunder Pichai, “AI at Google: our principles”, *blog.google*, June 7, 2018, p. 1, at <https://blog.google/technology/ai/ai-principles/>. Accessed on February 3, 2021.

57. US Department of Defense, “DOD Adopts Ethical Principles for Artificial Intelligence”, US DoD official site, February 24, 2020, p. 1, at <https://www.defense.gov/Newsroom/Releases/Release/Article/2091996/dod-adopts-ethical-principles-for-artificial-intelligence/>. Accessed on March 5, 2021.

58. Benjamin Boudreaux, “Does the US Face an AI Ethics Gap?”, *RAND blog*, January 11, 2019, p. 1, at <https://www.rand.org/blog/2019/01/does-the-us-face-an-ai-ethics-gap.html>. Accessed on February 7, 2021.

59. US Department of Defense, “Directive No. 3000.09”, US DoD official site, November 21, 2012, amended on May 8, 2017, p. 1, sub-para 4.a.(1), at <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/300009p.pdf>. Accessed on March 9, 2021.

Autonomy (URSA);<sup>60</sup> its most innovative feature is the inclusion of ethics from the very start and to develop technology to enable autonomous systems that US ground forces supervise and operate to detect hostile forces and establish positive identification before any US troops or UAVs assault them. DoD stresses that humans will continue to make the final decision on whether to escalate or reduce response to a perceived threat with URSA, providing additional intelligence for that decision making.

**Military AI is inevitable and the US, although shackled by public opinion in this regard, would have to accept that and continue to try and get ahead of China even in the face of public opprobrium. Alternatively, it could lose out to China.**

Military AI opponents' perceived inescapability of a human brain in weapon use is based on distrust in AI-driven autonomous weapons which, they argue, could be less ethical than human operators in the context of International Humanitarian Law (IHL) premised on the principles of humanity and of military necessity. Arguments have been offered to the contrary<sup>61</sup> suggesting that AI systems can be programmed to comply with IHL and would be more likely to follow them than humans who can forget them or disregard them due to a whole range of human emotions, cognitive biases and beliefs in the fog of war. DoD's official adoption of a series of ethical principles for AI was a bid to assuage public apprehensions about ethics of using AI so that the US could continue working towards maintaining the lead in AI (which is threatened by a speedily gaining China). Military AI is inevitable and the US, although shackled by public opinion in this regard, would have to accept that and continue to try and get ahead of China even in the face of public opprobrium. Alternatively, it could lose out to China.

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60. Bartlett Russell, "Urban Reconnaissance through Supervised Autonomy (URSA)", DARPA official site, undated, p. 1, at <https://www.darpa.mil/program/urban-reconnaissance-through-supervised-autonomy>. Accessed on March 7, 2021.

61. Adriel Hampton, "What if autonomous weapons are more ethical than humans?", in *Extra News Feed*, December 9, 2020, p. 1, at <https://extranewsfeed.com/what-if-autonomous-weapons-are-more-ethical-than-humans-5369890659cf>. Accessed on March 11, 2021.

The UN Convention on Certain Conventional Weapons (UNCCW), also known as the Inhumane Weapons Convention, has the stated purpose to ban or restrict the use of specific types of weapons that are considered to cause unnecessary or unjustifiable suffering to combatants or to affect civilians indiscriminately. Since 2014, it has included in its gambit “emerging technologies in the area of Lethal Autonomous Weapon Systems (LAWS).”<sup>62</sup> US DoD defines an autonomous weapon system as “a weapon system that, once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation.”<sup>63</sup> In 2019, UNCCW adopted 11 guiding principles on LAWS; the first one reiterates that IHL continues to apply to development and use of LAWS. However, only 97 nations have openly revealed their thinking on banning of LAWS; indeed, some—like Australia—have official, documented policies on ethical use of military AI.<sup>64</sup> Significantly, in UNCCW, Australia, France, Germany, Israel, New Zealand, Russia, South Korea, Spain, Turkey, the UK and the US have consistently opposed any ban,<sup>65</sup> while China has supported a ban on the use, but not on development, of LAWS. Thus, banning of LAWS (with repercussions on military use of AI) appears to be a distant dream.

Despite strong criticism of AI controlled weapon systems, global consensus on military AI appears to be a distant dream but a G-7 backed

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62. UN official site, “Background on LAWS in the CCW”, p. 1, at <https://www.un.org/disarmament/the-convention-on-certain-conventional-weapons/background-on-laws-in-the-ccw/>. Accessed on March 4, 2021.

63. US Department of Defense, “Directive No 3000.09”, US DoD official site, November 21, 2012, amended on May 8, 2017, p. 1, at <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/300009p.pdf>. Accessed on March 9, 2021.

64. Kate Devitt, Michael Gan, Jason Scholz and Robert Bolia, “A Method for Ethical AI in Defence” (Canberra: Aerospace Division, Defence Science and Technology Group, Australian Government Department of Defence, accessed on February, 2020), at <https://www.dst.defence.gov.au/sites/default/files/publications/documents/A%20Method%20for%20Ethical%20AI%20in%20Defence.pdf>. Accessed on March 9, 2021.

65. Kelley M. Sayler and Michael Moodle, “International Discussions Concerning Lethal Autonomous Weapon Systems”, Congressional Research Service, US Congress, p. 1, at <https://fas.org/sgp/crs/weapons/IF11294.pdf>. Accessed on March 6, 2021.

initiative called Global Partnership for Artificial Intelligence (GPAI) aims to bridge the gap between theory and practice on AI by supporting cutting-edge research and applied activities on AI-related priorities. India is a founding member while China is conspicuous by its absence; clearly its government is blinkered with respect to its objective of leading the world in AI by 2030. Ethics do not seem to be a serious consideration for China and the result could be that other players too may be compelled to disregard ethical and legal issues in pursuit of AI supremacy.

### **CONCLUDING REMARKS**

The penetration of AI into military aviation is inexorable and unlikely to be thwarted by protestations at national, public or organisational levels. Given UN's record at securing consensus on international treaties, ongoing (and rather inordinately slow-moving) proceedings of UNCCCW are unlikely to stop (or even slow down) the rapid advances being tendered by AI to military aviation. The projects and programmes outlined above are constantly being incrementally rendered more and more ambitious by the expanding potential of AI to enrich and enhance them. The single most significant AI munificence promises to be AI in the cockpit with the competence to autonomously fly an aircraft in its full spectrum of roles. That is not within reach of current day technology despite the sensational AlphaDogFight demonstration, but it is not hard to visualise it happening over the next few years. Besides cockpit AI, connectivity between manned and unmanned elements of the envisioned teams is going to be a problem with edge computing still not ready to deliver at speeds needed for aerial combat in teams. When that becomes possible, ethical demurrals are unlikely to be able to stop solo flights by AI in military aircraft because of the immense advantages intrinsic to that option. Meanwhile apprehensions about AI's ethical credentials for occupying a cockpit are being assuaged by projecting the near future as a manned and unmanned teamwork with a human in command of a mission and all its elements (in contrast to an autonomous decision-making AI in any cockpit).

Size, Weight and Power Consumption (SWaP) is critical to embedded AI in avionics, and technology is obsessed with reducing this set of parameters to make AI more usable and deployable. Another innovation is neuromorphic computing which endeavours to mimic the human brain's neural structure so as to reinforce what Intel calls the "third generation of AI"<sup>66</sup> dealing with human cognition, interpretation and autonomous adaptation. As these advances provoke AI to imitate human brain functions with increasing fidelity and reducing proneness to failure, the prospect of an AI-manned cockpit executing an autonomous mission becomes brighter and closer.

While the military world awaits that significant leap, the other benefits of AI in military aviation are worth exulting over. On the downside, with US and China grappling for the lead in AI and with AI gaining more and more leverage in military spheres, a Cold War kind of situation, replete with implacable distrust, deadly subterfuge and unyielding rivalry is already upon us. With an impressive number of AI companies, a very fecund start-up ecosystem, a highly productive scientific academia, and the world's fourth largest Air Force, India is at a rallying point of all the ingredients for inducting AI into its labouring aerospace industry. On January 15, 2021, the Indian Army staged an impressive demonstration with 75 UAVs in offensive roles; notwithstanding that demonstration, the ingress of AI into Indian military aviation is not consistent with the potential described above. Reports at the time of writing this prognosticate government's approval for development of India's Advanced Medium Combat Aircraft (AMCA); when that happens, it would be time to harness our best AI academic, technological and industry assets so as to endow the AMCA with the best in AI. Whether that campaign is spearheaded by an internally inefficient public sector, or an eager but deprived private sector, would decide the level of exploitation that India derives from AI in military aviation.

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66. "Neuromorphic Computing", Intel official site, p. 1, at <https://www.intel.in/content/www/in/en/research/neuromorphic-computing.html>. Accessed on March 14, 2021.

# WELCOME STEPS TOWARDS AN INDIGENOUSLY EQUIPPED INDIAN AIR FORCE

VIVEK KAPUR

## INTRODUCTION

The Indian Air Force (IAF) was formed on October 8, 1932 with the first flight of its No. 1 Squadron realised on the ground in April 1933 at Drigh Road Airfield, Karachi with four Westland Wapiti-II biplanes.<sup>1</sup> India was a colony ruled by the British, and it was only to be expected that the IAF would utilise imported British equipment. This was what happened. In later years, whenever equipment of British origin was unavailable or could not be obtained, aircraft, such as the DC-3/C-47 'Dakota', were sourced from Britain's former colony and close ally, the USA. This situation of utilising imported British or American equipment continued until India gained independence in 1947. For a variety of reasons that span the full gamut from policy decisions at the highest levels to the more technical and technological, IAF has continued (even after 1947) to be equipped primarily with imported equipment, albeit sourced from a wider selection of suppliers than was possible prior to 1947.

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Group Captain (Veteran) **Vivek Kapur**, PhD, MBA, served in IAF flying mostly MiG-21s and MiG-29s and has extensive instructional, operational and command experience on these aircraft. He earned his MBA from DU/FMS in 2009 and PhD from JNU/SIS in 2016. He currently resides in Secunderabad and pursues his personal interests.

1. Indian Air Force, "History of IAF", at <https://indianairforce.nic.in/content/history-iaf-0>. Accessed on March 8, 2021.

**Today, after a long time, there are unmistakable trends that point towards a future IAF equipped with cutting-edge equipment spanning from aerial platforms, sensors and advanced weapons designed, developed and manufactured in India. Several tests of equipment under development, and mature equipment undergoing pre-induction trials by the armed forces that are reported in the media, lead to this optimism.**

It should be clear to all strategically minded readers that at the end of the day when the chips are down one can depend only on what strength one *actually possesses*. Therefore, it is important for a country to own the technology and all aspects of the equipment that a country's armed forces need to utilise.

Today, after a long time, there are unmistakable trends that point towards a future IAF equipped with cutting-edge equipment spanning from aerial platforms, sensors and advanced weapons designed, developed and manufactured in India. Several tests of equipment under development, and mature equipment undergoing pre-induction trials by the armed forces that are reported in the media, lead to this optimism. Several

weapon systems under induction, or in late-stage development by the country's scientific and industrial agencies, are comparable with similar equipment available from foreign vendors. There are other weapons, such as the Brahmos supersonic cruise missile in its surface, air and sea-launched variants,<sup>2</sup> that are superior to most equivalent foreign weapons. This bodes well for the overall power of the country and the effectiveness of the IAF in carrying out its assigned tasks well.

## **DESIGN, DEVELOP AND BUILD Vs BUY/IMPORT**

Importing equipment from foreign vendors has advantages as well as risks. These are discussed below:

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2. "India successfully tests air and land-based variants of the BrahMos missile", PTI, December 17, 2019, at <https://www.theweek.in/news/india/2019/12/17/india-successfully-tests-air-and-land-based-variants-of-the-brahmos-missile.html>. Accessed on March 12, 2021.

**Advantages of Importing***Ready and Relatively Quick*

Through import, a country gets to induct ready weapons systems that have already gone through design, development, testing, evaluation, and manufacture processes in the country of origin and could already, in most cases, be in military service. This greatly reduces the risk for the buyer country in inducting a proven product that will work as expected. In contrast, indigenously developed equipment requires a lot of painstaking work in design and development of the sub-parts and systems that would make up the final product. In this process, it is quite likely that several avenues of research may lead to dead ends, which necessitate the exploring

of alternative methods to develop the required technology. This is likely to result in cost and time overruns. If the development teams are unable to resolve, or work around an issue, the entire project may get stuck with no final weapon system emerging, or a weapon system being offered for production and induction that does not meet all requirements. For instance, the Indian HF-24 “Marut” fighter, designed at HAL by a team led by Professor Kurt Tank (the German designer and test pilot who designed the famous and very successful Luftwaffe combat aircraft, the Focke Wulf Fw-190 fighter, of World War II<sup>3</sup>), was planned to be powered by two British Orpheus 12 afterburner equipped jet engines, each delivering a thrust of 3,705 kilograms static thrust (kgst).<sup>4</sup> Due to the engine not being developed by Britain, for its own reasons, the HF-24 team was forced to use the one

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3. John Zukowsky, “Kurt Tank German aircraft designer and test pilot”, February 20, 2021, at <https://www.britannica.com/biography/Kurt-Tank>. Accessed on March 14, 2021.

4. V. Narayan, “Indian Aviation—HF-24 Marut, first Indian designed jet fighter”, 2014, at <http://www.teambhp.com/forum/commercial-vehicles-india/159928-indian-aviation-hal-hf-24-marut-firstindian-jet-fighter.html>. Accessed on March 12, 2021.

available in India through the earlier Gnat programme. This was the non-afterburning Orpheus 703 engine that delivered only 2,200 kgst, which left the HF-24 with a total thrust deficiency of 3,010 kgst (deficiency in thrust from planned figures of 1,505 kgst per engine for the twin-engine fighter). With the reduced thrust the HF-24 was unable to meet all the performance parameters desired by the IAF. Thus, there is great benefit in reduced risk and potentially quicker availability of importing weapons systems and allied equipment from countries that have already developed and manufactured them.

### **Disadvantages of Importing**

#### *Limitations in Availability of High-Technology Platforms and Weapons*

No country is usually willing to export its very best equipment to other countries, irrespective of how close their ties might be. One reason for this is that nation states realise that it is quite possible for today's friends to become tomorrow's foes. In such a case, one would have exposed one's best equipment to a potential foe. In the fluid world of global geopolitics, it can never be certain that today's ally will not become an enemy in later years. For instance, the two large communist countries, the People's Republic of China (PRC) and the Union of Soviet Socialist Republics (USSR) were close allies based upon their shared communist ideology, with the USSR providing extensive assistance on favourable terms to the vastly less advanced PRC in the fields of industry, agriculture, military operational techniques and military hardware manufacturing from the time that the PRC was formed in 1949.<sup>5</sup> There was a split between these close allies that lasted from 1960 till 1989. During this period, in March 1969, the two countries clashed militarily near the Damanski island on the Ussuri river, resulting in tens of casualties, and raising the prospect of an all-out Sino-Soviet war, or even a Soviet nuclear attack on China.<sup>6</sup> Today, after the dismantlement of the USSR in

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5. "Establishment of the People's Republic", Britannica.com, at <https://www.britannica.com/place/China/Establishment-of-the-Peoples-Republic>. Accessed on March 10, 2021.

6. "The Sino-Soviet Border Conflict, 1969: US Reactions and Diplomatic Maneuvers", National Security Archive Electronic Briefing Book No. 49, edited by William Burr, June 12, 2001, at <https://nsarchive2.gwu.edu/NSAEBB/NSAEBB49/index2.html>. Accessed on March 10, 2021.

1991,<sup>7</sup> the PRC and Russia are again close allies.<sup>8</sup> This shows the extreme uncertainty about who will be friends and foes in the real world over a period of time.

### *Reluctance to Export*

The other possible cause for reluctance to export the best equipment could be the need to protect intellectual property (IP), developed with great effort and cost, from being copied by potential competitors and inadvertently leaked to enemies. The US has not exported its nuclear-powered super aircraft carriers, strategic bombers, such as the B-52, B-1, and B-2, or nuclear-powered submarines to any country, and is yet to permit export of its Lockheed F-22 “Raptor” Fifth-Generation fighter to even its closest allies. The Obey Amendment<sup>9</sup> to the 1998 Department of Defense Appropriations Act specifically prohibits the sale of the F-22 and its technology to even the closest of US’ allies, such as Israel, Japan, and the UK, let alone any other countries. The Research and Development cost of US\$ 62 billion of the F-22 programme led to its being the costliest fighter programme ever, until it was overtaken by the F-35 “Lightning-II” programme,<sup>10</sup> and ultimately the high cost of the F-22 led to the F-22 “Raptor” programme being terminated prematurely. On May 3, 2012 Lockheed delivered the 195th F-22, the last aircraft of the truncated contract, against the originally planned 750 aircraft procurement, to the USAF, and commenced mothballing the production facilities.<sup>11</sup> Despite the cost limitations due to a relatively small production run, the US Government has not lifted the Obey Amendment out of fears

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7. Adam Janos, “Was the Soviet Union’s Collapse Inevitable?”, April 17, 2018, at <https://www.history.com/news/why-did-soviet-union-fall>. Accessed on March 13, 2021.

8. Melinda Liu, “Xi Jinping Has Embraced Vladimir Putin—for Now”, October 3, 2019, at <https://foreignpolicy.com/2019/10/03/xi-jinping-has-embraced-vladimir-putin-for-now/>. Accessed on March 13, 2021.

9. Blake Stilwell, “This is why the US never exported the deadly F-22”, May 22, 2020, at <https://www.wearethemighty.com/mighty-tactical/why-f-22-never-exported/>. Accessed on March 7, 2021.

10. Sébastien Roblin, “The Air Force admits the F-35 fighter jet costs too much. So it wants to spend even more.”, March 7, 2021, at <https://www.nbcnews.com/think/opinion/air-force-admits-f-35-fighter-jet-costs-too-much-ncna1259781>. Accessed on March 10, 2021.

11. Jeremiah Gertler, “Air Force F-22 Fighter Program”, July 11, 2013, at <https://fas.org/sgp/crs/weapons/RL31673.pdf>, pp. 2-10. Accessed on March 10, 2021.

that the very high technology developed for and used in the F-22 could leak to countries such as People's Republic of China (PRC) and Russia.

*Possible Difficulties in Procurement of Supplies of Spares*

Another important drawback of reliance on aircraft and equipment imported from another country is the possibility of it becoming unusable in case the regular supply of spare parts, etc., is disrupted for any reason. Imperial Russia, under the Tsars in the first few years of the 20th century, though a great power of the time, lagged behind other European countries in technological prowess. Tsar Nickolas II earmarked one million roubles to add an aviation arm to the Russian military in 1909. However, due to lack of advanced aircraft availability in Russia, the aircraft were imported from France and Britain. By mid-1914 the Imperial Russian Military could boast of the largest military air arm in Europe, after France. The aircraft of the Russian air arm, however, were either direct imports or licence-built foreign designs.

During World War I German blockades of ports and the geographical fact that the common hostile country, Germany, lay between Russia and France and Great Britain—the source countries of the Russian Air Force's equipment—led to a severe shortage of spare parts and essential equipment. This rendered Russia's large and 'on paper' potent air arm practically useless against the enemy.<sup>12</sup> More recently, India faced a similar issue with some of its imported equipment. After Pokhran-II nuclear weapon tests in May 1998, the US and its close allies imposed sanctions on India resulting in stoppage of supply of spare parts for the Indian Navy's fleet of Sea King helicopters. As a result, these helicopters became less operationally available till some urgently needed parts were manufactured in India's HAL.<sup>13</sup> Reliance on imported equipment renders a country vulnerable to disruption in the supply of essential spare parts to keep the imported equipment serviceable and available. Disruption in the smooth supply of spares can render the imported

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12. Vivek Kapur, *Indian Aircraft Industry Possible Innovations for Success in the Twenty-first Century* (New Delhi: KW Publishers Pvt. Ltd., 2017), pp. 205, 206.

13. Sangeeta Saxena, "IMP Aerospace & Defence hopeful of keeping Indian Navy's Sea Kings flying", July 20, 2018, at <https://www.aviation-defence-universe.com/imp-aerospace-defence-hopeful-of-keeping-indian-navys-sea-kings-flying/>. Accessed on March 12, 2021.

equipment unavailable and near useless. This is possibly the greatest danger and risk of reliance on imported aircraft and allied equipment. Hence it is essential to a country striving to develop its power to invest in design, development and manufacture of the military equipment that it needs.

- Disruptions for any reason in the source country can also have serious consequences for one's own military equipment. More than 60 per cent to 70 per cent of India's military equipment, in the late 1980s and early 1990s, was sourced from the former Soviet Union and its successor state, the Russian Federation.<sup>14</sup> When the former Soviet Union disintegrated, some factories that supplied spare parts to India were within the new Russian Federation while others came to be located in the now newly independent countries such as Ukraine, etc. The relatively smooth supply lines for spares were severely disrupted. This caused great problems to India's defence forces in keeping Soviet/Russian origin equipment serviceable. An analogy is useful here to illustrate the main point. To become strong and powerful, a person cannot go to a shop and buy a few kilos of, say, biceps or other muscles and become powerful. It is only through discipline and hard work involving the required physical effort of exercising and disciplined eating that a person can become powerful. The same applies to an air force, or any other kind of power, military or economic/industrial. In order to build a powerful air force, the aircraft and equipment as also the operational philosophy for the air force must be designed, developed, manufactured and conceptualised in the country itself. This is the path that has been followed by all the powerful air forces in the world, such as the British Royal Air Force (RAF) and German Luftwaffe of World War I and II, the USAF, the French *Armee de l'Air*, the Soviet Air Force, *Voyenno-Vozdushnye Sily* (VVS), Soviet Air Defence Forces, *Voyska Protivovozdushnoy Oborony* or *Voyska PVO*<sup>15</sup> and the PRC's

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14. Dipanjan Roy Chaudhary, "More-Than-60-70-of-India-Armed-Forces-Equipped-With-Russian-Origin-Weapons-Indian-Envoy", July 11, 2020, at <https://m.economictimes.com/news/defence/more-than-60-70-of-india-armed-forces-equipped-with-russian-origin-weapons-indian-envoy/articleshow/76903811.cms>. Accessed on March 13, 2021.

15. The Voskaya-PVO was a separate military service and not a part of the VVS in the Soviet military system.

**Induction of the IAF while under colonial rule comprised British aircraft for the most part with very few American aircraft types supplementing them. This was perhaps because the first aircraft building enterprise in India—the privately set up Hindustan Aeronautics Limited (HAL)—based at Bangalore had, at inception in December 1940, obtained a licence from the American companies to build the Curtiss Hawk biplane fighter and Vultee Vengeance dive bomber and Harlow trainer aircraft.**

People's Liberation Army Air Force (PLAAF). All these powerful air forces have reached their positions of globally recognised power through the tireless efforts of their scientific communities and military personnel towards developing and manufacturing the kind of equipment and usage philosophies that they needed.

#### **PAST IAF EQUIPPING**

##### *1932-1947*

At formation, IAF comprised four Westland Wapiti-IIA biplanes forming 'A' Flight of No. 1 (Army Cooperation) Squadron. In April 1936 'B' Flight was formed. 'C' Flight, formed in June 1938, brought the Squadron up to full

strength.<sup>16</sup> Thereafter, six coastal defence flights were formed equipped with Westland Wapiti-IIAs and later with Armstrong Whitworth Atlanta transports, while No. 1 Squadron converted from Wapitis to the Hawker Hart. By 1940, new aircraft, such as the British Lysander, Hurricane, and Spitfire as well as the American Vultee Vengeance and Douglas DC-3/C-47 "Dakota" were in service.<sup>17</sup> These were followed by the British Typhoons.

As could be expected, the induction of the IAF while under colonial rule comprised British aircraft for the most part with very few American aircraft types supplementing them. This was perhaps because the first aircraft building enterprise in India—the privately set up Hindustan Aeronautics Limited (HAL)—based at Bangalore had, at inception in December 1940, obtained

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16. Indian Air Force, n. 1.

17. Akshay Chavan, "Indian Air Force: The Beginnings", October 8, 2018, at <https://www.livehistoryindia.com/history-daily/2018/10/08/indian-air-force-the-beginnings>. Accessed on March 9, 2021.

a licence from the American companies to build the Curtiss Hawk biplane fighter and Vultee Vengeance dive bomber and Harlow trainer aircraft. At that time, the British had no equivalent transport aircraft to match the rugged and very widely used—hence readily available—C-47 “Dakota”.

### *1947 Onwards*

After Independence, the IAF initially sourced aircraft from the United Kingdom perhaps due to familiarity with their equipment.

Thus, the Percival Prentice trainer was inducted, followed by the Vampire fighter in several variants, some of which were manufactured in India at HAL under licence. The British Folland Gnat and Hawker Hunter followed, with the former manufactured under licence at HAL. The Hawker Siddeley HS 748 “Avro” was selected for licensed manufacture as the first transport/passenger/cargo aircraft to be built in India, initially by one of the IAF’s Base Repair Depots (BRD). Alongside British aircraft, the IAF also inducted aircraft from other countries, notably the French Dassault *Ouragan*, “*Toofani*” in Indian service, and the Mystère IV, also from Dassault. Later, the American C-119 “Packet” was inducted to augment the transport fleet.

IAF’s first jet bomber was the British Canberra while helicopters were initially sourced from the USSR, the Mi-4, followed by the Alouette-III and Lama from France, both of which were built under licence at HAL as the “Chetak” and “Cheetah”, respectively. Later the USSR was the supplier of the MiG-21, built under licence in India, and the Sukhoi Su-7BMK, also sourced from the USSR. The 1960s saw induction of India’s first indigenous fighter, the HF-24 “Marut”. The Soviet Ilyushin (Il)-14, Tupolev (Tu)-124 and Antonov An-12 augmented IAF’s transport fleet, while the Canadian DHC Caribou saw limited service, as did the Otter. The 1970s saw induction of the British Aerospace SEPECAT Jaguar strike aircraft, followed in the 1980s by

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the Soviet MiG-23MF, MiG-23BN, MiG-27, MiG-29 and French Mirage-2000. Further inductions included Soviet Il-76 heavy cargo aircraft in the 1980s. The 1990s saw Soviet surplus Sukhoi Su-27UB trainer variants of the Su-27 single-seat fighter aircraft, modified by the Russians to IAF requirements as the Su-30K/MKI heavy fighters. Alongside these inductions, the Light Combat Aircraft (LCA) continued development from 1983 onwards.<sup>18</sup> Delays in the delivery of the LCA led to legacy equipment being upgraded, the MiG-21bis was upgraded with Russian help to the MiG-21 Upgrade (UPG) “Bison”, the Mirage 2000 underwent an upgrade through the services of Dassault Aviation, and MiG-29B aircraft were upgraded with Russian help to the much more capable MiG-29UPG standard. The long awaited LCA was inducted into IAF service on July 1, 2016, albeit in its Initial Operational Clearance (IOC) version.<sup>19</sup> The Final Operation Clearance (FOC) variant of the LCA—which includes integration of many more capabilities over the IOC variant—was inducted into IAF’s No. 18 Squadron on May 27, 2020.<sup>20</sup> Meanwhile, upgradation of capabilities drove the formulation of the IAF’s Medium Multi-Role Combat Aircraft (MMRCA) competition. Contenders for this contract were the F-16-I “Viper”, JAS-39E/F “Gripen”, F-18E/F “Super Hornet”, EF2000 “Typhoon”, MiG-35, and Rafale. The Typhoon and Rafale were shortlisted in 2012 as meeting the IAF’s requirements, and amongst them the Rafale was determined to be the L-1 and winner of the contract, based upon lower lifetime costs. A government-to-government order for 36 Rafale fighters—reduced from the earlier requirement of 126 aircraft, for reasons not relevant to this discussion—was finalised in 2016. The first five Rafales for IAF arrived on July 29, 2020.<sup>21</sup>

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18. Rajat Pandit, “Sanctioned in ‘83, LCA Tejas is yet to take off”, February 12, 2008, at [http://timesofindia.indiatimes.com/articleshow/2774912.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](http://timesofindia.indiatimes.com/articleshow/2774912.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst). Accessed on March 16, 2021.

19. PIB, “Light Combat Aircraft (LCA) ‘Tejas’ inducted into no 45 Squadron of Indian Air Force”, July 1, 2016, at <https://pib.gov.in/newsite/PrintRelease.aspx?relid=146697>. Accessed on March 9, 2021.

20. “First FOC Standard LCA Tejas inducted into IAF Squadron”, [Defenseworld.net](https://www.defenseworld.net/news/27073/First_FOC_Standard_LCA_Tejas_inducted_into_IAF_Squadron#.YEsGY9zhU2w), at [https://www.defenseworld.net/news/27073/First\\_FOC\\_Standard\\_LCA\\_Tejas\\_inducted\\_into\\_IAF\\_Squadron#.YEsGY9zhU2w](https://www.defenseworld.net/news/27073/First_FOC_Standard_LCA_Tejas_inducted_into_IAF_Squadron#.YEsGY9zhU2w). Accessed on March 9, 2021.

21. “Induction of Rafale in Indian Air Force”, [indianairforce.nic.in](http://indianairforce.nic.in), July 29, 2020, at <https://indianairforce.nic.in/content/induction-rafale-indian-air-force-0>. Accessed on March 16, 2021.

Radars were sourced from a mixed bag of countries. Soviet radars served alongside British and American types. Surface-to-Air Missiles (SAMs) initially came from the USSR in the form of SAM-2 (S-75 Dvina), SAM-3 (S-125 Neva/Pechora), SAM-6 (2K12 Kub/Kvadrat), SAM-7 (9K32 Strela), SAM-8 (9K33 Osa), and SAM-16 (9K38 Iгла). DRDO replaced some of the older imported SAMs with the development of the Akash SAM system which entered IAF service in July 2015<sup>22</sup> after extensive user trials. In collaboration with Israeli companies, DRDO is developing a modified variant of the Israeli Barak SAM system to meet India's Long-Range SAM (LR-SAM) requirement. Work is continuing on the Medium-Range SAM (MR-SAM), also with Israeli cooperation.

Interestingly, India's HAL had started design of its first powered aircraft, the HT-2 immediately after independence. This machine saw extensive service with IAF and was retired only in the late 1980s. The design of India's first jet trainer was undertaken a few years later to produce the HJT-16 "Kiran" that is flying even today, albeit in reduced numbers due to a shortage of Rolls Royce Viper-II engines on the Kiran Mk-1/1A and the Bristol-Siddeley Orpheus engine on the Kiran Mk-II. The 1960s saw the foreign assisted design of India's first indigenous fighter at HAL, the HF-24 "Marut". HAL built 141 copies of the HF-24 with 18 two-seat and 123 single-seat versions being delivered to IAF which equipped three fighter squadrons, No. 10, No. 31 and No. 220 Squadrons, with the "Marut".<sup>23</sup>

## INDIGENOUS R&D EFFORTS IN AVIATION

### *The HT-2*

Hindustan Aeronautics Limited (HAL), formed as an aircraft design and manufacture agency, was taken over by the Government of colonial India

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22. "Ingeniously-built Aakash missile inducted in IAF", IANS, July 10, 2015, at <https://www.indiatoday.in/india/story/ingeniously-built-aakash-missile-inducted-in-iaf-281780-2015-07-10>. Accessed on March 9, 2021.

23. Abhishek Saxena, "11 Facts India Completely Forgot About Its First Jet Fighter", April 15, 2015, at <https://www.indiatimes.com/technology/news/11-facts-india-completely-forgot-about-the-jet-fighter-231867.html>. Accessed on March 9, 2021.

in 1942, and later handed over to the US to serve as No. 84 Air Depot, an aircraft repair and overhaul agency to support the Allied World War II effort in the Asian theatre. In 1948, a year after HAL reverted to Indian control as a nationalised aircraft factory, Dr. V. M. Ghatage rejoined HAL as head of its reconstituted Design Department, and proposed the design and manufacture of a piston engine trainer primarily for use by IAF. Government of India (GoI) sanction was received on October 11, 1948.<sup>24</sup> The refinement of the design proceeded rapidly with extensive involvement of the IAF, and the aircraft—to be called the Hindustan Trainer (HT)-2—was formally launched on August 13, 1951. These trainers commenced IAF service in 1955 and were phased out in 1989.<sup>25</sup>

### *HJT-16 “Kiran”*

The basic jet trainer programme to replace Vampire trainers was initiated in December 1959 and the first aircraft flew in September 1964. The “Kiran” continues in service to date. The numbers, however, have declined due to reduced availability of the Kiran Mk-1/1A, and Kiran Mk-II aircraft’s Viper-II and Orpheus engines respectively.<sup>26</sup>

### *HF-24*

Professor Kurt Tank joined HAL at the invitation of GoI in August 1956. He led a design team of 18 German engineers, alongside 150 Indian personnel, and design work on the HF-24 started in June 1957. The aircraft carried out its first official flight on June 24, 1961.<sup>27</sup> The HF-24 was underpowered to the extent of 3,010 kgst against its planned thrust. Despite this, on December 7, 1971 an HF-24 piloted by then Sqn Ldr KK Bakshi of No. 10 Sqn, IAF got the better of a “pedigreed dogfighter”, a Pakistan Air Force (PAF) operated American F-86 Sabre jet being flown by then Flt Lt Hamid Khwaja of No. 15 Sqn, PAF,<sup>28</sup>

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24. Vivek Kapur, n. 12, pp. 25-29.

25. *Ibid.*, p. 26.

26. *Ibid.*, pp. 29-30.

27. *Ibid.*, pp. 41-43.

28. Polly Singh, “HAL HF-24 Marut—Where the wind blows”, at <http://www.bharat-rakshak.com/IAF/aircraft/past/1199-marut-polly.html#gsc.tab=0>. Accessed on March 14, 2021.

in close combat while returning from a deep strike mission in Pakistan. A total of 141 HF-24 aircraft were built and delivered to IAF by 1977. Attempts to upgrade the performance of the HF-24 by incorporating an afterburner on its Orpheus 703 engines did not find favour with IAF. Attempts by HAL to re-engine the HF-24 did not fructify either. These attempts to improve the HF-24 were then abandoned in preference to imported aircraft.

### **RECENT DEVELOPMENTS**

After the ill-fated HF-24 “Marut” project, domestic aircraft design and development languished while IAF resorted to import of aircraft from Western Europe and the Soviet Union to meet its needs. Trainer aircraft, such as the Hindustan Piston Trainer (HPT)-32 were designed but had a limited and less than distinguished service record. A few other trainer aircraft projects, the Hindustan Turbo Trainer (HTT)-40 and Intermediate Jet Trainer (IJT), the HJT-36 “Sitara”, are making progress. Things changed when in 1983 the GoI initiated the design and development of the Light Combat Aircraft (LCA) to replace the ageing MiG-21. Alongside this, HAL took it upon itself to design and develop an Advanced Light Helicopter (ALH). These projects, amongst others, initiated in the late 1970s to 1990s, continue till date and have breathed new life into the Indian indigenous aircraft industry. The LCA itself has given birth to a variety of variants and extensions of the original project which in themselves indicate a bright future for India’s military aviation sector in the years to come.

### **ALH**

The ALH project was launched in 1976 based upon the learning gained from the licensed production of French origin Alouette-III and Lama helicopters. ALH, named “Dhruv”, is a 4-5-ton class helicopter and is designed to undertake many diverse roles, such as heliborne assault, casualty evacuation, reconnaissance, logistics support, air observation post, logistics, and passenger transport. It is even capable of shipboard operation.

**Dhruv is the first helicopter designed and built in India. It has a few shortcomings, the significant one being the reported high vibration level. In all likelihood this is the result of meeting another design requirement, that is, a very quick response and high manoeuvrability which required the use of a hingeless composite material rotor system.**

The aircraft has two engines and uses the Ardiden 1H1 “Shakti”<sup>29</sup> engine co-developed with France’s Turbomecca to deliver 12-15 per cent higher thrust than the Turbomecca TM 333-2B2 engine to meet India’s requirements of operating at high altitudes in the Himalayas in the hot summer months, resulting in very challenging high-density altitudes. The engine drives a hingeless four-blade composite main rotor with electrometric bearings. The rotors have advanced configuration for higher lift generation combined with noise reduction, and are built to survive hits by bullets up to 12.7mm in calibre. The ALH has been built in four variants from Mk-I to Mk-IV, and as

on October 1, 2020, 300 ALH Dhruv have been built and delivered into service.<sup>30</sup> Dhruv is the first helicopter designed and built in India. It has a few shortcomings, the significant one being the reported high vibration level. In all likelihood this is the result of meeting another design requirement, that is, a very quick response and high manoeuvrability which required the use of a hingeless composite material rotor system. A rigid rotor, lacking rotor hinges, transmits more vibration to the aircraft fuselage. HAL has been working on reducing the vibration levels.

The ALH Dhruv—given its fairly wide utilisation in both military and civil fields and the large number of aircraft built—is a welcome success story of the Indian aircraft industry. It forms the bedrock of expectations that in the years ahead the aviation equipment for India’s military forces will become more and more indigenous.

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29. “Dhruv”, Hal-india.co.in, at [https://hal-india.co.in/Product\\_Details.aspx?Mkey=54&lKey=&CKey=24](https://hal-india.co.in/Product_Details.aspx?Mkey=54&lKey=&CKey=24). Accessed on March 15, 2021.

30. “HAL Rolls Out 300th Dhruv Advanced Light Helicopter from Bengaluru Hanger”, News18.com, at <https://www.news18.com/news/auto/hal-rolls-out-300th-dhruv-advanced-light-helicopter-from-bengaluru-hanger-2922077.html>. Accessed on March 15, 2021.

## RUDRA AND LIGHT COMBAT HELICOPTER (LCH)

**Rudra.** The first opportunity to more fully utilise the successful ALH platform was to develop the Weapon System Integrated (WSI) version of an ALH Mk-IV helicopter, named the “Rudra”. Initial Operation Clearance (IOC) was obtained in early 2013. There are 58 Rudra aircraft in Army service with two more on order, while the IAF has 12 in service with 4 more on order. This machine has a top speed of 270 kph and can fly up to altitudes of 20,000 ft.; apart from a modern cockpit, sensors and self-protection suite, it carries a chin-mounted 20mm turreted gun, rocket launchers and helicopter-launched Nag (Helina) anti-tank guided weapons.<sup>31</sup> The Helina—called “Dhruvastra” in its Air Force version—has a range of about 8 km. The Rudra demonstrates the opportunities open for spin-offs from a successful aircraft platform being developed indigenously.

**LCH.** While Rudra is an armed version of the ALH Mk-IV, the LCH is a dedicated attack helicopter derived from the basic Dhruv design and weighs about 5.5 tonne. The LCH has a maximum speed of 270 kph, a service ceiling of 6,500 metres and ferry range of 700 km. It has been landed at an altitude of 16,000 feet, and is the first attack helicopter to land in Siachen. The LCH was certified in 2016 and its limited series production (LSP) began in 2017. As of now, 176 aircraft are expected to be built, of which 114 are planned for the Army and 62 for the IAF. So far only two prototypes have been deployed by the IAF. The LCH is expected to field all the weaponry currently integrated with the Rudra. A helmet mounted sighting and guidance system is likely to be integrated with the LCH thereby increasing its potency further. Two

**While Rudra is an armed version of the ALH Mk-IV, the LCH is a dedicated attack helicopter derived from the basic Dhruv design and weighs about 5.5 tonne. The LCH has a maximum speed of 270 kph, a service ceiling of 6,500 metres and ferry range of 700 km.**

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31. Air Marshal BK Pandey (Retd.), 2020-09, “Combat Helicopters with the Indian Armed Forces”, at <http://www.sps-aviation.com/story/?id=2820&h=Combat-Helicopters-with-the-Indian-Armed-Forces>. Accessed on March 15, 2021.

LCHs were deployed for operations in Eastern Ladakh during the border stand-off with China in 2020.<sup>32</sup> HAL is expecting an order for an initial batch of 15 aircraft to equip IAF and the army. Increasing confidence with the initial ALH spin-offs bodes well for more such successful projects in future.

#### **HTT-40**

The IAF's primary trainer aircraft from the late 1950s onwards was the old HT-2. It was retired from service in the late 1980s, when the HPT-32 became the sole primary trainer. Shortage of this aircraft forced IAF to train a few courses purely on jets in the mid-1980s, using the HJT-16 for the purpose. With ab initio basic training being conducted on jet trainers, attrition was high. A new primary trainer was certainly needed and the already in-service HPT-32 was pushed to meet it. However, an apparent mismatch between the HPT-32's aircraft fuel system and the engine fuel system led to several instances of in-flight engine failure, evidently due to fuel starvation. These failures could not be resolved. Since the HPT-32's induction in 1984 there were persistent engine cuts in flight resulting in 108 incidents of unplanned engine stoppage, causing 23 fatalities.<sup>33</sup> HPT-32 was grounded and withdrawn from service in 2009 after a fatal crash killed two senior instructors on July 31, 2009.<sup>34</sup> Initially the utilisation of the HJT-16 for basic training was contemplated but an acute shortage of Viper-II and Orpheus engines forced IAF to continue to use the HPT-32 with a parachute recovery system.<sup>35</sup> Finally, it was decided to import 38 Pilatus PC-7 Mk-II, with another 68 to be built at HAL under licence<sup>36</sup> to meet immediate needs. HAL initiated the HTT-40 project to meet the IAF's primary trainer needs in the year 2013. HAL chose a tandem seat configuration

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32. "Two HAL Light Combat Helicopters Deployed for Operations at Leh", PTI, August 12, 2020, at <https://www.livemint.com/news/india/two-hal-light-combat-helicopters-deployed-for-operations-at-leh-11597236997702.html>. Accessed on March 16, 2021.

33. "HPT 32 Deepak trainer aircraft to fly no more", *India Strategic*, October 2011, at [https://www.indiastrategic.in/topstories1221\\_HPT32\\_Deepak\\_trainer.htm](https://www.indiastrategic.in/topstories1221_HPT32_Deepak_trainer.htm). Accessed on April 12, 2021.

34. *Ibid.*

35. Ravi Sharma, "IAF gives nod for HPT-32 revival", *The Hindu*, May 16, 2010, at <https://www.thehindu.com/news/national/IAF-gives-nod-for-HPT-32-revival/article16301107.ece>. Accessed on April 12, 2021.

36. "HAL HTT-40 Trainer Aircraft", *Airforce-technology.com*, at <https://www.airforce-technology.com/projects/hal-htt-40-trainer-aircraft/>. Accessed on April 12, 2021.

in keeping with IAF preference, a low wing with two Martin Baker zero-zero ejection seats under a large bubble canopy, conventional empennage and a retractable tricycle undercarriage for the project. The HTT-40 first flew in May 2016.<sup>37</sup> It is powered by the widely used and reliable Honeywell TPE331-12B turboprop engine. The TPE331-12B is equipped with Full-Authority Digital Engine Control (FADEC) system and develops a maximum power output of 950 shaft horsepower (shp),<sup>38</sup> enabling the aircraft to meet its performance objectives. In initial testing, the HTT-40 failed to meet the IAF's spin entry and recovery requirements. HAL worked on the issue and in 2019 the aircraft cleared IAF testing for six-turn spin and recovery to both left and right, allowing HAL to seek Final Operational Clearance (FOC).<sup>39</sup> Since then, GoI and IAF have ordered 70 HTT-40s with an option for a further 38 aircraft. The purchase of additional Pilatus PC-7 was cancelled.<sup>40</sup> This success is even more remarkable in view of the fact that, since 2012, IAF has persistently opposed the HTT-40 while pushing GoI to import more Pilatus PC-7 aircraft.<sup>41</sup>

Contrary to popular belief, a successful trainer design and development is no mean achievement. A basic trainer must be fully aerobatic with a respectably wide operational envelope in terms of acceleration or 'g' capability; negative flying ability; high enough service ceiling; high endurance, low take-off and landing speeds coupled with high maximum speed; possess benign stall and recovery characteristics; and the ability to spin and recover safely. This high flight performance must come with no surprises tucked away in its operational envelope. It must be reliable and rugged enough to survive gross mishandling by raw pupil pilots both

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37. Ibid.

38. Ibid.

39. Huma Siddiqui, "Success! HAL's HTT 40 Trainer aircraft completes six-turn spin test, now awaits FOC", October 2, 2019, at <https://www.financialexpress.com/defence/success-hals-htt-40-trainer-aircraft-completes-six-turn-spin-test-now-awaits-foc/1724459/>. Accessed on April 13, 2021.

40. Snehash Alex Philip, "Defence Ministry clears purchase of indigenous basic trainer aircraft, upgrade of Israeli UAVs", August 11, 2020, at <https://theprint.in/defence/defence-ministry-clears-purchase-of-indigenous-basic-trainer-aircraft-upgrade-of-israeli-uavs/479711/>. Accessed on April 13, 2021.

41. Ajai Shukla, "HAL-built trainer aircraft HTT-40 clears crucial flight test successfully", September 7, 2019, at [https://www.business-standard.com/article/companies/hal-built-trainer-aircraft-htt-40-clears-crucial-flight-test-successfully-119090700956\\_1.html](https://www.business-standard.com/article/companies/hal-built-trainer-aircraft-htt-40-clears-crucial-flight-test-successfully-119090700956_1.html). Accessed on April 13, 2021.

in-flight and during take-off and landing. The fact that HTT-40 cleared IAF's stringent testing specifications holds out hope for a new generation of experienced and capable designers coming of age in India to take on more complex projects in future.

### **HJT-36 INTERMEDIATE JET TRAINER (IJT)**

The HJT-16 has been in service since the 1960s. Seeing a need for a replacement intermediate trainer to smoothly transition pupil pilots from basic to advanced trainers, HAL initiated the development of the IJT—dubbed HJT-36—in 1999. The aircraft was initially planned to be powered by the SNECMA 04-30 “Larzac” turbofan. However, the thrust of this engine at 1,400 kgst proved inadequate hence the Russian AL-55I engine delivering 1,700 kgst was selected.<sup>42</sup> The IJT first flew in 2003 but problems soon emerged. The stalling speed of the aircraft was found to be too high and its spin characteristics unacceptable. With HAL unable to solve these problems, delays built up. During the Aero India air show at Bengaluru in 2007, an IJT skidded off the runway due to a tyre burst.<sup>43</sup> In flight trials the controllability of the aircraft at high angles of attack was found poor, leading to unsafe stall and spin performance. Unable to locate the problem HAL obtained consultancy from British Aerospace and from America's Bihrl Applied Research.<sup>44</sup> The result is a modified airframe at the forward fuselage and empennage to improve stall and spin characteristics. The modified aircraft has recommenced flight trials. The normal flight envelope that had been achieved earlier was first revalidated with the modified airframe and the spin trial phase

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42. Air Marshal BK Pandey (Retd.), “A Shot in the Arm for IJT”, August 2008, at <http://www.sps-aviation.com/story/?id=43>. Accessed on April 13, 2021.

43. Siva Govindasamy, “Picture: India's HAL scrapes Intermediate Jet Trainer, becoming second aircraft to crash at Bangalore's Aero India air show after Friday's Dhruv”, February 9, 2007, at <https://www.flightglobal.com/picture-indias-hal-scrapes-intermediate-jet-trainer-becoming-second-aircraft-to-crash-at-bangalores-aero-india-air-show-after-fridays-dhruv/71914.article>. Accessed on April 13, 2021.

44. Rahul Bedi, “India Is Still Throwing Good Money at Hopeless Military Programmes”, December 15, 2020, at <https://thewire.in/security/defence-spending-hal-drdo-military>. Accessed on April 13, 2021.

initiated, reportedly with one turn spins to both sides being performed successfully.<sup>45</sup>

In fact, the IJT HJT-36 project is likely to have taught Indian aircraft designers a lot more than it would have if the initial trials had encountered no problems. Transfer of learning really happens when a person is stuck trying to solve an issue and is assisted in finding the solution. This learning is likely to be invaluable to Indian designers of future aircraft of all types. MiG-29 operators from the early years will recall the story of the humble metal wedge at the base of that high performance aircraft's pitot tube and its significance as a fix to a massive design and performance problem. HJT-36 should soon be replacing the old HJT-16 as the Stage-II aircraft in IAF service.

### LCA

The LCA project was sanctioned in 1983 and the design finalised by 1990. While earlier projects kept HAL as the designer and manufacturer, for LCA GoI set up the Aeronautical Development Agency (ADA), a national consortium of defence laboratories, industrial manufacturing organisations and academic institutions. Responsibility for developing the sub-parts and systems for LCA was divided between these constituent parts of ADA, while HAL was designated the agency for airframe manufacture, final assembly, flight testing and in-service support. In the process many advanced systems—such as fully digital quadruplex fly-by-wire system with flight control laws, a multi-mission Active Electronically Scanned Array (AESA), multi-mission radar (MMR), mission computers, cockpit display systems, etc.—have been successfully designed and developed in India. One notable failure has been the development of the GTX-35VS “Kaveri” engine for LCA. This has forced the use of US origin General Electric (GE) F-404 engines, with the F-414 selected for later variants. Kaveri is now split into two sub-parts, the K-9 “Kaveri” which has achieved full dry thrust but is heavier than planned, and falls short of desired reheat thrust by about 1,000 kgst. The K-10 “Kaveri”

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45. “Intermediate Jet Trainer commences spin flight testing”, PTI, November 2020, at <https://www.thehindu.com/news/national/intermediate-jet-trainer-commences-spin-flight-testing/article33160015.ece>. Accessed on April 13, 2021.

**The LCA Mk-II was conceived as a capability enhanced variant of the LCA. Over time this morphed into redesign of the LCA to incorporate canard foreplanes, possibly a two-engine configuration, greatly enhanced capabilities similar to the “swing role” boasted by aircraft, such as the Dassault Rafale and the Euro fighter Typhoon.**

is still undergoing work to develop its thrust to the initial design value while reducing its weight. The indigenous MMR is also lagging in development time frames thus forcing use of the imported Israeli ELTA-2032 radars on initial aircraft.<sup>46</sup> IAF placed an order for 40 Initial Operational Clearance-II (IOC) configuration aircraft in 2015<sup>47</sup> and ordered a further 83 Mk-1A fighters in 2021.<sup>48</sup>

#### **LCA MK-1A**

The LCA fell short of the capabilities desired by IAF. Hence it was agreed to develop an enhanced capability variant called the LCA Mk-1A. Compared with the LCA Mk-1, the Mk-1A comes equipped with an Active Electronically Scanned Array (AESA) radar, Air-to-Air-Refuelling (AAR) capability, integration of Beyond Visual Range (BVR) missiles, and an electronic warfare suite, apart from a further 43 modifications requested by IAF based upon the experience of operating the first squadron of LCA Mk-1 aircraft.<sup>49</sup> This development indicates the life cycle of weapons systems the world over. As a yardstick, the F-16E/F or Block 52 F-16 offered to India under the MMRCAs competition is a slow upgrade over many years of the original F-16 Block 1, actually Block 15, which was a simple, day only, fighter with limited ground attack capability. There lie ahead many more enhancements to the LCA to keep it relevant in time to come, and

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46. Vivek Kapur, n. 12, pp. 59-77.

47. Air Marshal BK Pandey (Retd.), “Hype vs Reality”, January 2016, at <http://www.sps-aviation.com/story/?id=1815>. Accessed on March 16, 2021.

48. Huma Siddiqui, “After the Indian Air Force order for Tejas, HAL to export LCA Mk1A”, February 4, 2021, at <https://www.financialexpress.com/defence/after-the-indian-air-force-order-for-tejas-hal-to-export-lca-mk1a/2187839/>. Accessed on March 16, 2021.

49. Air Marshal BK Pandey (Retd.), “Procurement of 83 LCA Tejas Mk 1A Cleared”, January 2021, at <http://www.sps-aviation.com/story/?id=2879&h=Procurement-of-83-LCA-Tejas-Mk-1A-Cleared>. Accessed on April 13, 2021.

the LCA Mk-1 and Mk-1A should be considered projects in hand.

### LCA MK-II

The LCA Mk-II was conceived as a capability enhanced variant of the LCA. Over time this morphed into redesign of the LCA to incorporate canard foreplanes, possibly a two-engine configuration, greatly enhanced capabilities similar to the “swing role” boasted by aircraft, such as the Dassault Rafale and the Euro fighter Typhoon. This involves a full redesign of a larger aircraft, with timelines for completion of development based upon the LCA systems and subsystems being reasonably shorter than seen hitherto.

### LCA NAVY

At the inception of the LCA programme, a maritime carrier-based variant was considered. Once the LCA Mk-1 approached IOC capability, effort was put in to realise the Navy variant. Primarily, this meant an increase in aircraft weight due to strengthening of the airframe and undercarriage to bear the heavy loads imposed by carrier deck operations. The LCA Navy variant has been tested for launch and recoveries from a shore-based ski jump mock deck, and has successfully carried out landings and take-offs from the Indian Navy’s aircraft carrier, the INS Vikramaditya. More developments can be expected in this area.

More than just the LCA itself, it is the successful development of almost all subsystems of the LCA in India that creates optimism for the future. With a large number of essential combat aircraft subsystems already developed or approaching completion of development, the risks in development of follow-on aircraft, such as the LCA Mk-II, Advanced Medium Combat Aircraft (AMCA), etc., are likely to be much lower and costs and time overruns much less.

**More than just the LCA itself, it is the successful development of almost all subsystems of the LCA in India that creates optimism for the future.**

## **AMCA**

Advanced Medium Combat Aircraft (AMCA) was conceived as India's first Fifth-Generation fighter incorporating the attributes of a fifth-generation fighter that include low observability (LO) design, sensor fusion, supercruise capability, and greatly enhanced networked warfare capability. With the ongoing trainer and LCA programmes, the AMCA remained a laboratory or classroom study for some time. The basic layout with several macro design features were finalised and wind tunnel models were tested and displayed in public events, such as Air Shows. Given the complexity of such a project, it is early days to write about or to hazard a guess on the progress of the project. However, going by the major attributes of a pure fifth-generation fighter, it is likely that the systems on board—much more than the platform comprising the airframe and power plants—will pose a greater challenge to the designers of the AMCA. Judging by the recent successes displayed by our scientific community, there is room for optimism.

## **AIRBORNE EARLY WARNING AND CONTROL SYSTEM (AWACS OR AEW&C): "NETRA"**

DRDO initiated a technology development project for an indigenous AEW&C in 1985. Two HS-748 airframes were modified with a fuselage mounted radome to develop the software and radar techniques required for refining the radar performance for such an aircraft. This project remained a technology demonstrator and ended abruptly with the fatal crash of the modified HS-748 aircraft in January 1999. The programme was revived in 2002 using a more capable platform, the Embraer EMB-145 airframe,<sup>50</sup> mounting a fuselage top fixed 'beam shaped' antenna housing an indigenous AESA radar.<sup>51</sup> The resulting AEW&C aircraft dubbed

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50. Dinesh C. Sharma, "Netra early warning system—the unsung hero of Indian armed forces", November 21, 2019, at <https://vigyanprasar.gov.in/isw/Netra-early-warning-system-unsung-hero-of-Indian-armed-forces.html>. Accessed on March 17, 2021.

51. Huma Siddiqui, "Atmanibhar Bharat boost for India's security: IAF to get Made in India AEW&C systems; Check details", December 18, 2020, at <https://www.financialexpress.com/defence/atmanibhar-bharat-boost-for-indias-security-iaf-to-get-made-in-india-aew-check-details/2152494/>. Accessed on March 18, 2021.

“Netra”, was inducted into IAF in 2017 with two aircraft in service and more on order.<sup>52</sup>

The successful development of such complicated cutting-edge technology augurs well for further enhancements in AEW&C performance and for development of other applications of these advanced sensors and accompanying software. Plans are reportedly ready to develop a full size 360 degrees coverage AWACS on a larger aircraft by DRDO.

### QUANTUM ENCRYPTION

Encryption of communications and data transmissions is essential for success in peacetime as well as in war for economic, other government and military purposes. Modern warfare is moving beyond the nature of war as emerges from the ‘Treaty of Westphalia’ towards a more total war best described in the PLA publication “Unrestricted Warfare”; securing our communications and other data becomes even more important. On Sunday, February 21, 2021, a research team in Bengaluru demonstrated quantum encryption involving open space quantum transmission of encryption keys across a 50-metre free space from one building to another. The team described the limited range of their demonstration as limited only by the space available to demonstrate the technology, and were optimistic that much greater distances could be achieved in future developments. To effectively transmit keys from ground stations to satellites means covering ranges in excess of 12 km from the surface of the earth to orbit altitudes. The team went on record to state that further developments could deliver practical encrypted quantum communication technology to the country. In 2017, China managed to transfer a key down from a satellite to a ground station. The team further stated that over time they would be able to achieve a two-way uplink to a satellite as well as downlink from a satellite quantum communication with

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52. Rahul Singh, “Aero India-2017: IAF inducts first indigenously developed surveillance plane”, February 14, 2017, at <https://www.hindustantimes.com/india-news/iaf-inducts-netra-aew-c-the-first-indigenously-developed-surveillance-plane/story-UxyMeY9oH4XvamNEd9JNTP.html>. Accessed on March 17, 2021.

encryption, thus catching up with the cutting-edge technology in this field, as demonstrated by the PRC and other technologically advanced countries.<sup>53</sup>

## MISSILES

**Brahmos.** The Brahmos supersonic cruise missile needs no introduction. While India requested Russian assistance in modifying the missile to reduce its weight and profile to enable air launching the weapon, Indian scientists simultaneously went to work and by January 2020 had managed to reduce the weight and profile of the weapon to obtain “fleet release clearance” for the missile on the Su-30MKI.<sup>54</sup>

**Helina/Dhruvastra.** The Nag top attack Anti-Tank Guided Missile (ATGM) has been under development since the Integrated Guided Missile Development Programme (IGMDP) was initiated in 1983. The IGMDP was terminated in March 2012.<sup>55</sup> The Nag missile was taken up to develop an air-launched version for arming helicopters, notably the Rudra and LCH. This missile, boasting an imaging infra-red (IIR) seeker, has recently undergone trials with a 100 per cent success rate and been accepted for induction in the armed forces.<sup>56</sup> Videos of the test firings of the Helina, posted on YouTube, show a welcome lack of smoke trail from the test launched weapons. This is important as the presence of a smoke trail could betray the launch of the weapon to the enemy as well as give away the position of the launch platform.

**Astra.** The Astra is India’s first indigenous air-to-air missile boasting of radar guidance and Beyond Visual Range (BVR) capability. After successful trials

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53. Akhil Kadidal, “Bengaluru scientists make quantum technology breakthrough”, February 23, 2021, at <https://www.deccanherald.com/science-and-environment/bengaluru-scientists-make-quantum-technology-breakthrough-954329.html>. Accessed on March 18, 2021.

54. “BRAHMOS-Air Launched Cruise Missile gets Fleet Release clearance”, Drdo.gov.in, July 2020, at [https://drdo.gov.in/sites/default/files/newsletter-document/NL\\_July\\_2020.pdf](https://drdo.gov.in/sites/default/files/newsletter-document/NL_July_2020.pdf). Accessed on March 18, 2021.

55. “Missile Development Programme”, Pib.gov.in, August 13, 2012, at <https://pib.gov.in/newsite/PrintRelease.aspx?relid=85986>. Accessed on March 18, 2021.

56. Shishir Gupta, “HELINA missile strikes 5 out 5, ready for induction”, February 19, 2021, at <https://www.hindustantimes.com/india-news/helina-missile-strikes-5-out-5-ready-for-induction-101613719486762.html>. Accessed on March 18, 2021.

the Mk-I variant was cleared for IAF induction and is reported to have a range of 80 to 100 km, again with a smokeless rocket motor. A Mk-II variant of the missile with enhanced range is reported to be under development.<sup>57</sup>

**SAAW.** In a boost to the indigenous Hawk-i programme, defence PSU Hindustan Aeronautics Limited (HAL), on Thursday, January 21, 2021, successfully test-fired the Smart Anti-Airfield Weapon (SAAW) from a Hawk-i aircraft flown by HAL test pilots, Wing Commander P. Awasthi (Retd.) and Wing Commander M. Patel (Retd.).<sup>58</sup> This indigenous weapon had earlier been tested from the Jaguar aircraft. SAAW has been developed by Defence Research and Development Organisation's (DRDO) Research Centre Imarat (RCI). The SAAW is a 125 kg weight stand-off weapon that is designed to cause damage to airfield infrastructure, such as radars, bunkers, and taxi tracks and runways. SAAW has a stand-off range of 100 km. With this the Hawk-132 gets to field a stand-off attack capability. The weapon, being indigenous, can be further developed and integrated with other airborne platforms in IAF service. The ability of the Hawk to carry a stand-off ability smart weapon will enhance the aircraft's combat utilisation considerably. The Hawk-i combat enhancement—apart from the SAAW itself—is laudable, and marks the success of indigenous attempts to develop ever more capable airborne weapons. Indigenous technology provides the IAF precisely the weapons suited to its envisaged combat employment.

## REASONS FOR OPTIMISM

Electronic Warfare, sensors, displays, materials, and several other aspects of advanced aerospace technology have been in the news in the past few months,

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57. Snehash Alex Philip, "India working on next 'Astra' missile with 160 km range as Mk1 is integrated in IAF & Navy", December 15, 2020, at <https://theprint.in/defence/india-working-on-next-astra-missile-with-160-km-range-as-mk1-is-integrated-in-iaf-navy/566699/>. Accessed on March 18, 2021.

58. Chethan Kumar, "Hawk-i test fires smart anti-airfield weapon that can destroy enemy assets from 100km", January 21, 2021, at [https://timesofindia.indiatimes.com/india/hawk-i-test-fires-smart-anti-airfield-weapon-that-can-destroy-enemy-assets-from-100km/articleshow/80385067.cms?utm\\_source=google\\_newsstand&utm\\_source=contentofinterest&utm\\_campaign=rss\\_feed&utm\\_campaign=cppst&utm\\_medium=referral&utm\\_medium=text](https://timesofindia.indiatimes.com/india/hawk-i-test-fires-smart-anti-airfield-weapon-that-can-destroy-enemy-assets-from-100km/articleshow/80385067.cms?utm_source=google_newsstand&utm_source=contentofinterest&utm_campaign=rss_feed&utm_campaign=cppst&utm_medium=referral&utm_medium=text). Accessed on March 19, 2021.

all indicating the success of India's scientific community in developing cutting-edge capabilities. This is the fructification of many years of dedicated work by Indian scientists in DRDO as well as in civil institutes of scientific research. Given that many programmes have been successful augurs well for building further for greater success. Incremental improvements on technologies already developed will facilitate future advancements.

### CONCLUSION

During colonial times India perforce had to use imported aerospace equipment. After independence, the low level of technological expertise in the country forced IAF to continue import of needed weapons and allied equipment. In the past few years, the efforts of the country's scientific community to develop indigenous capabilities have borne fruit. This is encouraging, for in the future we can look forward to an IAF equipped entirely with Indian equipment and weapons. Many of the weapons and systems touched upon earlier in this article deserve a complete independent treatment to derive the needed learning and understanding about aerospace technologies and Indian air power.

# AIRLIFT WISDOM OF YORE

ASHOK K CHORDIA

## RUMMAGING AIRLIFT HISTORY

Long before the invention of the parachute and the aeroplane, Napoleon Bonaparte threatened England with an invasion by French soldiers carried over the English Channel in hot air balloons.<sup>1</sup> The French emperor did not carry out his threat but the carriage of men, military equipment, arms and ammunition through the medium of air did shape the outcome of many a war in the last century, and those fought in the first two decades of the present century. On some occasions, airlift<sup>2</sup> has even steered the course of history. Besides war, it has also determined the way countries and organisations deal with Humanitarian Assistance and Disaster Relief (HADR) and other operations for which timely delivery of men and material is extremely critical. Despite its dire importance in warfighting, HADR and nation building, airlift has generally been the focus of *less-than-due* or intermittent attention of the stakeholders. A travel back in time to rummage history for some of the less observed and acknowledged wisdom might enable better exploitation of the airlift resources in the future.

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Group Captain **Ashok K Chordia** is a Non Resident Senior Fellow of the Centre for Air Power Studies, New Delhi.

1. Chris Ellis and Mike Verier, *Elite Attack Forces: Airborne at War* (New Jersey: Chartwell Books Inc., 2007), p. 6.
2. As different from the nuanced terms like, airborne operations and air-landed operations, the term *airlift* is being used here to talk about the act of “picking men and cargo from a point A and delivering them to a point B through the medium of air using an airborne platform”.

**Prior to World War II, airlift was seen as some kind of speciality service, capable of carrying small, precious cargoes like diphtheria serum. And, even during the War, airlift had been tentative, with mixed results, and accepted with varied responses by those in command and authority.**

Brigadier General Billy Mitchell had visualised parachute landing of large numbers of troops behind enemy lines during World War I but his idea could not be implemented for want of parachutes, aircraft and trained personnel. Prior to World War II, airlift was seen as some kind of speciality service, capable of carrying small, precious cargoes like diphtheria serum. And, even during the War, airlift had been tentative, with mixed results, and accepted with varied responses by those in command and authority.

The effectiveness of airborne troops, as propounded by Mitchell, was demonstrated soon after World War I when six soldiers parachuted from a Martin Bomber at Kelly Field at San Antonio, Texas. They landed safely, and in less than three minutes after exiting the aircraft assembled their weapons and were ready for action. The American decision makers were not sufficiently impressed, so the US went rather slow on building an airborne force.

The Soviets, however, viewed the war potential of air transportation differently—they were awed by the possibilities. They were among the first to consider paradrop as a means to induct ground forces into battle. They introduced static line parachuting as a national sport and encouraged people to join the Airborne Corps. They formed their first parachute units by 1928 and in 1933, paradropped troops and a small combat tank. In March 1935, they dropped two battalions of infantry and landed 18 passenger gliders in Kiev. Later still, in the summer of 1935, they paradropped a thousand troops and air-landed 5,000. Between September and October 1936, they dropped 1,200 paratroopers at Minsk and 5,200 at Moscow.<sup>3</sup>

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3. This chronology and statistics have been compiled by the author from different books/internet sites and may vary from source to source.

The Soviet example enthused the British, the Germans and the French. As a result, beginning in the mid-1930s, several European countries followed suit. The British organised parachute forces in 1936 and used them continually in their manoeuvres. The Germans, too, under Major Kurt Student,<sup>4</sup> began building the capability. They worked quickly to develop an effective military parachute organisation. Their glider units were an outcome of the sport-gliding programme that developed flying skills, while Germany was under the restrictions imposed by the Treaty of Versailles.

**By 1940, Germany had 4,500 paratroopers and 12,000 men formed an air infantry division designed as an air-landed follow-up to a parachute assault. A force of 700 Ju-52 transport planes was available to carry these troops into combat.**

The Spanish Civil War (1936) saw Germany send a few Ju-52 aircraft to Spanish Morocco, where members of the Nationalist Army, and their leader, Francisco Franco, were confined and were unable to sail across the Strait of Gibraltar. They airlifted 20,000 stranded troops to Spain in 677 sorties<sup>5</sup> enabling the Nationalist Army to consolidate and win the war. This triggered the development and consolidation of airlift capability by many countries. By 1940, Germany had 4,500 paratroopers and 12,000 men formed an air infantry division designed as an air-landed follow-up to a parachute assault. A force of 700 Ju-52 transport planes was available to carry these troops into combat.

Then, in Belgium, on May 10, 1940, in a daring pre-dawn raid, nine flimsy fabric covered gliders landed 71 German paratroopers at the fort at Eben-Emael and overpowered the Belgian troops in just over 30 minutes. That raid opened the gateway for the Germans to enter Belgium and France.<sup>6</sup>

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4. Kurt Student, as a young Captain, had seen the demonstration of the airborne assault capability of the Soviets and was determined to develop similar capability for Germany.

5. Pamela Feltus, "Airlift and Transport Operations", *Air Power*, p. 1, at [https://www.centennialofflight.net/essay/Air\\_Power/cargo/AP19.htm](https://www.centennialofflight.net/essay/Air_Power/cargo/AP19.htm). Accessed on April 2, 2021.

6. E. M. Flanagan Jr., *Airborne: A Combat History of American Airborne Forces* (New York: Ballantine Books, 2002), p. 6.

## ONE AIRBORNE OPERATION, DIAMETRICALLY OPPOSITE INFERENCES

Ideally, the success at Eben-Emael should have nudged the Germans to exploit their airlift resources to the fullest to realise their military ambitions, but the very next year, they suffered heavy losses in Crete (Operation Mercury, May 1941)—3,774 killed or missing; 2,120 wounded.<sup>7</sup> A large number of them were killed after landing safely, when they were running helter-skelter trying to get hold of their personal weapons which had been dropped separately in small containers.<sup>8</sup> The German experience was traumatic—their victory turned out to be *pyrrhic*. The Allied forces (comprising British, Australian, New Zealand and Greek soldiers) also suffered many casualties—3,990 dead; 1,925 wounded and 17,090 captured. The losses on both sides were heavy and deserved a well informed and weighted reassessment of airborne operations.

Crete had many lessons which were followed up for many years after the War. Airborne Individual Weapon Containers were developed for paratroopers to carry personal weapons. With limited success, countries even experimented with firing of a weapon while the paratrooper was still descending under the canopy of his parachute. The Soviets experimented with dropping manned vehicles which could go into battle instantly on touchdown. They tried platforms whose landing was cushioned by rockets, which fired in the proximity of the ground. That said, the two warring sides drew hurried and diametrically opposite inferences from the debacle in Crete about the effectiveness and usefulness of airborne operations. With the war raging in Europe, they reacted fast and decisively.

Hitler concluded that the surprise element of airborne assaults had been lost forever—they were a costly tactic whose time had passed. He gave up on airborne operations; Germany never again launched a major airborne operation during the rest of the War. The well trained and highly motivated

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7. "Battle of Crete", at [http://en.wikipedia.org/wiki/Battle\\_of\\_Crete](http://en.wikipedia.org/wiki/Battle_of_Crete). Accessed on April 2, 2021.

8. Carriage of personal weapons by paratroopers drew much attention during WWII. The Russians worked diligently to address this issue and improved the equipment and the procedures considerably.

*fallschirmjäger* (the German parachute rangers) were mostly used as 'normal' infantry thereafter.

The British saw their own losses in isolation—disregarding the German losses—and attributed them to the effectiveness of the German airborne assault. Following this, the British and the Americans trained large numbers of pilots and paratroopers. So that the effort to bolster their airborne capacity was not interrupted by the War in Europe, the British commenced paratrooping training in India too. Paratroopers' Training School was established at Chaklala (now in Pakistan). To begin with, only two (later increased to five) Vickers' Valencia aircraft were spared for paratrooping training. They were considered ideal due to their slow speed. A modest beginning was made by using the fourteen parachutes the British instructors had brought from England as personal baggage.<sup>9</sup> The first experimental test jump was carried out in October 1941 in Karachi. After independence, India established Paratroopers' Training School in Agra.

During the rest of World War II, and in the decades following it, countries have made judicious use of their airlift capabilities and reaped huge dividends. Discussed in the following sections are some instances which demonstrate not only the limitlessness of possibilities but also the pitfalls on the way.<sup>10</sup>

### **AIRLIFT PLATFORMS—A MATTER OF MEANS AND ENDS**

For long, fixed wing and rotary wing transport aircraft have epitomised airlift platforms. But there have been instances when other than these 'conventional' means of airlift have been used to great effect. As stated earlier, in the airborne assault on the fort at Eben-Emael (Belgium, May 1940) nine flimsy (fabric covered) gliders airlanded 78 *fallschirmjägers*<sup>11</sup> in the midst of action. The success of that airborne operation opened the gateway for the Germans for further invasion of Belgium, France and other

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9. K. C. Praval, *India's Paratroopers: A History of the Parachute Regiment of India* (Delhi: Vanity Books, 1993), p. 21.

10. These have been organised contextually rather than chronologically.

11. German paratroopers.

low countries. Again, in 1943, glider-borne German paratroopers rescued Benito Mussolini from Imperatore Hotel at Gran Sasso (Operation Eiche, Italy), in the Apennine Mountains where he had been imprisoned after his ouster.<sup>12</sup> The numbers airlifted by gliders on those two occasions were small, yet the results were spectacular.

Theoretically speaking, it is possible to use any airborne platform to deliver critically required payload; it need not necessarily be a 'conventional' transport aircraft or a helicopter. What matters is the end state. The IAF, unable to use its transport aircraft across the high Himalayan mountain ranges, used Tempest fighters to airdrop ammunition at the besieged fort at Skardu during the Kashmir War (1947-1948).<sup>13</sup> Around the same time (1948-1949), the city of Berlin needed 38 tonnes of salt per day. Carriage of this daily necessity corroded the metal alloys used in the aircraft and the cables. British Sunderland flying boats, which were treated to resist corrosion caused by seawater, were used to land salt on Havel Lake. This arrangement worked well during the warm weather days. In winter, when the lake froze, salt was carried in panniers slung in the bomb bay of special section of Halifax Bombers.<sup>14</sup>

Airships, likewise, are less acknowledged flying machines whose airlift capabilities can be exploited imaginatively. They were much in use in the 1930s. They went into oblivion after the Hindenburg disaster (Lakehurst Naval Air Station, 1937) when an airship burst into flames in media glare. It has taken decades for the stakeholders to realise and accept the fact that hydrogen gas was not the main cause for the disaster; it was the highly inflammable paint used on the surface of the ill-fated dirigible which caused the ghastly fire.

The development of *lighter-than-air* flying machines has recommenced with renewed interest. They are already being used for airlift of unwieldy

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12. Otto Skorzeny, *Skorzeny's Special Missions: The Memoirs of Hitler's Most Daring Commando* (South Yorkshire: Frontline Books, Kindle Edition, 2011), loc. 1432.

13. Air Commodore Jasjit Singh (Retd.), *The ICON: An authorized biography of the Marshal of the Indian Air Force, Arjan Singh, DFC* (New Delhi: KW Publishers, 2nd edn., 2011), p. 165.

14. Lt. Gen. William H. Tunner, USAF, *Over the Hump* (Washington, D.C.: Office of Air Force History, USAF, 1985), p. 205.

over-dimensional items of equipment like the blades of windmills that cannot be carried on winding roads across jungles and hilly terrain. If *Skylifter*, an Australian firm, succeeds in its attempts, it will be able to build an airship that will carry up to 150 tonnes over 1,000 km.<sup>15</sup> The firm seeks to carry entire hospitals in times of distress. Imagine on a day, not too far off in the future, UAVs operating from a *Mother Airship*, hovering on a disaster zone, making pinpoint deliveries of medicines, food packets and water to people stranded on roof tops—more people benefiting from aerial delivery with practically no losses. Or, imagine unmanned airships carrying tonnes of water to douse fires in contaminated zones, as in Fukushima.

Addressing the vulnerability of crew of an *airborne troop carrier*, Lockheed Martin and Kaman Aerospace have jointly designed pilotless cargo aircraft to deliver vital supplies to territories infested by roadside bombs. A remote-control version, the K-MAX Unmanned Multi-Mission Helicopter has been designed for hazardous missions. It is meant to deliver supplies to the battlefield, as well as peaceful situations involving chemical, biological, or radiological hazards. The helicopter version was put to operational use in Afghanistan.<sup>16</sup> The prototype delivered 100,000 pounds of cargo in 50 unmanned missions in January 2012.<sup>17</sup> According to Air Vice Marshal Manmohan Bahadur, “The operationalisation of robotic aerial logistic delivery has brought in a new paradigm in battlefield logistics supply and could be a watershed in a world whose index of casualty sensitivity is decreasing by the day.”

War zones like Afghanistan have increased the threat to aircraft crews and airlift platforms conducting manned medical and casualty evacuation operations. This increased threat puts additional lives at risk—not only are the casualties at risk, but so are the members of the evacuation team, including the aircrew. Some other experiments with robotic aircraft have met

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15. “Giant airship that can carry entire buildings 2000 kms,” *The Times of India*, Wednesday, October 6, 2010, p. 21.

16. “Cargo Drone to Rescue of Areas Strawn with Bombs”, *The Times of India*, Monday, January 9, 2012.

17. Paul McLeary, “K-MAX Chugging Along in Afghanistan”, posted in *Asian Week* (online) on February 3, 2012, accessed on June 22, 2012.

**Cherished characteristics of military airlift platforms include: ruggedness, requiring minimum servicing and maintenance; multirole with all-weather and night operations capability; capability to operate in high ambient temperature conditions even at high-altitude airfields; high cruising speeds and good slow flying characteristics; long range and radius of action with STOL/VTOL operations from semi prepared and unprepared surfaces; a large passenger/cargo compartment allowing maximum possible payload, rear loading capability using integral ramps and stealth to the extent possible, and capacity to carry armament.**

surfaces; a large passenger/cargo compartment allowing maximum possible payload, rear loading capability using integral ramps and stealth to the extent possible, and capacity to carry armament.

A few of these requirements are conflicting, for example, large payload conflicts with short take-off. Therein come the judicious use of the available technology, and the ingenuity of the men behind the machines. A jet pack fitted on the fuselage of the C-119 Packet aircraft, months before the India-China War (1962), reduced the take-off runs and enabled operations from

with initial successes. As per a NATO report, Urban Aeronautics an Israeli firm has developed *AirMule*, a ducted-fan craft for unmanned evacuation of wounded soldiers from combat zones. It has been specifically designed for logistics and medical missions (resupply and medical evacuation). The prototypes still have to prove in operations.

#### **THINKING OUT OF THE BOX**

Cherished characteristics of military airlift platforms include: ruggedness, requiring minimum servicing and maintenance; multirole with all-weather and night operations capability; capability to operate in high ambient temperature conditions even at high-altitude airfields; high cruising speeds and good slow flying characteristics; long range and radius of action with STOL/VTOL operations from semi prepared and unprepared

high-altitude airfields. Again, thanks to this modification, Packet remained a workhorse of the IAF for many years until induction of An-32 aircraft in the 1980s. In another display of ingenuity, Skunkworks (Lockheed Martin) fitted rockets on the fuselage of C-130 Hercules aircraft to achieve a near VTOL capability for a second rescue plan of the American hostages in Iran (Operation Credible Sport, 1980). There is no limit to innovation.

#### **INFRASTRUCTURE ALONG THE BORDER**

Creation of infrastructure of any type costs a fortune and great effort in manning and maintaining it. It is neither humanly possible nor prudent to create assets all over—along the border, in particular—to counter the adversary, or to meet the demands placed on the Disaster Management organisations by occasional disasters. And then, there is no guarantee that the adversary would give an opportunity to reap benefits of the infrastructure. An option, after creating the bare necessary permanent infrastructure, is to develop capability and capacity to create assets expeditiously.

For the US, that has expeditionary agenda and a force to match it, it makes sense to have such capability. The US Navy's Construction Battalions (CBs), better known as Seabees have a history of building bases, bulldozing and paving thousands of miles of roadway and airstrips, and accomplishing myriad other construction projects in a wide variety of military theatres. They constructed six 8,500+ feet runways at the rate of one runway per 53 days; over 18 km of taxiways; hard-standing to accommodate over 400 bombers, and accommodation for 50,000 personnel and office complexes, on the islands of Tinian and Saipan in the Pacific in a record time of less than a year during World War II. In midsummer

**With no earth movers and heavy road rolling equipment, service personnel and the refugees led by Lieutenant Colonel Pritam Singh had built a 600-yard runway in six days at Poonch. That was 1947. Today, it should be possible to create similar infrastructure even more expeditiously, wherever required.**

1945, Tinian became the largest single, and the busiest, airport in the world. Nearly 19,000 combat missions were launched from these islands including the sorties that dropped atomic bombs on Nagasaki and Hiroshima.<sup>18</sup>

About 2,600 Seabees were deployed in about 20 different countries around the globe supporting a variety of humanitarian missions and contingency operations as late as in 2009. Seabees were among the first forces in Afghanistan after the 9/11 attacks to upgrade and repair airfields.<sup>19</sup>

With no earth movers and heavy road rolling equipment, service personnel and the refugees led by Lieutenant Colonel Pritam Singh had built a 600-yard runway in six days at Poonch.<sup>20</sup> That was 1947. Today, it should be possible to create similar infrastructure even more expeditiously, wherever required—be it Daulat Beg Oldi or any Advanced Landing Ground (ALG). There is more to learn from the following example.

At the peak of the Berlin Airlift, need was felt to construct a runway at Tegel in the French sector of Berlin. It had to be built from scratch. The earth movers, other heavy machinery and construction material required for the purpose could not be moved into Berlin by surface means due to the restrictions imposed by the Soviets. Besides, such airlift of construction material and machinery would be at the cost of critical food supplies. The problem was circumvented in steps. First, the need to airlift construction material was obviated by utilising the bricks and the rubble caused by the Allied bombing of the buildings in Berlin. Then, the heavy items of equipment were dismantled into smaller parts. And finally, those dismantled parts which could not be airlifted (owing to their dimensions or weight) were *cut* into smaller manageable parts; airlifted to Berlin, and then, *welded* together into their original forms.<sup>21</sup> All this was done in record time.

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18. "The Use of Tinian Island During World War II", at <http://web.mst.edu/~rogersda/umrcourses/ge342/Tinian%20Island.pdf>. Accessed on April 9, 2021.

19. "Additional Seabee Battalions Deploying to Afghanistan", Story Number: NNS091222-01; Release Date: December 22, 2009, 7:58:00 AM on Navy.mil, the official website of the US Navy, at [http://www.navy.mil/search/display.asp?story\\_id=50316](http://www.navy.mil/search/display.asp?story_id=50316). Accessed on April 9, 2021.

20. Air Marshal Bharat Kumar (Retd.), *An Incredible War: IAF in Kashmir War 1947-1948* (New Delhi: Knowledge World, 2nd edn., 2007), p. 179.

21. Lt. Gen. William H. Tunner, n. 14, pp. 211-12.

In today's age and time, it should be possible to create infrastructure at a very rapid rate. Three points need to be borne in mind: One, a pool of highly skilled and dedicated men capable of creating infrastructure of any kind would be an asset; possibly teams that could be paraded. Two, ensuring earmarked sources of failsafe supply of construction material in all parts of the country. Three, ability to deliver (airland or paradrop) construction materials and equipment wherever required at short notice. A potent airlift capability can, to a great extent, do away with the need of creating and maintaining less essential infrastructure.

### **TONNAGE VERSUS EFFECTIVENESS**

Generally, tonnage is a yardstick used to evaluate airlifts—the weight airlifted over distance and time—the more the weight airlifted over the greater the distance in less time, the better. In addition, during HADR missions, evaluation is based on the casualties evacuated or lives saved. This thought process needs to change, as brought out by the following examples.

It is a recorded fact that one in every three aircraft (i.e., nearly 65 per cent of the airlift effort) to Berlin carried coal. Without coal the city could not survive. More than personal comfort, it meant light and power, and water and sewage. Coal generated the power which ran pumps and other municipal facilities. So, no one bothered about the quantity of coal being airlifted, until an interesting study revealed that beans, otherwise an excellent foodstuff for the hungry citizens of the beleaguered city—cheap and rich in both carbohydrates and protein—was not a practical food because it took a lot of time to boil and needed a large quantity of coal for cooking.<sup>22</sup> Focus on *ready-to-eat* food and substitutes for beans in the later stages led to greater effectiveness of the airlift.

The Air Force (or the civilian airliners that are required to provide airlift) has little say in matters related to the nature of load provided for airlift. Tonnes of barbed wire were airdropped at Senge and Se La during the 1962

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22. Lt. Gen. William H. Tunner, n. 14, p. 203.

War with China.<sup>23</sup> To what avail? Six decades after the war, it would be unfair to comment on the effectiveness of those supplies from the air or on the compulsion to prefer 'barbed wire' to winter clothing and ammunition for the troops. But, for sure, a little thoughtfulness on the part of the load provider can make a huge difference to the effectiveness of an airlift.

Operation Cactus (the Maldives, November 1988) to rescue President M. A. Gayoom was launched at an extremely short notice. Because of the urgency and for reasons of secrecy, people had been briefed on a *need-to-know* basis. The result was that everyone turned up at the tarmac with what one thought was most essential. Thus it was that artillery guns and goose necks vied with kitchen utensils and field mess furniture for the limited space in the aircraft. Major (later, Major General) Harkirat Singh had to intervene to calm tempers between the loadmaster and the Quarter Master.<sup>24</sup>

The Indian Air Force (IAF) is called upon to airlift relief material during natural calamities which have started recurring with the regularity of the equinoxes (exaggeration intended). With reference to the airlift operations undertaken during the Uttarkhand Disaster of 2013, there is much to introspect. Within the first ten days, the IAF (as apart of Operation Rahat) airlifted over 13,000 people and dropped over 200,000 kg of relief material in more than 1,500 airlift sorties. The rescue work continued unabated despite the crash of an Mi-17V5 helicopter killing all 20 on board. The Indian Army (Operation Surya Hope) saved over 2,700 pilgrims in over 600 sorties in the same period. When it was all over, the statistics did not talk about the many more lives that could have been saved had the planners been more pragmatic in the choice of the loads airlifted. At a time when people were dying for want of food, water, medicines, blankets and other necessities, the IAF was tasked to airdrop firewood for cremation of the dead. The few helicopter-loads of firewood airdropped

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23. Wing Commander M. Sadatulla (Retd.), *1962 War: Supplying from the Air* (New Delhi: KW Publishers, 2012), pp. 76, 78.

24. Group Captain Ashok K. Chordia (Retd.), *Operation Cactus: Anatomy of One of India's Most Daring Military Operations* (New Delhi: KW Publishers, 2018), p. 88.

would hardly have been sufficient to cremate thirty or forty people (out of the thousand and more dead) but the same tonnage of medicines and food would have saved many more lives. This a sensitive issue, but priorities need to be laid down with open mind and at a time when the country is not facing a crisis.<sup>25</sup> Another thing that sounds ridiculous is the sorties that are devoted to airlifting the so-called VIPs and the media persons. A study on the cost of airlift—in terms of *additional* lives lost—for such avoidable purposes could be an eye-opener.

*“For India to be better prepared to meet disasters, it needs to levitate into becoming another kind of country.”*

—Santosh Desai<sup>26</sup>

## EDUCATION OF STAKEHOLDERS

Professionally trained aircrew and aircraft are a constant in matters of airlift. One thing that makes a great difference—one that can make or mar an airlift effort—is the education of the other stakeholders. Here are some examples that shed light on this extremely important aspect.

During the Berlin Airlift, there was a curious case of a large number of pilots (flying bags of charcoal into Berlin) experiencing sluggish controls. An investigation revealed that ‘over-enthusiastic’ loaders were packing, on an average 15 per cent extra coal in each bag (purportedly) weighing a hundred kilograms. But while preparing the manifest they were accounting for a hundred kilograms per bag. It amounted to a tonne and a half ‘extra and unaccounted’ weight on each C-54 aircraft. It had to be conveyed to the loading crews that their overzealousness was *hurting*, not helping, the airlift effort.<sup>27</sup> In the same context, it was reported that about 300 to 400 pounds of coal dust was being carried back in the nooks and corners of each aircraft without people realising it. This revelation led to special

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25. Group Captain Ashok K. Chordia (Retd.), “Airlift During Disasters: The Uttarakhand Experience: Can We Save More Lives?”, CAPS Issue Brief 90/13, July 11, 2013.

26. Santosh Desai, “A catastrophe called disaster”, *The Times of India*, Monday, June 24, 2013, p. 6.

27. Tunner, n. 14, p. 204.

instructions to 'clean' each aircraft after transporting coal. This cleaning was not very effective and forced the use of vacuum cleaners. Notwithstanding the efforts, mechanics could find charcoal dust in *Skytrain* and *Skymaster* as late as in the 1960s.<sup>28</sup>

During the *Over the Hump*<sup>29</sup> airlift, there is one freak instance of an aircraft crashing on the take-off run. It so happened that the Chinese troops who were made to travel in that aircraft were not *volunteers*. They were scared of flying. When the aircraft started rolling for take-off, the troops started jumping out of the open door on to the runway. In seconds, all the troops rushed to the aft end of the aircraft. This caused a sudden overweighting of the tail, leading to a premature take-off and eventual crash.<sup>30</sup> They were still uneducated unsafe passengers when, in the later years, their anxiety had been sufficiently allayed. They would build a fire on the floor of the aircraft to keep themselves warm. Still worse—they would not hesitate to push a buddy out of an aircraft in flight—just for fun.

Education of 'other stakeholders' is a universal issue. India is no exception. Comical as these may appear, the following incidents leave much for introspection. During Operation Pawan (Sri Lanka, 1987-1990), Indian Airlines aircraft were requisitioned to airlift some Indian Army formations. At Pune, the ignorance of the loading norms led the troops to *push in* a large battalion flagpole through the doorway of the aircraft. When they failed to load it *in* because of its size, they tried to 'lash' it on top of the aircraft. If that was not enough, they loaded live ammunition in the hold of the aircraft without the knowledge of the aircrew. The exact details were neither declared in the manifest nor conveyed to the aircrew. The pilots of the Indian Airlines aircraft, like the airlifters of coal of Berlin, had a tough time flying the overloaded aircraft. When, on reaching the destination, the crew of the aircraft came to know that the aircraft had been overloaded with mortar ammunition (something which

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28. Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-49* (Texas: Texas A&M University, 2000), p. 155.

29. *Over the Hump*: These airlifts were undertaken by (mainly) the US Air Force from India and Myanmar (then Burma) to supply the Chinese forces fighting the Japanese Army.

30. Tunner, n. 14, p. 126.

needs special clearance and prior permission), they were alarmed and vowed never to fly the Indian Army again.<sup>31</sup>

Equally alarming is the case of personnel detailed to load the guns and ammunition on behalf of 17 Para Field Artillery during the preparation for airlift of troops to the Maldives (Operation Cactus, November 1988). When they were told to reduce the weight, they did not physically *cut down* on their load, but just *pruned it on paper*.

Flouting of airlift norms (even if deliberate) by the stakeholder is mainly because of lack of education. This aspect must be borne in mind by all concerned with the success of airlift operations. Education alone can prevent catastrophe.

### THE AIRCREW

It is almost axiomatic that an aircraft parked on the tarmac contributes *nothing* to the achievement of airlift goals. But, for the airlift aircraft to be airborne all the time (or most of the time), extra sets of aircrews, medically fit and well-rested, is an understandable necessity. Not really! During the 1962 War with China when the IAF transport aircrew were overworked, having been on their feet for nearly 48 hours, young fighter pilots (who had flown *Mystère* aircraft) with no experience on the type (IL-14), took control of the transport aircraft after take-off and flew the machine till landing, to give in-flight rest to the fatigued transport pilots.<sup>32</sup> This spirit of *Mission First* is unique to military pilots (the three services).

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31. General V. K. Singh, cited in Air Marshal Bharat Kumar, *Operation Pawan: Role of Airpower with IPKF* (Delhi: Manohar, 2015), pp. 79-81.

32. Air Marshal Bharat Kumar (Retd.), *Unknown and Unsung: Indian Air Force in Sino-Indian War of 1962* (New Delhi: KW Publishers, 2013), p. xiii.

**Airlifts are the lifeblood of military operations and HADR missions. Over the years, aircraft evolution and new techniques have turned airlift into a very specialised art.**

During the airlift of Indian expatriates from Kuwait (1990), problems cropped up even before commencement of the airlift. One set of Air India crew was stranded in Kuwait having flown in an earlier flight. The Air India pilots and staff “threatened” that unless the crew were got out of Kuwait, they would ground the flights. According to K. P. Fabian who was then the Head of the Gulf Division in the Ministry of External Affairs, “The threat was indeed serious.”<sup>33</sup> The IAF placed six IL-76 aircraft along with crew under the operational control of Air India for the evacuation. They operated from Mumbai and effected at least 25 per cent of the air evacuation. More importantly, the IAF pilots evacuated Indians from Basra and Kuwait<sup>34</sup>—difficult airports to operate from, considering the clouds of war. The Air India pilots operated from Amman, a relatively *safer* airport.

#### IN CONCLUSION: A VALUABLE QUESTION

Airlifts are the lifeblood of military operations and HADR missions. Over the years, aircraft evolution and new techniques have turned airlift into a very specialised art (read, *Art of War*). There is much to airlift operations than brought out through a few random examples cited above. It is important to revisit these operations, and many others, to be able to draw maximum advantage from similar operations in the future.

Through revisits, it is relatively simple and easier to learn, educate and build on the HADR capabilities; not so much with regard to wartime military airlifts, because each of the warring sides (the ‘blue’ force and the ‘red’ force<sup>35</sup>) draws its own inferences and conclusions. In a future war, both sides are better prepared.

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33. K. P. Fabian, “Biggest Ever Air Evacuation in History”, Oral History, *Indian Foreign Affairs Journal*, vol. 7, no. 1, January-March, 2011, pp. 93-107.

34. Air Marshal A. K. Goel (Retd.), Director Operations (Transport & Helicopter) at Air Headquarters at the time of the airlift, in an interview by the author on January 31, 2013.

35. The ‘friendly’ force and the ‘enemy’ force, in military parlance.

*Redo* is not an option.

A good way to go about—after revisiting historical airlifts and assessing the current capabilities—is to seek answers to the valuable question: How can an airlift operation (airborne operation/air-landed operation or HADR, etc.) be repeated with greater probability of success?



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